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902 MHz and 432 MHz Patch Feeds

Al Ward

W5LUA

July 28, 2023

PY2BS 902 MHz Patch Feed

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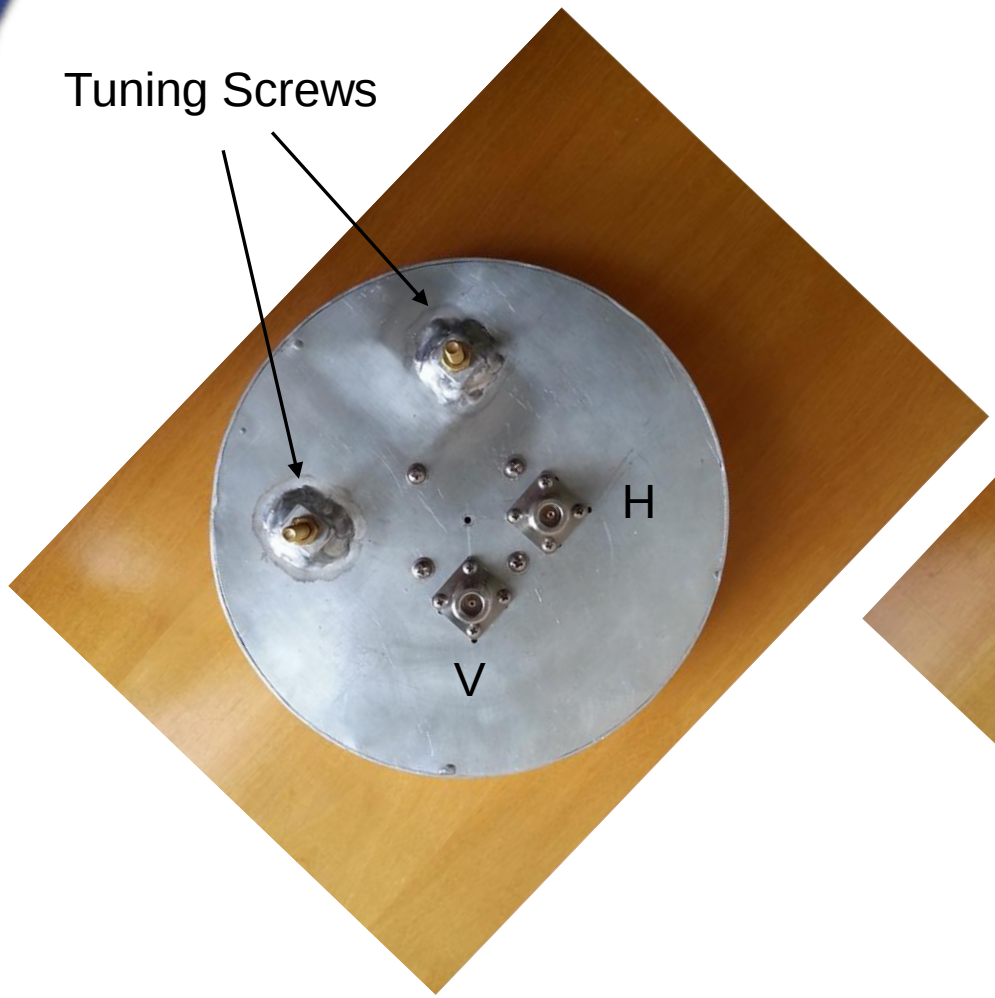

W5LUA version 902 MHz

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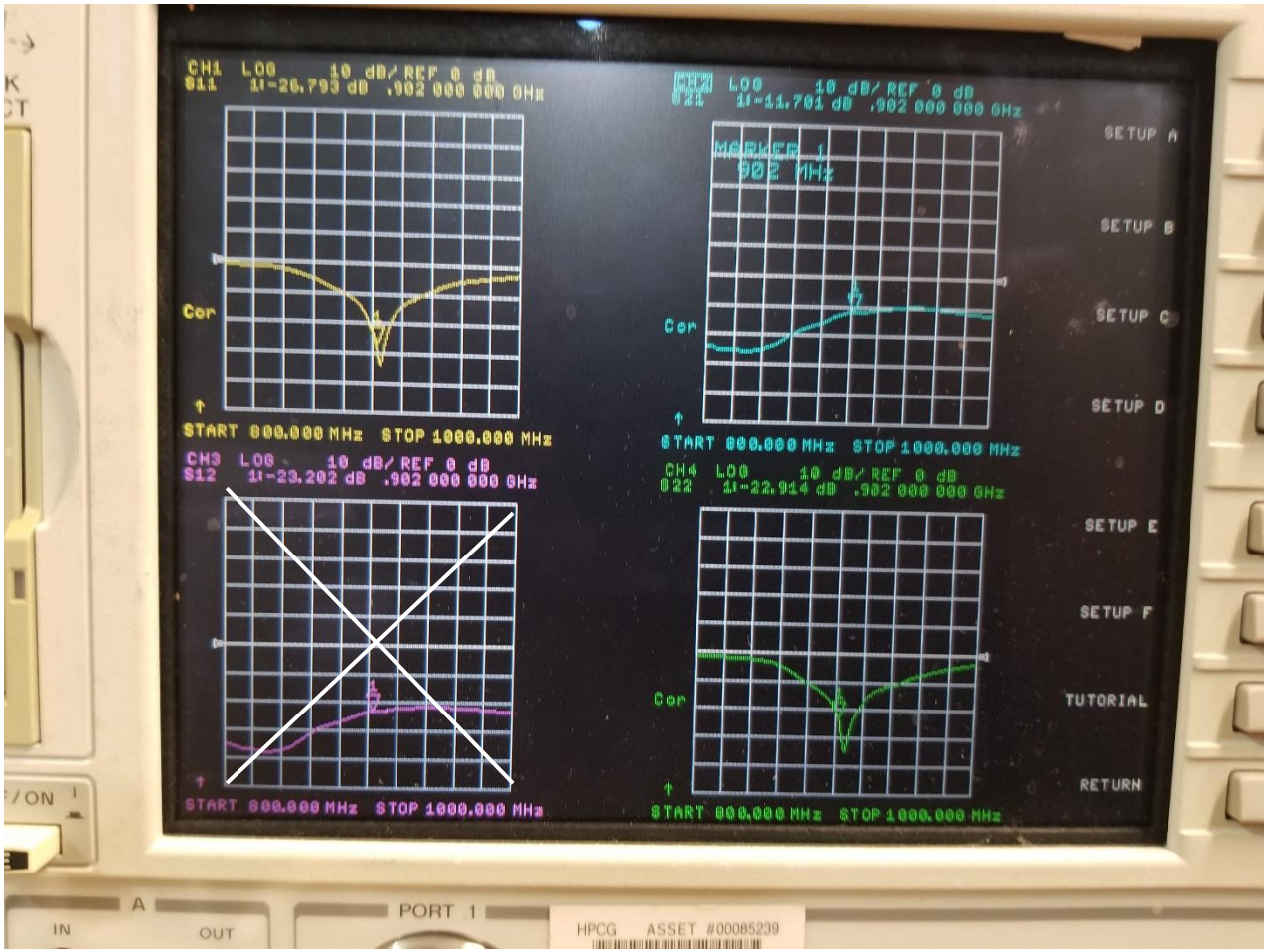
Patch 6.25 inch diameter .023 inch thickness copper spaced .5 inch above ground plane

Ground plane 8.25 inch diameter .023 inch thickness copper – next time I would make thicker

Choke ring is 2 inch wide .040 inch copper

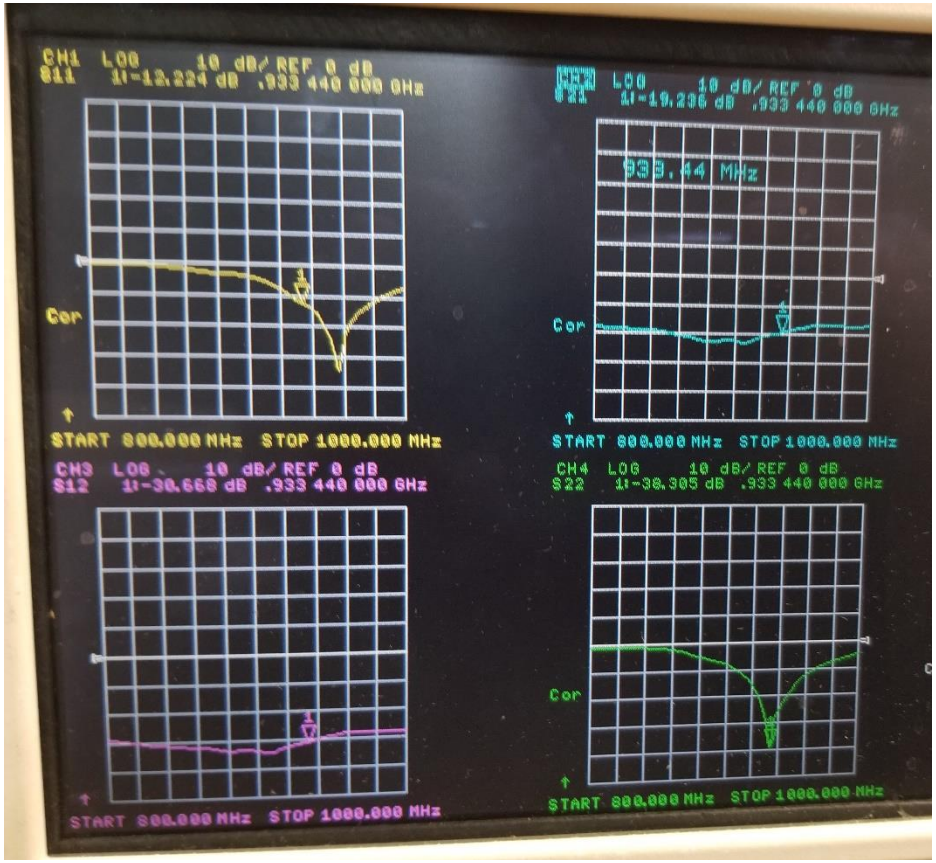
Original PY2BS 902 MHz Patch Feed built by W5LUA



