



SYSTEMS WITH RELIABILITY, LLP
BROADCAST ANTENNAS AND TRANSMISSION LINE

PATTERN CERTIFICATION
DIRECTIONAL FM ANTENNA
WUPJ
December 13, 2013

Call Sign	:	WUPJ
Location	:	Escanaba, MI
Frequency	:	90.9 MHz
Channel	:	215C1
Antenna Model	:	FM3/10-CFS-0.9WS-DA
Maximum Antenna Gain	:	
Horizontal	:	11.542 / 10.623 dB
Vertical	:	11.542 / 10.623 dB

ANTENNA DESCRIPTION

A custom designed FM3/10-CFS-0.9WS-DA antenna was fabricated to conform to the prescribed directional azimuth pattern. The antenna bay consists of ten (10) circularly polarized, cross-V dipole radiating elements spaced 0.9 wave spacing and parasitic system mounted to a 2" (inch) schedule 40 support pole. The support pole is mounted to a twenty-four (24)" (inch) face Allstate tower. The antenna array points 56 degrees true north.

DESCRIPTION OF TEST PROCEDURE

The test antenna consisted of a single third-scale bay and parasitic system. 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 using horizontal parasitics, adjusting the distance between the tower and the antenna, and modifying the direction of the azimuth heading.

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 transmit mode, at frequency 272.7 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 272.7 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 **97.6%** of the **RMS** value of the pattern authorized in the related construction permit **BMPED-20130625ADH**. The vertical component **RMS** value is **0.730**. The horizontal component **RMS** value is **0.634**. The circular polarized component **RMS** value is **0.749**.

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

Measured vertical polarized directivity:	1.877 / 2.736 dB
Measured horizontal polarized directivity:	2.492 / 3.965 dB
Measured circular polarized pattern directivity:	1.783 / 2.510 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 = (1.877)(.570)(10.78)	= 11.542 / 10.623 dB
H-Pol. Gain = (2.492)(.430)(10.78)	= 11.542 / 10.623 dB

INSTALLATION AND MOUNTING

The antenna is to be mounted in accordance with the supplied drawings. The antenna center of radiation is to be **74.69 meters (245.06 ft.)** above ground level. The antenna aperture is **87.65 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 **56 degrees** true North.

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

DRAWING NO.	TITLE
1835D00R	ELEVATION
1835D01R	ANTENNA ORIENTATION
1835D02R	ANTENNA PARASITIC PLACEMENT
2105A10	TEST RANGE SCHEMATIC

The array shall be mounted according to all details outlined in **DWG. 1835D00R**. The antenna elements shall be aligned at the same heading as in **DWG. 1835D01R**. This will ensure that the antenna is oriented properly at 56 degrees true north. **DWG. 1835D02R** shows the parasitic placement and mounting detail for each bay. 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

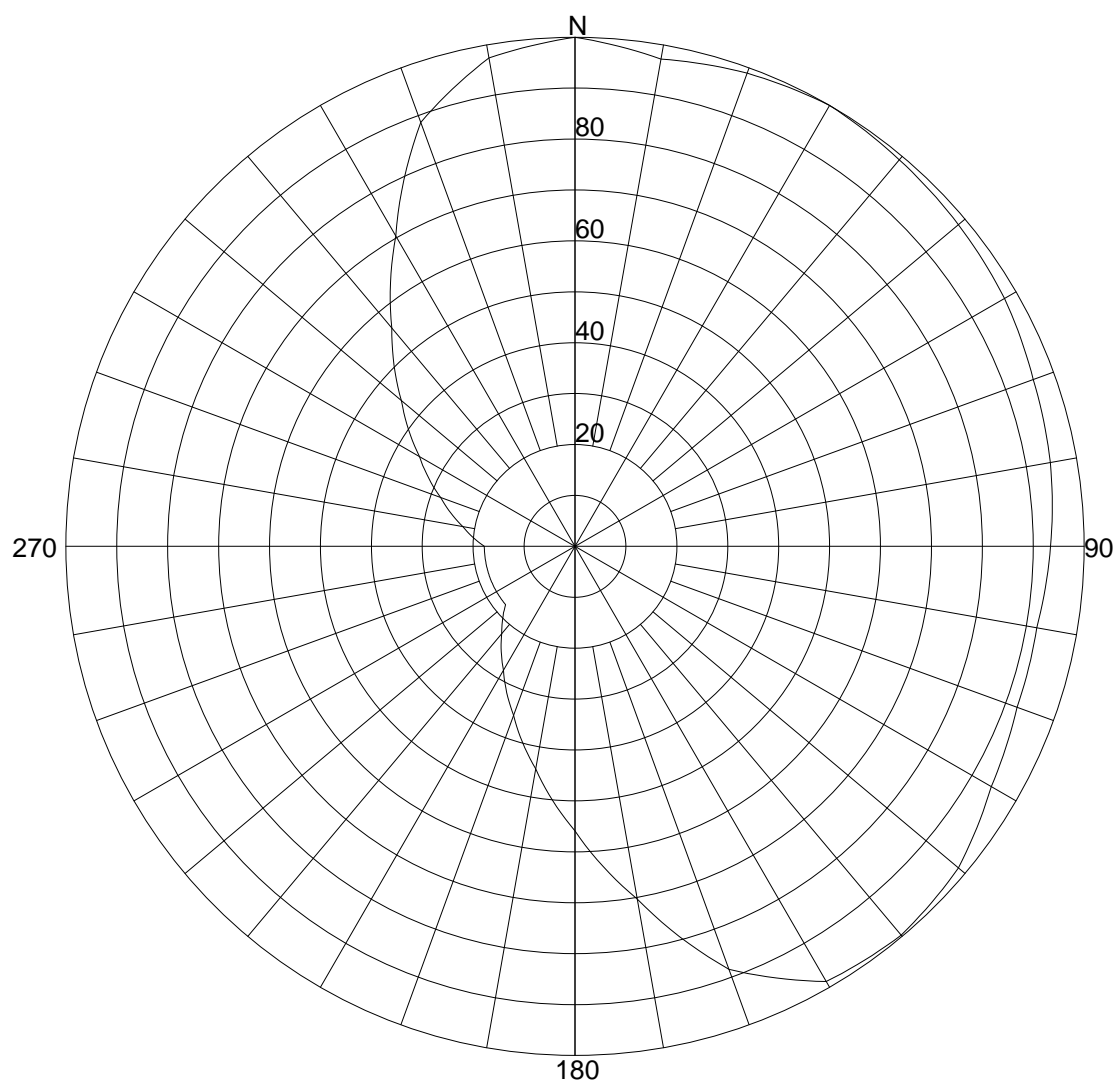
All equipment is calibrated to ANSI/NCSS Z540-1-1994 specs

Prepared by:



Kevin W. Rager
Antenna Engineer
Systems With Reliability LLP

Exhibit 1: Circular Polarized Azimuth Pattern



Azimuth Pattern

Systems With Reliability

Scale: Linear

Unit: Relative Field

CLIENT: *WUPJ*

Date: 8/20/2013

ANTENNA TYPE: FM3/10-0.9WS-DA

FREQUENCY: 90.9 MHz

PATTERN POL.: Circular

CIRCULARITY(+/-dB):

AZ. DIRECTIVITY: 1.7825 / 2.51dB

PATTERN RMS: 0.749

Relative Field Tabulation(Azimuth)

