Proof of Performance Report

prepared 7/18/2022 for

WLII/WSUR License Partnership, G.P.

WKAQ San Juan, PR

580 kHz 10 kW U DA-1

A Method of Moments Proof of Performance was conducted on the WKAQ 2-tower inline directional antenna system, following its restoration after nearly 24 years of "temporary" non-directional operation. The array's electromagnetic characteristics were modeled using Expert Mininec Broadcast Professional (Revision 14) software (referred to as MBPro hereafter). Test equipment used for field measurements to validate the model and the antenna monitor sampling system is described in Appendix A.

Throughout this report, data is generally stated to three significant digits, as the accuracy of the test and monitoring instruments employed does not exceed that. Underlying calculations were conducted to a greater level of precision. Accordingly, single-last-digit differences may exist between stated values and those derived by adding/subtracting them.

A. Description of Array Model

The geometrical setup of the array model is described below.

Table I: MBPro Array Geometry Configuration

	Wire Node			Feed	Wire Length (Height)			Face	Wire
Tower	Bottom	Top	Segments	Segment	Nominal	Modeled	Increase	Width	Radius
					(°)	(°)	(%)	(m)	(m)
1	1	2	20	1	64.1	68.6	7.0	0.91	0.44
2	3	4	20	21	64.1	69.9	9.0	0.61	0.29

The modeled antenna heights (wire lengths) were established by measurement of antenna terminating unit (ATU) drive point impedances at each tower with the other tower's base grounded directly, as further described in section *B. Model Validation* below. Wire radii were calculated from the tower circumferences, without adjustment. Base drive voltages were derived to produce the desired field ratio and phase relationships, using the MBPro array excitation synthesis function. Model parameters derived are as follows:

Table II: MBPro Array Model Calculated Parameters

	Base Voltage		Base Current		Normalized Current		Base Impedance		
Tower	Voltage	Phase	Current	Phase	Ratio	Phase	Resistance	Reactance	Power
	(kV)	(°)	(A)	(°)		(°)	(Ohms)	(Ohms)	(kW)
1	0.979	306.4	7.25	4.9	0.337	-78.6	49.8	-81.4	2.62
2	2.922	3	21.5	83.5	1.000	0	15.9	-94.6	7.38

Appendix B contains the MBPro summary data output for the model discussed above.

The base regions of the towers were modeled by a series inductance between the feed point and the tower base, along with a shunt capacitance across that base. The tower feed tubing exits the concrete-walled ATU shelters via a Plexiglas panel, but there is no surrounding, grounded metal whatsoever. Accordingly, no shunt capacitance assumption at the ATU output is appropriate. Base capacitance is an assumption based on this engineer's experience. Feed tubing inductance assumed was consistent with that measured.

Figure 1
ATU Output & Tower Base Region Equivalent Circuit

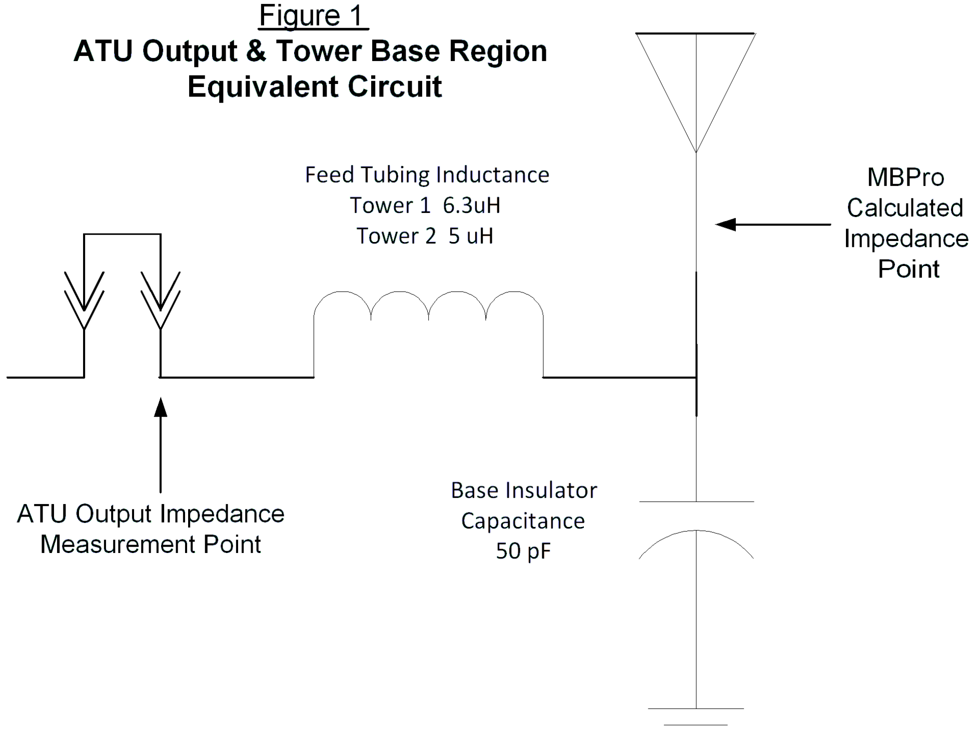

Table III: ATU Feed/Sample Point Modeled Operating Impedance Derivation

	MBPro Model		Base Shunt		Tower Base		Feed Tubing		ATU Output Jack	
Tower	R	X	Cap.	X	R	X	Ind.	X	R	X
	(Ohms)	(Ohms)	(pF)	(Ohms)	(Ohms)	(Ohms)	(µH)	(Ohms)	(Ohms)	(Ohms)
1	49.8	-81.4	50	-5488	48.3	-80.6	6.3	23.0	48.3	-57.7
2	15.9	-94.6	50	-5488	15.4	-93.1	5.0	18.2	15.4	-74.8

There is a small current division at the tower base, between the tower load impedance and the assumed base insulator capacitance. This causes small deviation of the feed point sampled currents from the MBPro derived base currents.

