



SYSTEMS WITH RELIABILITY, LP
BROADCAST ANTENNAS AND TRANSMISSION LINE

PATTERN CERTIFICATION
DIRECTIONAL FM ANTENNA
WWFW
August 14, 2014

Call Sign	:	WWFW
Location	:	Fort Wayne, IN
Frequency	:	103.9 MHz
Channel	:	280A
Antenna Model	:	FMECD/2-PLUS-DA
Maximum Antenna Gain	:	
Horizontal	:	1.789 / 2.526 dB
Vertical	:	1.789 / 2.526 dB

ANTENNA DESCRIPTION

A custom designed FMECD/2-PLUS-DA antenna was fabricated to conform to the prescribed directional azimuth pattern. The antenna consists of two (2) circularly polarized, cross-V dipole radiating elements full-wave spaced mounted to a forty-two (42)" (inch) face tower. The antenna array points 120 degrees true north.

DESCRIPTION OF TEST PROCEDURE

The test antenna consisted of a single third-scale bay. The antenna was mounted to a third-scale pipe, which was mounted to a third-scale tower by use of third-scale brackets identical to those shipped with the final, full-scale antenna. For testing, the entire third-scale model was then mounted atop a 20' (foot) high platform, and all feed cables were properly grounded. Horizontal and vertical readings were taken. The desired directional pattern was obtained by adjusting the distance between the tower and the antenna, and modifying the direction of the azimuth heading. Parasitic elements were used for performance enhancement.

DESCRIPTION OF TEST PARAMETERS AND EQUIPMENT

Horizontal and vertical pattern readings were taken by mounting a source antenna - a vertical/horizontal dipole, Cavity Back Resonator (CBR) antenna bay - approximately 100' (feet) from the third-scale antenna model. The source antenna's height was adjusted to achieve a uniform field at the third-scale test antenna location. The CBR antenna was operated in receive mode, at frequency 311.7 MHz. The third-scale test antenna was then rotated clockwise in order to achieve 360° (degree) pattern readings. A gain reference was taken using a dipole tuned to 311.7 MHz. Nowhere did the received signal, or resultant documentation, exceed a maximum to minimum ratio of 15dB (decibels).

TEST RESULTS

The attached calculations verify that the **RMS** value of this antenna is **91.6%** of the **RMS** value of the pattern authorized in the related construction permit **BPH-20140624ABV**. The vertical component **RMS** value is **0.750**. The horizontal component **RMS** value is **0713**. The circular polarized component **RMS** value is **0.827**.

Azimuth and elevation plots and associated tabulations of this antenna are included with this package.

Measured vertical polarized directivity:	1.776 / 2.490 dB
Measured horizontal polarized directivity:	1.965 / 2.930 dB
Measured circular polarized pattern directivity:	1.461 / 1.650 dB

Gain in each polarization was calculated using the following relation:

GAIN = Azimuth Directivity x Power Ratio Between Polarizations x Elevation Directivity

Using this relationship along with ratio measured at our testing facilities:

V-Pol. Gain = (1.776)(.5253)(1.918)	= 1.789 / 2.526 dB
H-Pol. Gain = (1.965)(.4747)(1.918)	= 1.789 / 2.526 dB

INSTALLATION AND MOUNTING

The antenna is to be mounted in accordance with the supplied drawings. The antenna center of radiation is to be **137 meters (450 ft.)** above ground level. The antenna aperture is **9.47 feet**. No other antennas are to be mounted within **10 feet** of the antenna. No other obstructions other than those specified by original drawings supplied are to be mounted at the same level as the antenna. The antenna is to be oriented **120 degrees** true North.

The system's orientation and the mounting details are described in the following drawings:

DRAWING NO.	TITLE
1917D00	ELEVATION
1917D01	ANTENNA ORENTATION
1917D02	PARASITIC PLACEMENT
2105A10	TEST RANGE SCHEMATIC

The array shall be mounted according to all details outlined in **DWG. 1917D00**. The antenna elements shall be aligned at the same heading as in **DWG. 1917D01**. This will ensure that the antenna is oriented properly at 120 degrees true north. The parasitic placement is shown on **DWG. 1917D02**. The test range schematic **DWG. 2105A10** shows the mounting configuration of the antenna setup on our range.

DOCUMENT EXHIBITS

The following exhibits are included as part of this Certificate of Compliance:

Exhibit 1	Circular Polarized Azimuth Pattern Field Strength Tabulations (Composite)
Exhibit 2	Measured Horizontal Polarized Azimuth Pattern Measured Field Strength Tabulations (Horizontal)
Exhibit 3	Measured Vertical Polarized Azimuth Pattern Measured Field Strength Tabulations (Vertical)
Exhibit 4	Elevation Pattern Elevation Tabulations
Exhibit 5	Antenna Data Sheet
Exhibit 6	RMS Calculations
Exhibit 7	Drawings

TEST EQUIPMENT

Network Analyzer	:	Hewlett Packard Model # 8753C Serial Number: 08753 – 69138
Computer	:	Pentium 3, 450 MHz, SAMS Range Program
Printer	:	Hewlett-Packard Laser Jet 6L
Positioner	:	Orbit Positioner

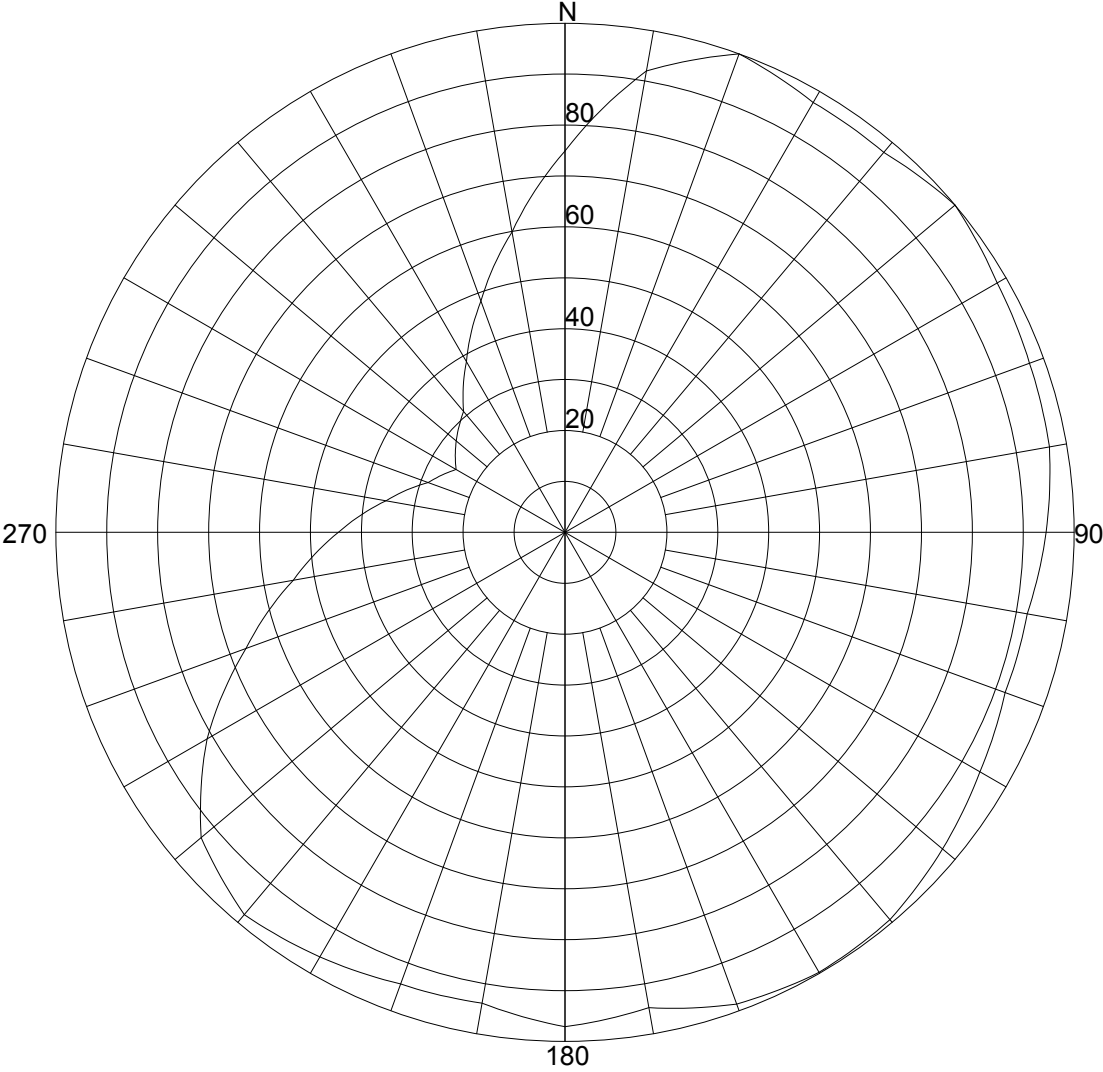
All equipment is calibrated to ANSI/NCSS Z540-1-1994 specs

