WB4GCS	Modeling and Characterizing N3SH 40 and 75 Meter Diplexers for Field Day	5. Apr. 2018	1/17

Initiation Date:
5 April 2018
Continued on 8 April 2018

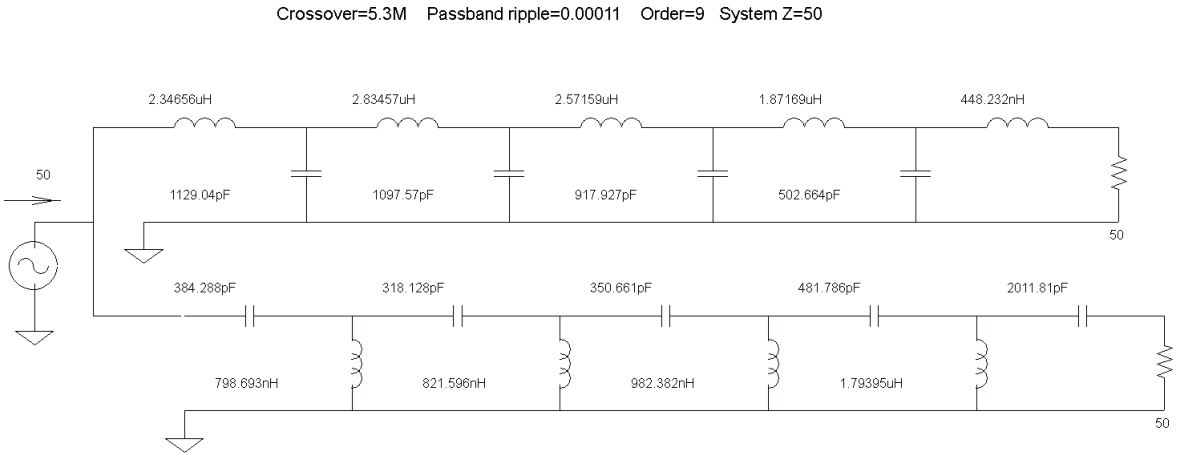
Participant(s):
WB4GCS, N3FB

Initial Symptoms:
Desire a diplexer which will allow simultaneous operation of 40m and 80m equipment/antennas using a single feed line.

Actions:

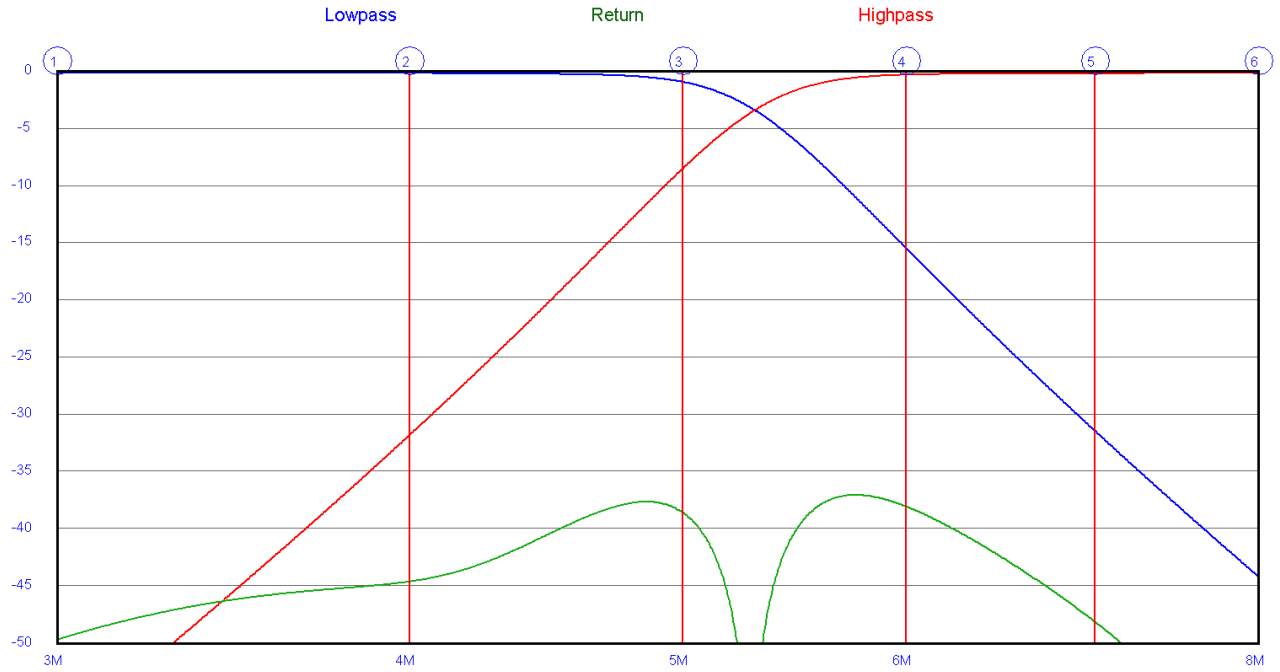
1. Define requirements:
   Noise floor on 75m tonight is -105 dbm.
   100 Watt transmitter is +50 dbm.
   System requirement is -105dbm – 50 dbm = -155 db of attenuation to keep the other transmitter below the noise floor!!
2. Use *Elsie* to design a diplexer.
3. Model and evaluate results; refine design.
4. Build prototype.
5. Measure and assess.
6. Refine.

Observations:
First effort at design:



Crossover frequency was chosen as the geometric mean between 75m and 40m.

Analyzed results:



Cascade two of these, and we get 65 – 70 db of attenuation between 40m TX and 80m RX and vice-versa. Transmitter had better be another 80 db down!

This 9th order filter will be a bear to build and a bitch to tune.

Consider a pair of parallel resonant circuits.

Then consider separately designed high pass and low pass networks, which can work in parallel.

Analysis:

1. I found a pair of 40m 75m diplexers at DXEngineering. They claim 35 db attenuation at the other band, for a total of 70 db with two cascaded. We still need *at least* another 40 db of attenuation.

From prior measurements (30 July 2016), two of the N3SH 80M filters have about 14 - 16 db of attenuation at 7 MHz, each. A third, labeled N3SH80-3, has 65 db of attenuation at 7 MHz. The WA3SH40 filter has 34 db of attenuation at 4 MHz and 40db at 3.5 MHz.

Even with the diplexers, this is insufficient.

Hypothesis:

This is going to be problematic.

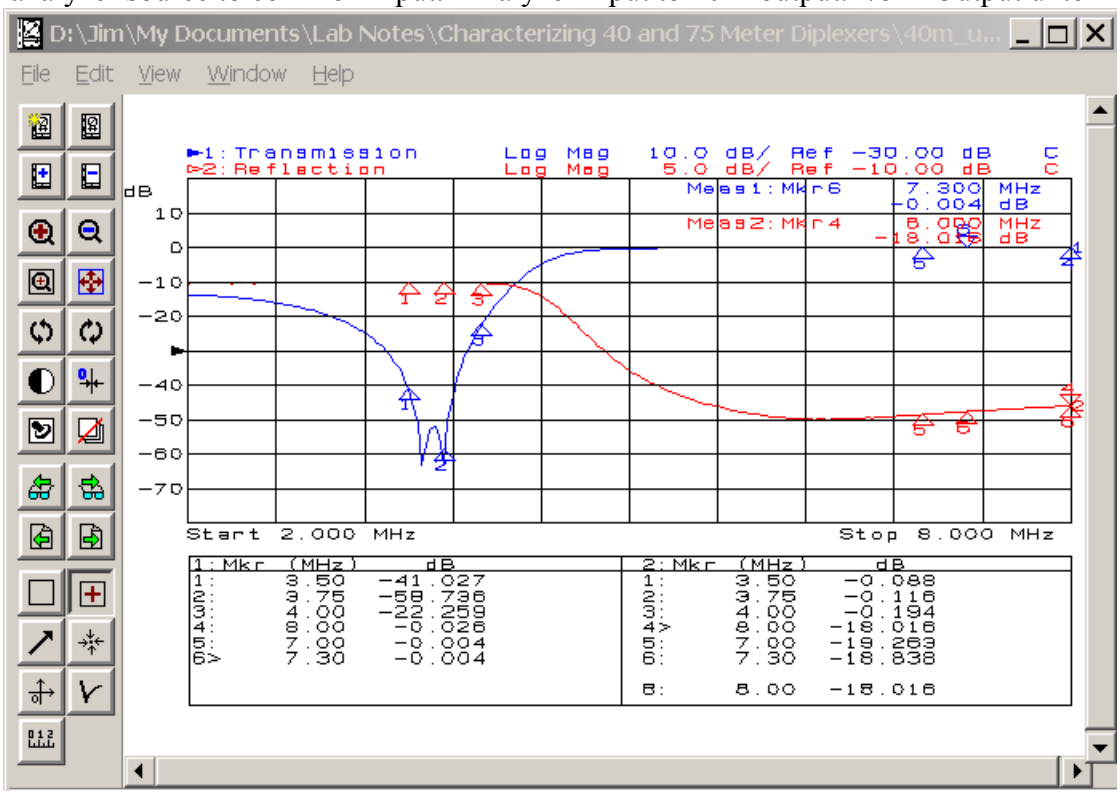
Plan:

1. Calibrate Network Analyzer over 2 – 8 MHz.
2. Terminate all unused ports with 50 ohms.
3. Characterize one diplexer; compare with OEM data.
4. Setup test system: Analyzer ==> diplexer ==> feedline ==> diplexer.
5. Measure.
6. Measure with different feedline length.
7. Measure again with one unused port terminated in 25 or 33 ohms. (Ultimately used 27 ohms.)