Table IV: Antenna Monitor Operating Parameter Derivation

	Model	Base	Sample		ATU Output Jack			Monitor Sample	
Tower	Phase	Division	Phase	Power	Resistance	Reactance	Current	Ratio	Phase
	(°)	(°)	(°)	(kW)	(ohms)	(ohms)	(A)		(°)
1	4.9	0.5	5.5	2.62	48.3	-57.7	7.36	0.336	-78.2
2	83.5	0.2	83.7	7.38	15.4	-74.1	21.9	1.000	0

B. Model Validation

The MBPro model parameters were established based on shorted-base ATU drive point impedance measurements.[1] The ATU output drive point impedance was measured at each tower with the other's base shorted. Each tower was shorted directly across its base insulator, using wide copper braid clamped to the tower feed point and the copper strap matrix atop the tower base pier and under the base insulator. Measurements were conducted at 5 kHz intervals across a 20 kHz range, centered on the station's operating frequency, but only the results for the operating frequency are reported herein.[2] When each tower base was shorted as noted above, the inductance of the feed tubing from its corresponding ATU output point was measured, using the same network analyzer setup.

The MBPro model of the shorted tower assumed a terminating resistance of 0.1 Ohm to account for materials resistance. As noted previously, the base region of the tower was modeled as a lumped series inductance for the feed tubing and shunt capacitance for the base insulator. Base conditions at both towers are nearly identical. A shunt capacitance of 50 pF was assumed for both, based on this engineer's experience. The inductances assumed were comparable to the inductances measured. Figure 1 above is a schematic drawing of the equivalent circuit:

Wire lengths in MBPro were varied until the measured ATU drive point resistances were matched or very closely approximated. Predicted ATU drive point impedances were then compared to the measured values. Model wire lengths were extended modestly from the nominal tower heights. The guy wires of tower 2 have fewer insulators, particularly close to the tower attachment point, than those of tower 1, which causes the tower 2 modeled height to be greater than that of tower 1. Tower base circumferences were used to establish wire radii, without adjustment. Wire lengths and radii used were described in Table I above. The modeled and measured impedances at each tower, with the other shorted at its base, are detailed below. Variances were within the 2 Ohm resistance tolerance and 4% reactance tolerance stated in the rule.

[1] Open-circuit impedance measurements were also made and agreed with the modeled values within the tolerance specified in the modeling rule.

[2] Multiple frequencies were used to reveal any anomalous measurements. The data obtained varied consistently across the frequency sweep range, validating the accuracy of the measurements at the center frequency.

Table IV: Shorted-Base ATU Output Impedances

	Array Model				Measured			
	Tower Base		ATU Output		ATU Output		Variances	
Tower	R (Ohms)	X (Ohms)	R (Ohms)	X (Ohms)	R (Ohms)	X (Ohms)	R (Ohms)	X (%)
1	17.1	-88.9	16.5	-64.6	16.4	-64.2	0.1	0.6
2	18.0	-91.3	17.4	-71.7	17.4	-73.6	0.0	-2.6

Appendix C contains the MBPro summary output data for the simulations of each tower with the other's base shorted.

C. Antenna Monitor Sampling System Measurements

Antenna monitor sampling system measurements were conducted in accordance with requirements of §73.151(c)(2)(i). All sampling line measurements were made using the Advantest VNA and accessories as noted above.

The Cablewave FCC38-50J flexible coaxial sampling lines have a velocity factor of 0.81, yielding an effective velocity of propagation within the transmission line of 242.8 m/µS, 580 kHz wavelength of 418.7 m, and 90° resonant frequency of approximately 344 kHz, the latter based on the line length reported in the 1984 Proof of Performance report by Ing. Grafton Olivera Mariani, 176.2 m (578'). The lines are phase-stabilized, if not at the factory then by 38 years of on-site thermal cycling.

1. Sampling Line Length:

   The Potomac Instruments AM-19(204) antenna monitor and its sampling system was installed in 1984, when 10 kW, DA-1 operation of WKAQ commenced. Open-circuit resonance frequency measurements were made to verify the sample line lengths. For the nominal length, the 90° and 270° open circuit resonance frequencies are approximately 344 kHz and 1034 kHz, with the former closest to the station's 580 kHz operating frequency. Length difference is within the tolerance specified in the rule.[3]

Table V: Sample Line Length Measurement

Tower	Nominal Length (m)	90° Resonance (kHz)	Measured Length (m)	Measured Length (580 kHz °)	Difference (°)
1	174.3	342.4	177.3	152.5	0.3
2	174.3	343.1	176.9	152.1	

[3] Sampling line length measurements were also performed by wideband, time-domain distance-to-fault sweep measurements, using a Rohde & Schwarz ZVL network analyzer. These measurements indicated line lengths closer to those reported in the 1984 Proof, with the variance at the station's frequency being 0.2°, within 0.1° of that measured by the open-circuit resonance method.

2. Sampling Line Characteristic Impedance:

Open-circuit impedance measurements were made at frequencies an eighth-wave intervals (45°, 135°) from the 90° open-circuit resonance frequency. These correspond to frequencies at approximately 172, and 516 kHz. These two frequencies "bracket" the open-circuit resonance frequency, as required by§73.151(c)(2)(i).

Table VI: Sample Line Characteristic Impedance Measurement

	45°	Measured Impedance			135°	Measured Impedance			Line
Tower	Frequency	R	X	Z	Frequency	R	X	Z	Impedance
	(kHz)	(Ohms)	(Ohms)	(Ohms)	(kHz)	(Ohms)	(Ohms)	(Ohms)	(Ohms)
1	171.2	1.2	-51.8	51.8	513.6	6.4	50.8	51.2	51.5
2	171.2	1.2	-51.8	51.8	513.6	6.3	50.7	51.1	51.5

3. Toroidal Current Transformer (TCT) Calibration:

The Delta Electronics TCT-HV current samplers are located near the ATU output jack, as are the corresponding TCTs that feed the antenna current meters. At ATU 1, the meter TCT was removed and the sampling TCT from ATU 2 installed in its place, allowing back-to-back calibration of the sampling TCTs. Output current ratio and phase were measured, with respect to the ATU 2 TCT, using the Advantest network analyzer, following calibration of its two inputs (and test cables) using a common source. The measured values were ***0.999 for ratio and +1.35° for phase***, well within the manufacturer's stated tolerance.

