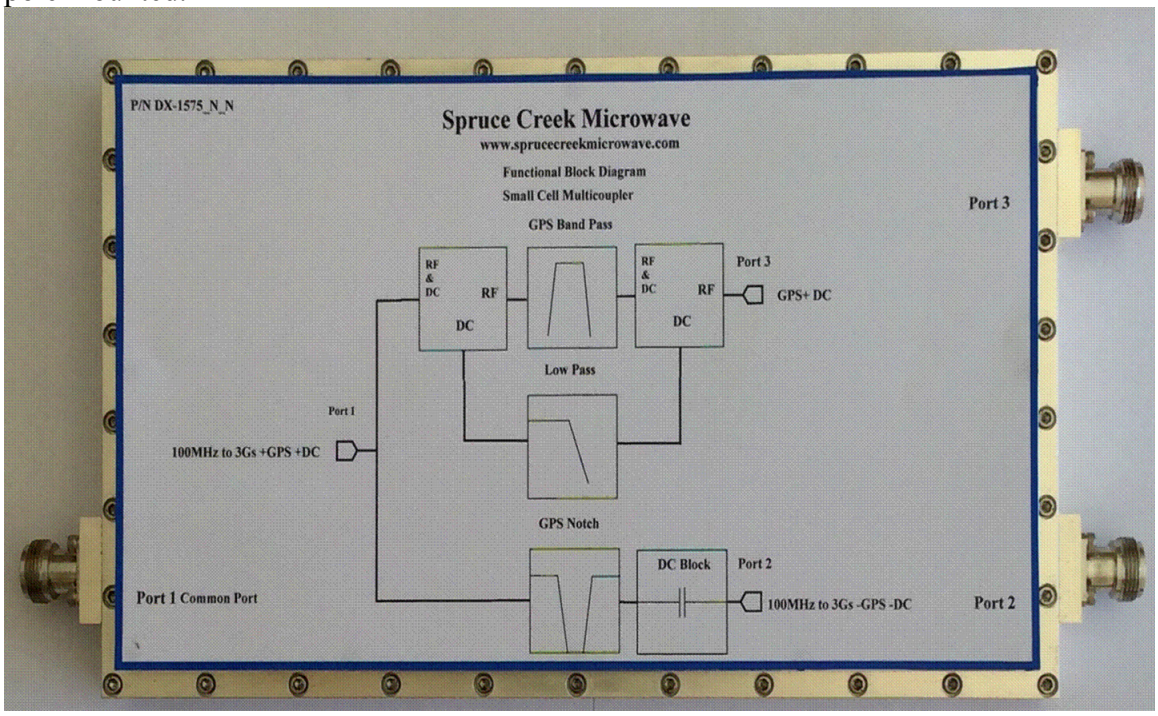
DX-1575_N_N Small Cell Multicoupler

By Wayne Barbely of Spruce Creek Microwave

With the advent of new frequencies and new equipment, now requires wider band couplers and innovation to bring more services in to buildings and infrastructure. One major requirement is now GPS for timing as well as location for cell phones. GPS signal must be included as part of the RF services. This requirement adds some complexity to the system because of its vulnerability to high level energy from the system itself or nearby transmitters. By combining the GPS signal with other services will require some unique hardware. The traditional approach is multiple feed lines and or narrow band filters. Multiple feed lines are expensive to install and expensive to maintain, so the fewer the better. From a proof of performance per year is obvious. It would be beneficial to have a wide RF combiner with one feed line. This would allow for simpler installation and maintenance. One approach to the problem would be two combiners one located at the base of the tower or equipment room and the other at the top of the tower and one feed line as shown in Fig 1. The Diplexer configuration could used this way where the equipment location would be inside the building.

The size is 10.5 X 6 X 1 5/16 inches The unit can be rack mounted or , for outside use, pole mounted.



