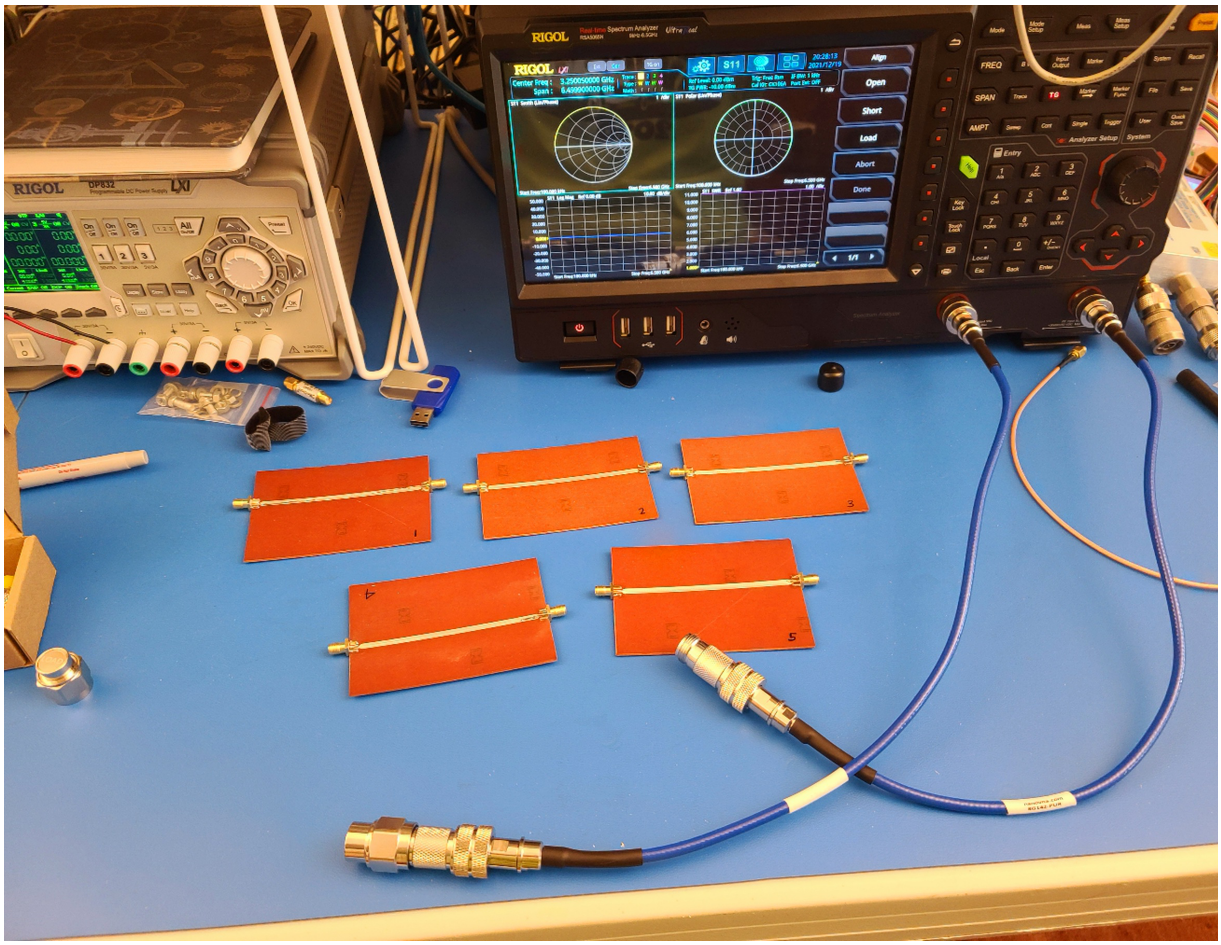
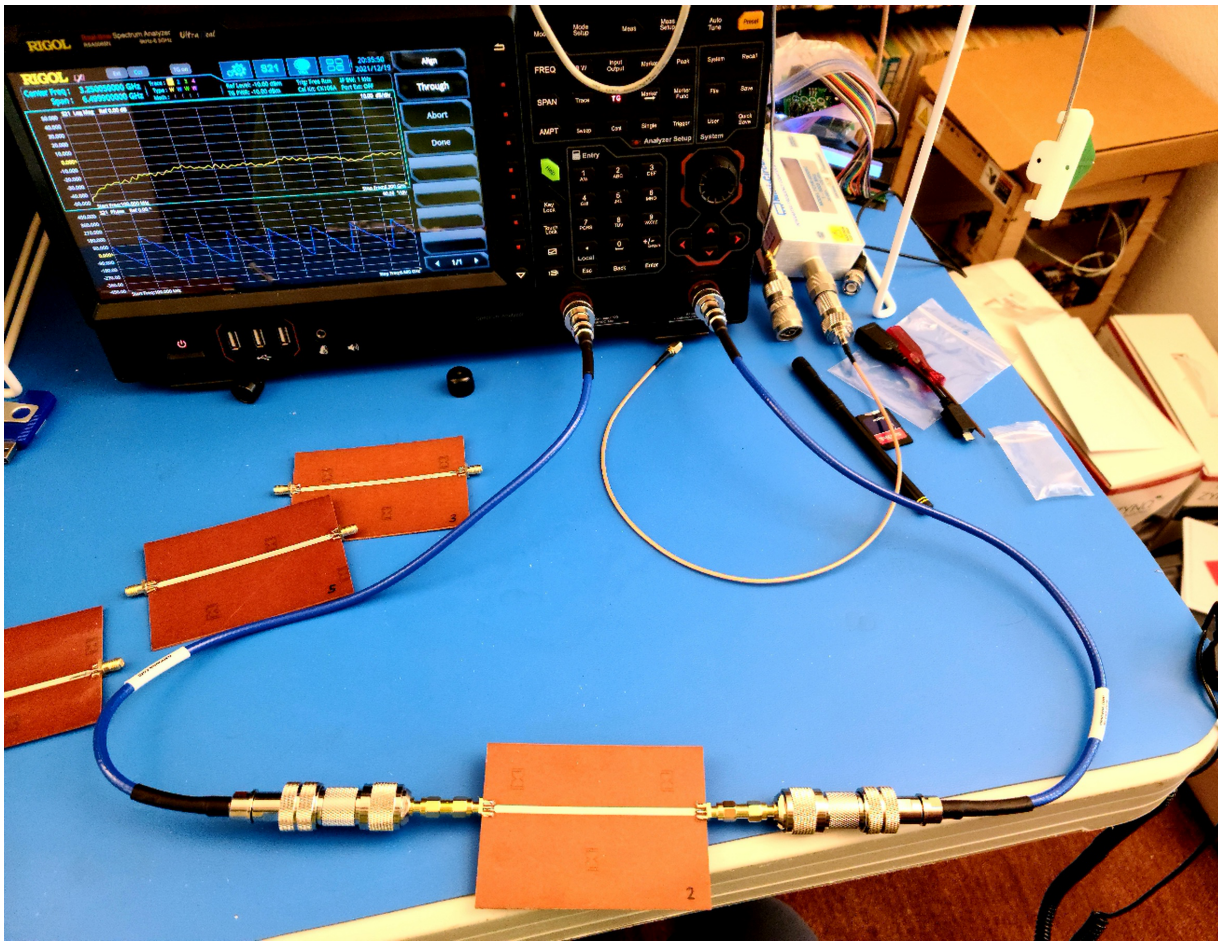
Five boards with 10 GHz transmission lines and SMA connecters were printed using the Voltera circuit printer, “Perky Pegasus” version ink, and ink-compatible solder. The PCBs were copper clad on one side and blank on the other, described as uxcell Single-Sided Copper Clad Laminate PCB Circuit Board, FR4 100x70mm 3.94x2.76 inch, 1.5mm Thickness DIY Prototyping PCB Boards. SMA Female Jack Edge 1.6mm PCB Mount Straight RF Connectors were ordered. Boards were printed and the SMA connectors soldered on each end of the transmission line.