4. Connected Sampling System Impedance:

After the sampling system line and TCT measurements were completed, the normal placements and connections were restored and the system impedance, measured from the line termination at the antenna monitor[4] to the TCTs, were ***48.8 Ohms*** for both towers.

D. Common Point Impedance Measurement

After system setup, the common point impedance was measured at the input jack of the phasor component of the antenna feed system, shown on the left-hand side of the schematic diagram

[4] But not including short, identical-length line pigtails used to match the sample lines' Type N connectors to the antenna monitor's PL-259 input connectors

attached as Appendix D. The common point impedance was adjusted to ***50±j0 Ohms*** using the test equipment setup of Appendix A and then checked at 5 kW power using the station's Delta Electronics OIB-3 operating impedance bridge.

E. Reference Field Strength Measurement Locations

Field strengths were measured on the two radial bearings corresponding to pattern minima and the two opposite bearings of the tower line, which define the centers of the major and minor lobes. All measurements were conducted using a Potomac Instruments FIM-41 field strength meter, with "current" calibration. Geographic coordinates are referenced to WGS-84 datum (WKAQ array center 18° 25' 48.7" N, 66° 08' 07.3" W). The measurement data is detailed in Table VII on the following page.

18 July 2022

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Table VII: Field Strength Measurement Locations

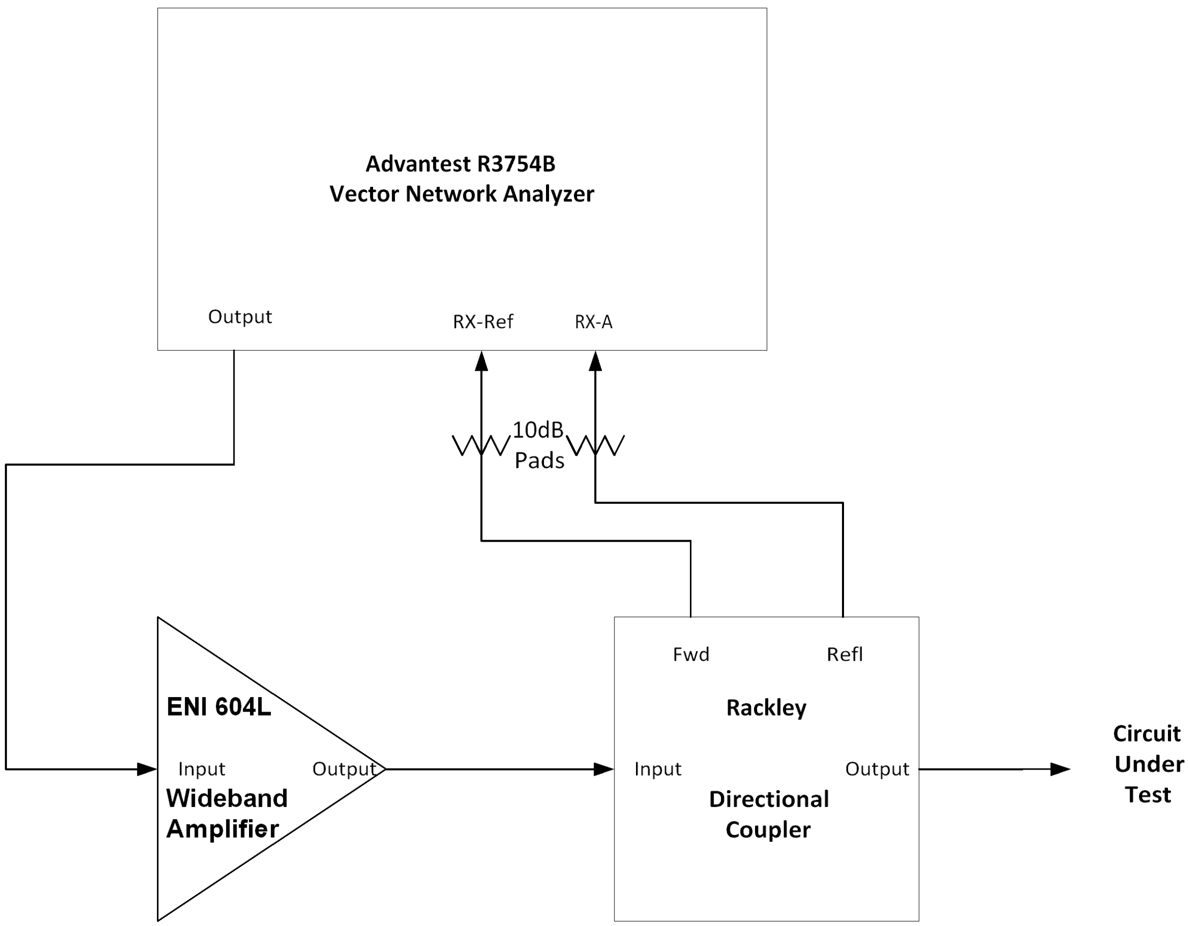
Point	Distance (km)	Field (mV/m)	Date Time	North Latitude	West Longitude	Location Description
140° Radial Measurement Locations						
140A	1.43	800	6/12/22 17:35	18 ° 25 ' 14.3 "	66 ° 7 ' 34.5 "	PR Rte. 28, N side of road opposite main entrance to Fort Buchanan
140B	3.64	319	6/13/22 16:25	18 ° 24 ' 19.4 "	66 ° 6 ' 45.7 "	PR Rte. 2, S side of road at KM 6.8 marker, opposite building M219 (Villa Capara, Guaynabo)
140C	3.79	235	6/13/22 16:55	18 ° 24 ' 15.6 "	66 ° 6 ' 42.6 "	Calle A, at house A34, near front of San Jose Academy (Villa Capara, Guaynabo)
285° Radial Measurement Locations						
285A	2.08	238	6/12/22 12:21	18 ° 26 ' 9.1 "	66 ° 9 ' 14.7 "	PR Rte. 869, in front of Mausoleo of Cantaño Municipal Cemetery
285B	3.38	145	6/13/22 11:38	18 ° 26 ' 20.1 "	66 ° 9 ' 57.8 "	#53 Avenida Luis Pales Matos, W side of street behind First Bank (Levittown Toja Bajo)
285C	3.94	131	6/13/22 12:00	18 ° 26 ' 24.8 "	66 ° 10 ' 15.9 "	FJ13 Calle Francisco Gonzalo Marin, W side of street (Levittown Toa Bajo)
320° Radial Measurement Locations						
320A	2.42	265	6/13/22 13:15	18 ° 26 ' 50.2 "	66 ° 8 ' 58.8 "	#B19 Calle Pitirre, front of house next to baseball field (Cataño)
320B	2.60	232	6/12/22 19:05	18 ° 26 ' 54.7 "	66 ° 9 ' 2.9 "	PR Rte. 869 at KM 4.0 sign, SE side of road opposite power towers (Cataño)
320C	3.30	187	6/13/22 15:30	18 ° 27 ' 12.7 "	66 ° 9 ' 17 "	PR Rte. 165 at KM 30.9 sign, N side of road, W of PR Rte. 870 (Cataño)
355° Radial Measurement Locations						
355A	1.81	465	6/13/22 13:49	18 ° 26 ' 47.3 "	66 ° 8 ' 12.5 "	PR Rte. 165, SW side at middle of bridge, 16 m SE of 33.2 sign (Cataño)
355B	1.99	185	6/13/22 14:22	18 ° 26 ' 53.3 "	66 ° 8 ' 12.5 "	#116 Calle Canal, SW edge of road by mailbox (Cataño)
355C	2.27	205	6/16/22 14:56	18 ° 27 ' 2.2 "	66 ° 8 ' 14.8 "	PR Rte. 888 just N of Calle Laguna, center of clearing between Rte. 888 and water's edge (Cataño)