Results:

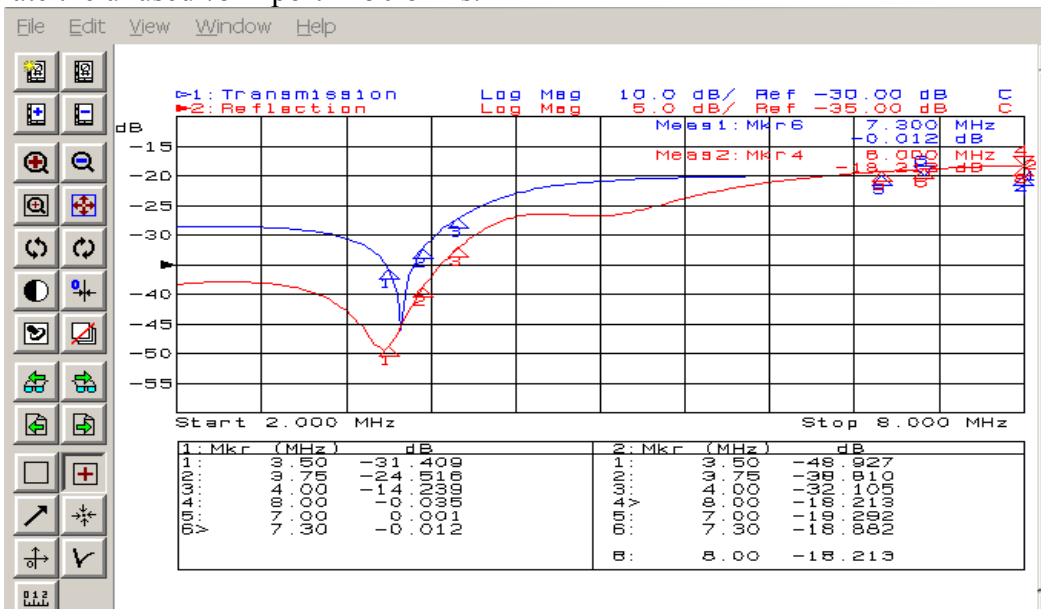
Serial number: 1217_866

Connect analyzer source to common input. Analyzer input to 40M output. 75M Output unterminated.



Note that in-band return loss is only -10db, probably due to unterminated 75M port.

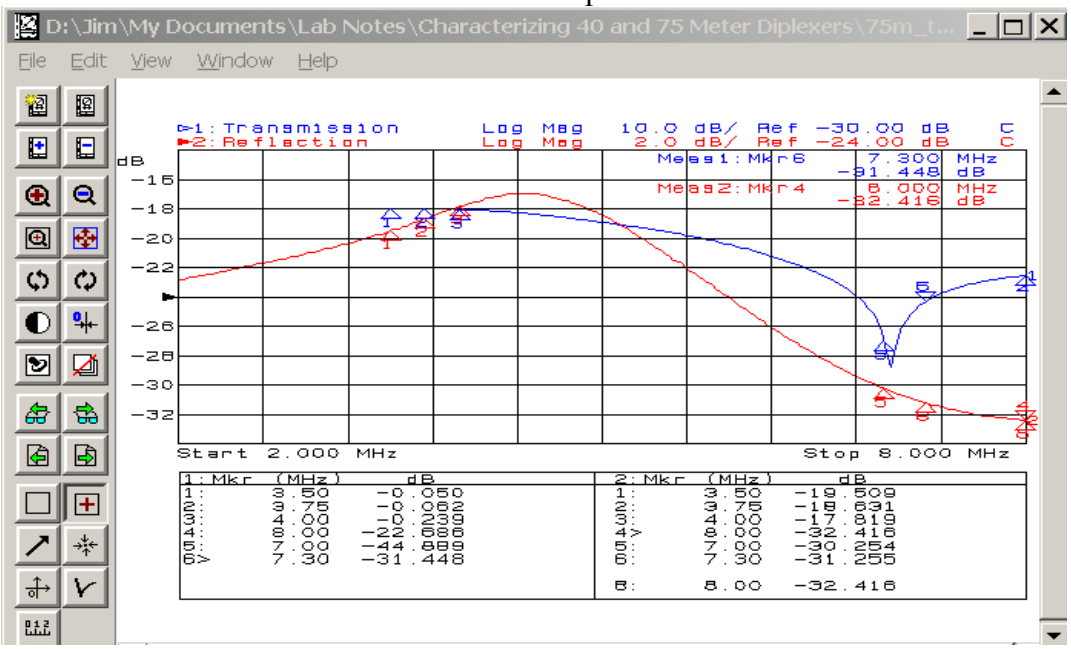
Now terminate the unused 75M port in 50 ohms.



Note the improvement in in-band return loss!

Comparing to OEM data: Return loss/SWR is as specified. Transmission loss in pass band is better than spec. (OEM measurements are in the appendix.)

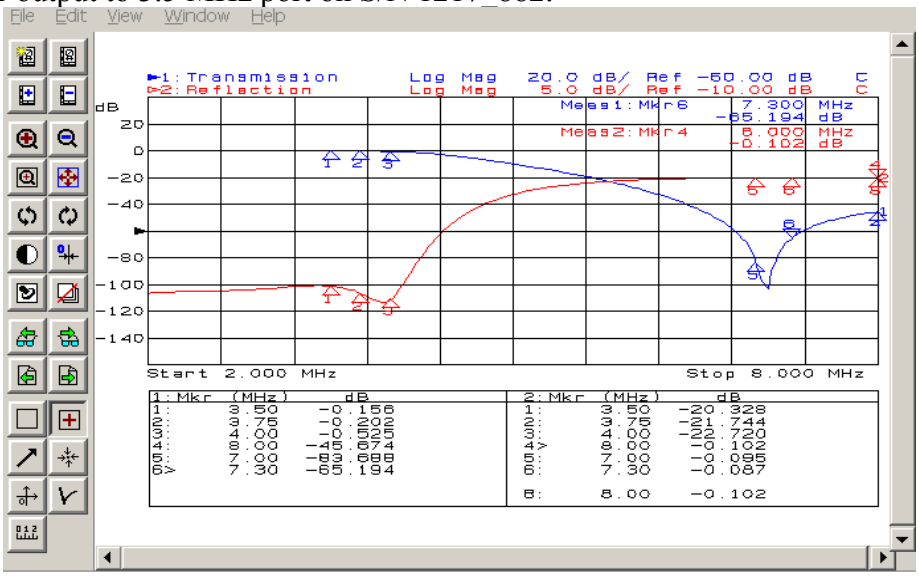
Now measure transmission from common node to 75M port.



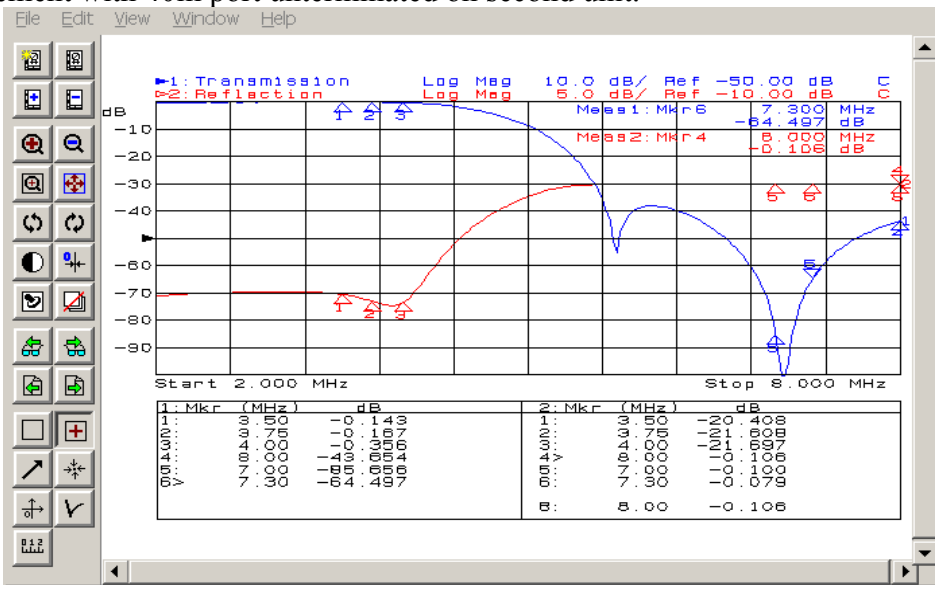
Performance is as specified.