S11 = -26.8 dB
S22 = -22.9 dB

Isolation between ports only 11.7 dB

Original patch feed with tuning screws at Minimum



Shows natural resonant frequency of patch is around 930 MHz plus

Also note that port to port isolation is nearly 20 dB at 930 MHz

432 MHz Patch Feed

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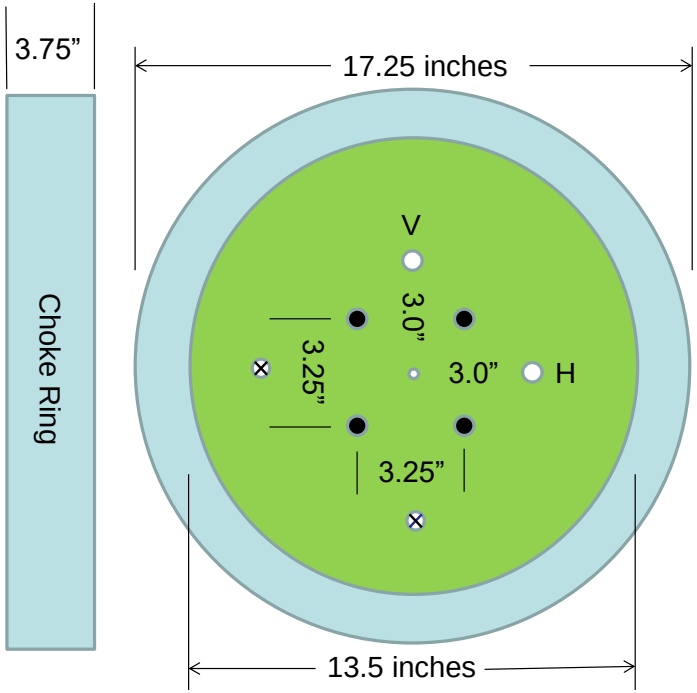

Scaled from original PY2BS feed which was naturally resonant at 930 MHz

V, H port return loss = 27 dB
Port to port isolation 22 dB

W5LUA 432 MHz Patch Feed

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432 MHz Patch feed made using .062 inch thickness double sided printed circuit board. Choke ring to be added

432 MHz Patch feed installed in mount of 1296 MHz septum feed. Feed is in front of dish focal point but still works!

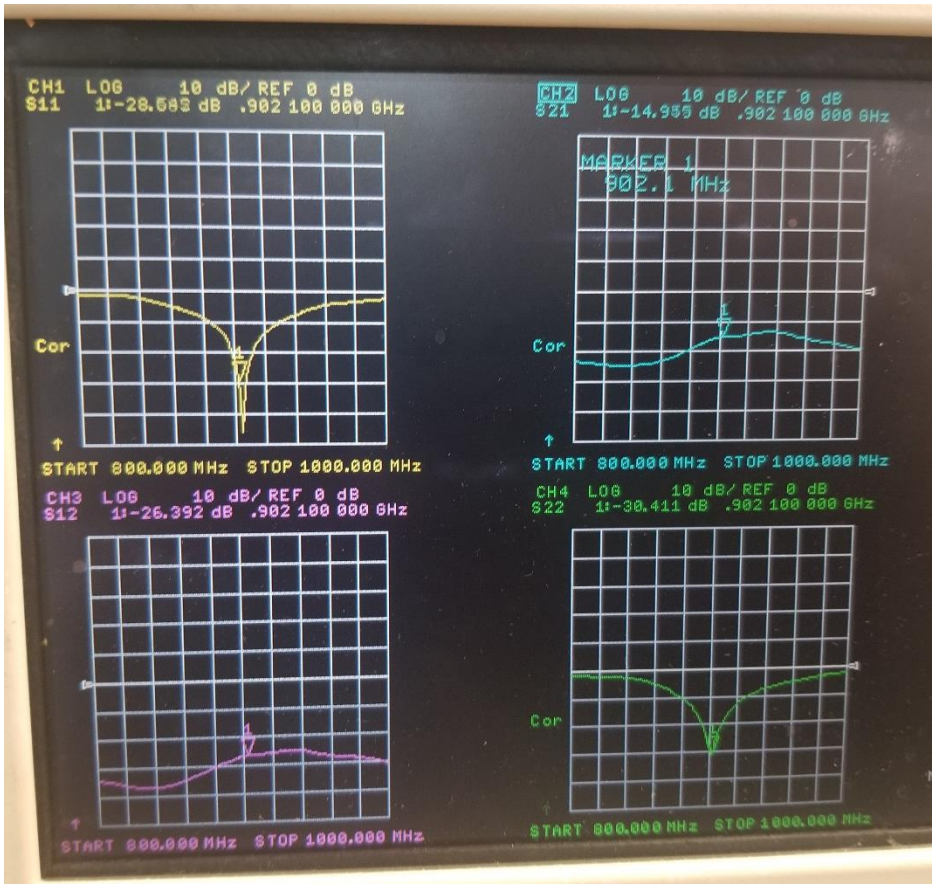
- Recently there has been some discussion as to whether or not circular polarity would offer any benefit on 902 MHz.
- Faraday rotation at 902 MHz is thought to be very slow or non-existent. To date all stations have been linear with horizontal polarity.
- Since the 33 cm band is a IARU Region 2 only allocation, there is not a big concern about spacial offset between stations as there is on 3cm where there is a 90 degree spacial offset between the US and EU.
- I decided that the first thing I needed to do was to improve my port to port isolation to help validate my measurements

6.45 inch Diameter Patch

Scaling 930 MHz back down to 902 MHz suggested an increase in patch size to 6.45 inches

I used aluminum for the patch as I was out of copper

6.45 inch diameter patch



Swapped out 6.25 in patch for a 6.45 in diameter patch.
Only took a small amount of tuning with the screws to bring return loss in at 902 MHz
Port to port isolation improved from 11 dB to nearly 15 dB
S11 and S22 Return loss greater than 25 dB

S12 not calibrated - ignore

Need to improve isolation

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- I decided to experiment with an “isolation” stub” as has been done with the original VE4MA and W2IMU feeds.

902 MHz Patch Feed with improved isolation

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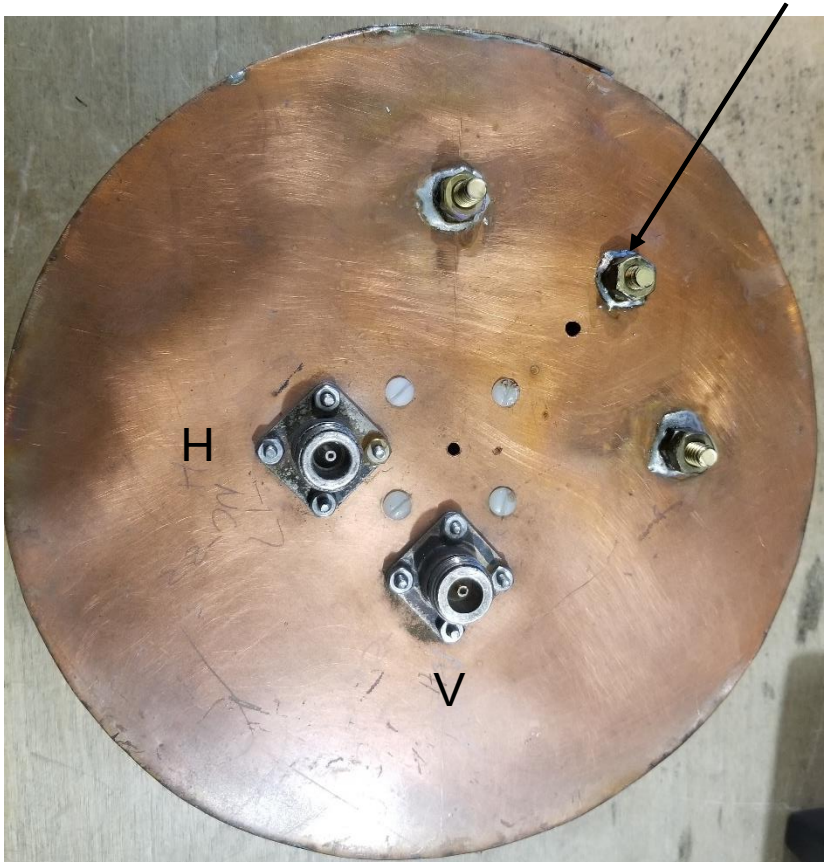
Back side view

Isolation Stub

View with patch removed



Feed is a little bent up due to a fall from a 10 ft step ladder, just the feed fell !

Modified Patch Feed with additional stub for optimizing isolation

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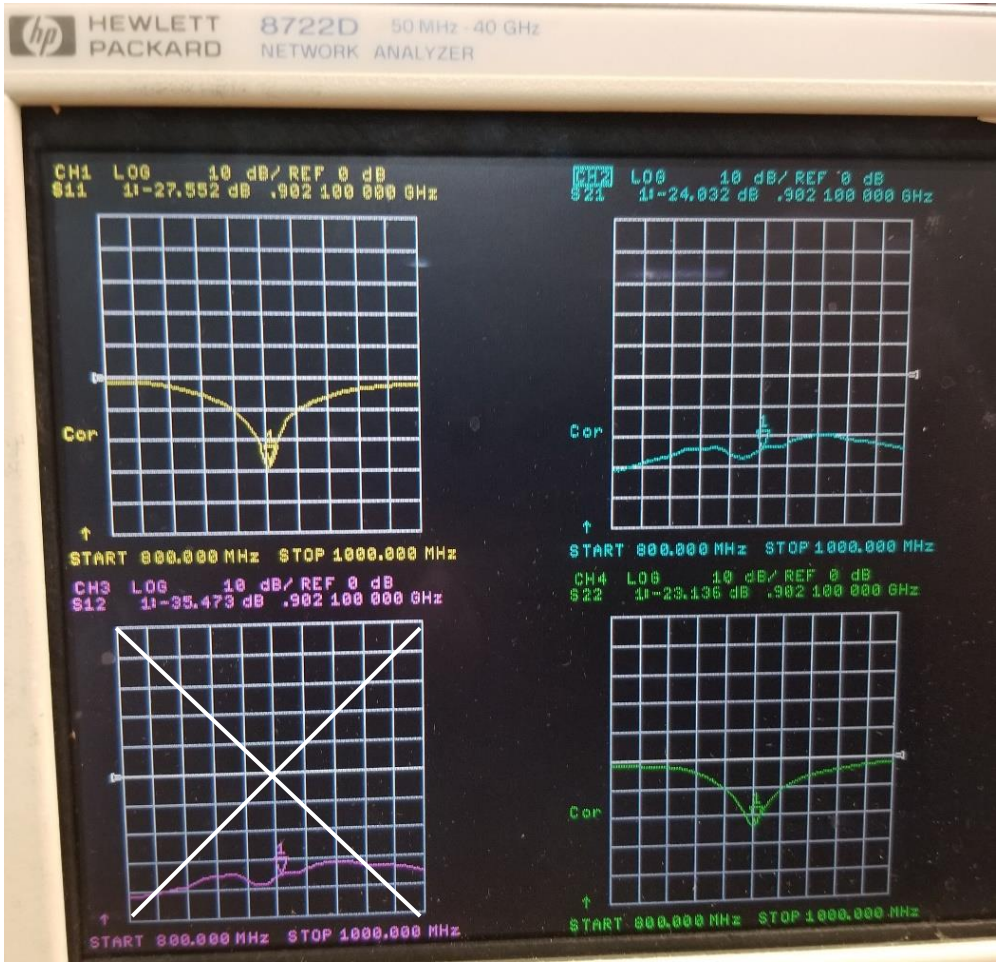