Appendix A
Test Equipment Used

Instrument	Manufacturer & Model	Serial No.
Antenna Monitor	Potomac Instruments AM-19(204)	1992
Current Transformer (T1)	Delta Electronics TCT-HV	3695
Current Transformer (T2)+	Delta Electronics TCT-HV	689
Network Analyzer	Advantest R3754B	03960237
Linear Amplifier	ENI 604L	316
Directional Coupler	Ronald D. Rackley, P.E.[5]	03
Calibration Block	Rohde & Schwarz ZV-Z170	101425
Field Strength Meter	Potomac FIM-41	1608

[5] The directional couplers designed and constructed by the late Mr. Rackley are the prototypes for the couplers sold by Tunwall Radio. Performance measurements for the subject coupler are found on the following pages.

Figure A-1
Impedance Measurement Equipment Configuration



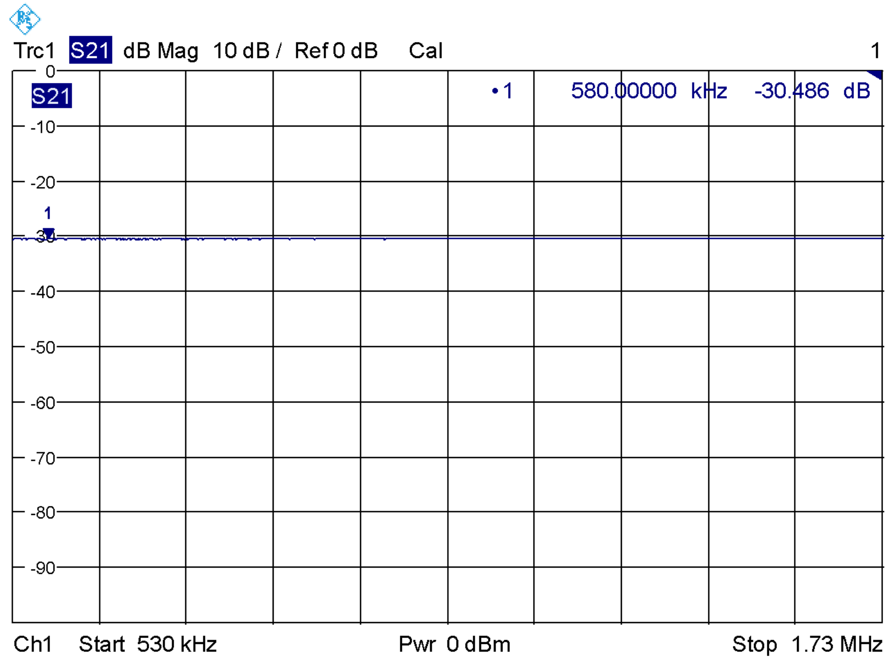
When terminated in 50 Ohms, the directivity of the Rackley directional coupler can be measured directly by the Advantest analyzer. The following data were so obtained:

Frequency (kHz)	Directivity (dB)
570	50.9
575	50.9
580	50.8
585	50.7
590	50.7

The transmission plots of the following figures show that the directivity exceeds 40 dB across the AM band and is lost in the network analyzer noise floor at the lower frequencies.