Connect the pair:

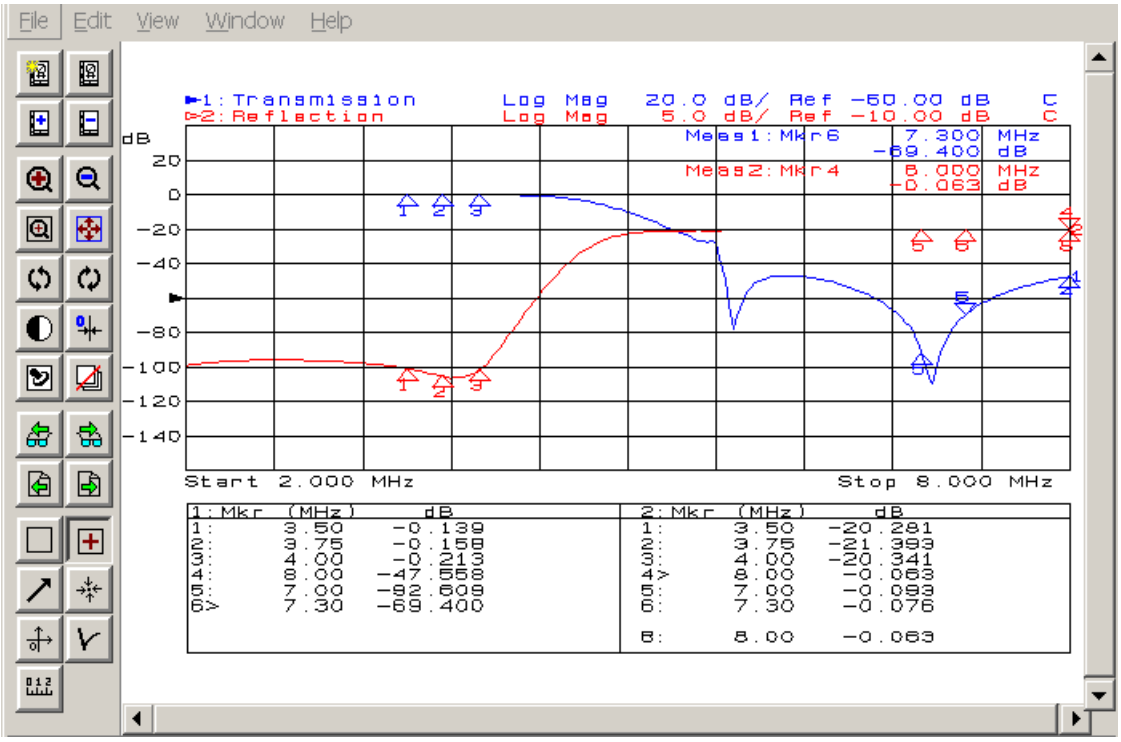
1. Input to 3.5 MHz port
2. Common ports connected through approximately 2-foot length of RG58.
3. Analyzer output to 3.5 MHz port on S/N 1217_882.



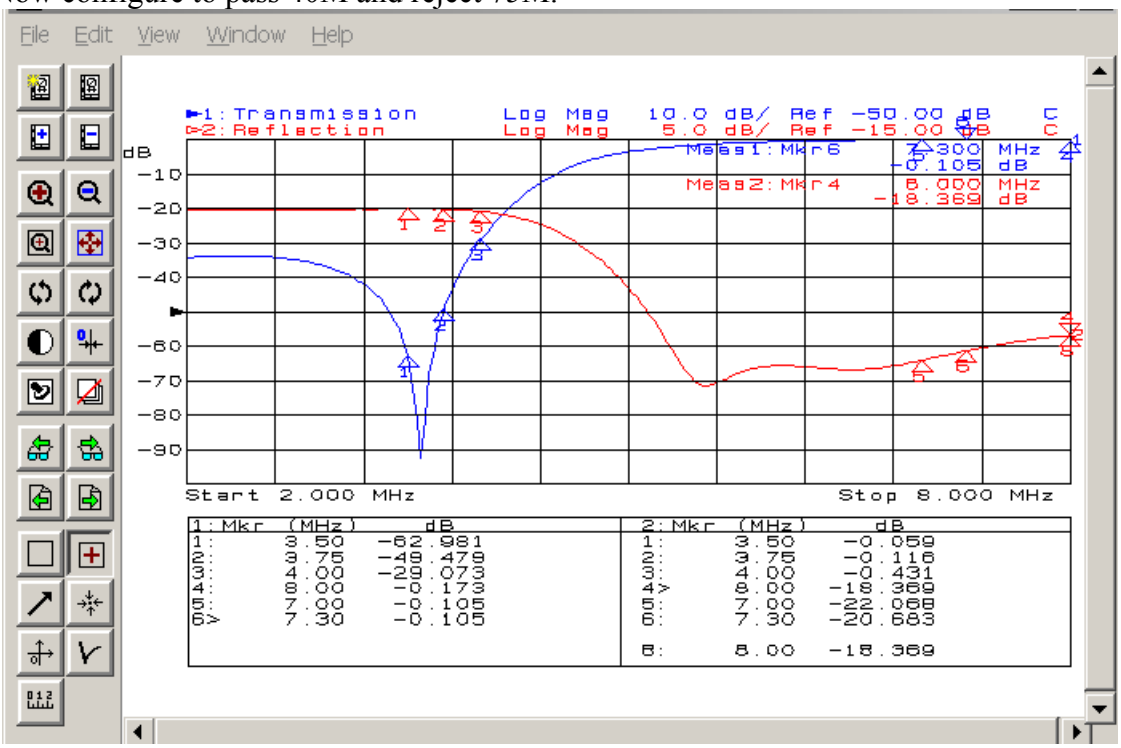
Repeat measurement with 40m port unterminated on second unit.



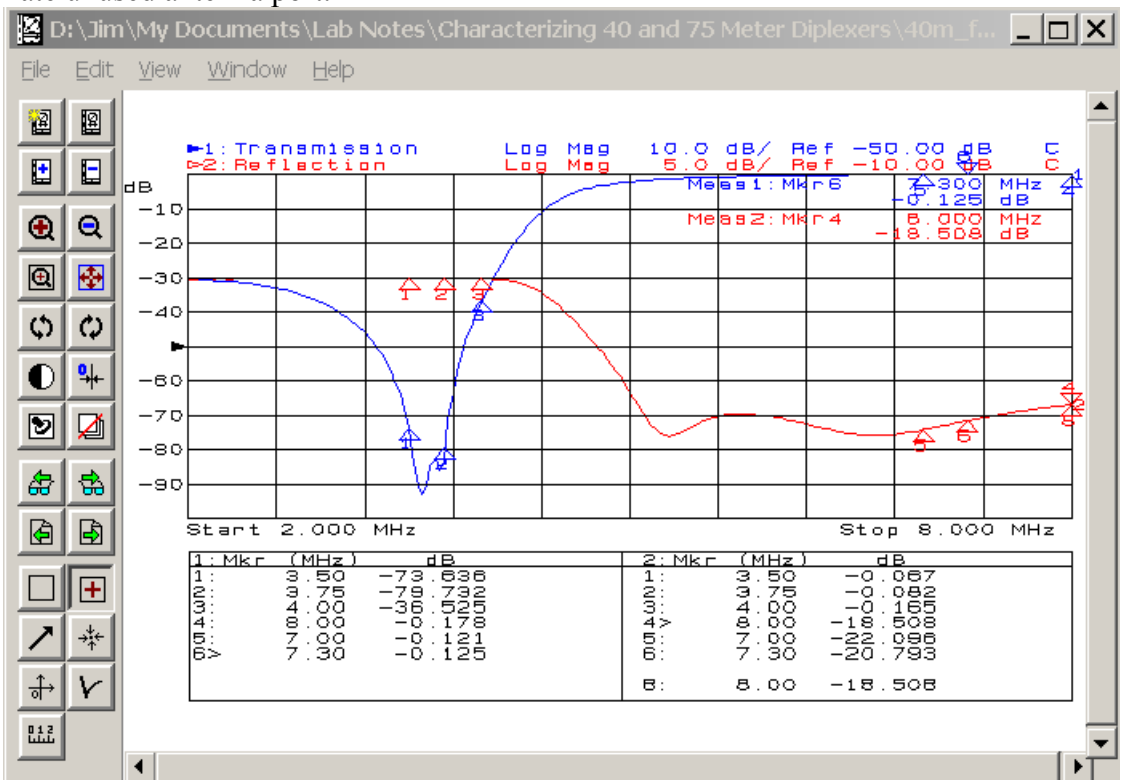
Now unterminate (open-circuit) both 40m ports:



