Six-Band Filter-Combiner

User's Guide and Specifications

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Introducing the Six-Band Filter-Combiner

What it Does

- The Six-Band Filter-Combiner (**6BFC**) is designed to take six 1W signals on the 80, 40, 30, 20, 15, and 10-meter amateur bands, and combine them onto a single antenna port. Each channel is filtered to reduce harmonics.

Why

- The 6BFC was developed for use with the WSPRSONDE, which provides multiple WSPR or FST4W signals, simultaneously on multiple bands. Rather than requiring different antennas, the 6BFC allows the use of a single multi-band antenna. The frequency-flexible outputs of the WSPRSONDE are square-waves (with strong harmonics), the 6BFC filtering attenuates these harmonics, resulting in a spectrally clean output signal.

Dimensions

The 6BFC is housed in a small aluminum enclosure:

8.5 cm wide x 3.5 cm high x 12 cm deep (this includes the connectors)

Weight: 180 gm.

Connections

- Ports 1-6
- -40 dB monitor, connected to the Antenna port.
- Antenna

All connectors are SMA jacks.

Performance

- Input to Antenna loss: 1.5 db typical.
- Input port-to-port isolation: typically better than 20 dB
- Second harmonic attenuation: Better than 40 dB
- Third harmonic attenuation: Better than 60 dB

When used with the WSPRSONDE, all transmitted harmonics are lower than -50 dBc.

Note that the port isolation is sufficient to reduce WSPRSONDE output amplifier intermodulation to a very low level, other amplifier designs may be more sensitive to such coupling. This has not been studied.

Single-Band Filters

In some cases a single filter is required:

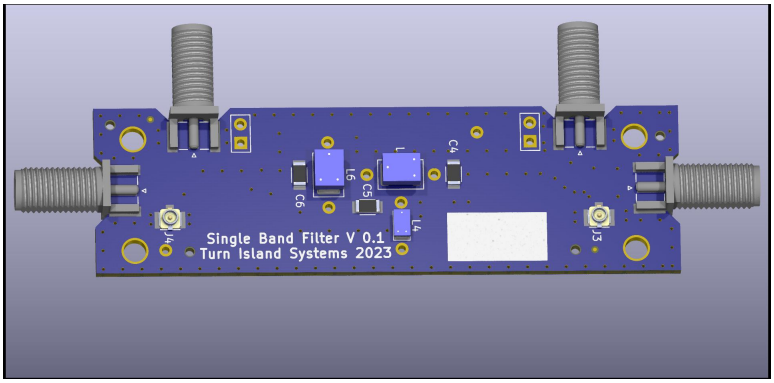


Illustration 1: Single-Band Filter

The Single-Band filter has the option of in-line or right-angle connectors, and can be special-ordered for any frequency between 3.5 and 50 MHz.

Technical Details

Filter Characteristics

These filters were developed for use with the Turn Island Systems WSPRSONDE multi-band transmitter, but they can be used with other transmitters having 1W or lower output power. The WSPRSONDE channels generates a square-wave output, which can be set to operate between 1 MHz and 60 MHz, and requires an external filter to attenuate the strong harmonic content of the square-wave. This is the output of an unfiltered WSPRSONDE amplifier transmitting a 3.5 MHz signal.

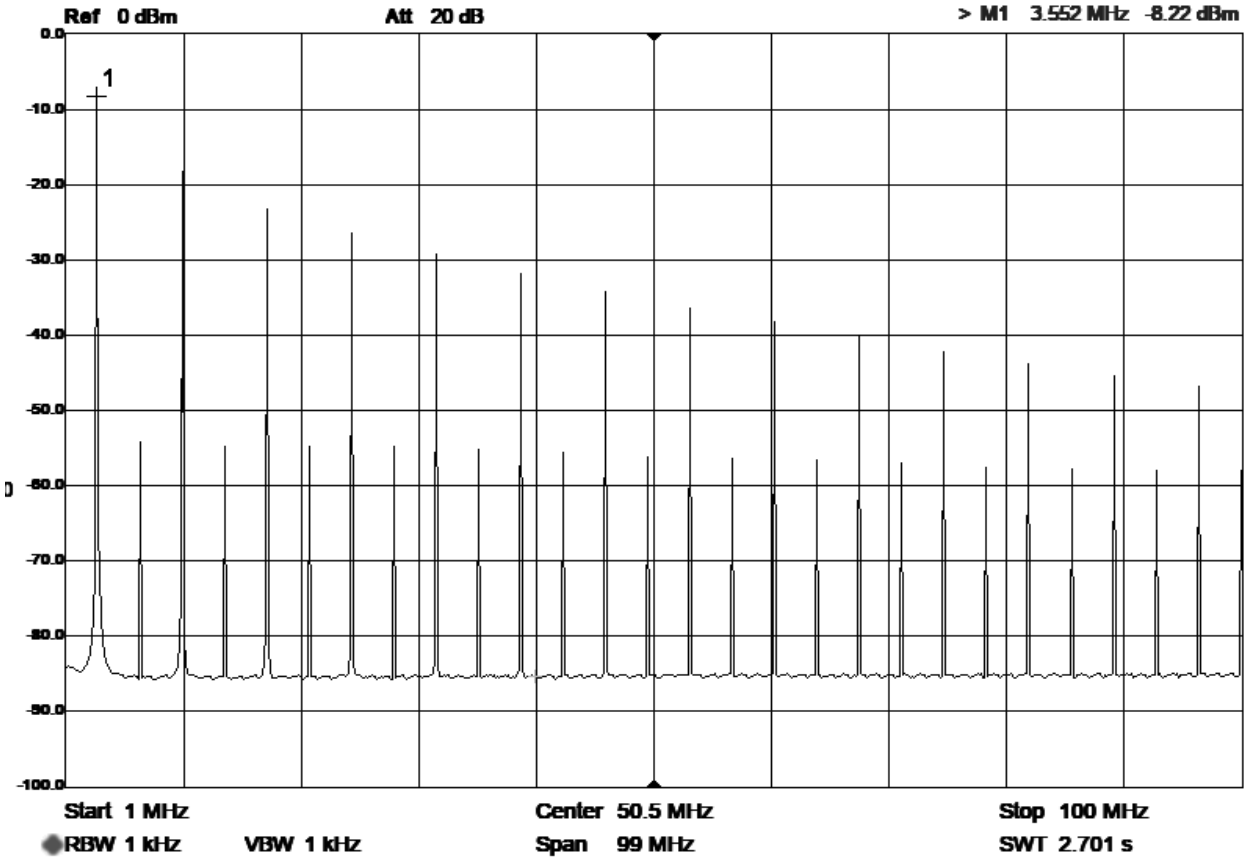


Illustration 2: 80 Meters Without Filter

The Filter/Combiners are designed to attenuate these harmonics, and the resulting output signal will have harmonic content better than -50 dBc (decibels relative to the carrier.)