The purpose of this test was to confirm the ink worked well enough at microwave frequencies to prototype boards quickly in the lab.

Jay Francis prepared the Gerber file and Michelle Thompson printed and constructed the boards. The boards were tested on two VNAs in Remote Lab West by Paul Williamson and Michelle Thompson on 19 December 2021.

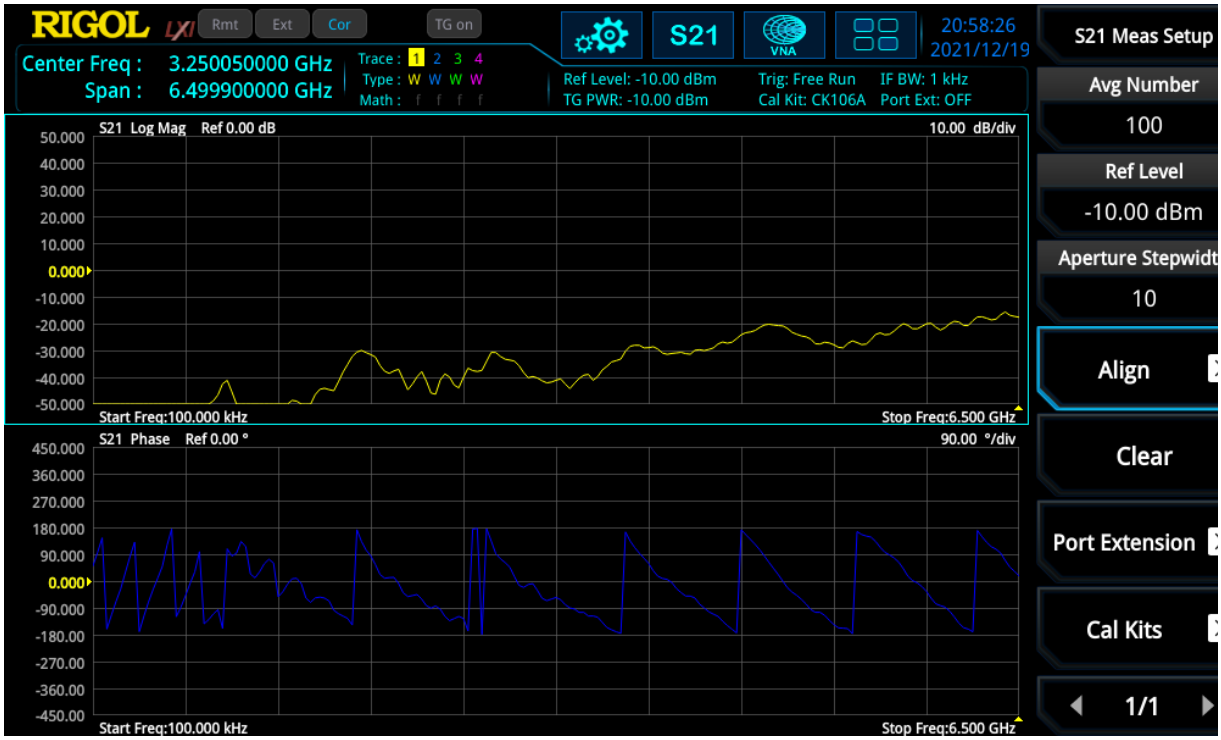
First, the Rigol 5095N.