Azimuth Heading	Normalized Field(dB)	Azimuth Heading	Normalized Field(dB)
0	1.0000 (0)	180	.5590 (-5.05)
5	.9860 (-0.12)	185	.5015 (-5.99)
10	.9720 (-0.25)	190	.4440 (-7.05)
15	.9805 (-0.17)	195	.3985 (-7.99)
20	.9890 (-0.1)	200	.3530 (-9.04)
25	.9945 (-0.05)	205	.3170 (-9.98)
30	1.0000 (0)	210	.2810 (-11.03)
35	.9955 (-0.04)	215	.2525 (-11.95)
40	.9910 (-0.08)	220	.2240 (-13)
45	.9870 (-0.11)	225	.2010 (-13.94)
50	.9830 (-0.15)	230	.1780 (-14.99)
55	.9785 (-0.19)	235	.1780 (-14.99)
60	.9740 (-0.23)	240	.1780 (-14.99)
65	.9660 (-0.3)	245	.1780 (-14.99)
70	.9580 (-0.37)	250	.1780 (-14.99)
75	.9530 (-0.42)	255	.1780 (-14.99)
80	.9480 (-0.46)	260	.1780 (-14.99)
85	.9410 (-0.53)	265	.1780 (-14.99)
90	.9340 (-0.59)	270	.1780 (-14.99)
95	.9275 (-0.65)	275	.2010 (-13.94)
100	.9210 (-0.71)	280	.2240 (-13)
105	.9225 (-0.7)	285	.2525 (-11.95)
110	.9240 (-0.69)	290	.2810 (-11.03)
115	.9340 (-0.59)	295	.3170 (-9.98)
120	.9440 (-0.5)	300	.3530 (-9.04)
125	.9635 (-0.32)	305	.3990 (-7.98)
130	.9830 (-0.15)	310	.4450 (-7.03)
135	.9900 (-0.09)	315	.5025 (-5.98)
140	.9970 (-0.03)	320	.5600 (-5.04)
145	.9920 (-0.07)	325	.6320 (-3.99)
150	.9870 (-0.11)	330	.7040 (-3.05)
155	.9355 (-0.58)	335	.7950 (-1.99)
160	.8840 (-1.07)	340	.8860 (-1.05)
165	.7935 (-2.01)	345	.9300 (-0.63)
170	.7030 (-3.06)	350	.9740 (-0.23)
175	.6310 (-4)	355	.9870 (-0.11)

Systems With Reliability

CLIENT: *WUPJ*

Date: 8/20/2013

ANTENNA TYPE: FM3/10-0.9WS-DA

FREQUENCY: 90.9 MHz

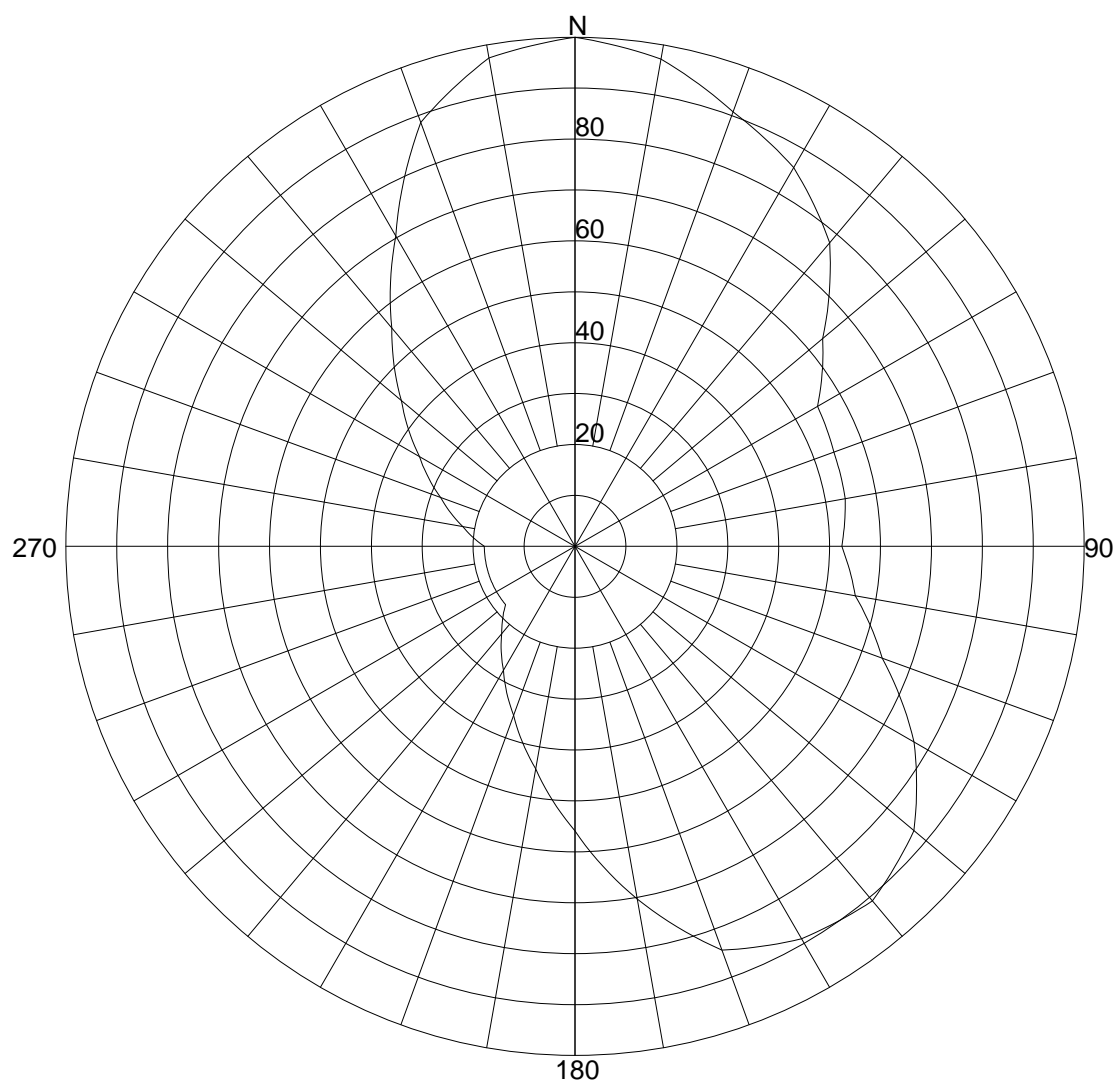
PATTERN POL.: Circular

CIRCULARITY(+/-dB):

AZ. DIRECTIVITY: 1.7825 / 2.51dB

PATTERN RMS: 0.749

Exhibit 2: Measured Horizontal Polarized Azimuth Pattern



Azimuth Pattern

Systems With Reliability

Scale: Linear

Unit: Relative Field

CLIENT: *WUPJ*

Date: 8/20/2013

ANTENNA TYPE: FM3/10-0.9WS-DA

FREQUENCY: 90.9 MHz

PATTERN POL.: Horizontal

CIRCULARITY(+/-dB):

AZ. DIRECTIVITY: 2.49176 / 3.97dB

PATTERN RMS: 0.634

Relative Field Tabulation(Azimuth)

Azimuth Heading	Normalized Field(dB)	Azimuth Heading	Normalized Field(dB)
0	1.0000 (0)	180	.5590 (-5.05)
5	.9860 (-0.12)	185	.5015 (-5.99)
10	.9720 (-0.25)	190	.4440 (-7.05)
15	.9400 (-0.54)	195	.3985 (-7.99)
20	.9080 (-0.84)	200	.3530 (-9.04)
25	.8835 (-1.08)	205	.3170 (-9.98)
30	.8590 (-1.32)	210	.2810 (-11.03)
35	.8185 (-1.74)	215	.2525 (-11.95)
40	.7780 (-2.18)	220	.2240 (-13)
45	.7065 (-3.02)	225	.2010 (-13.94)
50	.6350 (-3.94)	230	.1780 (-14.99)
55	.5925 (-4.55)	235	.1780 (-14.99)
60	.5500 (-5.19)	240	.1780 (-14.99)
65	.5455 (-5.26)	245	.1780 (-14.99)
70	.5410 (-5.34)	250	.1780 (-14.99)
75	.5400 (-5.35)	255	.1780 (-14.99)
80	.5390 (-5.37)	260	.1780 (-14.99)
85	.5315 (-5.49)	265	.1780 (-14.99)
90	.5240 (-5.61)	270	.1780 (-14.99)
95	.5415 (-5.33)	275	.2010 (-13.94)
100	.5590 (-5.05)	280	.2240 (-13)
105	.6005 (-4.43)	285	.2525 (-11.95)
110	.6420 (-3.85)	290	.2810 (-11.03)
115	.7055 (-3.03)	295	.3170 (-9.98)
120	.7690 (-2.28)	300	.3530 (-9.04)
125	.8190 (-1.73)	305	.3990 (-7.98)
130	.8690 (-1.22)	310	.4450 (-7.03)
135	.8890 (-1.02)	315	.5025 (-5.98)
140	.9090 (-0.83)	320	.5600 (-5.04)
145	.8995 (-0.92)	325	.6320 (-3.99)
150	.8900 (-1.01)	330	.7040 (-3.05)
155	.8670 (-1.24)	335	.7950 (-1.99)
160	.8440 (-1.47)	340	.8860 (-1.05)
165	.7735 (-2.23)	345	.9300 (-0.63)
170	.7030 (-3.06)	350	.9740 (-0.23)
175	.6310 (-4)	355	.9870 (-0.11)