Prepared by:



Kevin W. Rager
Antenna Engineer
Systems With Reliability LLP

Exhibit 1: Circular Polarized Azimuth Pattern



Azimuth Pattern

Systems With Reliability LP

Scale: Linear
Unit: Relative Field

CLIENT: WWFW / Greg Case	Date: 8/5/2014
ANTENNA TYPE: FMECD/2-PLUS-DA	
FREQUENCY: 103.9 MHz	
PATTERN POL.: Circular	CIRCULARITY(+/-dB):
AZ. DIRECTIVITY: 1.46132 / 1.65dB	PATTERN RMS: 0.827

Relative Field Tabulation(Azimuth)

Azimuth Heading	Relative Field(dB)	Azimuth Heading	Relative Field(dB)
0	.7490 (-2.5)	180	.9710 (-0.25)
5	.8345 (-1.56)	185	.9550 (-0.39)
10	.9200 (-0.71)	190	.9390 (-0.54)
15	.9600 (-0.35)	195	.9415 (-0.51)
20	1.0000 (0.01)	200	.9440 (-0.49)
25	.9875 (-0.1)	205	.9535 (-0.4)
30	.9750 (-0.21)	210	.9630 (-0.32)
35	.9745 (-0.22)	215	.9715 (-0.24)
40	.9740 (-0.22)	220	.9800 (-0.17)
45	.9870 (-0.1)	225	.9565 (-0.38)
50	1.0000 (0.01)	230	.9330 (-0.59)
55	.9900 (-0.08)	235	.8725 (-1.17)
60	.9800 (-0.17)	240	.8120 (-1.8)
65	.9755 (-0.21)	245	.7395 (-2.61)
70	.9710 (-0.25)	250	.6670 (-3.5)
75	.9685 (-0.27)	255	.6045 (-4.36)
80	.9660 (-0.29)	260	.5420 (-5.3)
85	.9555 (-0.39)	265	.4935 (-6.12)
90	.9450 (-0.48)	270	.4450 (-7.01)
95	.9335 (-0.59)	275	.4010 (-7.92)
100	.9220 (-0.7)	280	.3570 (-8.92)
105	.9210 (-0.71)	285	.3215 (-9.83)
110	.9200 (-0.71)	290	.2860 (-10.84)
115	.9305 (-0.62)	295	.2665 (-11.45)
120	.9410 (-0.52)	300	.2470 (-12.11)
125	.9545 (-0.4)	305	.2630 (-11.57)
130	.9680 (-0.27)	310	.2790 (-11.06)
135	.9805 (-0.16)	315	.2945 (-10.59)
140	.9930 (-0.05)	320	.3100 (-10.14)
145	.9955 (-0.03)	325	.3485 (-9.13)
150	.9980 (-0.01)	330	.3870 (-8.22)
155	.9920 (-0.06)	335	.4350 (-7.21)
160	.9860 (-0.11)	340	.4830 (-6.3)
165	.9670 (-0.28)	345	.5410 (-5.32)
170	.9480 (-0.45)	350	.5990 (-4.44)
175	.9595 (-0.35)	355	.6740 (-3.41)

Systems With Reliability LP

CLIENT: *WWFW / Greg Case*

Date: 8/5/2014

ANTENNA TYPE: FMECD/2-PLUS-DA

FREQUENCY: 103.9 MHz

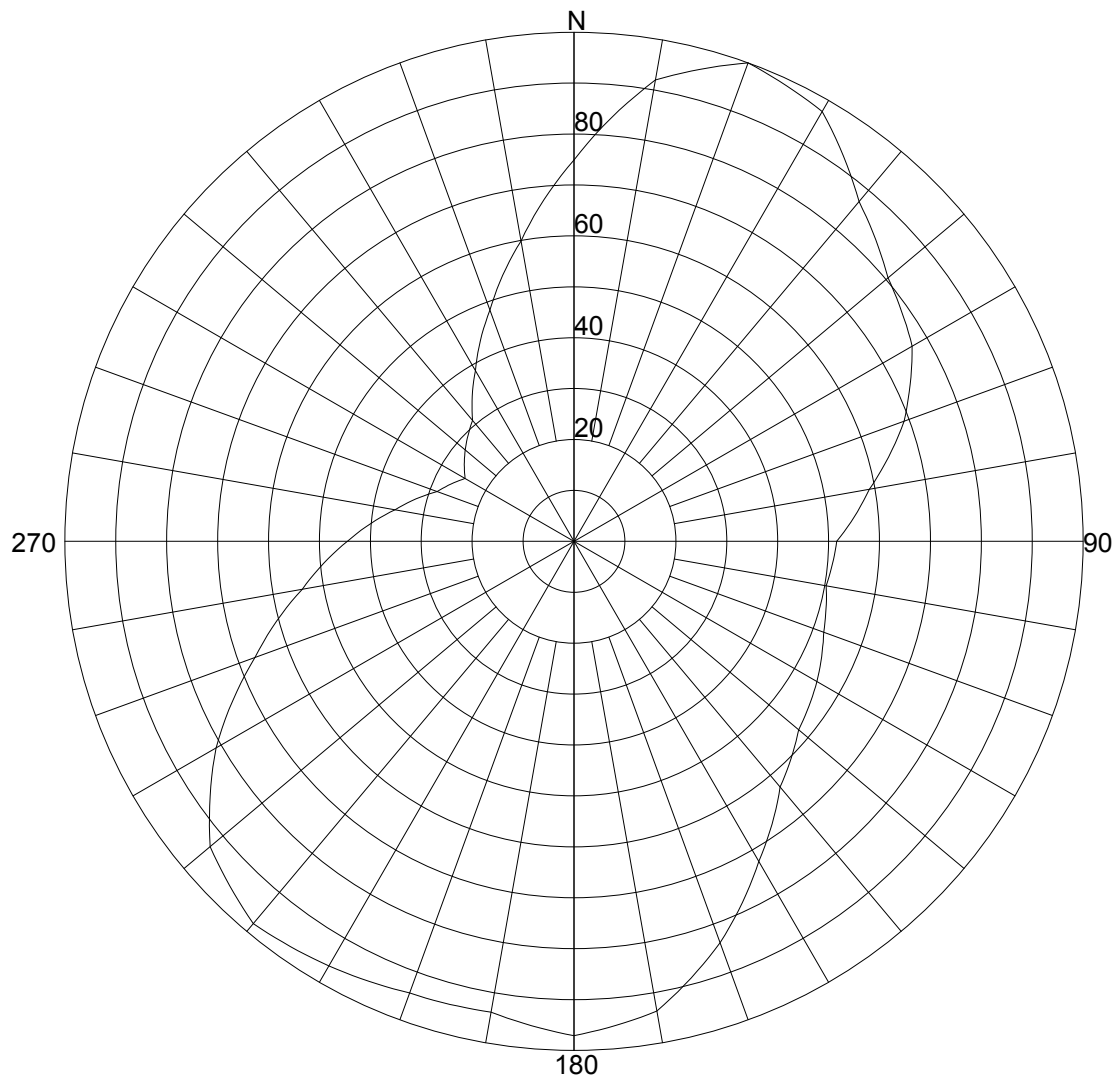
PATTERN POL.: Circular

CIRCULARITY(+/-dB):