RIGOL
Open
Short
Load
Abort
Done
Align

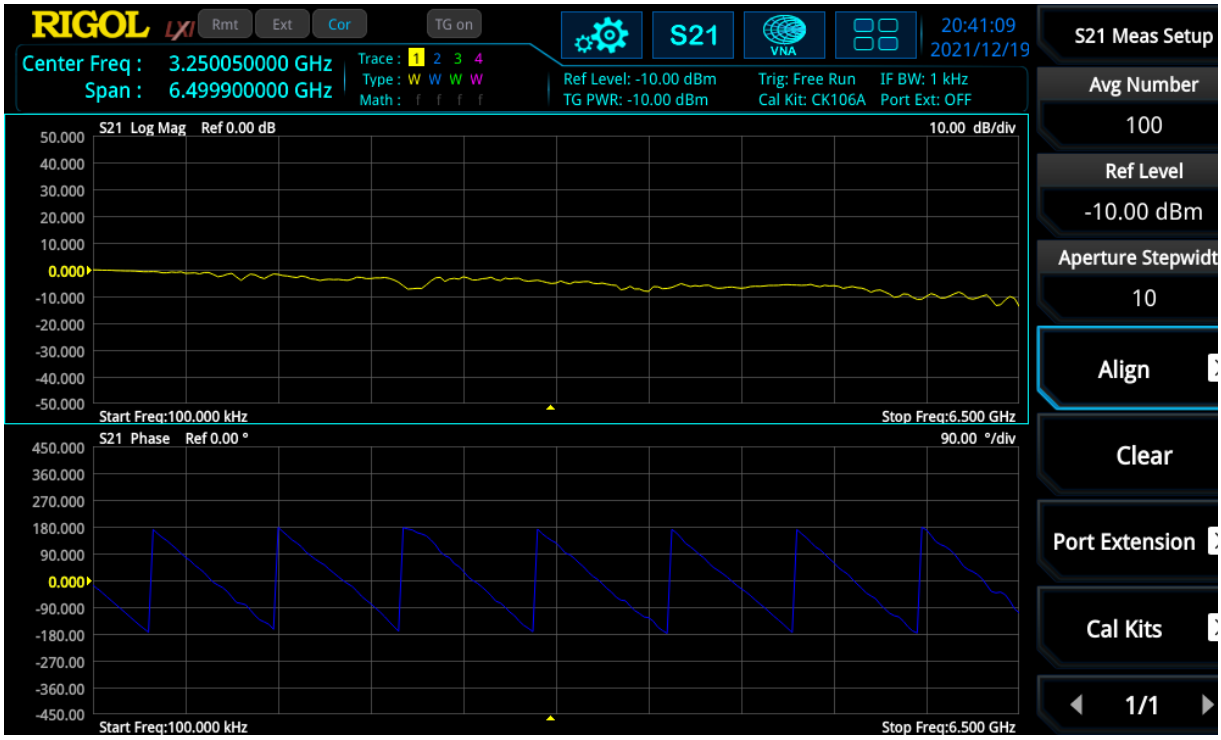


Board #1 was damaged during connection. Solder repairs failed. The ink is extremely brittle and the end of the transmission line split in a way that could not be reconnected.