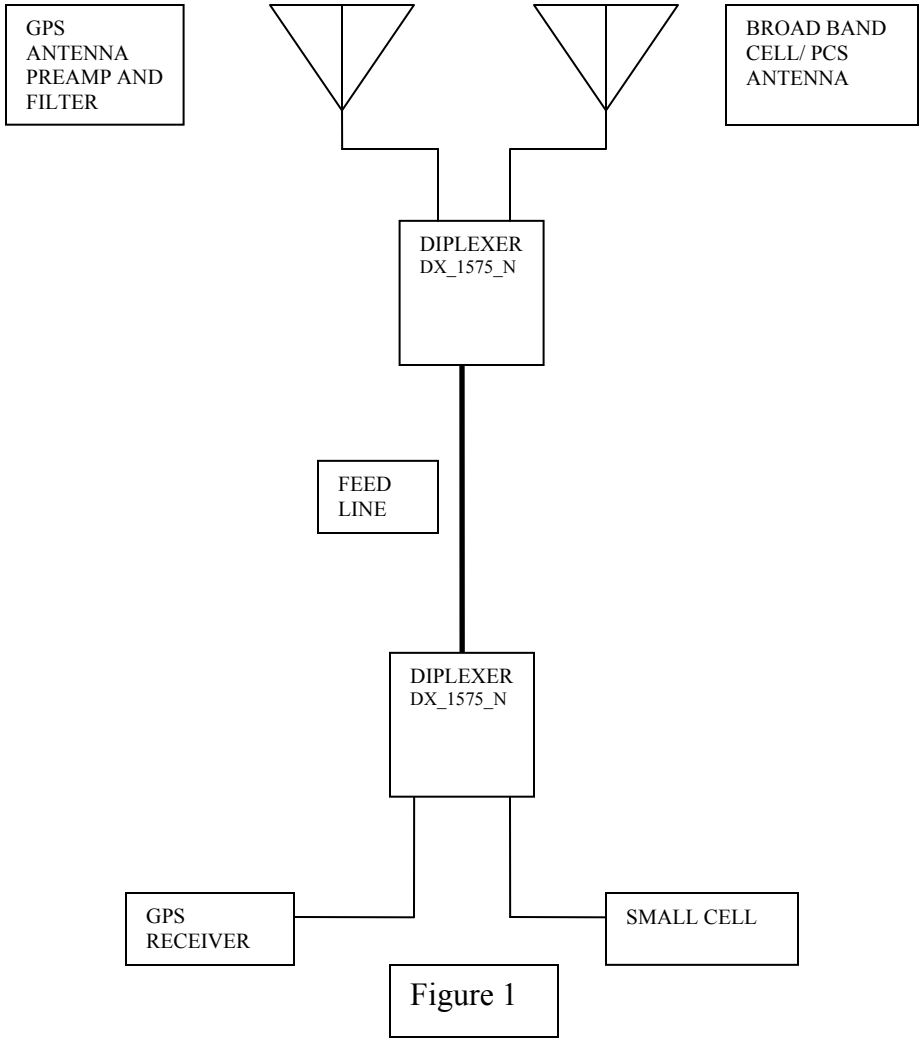



Figure 1

**Design Specifications**

Pass band loss (Port 1-Port 2) 500MHz to 1350MHz ------ .5db MAX .25db typical
Pass band loss (Port 1-Port 2) 1700MHz to 3000MHz ------ .5db MAX .25db typical
Pass band return loss (Port 1-Port 2) 500MHz to 1350MHz------ 14 db MIN
Pass band return loss (Port 1-Port 2) 1700MHz to 3000MHz------ 14 db MIN
Stop band loss (Port 1-Port 2) 1575.42 MHz +/- 5MHz ----- 70 db Min.
Pass band loss (Port 1 to Port 3) 1575.42 MHz +/-10 MHZ .7 DB MAX .5DB Typical
Stop band loss (Port 1 to Port 3) 500MHz to 1350 MHz 70DBC min 80DBC typical
Stop band loss (Port 1 to Port 3) 1700MHz to 3000MHz 70DBC min 80DBC typical
Pass band return loss (Port 1-Port 3) Input/Output 14 DB Max. ( 1575.42 MHz +/-10).
DC block (Port 1 to Port 2) 40vdc > 10MEG
DC block (Port 3 to Port 1) 40vdc > 10MEG
MAX DC Current 200ma.
RF-DC Isolation >80DB Frequency Dependent
Temperature Operation -20 to 70 degrees C
Temperature Storage -40 to 85 degrees C

PIM min -153dbc
At the common port Broad band RF+GPS+DC will be coupled to the GPS filter Port # 3. Port # 2 is DC blocked and contains RF in two bands – GPS that is notched to -70DBC 1575.42 +/- 10mhz. The DC bias will provide power to the GPS preamp.

**Design**

In order to meet the above requirements, a diplexer that incorporates a band pass filter that passes the GPS frequencies and a notch filter that passes all other frequencies and rejects the GPS frequencies. Also included for the provision of providing DC power to the remote GPS preamp, a low pass filter that isolates the DC from the cell, PCS, and Wifi equipment that would be connected to the broad band port (port 1). A DC block will be used to prevent DC on the broad band port just in case the equipment is not protected. As shown in the block diagram (figure 2), the DC path can only flow from the common port to the GPS port. The overall design requirement is low PIM (-153 DBC). PIM, by definition, is the nonlinearity of passive components. When power is applied to a system or a component unwanted distortion products are produced that generate interfering signals to cause dropped calls and limits the number of users on any given system.
All the components in the design must not contribute to Passive Intermodulation distortion. Any bimetal components will contribute to this parameter. The connectors, DC Blocks, coils, capacitors, and plating can be contributors.