AZ. DIRECTIVITY: 1.46132 / 1.65dB

PATTERN RMS: 0.827

Exhibit 2: Measured Horizontal Polarized Azimuth Pattern



Azimuth Pattern

Scale: Linear

Unit: Relative Field

Systems With Reliability LP

CLIENT: WWFW / Greg Case

Date: 8/5/2014

ANTENNA TYPE: FMECD/2-PLUS-DA

FREQUENCY: 103.9 MHz

PATTERN POL.: Horizontal

CIRCULARITY(+/-dB):

AZ. DIRECTIVITY: 1.96455 / 2.93dB

PATTERN RMS: 0.713

Relative Field Tabulation(Azimuth)

Azimuth Heading	Relative Field(dB)	Azimuth Heading	Relative Field(dB)
0	.7490 (-2.5)	180	.9710 (-0.25)
5	.8345 (-1.56)	185	.9550 (-0.39)
10	.9200 (-0.71)	190	.9390 (-0.54)
15	.9600 (-0.35)	195	.9415 (-0.51)
20	1.0000 (0.01)	200	.9440 (-0.49)
25	.9875 (-0.1)	205	.9535 (-0.4)
30	.9750 (-0.21)	210	.9630 (-0.32)
35	.9230 (-0.69)	215	.9715 (-0.24)
40	.8710 (-1.19)	220	.9800 (-0.17)
45	.8380 (-1.52)	225	.9565 (-0.38)
50	.8050 (-1.87)	230	.9330 (-0.59)
55	.7860 (-2.08)	235	.8725 (-1.17)
60	.7670 (-2.29)	240	.8120 (-1.8)
65	.7285 (-2.74)	245	.7395 (-2.61)
70	.6900 (-3.21)	250	.6670 (-3.5)
75	.6395 (-3.87)	255	.6045 (-4.36)
80	.5890 (-4.58)	260	.5420 (-5.3)
85	.5525 (-5.14)	265	.4935 (-6.12)
90	.5160 (-5.73)	270	.4450 (-7.01)
95	.5095 (-5.84)	275	.4010 (-7.92)
100	.5030 (-5.95)	280	.3570 (-8.92)
105	.5125 (-5.79)	285	.3215 (-9.83)
110	.5220 (-5.63)	290	.2860 (-10.84)
115	.5365 (-5.39)	295	.2665 (-11.45)
120	.5510 (-5.16)	300	.2470 (-12.11)
125	.5635 (-4.97)	305	.2630 (-11.57)
130	.5760 (-4.78)	310	.2790 (-11.06)
135	.6030 (-4.38)	315	.2945 (-10.59)
140	.6300 (-4)	320	.3100 (-10.14)
145	.6780 (-3.36)	325	.3485 (-9.13)
150	.7260 (-2.77)	330	.3870 (-8.22)
155	.7825 (-2.12)	335	.4350 (-7.21)
160	.8390 (-1.51)	340	.4830 (-6.3)
165	.8880 (-1.02)	345	.5410 (-5.32)
170	.9370 (-0.56)	350	.5990 (-4.44)
175	.9540 (-0.4)	355	.6740 (-3.41)

Systems With Reliability LP

CLIENT: *WWFW / Greg Case*

Date: 8/5/2014

ANTENNA TYPE: FMECD/2-PLUS-DA

FREQUENCY: 103.9 MHz

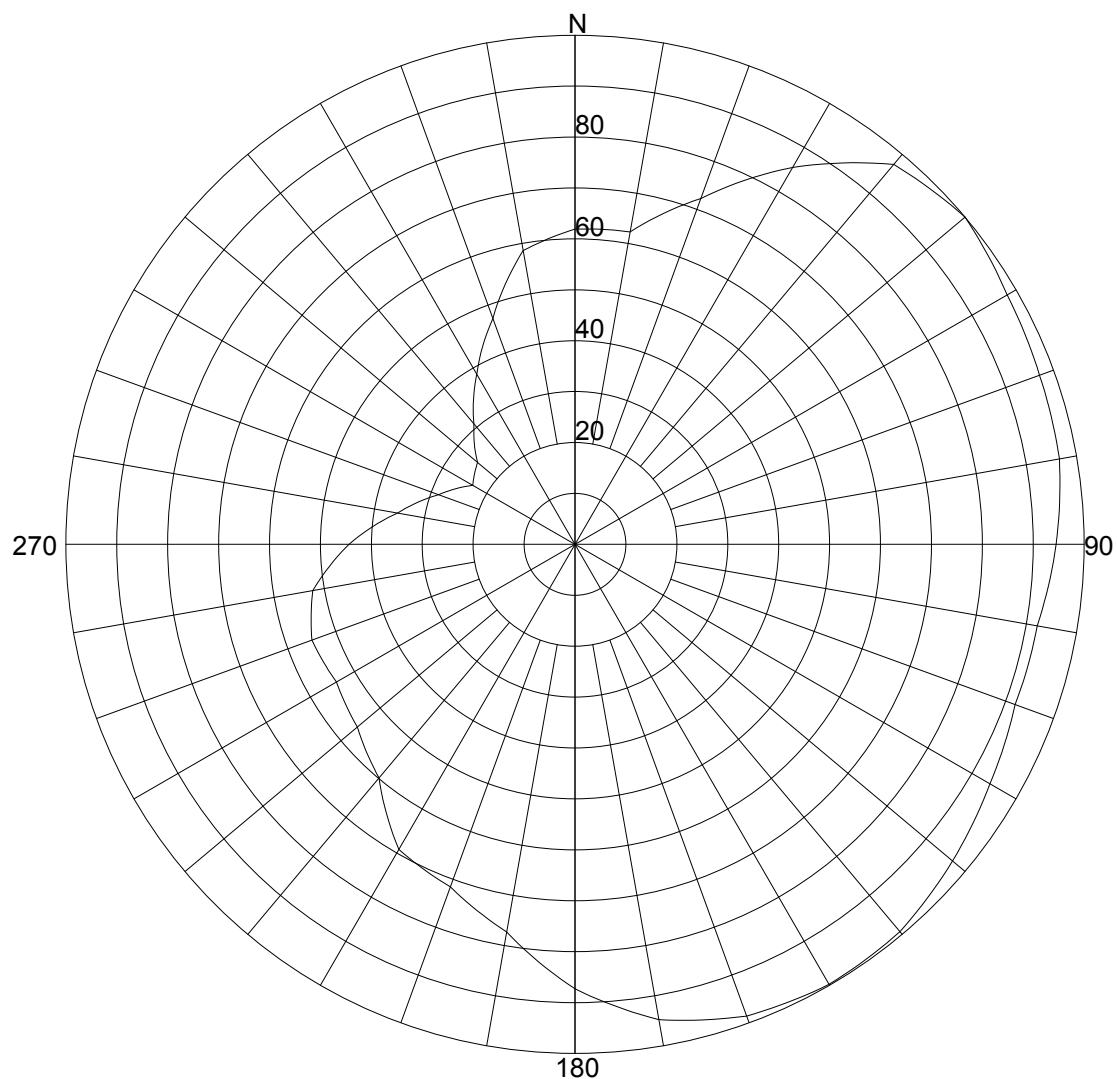
PATTERN POL.: Horizontal

CIRCULARITY(+/-dB):

AZ. DIRECTIVITY: 1.96455 / 2.93dB

PATTERN RMS: 0.713

Exhibit 3: Measured Vertical Polarized Azimuth Pattern



Azimuth Pattern

Systems With Reliability LP

Scale: Linear

Unit: Relative Field

CLIENT: WWFW / Greg Case

Date: 8/5/2014

ANTENNA TYPE: FMECD/2-PLUS-DA

FREQUENCY: 103.9

PATTERN POL.: Vertical

CIRCULARITY(+/-dB):