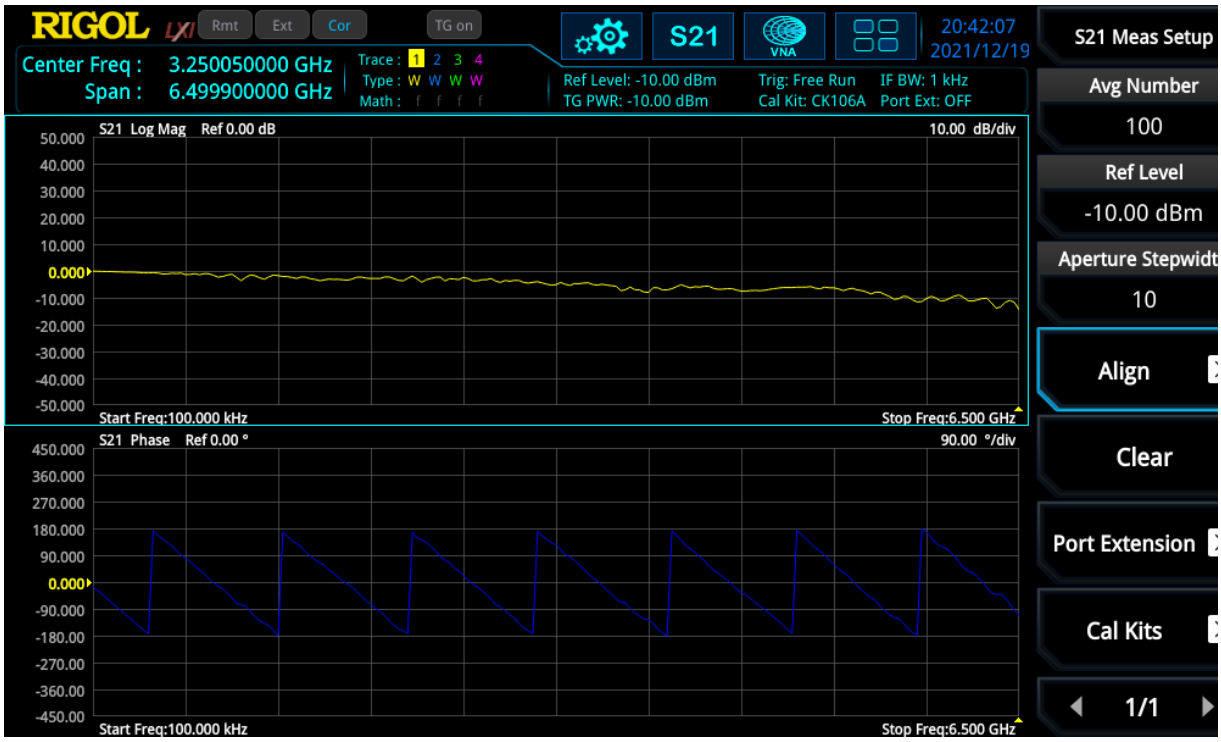
Board #2 had problems at DC due to a cracked trace. It was capacitively coupled at higher frequencies. Board #2 is below.


RIGOL
Rmt
Ext
Cor
TG on
S21
VNA
20:58:26
2021/12/19
Center Freq : 3.250050000 GHz
Span : 6.499900000 GHz
Trace : 1 2 3 4
Type : W W W W
Math : f f f f
Ref Level: -10.00 dBm
TG PWR: -10.00 dBm
Trig: Free Run
Cal Kit: CK106A
IF BW: 1 kHz
Port Ext: OFF
S21 Log Mag Ref 0.00 dB
10.00 dB/div
50.000
40.000
30.000
20.000
10.000
0.000
-10.000
-20.000
-30.000
-40.000
-50.000
Start Freq:100.000 kHz
Stop Freq:6.500 GHz
S21 Phase Ref 0.00 °
90.00 °/div
450.000
360.000
270.000
180.000
90.000
0.000
-90.000
-180.00
-270.00
-360.00
-450.00
Start Freq:100.000 kHz
Stop Freq:6.500 GHz
S21 Meas Setup
Avg Number
100
Ref Level
-10.00 dBm
Aperture Stepwidt
10
Align
Clear
Port Extension
Cal Kits
1/1