Figure A-2

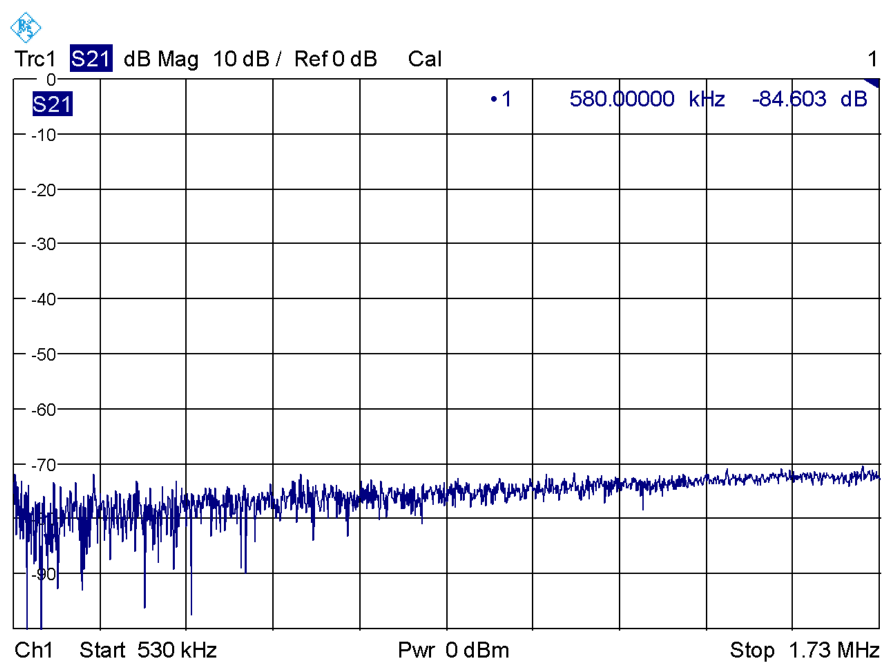
Rackley Coupler 03 S_{21} Input to Forward Sample Port



Date: 7.JUL.2022 23:45:42

Figure A-3

Rackley Coupler 03 S_{21} Input to Reflected Sample Port



Date: 7.JUL.2022 23:47:04

Figure A-4

Rackley Coupler 03 S_{12} Output to Forward Sample Port

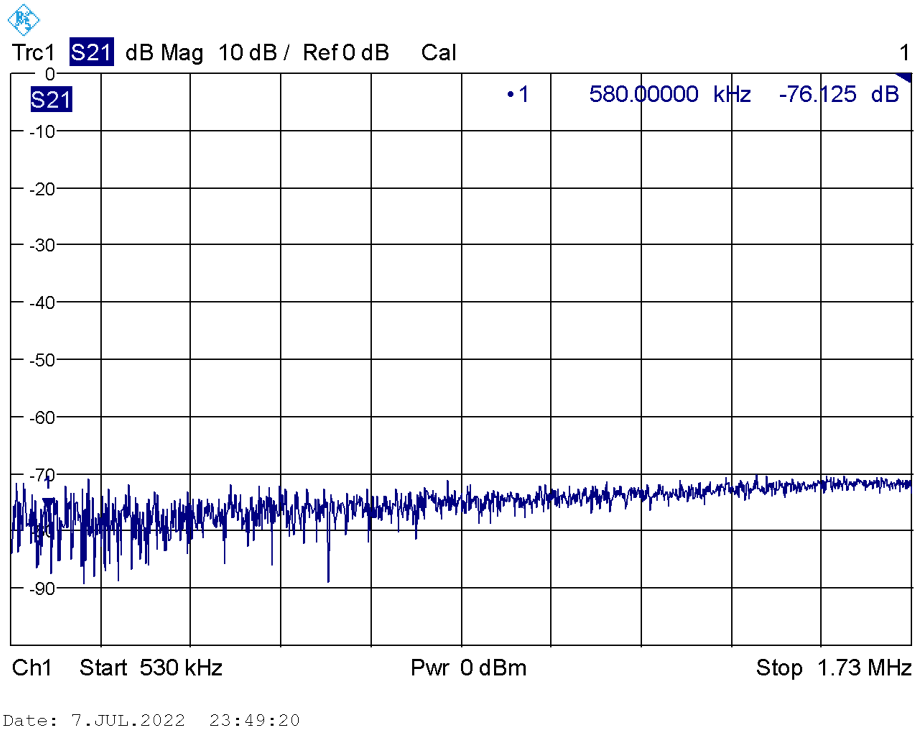
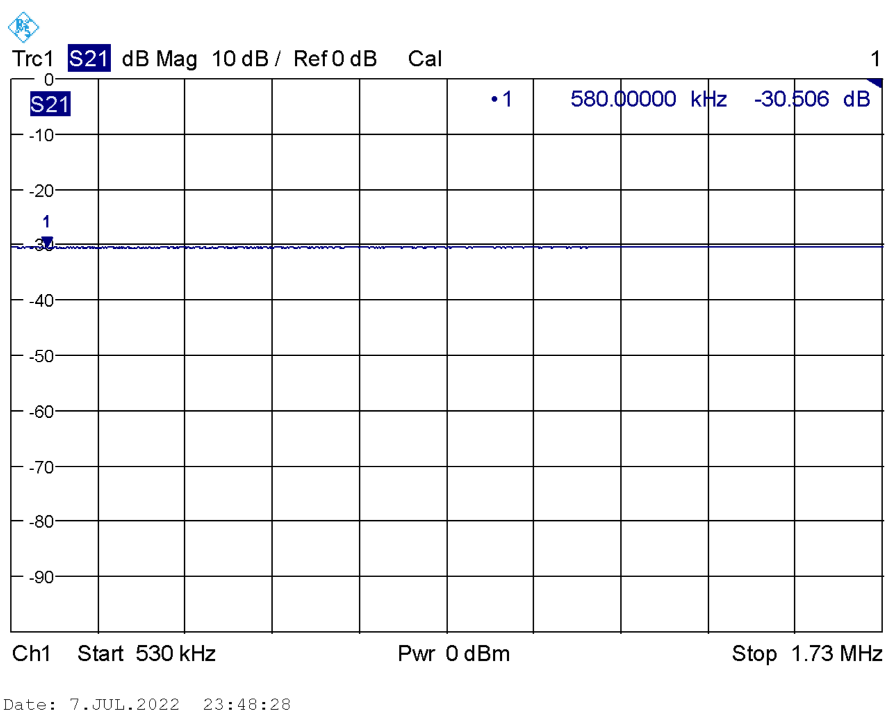