AZ. DIRECTIVITY: 1.77566 / 2.49dB

PATTERN RMS: 0.750

Relative Field Tabulation(Azimuth)

Azimuth Heading	Relative Field(dB)	Azimuth Heading	Relative Field(dB)
0	.6190 (-4.15)	180	.8730 (-1.17)
5	.6210 (-4.12)	185	.8230 (-1.68)
10	.6230 (-4.1)	190	.7730 (-2.23)
15	.6730 (-3.43)	195	.7445 (-2.55)
20	.7230 (-2.81)	200	.7160 (-2.89)
25	.7890 (-2.05)	205	.7040 (-3.04)
30	.8550 (-1.35)	210	.6920 (-3.19)
35	.9145 (-0.77)	215	.6455 (-3.79)
40	.9740 (-0.22)	220	.5990 (-4.44)
45	.9870 (-0.1)	225	.5785 (-4.74)
50	1.0000 (0.01)	230	.5580 (-5.05)
55	.9900 (-0.08)	235	.5495 (-5.18)
60	.9800 (-0.17)	240	.5410 (-5.32)
65	.9755 (-0.21)	245	.5455 (-5.25)
70	.9710 (-0.25)	250	.5500 (-5.18)
75	.9685 (-0.27)	255	.5365 (-5.39)
80	.9660 (-0.29)	260	.5230 (-5.61)
85	.9555 (-0.39)	265	.4835 (-6.29)
90	.9450 (-0.48)	270	.4440 (-7.03)
95	.9335 (-0.59)	275	.3990 (-7.96)
100	.9220 (-0.7)	280	.3540 (-9)
105	.9210 (-0.71)	285	.3195 (-9.88)
110	.9200 (-0.71)	290	.2850 (-10.87)
115	.9305 (-0.62)	295	.2585 (-11.72)
120	.9410 (-0.52)	300	.2320 (-12.65)
125	.9545 (-0.4)	305	.2410 (-12.32)
130	.9680 (-0.27)	310	.2500 (-12.01)
135	.9805 (-0.16)	315	.2795 (-11.04)
140	.9930 (-0.05)	320	.3090 (-10.17)
145	.9955 (-0.03)	325	.3475 (-9.16)
150	.9980 (-0.01)	330	.3860 (-8.25)
155	.9920 (-0.06)	335	.4290 (-7.33)
160	.9860 (-0.11)	340	.4720 (-6.5)
165	.9670 (-0.28)	345	.5290 (-5.51)
170	.9480 (-0.45)	350	.5860 (-4.63)
175	.9105 (-0.8)	355	.6025 (-4.39)

Systems With Reliability LP

CLIENT: *WWFW / Greg Case*

Date: 8/5/2014

ANTENNA TYPE: FMECD/2-PLUS-DA

FREQUENCY: 103.9

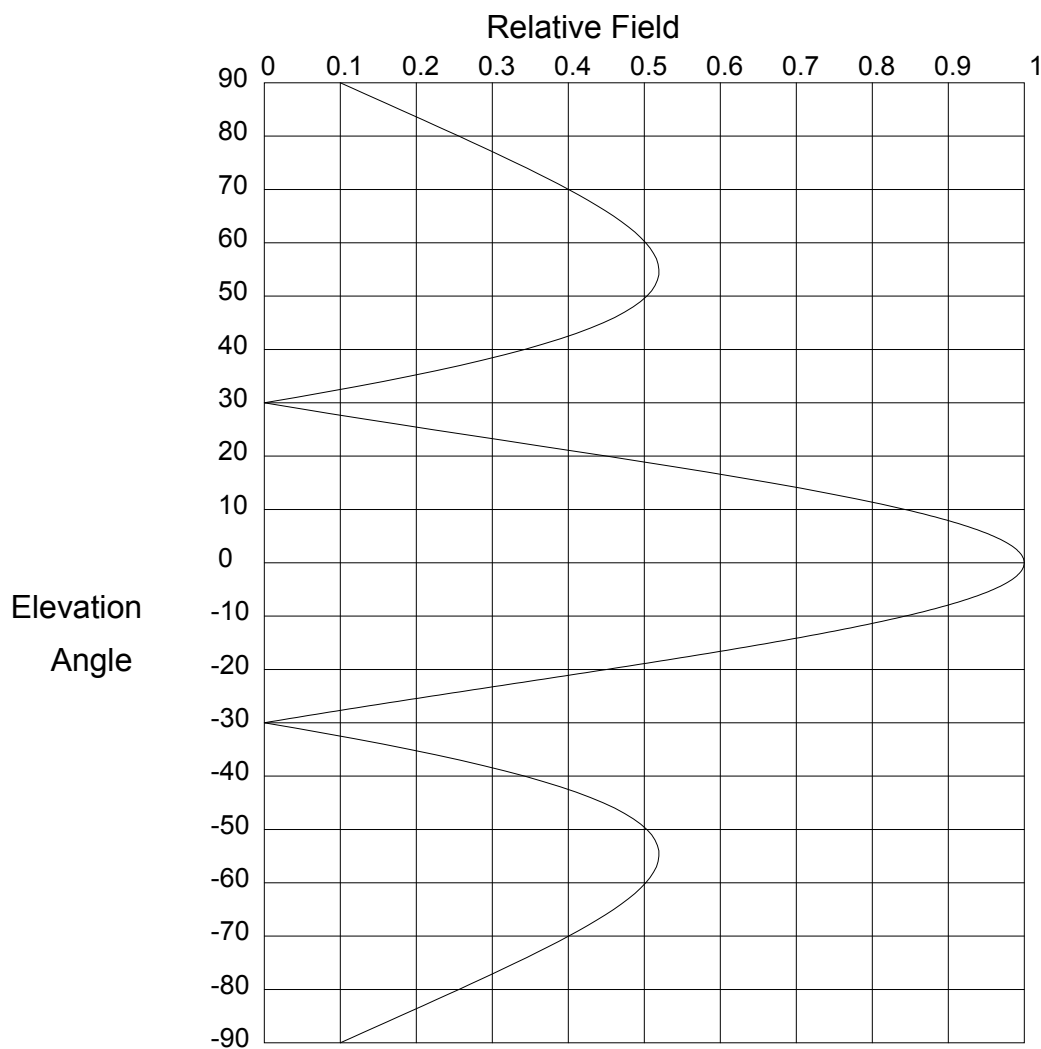
PATTERN POL.: Vertical

CIRCULARITY(+/-dB):

AZ. DIRECTIVITY: 1.77566 / 2.49dB

PATTERN RMS: 0.750

Exhibit 4: Elevation Pattern



Elevation Pattern

Scale: Linear

Units: Field, Relative

Systems With Reliability LP

CLIENT: WWFW / Greg Case
ANTENNA TYPE: FMECD/2-PLUS-DA
FREQUENCY: 103.9 MHz
PATTERN POL.: Circular
DIRECTIVITY(Peak): 1.918/2.828 dBd
DIRECTIVITY(Horiz): 1.918/2.828 dBd