S11 = -27.5 dB
S22 = -23.1 dB

S21 or Isolation between ports now 24.0 dB

Modified 902 Patch for improved isolation

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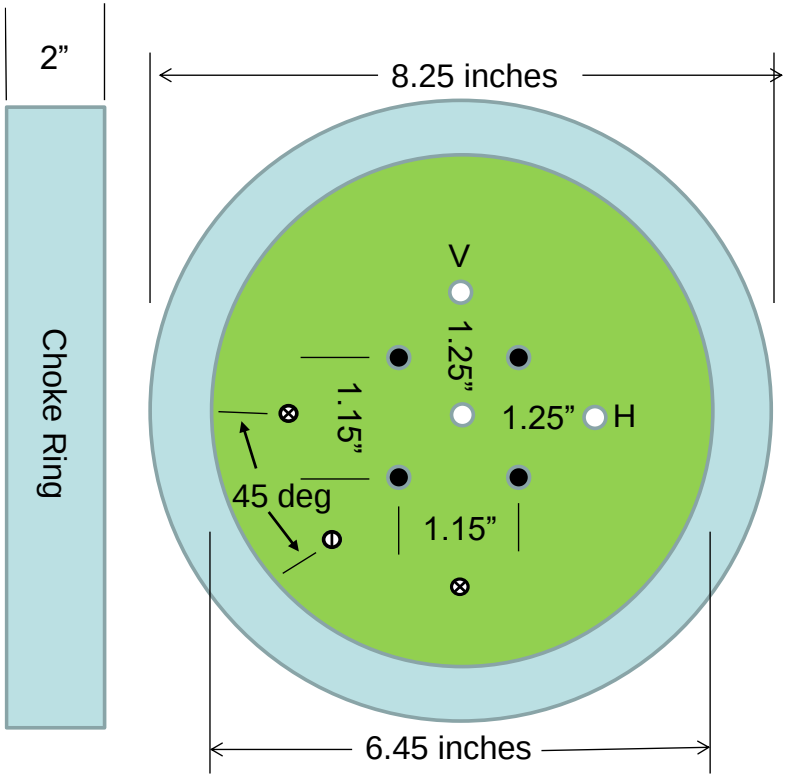

- ○ Center hole for alignment
- ● Locations of .5 inch ceramic spacers with nylon screws. The 4 spacers make a 1.15 inch square box centered on the disk
- ○ The H and V probes are located 1.25 inches from the center of the disk
- ⊗ Capacitance probes for fine tuning VSWR ¼ 20 brass screw with brass washer soldered to end of screw – spaced 2.7 inches from center of disc
- Φ Isolation stub 45 degrees from each tuning stub, spaced 2.7 inches from center of disc, adjust for best port to port isolation

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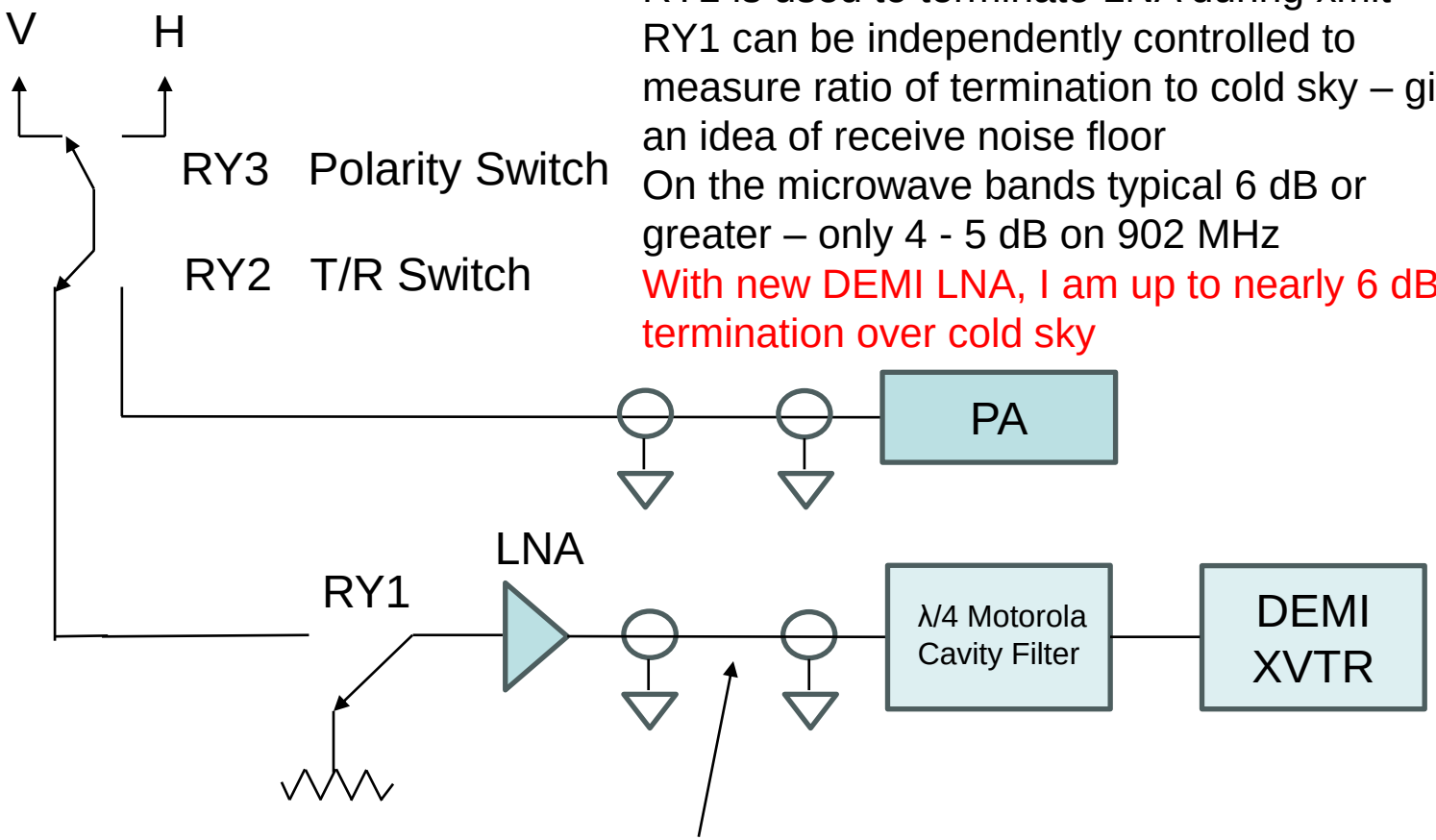
Setup for Linear Polarity



RY1 is used to terminate LNA during xmit
RY1 can be independently controlled to measure ratio of termination to cold sky – gives an idea of receive noise floor
On the microwave bands typical 6 dB or greater – only 4 - 5 dB on 902 MHz
With new DEMI LNA, I am up to nearly 6 dB of termination over cold sky

40 ft ½" Heliax to shack

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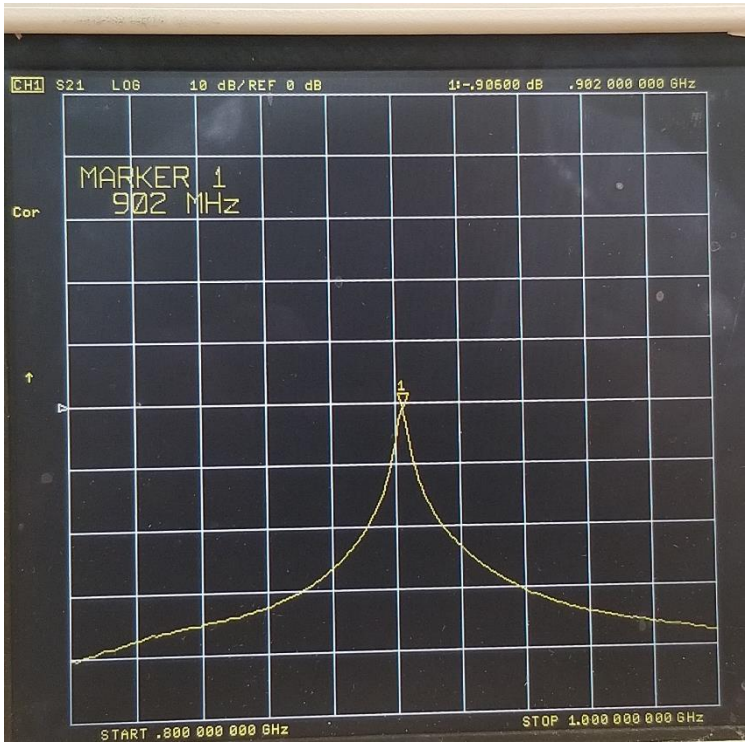
Motorola Cavity Filter

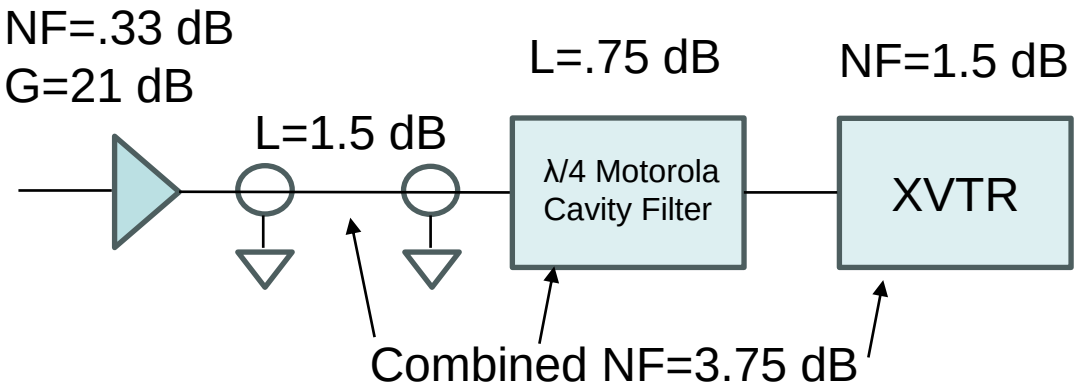


-26 dB at 880 MHz
-23 dB at 920 MHz

Using this filter in front of my 902 MHz transverter was the ONLY way I could operate terrestrial

The Noise Figure Equation

$$NFt = NF1 + \frac{NF2}{G1} + \frac{NF3}{G1G2}$$



After converting dBs to ratios by dividing by 10 and taking the inverse log we get

= 1.079 + 2.37/125.9
= 1.079 + .0188
= 1.0978 = .41 dB NF

We have sacrificed .08 dB NF in the interest of generating less IMD in our receiver
For every dB increase in gain, the third order IMD will rise 3 dB
A possible solution is two stages with a cavity filter or SAW filter in between out at the feed.