**Functional Block Diagram**

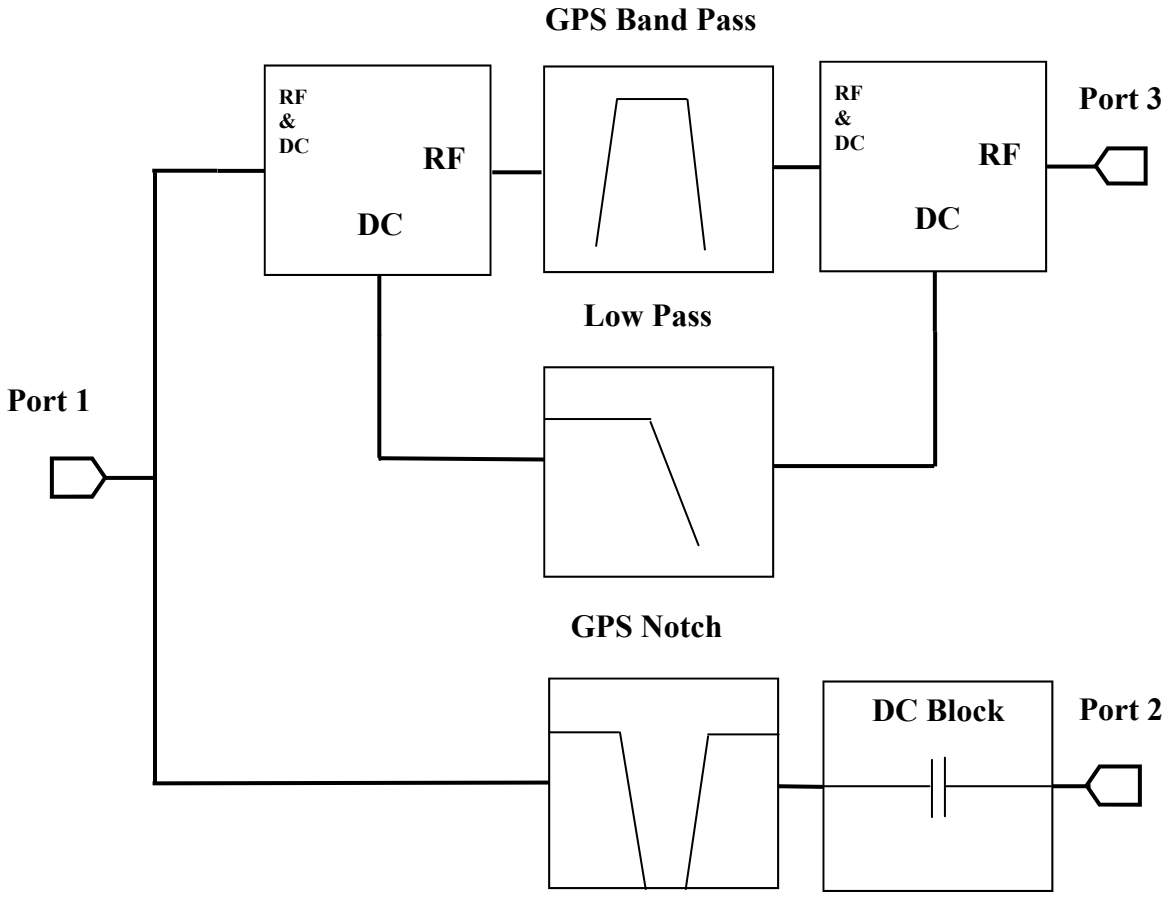
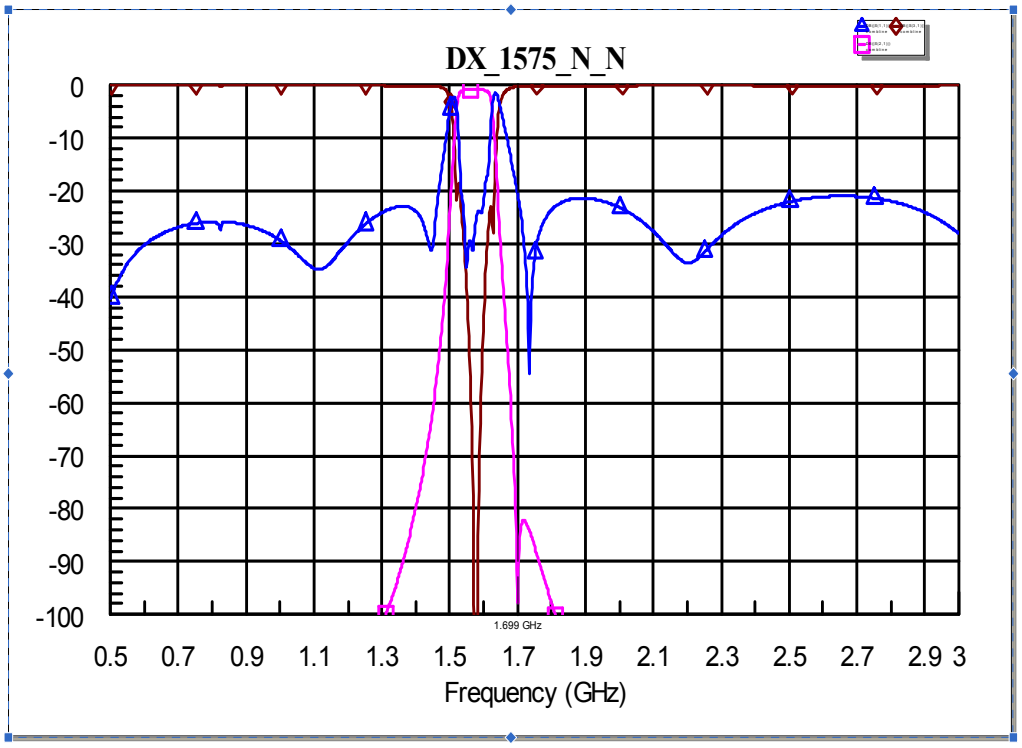
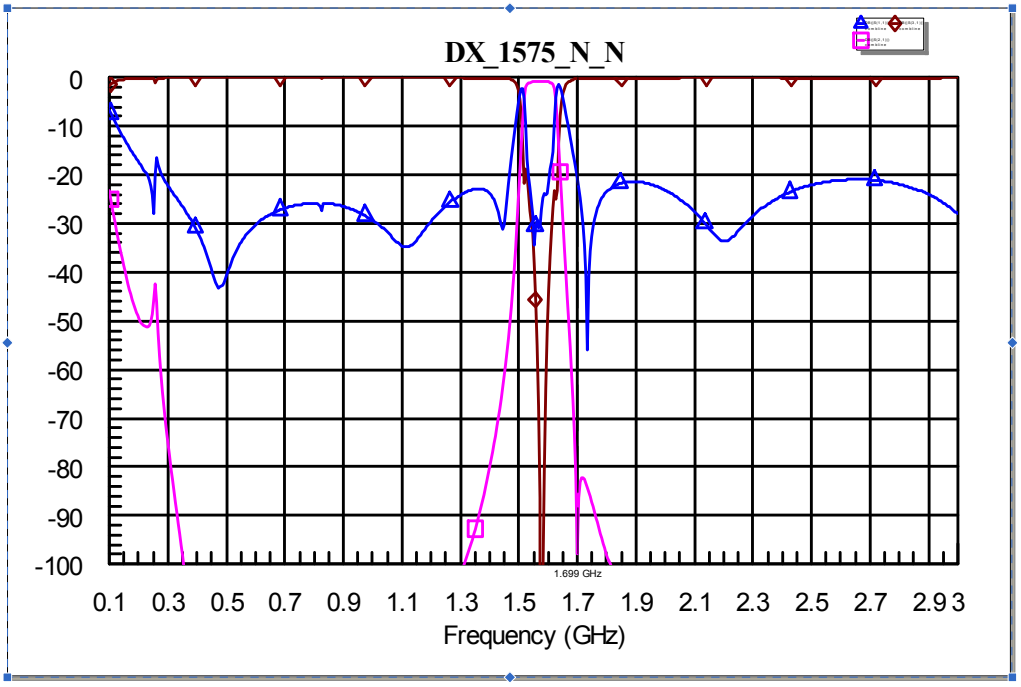