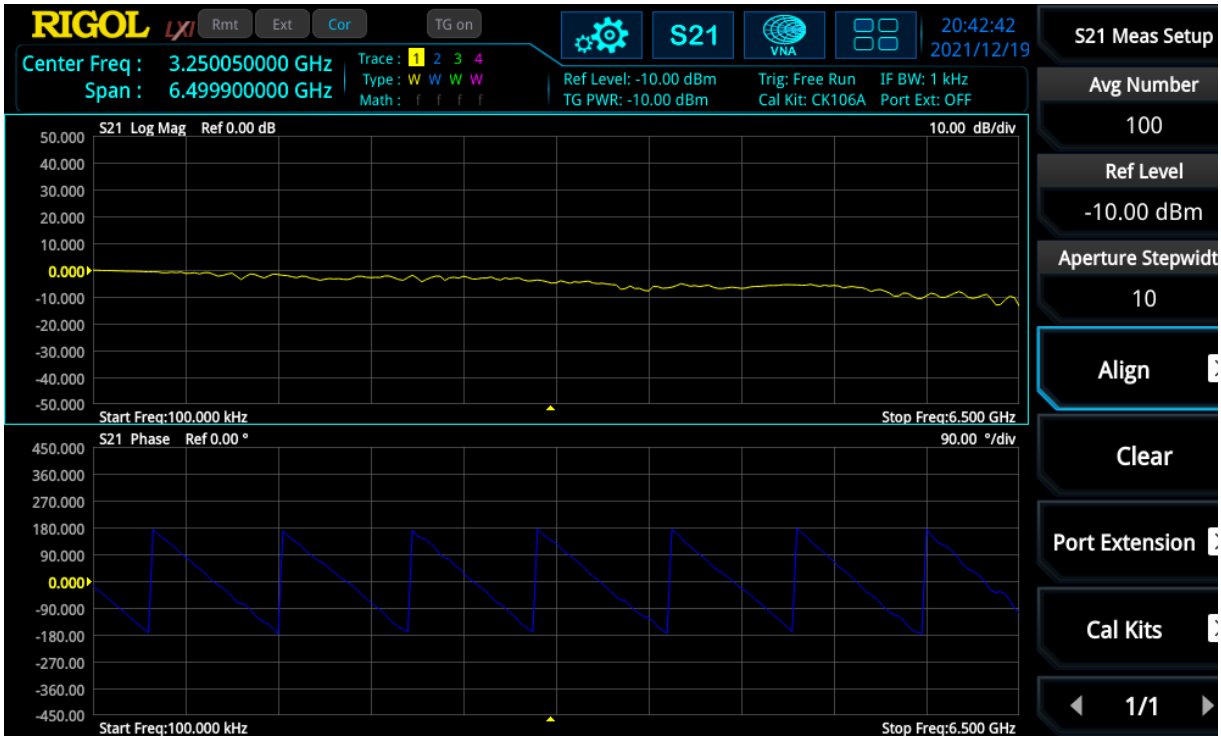
Board #3


RIGOL
Rmt
Ext
Cor
TG on
S21
VNA
20:41:09
2021/12/19
Center Freq : 3.250050000 GHz
Span : 6.499900000 GHz
Trace : 1 2 3 4
Type : W W W W
Math : f f f f
Ref Level: -10.00 dBm
TG PWR: -10.00 dBm
Trig: Free Run
Cal Kit: CK106A
IF BW: 1 kHz
Port Ext: OFF
S21 Log Mag Ref 0.00 dB
10.00 dB/div
50.000
40.000
30.000
20.000
10.000
0.000
-10.000
-20.000
-30.000
-40.000
-50.000
Start Freq:100.000 kHz
Stop Freq:6.500 GHz
S21 Phase Ref 0.00 °
90.00 °/div
450.000
360.000
270.000
180.000
90.000
0.000
-90.000
-180.00
-270.00
-360.00
-450.00
Start Freq:100.000 kHz
Stop Freq:6.500 GHz
S21 Meas Setup
Avg Number
100
Ref Level
-10.00 dBm
Aperture Stepwidt
10
Align
Clear
Port Extension
Cal Kits
1/1