Figure A-5

Rackley Coupler 03 S_{12} Output to Reflected Sample Port



Appendix B

MBPro Directional Antenna Model Summary Data Output

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C:\Documents and Settings\...\WKAQ Final DA  07-01-2022   10:04:26

WKAQ Final DA Model

GEOMETRY
Wire coordinates in degrees; other dimensions in meters
Environment: perfect ground

wire   caps Distance     Angle        Z            radius      segs
 1     none 0            0            0            .44          20
            0            0            68.6
 2     none 120.         320.         0            .29          20
            120.         320.         69.9

Number of wires          =  2
          current nodes  =  40

                       minimum                    maximum
Individual wires      wire     value             wire  value
segment length         1       3.43               2     3.495
radius                 2       .29                1     .44


ELECTRICAL DESCRIPTION
Frequencies (KHz)
     frequency                no. of  segment length (wavelengths)
 no. lowest       step        steps   minimum         maximum
 1   580.         0            1      9.53E-03        9.71E-03

Sources
source node     sector  magnitude       phase           type
 1      1        1      978.812         306.4           voltage
 2      21       1      2,922.1         3.              voltage

C:\Documents and Settings\...\WKAQ Final DA  07-01-2022   10:06:32

IMPEDANCE
   normalization = 50.
freq      resist    react     imped     phase     VSWR     S11      S12
(KHz)     (ohms)    (ohms)    (ohms)    (deg)              dB       dB
source =  1; node 1, sector 1
580.      49.772    -81.375   95.389    301.5     4.4354   -3.9851  -2.2147

source =  2; node 21, sector 1
580.      15.92     -94.64    95.969    279.5     14.643   -1.1882  -6.2095
```

C:\Documents and Settings\...\WKAQ Final DA 07-01-2022   10:06:32

CURRENT rms
Frequency   = 580 KHz
Input power = 10,000. watts
Efficiency   = 100. %
coordinates in degrees

current no.	X	Y	Z	mag (amps)	phase (deg)	real (amps)	imaginary (amps)
GND	0	0	0	7.25583	4.9	7.22879	.625862
2	0	0	3.43	6.97295	3.6	6.95911	.439193
3	0	0	6.86	6.76588	2.8	6.75796	.327283
4	0	0	10.29	6.55347	2.	6.54929	.233956
5	0	0	13.72	6.32768	1.4	6.32581	.15369
6	0	0	17.15	6.08496	.8	6.08438	.0839198
7	0	0	20.58	5.82373	.2	5.82369	.0233901
8	0	0	24.01	5.54333	359.7	5.54325	-.0286051
9	0	0	27.44	5.24352	359.2	5.24302	-.0725
10	0	0	30.87	4.9244	358.7	4.9232	-.10858
11	0	0	34.3	4.58619	358.3	4.58415	-.137044
12	0	0	37.73	4.22922	357.9	4.22626	-.158038
13	0	0	41.16	3.85381	357.4	3.84999	-.171669
14	0	0	44.59	3.46028	357.1	3.4557	-.178018
15	0	0	48.02	3.04877	356.7	3.04362	-.177133
16	0	0	51.45	2.61913	356.3	2.61367	-.169021
17	0	0	54.88	2.17061	355.9	2.16517	-.153623
18	0	0	58.31	1.7013	355.6	1.69627	-.130748
19	0	0	61.74	1.20651	355.3	1.20236	-.0999033
20	0	0	65.17	.675289	354.9	.672624	-.0599361
END	0	0	68.6	0	0	0	0
GND	91.9254	77.1345	0	21.5303	83.5	2.45543	21.3898
22	91.9254	77.1345	3.495	20.6991	83.1	2.49022	20.5488
23	91.9254	77.1345	6.99	20.0467	82.8	2.49688	19.8906
24	91.9254	77.1345	10.485	19.3782	82.6	2.48582	19.2181
25	91.9254	77.1345	13.98	18.67	82.4	2.45842	18.5074
26	91.9254	77.1345	17.475	17.9128	82.3	2.41534	17.7492
27	91.9254	77.1345	20.97	17.1029	82.1	2.35701	16.9397
28	91.9254	77.1345	24.465	16.2387	81.9	2.28375	16.0774
29	91.9254	77.1345	27.96	15.3205	81.8	2.19589	15.1624
30	91.9254	77.1345	31.455	14.3489	81.6	2.09368	14.1953
31	91.9254	77.1345	34.95	13.3252	81.5	1.97744	13.1776
32	91.9254	77.1345	38.445	12.2508	81.3	1.84743	12.1107
33	91.9254	77.1345	41.94	11.1272	81.2	1.70391	10.996
34	91.9254	77.1345	45.435	9.95606	81.1	1.54709	9.83512
35	91.9254	77.1345	48.93	8.73828	80.9	1.37713	8.62908
36	91.9254	77.1345	52.425	7.47412	80.8	1.19402	7.37813
37	91.9254	77.1345	55.92	6.16247	80.7	.997499	6.0812
38	91.9254	77.1345	59.415	4.79893	80.6	.786759	4.734
39	91.9254	77.1345	62.91	3.37223	80.4	.559788	3.32545
40	91.9254	77.1345	66.405	1.85268	80.3	.311364	1.82632
END	91.9254	77.1345	69.9	0	0	0	0

```
C:\Users\klahm\Documents\WKAQ Final DA  07-12-2022   15:12:34

CURRENT MOMENTS(amp-degrees) rms

Frequency =  580 KHz
Input power = 10,000. watts
                                         vertical current moment
wire   magnitude    phase (deg)  magnitude    phase (deg)
 1     594.207      360.         594.207      360.
 2     1,770.74     82.          1,770.74     82.