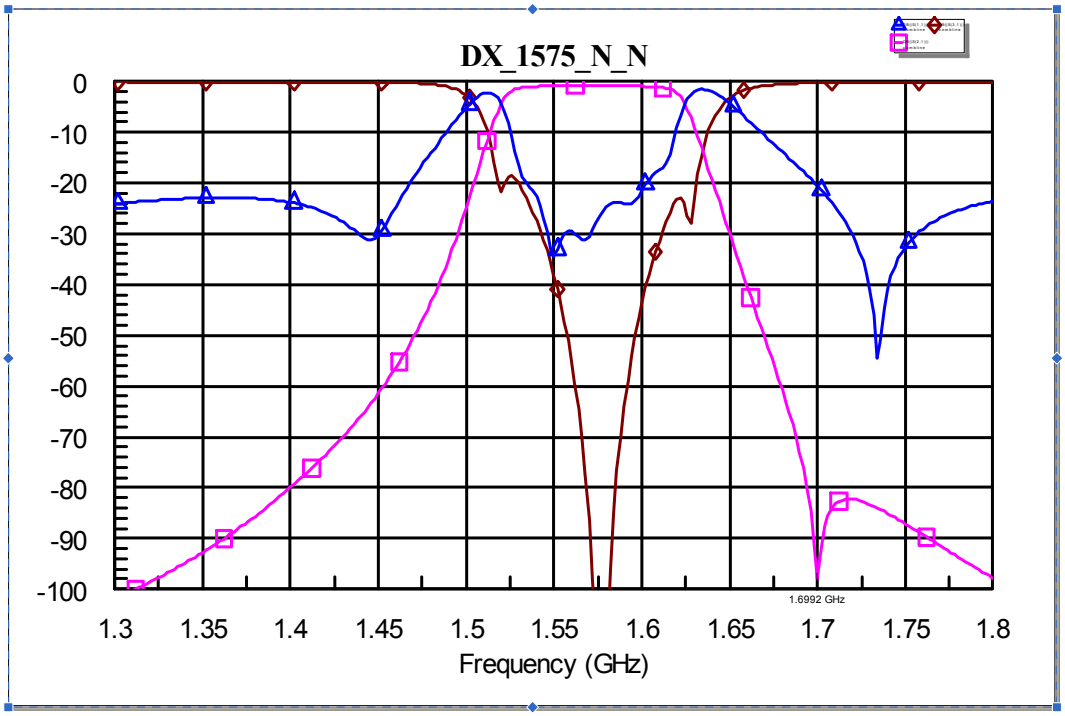

Figure 2




This shows a simulation of the actual circuit of the Diplexer from the common port to port # 2 and port # 3.