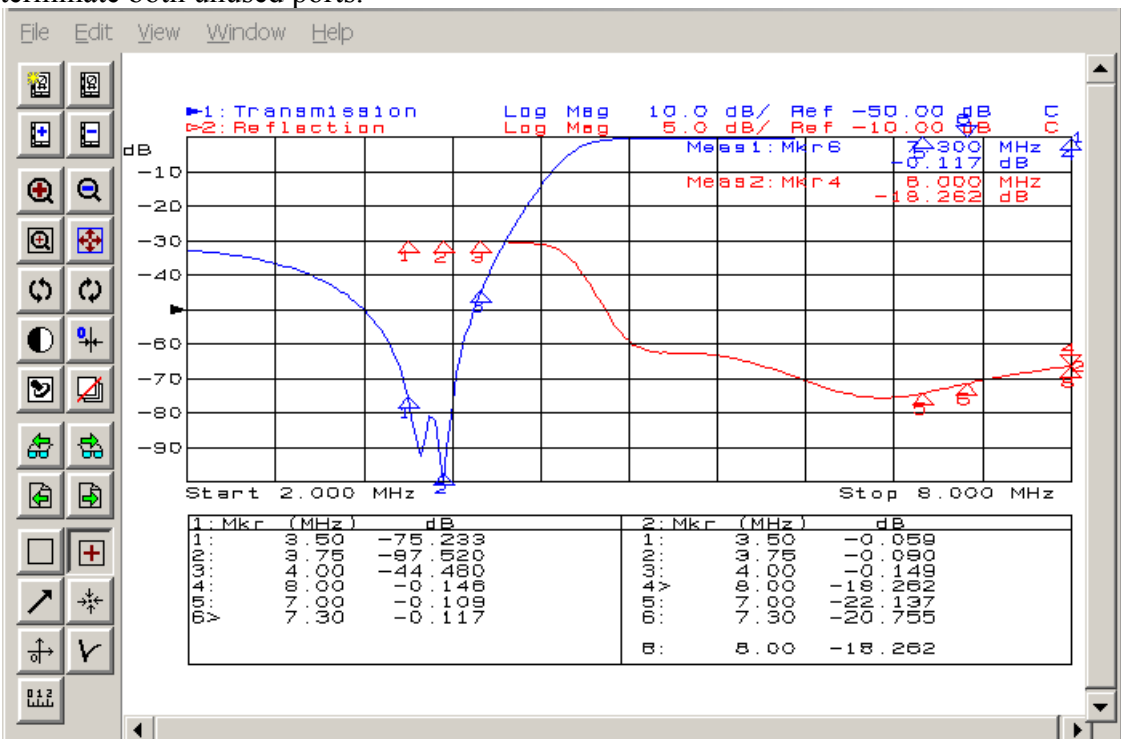
1. Now configure to pass 40M and reject 75M.



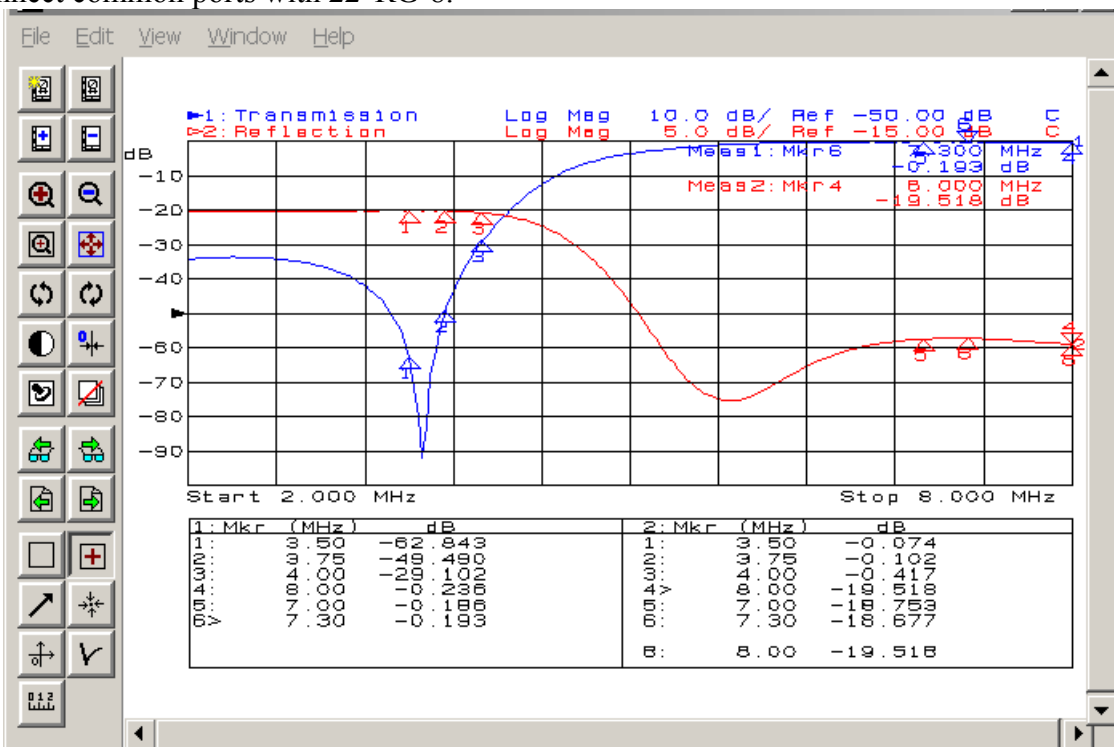
Unterminate unused antenna port:



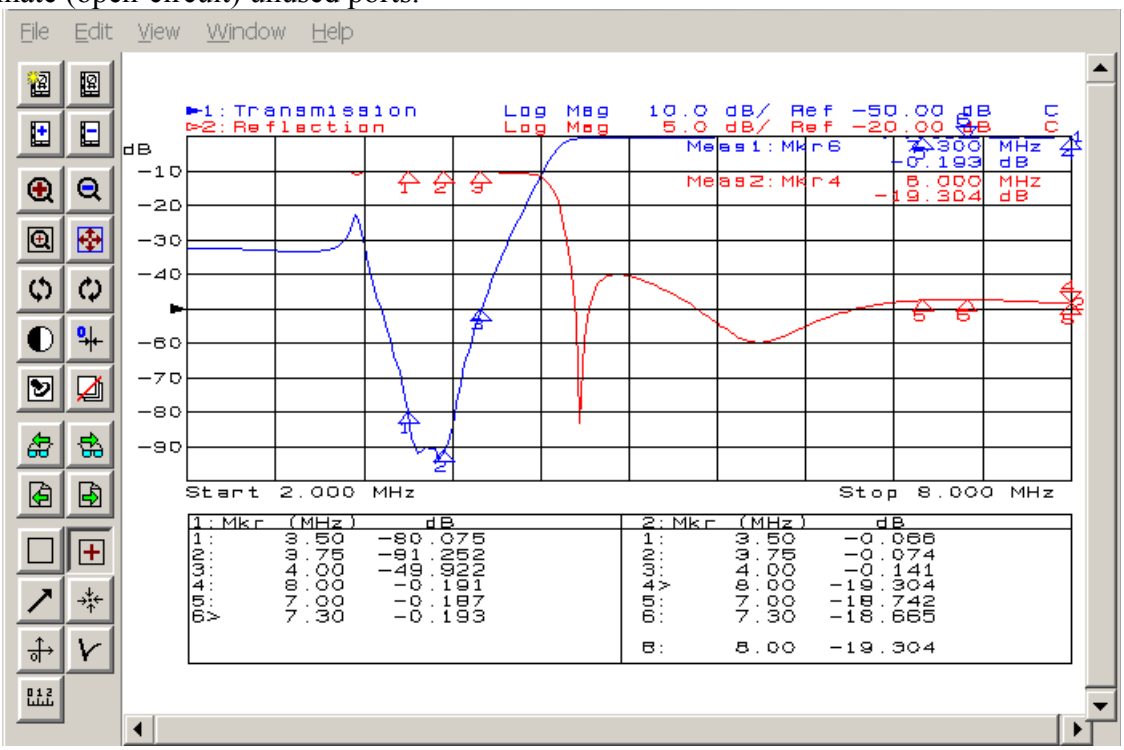
Now unterminate both unused ports.



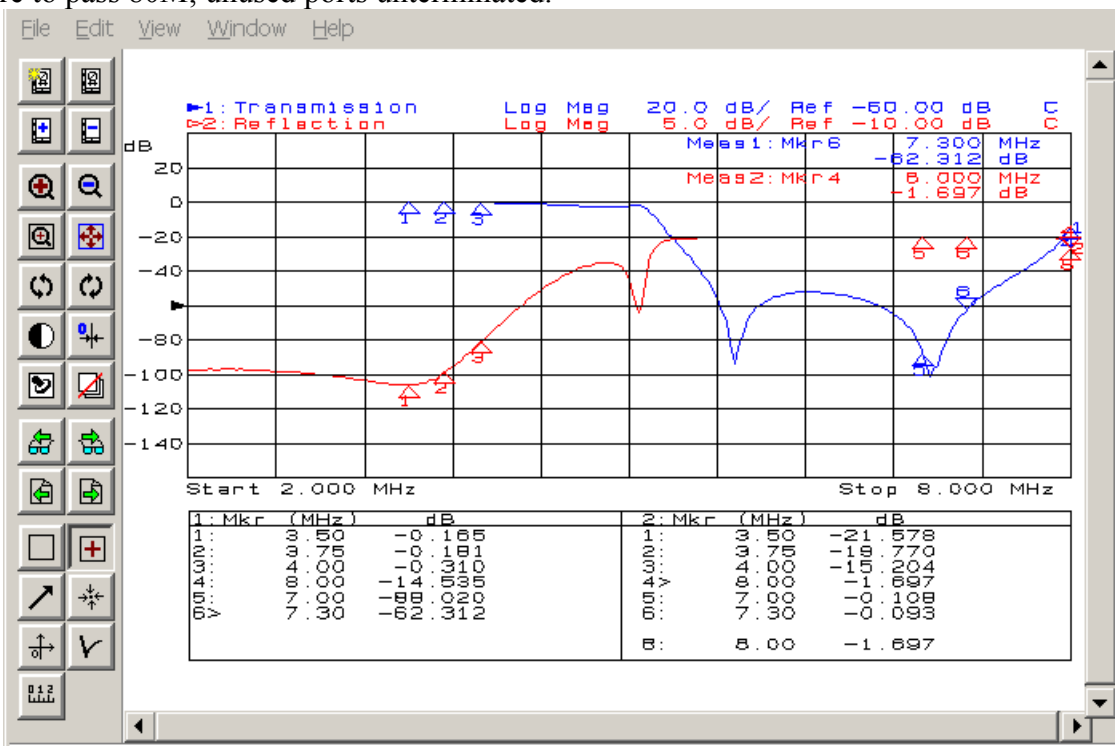
Now connect common ports with 22' RG-8.