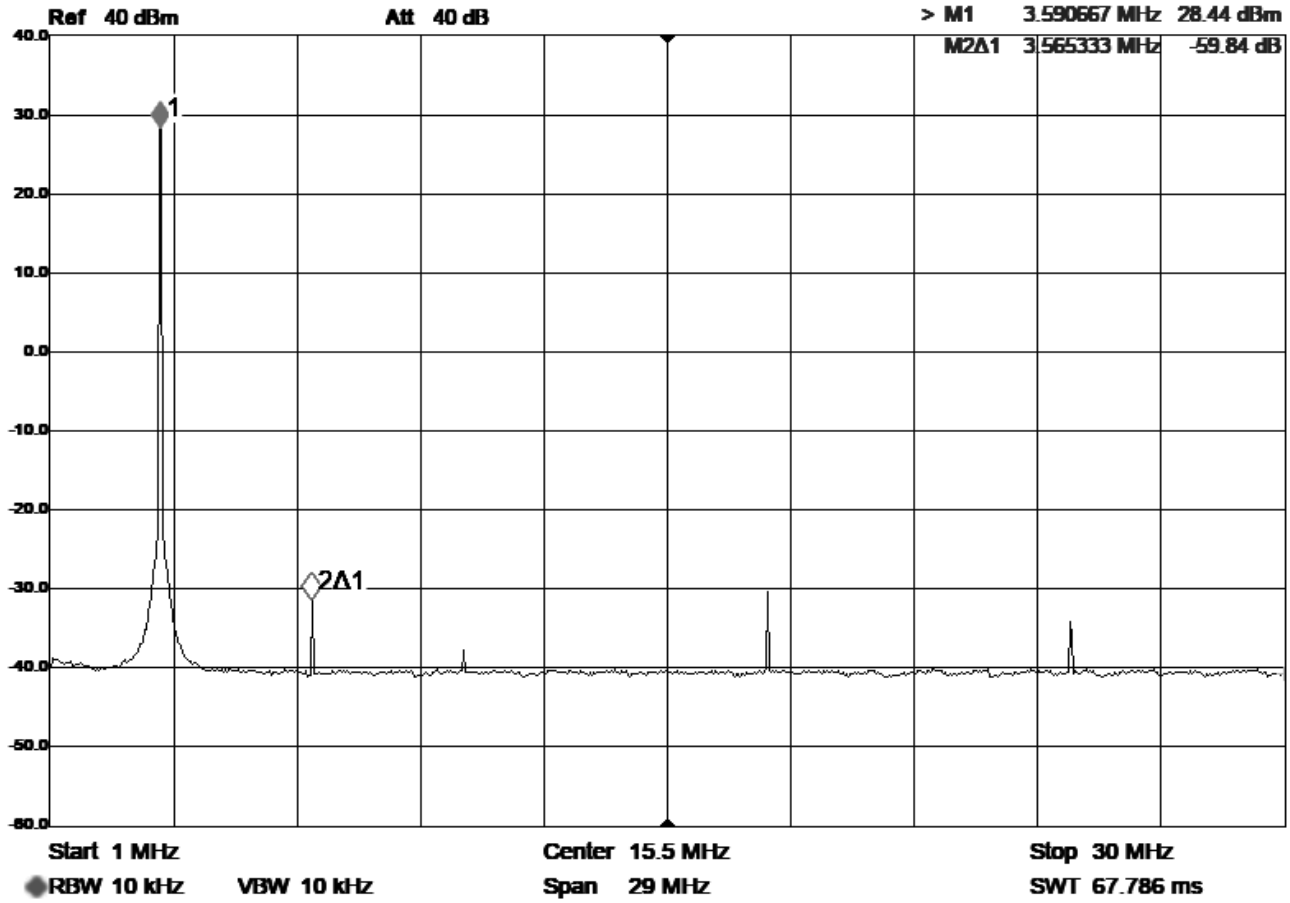


Illustration 3: 80 Meters With Four-Band Filter/Combiner

At the output of the Filter-Combiner the second harmonic is -60 dBc, the third harmonic is about -68 dBc, and the fifth has been reduced to -60 dBc.

80 Meters:

Here is the typical 80-meter filter response, and input impedance:

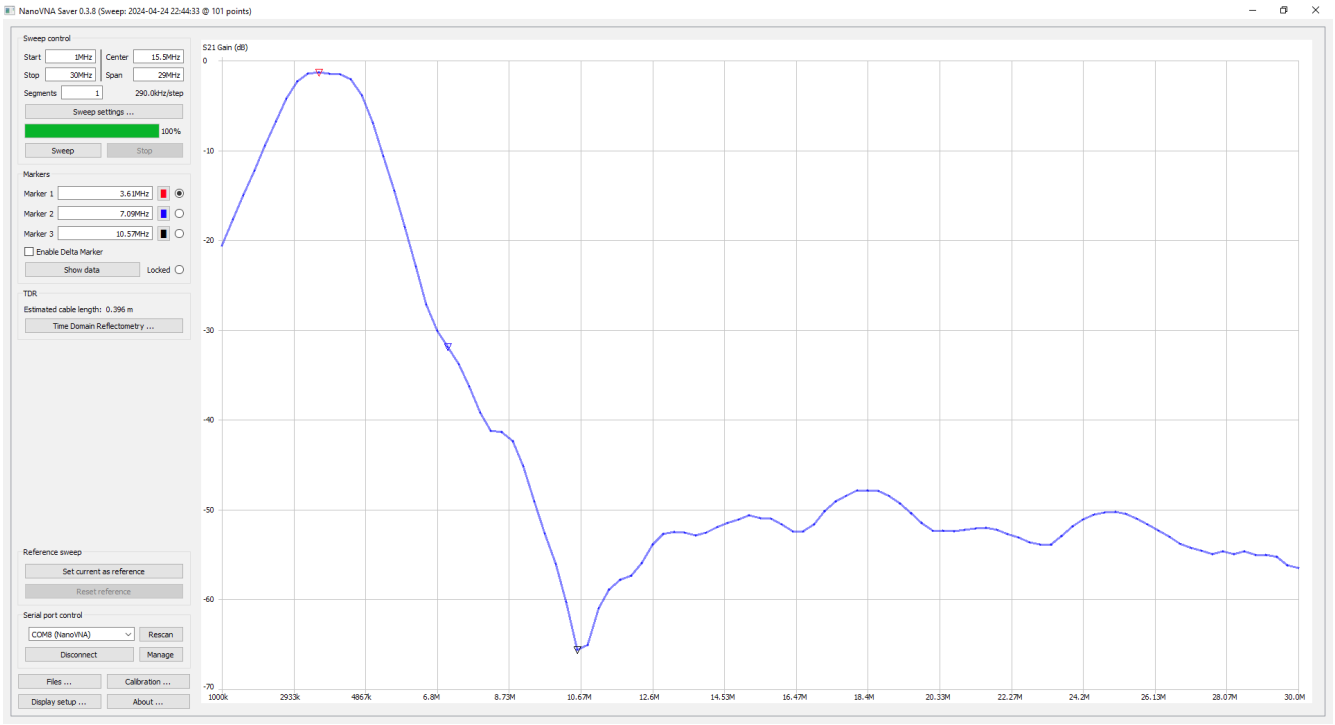
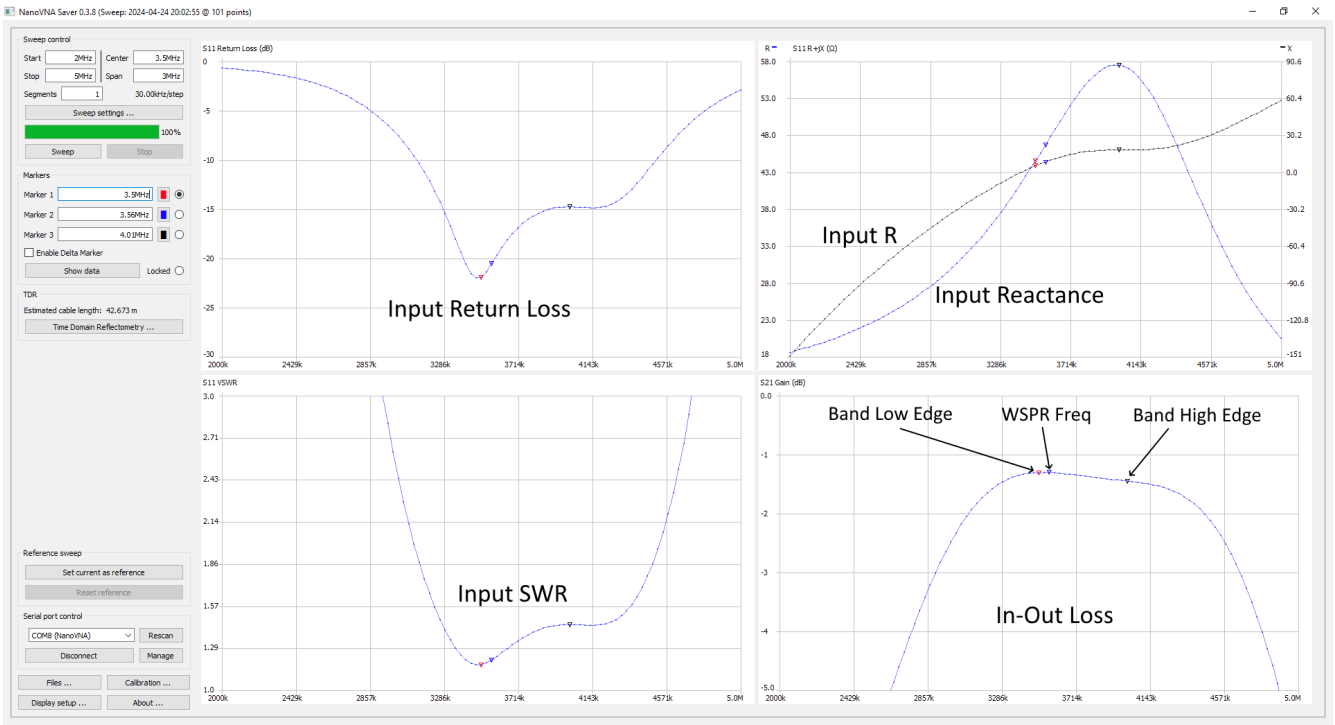
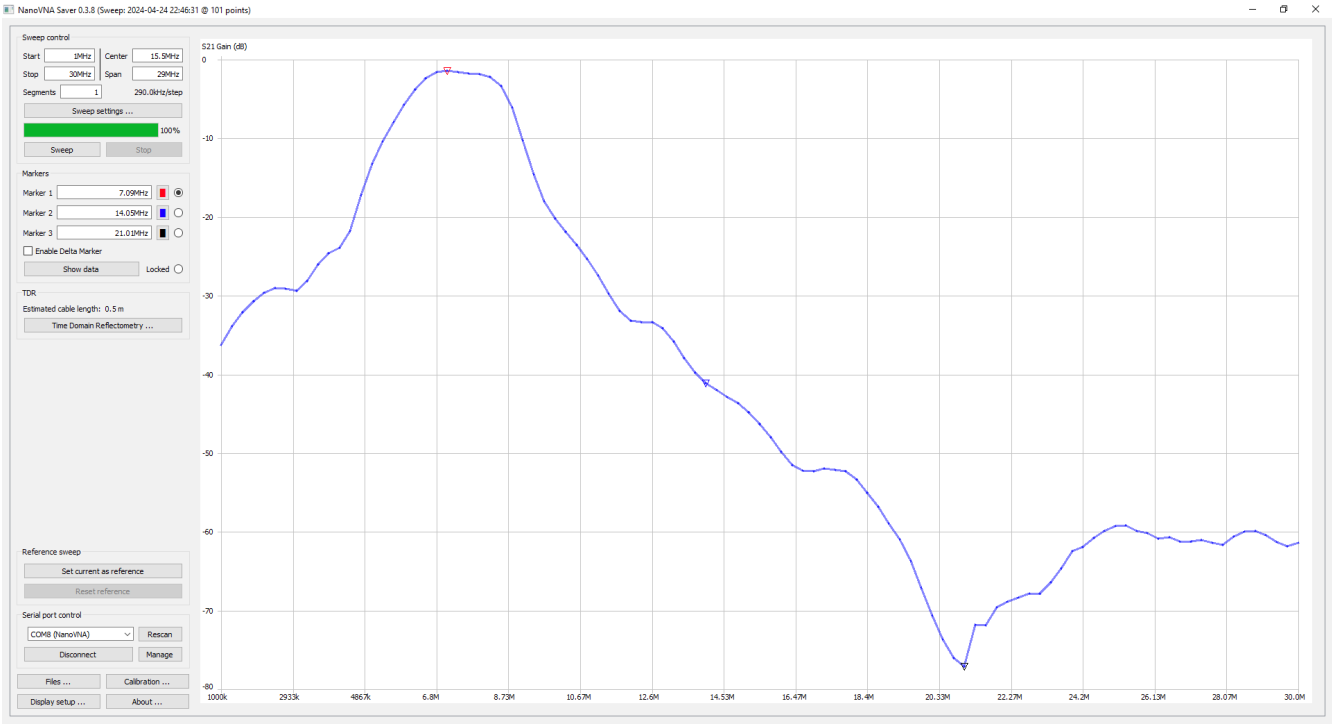