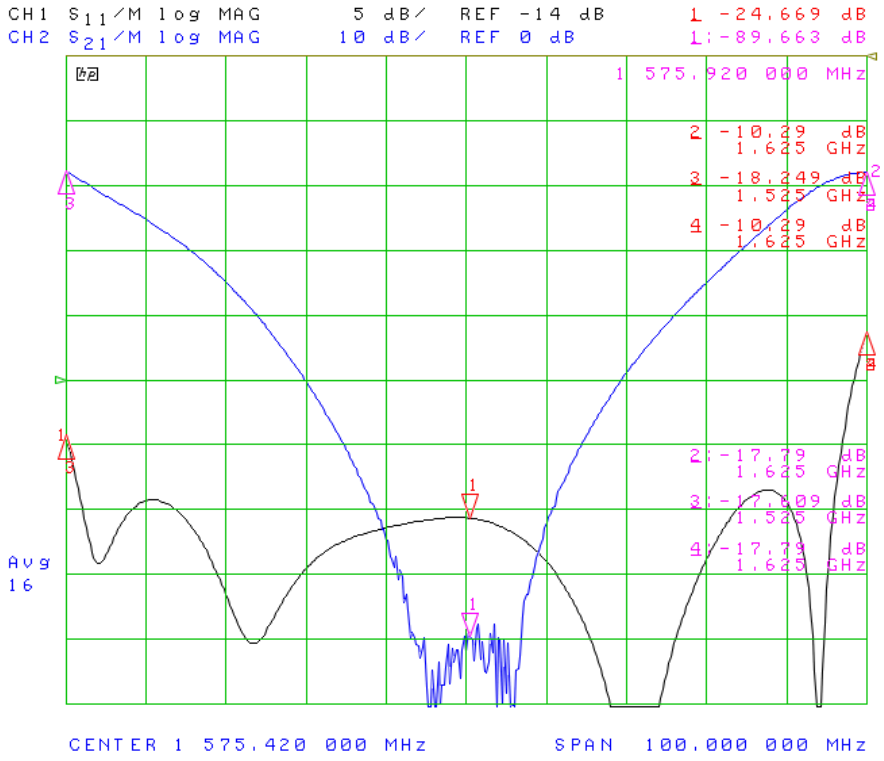


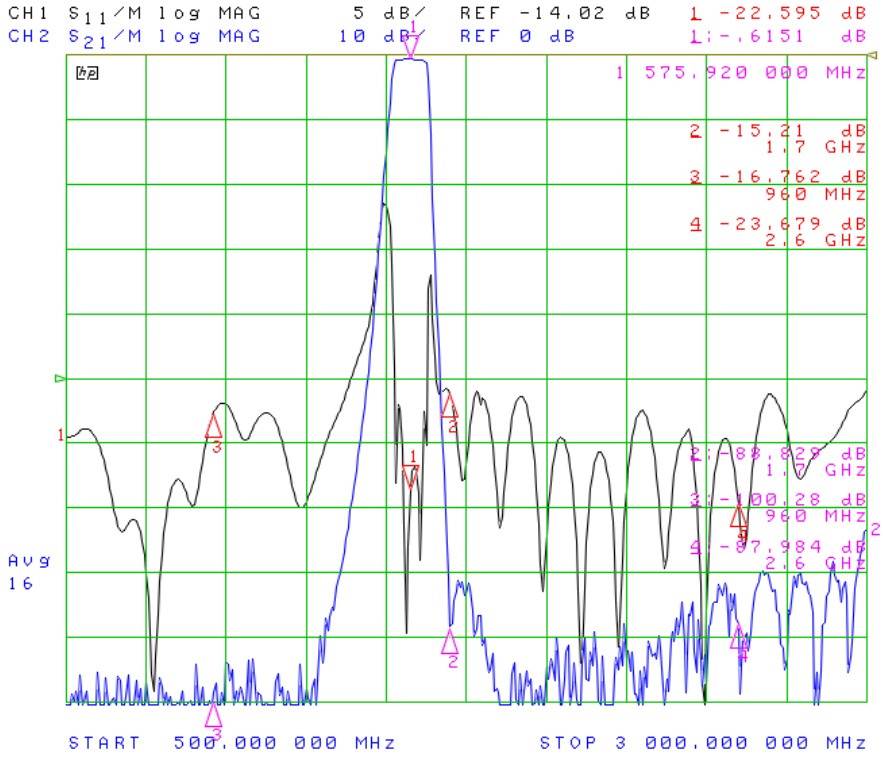

This plot using the same ports as above only a wider sweep. Notice the path provided by the low pass bias tee.