Medium wave array vertical current moment (amps-degrees) rms
(Calculation assumes tower wires are grouped together.
The first wire of each group must contain the source.)

tower  magnitude    phase (deg)
 1     594.207      360.
 2     1,770.74     82.
```

Normalized Integrated Currents (Radiated Fields):

Tower	Magnitude	Phase
1	1.00	0.0
2	2.98	82.0

Appendix C

MBPro Shorted Tower Validation Data

```
C:\Documents and Settings\...\WKAQ T1sT2  07-01-2022   09:35:46

WKAQ Tower 1 with Tower 2 shorted

GEOMETRY
Wire coordinates in degrees; other dimensions in meters
Environment: perfect ground

wire  caps Distance     Angle        Z            radius       segs
 1    none 0            0            0            .44           20
           0            0            68.6
 2    none 120.         320.         0            .29           20
           120.         320.         69.9

Number of wires          =  2
          current nodes  =  40

                        minimum                    maximum
Individual wires      wire    value              wire  value
segment length         1      3.43                2    3.495
radius                 2      .29                 1    .44


ELECTRICAL DESCRIPTION
Frequencies (KHz)
     frequency                 no. of  segment length (wavelengths)
 no. lowest       step         steps   minimum         maximum
 1   580.         0             1      9.53E-03        9.71E-03

Sources
source node     sector  magnitude      phase          type
 1      1       1       1.             0              voltage

Lumped loads
             resistance    reactance     inductance  capacitance passive
load  node   (ohms)        (ohms)        (mH)        (uF)        circuit
 1     21    .1            0             0           0            0