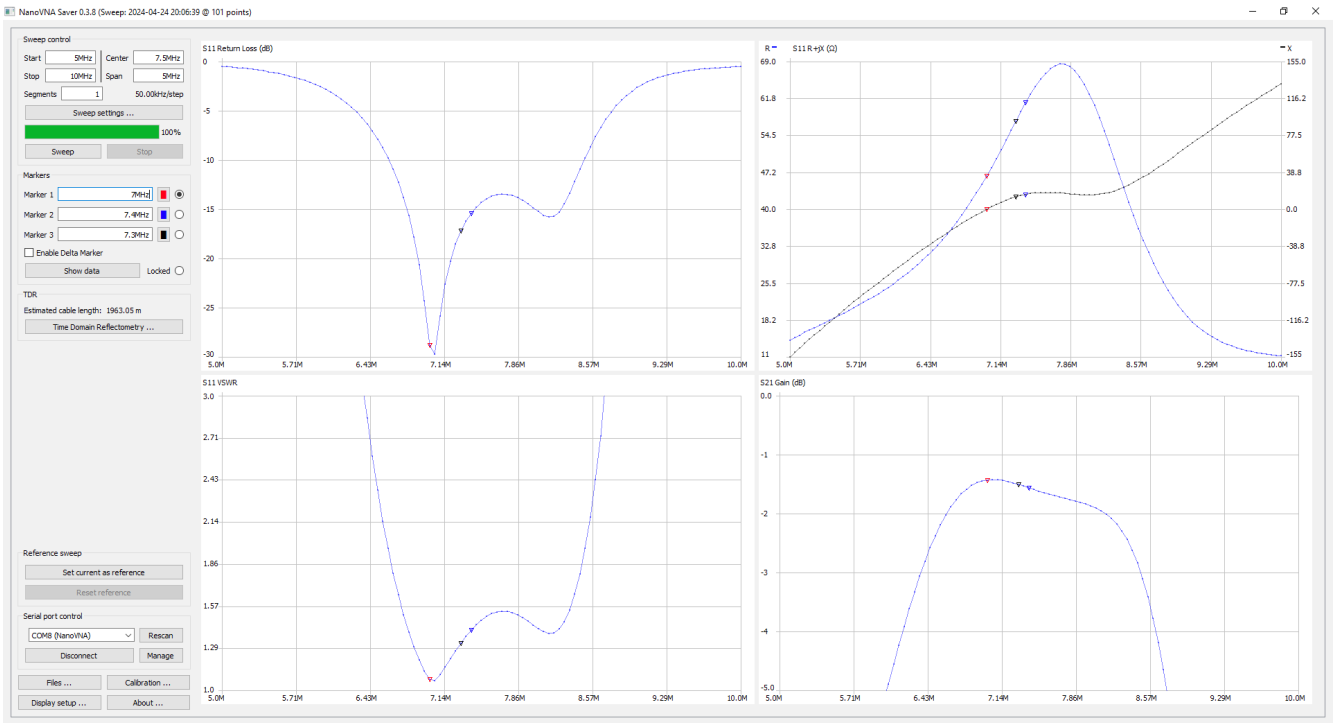
Illustration 4: 80m Filter Response



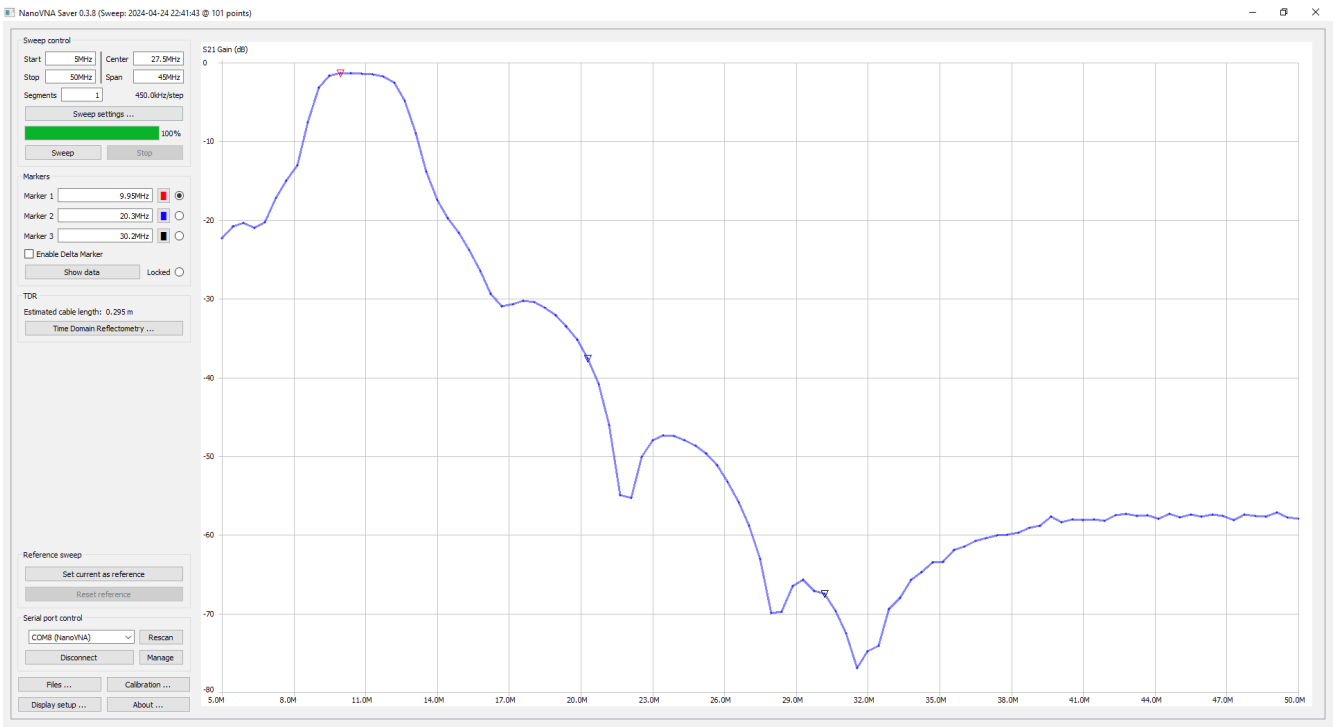
You can see how the filter notch provides excellent attenuation of the third harmonic.

40 Meters:


NanoVNA Saver 0.3.8 (Sweep: 2024-04-24 22:46:31 @ 101 points)
Sweep control
Start 1MHz
Center 15.5MHz
Stop 30MHz
Span 29MHz
Segments 1
290.0kHz/step
Sweep settings ...
100%
Sweep
Stop
Markers
Marker 1 7.09MHz
Marker 2 14.05MHz
Marker 3 21.01MHz
Enable Delta Marker
Show data
Locked
TDR
Estimated cable length: 0.5 m
Time Domain Reflectometry ...
Reference sweep
Set current as reference
Reset reference
Serial port control
COM8 (NanoVNA)
Rescan
Disconnect
Manage
Files ...
Calibration ...
Display setup ...
About ...
S21 Gain (dB)
0
-10
-20
-30
-40
-50
-60
-70
-80
1000k
2933k
4867k
6.8M
8.73M
10.67M
12.6M
14.53M
16.47M
18.4M
20.33M
22.27M
24.2M
26.13M
28.07M
30.0M


NanoVNA Saver 0.3.8 (Sweep: 2024-04-24 20:06:39 @ 101 points)
Sweep control
Start 5MHz
Center 7.5MHz
Stop 10MHz
Span 5MHz
Segments 1
50.00kHz/step
Sweep settings ...
100%
Sweep
Stop
Markers
Marker 1 7MHz
Marker 2 7.4MHz
Marker 3 7.3MHz
Enable Delta Marker
Show data
Locked
TDR
Estimated cable length: 1963.05 m
Time Domain Reflectometry ...
Reference sweep
Set current as reference
Reset reference
Serial port control
COM8 (NanoVNA)
Rescan
Disconnect
Manage
Files ...
Calibration ...
Display setup ...
About ...
S11 Return Loss (dB)
S11 R+jX (Ω)
R
X
S11 VSWR
S21 Gain (dB)
5.0M
5.71M
6.43M
7.14M
7.86M
8.57M
9.29M
10.0M