902 MHz LNAs

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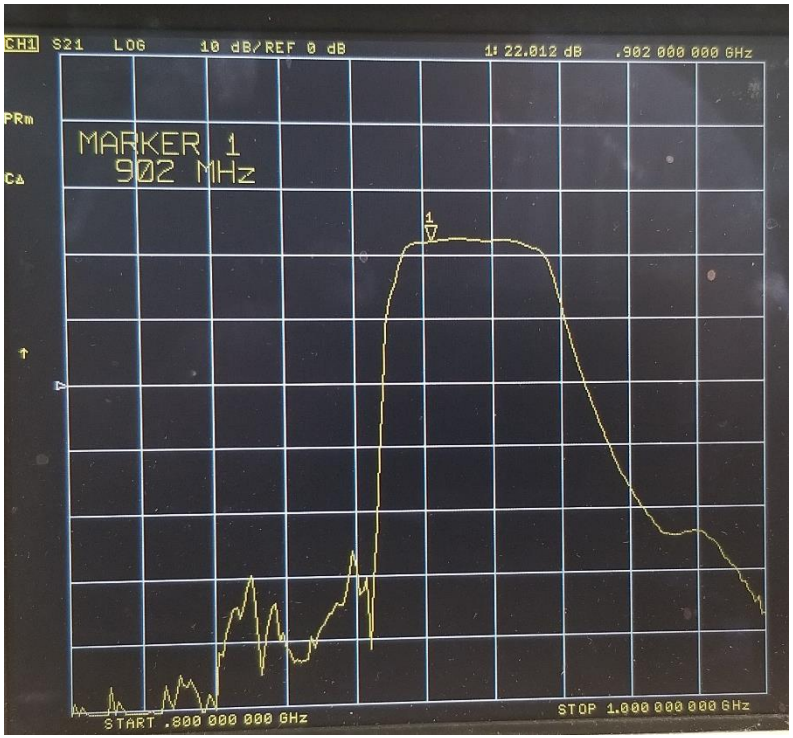
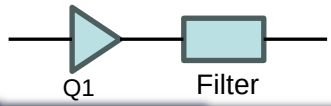
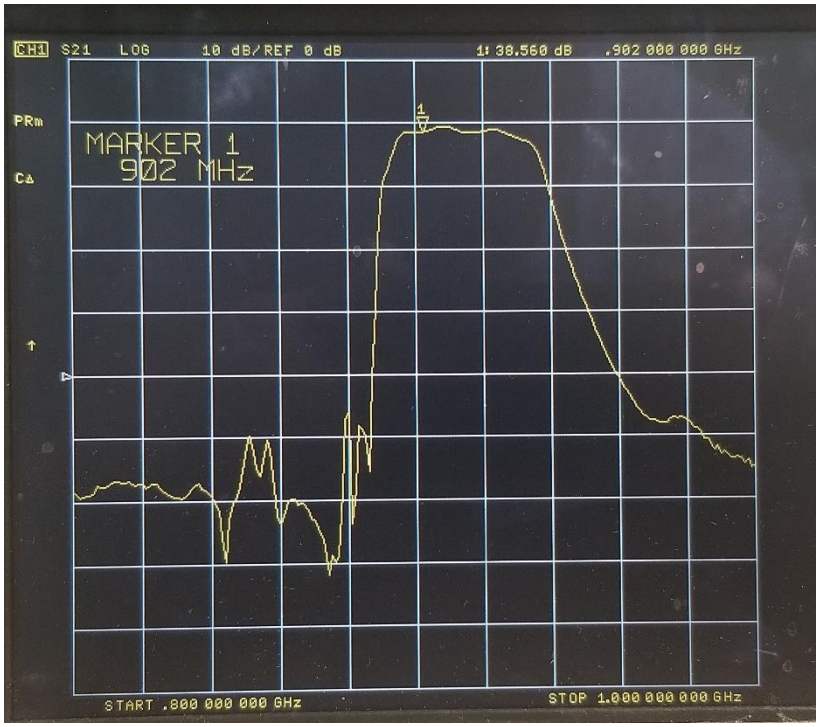
1 Stage LNA



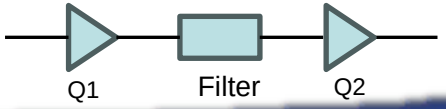
DEMI NBLNA33
NF = .33 dB, G = 22 dB



2 Stage LNA



DEMI NBLNAH33
NF = .35 dB, G = 38 dB



Generating Circular Polarization

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The 432 MHz & Above
EME-Newsletter Collection

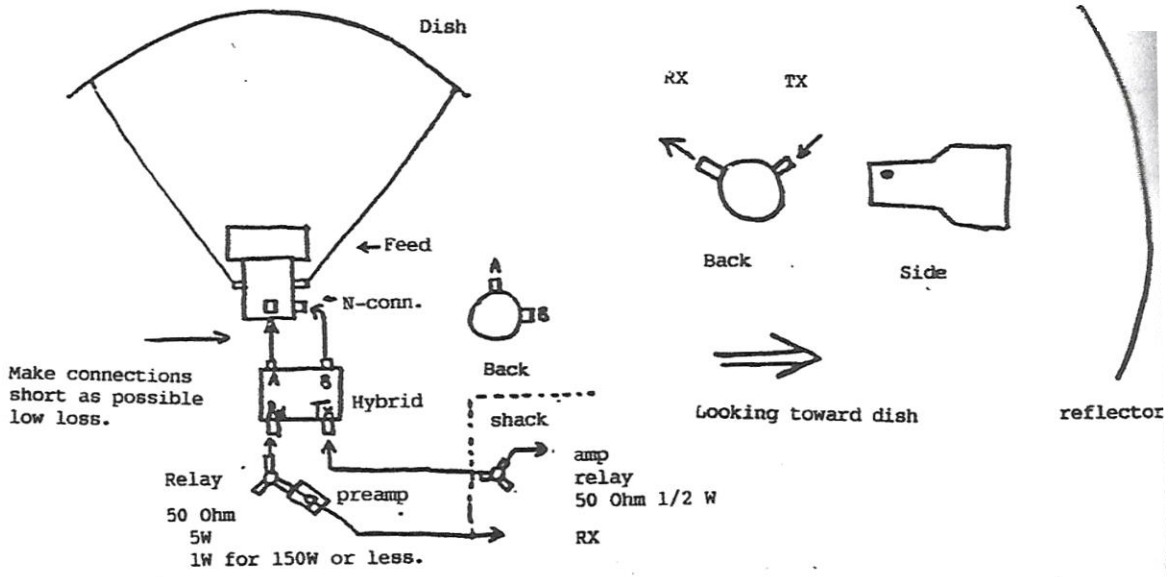
Issued at the 5th International EME Conference, 31 july-2 august 1992, Thorn The Netherlands.

3.57 Circular Polarisation Standard

Allen Katz K2UYH - November 1989

The I.A.R.U. has decided that the standard currently in use on 1296 MHz is also the one on use on 2. GHz. The diagram below shows the correct polarisation connections to an W2IMU horn. Remembe the circular sense produced by the feed is reversed by the reflector. Thus for right hand circular o transmit, you connect the transmitter to the left circular port of the horn. In any case if you conne your feed as shown in Figure 3–73, it should produce the correct sense.

Figure 3–73: Circular Polarisation Standard



Generating Circular Polarization

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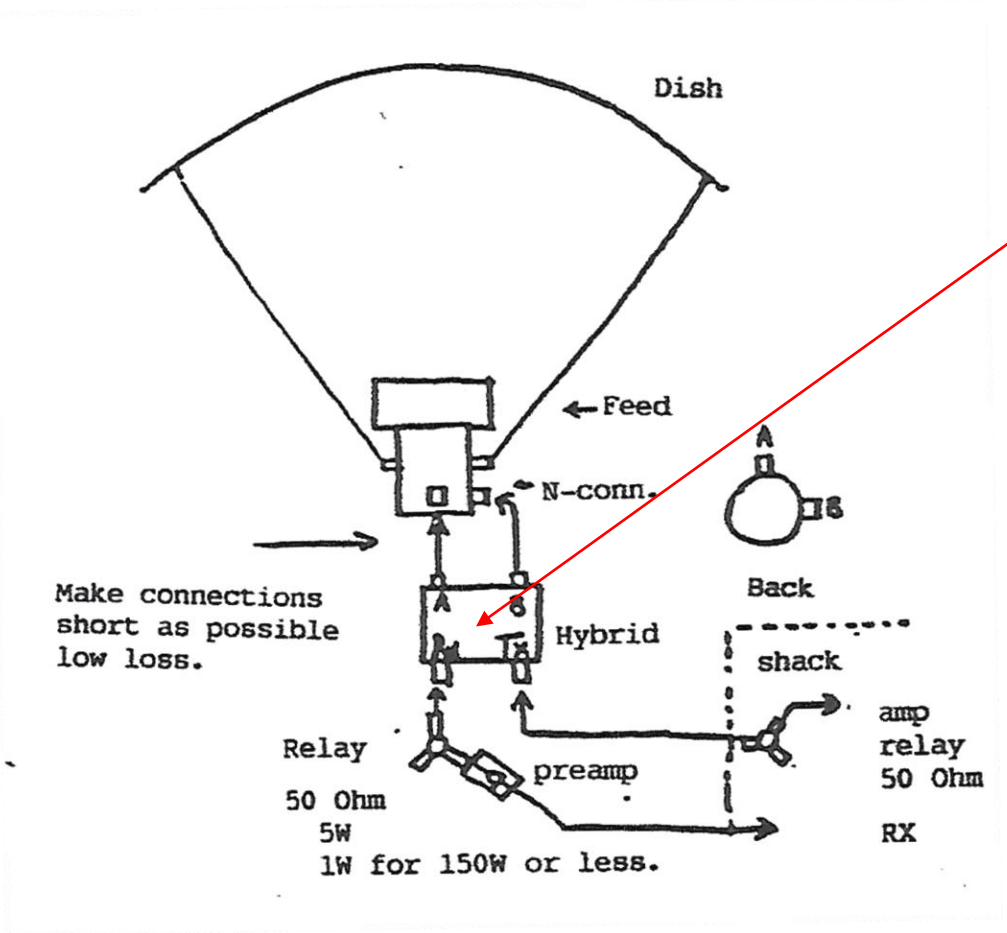
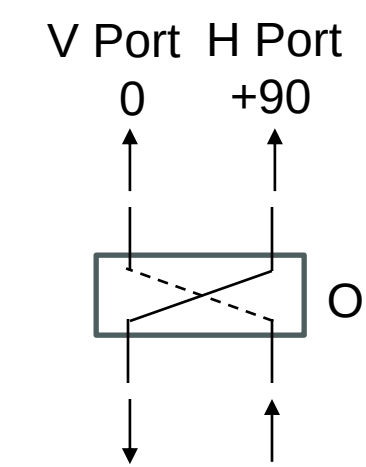