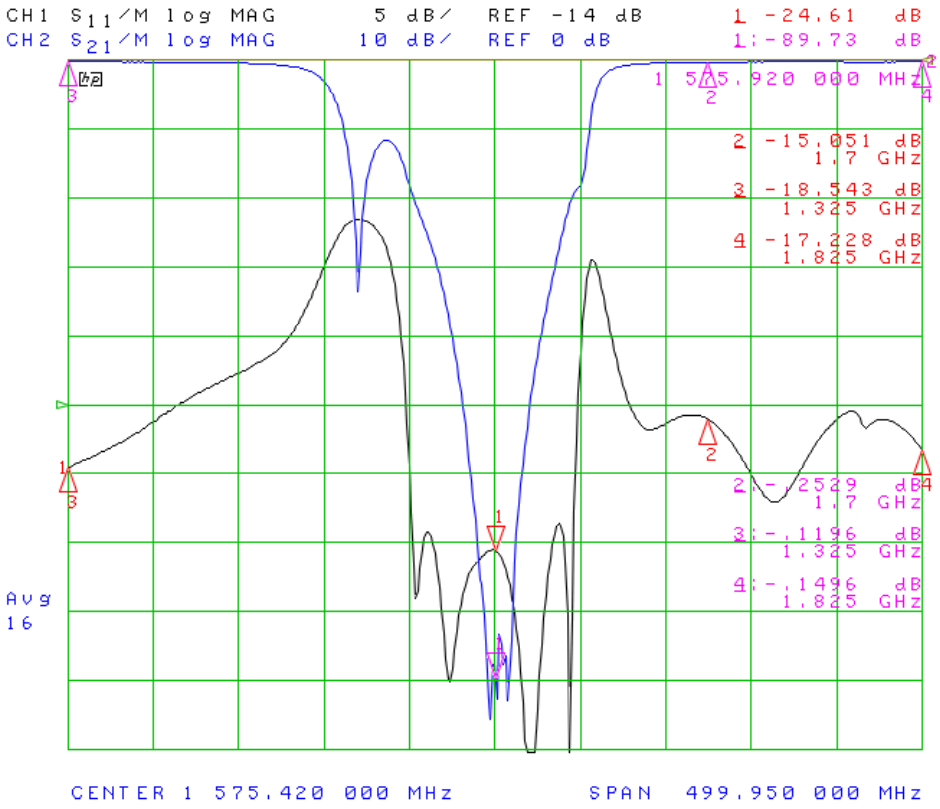


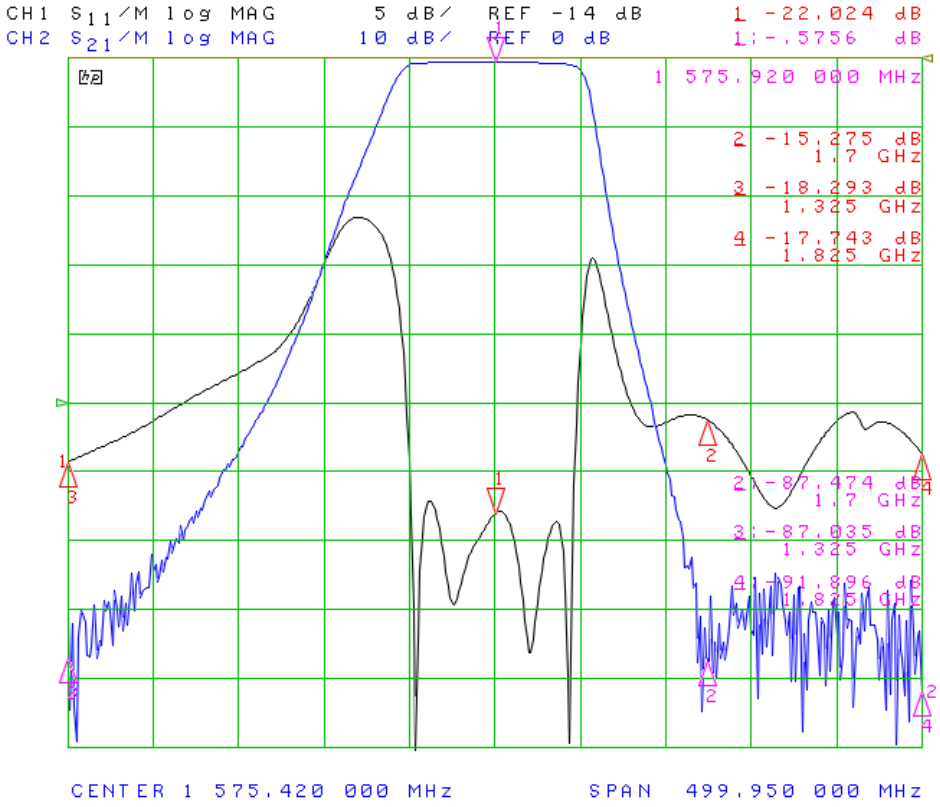

This is a plot of a narrow sweep highlighting the pass band and stop band of the GPS band pass filter as well as the GPS notch filter.