Date: 6/10/2014

Beam Tilt (Deg.) : 0
Null Fill(s)(%) : 0, 0, 0

Relative Field Tabulation

Elev. Angle	Rel. Fld(dB)	Elev. Angle	Rel. Fld(dB)	Elev. Angle	Rel. Fld(dB)
90.0	.10 (-20)	52.0	.514 (-5.775)	14.0	.705 (-3.031)
89.0	.116 (-18.733)	51.0	.51 (-5.855)	13.0	.743 (-2.581)
88.0	.131 (-17.627)	50.0	.503 (-5.963)	12.0	.779 (-2.174)
87.0	.147 (-16.648)	49.0	.495 (-6.101)	11.0	.812 (-1.809)
86.0	.163 (-15.768)	48.0	.486 (-6.272)	10.0	.843 (-1.482)
85.0	.178 (-14.971)	47.0	.474 (-6.479)	9.8	.849 (-1.421)
84.0	.194 (-14.242)	46.0	.461 (-6.724)	9.6	.855 (-1.361)
83.0	.21 (-13.571)	45.0	.446 (-7.013)	9.4	.861 (-1.303)
82.0	.225 (-12.951)	44.0	.429 (-7.349)	9.2	.866 (-1.246)
81.0	.241 (-12.374)	43.0	.41 (-7.738)	9.0	.872 (-1.191)
80.0	.256 (-11.836)	42.0	.39 (-8.189)	8.8	.877 (-1.137)
79.0	.271 (-11.332)	41.0	.367 (-8.709)	8.6	.883 (-1.084)
78.0	.286 (-10.859)	40.0	.342 (-9.31)	8.4	.888 (-1.033)
77.0	.301 (-10.415)	39.0	.316 (-10.008)	8.2	.893 (-0.983)
76.0	.316 (-9.997)	38.0	.288 (-10.824)	8.0	.898 (-0.935)
75.0	.331 (-9.603)	37.0	.257 (-11.786)	7.8	.903 (-0.887)
74.0	.345 (-9.231)	36.0	.225 (-12.937)	7.6	.908 (-0.841)
73.0	.36 (-8.881)	35.0	.192 (-14.343)	7.4	.912 (-0.797)
72.0	.374 (-8.551)	34.0	.156 (-16.113)	7.2	.917 (-0.753)
71.0	.387 (-8.24)	33.0	.119 (-18.454)	7.0	.921 (-0.711)
70.0	.401 (-7.948)	32.0	.081 (-21.828)	6.8	.926 (-0.67)
69.0	.413 (-7.673)	31.0	.041 (-27.712)	6.6	.93 (-0.631)
68.0	.426 (-7.417)	30.0	.00 (-50)	6.4	.934 (-0.593)
67.0	.438 (-7.178)	29.0	.042 (-27.469)	6.2	.938 (-0.556)
66.0	.449 (-6.956)	28.0	.086 (-21.343)	6.0	.942 (-0.52)
65.0	.46 (-6.751)	27.0	.13 (-17.727)	5.8	.946 (-0.485)
64.0	.47 (-6.563)	26.0	.175 (-15.145)	5.6	.949 (-0.452)
63.0	.479 (-6.392)	25.0	.22 (-13.135)	5.4	.953 (-0.42)
62.0	.488 (-6.239)	24.0	.266 (-11.491)	5.2	.956 (-0.389)
61.0	.495 (-6.103)	23.0	.312 (-10.103)	5.0	.959 (-0.36)
60.0	.502 (-5.986)	22.0	.359 (-8.906)	4.8	.963 (-0.331)
59.0	.508 (-5.887)	21.0	.405 (-7.858)	4.6	.966 (-0.304)
58.0	.512 (-5.807)	20.0	.45 (-6.929)	4.4	.969 (-0.278)
57.0	.516 (-5.747)	19.0	.495 (-6.1)	4.2	.971 (-0.253)
56.0	.518 (-5.708)	18.0	.54 (-5.356)	4.0	.974 (-0.229)
55.0	.519 (-5.69)	17.0	.583 (-4.685)	3.8	.976 (-0.207)
54.0	.519 (-5.694)	16.0	.625 (-4.078)	3.6	.979 (-0.186)
53.0	.517 (-5.722)	15.0	.666 (-3.528)	3.4	.981 (-0.165)

Systems With Reliability LP

Page 1 of 3

CLIENT: WWFW / Greg Case

Date: 6/10/2014

ANTENNA TYPE: FMECD/2-PLUS-DA

FREQUENCY: 103.9 MHz

PATTERN POL.: Circular

DIRECTIVITY(Peak): 1.918/2.828 dBd

Beam Tilt (Deg.) : 0

DIRECTIVITY(Horiz): 1.918/2.828 dBd

Null Fill(s)(%) : 0, 0, 0

Relative Field Tabulation

Elev. Angle	Rel. Fld(dB)	Elev. Angle	Rel. Fld(dB)	Elev. Angle	Rel. Fld(dB)
3.2	.983 (-0.146)	-4.4	.969 (-0.278)	-12.0	.779 (-2.174)
3.0	.985 (-0.129)	-4.6	.966 (-0.304)	-12.2	.772 (-2.252)
2.8	.987 (-0.112)	-4.8	.963 (-0.331)	-12.4	.765 (-2.332)
2.6	.989 (-0.097)	-5.0	.959 (-0.36)	-12.6	.757 (-2.413)
2.4	.991 (-0.082)	-5.2	.956 (-0.389)	-12.8	.75 (-2.496)
2.2	.992 (-0.069)	-5.4	.953 (-0.42)	-13.0	.743 (-2.581)
2.0	.993 (-0.057)	-5.6	.949 (-0.452)	-13.2	.736 (-2.667)
1.8	.995 (-0.046)	-5.8	.946 (-0.485)	-13.4	.728 (-2.755)
1.6	.996 (-0.037)	-6.0	.942 (-0.52)	-13.6	.721 (-2.845)
1.4	.997 (-0.028)	-6.2	.938 (-0.556)	-13.8	.713 (-2.937)
1.2	.998 (-0.021)	-6.4	.934 (-0.593)	-14.0	.705 (-3.031)
1.0	.998 (-0.014)	-6.6	.93 (-0.631)	-14.2	.698 (-3.126)
.8	.999 (-0.009)	-6.8	.926 (-0.67)	-14.4	.69 (-3.224)
.6	.999 (-0.005)	-7.0	.921 (-0.711)	-14.6	.682 (-3.323)
.4	1.00 (-0.002)	-7.2	.917 (-0.753)	-14.8	.674 (-3.425)
.2	1.00 (-0.001)	-7.4	.912 (-0.797)	-15.0	.666 (-3.528)
.0	1.00 (0)	-7.6	.908 (-0.841)	-15.2	.658 (-3.634)
-.2	1.00 (-0.001)	-7.8	.903 (-0.887)	-15.4	.65 (-3.742)
-.4	1.00 (-0.002)	-8.0	.898 (-0.935)	-15.6	.642 (-3.851)
-.6	.999 (-0.005)	-8.2	.893 (-0.983)	-15.8	.634 (-3.963)
-.8	.999 (-0.009)	-8.4	.888 (-1.033)	-16.0	.625 (-4.078)
-1.0	.998 (-0.014)	-8.6	.883 (-1.084)	-16.2	.617 (-4.194)
-1.2	.998 (-0.021)	-8.8	.877 (-1.137)	-16.4	.609 (-4.313)
-1.4	.997 (-0.028)	-9.0	.872 (-1.191)	-16.6	.60 (-4.435)
-1.6	.996 (-0.037)	-9.2	.866 (-1.246)	-16.8	.592 (-4.558)
-1.8	.995 (-0.046)	-9.4	.861 (-1.303)	-17.0	.583 (-4.685)
-2.0	.993 (-0.057)	-9.6	.855 (-1.361)	-17.2	.575 (-4.814)
-2.2	.992 (-0.069)	-9.8	.849 (-1.421)	-17.4	.566 (-4.945)
-2.4	.991 (-0.082)	-10.0	.843 (-1.482)	-17.6	.557 (-5.079)
-2.6	.989 (-0.097)	-10.2	.837 (-1.544)	-17.8	.549 (-5.216)
-2.8	.987 (-0.112)	-10.4	.831 (-1.608)	-18.0	.54 (-5.356)
-3.0	.985 (-0.129)	-10.6	.825 (-1.674)	-18.2	.531 (-5.499)
-3.2	.983 (-0.146)	-10.8	.818 (-1.74)	-18.4	.522 (-5.644)
-3.4	.981 (-0.165)	-11.0	.812 (-1.809)	-18.6	.513 (-5.793)
-3.6	.979 (-0.186)	-11.2	.805 (-1.879)	-18.8	.504 (-5.945)
-3.8	.976 (-0.207)	-11.4	.799 (-1.95)	-19.0	.495 (-6.1)
-4.0	.974 (-0.229)	-11.6	.792 (-2.023)	-19.2	.486 (-6.259)
-4.2	.971 (-0.253)	-11.8	.785 (-2.098)	-19.4	.477 (-6.421)