Board #4



Board #5

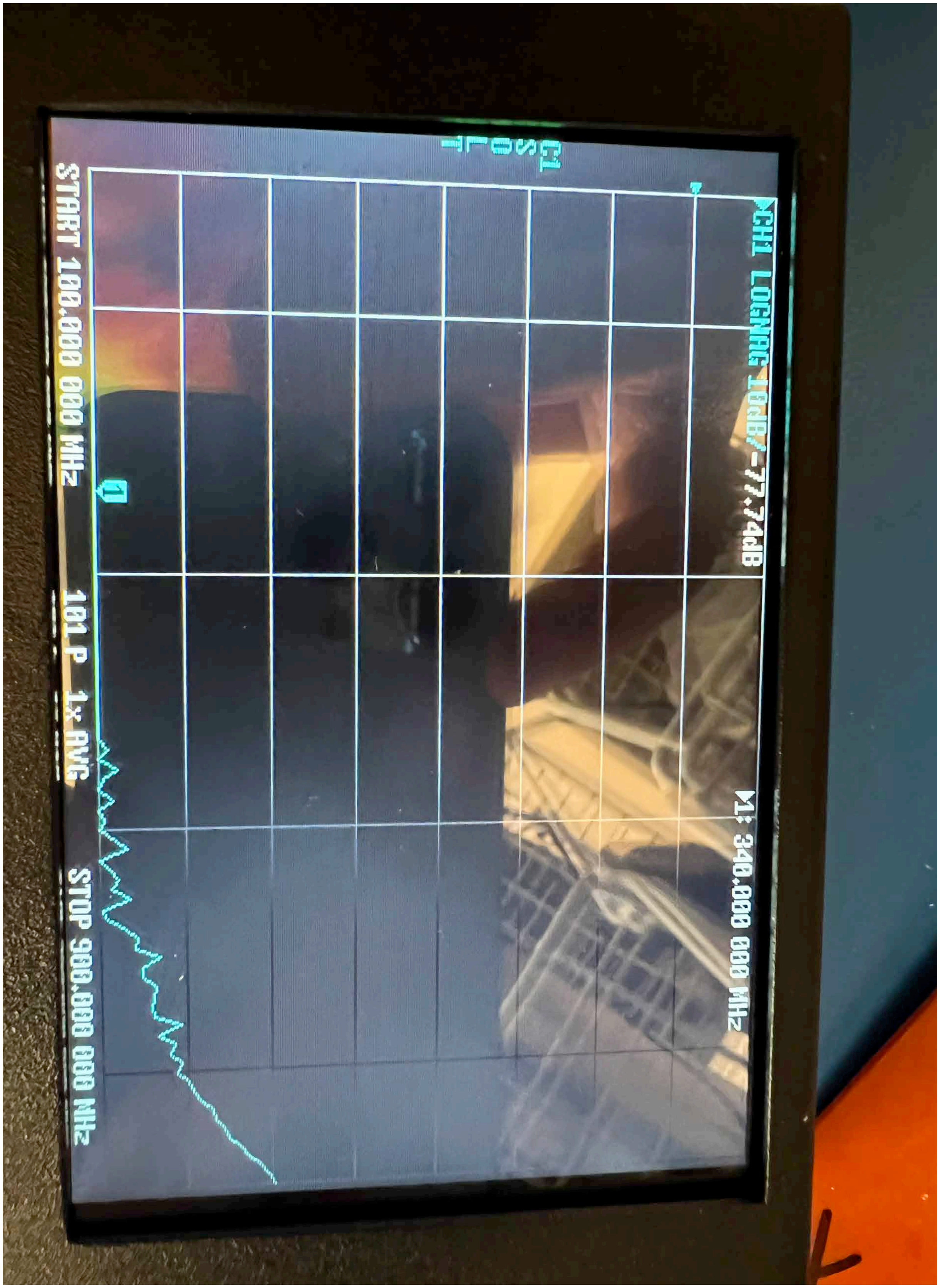


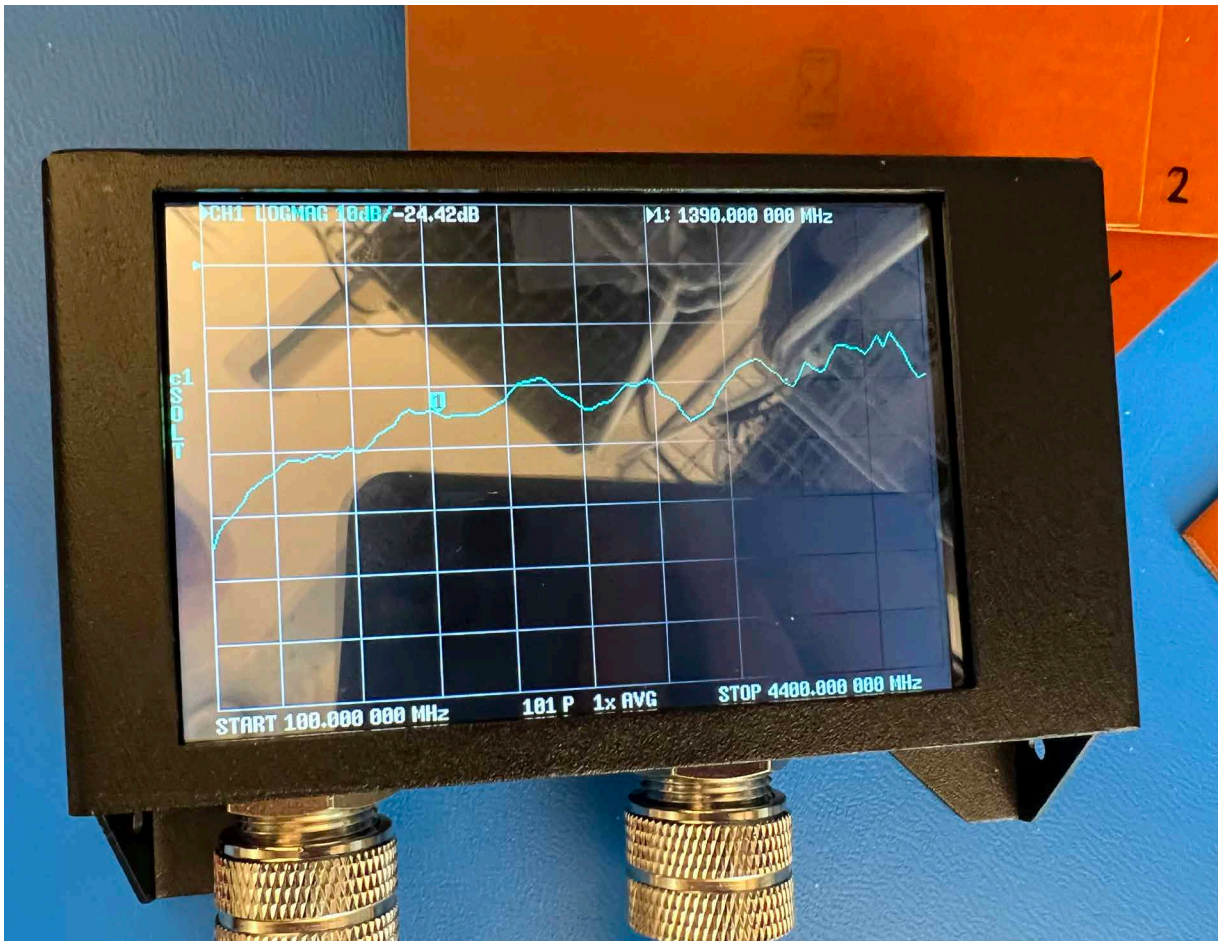
Second, a Nano VNA SSAA2 was used to measure the boards. VNA was calibrated. Measurements were made with 900 MHz scan and 4400 MHz scan.