30 Meters: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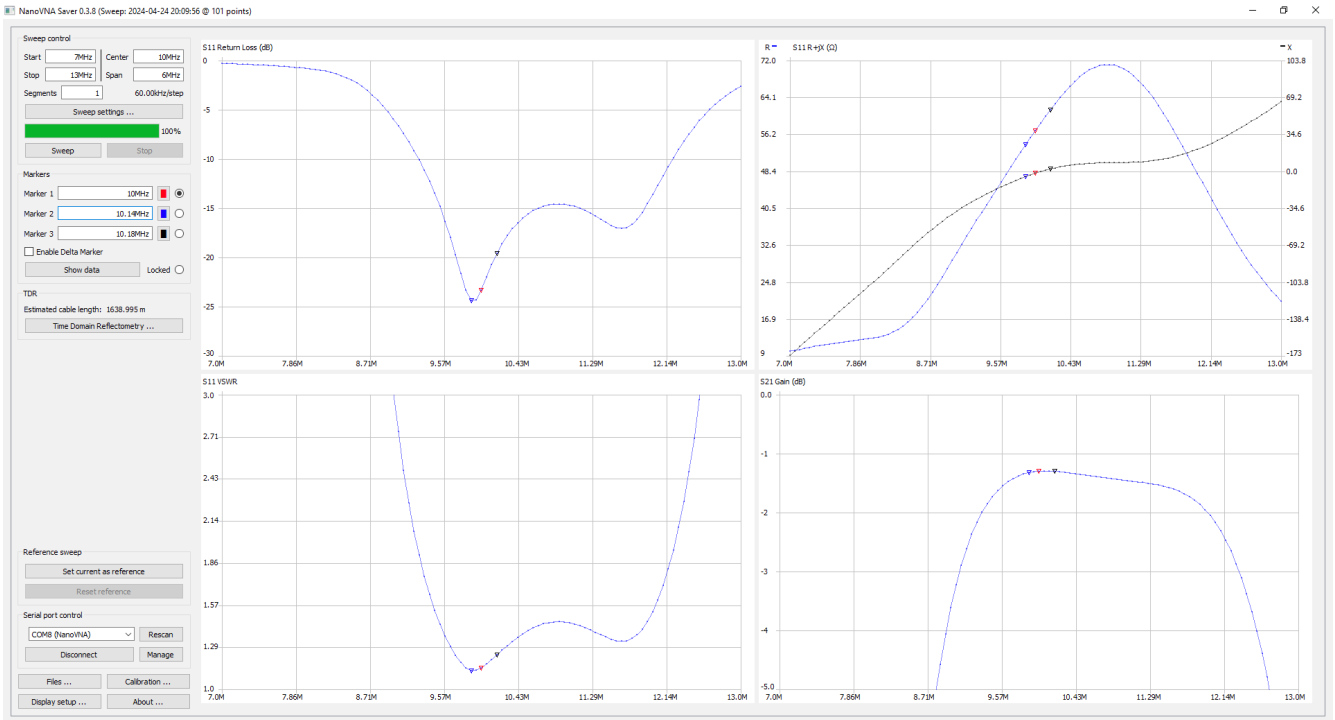
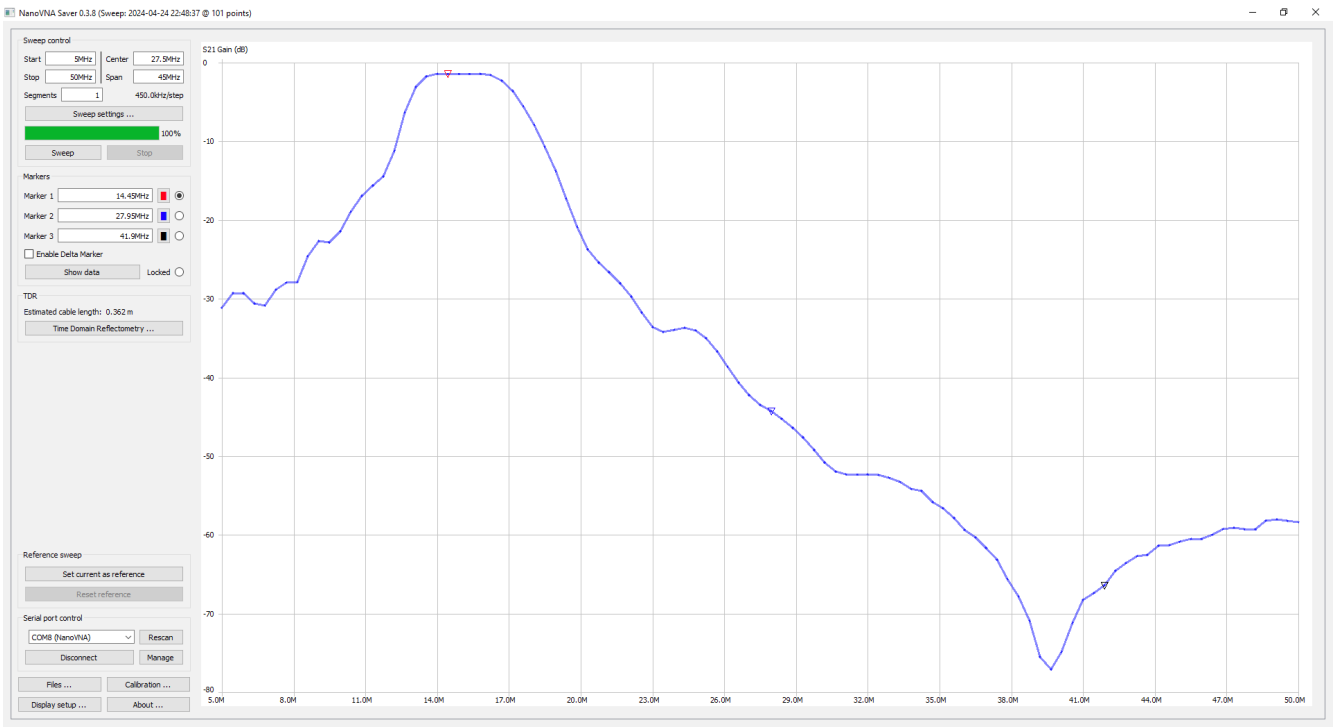
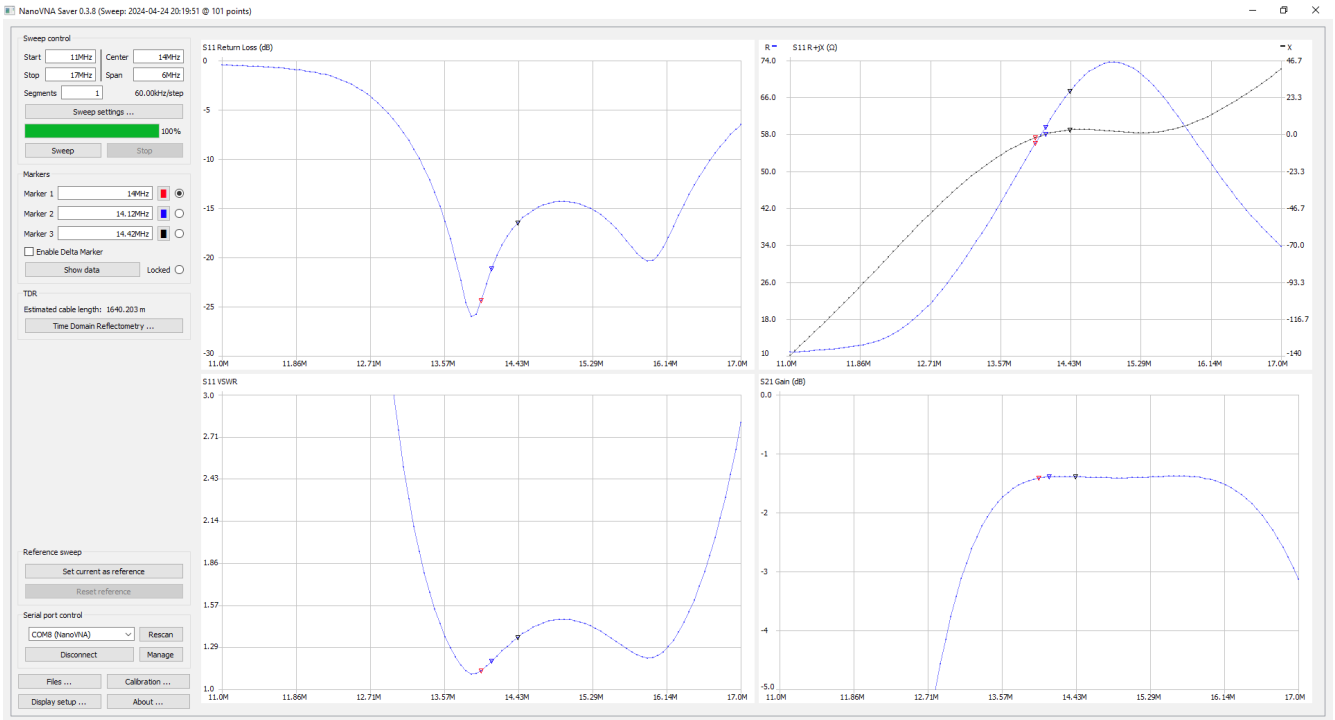
Sweep control
Start 5MHz
Center 27.5MHz
Stop 50MHz
Span 45MHz
Segments 1
450.0kHz/step
Sweep settings ...
100%
Sweep
Stop
Markers
Marker 1 9.95MHz
Marker 2 20.3MHz
Marker 3 30.2MHz
Enable Delta Marker
Show data
Locked
TDR
Estimated cable length: 0.295 m
Time Domain Reflectometry ...
Reference sweep
Set current as reference
Reset reference
Serial port control
COM8 (NanoVNA)
Rescan
Disconnect
Manage
Files ...
Calibration ...
Display setup ...
About ...
S21 Gain (dB)
0
-10
-20
-30
-40
-50
-60
-70
-80
5.0M
8.0M
11.0M
14.0M
17.0M
20.0M
23.0M
26.0M
29.0M
32.0M
35.0M
38.0M
41.0M
44.0M
47.0M
50.0M