90 Degree Hybrids can take on several forms

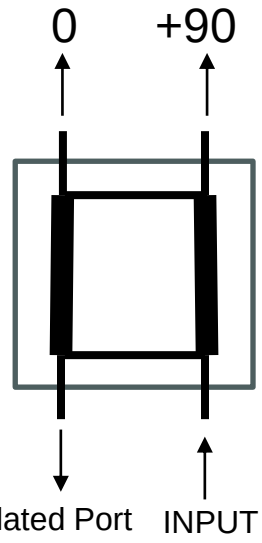
90 Deg broadside coupled Hybrid



Narda, Meca Commercial

OR

90 deg branch line hybrid



OE9PMJ, W0RAP HB

On a broadside coupled hybrid, I always remember Coupled port leads Direct port by 90 degrees

Generating CP on 902 MHz with a Dual Polarity Patch Feed

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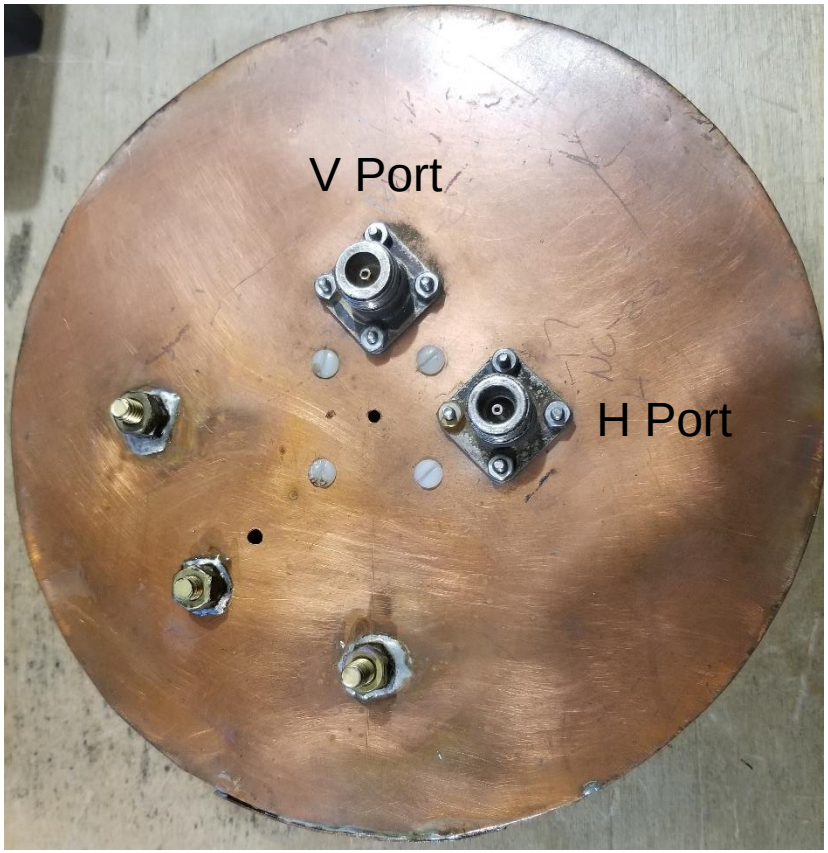
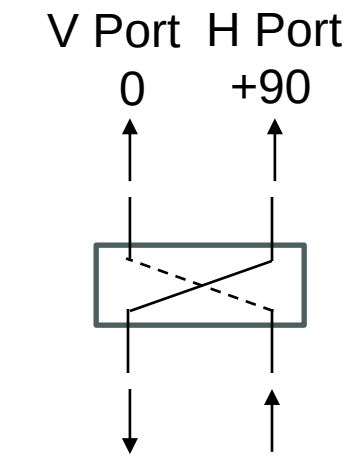


90 Deg broadside coupled Hybrid



Narda, Meca Commercial

Generating CP on 902 MHz with a Dual Polarity Patch Feed

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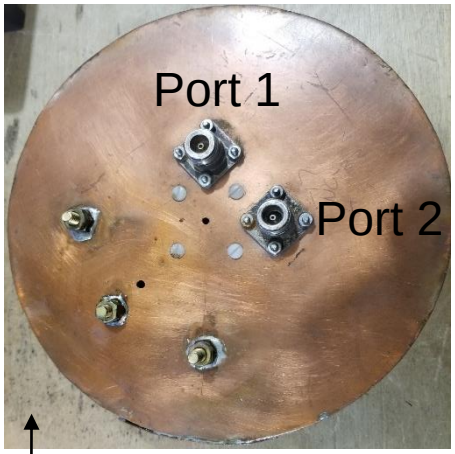
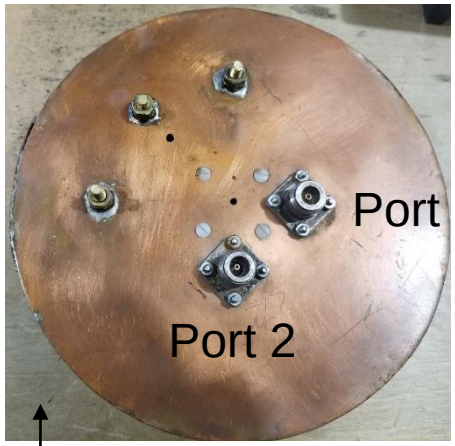
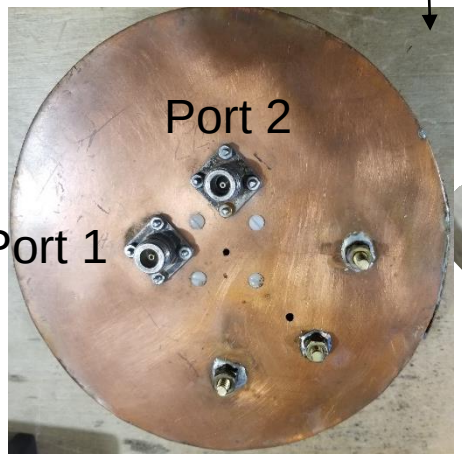
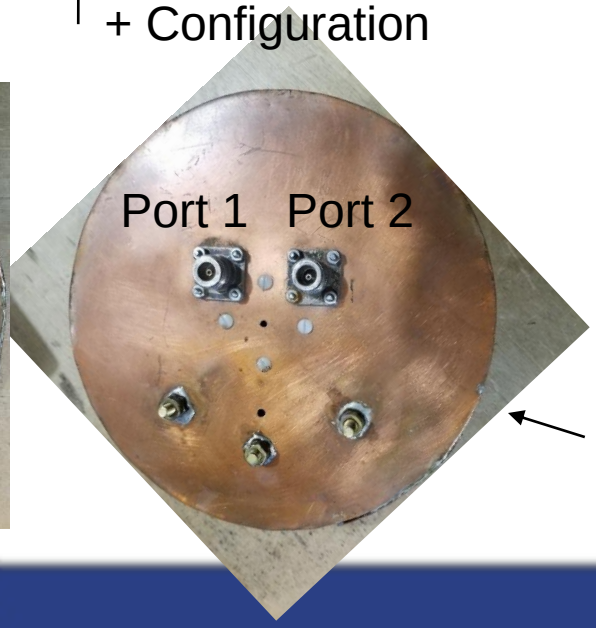