Having a comparison between the two categories of VNAs was desired.

The Nano VNA goes up to 4400 MHz, which does not match the Rigol 5095N at 6000 MHz. The results of the Nano VNA were not as accurate or steady as the Rigol, but the overall characteristics of the transmission line were consistent between the two pieces of test equipment.

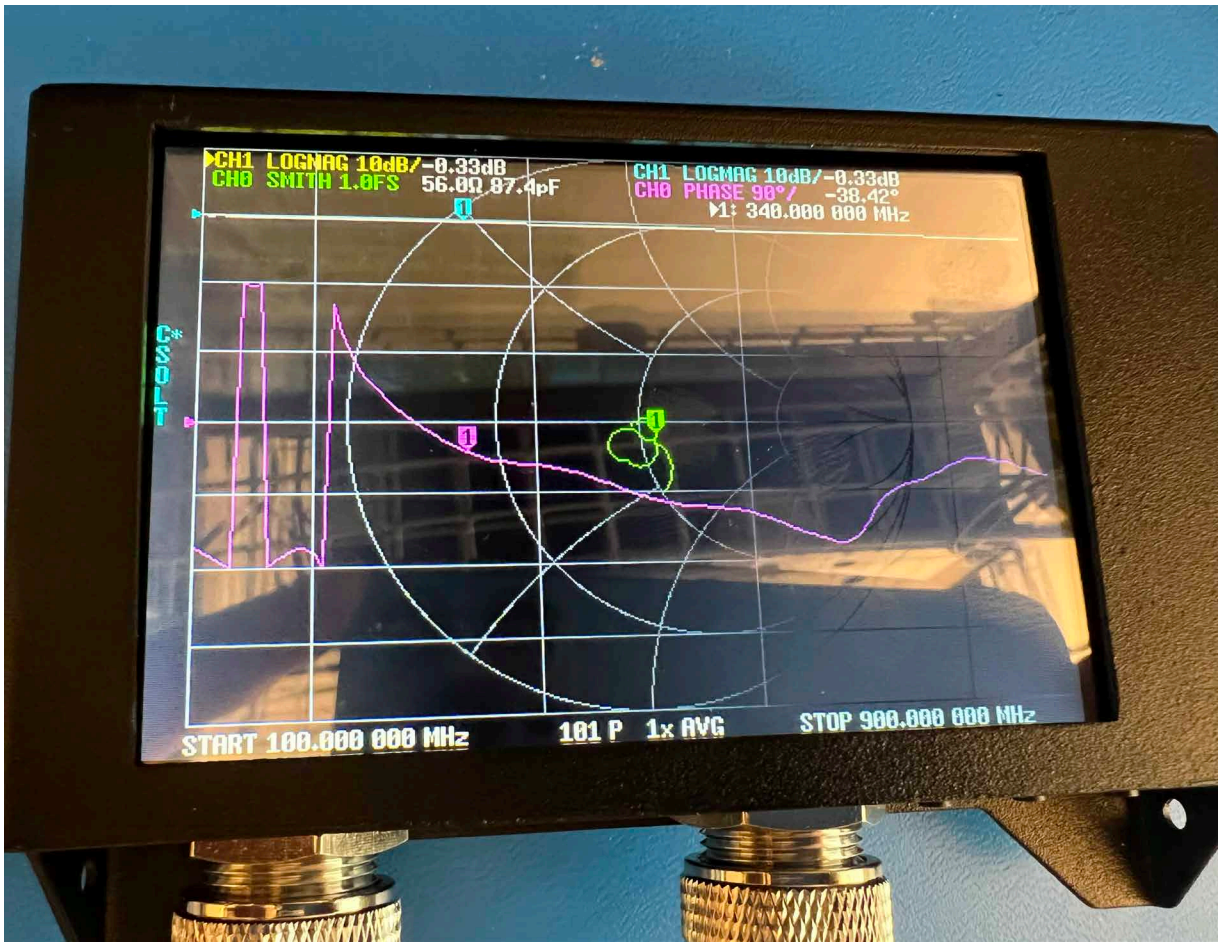
Board #2


CH1 LOGMAG 10dB/-77.74dB
M1: 340.000 000 MHz
START 100.000 000 MHz
101 P 1x AVG
STOP 900.000 000 MHz


CH1 LOGMAG 10dB/ -24.42dB
M1: 1390.000 000 MHz
START 100.000 000 MHz
101 P 1x AVG
STOP 4400.000 000 MHz
Board #3


CH1 LOGMAG 10dB/-35.47dB
CH0 SMITH 1.0FS 3.08Ω 1.73nH
CH1 LOGMAG 10dB/-35.47dB
CH0 PHASE 90°/ 171.46°
▶1: 340.000 000 MHz
START 100.000 000 MHz
101 P 1x AVG
STOP 900.000 000 MHz