Systems With Reliability

CLIENT: *WUPJ*

Date: 8/20/2013

ANTENNA TYPE: FM3/10-0.9WS-DA

FREQUENCY: 90.9 MHz

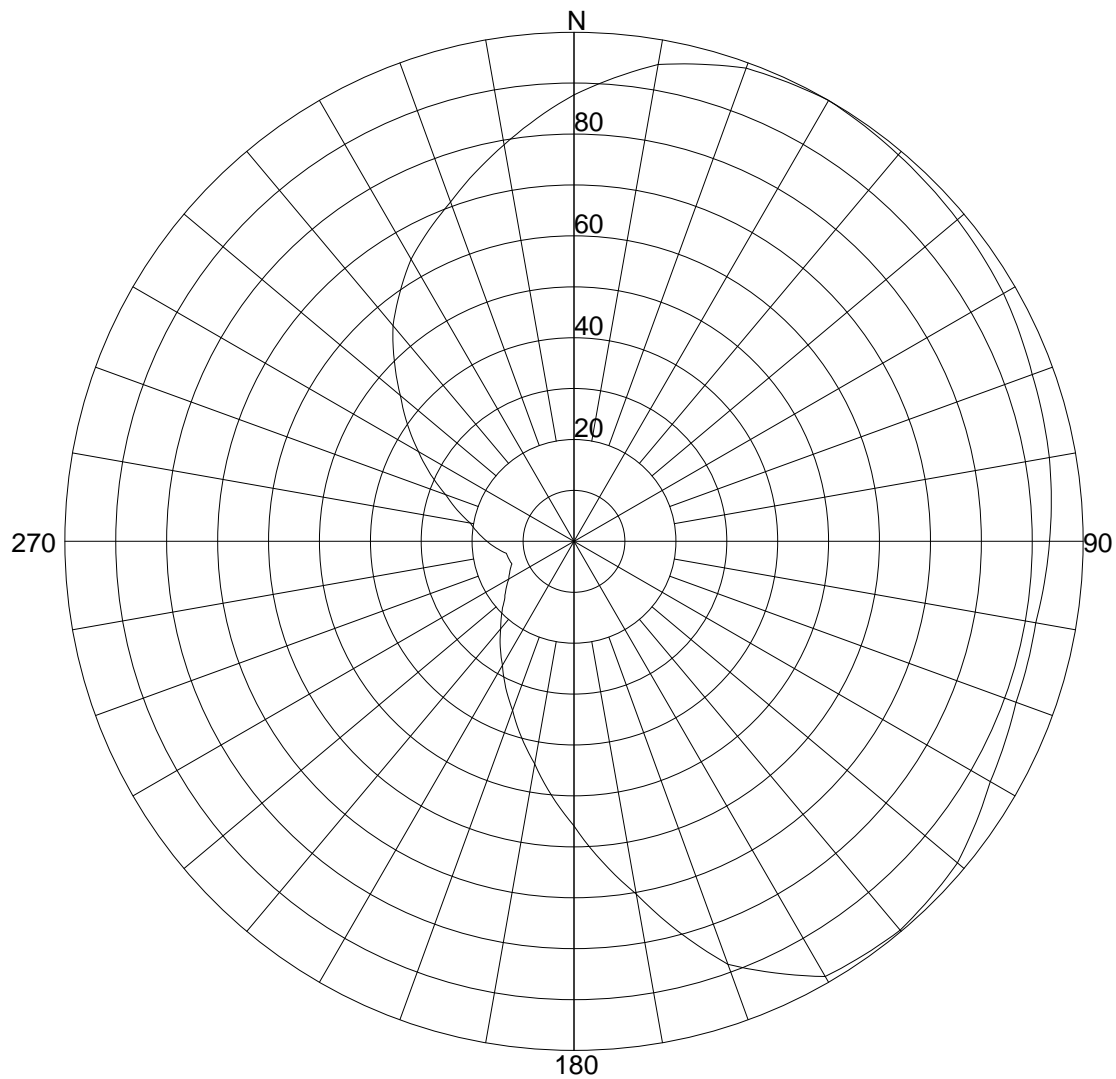
PATTERN POL.: Horizontal

CIRCULARITY(+/-dB):

AZ. DIRECTIVITY: 2.49176 / 3.97dB

PATTERN RMS: 0.634

Exhibit 3: Measured Vertical Polarized Azimuth Pattern



Azimuth Pattern

Systems With Reliability

Scale: Linear

Unit: Relative Field

CLIENT: *WUPJ*

Date: 8/20/2013

ANTENNA TYPE: FM3/10-0.9WS-DA

FREQUENCY: 90.9 MHz

PATTERN POL.: Vertical

CIRCULARITY(+/-dB):

AZ. DIRECTIVITY: 1.87739 / 2.74dB

PATTERN RMS: 0.730

Relative Field Tabulation(Azimuth)

Azimuth Heading	Normalized Field(dB)	Azimuth Heading	Normalized Field(dB)
0	.8770 (-1.14)	180	.5590 (-5.05)
5	.9140 (-0.78)	185	.5015 (-5.99)
10	.9510 (-0.44)	190	.4440 (-7.05)
15	.9700 (-0.26)	195	.3985 (-7.99)
20	.9890 (-0.1)	200	.3530 (-9.04)
25	.9945 (-0.05)	205	.3170 (-9.98)
30	1.0000 (0)	210	.2810 (-11.03)
35	.9955 (-0.04)	215	.2525 (-11.95)
40	.9910 (-0.08)	220	.2240 (-13)
45	.9870 (-0.11)	225	.2010 (-13.94)
50	.9830 (-0.15)	230	.1780 (-14.99)
55	.9785 (-0.19)	235	.1630 (-15.76)
60	.9740 (-0.23)	240	.1480 (-16.59)
65	.9660 (-0.3)	245	.1390 (-17.14)
70	.9580 (-0.37)	250	.1300 (-17.72)
75	.9530 (-0.42)	255	.1325 (-17.56)
80	.9480 (-0.46)	260	.1350 (-17.39)
85	.9410 (-0.53)	265	.1530 (-16.31)
90	.9340 (-0.59)	270	.1710 (-15.34)
95	.9275 (-0.65)	275	.1890 (-14.47)
100	.9210 (-0.71)	280	.2070 (-13.68)
105	.9225 (-0.7)	285	.2375 (-12.49)
110	.9240 (-0.69)	290	.2680 (-11.44)
115	.9340 (-0.59)	295	.3105 (-10.16)
120	.9440 (-0.5)	300	.3530 (-9.04)
125	.9635 (-0.32)	305	.3990 (-7.98)
130	.9830 (-0.15)	310	.4450 (-7.03)
135	.9900 (-0.09)	315	.4990 (-6.04)
140	.9970 (-0.03)	320	.5530 (-5.15)
145	.9920 (-0.07)	325	.5965 (-4.49)
150	.9870 (-0.11)	330	.6400 (-3.88)
155	.9355 (-0.58)	335	.6745 (-3.42)
160	.8840 (-1.07)	340	.7090 (-2.99)
165	.7935 (-2.01)	345	.7500 (-2.5)
170	.7030 (-3.06)	350	.7910 (-2.04)
175	.6310 (-4)	355	.8340 (-1.58)