Systems With Reliability LP

Page 2 of 3

CLIENT: WWFW / Greg Case

Date: 6/10/2014

ANTENNA TYPE: FMECD/2-PLUS-DA

FREQUENCY: 103.9 MHz

PATTERN POL.: Circular

DIRECTIVITY(Peak): 1.918/2.828 dBd

Beam Tilt (Deg.) : 0

DIRECTIVITY(Horiz): 1.918/2.828 dBd

Null Fill(s)(%) : 0, 0, 0

Relative Field Tabulation

Elev. Angle	Rel. Fld(dB)	Elev. Angle	Rel. Fld(dB)	Elev. Angle	Rel. Fld(dB)
-19.6	.468 (-6.587)	-27.2	.121 (-18.344)	-54.0	.519 (-5.694)
-19.8	.459 (-6.756)	-27.4	.112 (-19.006)	-55.0	.519 (-5.69)
-20.0	.45 (-6.929)	-27.6	.103 (-19.721)	-56.0	.518 (-5.708)
-20.2	.441 (-7.106)	-27.8	.094 (-20.496)	-57.0	.516 (-5.747)
-20.4	.432 (-7.288)	-28.0	.086 (-21.343)	-58.0	.512 (-5.807)
-20.6	.423 (-7.473)	-28.2	.077 (-22.278)	-59.0	.508 (-5.887)
-20.8	.414 (-7.663)	-28.4	.068 (-23.322)	-60.0	.502 (-5.986)
-21.0	.405 (-7.858)	-28.6	.06 (-24.503)	-61.0	.495 (-6.103)
-21.2	.396 (-8.057)	-28.8	.051 (-25.863)	-62.0	.488 (-6.239)
-21.4	.386 (-8.261)	-29.0	.042 (-27.469)	-63.0	.479 (-6.392)
-21.6	.377 (-8.471)	-29.2	.034 (-29.429)	-64.0	.47 (-6.563)
-21.8	.368 (-8.686)	-29.4	.025 (-31.951)	-65.0	.46 (-6.751)
-22.0	.359 (-8.906)	-29.6	.017 (-35.496)	-66.0	.449 (-6.956)
-22.2	.349 (-9.132)	-29.8	.008 (-41.54)	-67.0	.438 (-7.178)
-22.4	.34 (-9.365)	-30.0	.00 (-50)	-68.0	.426 (-7.417)
-22.6	.331 (-9.604)	-31.0	.041 (-27.712)	-69.0	.413 (-7.673)
-22.8	.322 (-9.85)	-32.0	.081 (-21.828)	-70.0	.401 (-7.948)
-23.0	.312 (-10.103)	-33.0	.119 (-18.454)	-71.0	.387 (-8.24)
-23.2	.303 (-10.364)	-34.0	.156 (-16.113)	-72.0	.374 (-8.551)
-23.4	.294 (-10.632)	-35.0	.192 (-14.343)	-73.0	.36 (-8.881)
-23.6	.285 (-10.909)	-36.0	.225 (-12.937)	-74.0	.345 (-9.231)
-23.8	.276 (-11.195)	-37.0	.257 (-11.786)	-75.0	.331 (-9.603)
-24.0	.266 (-11.491)	-38.0	.288 (-10.824)	-76.0	.316 (-9.997)
-24.2	.257 (-11.797)	-39.0	.316 (-10.008)	-77.0	.301 (-10.415)
-24.4	.248 (-12.113)	-40.0	.342 (-9.31)	-78.0	.286 (-10.859)
-24.6	.239 (-12.441)	-41.0	.367 (-8.709)	-79.0	.271 (-11.332)
-24.8	.23 (-12.781)	-42.0	.39 (-8.189)	-80.0	.256 (-11.836)
-25.0	.22 (-13.135)	-43.0	.41 (-7.738)	-81.0	.241 (-12.374)
-25.2	.211 (-13.503)	-44.0	.429 (-7.349)	-82.0	.225 (-12.951)
-25.4	.202 (-13.887)	-45.0	.446 (-7.013)	-83.0	.21 (-13.571)
-25.6	.193 (-14.287)	-46.0	.461 (-6.724)	-84.0	.194 (-14.242)
-25.8	.184 (-14.706)	-47.0	.474 (-6.479)	-85.0	.178 (-14.971)
-26.0	.175 (-15.145)	-48.0	.486 (-6.272)	-86.0	.163 (-15.768)
-26.2	.166 (-15.606)	-49.0	.495 (-6.101)	-87.0	.147 (-16.648)
-26.4	.157 (-16.092)	-50.0	.503 (-5.963)	-88.0	.131 (-17.627)
-26.6	.148 (-16.605)	-51.0	.51 (-5.855)	-89.0	.116 (-18.733)
-26.8	.139 (-17.149)	-52.0	.514 (-5.775)	-90.0	.10 (-20)
-27.0	.13 (-17.727)	-53.0	.517 (-5.722)	90.0	.00 (-50)

Systems With Reliability LP

Page 3 of 3

CLIENT: WWFW / Greg Case

Date: 6/10/2014

ANTENNA TYPE: FMECD/2-PLUS-DA

FREQUENCY: 103.9 MHz

PATTERN POL.: Circular

DIRECTIVITY(Peak): 1.918/2.828 dBd

Beam Tilt (Deg.) : 0

DIRECTIVITY(Horiz): 1.918/2.828 dBd

Null Fill(s)(%) : 0, 0, 0

Exhibit 5: Antenna Data Sheet



SYSTEMS WITH RELIABILITY, LP
BROADCAST ANTENNAS AND TRANSMISSION LINE

SYSTEM DATA SHEET

Customer	WWFW
Contact	Greg Case
Location	Fort Wayne, IN
Antenna Model	FMECD/2-PLUS-DA
Channel / Frequency	280A / 103.9 MHz

ELECTRICAL SPECIFICATIONS

Antenna Specifications:

	H-POL			V. Pol.	
License ERP (KW)	1.600			1.600	
FCC Limit Pattern Directivity	1.225	0.883	dB	1.225	0.883 dB
Elevation Directivity	1.918	2.828	dB	1.918	2.828 dB
Azimuth Directivity	1.965	2.933	dB	1.776	2.494 dB
Composite Pattern	1.461	1.647	dB	1.461	1.647 dB
Polarization Ratio	0.475			0.525	
RMS Comp./RMS Limit	91.6 %				
Antenna Efficiency %	100			100	
Power Ratio (Pol. Ratio X Efficiency)	0.4747			0.5253	
Antenna Gain	1.789	2.526	dB	1.789	2.526 dB

Antenna Input Power (KW)	0.894 kW	-0.485 (dBK)
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Feed Line Specifications:

Line Type:Cablewave	1 5/8" Air	50 Ω HJ7-50A
Attenuation Per 100 ft (dB)	0.21	dB
Line Length (ft) AGL + 68' Horizontal Run	470.00	ft.
Total Line Attenuation (dB)	0.9917	dB
Line Efficiency	79.58 %	
Power Input to the Line (KW)	1.124 kW	0.507 (dBK)

MECHANICAL SPECIFICATIONS

No. Of Bays	2		
Antenna Aperture	9.47	ft.	2.89 meter
Center of Radiation AGL	450.00	ft.	137.15 meter
Antenna Weight (Everything)	160.00	lbs.	72.73 kg
Windload (50/33)	350.00	lbs.	Windload CaAc 10.00 ft^2

Prepared by:

Kevin W. Rager
 SWR, LP

Exhibit 6: RMS Calculations



SYSTEMS WITH RELIABILITY, LP
Broadcast Antennas and Transmission Systems

WWFW Antenna RMS Comparison

PROPOSED ANTENNA

Azimuth Heading	Relative Field
0	0.888
10	1
20	1
30	1
40	1
50	1
60	1
70	1
80	1
90	1
100	1
110	1
120	1
130	1
140	1
150	1
160	1
170	1
180	1
190	1
200	1
210	1
220	1
230	1
240	1
250	1
260	0.929
270	0.738
280	0.586
290	0.481
300	0.44
310	0.44
320	0.45
330	0.48
340	0.56
350	0.705