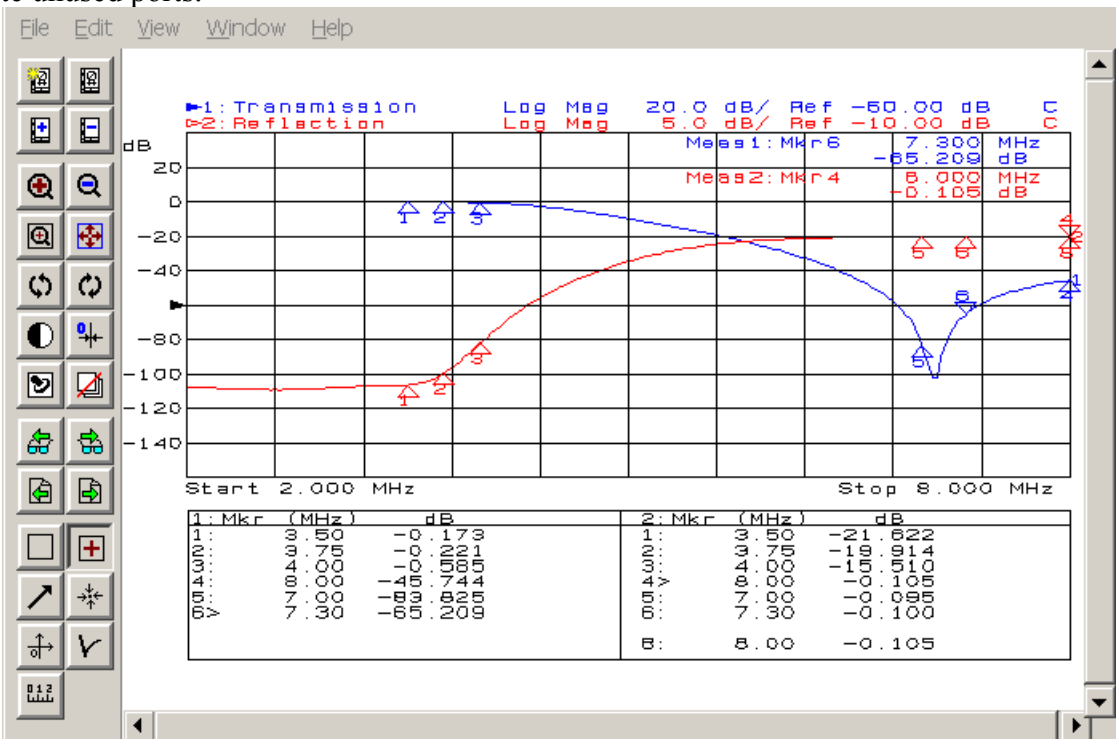
Unterminate (open-circuit) unused ports.



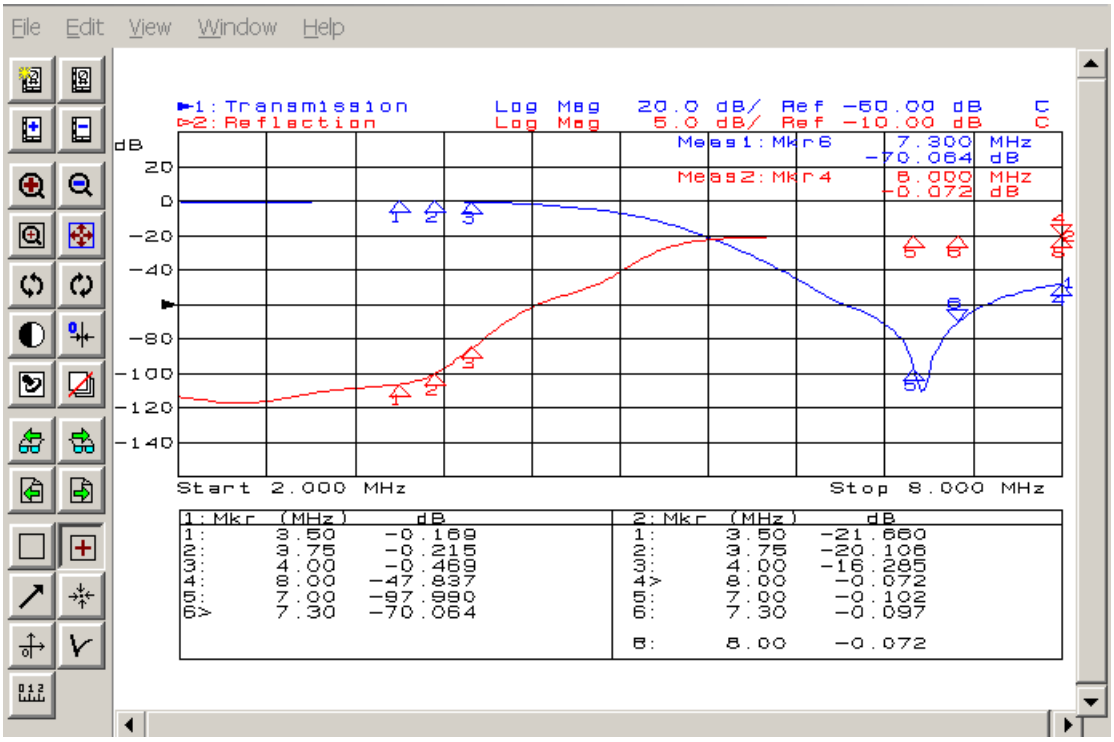
Configure to pass 80M; unused ports unterminated.



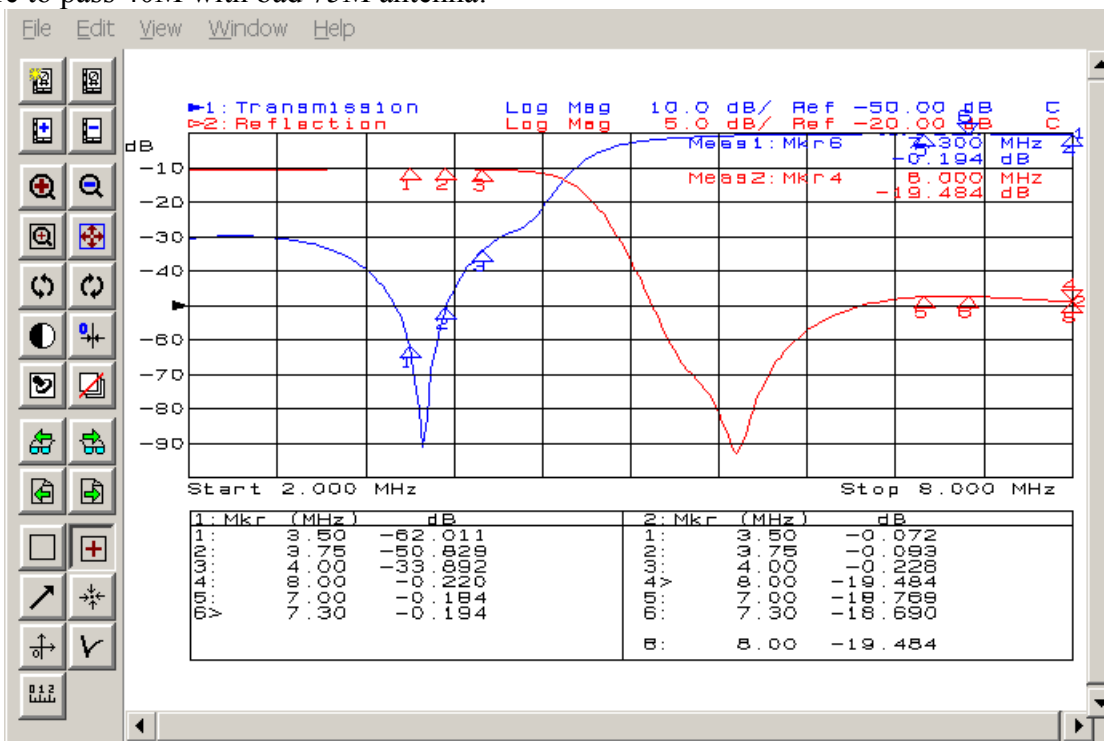
Terminate unused ports.