Systems With Reliability

CLIENT: *WUPJ*

Date: 8/20/2013

ANTENNA TYPE: FM3/10-0.9WS-DA

FREQUENCY: 90.9 MHz

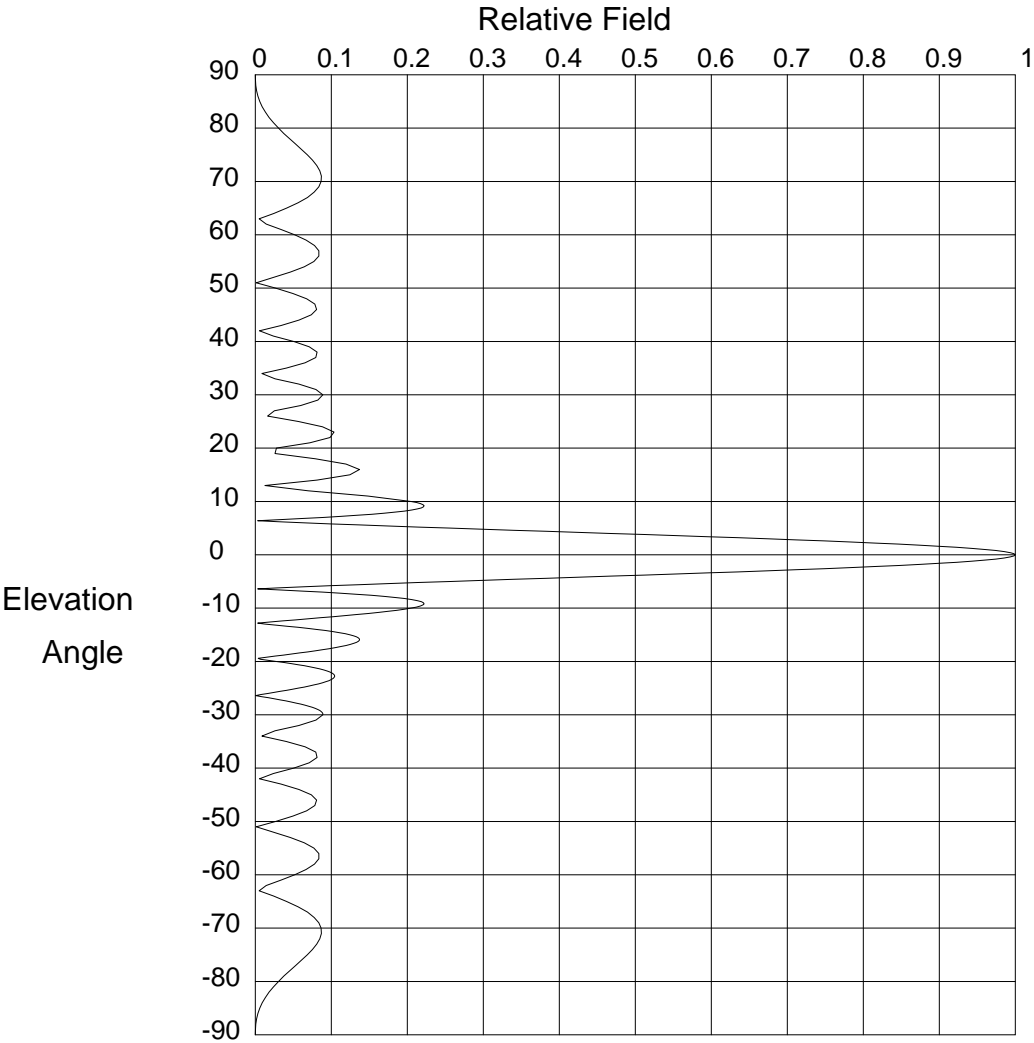
PATTERN POL.: Vertical

CIRCULARITY(+/-dB):

AZ. DIRECTIVITY: 1.87739 / 2.74dB

PATTERN RMS: 0.730

Exhibit 4: Elevation Pattern



Elevation Pattern

Systems With Reliability

Scale: Linear
Units: Field, Relative

CLIENT: <i>WUPJ</i>		Date: 8/6/2013
ANTENNA TYPE: FM3/10-CFS-0.9WS-DA		
FREQUENCY: 90.9 MHz		
PATTERN POL.: Circular		
DIRECTIVITY(Peak): 10.78/10.326 dBd	Beam Tilt (Deg.) :	0
DIRECTIVITY(Horiz): 10.78/10.326 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)
90.0	.00 (-50)	52.0	.024 (-32.552)	14.0	.081 (-21.785)
89.0	.00 (-75.86)	51.0	.001 (-56.656)	13.0	.013 (-37.94)
88.0	.001 (-62.75)	50.0	.027 (-31.474)	12.0	.07 (-23.149)
87.0	.002 (-54.787)	49.0	.05 (-26.097)	11.0	.149 (-16.563)
86.0	.004 (-48.995)	48.0	.068 (-23.405)	10.0	.205 (-13.759)
85.0	.006 (-44.433)	47.0	.079 (-22.101)	9.8	.212 (-13.468)
84.0	.009 (-40.678)	46.0	.081 (-21.853)	9.6	.217 (-13.256)
83.0	.013 (-37.501)	45.0	.074 (-22.653)	9.4	.221 (-13.122)
82.0	.018 (-34.767)	44.0	.058 (-24.797)	9.2	.222 (-13.068)
81.0	.024 (-32.388)	43.0	.034 (-29.371)	9.0	.221 (-13.095)
80.0	.031 (-30.305)	42.0	.006 (-44.974)	8.8	.219 (-13.208)
79.0	.038 (-28.477)	41.0	.024 (-32.401)	8.6	.213 (-13.412)
78.0	.045 (-26.878)	40.0	.051 (-25.869)	8.4	.206 (-13.718)
77.0	.053 (-25.486)	39.0	.071 (-22.96)	8.2	.196 (-14.138)
76.0	.061 (-24.291)	38.0	.081 (-21.785)	8.0	.184 (-14.691)
75.0	.069 (-23.285)	37.0	.08 (-21.966)	7.8	.17 (-15.403)
74.0	.075 (-22.467)	36.0	.066 (-23.646)	7.6	.153 (-16.313)
73.0	.081 (-21.841)	35.0	.041 (-27.768)	7.4	.134 (-17.484)
72.0	.085 (-21.415)	34.0	.009 (-41.223)	7.2	.112 (-19.017)
71.0	.087 (-21.205)	33.0	.026 (-31.707)	7.0	.088 (-21.103)
70.0	.087 (-21.236)	32.0	.057 (-24.824)	6.8	.062 (-24.163)
69.0	.084 (-21.545)	31.0	.08 (-21.948)	6.6	.034 (-29.47)
68.0	.078 (-22.191)	30.0	.089 (-21.008)	6.4	.003 (-49.775)
67.0	.069 (-23.273)	29.0	.082 (-21.692)	6.2	.029 (-30.73)
66.0	.056 (-24.966)	28.0	.06 (-24.448)	6.0	.063 (-23.983)
65.0	.042 (-27.638)	27.0	.025 (-32.015)	5.8	.099 (-20.083)
64.0	.024 (-32.324)	26.0	.016 (-35.69)	5.6	.136 (-17.302)
63.0	.005 (-45.645)	25.0	.057 (-24.888)	5.4	.175 (-15.131)
62.0	.015 (-36.755)	24.0	.088 (-21.067)	5.2	.215 (-13.348)
61.0	.034 (-29.379)	23.0	.104 (-19.677)	5.0	.256 (-11.834)
60.0	.052 (-25.703)	22.0	.099 (-20.127)	4.8	.298 (-10.522)
59.0	.067 (-23.487)	21.0	.072 (-22.848)	4.6	.34 (-9.367)
58.0	.078 (-22.165)	20.0	.028 (-31.077)	4.4	.383 (-8.339)
57.0	.084 (-21.536)	19.0	.026 (-31.693)	4.2	.426 (-7.416)
56.0	.084 (-21.548)	18.0	.079 (-22.034)	4.0	.469 (-6.582)
55.0	.077 (-22.247)	17.0	.12 (-18.444)	3.8	.511 (-5.826)
54.0	.064 (-23.813)	16.0	.137 (-17.261)	3.6	.553 (-5.139)
53.0	.046 (-26.714)	15.0	.125 (-18.081)	3.4	.595 (-4.512)