+ Configuration



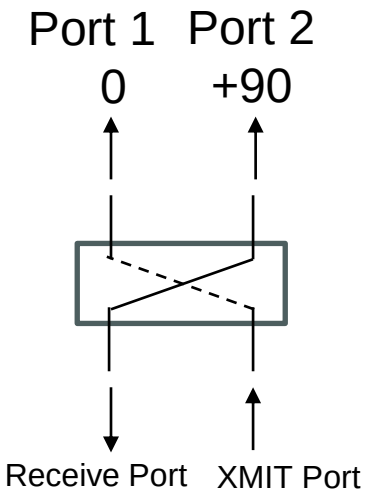
+ Configuration





X configuration +/- 45 degrees from vertical

90 Deg broadside coupled Hybrid



Port 2 is always the most CW port as viewed from the back of the feed

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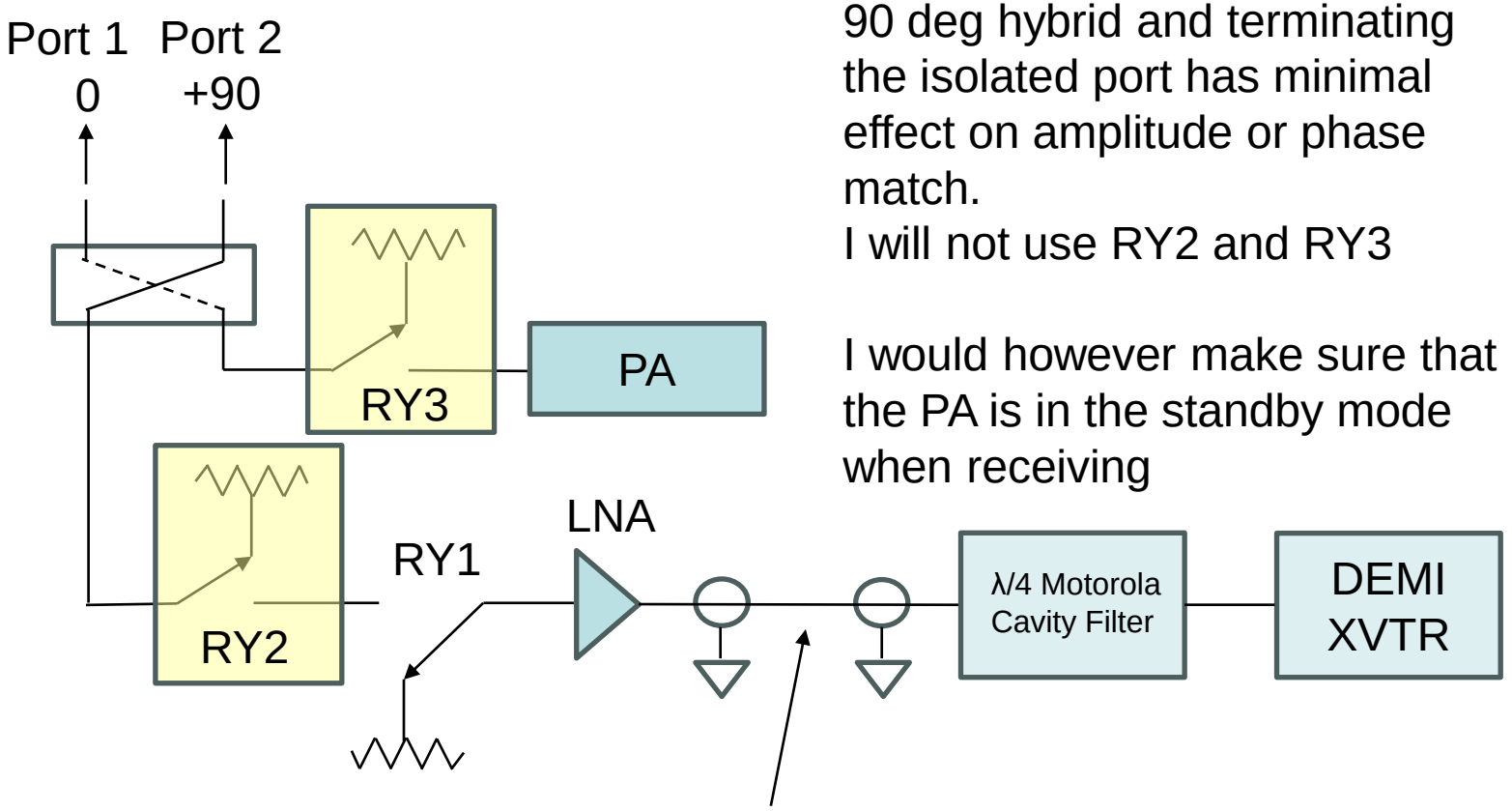
Proposed Setup for CP



I have tested the Meca 900 MHz 90 deg hybrid and terminating the isolated port has minimal effect on amplitude or phase match.
I will not use RY2 and RY3

I would however make sure that the PA is in the standby mode when receiving

40 ft ½" Heliax to shack

Hybrids tested

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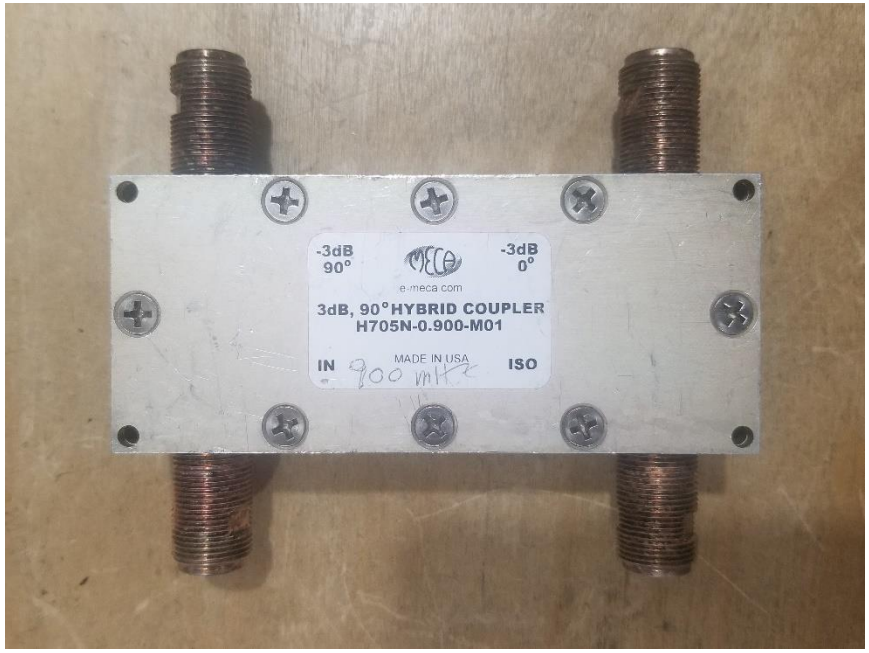

MECA 900 MHz Coupler

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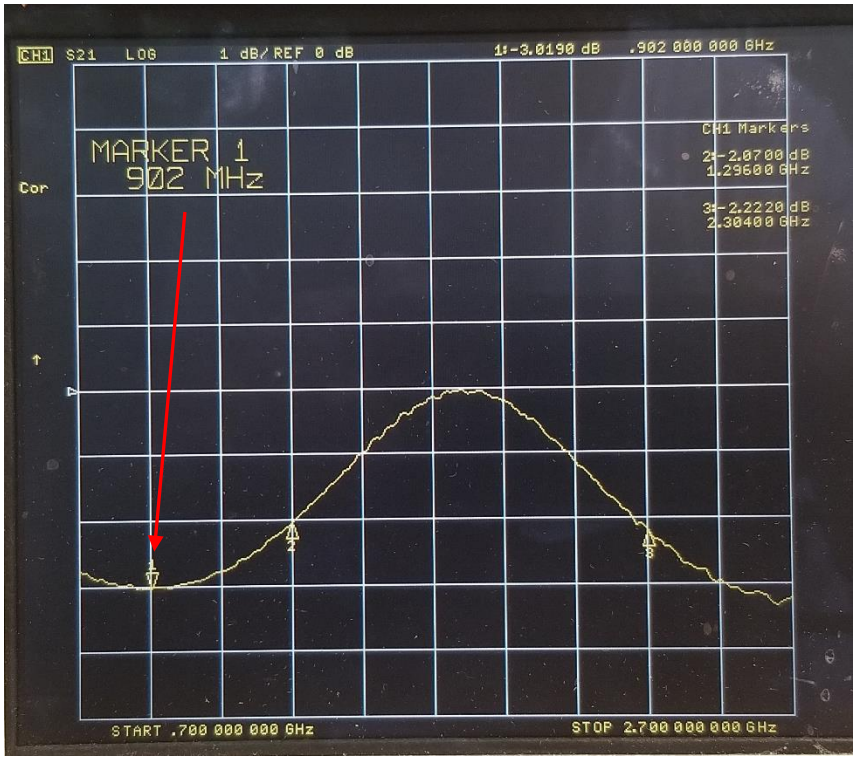
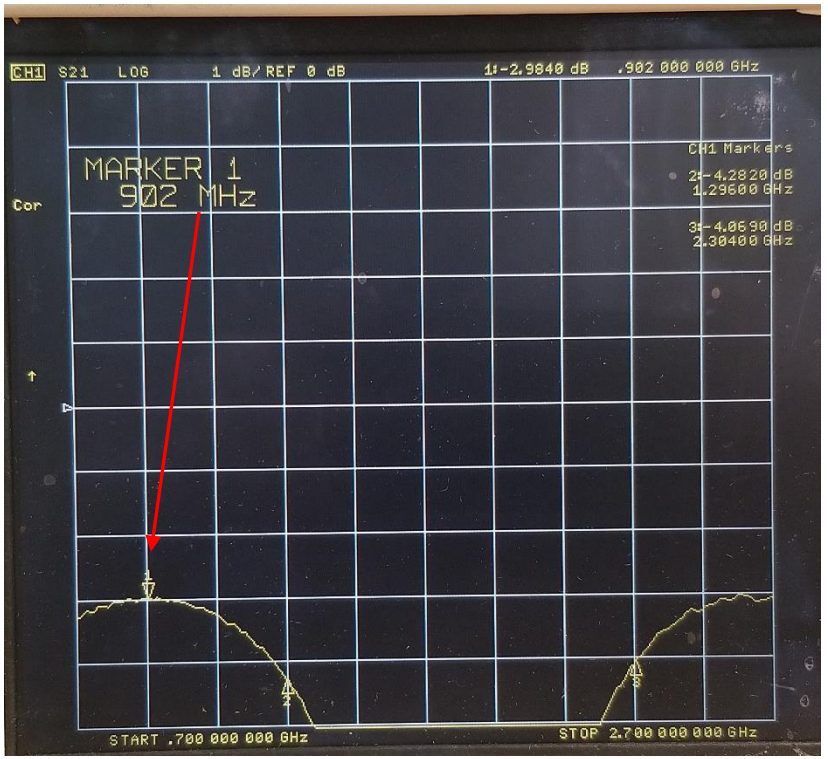