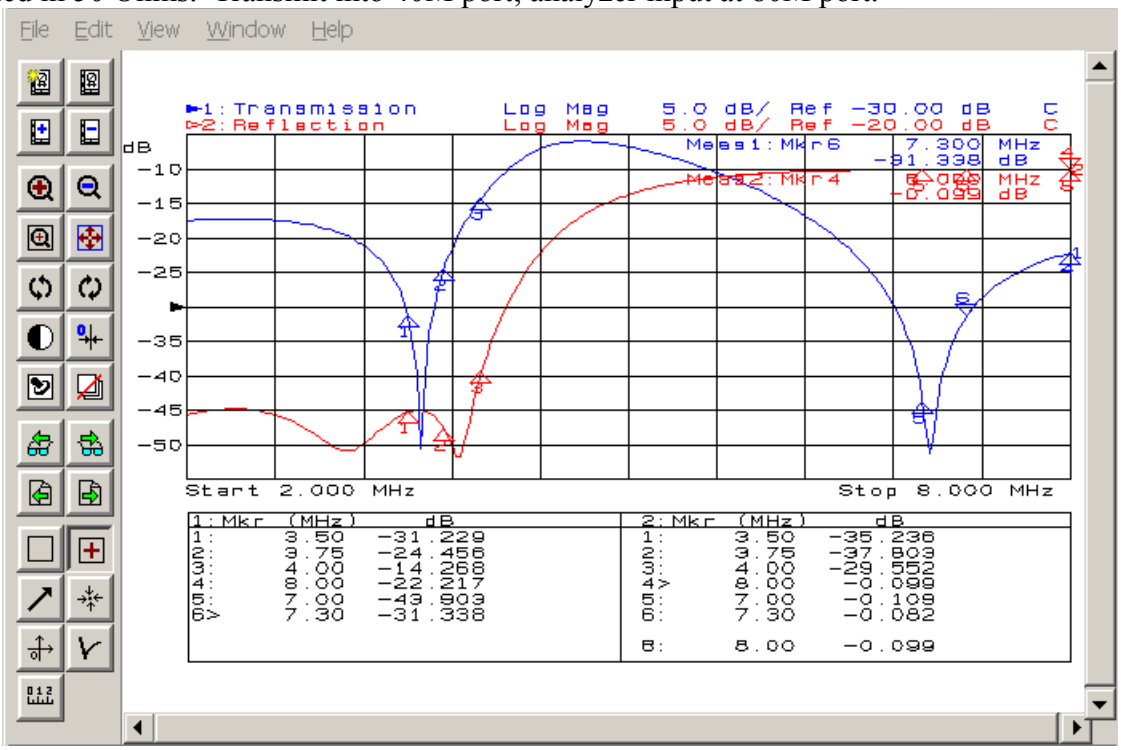
Use clipleads and 27 ohm resistor (may be inductive) to simulate bad 40m antenna.



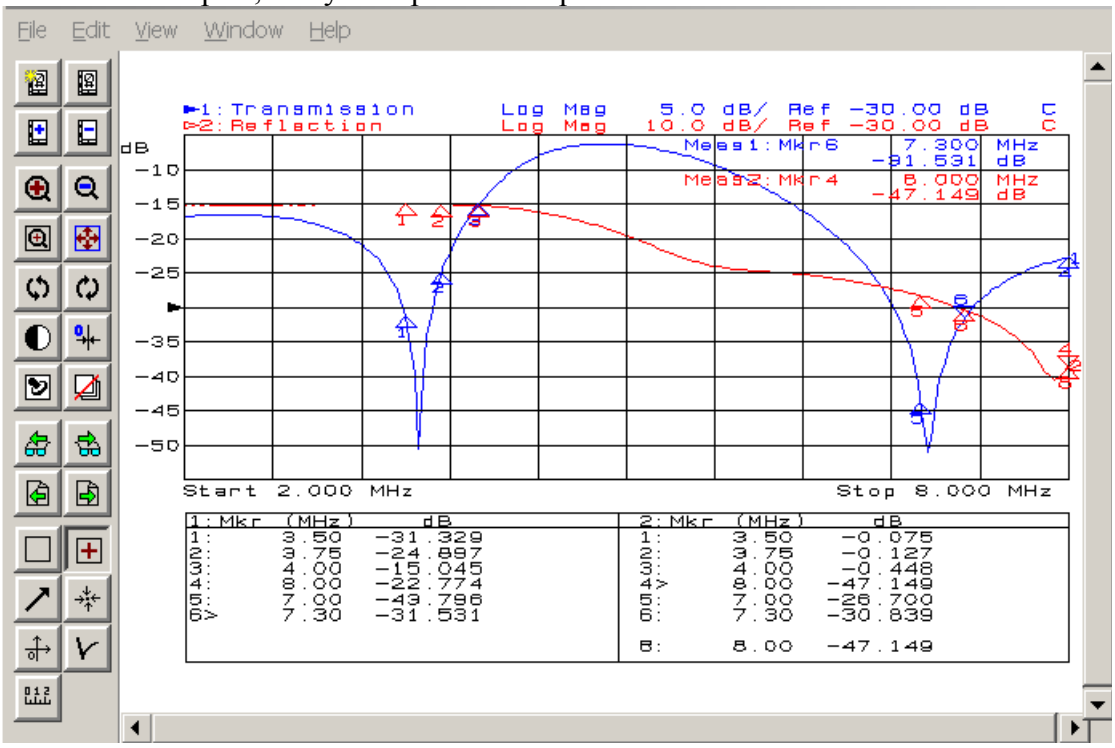
Configure to pass 40M with bad 75M antenna:



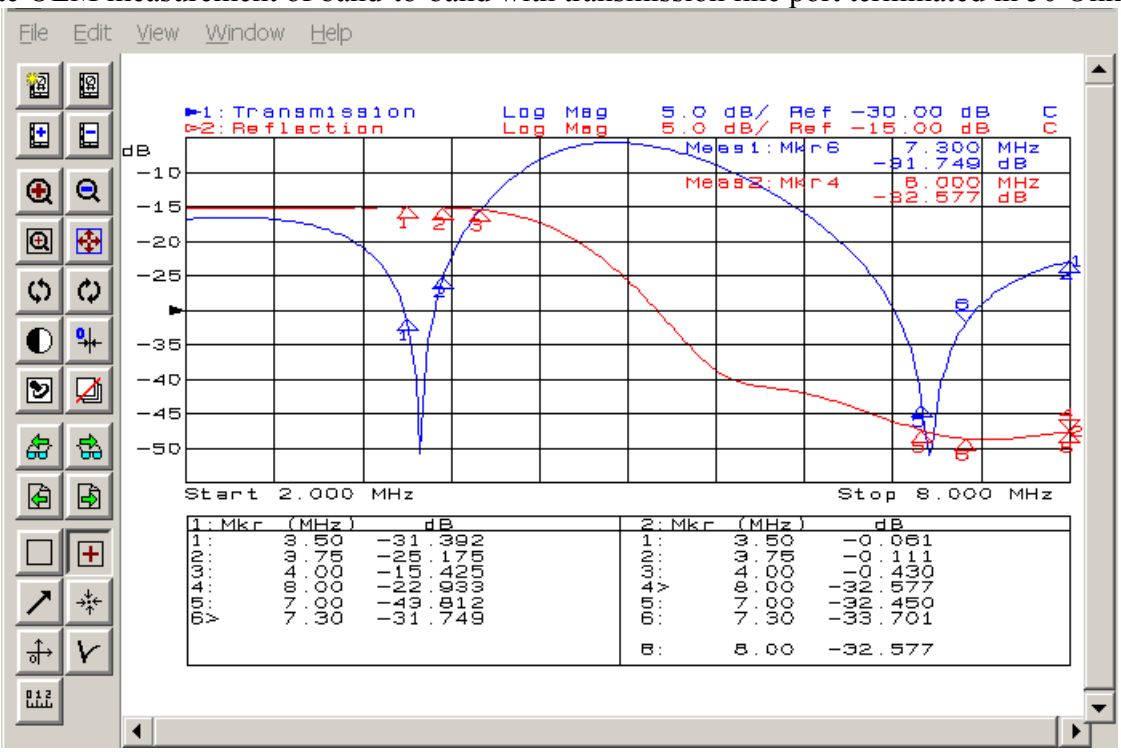
Duplicate OEM measurement of performance between 40M and 80M radios with common port terminated in 50 Ohms. Transmit into 40M port; analyzer input at 80M port.

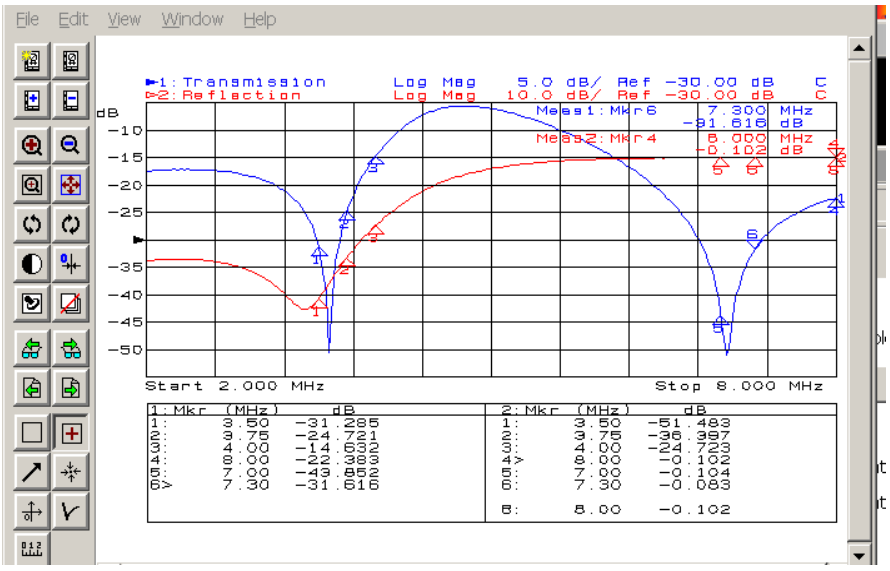


Now transmit into 80M port; analyzer input at 40M port.