C:\Documents and Settings\...\WKAQ T1sT2  07-01-2022   09:35:46

IMPEDANCE
   normalization = 50.
freq      resist   react    imped    phase    VSWR     S11      S12
(KHz)     (ohms)   (ohms)   (ohms)   (deg)             dB       dB
source =  1; node 1, sector 1
580.      17.082   -88.913  90.539   280.9    12.445  -1.399   -5.6005
```

C:\Documents and Settings\...\WKAQ T1sT2 07-01-2022   09:35:46

CURRENT rms
Frequency   = 580 KHz
Input power = .0010419 watts
Efficiency   = 99.99 %
coordinates in degrees

current no.	X	Y	Z	mag (amps)	phase (deg)	real (amps)	imaginary (amps)
GND	0	0	0	7.81E-03	79.1	1.47E-03	7.67E-03
2	0	0	3.43	7.48E-03	78.7	1.47E-03	7.33E-03
3	0	0	6.86	7.24E-03	78.4	1.46E-03	7.09E-03
4	0	0	10.29	6.99E-03	78.1	1.44E-03	6.84E-03
5	0	0	13.72	6.74E-03	77.9	1.41E-03	6.59E-03
6	0	0	17.15	6.46E-03	77.7	1.38E-03	6.31E-03
7	0	0	20.58	6.17E-03	77.5	1.34E-03	6.02E-03
8	0	0	24.01	5.86E-03	77.3	1.29E-03	5.72E-03
9	0	0	27.44	5.53E-03	77.1	1.24E-03	5.39E-03
10	0	0	30.87	5.19E-03	76.9	1.17E-03	5.05E-03
11	0	0	34.3	4.82E-03	76.8	1.1E-03	4.69E-03
12	0	0	37.73	4.44E-03	76.6	1.03E-03	4.31E-03
13	0	0	41.16	4.03E-03	76.4	9.45E-04	3.92E-03
14	0	0	44.59	3.62E-03	76.3	8.56E-04	3.51E-03
15	0	0	48.02	3.18E-03	76.1	7.61E-04	3.09E-03
16	0	0	51.45	2.73E-03	76.	6.59E-04	2.64E-03
17	0	0	54.88	2.25E-03	75.9	5.51E-04	2.19E-03
18	0	0	58.31	1.76E-03	75.7	4.35E-04	1.71E-03
19	0	0	61.74	1.25E-03	75.6	3.11E-04	1.21E-03
20	0	0	65.17	6.98E-04	75.5	1.75E-04	6.75E-04
END	0	0	68.6	0	0	0	0
GND	91.9254	77.1345	0	9.2E-04	274.	6.42E-05	-9.18E-04
22	91.9254	77.1345	3.495	9.17E-04	274.	6.4E-05	-9.15E-04
23	91.9254	77.1345	6.99	9.1E-04	274.	6.35E-05	-9.08E-04
24	91.9254	77.1345	10.485	8.98E-04	274.	6.27E-05	-8.96E-04
25	91.9254	77.1345	13.98	8.81E-04	274.	6.16E-05	-8.79E-04
26	91.9254	77.1345	17.475	8.6E-04	274.	6.01E-05	-8.58E-04
27	91.9254	77.1345	20.97	8.34E-04	274.	5.83E-05	-8.31E-04
28	91.9254	77.1345	24.465	8.03E-04	274.	5.61E-05	-8.01E-04
29	91.9254	77.1345	27.96	7.67E-04	274.	5.37E-05	-7.66E-04
30	91.9254	77.1345	31.455	7.28E-04	274.	5.09E-05	-7.26E-04
31	91.9254	77.1345	34.95	6.84E-04	274.	4.79E-05	-6.82E-04
32	91.9254	77.1345	38.445	6.36E-04	274.	4.45E-05	-6.34E-04
33	91.9254	77.1345	41.94	5.84E-04	274.	4.09E-05	-5.82E-04
34	91.9254	77.1345	45.435	5.27E-04	274.	3.69E-05	-5.26E-04
35	91.9254	77.1345	48.93	4.67E-04	274.	3.27E-05	-4.66E-04
36	91.9254	77.1345	52.425	4.03E-04	274.	2.83E-05	-4.02E-04
37	91.9254	77.1345	55.92	3.36E-04	274.	2.35E-05	-3.35E-04
38	91.9254	77.1345	59.415	2.64E-04	274.	1.85E-05	-2.63E-04
39	91.9254	77.1345	62.91	1.87E-04	274.	1.31E-05	-1.86E-04
40	91.9254	77.1345	66.405	1.03E-04	274.	7.24E-06	-1.03E-04
END	91.9254	77.1345	69.9	0	0	0	0

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WKAQ Tower 2 with Tower 1 shorted

GEOMETRY
Wire coordinates in degrees; other dimensions in meters
Environment: perfect ground

wire	caps	Distance	Angle	Z	radius	segs
1	none	0	0	0	.44	20
		0	0	68.6		
2	none	120.	320.	0	.29	20
		120.	320.	69.9		

Number of wires = 2
current nodes = 40

	minimum		maximum	
Individual wires	wire	value	wire	value
segment length	1	3.43	2	3.495
radius	2	.29	1	.44

ELECTRICAL DESCRIPTION
Frequencies (KHz)

	frequency		no. of	segment length (wavelengths)	
no.	lowest	step	steps	minimum	maximum
1	580.	0	1	9.53E-03	9.71E-03

Sources

source	node	sector	magnitude	phase	type
1	21	1	1.	0	voltage

Lumped loads

load	node	resistance (ohms)	reactance (ohms)	inductance (mH)	capacitance (uF)	passive circuit
1	1	.1	0	0	0	0

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IMPEDANCE
normalization = 50.

freq (KHz)	resist (ohms)	react (ohms)	imped (ohms)	phase (deg)	VSWR	S11 dB	S12 dB
source = 1; node 21, sector 1							
580.	17.976	-91.335	93.087	281.1	12.341	-1.4107	-5.5697

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CURRENT rms
Frequency = 580 KHz
Input power = .00103726 watts
Efficiency = 99.99 %
coordinates in degrees

current no.	X	Y	Z	mag (amps)	phase (deg)	real (amps)	imaginary (amps)
GND	0	0	0	9.2E-04	274.	6.41E-05	-9.18E-04
2	0	0	3.43	9.17E-04	274.	6.4E-05	-9.15E-04
3	0	0	6.86	9.1E-04	274.	6.36E-05	-9.08E-04
4	0	0	10.29	8.98E-04	274.	6.27E-05	-8.96E-04
5	0	0	13.72	8.82E-04	274.	6.16E-05	-8.8E-04
6	0	0	17.15	8.61E-04	274.	6.01E-05	-8.59E-04
7	0	0	20.58	8.35E-04	274.	5.84E-05	-8.33E-04
8	0	0	24.01	8.04E-04	274.	5.63E-05	-8.02E-04
9	0	0	27.44	7.7E-04	274.	5.38E-05	-7.68E-04
10	0	0	30.87	7.3E-04	274.	5.11E-05	-7.29E-04
11	0	0	34.3	6.87E-04	274.	4.81E-05	-6.85E-04
12	0	0	37.73	6.39E-04	274.	4.48E-05	-6.38E-04
13	0	0	41.16	5.88E-04	274.	4.12E-05	-5.86E-04
14	0	0	44.59	5.32E-04	274.	3.73E-05	-5.31E-04
15	0	0	48.02	4.72E-04	274.	3.31E-05	-4.71E-04
16	0	0	51.45	4.09E-04	274.	2.86E-05	-4.08E-04
17	0	0	54.88	3.41E-04	274.	2.39E-05	-3.4E-04
18	0	0	58.31	2.69E-04	274.	1.89E-05	-2.69E-04
19	0	0	61.74	1.92E-04	274.	1.35E-05	-1.92E-04
20	0	0	65.17	1.08E-04	274.	7.58E-06	-1.08E-04
END	0	0	68.6	0	0	0	0
GND	91.9254	77.1345	0	7.6E-03	78.9	1.47E-03	7.45E-03
22	91.9254	77.1345	3.495	7.31E-03	78.5	1.46E-03	7.16E-03
23	91.9254	77.1345	6.99	7.09E-03	78.2	1.45E-03	6.94E-03
24	91.9254	77.1345	10.485	6.86E-03	77.9	1.43E-03	6.71E-03
25	91.9254	77.1345	13.98	6.61E-03	77.7	1.41E-03	6.46E-03
26	91.9254	77.1345	17.475	6.35E-03	77.5	1.37E-03	6.2E-03
27	91.9254	77.1345	20.97	6.06E-03	77.3	1.33E-03	5.92E-03
28	91.9254	77.1345	24.465	5.76E-03	77.1	1.28E-03	5.62E-03
29	91.9254	77.1345	27.96	5.44E-03	77.	1.23E-03	5.3E-03
30	91.9254	77.1345	31.455	5.1E-03	76.8	1.16E-03	4.96E-03
31	91.9254	77.1345	34.95	4.74E-03	76.6	1.09E-03	4.61E-03
32	91.9254	77.1345	38.445	4.36E-03	76.5	1.02E-03	4.24E-03
33	91.9254	77.1345	41.94	3.96E-03	76.3	9.34E-04	3.85E-03
34	91.9254	77.1345	45.435	3.54E-03	76.2	8.45E-04	3.44E-03
35	91.9254	77.1345	48.93	3.11E-03	76.1	7.49E-04	3.02E-03
36	91.9254	77.1345	52.425	2.66E-03	75.9	6.48E-04	2.58E-03
37	91.9254	77.1345	55.92	2.2E-03	75.8	5.39E-04	2.13E-03
38	91.9254	77.1345	59.415	1.71E-03	75.7	4.24E-04	1.66E-03
39	91.9254	77.1345	62.91	1.2E-03	75.5	3.01E-04	1.16E-03
40	91.9254	77.1345	66.405	6.61E-04	75.4	1.67E-04	6.4E-04
END	91.9254	77.1345	69.9	0	0	0	0

Appendix D

Antenna Feed System Schematic Diagram