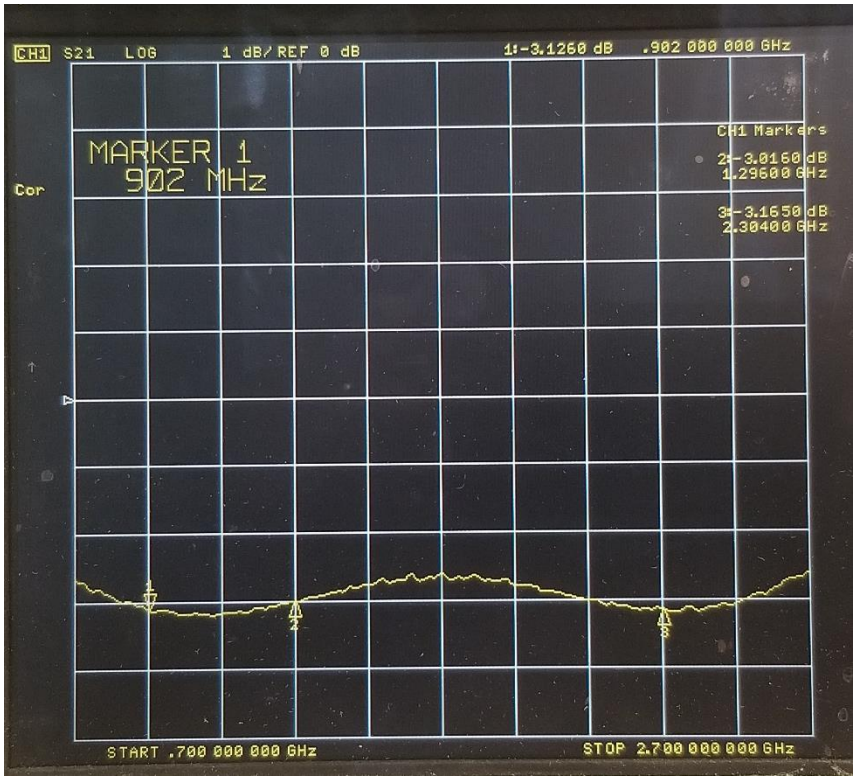
Direct Port



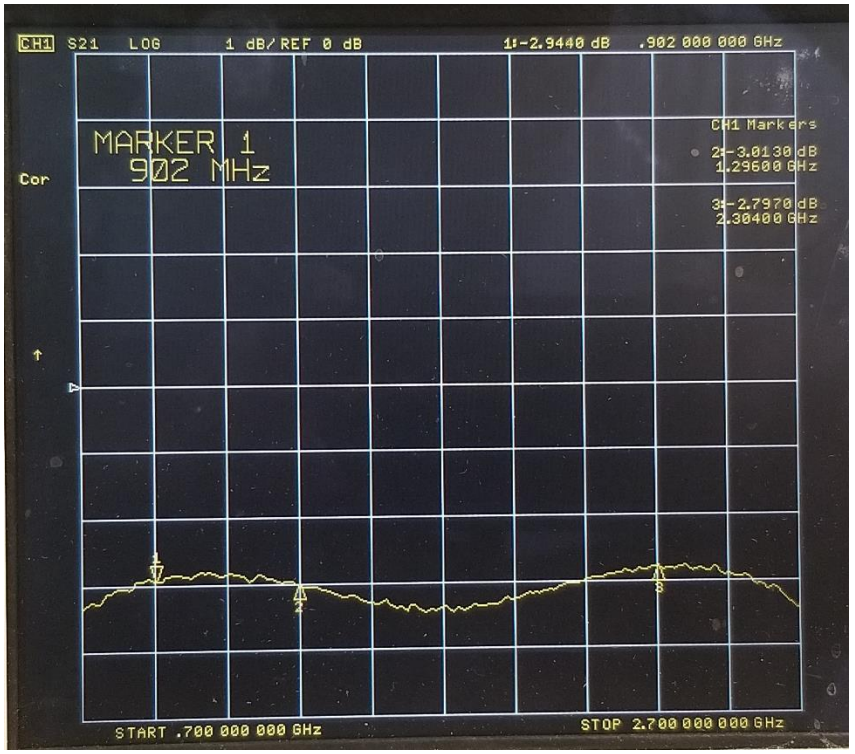
Coupled Port

Nominal 3 dB coupling at 902 MHz

Commscope 700 – 2700 MHz Hybrid



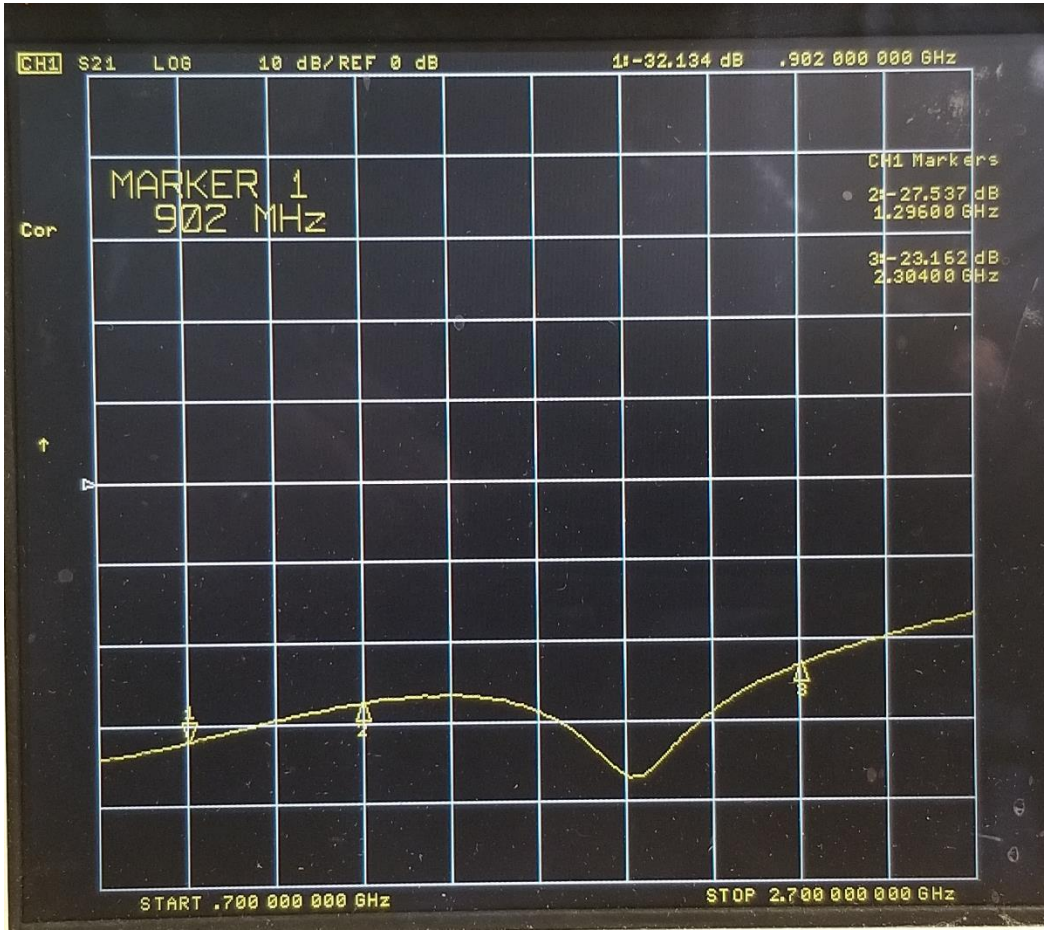
Direct Port



Coupled Port

Nominal 3 dB coupling over the entire band
Matched within.18 dB at 902 MHz and .003 dB at 1296 MHz

MECA Isolation



32 dB at 902 MHz

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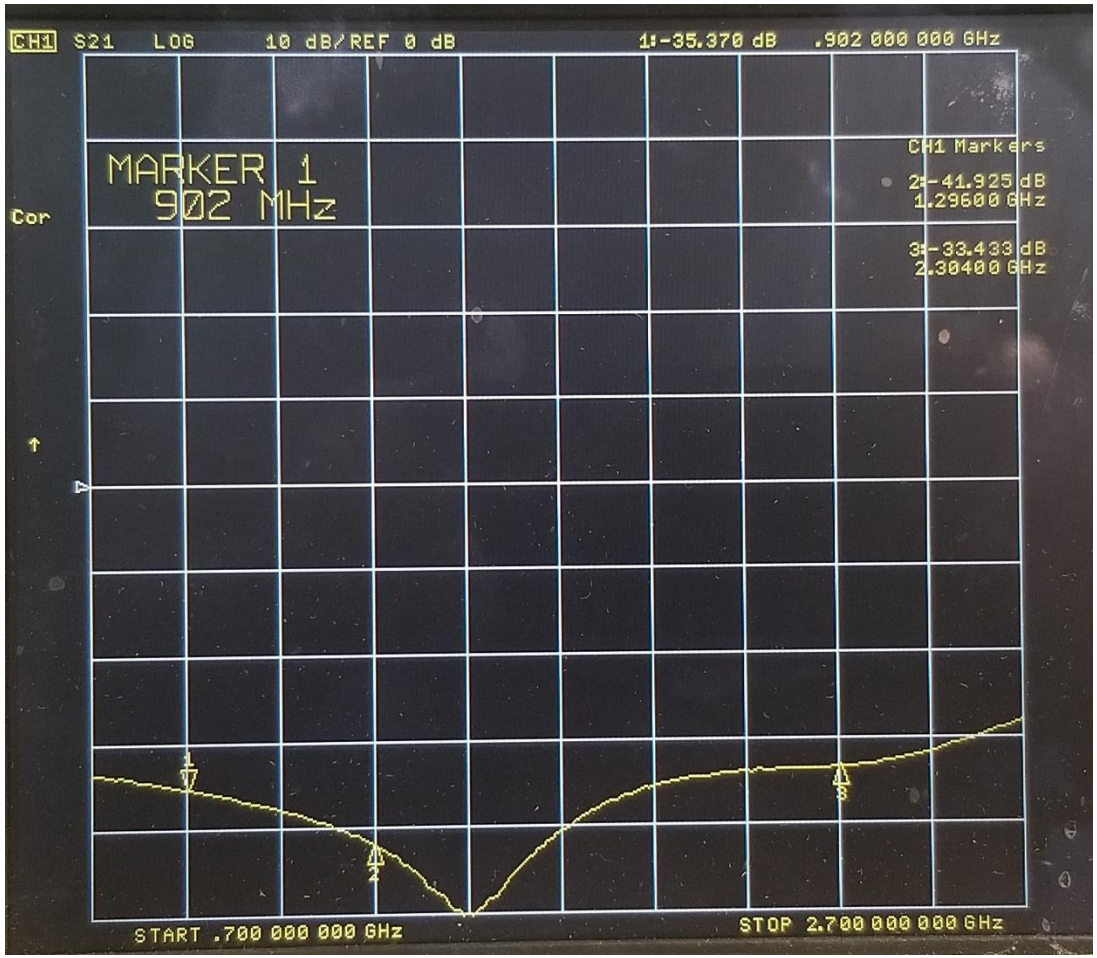
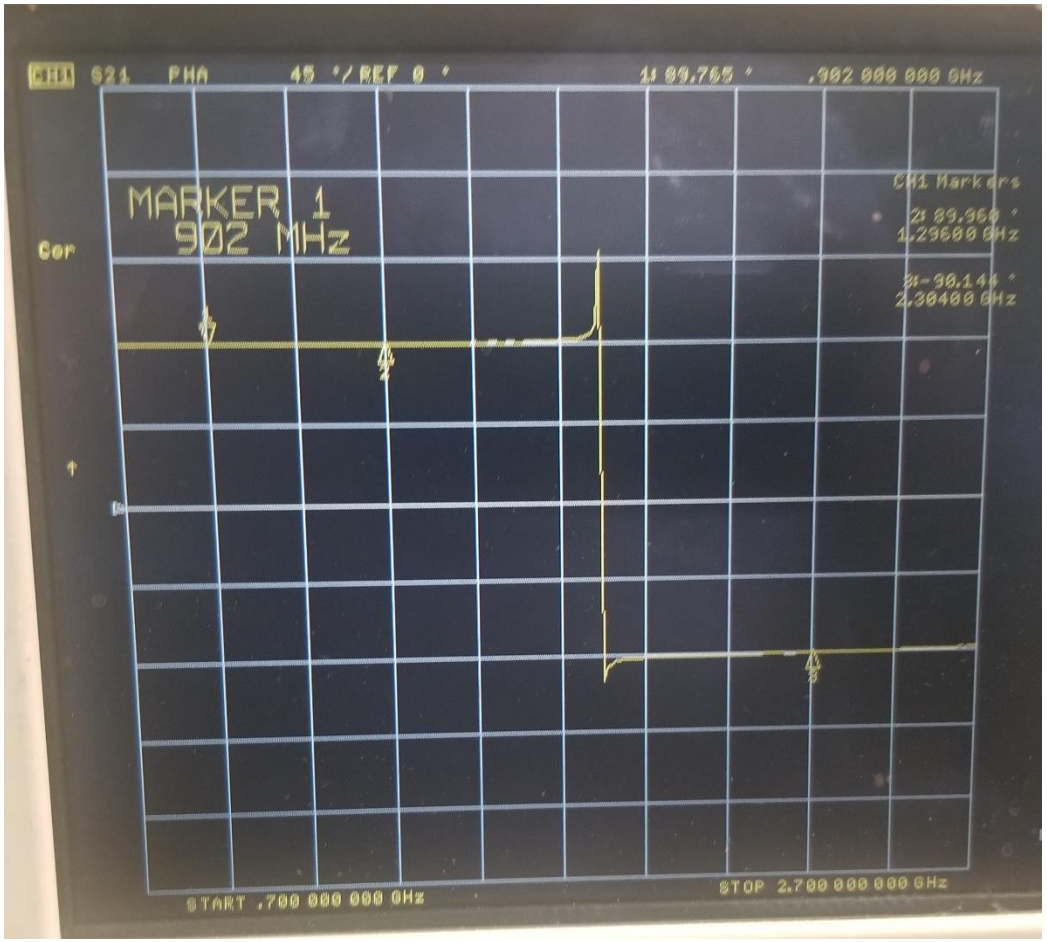
Commscope Isolation