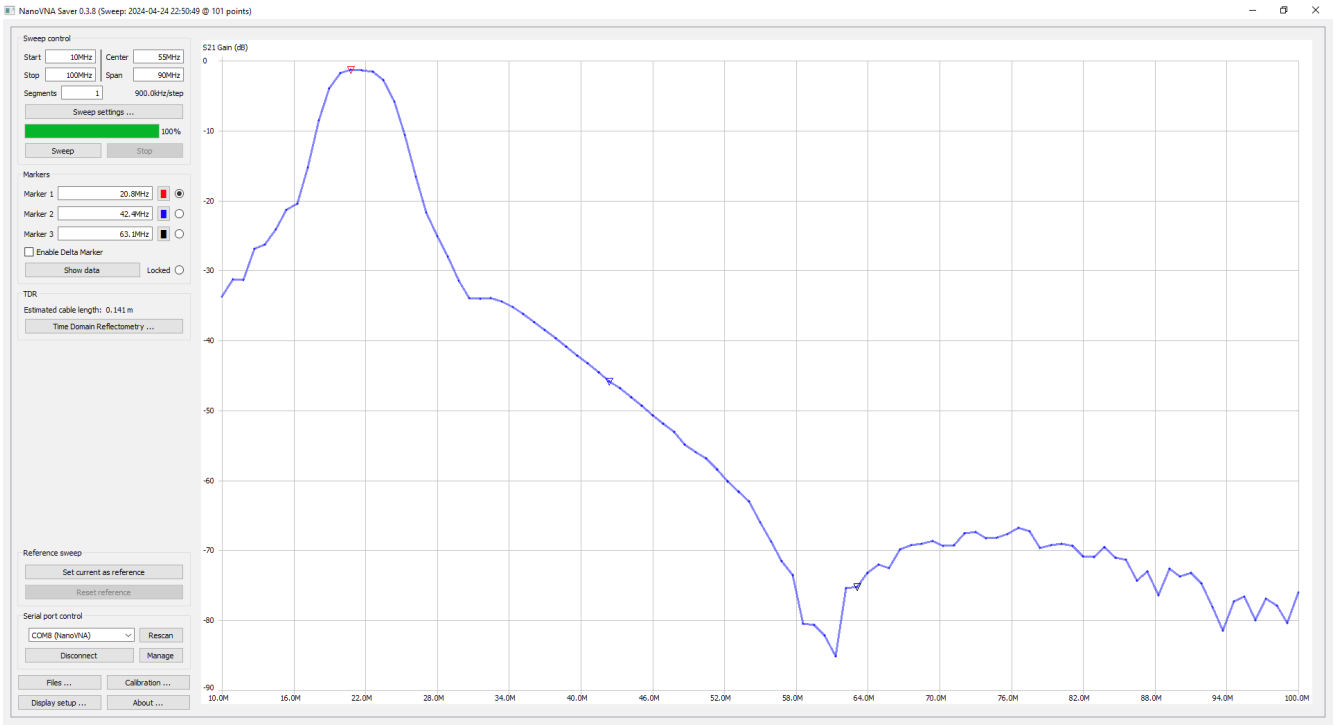

NanoVNA Saver 0.3.8 (Sweep: 2024-04-24 20:09:56 @ 101 points)
Sweep control
Start 7MHz
Center 10MHz
Stop 13MHz
Span 6MHz
Segments 1
60.00kHz/step
Sweep settings ...
100%
Sweep
Stop
Markers
Marker 1 10MHz
Marker 2 10.14MHz
Marker 3 10.18MHz
Enable Delta Marker
Show data
Locked
TDR
Estimated cable length: 1638.995 m
Time Domain Reflectometry ...
Reference sweep
Set current as reference
Reset reference
Serial port control
COM8 (NanoVNA)
Rescan
Disconnect
Manage
Files ...
Calibration ...
Display setup ...
About ...
S11 Return Loss (dB)
S11 R+jX (Ω)
S11 VSWR
S21 Gain (dB)
7.0M
7.86M
8.71M
9.57M
10.43M
11.29M
12.14M
13.0M

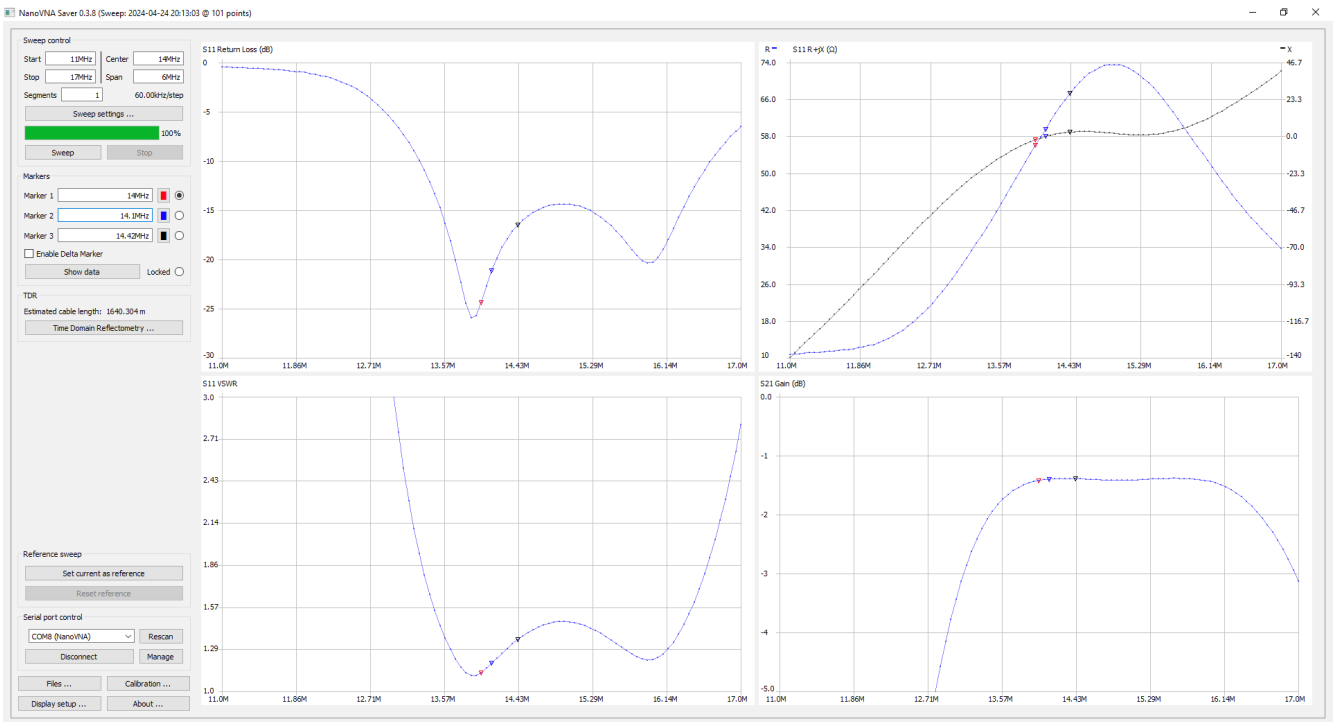
20 Meters:


NanoVNA Saver 0.3.8 (Sweep: 2024-04-24 22:48:37 @ 101 points)
Sweep control
Start 5MHz
Center 27.5MHz
Stop 50MHz
Span 45MHz
Segments 1
450.0kHz/step
Sweep settings ...
100%
Sweep
Stop
Markers
Marker 1 14.45MHz
Marker 2 27.95MHz
Marker 3 41.9MHz
Enable Delta Marker
Show data
Locked
TDR
Estimated cable length: 0.362 m
Time Domain Reflectometry ...
Reference sweep
Set current as reference
Reset reference
Serial port control
COM8 (NanoVNA)
Rescan
Disconnect
Manage
Files ...
Calibration ...
Display setup ...
About ...
S21 Gain (dB)
0
-10
-20
-30
-40
-50
-60
-70
-80
5.0M
8.0M
11.0M
14.0M
17.0M
20.0M
23.0M
26.0M
29.0M
32.0M
35.0M
38.0M
41.0M
44.0M
47.0M
50.0M