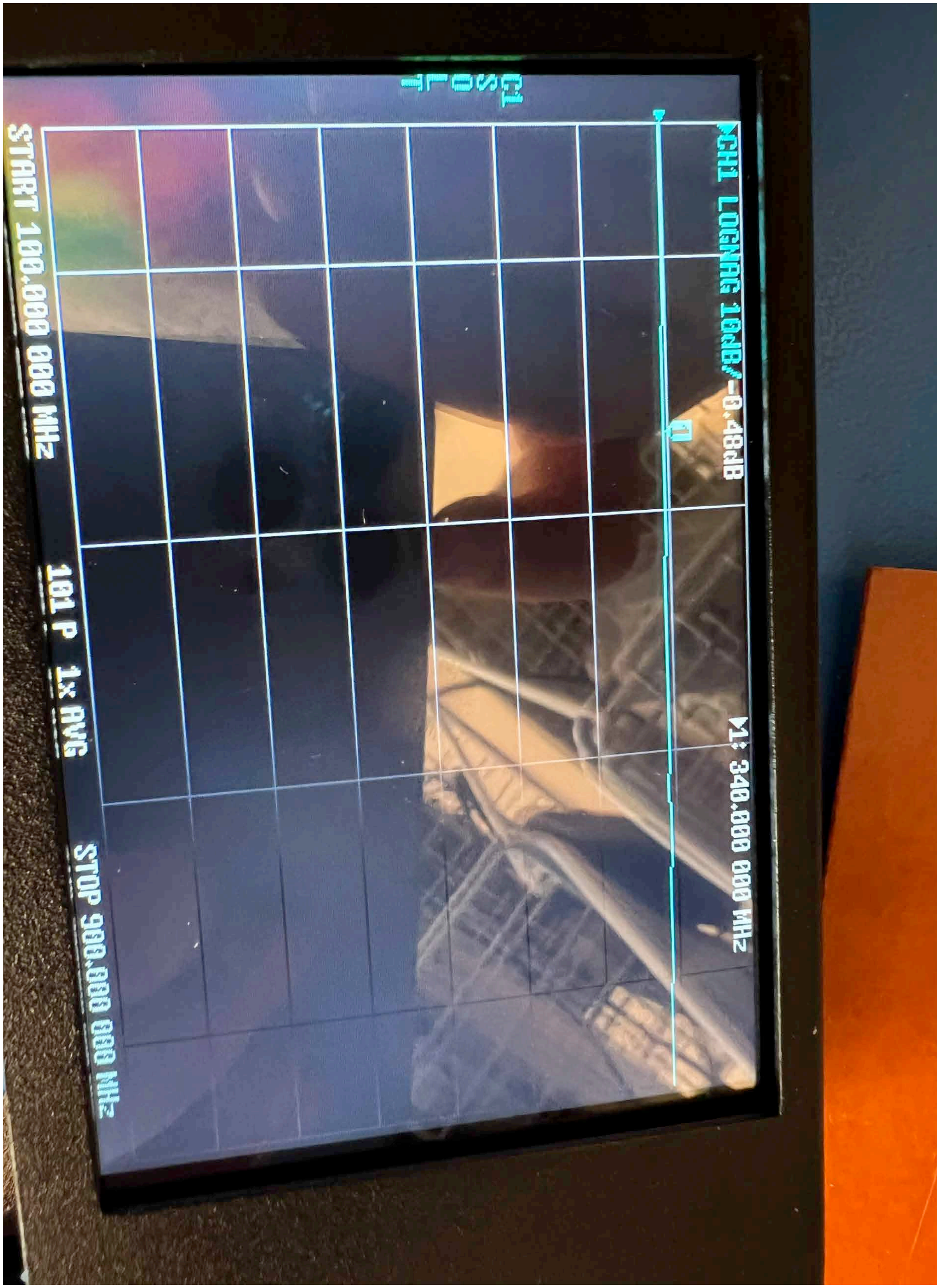
Board #4


CH1 LOGMAG 10dB/-0.33dB
CH0 SMITH 1.0FS 56.8Ω 87.4pF
CH1 LOGMAG 10dB/-0.33dB
CH0 PHASE 90°/ -38.42°
▶1: 340.000 000 MHz
C*
SOLT
START 100.000 000 MHz
101 P 1x AVG
STOP 900.000 000 MHz


CH1 LOGMAG 10dB/-1.65dB
M1: 1390.000 000 MHz
1
10dB/
START 100.000 000 MHz
101 P
1x AVG
STOP 4400.000 000 MHz

Board #5


CH1 LOGMAG 10dB/-0.32dB
CH0 SMITH 1.0FS 54.2Ω 200pF
CH1 LOGMAG 10dB/-0.32dB
CH0 PHASE 90°/ -27.22°
▶1: 340.000 000 MHz
C*
SOLT
START 100.000 000 MHz
101 P 1x AVG
STOP 900.000 000 MHz


CH1 LOGMAG 10dB/-0.48dB
M1: 340.000 000 MHz
C1
SOLT
START 100.000 000 MHz
101 P 1x AVG
STOP 900.000 000 MHz