DESIGNED ANTENNA

Azimuth Heading	Relative Field
0	0.749
10	0.92
20	1
30	0.975
40	0.974
50	1
60	0.98
70	0.971
80	0.966
90	0.945
100	0.922
110	0.92
120	0.941
130	0.968
140	0.993
150	0.998
160	0.986
170	0.948
180	0.971
190	0.939
200	0.944
210	0.963
220	0.98
230	0.933
240	0.812
250	0.667
260	0.542
270	0.445
280	0.357
290	0.286
300	0.247
310	0.279
320	0.31
330	0.387
340	0.483
350	0.599

Sum of Relative Field Squared : 29.402
Sum Divided by 36 (Readings) : 0.817
Square Root : 0.904

Sum of Relative Field Squared : 24.664
Sum Divided by 36 (Readings) : 0.685
Square Root : 0.828

Percentage of Construction Permit Antenna Filled :

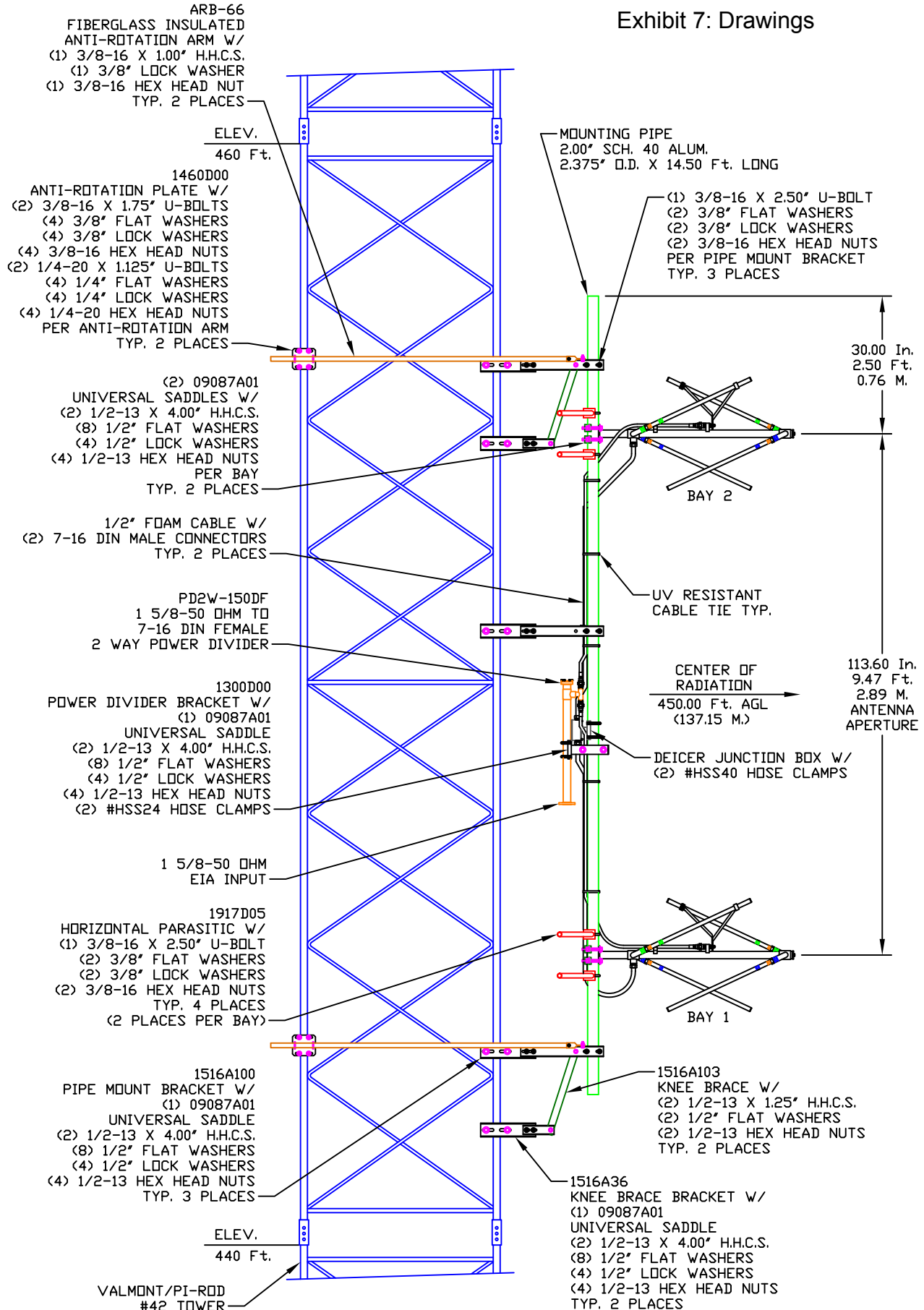
91.6%

NOTES:

1. REFERENCE DWG. 1917D01 FOR ANTENNA ORIENTATION.
2. REFERENCE DWG. 1917D02 FOR PARASITIC PLACEMENT.

DRAWING NUMBER: 1917D00

Exhibit 7: Drawings



SYSTEMS WITH RELIABILITY, LP
619 INDUSTRIAL PARK ROAD
EBENSBURG, PENNSYLVANIA 15931

TITLE: FMECD/2-PLUS-DA, FREQ. 103.9
WWFW, FORT WAYNE, IN

MATERIAL:

SIZE REV APPR. DATE
C 1
2
3

ENGINEER:

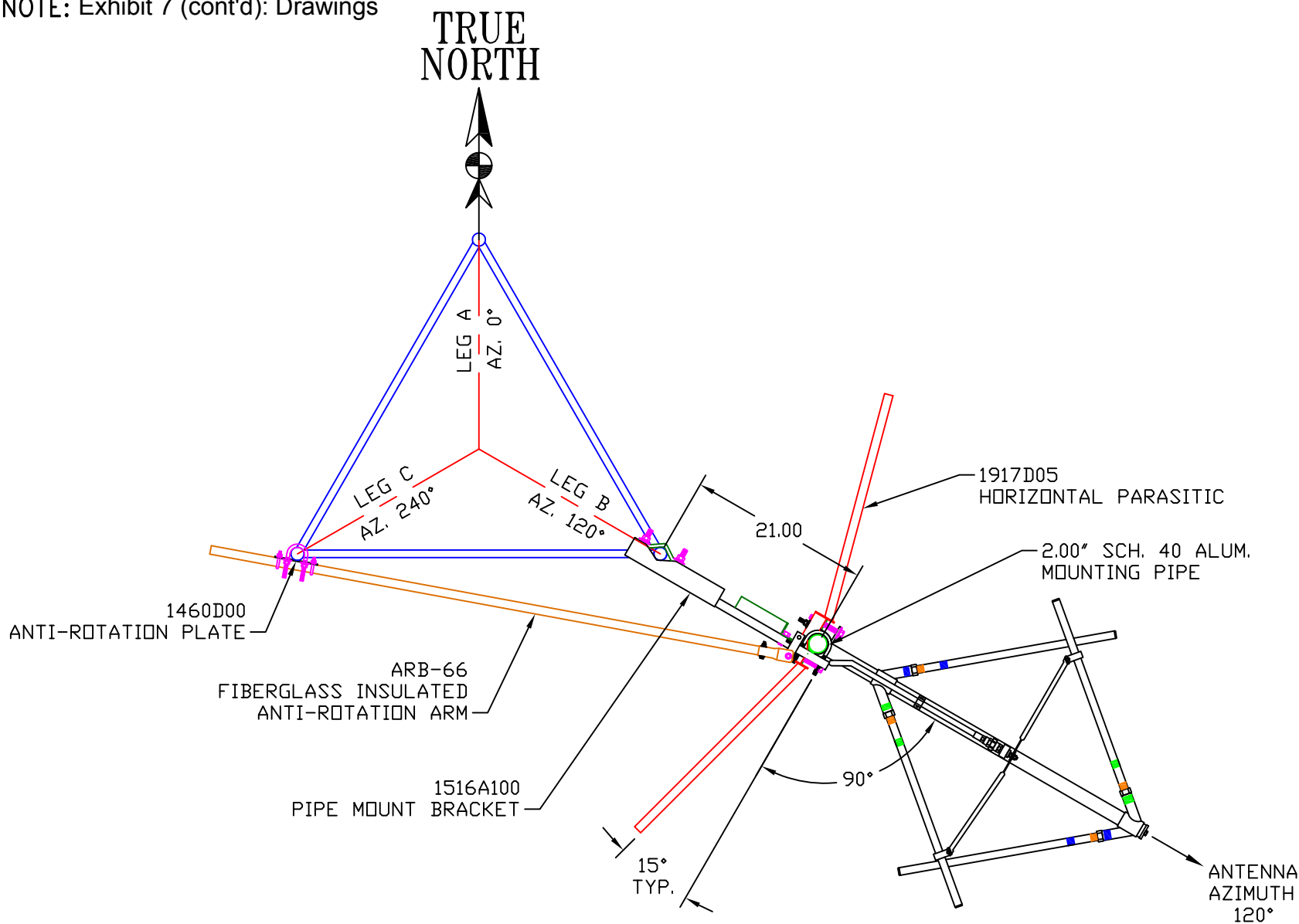
SCALE: NTS

NAME: RAC

DATE: 8/13/14

SHEET 1 OF 1

DRAWING NUMBER: 1917D00



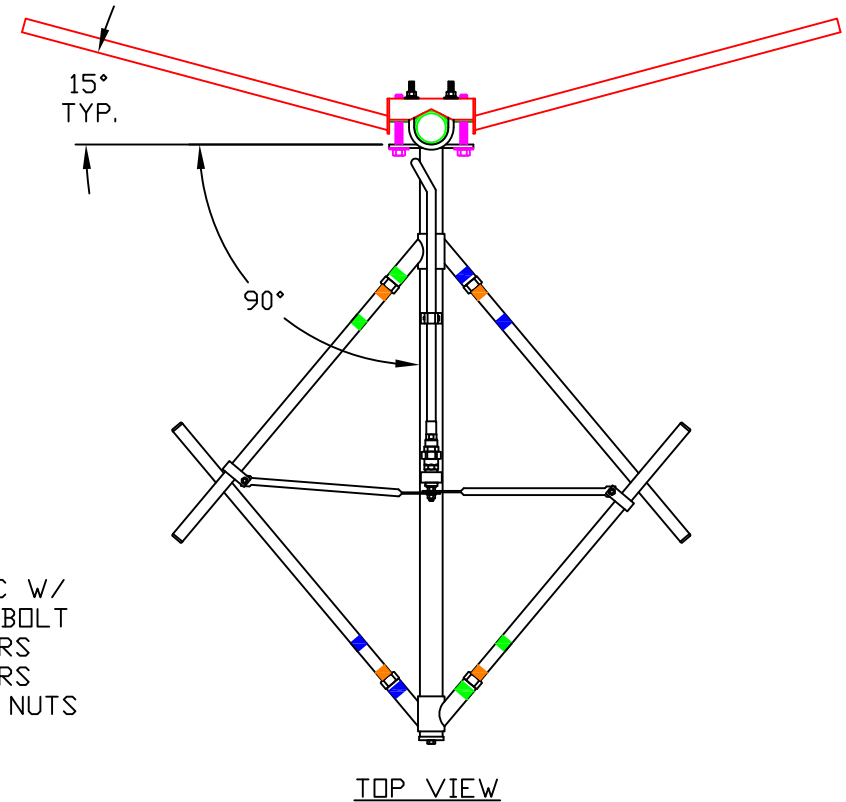
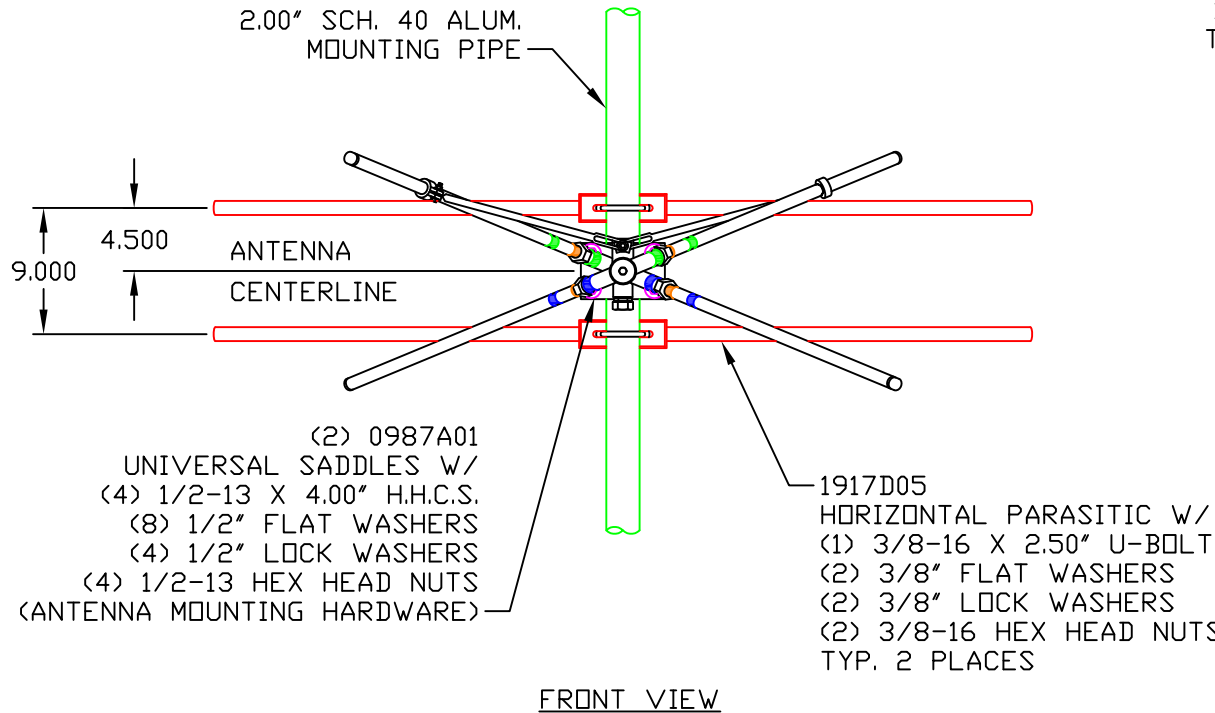
REVISION RECORD		
REV	APPROVAL	DATE
DRAWING NUMBER: 1917D01		
SCALE: NTS	NAME: RAC	DATE: 8/13/14 SHEET 1 OF 1

NOTE: Exhibit 7 (cont'd): Drawings

DRAWING
NUMBER:

1917D02

THIS INSTALLATION IS TYPICAL FOR BOTH BAYS.



TOLERANCES	
.X	± .015
.XX	± .005
.XXX	± .002
X/X	± 1/32
DEG.	± 1/2
UNLESS OTHERWISE SPECIFIED	

REVISION RECORD		
REV	APPROVAL	DATE
DRAWING NUMBER: 1917D02		
SCALE: NTS	NAME: RAC	DATE: 8/13/14 SHEET 1 OF 1



SYSTEMS WITH RELIABILITY, LP
619 INDUSTRIAL PARK ROAD
EBENSBURG, PENNSYLVANIA 15931

TITLE: FMECD/2-PLUS-DA, FREQ. 103.9
WWFW, FORT WAYNE, IN

MATERIAL: PARASITIC PLACEMENT

SIZE

A

PARTS MADE BY THIS DRAWING