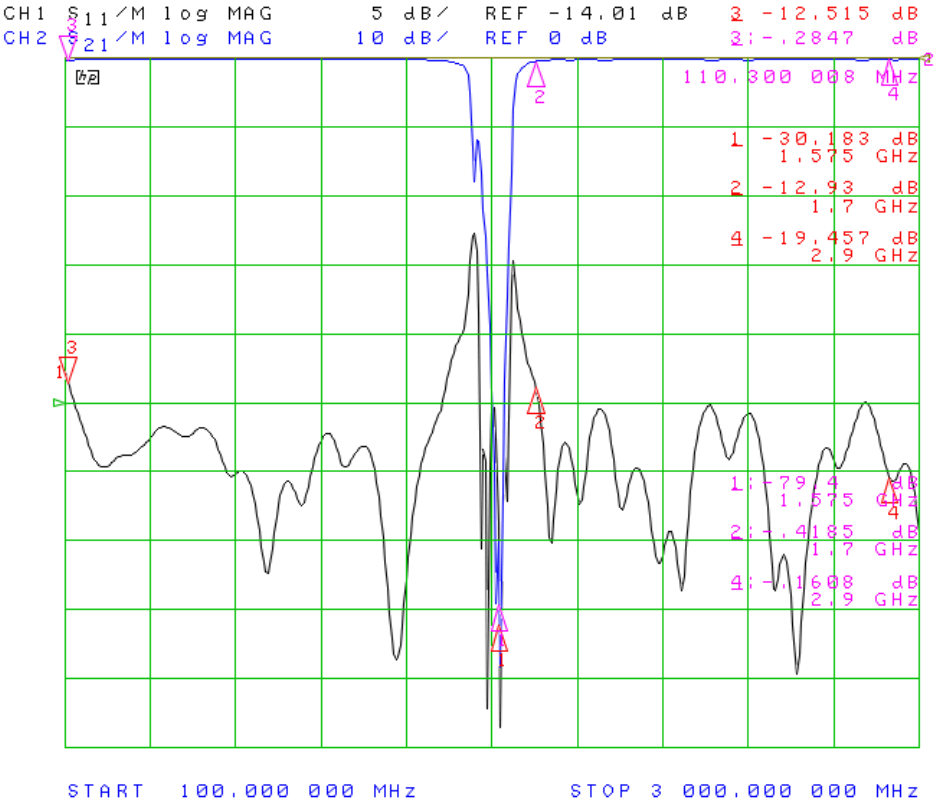
Actual hardware plots for the DX_1575_N_N


CH1 S11/M log MAG 5 dB/ REF -14 dB 1 -24.669 dB
CH2 S21/M log MAG 10 dB/ REF 0 dB 1:-89.663 dB
1 575.920 000 MHz
2 -10.29 dB
1.625 GHz
3 -18.249 dB
1.525 GHz
4 -10.29 dB
1.625 GHz
2:-17.79 dB
1.625 GHz
3:-17.809 dB
1.525 GHz
4 -17.79 dB
1.625 GHz
Avg
16
CENTER 1 575.420 000 MHz
SPAN 100.000 000 MHz


CH1 S11/M log MAG 5 dB/ REF -14.02 dB 1 -22.595 dB
CH2 S21/M log MAG 10 dB/ REF 0 dB 1:-.6151 dB
1 575.920 000 MHz
2 -15.21 dB
1.7 GHz
3 -16.762 dB
960 MHz
4 -23.679 dB
2.6 GHz
2:-82.828 dB
1.7 GHz
3:-100.28 dB
960 MHz
4:-97.984 dB
2.6 GHz
Avg
16
START 500.000 000 MHz
STOP 3 000.000 000 MHz