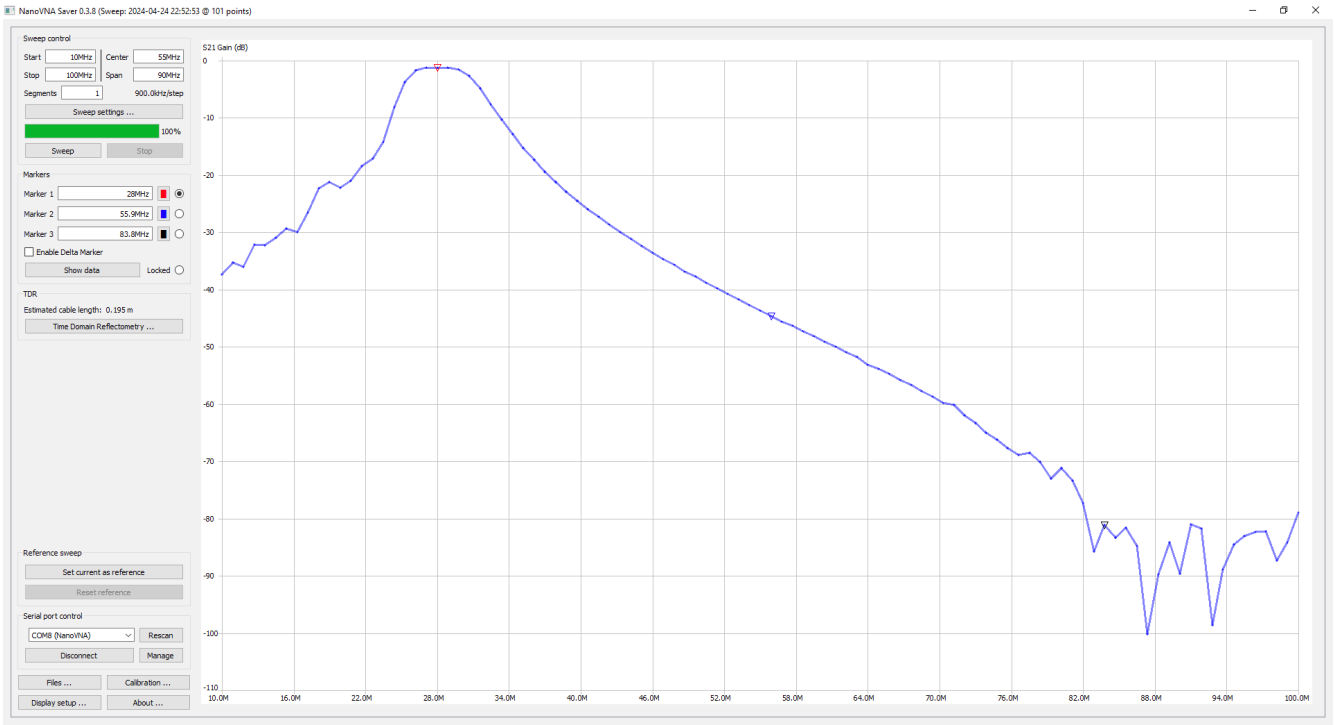

NanoVNA Saver 0.3.8 (Sweep: 2024-04-24 20:19:51 @ 101 points)
Sweep control
Start 11MHz
Center 14MHz
Stop 17MHz
Span 6MHz
Segments 1
60.00kHz/step
Sweep settings ...
100%
Sweep
Stop
Markers
Marker 1 14MHz
Marker 2 14.12MHz
Marker 3 14.42MHz
Enable Delta Marker
Show data
Locked
TDR
Estimated cable length: 1640.203 m
Time Domain Reflectometry ...
Reference sweep
Set current as reference
Reset reference
Serial port control
COM8 (NanoVNA)
Rescan
Disconnect
Manage
Files ...
Calibration ...
Display setup ...
About ...
S11 Return Loss (dB)
S11 R+jX (Ω)
S11 VSWR
S21 Gain (dB)
11.0M
11.86M
12.71M
13.57M
14.43M
15.29M
16.14M
17.0M

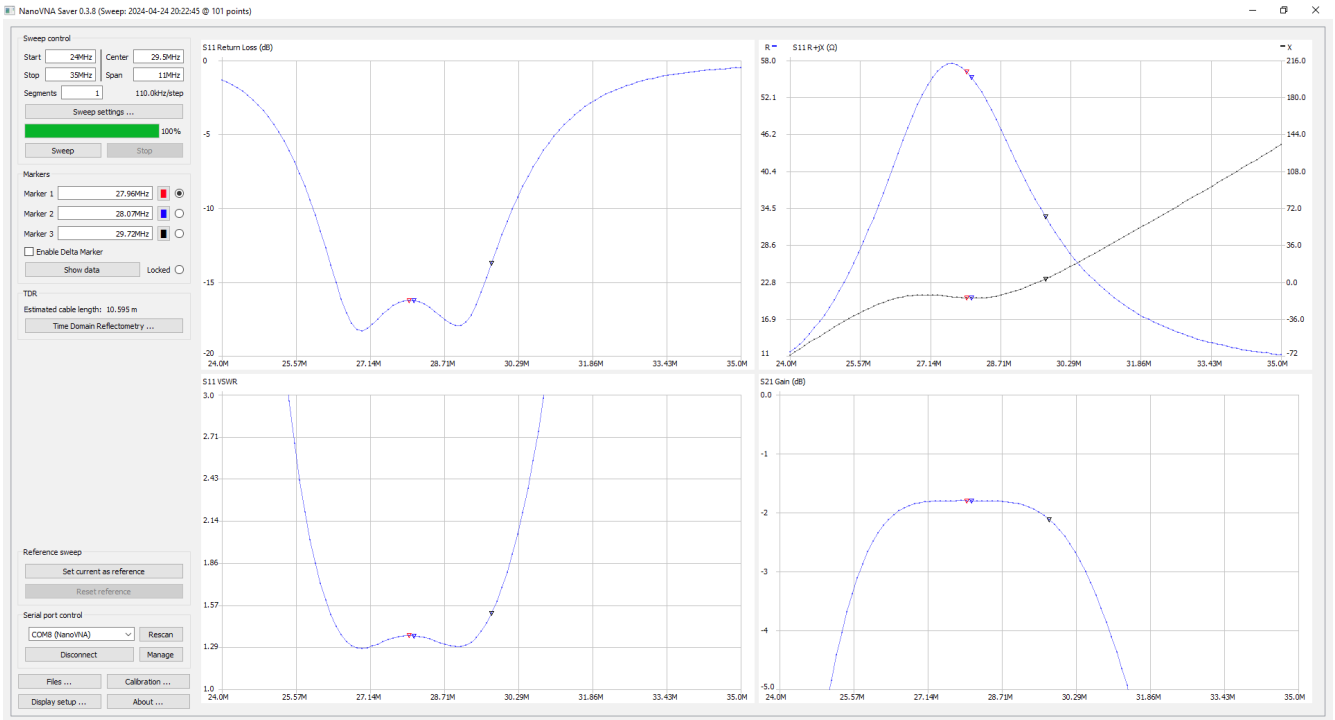
15 Meters:


NanoVNA Saver 0.3.8 (Sweep: 2024-04-24 22:50:49 @ 101 points)
Sweep control
Start 10MHz
Center 55MHz
Stop 100MHz
Span 90MHz
Segments 1
900.0kHz/step
Sweep settings ...
100%
Sweep
Stop
Markers
Marker 1 20.8MHz
Marker 2 42.4MHz
Marker 3 63.1MHz
Enable Delta Marker
Show data
Locked
TDR
Estimated cable length: 0.141 m
Time Domain Reflectometry ...
Reference sweep
Set current as reference
Reset reference
Serial port control
COM8 (NanoVNA)
Rescan
Disconnect
Manage
Files ...
Calibration ...
Display setup ...
About ...
S21 Gain (dB)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
10.0M
16.0M
22.0M
28.0M
34.0M
40.0M
46.0M
52.0M
58.0M
64.0M
70.0M
76.0M
82.0M
88.0M
94.0M
100.0M


NanoVNA Saver 0.3.8 (Sweep: 2024-04-24 20:13:03 @ 101 points)
Sweep control
Start 11MHz
Center 14MHz
Stop 17MHz
Span 6MHz
Segments 1
60.00kHz/step
Sweep settings ...
100%
Sweep
Stop
Markers
Marker 1 14MHz
Marker 2 14.1MHz
Marker 3 14.42MHz
Enable Delta Marker
Show data
Locked
TDR
Estimated cable length: 1640.304 m
Time Domain Reflectometry ...
Reference sweep
Set current as reference
Reset reference
Serial port control
COM8 (NanoVNA)
Rescan
Disconnect
Manage
Files ...
Calibration ...
Display setup ...
About ...
S11 Return Loss (dB)
S11 R+jX (Ω)
S11 VSWR
S21 Gain (dB)
11.0M
11.86M
12.71M
13.57M
14.43M
15.29M
16.14M
17.0M

10 Meters:


NanoVNA Saver 0.3.8 (Sweep: 2024-04-24 22:52:53 @ 101 points)
Sweep control
Start 10MHz
Center 55MHz
Stop 100MHz
Span 90MHz
Segments 1
900.0kHz/step
Sweep settings ...
100%
Sweep
Stop
Markers
Marker 1 28MHz
Marker 2 55.9MHz
Marker 3 83.8MHz
Enable Delta Marker
Show data
Locked
TDR
Estimated cable length: 0.195 m
Time Domain Reflectometry ...
Reference sweep
Set current as reference
Reset reference
Serial port control
COM8 (NanoVNA)
Rescan
Disconnect
Manage
Files ...
Calibration ...
Display setup ...
About ...
S21 Gain (dB)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
10.0M
16.0M
22.0M
28.0M
34.0M
40.0M
46.0M
52.0M
58.0M
64.0M
70.0M
76.0M
82.0M
88.0M
94.0M
100.0M


NanoVNA Saver 0.3.8 (Sweep: 2024-04-24 20:22:45 @ 101 points)
Sweep control
Start 24MHz
Center 29.5MHz
Stop 35MHz
Span 11MHz
Segments 1
110.0kHz/step
Sweep settings ...
100%
Sweep
Stop
Markers
Marker 1 27.96MHz
Marker 2 28.07MHz
Marker 3 29.72MHz
Enable Delta Marker
Show data
Locked
TDR
Estimated cable length: 10.595 m
Time Domain Reflectometry ...
Reference sweep
Set current as reference
Reset reference
Serial port control
COM8 (NanoVNA)
Rescan
Disconnect
Manage
Files ...
Calibration ...
Display setup ...
About ...
S11 Return Loss (dB)
S11 R+jX (Ω)
S11 VSWR
S21 Gain (dB)
24.0M
25.57M
27.14M
28.71M
30.29M
31.86M
33.43M
35.0M

Operating With Unconnected Input Ports

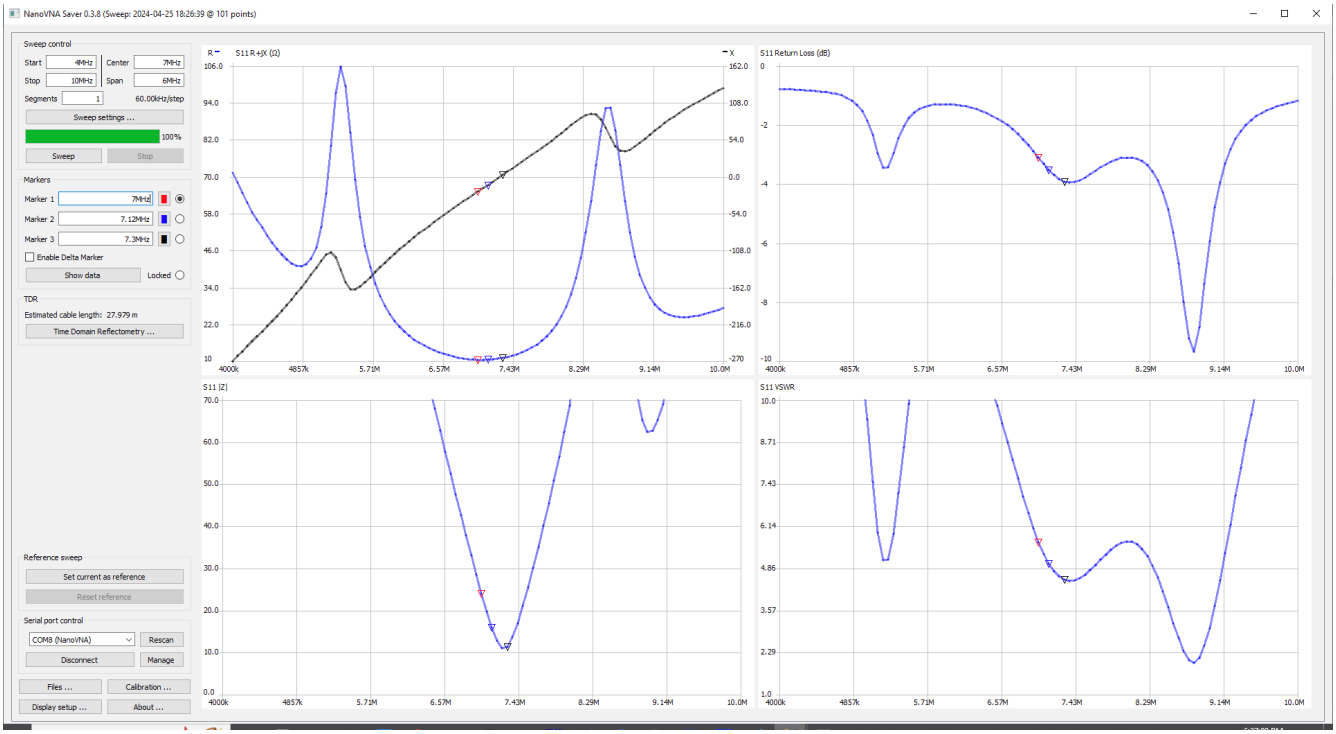
This is perfectly acceptable, as the port-to-port isolation prevents any significant interaction.

Operating With Unconnected Antenna Port

Short version: **Don't do it!**

Longer version: Around the channel center frequency, the filters act as a quarter-wave transmission line: A 50 Ohm load remains a 50 Ohm load. A short-circuit is transformed to an open-circuit. And an open circuit is transformed to a short.

That's the theory. In practice, because of inductor losses, and adjacent-channel-filter interaction the actual result isn't quite so ideal, but the transformed open-circuit impedance can still be quite low, resulting in amplifier overload. The chart below shown what happens at the 40-meter port when there is no antenna load:



You can see that the impedance drops as low as 10 Ohms.

When used with a WSPRSONDE this load will cause the channel power amplifier to protect itself by shutting down. Other transmitters may be damaged by such a near-short.

In addition, when a low-impedance load is connected to the antenna port, the reflected high impedance will appear at the channel port. The WSPRSONDE can tolerate high-impedance loads, but other transmitters may experience transistor-destroying over-voltages under these conditions.