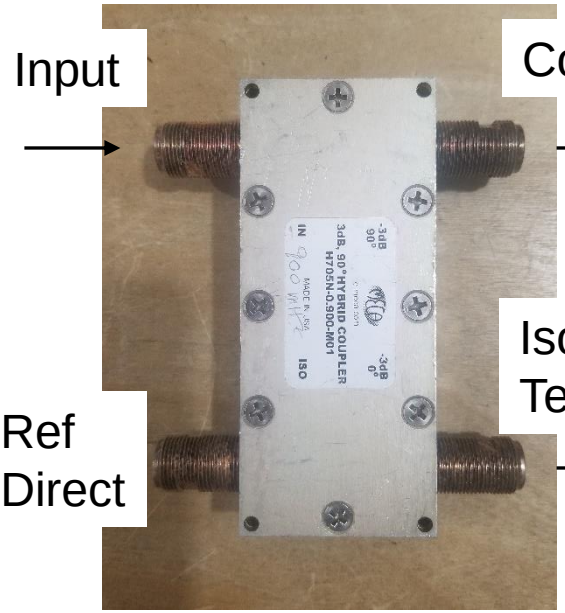


35 dB at 902 MHz
42 dB at 1296 MHz
33 dB at 2304 MHz

Meca 90 Deg Hybrid



Phase is normalized to Direct port



902 MHz 89.8 deg
1296 MHz 90.0 deg
2304 MHz -90.1 deg
The flip at 2300 MHz is interesting but this hybrid was only designed for 900 MHz

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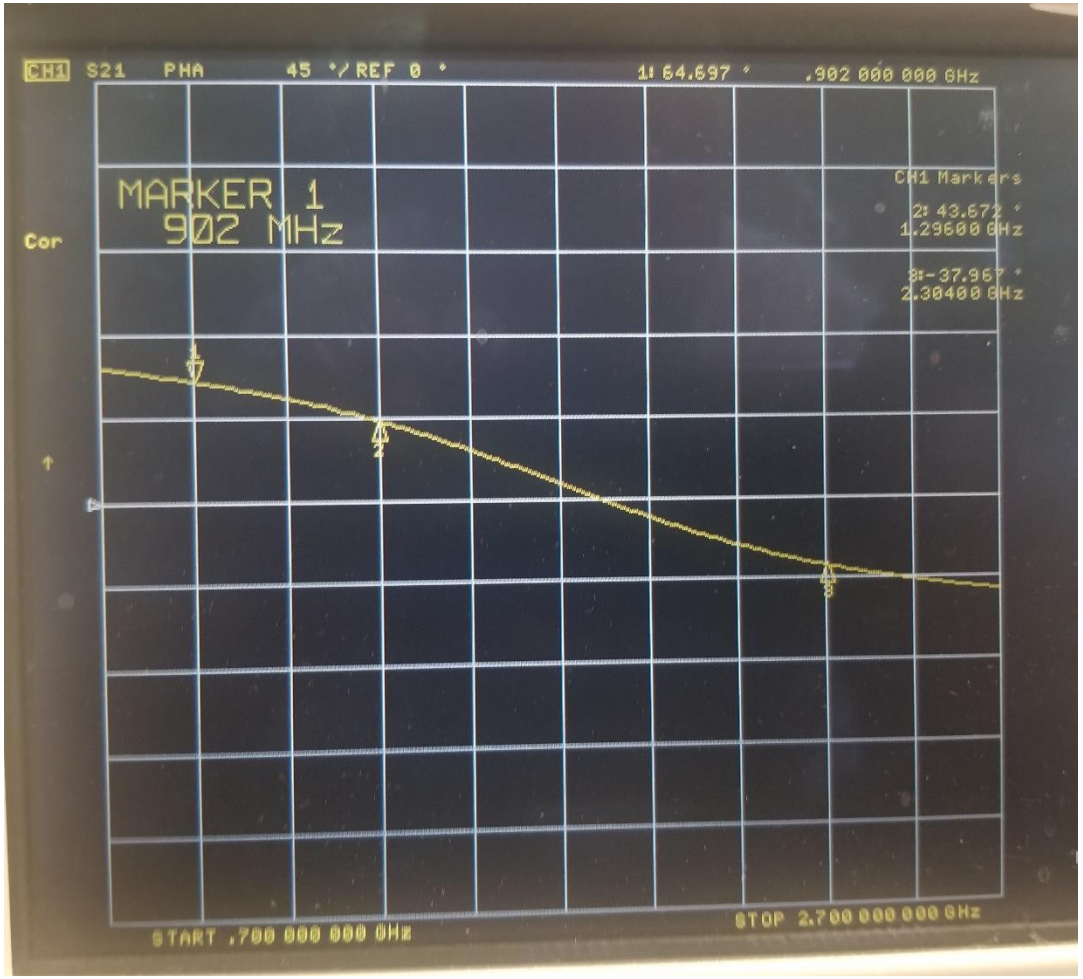
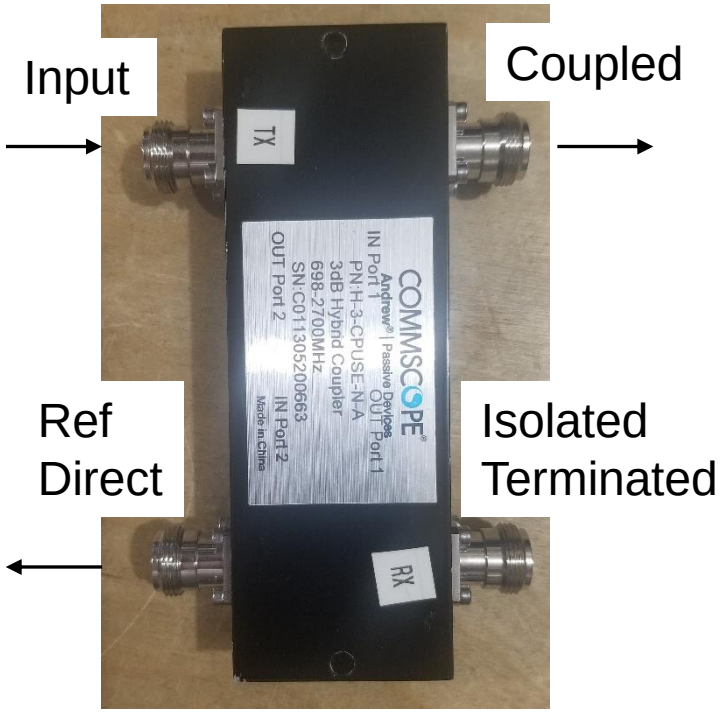
Commscope Hybrid



Phase is normalized to Direct port



902 MHz 64.7 deg
1296 MHz 43.7 deg
2304 MHz 38.0 deg

Hybrid Discussion

- Both hybrids provide a 3 dB power split with good amplitude match and very good isolation.
- The Meca hybrid provides a nice 90 degree phase shift at multiple frequencies
- The Commscope hybrid exhibits a frequency dependent phase shift as noted on the previous slide.
- At 900 MHz, a line length of 90 – 64.7 = 25.3 degrees would be required at the direct port. Assuming a velocity factor for Teflon of .66, the required additional line length would be .6 inches
- At 1296 MHz, a line length of 90 – 43.7 = 46.3 degrees would be required at the direct port. Assuming a velocity factor for Teflon of .66, the required additional line length would be .77 inches
- I decided to test both hybrids on my 902 MHz patch antenna and look at parameters such as Axial Ratio and Cross Polarization Rejection Ratio

Axial Ratio Tests

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- Axial ratio is defined as the ratio between the major and minor axis of a circularly polarized antenna
- We measure this by transmitting into a circular polarized antenna (DUT) and receiving on a dipole connected to a power meter and making note in dB the difference between maximum and minimum signal as the dipole is rotated 360 degrees.

Measuring Axial Ratio

Range length should be >/= far field =$2d^2/\lambda$ = 12.5 inches

I chose about 24 inches

Greater distances allowed more reflections to occur

Axial Ratio Test Results

Hybrid	Axial Ratio	Variation with isolated port unterminated
Meca	1 dB	<.1 dB
Comscope	4 dB	<.1 dB

Cross Polarization Rejection Ratio

- Cross Polarization Rejection Ratio is the difference between LHCP and RHCP expressed in dB (or the opposite)
- I used an AEL 1 to 12.4 GHz LHCP ASN-116A cavity backed spiral in place of my rotating dipole.
- Results were interesting
- Using the Meca hybrid, the ratio was 26 plus dB..very good
- Using the Comscope hybrid, the ratio was 14 dB ….not bad, reasonable considering higher axial ratio – should still play well.

Further work to be done

- I plan to repeat these tests on the Comscope unit with optimized cable lengths.
- I also plan to repeat these tests on other hybrids including Narda.

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Summary

- The resurgence of new activity on 902 MHz EME has been nice to see.
- The discussion over linear vs circular polarity has provided some interesting results. Testing continues.
- Come join us and see what is going on by visiting https://hb9q.ch and click on 902
- Also check out 902eme@groups.io
- Any Questions?