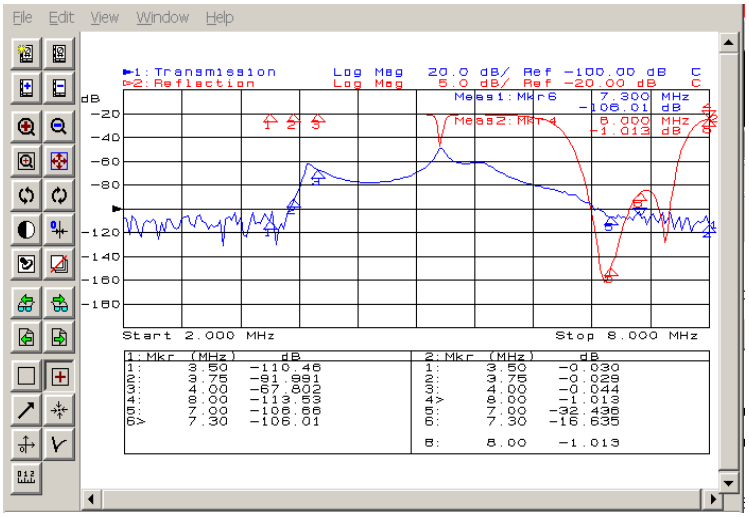
Duplicate OEM measurement of band-to-band with transmission line port terminated in 50 Ohms.



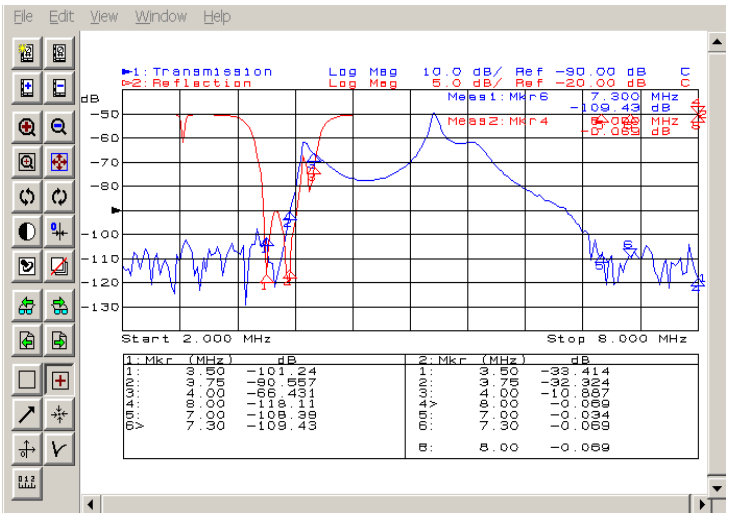


Pretty much as measured by OEM.

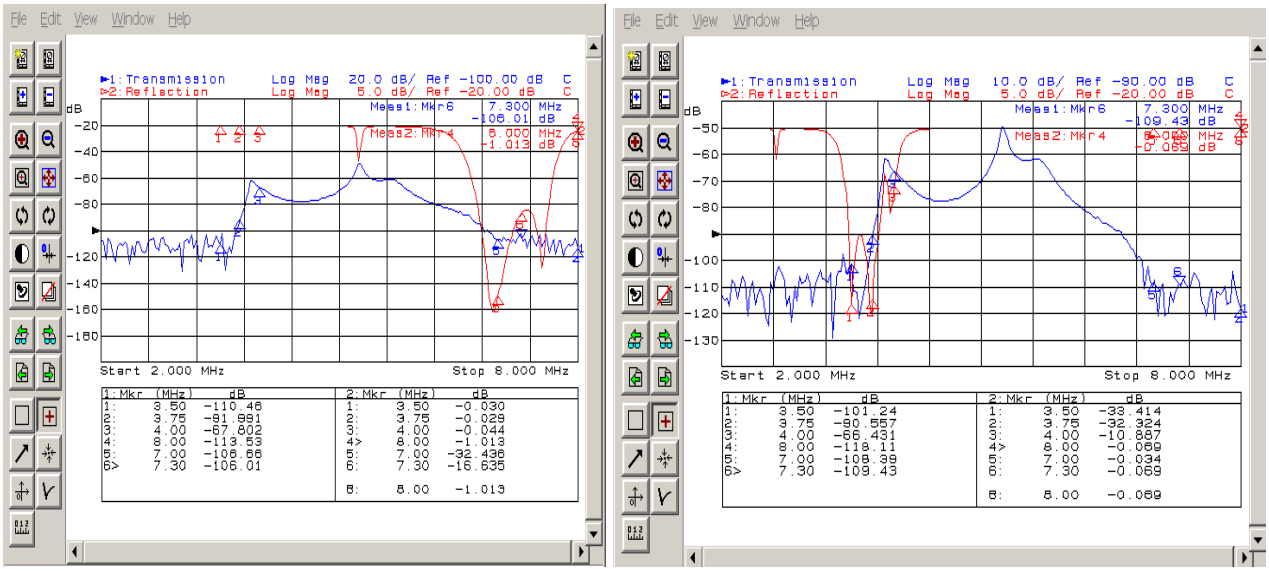
Now measure the system with some of the better bandpass filters (N3FBs Array Solutions units).
Configuration: Source to 40M filter, then to diplexer, then to 80 M filter, then to analyzer input.



Configuration: Source to 80M filter, then to diplexer, then to 40 M filter, then to analyzer input.



Comparison

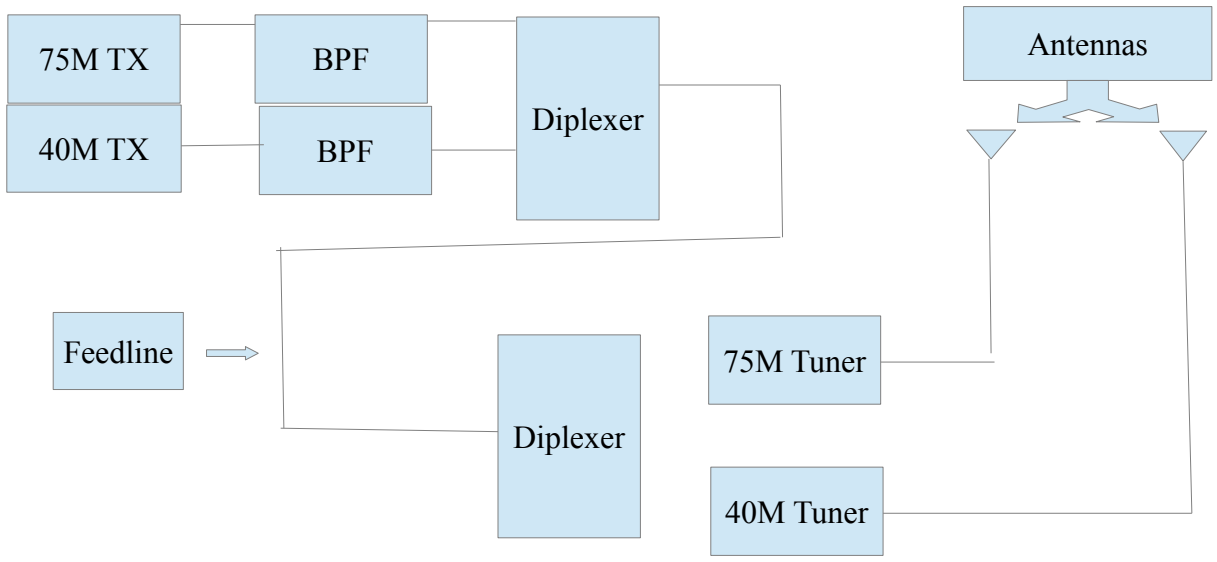


(Remainder of this page blank.)

Conclusion:

1. Radio with good antenna is relatively insensitive to the other band. HOWEVER, sending 100 watts into these diplexers with bad termination at any port will not do them any good, as voltages and currents will be way outside of design parameters – this was explosively demonstrated by some of the WASH filters which were damaged.
2. Total attenuation is NOT sufficient. As the diplexer OEM specifies, additional bandpass filtering will be required.
3. The filters that WASH owns are *not good enough* to use with these diplexers to feed 80 M and 40 M antennas with one feedline. (The filter labeled N3SH80-3 might be an exception and OK.)
4. The anticipated dependence on feed line length was not manifested in our tests.
5. Do NOT use preamps on receive!

This is how the system would look:



The antennas must show near 50 ohm impedance to the network of diplexers, filters and feedline.

This means there must be a tuner at or near the antenna.

I'm going to say this again:

The antennas must show near 50 ohm impedance to the network of diplexers, filters and feedline!!!!!!

This means that there must be a tuner at or near the antenna!

Alternatives for Consideration:

An additional 500 foot run of LMR400 type coax would cost $404.00 (Wireman, price as of 8 April18). While that is about 15% more than the cost of a pair of diplexers, it is *less* than the price of the diplexers and required filters.

Five hundred feet of RG-8X is $190.00, considerably cheaper, but this has 3db more loss at 10 MHz than RG-8 or LMR400.

Separate receiving antennas, such as loops – there are MANY possibilities here.

Recommendation:

1. Since we have these, recommend that we try them this year at Field Day. Doing so will require WASH to invest in better 80 and 40 meter filters, which is a good thing in its own right. Recommend the Array Solutions "Luxury" filters.