Systems With Reliability

Page 1 of 3

CLIENT: *WUPJ*

Date: 8/6/2013

ANTENNA TYPE: FM3/10-CFS-0.9WS-DA

FREQUENCY: 90.9 MHz

PATTERN POL.: Circular

DIRECTIVITY(Peak): 10.78/10.326 dBd

Beam Tilt (Deg.) : 0

DIRECTIVITY(Horiz): 10.78/10.326 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	.635 (-3.94)	-4.4	.383 (-8.339)	-12.0	.07 (-23.149)
3.0	.675 (-3.419)	-4.6	.34 (-9.367)	-12.2	.053 (-25.546)
2.8	.713 (-2.944)	-4.8	.298 (-10.522)	-12.4	.036 (-28.861)
2.6	.749 (-2.512)	-5.0	.256 (-11.834)	-12.6	.019 (-34.216)
2.4	.783 (-2.12)	-5.2	.215 (-13.348)	-12.8	.003 (-49.961)
2.2	.816 (-1.767)	-5.4	.175 (-15.131)	-13.0	.013 (-37.94)
2.0	.846 (-1.449)	-5.6	.136 (-17.302)	-13.2	.028 (-31.065)
1.8	.874 (-1.166)	-5.8	.099 (-20.083)	-13.4	.043 (-27.412)
1.6	.90 (-0.916)	-6.0	.063 (-23.983)	-13.6	.056 (-24.968)
1.4	.923 (-0.698)	-6.2	.029 (-30.73)	-13.8	.069 (-23.171)
1.2	.943 (-0.51)	-6.4	.003 (-49.775)	-14.0	.081 (-21.785)
1.0	.96 (-0.353)	-6.6	.034 (-29.47)	-14.2	.092 (-20.688)
.8	.974 (-0.225)	-6.8	.062 (-24.163)	-14.4	.102 (-19.806)
.6	.986 (-0.126)	-7.0	.088 (-21.103)	-14.6	.111 (-19.097)
.4	.994 (-0.056)	-7.2	.112 (-19.017)	-14.8	.118 (-18.529)
.2	.998 (-0.014)	-7.4	.134 (-17.484)	-15.0	.125 (-18.081)
.0	1.00 (0)	-7.6	.153 (-16.313)	-15.2	.13 (-17.74)
-.2	.998 (-0.014)	-7.8	.17 (-15.403)	-15.4	.133 (-17.494)
-.4	.994 (-0.056)	-8.0	.184 (-14.691)	-15.6	.136 (-17.335)
-.6	.986 (-0.126)	-8.2	.196 (-14.138)	-15.8	.137 (-17.258)
-.8	.974 (-0.225)	-8.4	.206 (-13.718)	-16.0	.137 (-17.261)
-1.0	.96 (-0.353)	-8.6	.213 (-13.412)	-16.2	.136 (-17.341)
-1.2	.943 (-0.51)	-8.8	.219 (-13.208)	-16.4	.133 (-17.497)
-1.4	.923 (-0.698)	-9.0	.221 (-13.095)	-16.6	.13 (-17.731)
-1.6	.90 (-0.916)	-9.2	.222 (-13.068)	-16.8	.125 (-18.045)
-1.8	.874 (-1.166)	-9.4	.221 (-13.122)	-17.0	.12 (-18.444)
-2.0	.846 (-1.449)	-9.6	.217 (-13.256)	-17.2	.113 (-18.933)
-2.2	.816 (-1.767)	-9.8	.212 (-13.468)	-17.4	.106 (-19.521)
-2.4	.783 (-2.12)	-10.0	.205 (-13.759)	-17.6	.097 (-20.222)
-2.6	.749 (-2.512)	-10.2	.197 (-14.132)	-17.8	.089 (-21.051)
-2.8	.713 (-2.944)	-10.4	.186 (-14.591)	-18.0	.079 (-22.034)
-3.0	.675 (-3.419)	-10.6	.175 (-15.143)	-18.2	.069 (-23.205)
-3.2	.635 (-3.94)	-10.8	.162 (-15.795)	-18.4	.059 (-24.621)
-3.4	.595 (-4.512)	-11.0	.149 (-16.563)	-18.6	.048 (-26.371)
-3.6	.553 (-5.139)	-11.2	.134 (-17.462)	-18.8	.037 (-28.616)
-3.8	.511 (-5.826)	-11.4	.119 (-18.521)	-19.0	.026 (-31.693)
-4.0	.469 (-6.582)	-11.6	.103 (-19.775)	-19.2	.015 (-36.52)
-4.2	.426 (-7.416)	-11.8	.086 (-21.285)	-19.4	.004 (-48.187)

Systems With Reliability

Page 2 of 3

CLIENT: WUPJ

Date: 8/6/2013

ANTENNA TYPE: FM3/10-CFS-0.9WS-DA

FREQUENCY: 90.9 MHz

PATTERN POL.: Circular

DIRECTIVITY(Peak): 10.78/10.326 dBd

Beam Tilt (Deg.) : 0

DIRECTIVITY(Horiz): 10.78/10.326 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	.007 (-43.12)	-27.2	.033 (-29.684)	-54.0	.064 (-23.813)
-19.8	.018 (-35.08)	-27.4	.04 (-27.918)	-55.0	.077 (-22.247)
-20.0	.028 (-31.077)	-27.6	.047 (-26.52)	-56.0	.084 (-21.548)
-20.2	.038 (-28.44)	-27.8	.054 (-25.385)	-57.0	.084 (-21.536)
-20.4	.047 (-26.507)	-28.0	.06 (-24.448)	-58.0	.078 (-22.165)
-20.6	.056 (-25.011)	-28.2	.066 (-23.67)	-59.0	.067 (-23.487)
-20.8	.064 (-23.818)	-28.4	.071 (-23.023)	-60.0	.052 (-25.703)
-21.0	.072 (-22.848)	-28.6	.075 (-22.486)	-61.0	.034 (-29.379)
-21.2	.079 (-22.055)	-28.8	.079 (-22.046)	-62.0	.015 (-36.755)
-21.4	.085 (-21.405)	-29.0	.082 (-21.692)	-63.0	.005 (-45.645)
-21.6	.09 (-20.877)	-29.2	.085 (-21.417)	-64.0	.024 (-32.324)
-21.8	.095 (-20.455)	-29.4	.087 (-21.215)	-65.0	.042 (-27.638)
-22.0	.099 (-20.127)	-29.6	.088 (-21.081)	-66.0	.056 (-24.966)
-22.2	.101 (-19.885)	-29.8	.089 (-21.013)	-67.0	.069 (-23.273)
-22.4	.103 (-19.722)	-30.0	.089 (-21.008)	-68.0	.078 (-22.191)
-22.6	.104 (-19.635)	-31.0	.08 (-21.948)	-69.0	.084 (-21.545)
-22.8	.104 (-19.62)	-32.0	.057 (-24.824)	-70.0	.087 (-21.236)
-23.0	.104 (-19.677)	-33.0	.026 (-31.707)	-71.0	.087 (-21.205)
-23.2	.102 (-19.805)	-34.0	.009 (-41.223)	-72.0	.085 (-21.415)
-23.4	.10 (-20.005)	-35.0	.041 (-27.768)	-73.0	.081 (-21.841)
-23.6	.097 (-20.279)	-36.0	.066 (-23.646)	-74.0	.075 (-22.467)
-23.8	.093 (-20.632)	-37.0	.08 (-21.966)	-75.0	.069 (-23.285)
-24.0	.088 (-21.067)	-38.0	.081 (-21.785)	-76.0	.061 (-24.291)
-24.2	.083 (-21.594)	-39.0	.071 (-22.96)	-77.0	.053 (-25.486)
-24.4	.077 (-22.222)	-40.0	.051 (-25.869)	-78.0	.045 (-26.878)
-24.6	.071 (-22.965)	-41.0	.024 (-32.401)	-79.0	.038 (-28.477)
-24.8	.064 (-23.844)	-42.0	.006 (-44.974)	-80.0	.031 (-30.305)
-25.0	.057 (-24.888)	-43.0	.034 (-29.371)	-81.0	.024 (-32.388)
-25.2	.049 (-26.138)	-44.0	.058 (-24.797)	-82.0	.018 (-34.767)
-25.4	.041 (-27.662)	-45.0	.074 (-22.653)	-83.0	.013 (-37.501)
-25.6	.033 (-29.573)	-46.0	.081 (-21.853)	-84.0	.009 (-40.678)
-25.8	.025 (-32.086)	-47.0	.079 (-22.101)	-85.0	.006 (-44.433)
-26.0	.016 (-35.69)	-48.0	.068 (-23.405)	-86.0	.004 (-48.995)
-26.2	.008 (-42.002)	-49.0	.05 (-26.097)	-87.0	.002 (-54.787)
-26.4	.001 (-65.786)	-50.0	.027 (-31.474)	-88.0	.001 (-62.75)
-26.6	.009 (-41.036)	-51.0	.001 (-56.656)	-89.0	.00 (-75.86)
-26.8	.017 (-35.349)	-52.0	.024 (-32.552)	-90.0	.00 (-50)
-27.0	.025 (-32.015)	-53.0	.046 (-26.714)	90.0	.00 (-50)