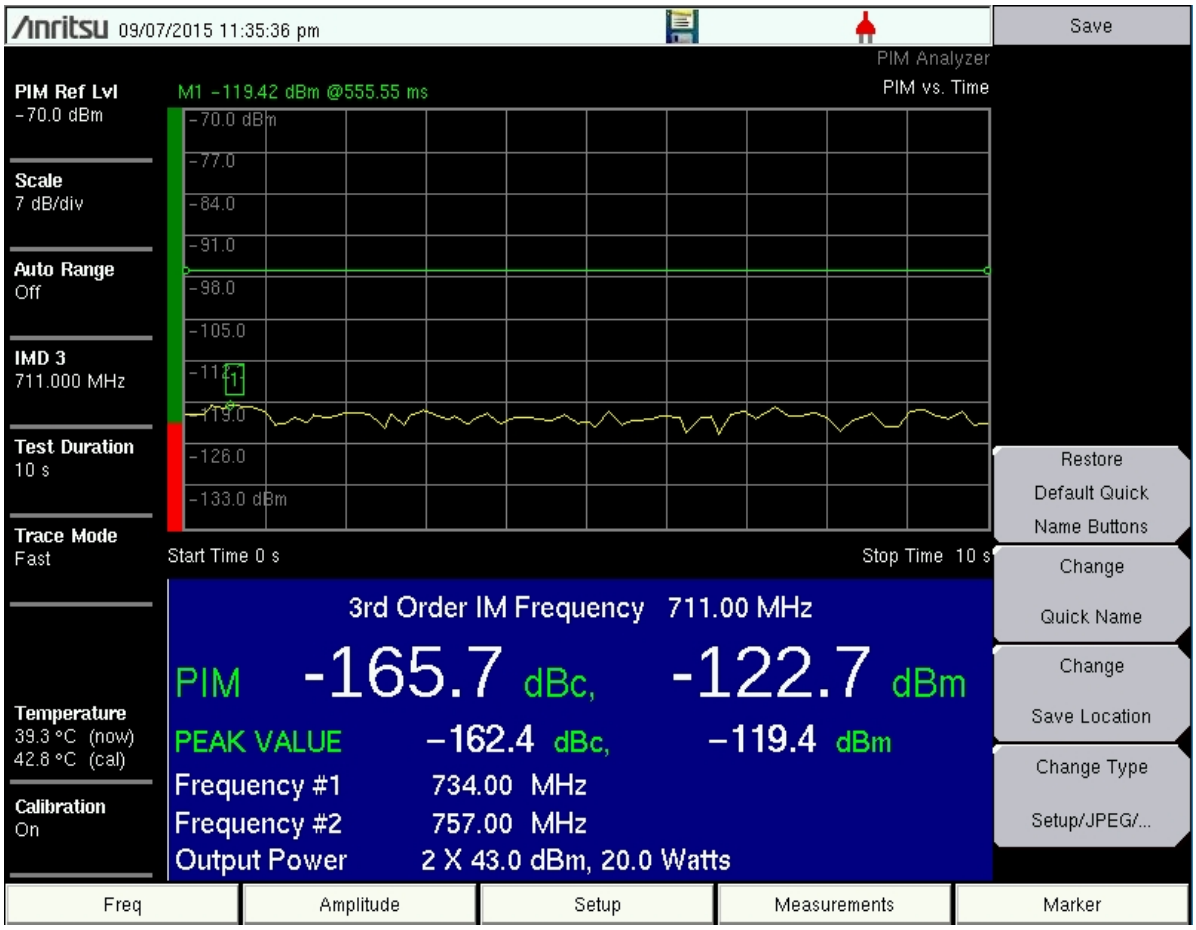

CH1 S11/M log MAG 5 dB/ REF -14 dB
CH2 S21/M log MAG 10 dB/ REF 0 dB
1 -24.61 dB
1: -89.73 dB
1 575.920 000 MHz
2 -15.051 dB
1.7 GHz
3 -18.543 dB
1.325 GHz
4 -17.228 dB
1.825 GHz
2: -.2529 dB
1.7 GHz
3: -.1196 dB
1.325 GHz
4: -.1496 dB
1.825 GHz
Avg
16
CENTER 1 575.420 000 MHz
SPAN 499.950 000 MHz


CH1 S11/M log MAG 5 dB/ REF -14 dB
CH2 S21/M log MAG 10 dB/ REF 0 dB
1 -22.024 dB
1: -.5756 dB
1 575.920 000 MHz
2 -15.275 dB
1.7 GHz
3 -18.293 dB
1.325 GHz
4 -17.743 dB
1.825 GHz
2: -87.474 dB
1.7 GHz
3: -87.035 dB
1.325 GHz
4: -91.896 dB
1.825 GHz
CENTER 1 575.420 000 MHz
SPAN 499.950 000 MHz


CH1 S11/M log MAG 5 dB/ REF -14.01 dB
CH2 S21/M log MAG 10 dB/ REF 0 dB
3 -12.515 dB
3:-.2847 dB
110.300 008 MHz
1 -30.183 dB
1.575 GHz
2 -12.93 dB
1.7 GHz
4 -19.457 dB
2.9 GHz
1:-79.4 dB
1.575 GHz
2:-.4185 dB
1.7 GHz
4:-.1608 dB
2.9 GHz
START 100.000 000 MHz
STOP 3 000.000 000 MHz

**Wide band PIM**

The plots indicate a wide band that opens up the possibility of passive intermod distortion. Care must be taken to insure that any materials used in the construction must conform. Here are the plots that show the hardware performance.




About the Author

Wayne Barbely was the former owner and CEO of Salisbury Engineering in Delmar, Delaware. He operated the company from 1982-2004 and was responsible for the design and manufacturing of RF and microwave filters. Wayne started his career with NASA in 1962 and also received training from The University of Virginia. He has 54 years of experience in the field of RF and microwave filters and currently owns Spruce Creek Microwave in Port Orange, Florida where he is in charge of sales and designs. Wayne can be reached by email at: rwbarbely@reagan.com.