2. Run one 80/40 pair with the diplexers and one pair with separate feed lines and compare results.

3. Have 100 watt loads available to substitute for a transmitter that is removed from service. Have a wattmeter available to measure power into the load before connecting the second transceiver. If all is well, a Bird will show next to nothing; an HP432A (etc.) could confirm low or no power.

4. Have placards at affected transmitters with cautions and instructions:
   a) No preamp
   b) Do not disconnect antenna
   c) Do not use external tuner
   d) Do not change bands
   e) Range of acceptable frequencies

Appendix

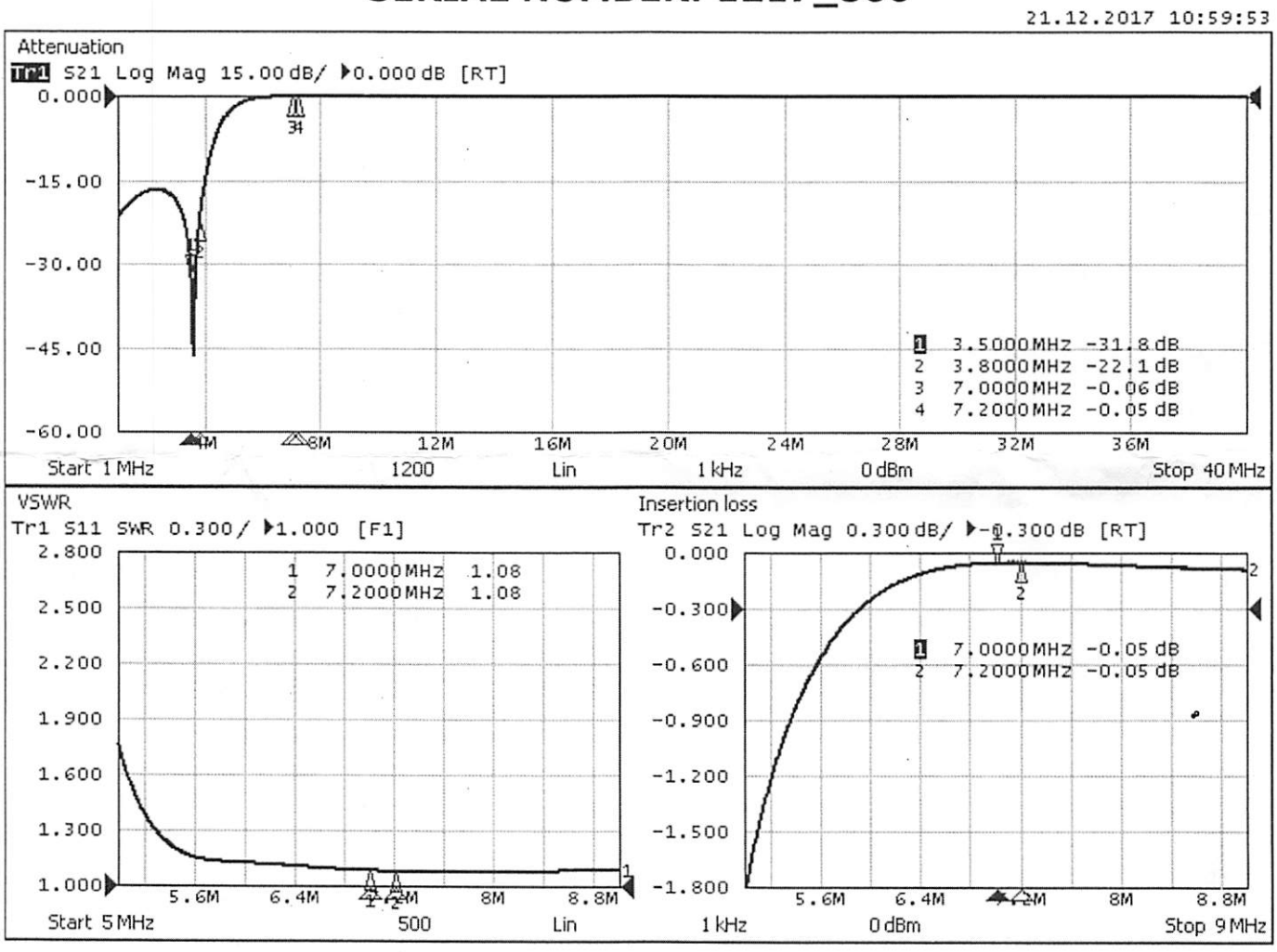
OEM Measured Data

Filter solutions for HAM RADIO

LOW BAND SYSTEMS

RA6LBS
Volgodonsk,
347382
Russian Federation

DiPlexer "PerfoBox-200"
IN – OUT 7MHz (40m)
SERIAL NUMBER: 1217_866



Specifications:

Loss in the passband:	typical 0.1 dB
Rejection:	typical ≥ 25 dB
VSWR:	typical less 1:1.25
Impedance:	50 OHm
Maximum ICAS power:	200W
Dimensions of the filter:	220x120x70 mm
Weight:	not more than 0.5 kg.

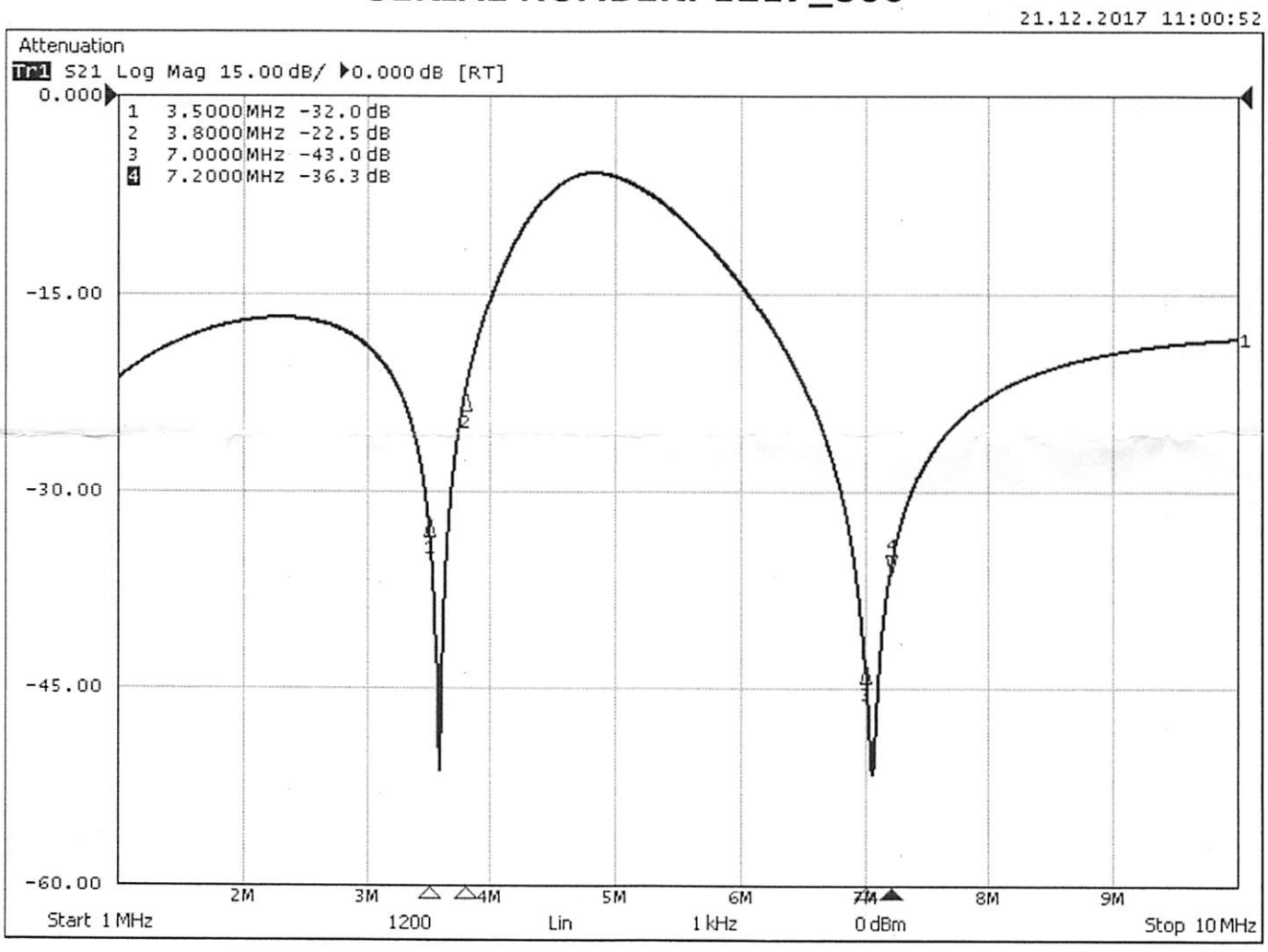
December 22, 2017

Filter solutions for HAM RADIO

LOW BAND SYSTEMS

RA6LBS
Volgodonsk,
347382
Russian Federation

DiPlexer "PerfoBox-200"
OUT 3.5MHz (80m) – OUT 7MHz (40m)
SERIAL NUMBER: 1217_866



Specifications:

Impedance:	50 OHm
Maximum allowable continuous power:	200W
Dimensions of the filter:	220x120x70 mm
Weight:	not more than 0.5 kg.

December 22, 2017