Systems With Reliability

Page 3 of 3

CLIENT: *WUPJ*

Date: 8/6/2013

ANTENNA TYPE: FM3/10-CFS-0.9WS-DA

FREQUENCY: 90.9 MHz

PATTERN POL.: Circular

DIRECTIVITY(Peak): 10.78/10.326 dBd

Beam Tilt (Deg.) : 0

DIRECTIVITY(Horiz): 10.78/10.326 dBd

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

Exhibit 5: Antenna Data Sheet



SYSTEMS WITH RELIABILITY, LLP
BROADCAST ANTENNAS AND TRANSMISSION LINE
SYSTEM DATA SHEET

Customer	WUPJ
Contact	David Bolduc
Location	Escanaba, MI
Antenna Model	FM3/10-CFS-0.9WS-DA
Channel / Frequency	215C1 / 90.9 MHz

ELECTRICAL SPECIFICATIONS

Antenna Specifications:

	H-POL			V. Pol.	
		dB			dB
License ERP (KW)	100.000			100.000	
FCC Limit Pattern Directivity	1.697	2.297	dB	1.697	2.297 dB
Elevation Directivity	10.780	10.326	dB	10.780	10.326 dB
Azimuth Directivity	2.492	3.965	dB	1.877	2.736 dB
Composite Pattern	1.783	2.510	dB	1.783	2.510 dB
Polarization Ratio	0.430			0.570	
RMS Comp./RMS Limit	97.6 %				
Antenna Efficiency %	100			100	
Power Ratio (Pol. Ratio X Efficiency)	0.4297			0.5703	
Antenna Gain	11.542	10.623	dB	11.542	10.623 dB

Antenna Input Power (KW)	8.664 kW	9.377 (dBK)
---------------------------------	----------	-------------

Feed Line Specifications:

Line Type:Cablewave	3 1/8" Air	50 Ω	HCA300-50J
Attenuation Per 100 ft (dB)	0.13	dB	
Line Length (ft) AGL + 20' Horizontal Run	265.06	ft.	
Total Line Attenuation (dB)	0.3446	dB	
Line Efficiency	92.37	%	
Power Input to the Line (KW)	9.379 kW	9.722 (dBK)	

MECHANICAL SPECIFICATIONS

No. Of Bays	10		
Antenna Aperture	87.65	ft.	26.72 meter
Center of Radiation AGL	245.06	ft.	74.69 meter
Antenna Weight (Everything)	1050.00	lbs.	404.55 kg
Windload (50/33)	2720.00	lbs.	Windload CaAc 78.40 ft^2

Prepared by:

David K. Edmiston Jr.

David K. Edmiston Jr.
 SWR, LLP

Exhibit 6: RMS Calculations



SYSTEMS WITH RELIABILITY, INC.
Broadcast Antennas and Transmission Systems

WUPJ Antenna RMS Comparison

PROPOSED ANTENNA

Azimuth Heading	Relative Field
0	1.000
10	1.000
20	1.000
30	1.000
40	1.000
50	1.000
60	1.000
70	1.000
80	1.000
90	1.000
100	1.000
110	1.000
120	1.000
130	1.000
140	1.000
150	1.000
160	0.885
170	0.703
180	0.559
190	0.444
200	0.353
210	0.281
220	0.224
230	0.178
240	0.178
250	0.178
260	0.178
270	0.178
280	0.224
290	0.281
300	0.353
310	0.445
320	0.560
330	0.704
340	0.886
350	1.000

Sum of Relative Field Squared : 21.245
Sum Divided by 36 (Readings) : 0.590
Square Root : 0.768

DESIGNED ANTENNA

Azimuth Heading	Relative Field
0	1.000
10	0.972
20	0.989
30	1.000
40	0.991
50	0.983
60	0.974
70	0.958
80	0.948
90	0.934
100	0.921
110	0.924
120	0.944
130	0.983
140	0.997
150	0.987
160	0.884
170	0.703
180	0.559
190	0.444
200	0.353
210	0.281
220	0.224
230	0.178
240	0.178
250	0.178
260	0.178
270	0.178
280	0.224
290	0.281
300	0.353
310	0.445
320	0.560
330	0.704
340	0.886
350	0.974

Sum of Relative Field Squared : 20.229
Sum Divided by 36 (Readings) : 0.562
Square Root : 0.750

Percentage of Construction Permit Antenna Filled :

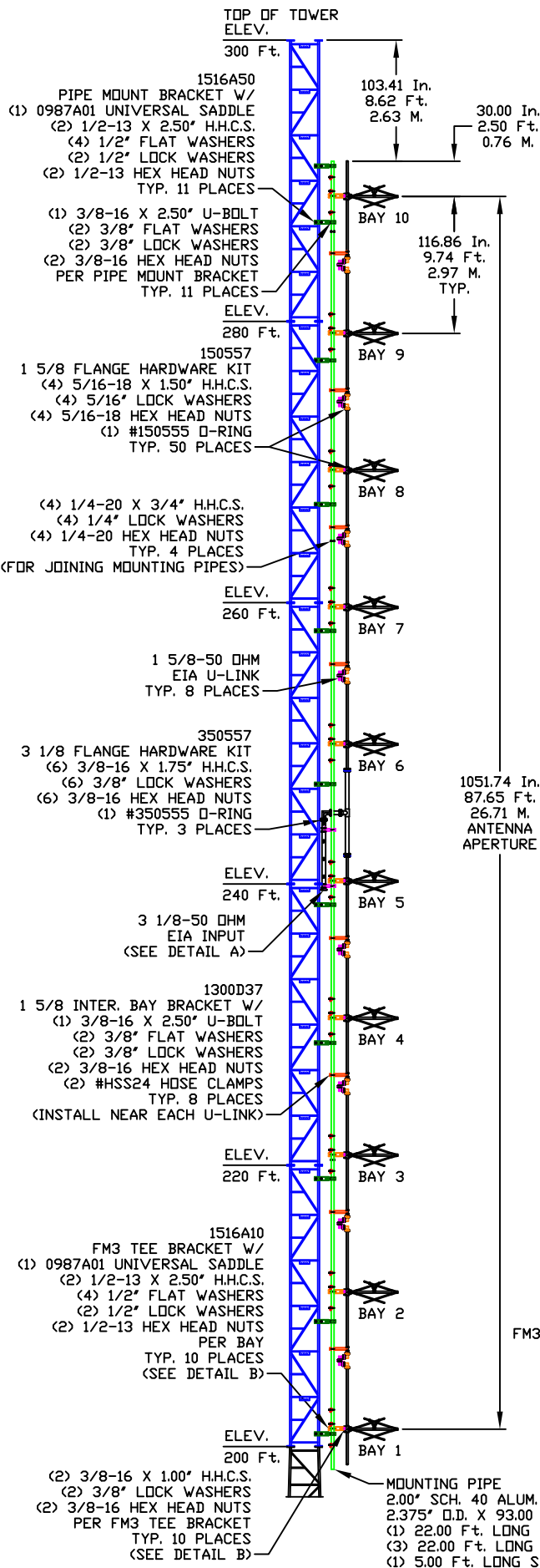
97.6%

NOTES:

1. REFERENCE DWG. 1835D01R FOR ANTENNA ORIENTATION.
2. REFERENCE DWG. 1835D02R FOR PARASITIC PLACEMENT.

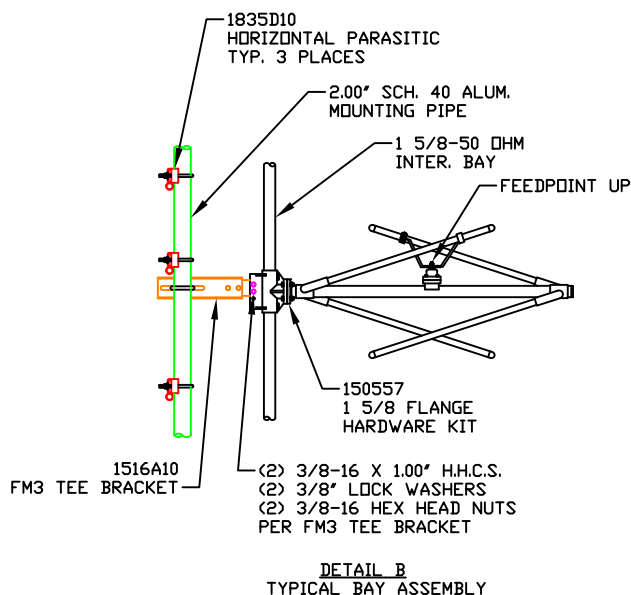
Exhibit 7: Drawings

DRAWING NUMBER: 1835D00R



1051.74 In.
87.65 Ft.
26.71 M.
ANTENNA
APERTURE

CENTER OF
RADIATION
245.06 Ft. AGL
(74.69 M.)



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

TITLE: FM3/10-CFS-0.9WS-DA, FREQ. 90.9
WUPJ, ESCANABA, MI

MATERIAL:

SIZE REV APPR. DATE

1			
2			
3			

ENGINEER:

SCALE: NTS

NAME: RAC

DATE: 12/13/13

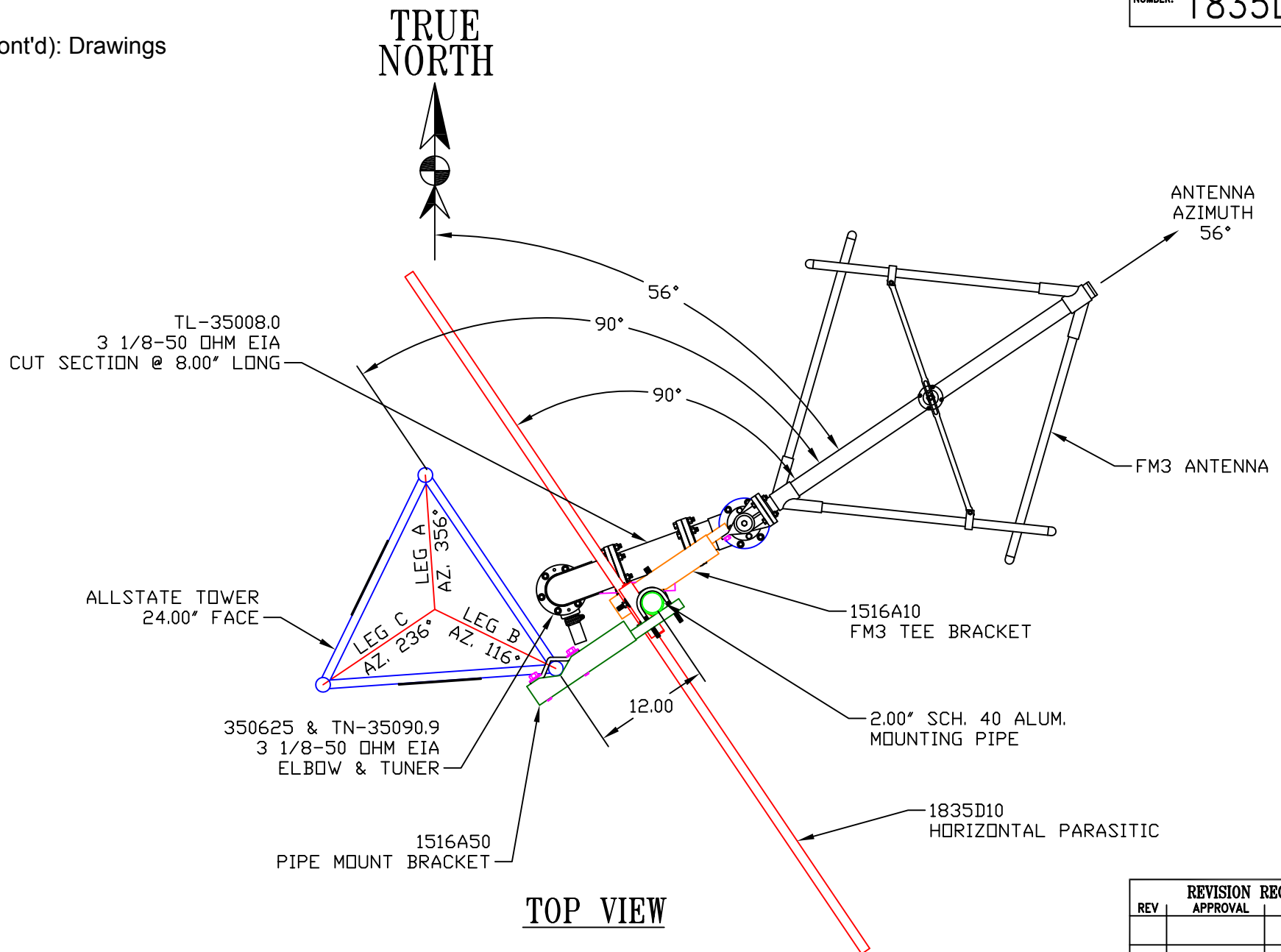
SHEET

1 OF 1

DRAWING NUMBER: 1835D00R

NOTE:
Exhibit 7 (cont'd): Drawings

DRAWING
NUMBER: 1835D01R



REVISION RECORD		
REV	APPROVAL	DATE
DRAWING NUMBER: 1835D01R		
SCALE: NTS	NAME: RAC	DATE: 12/13/13 SHEET 1 OF 1



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

TITLE: FM3/10-CFS-0.9WS-DA, FREQ. 90.9
WUPJ, ESCANABA, MI
MATERIAL: ANTENNA ORIENTATION
FROM TRUE NORTH

SIZE
A

PARTS MADE BY THIS DRAWING

DATE: 12/13/13 SHEET 1 OF 1

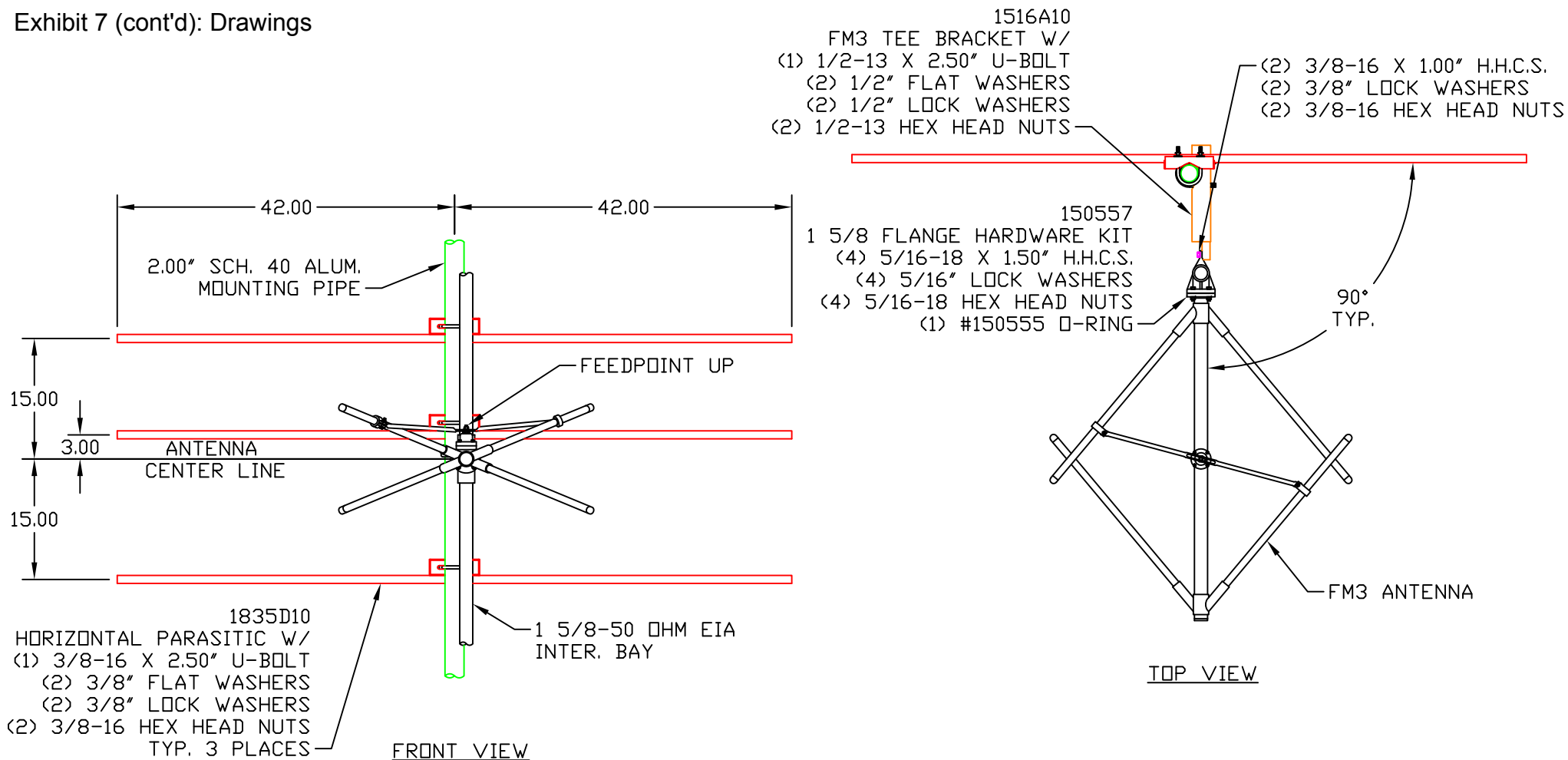
NOTE:

THIS ASSEMBLY IS TYPICAL FOR ALL BAYS.

DRAWING
NUMBER:

1835D02R

Exhibit 7 (cont'd): Drawings



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

TITLE:

FM3/10-CFS-0.9WS-DA, FREQ. 90.9
WUPJ, ESCANABA, MI

MATERIAL:

PARASITIC
PLACEMENT

SIZE

A

PARTS MADE BY THIS DRAWING

SCALE: NTS

NAME: RAC

DATE: 12/13/13

SHEET 1 OF 1

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

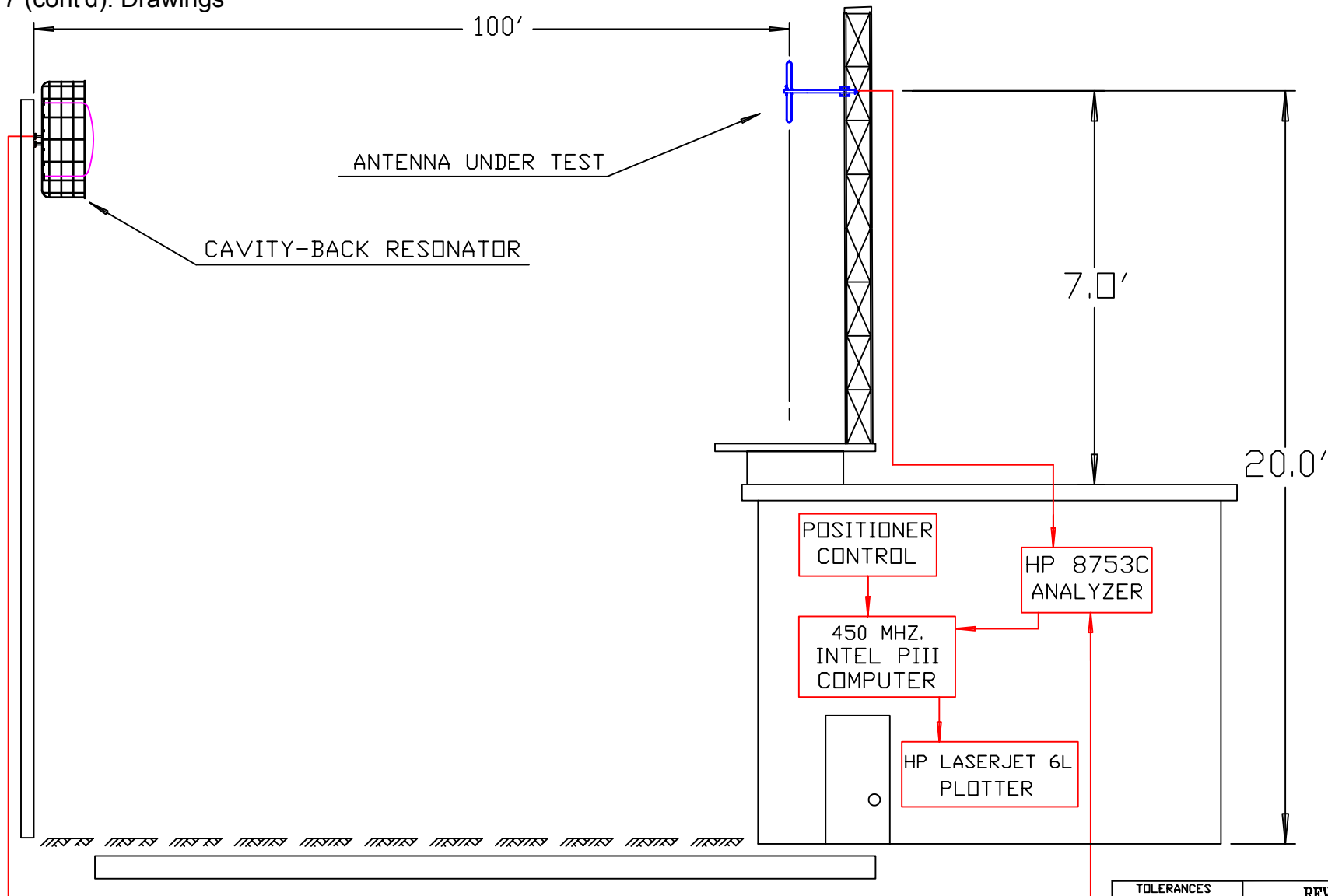
REVISION RECORD		
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NOTE:

Exhibit 7 (cont'd): Drawings

DRAWING
NUMBER:

2105A10



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

REVISION RECORD		
REV	APPROVAL	DATE
2		10/7/05
1		4/30/02



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

TITLE:

TEST RANGE SCHEMATIC

MATERIAL:

SIZE

A

PARTS MADE BY THIS DRAWING

SCALE: NTS

NAME: JRM

DATE: 11/1/98

SHEET 1 OF 1

DRAWING
NUMBER:

2105A10