



**SYSTEMS WITH RELIABILITY, LLP**  
**BROADCAST ANTENNAS AND TRANSMISSION LINE**

## **PATTERN CERTIFICATION**

### **DIRECTIONAL FM ANTENNA**

**WBHL**

**September 13, 2012**

<b>Call Sign</b>	:	WBHL
<b>Location</b>	:	Harrison, MI
<b>Frequency</b>	:	90.7 MHz
<b>Channel</b>	:	214C3
<b>Antenna Model</b>	:	FM3/4-DA
<b>Maximum Antenna Gain</b>	:	
<b>Horizontal</b>	:	<b>4.343 / 6.378 dB</b>
<b>Vertical</b>	:	<b>4.343 / 6.378 dB</b>

### **ANTENNA DESCRIPTION**

A custom designed **FM3/4-DA** antenna was used to produce the required directional azimuth pattern. Each antenna bay consists of a circularly polarized cross-V dipole-radiating element. The array is comprised of four bays, that are spaced a wavelength apart, mounted to a 2.0" schedule 40 support pipe and mounted to a 36 inch face Stellar tower pointing 255 degrees true north.

### **DESCRIPTION OF TEST PROCEDURE**

The test antenna consists of a single bay third-scale model antenna. This antenna was mounted to a third scaled pipe attached to an exact replicated third scale model Stellar tower with the use of mounting brackets supplied with the finalized antenna. The tower was placed on a 20 ft. high platform. All feed cables are properly grounded during pattern testing. The azimuth pattern was achieved by placing horizontal parasitics behind the antenna and adjusting the separation distance of the antenna from the tower.

The source antenna, a vertical/horizontal dipole Cavity Back Resonator antenna configuration was mounted approximately 100 feet from the test antenna. The source's height was adjusted to provide a uniform field at the test antenna location. The CBR antenna was operated in the transmit mode at a frequency of 272.1 MHz. The antenna under test was rotated in a clockwise direction. A gain reference was taken using a dipole tuned to 272.1 MHz. Nowhere, does the received signal exceed a maximum to minimum ratio of 15 dB.

## TEST RESULTS

The attached calculations verify that the **RMS** value of this antenna is **95.9%** of the **RMS** value of the pattern authorized in the related construction permit **BPED-20120131ALK**. The vertical component **RMS** value is **0.694**. The horizontal component **RMS** value is **0.678**. The circular polarized component **RMS** value is **0.815**.

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

<b>Measured vertical polarized directivity:</b>	<b>2.078 / 3.180 dB</b>
<b>Measured horizontal polarized directivity:</b>	<b>2.174 / 3.370 dB</b>
<b>Measured circular polarized pattern directivity:</b>	<b>1.507 / 1.780 dB</b>

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:

<b>V-Pol. Gain</b>	<b>= (2.078)(.511)(4.088)</b>	<b>= 4.343 / 6.378 dB</b>
<b>H-Pol. Gain</b>	<b>= (2.174)(.489)(4.088)</b>	<b>= 4.343 / 6.378 dB</b>

## INSTALLATION AND MOUNTING

The antenna is to be mounted in accordance with the supplied drawings. The antenna center of radiation is to be **130 meters (426.53 ft.)** above ground level. The antenna aperture is **32.53 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 **255 degrees** true North.

The parasitic system is custom designed to shape and direct the antenna pattern as required. The systems orientation and the mounting details are described in the following drawings:

<b>DRAWING NO.</b>	<b>TITLE</b>
1730D00	ELEVATION
1730D01	ANTENNA ORIENTATION
1730D02	PARASITIC PLACEMENT BAYS 1-3
1730D03	PARASITIC PLACEMENT BAY 4 & TOP OF POLE
2105A10	TEST RANGE SCHEMATIC

The array shall be mounted according to **DWG. 1730D00**. The antenna elements shall be aligned at the same heading as in **DWG. 1730D01**. This will ensure that the antenna is oriented properly at 255 degrees true north. **DWG. 1730D02-03** show how the parasitics will be placed behind the antenna bays. The test range schematic 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:


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

## TEST EQUIPMENT

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

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

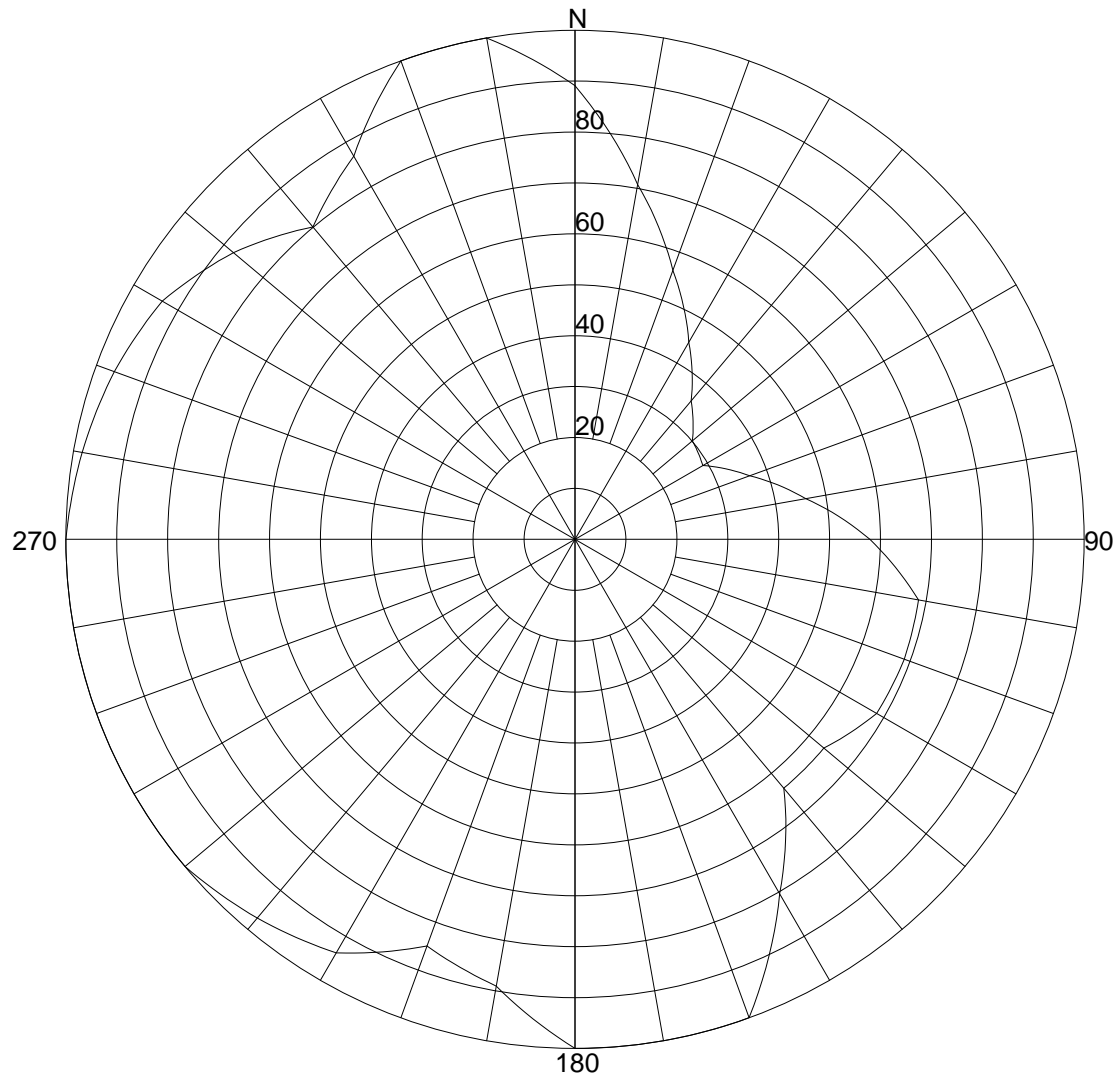
Prepared by:



---

**Mark A. Gergely**  
Electrical Engineer  
Systems With Reliability LLP

## Exhibit 1: Circular Polarized Azimuth Pattern (Composite)



### Azimuth Pattern

Scale: Linear

Unit: Relative Field

## Systems With Reliability

CLIENT: *WBHL*

Date: 8/28/2012

ANTENNA TYPE: FM3/4-DA

FREQUENCY: 90.7 MHz

PATTERN POL.: Circular

CIRCULARITY(+/-dB):

AZ. DIRECTIVITY: 1.50669 / 1.78dB

PATTERN RMS: 0.815

## Exhibit 1 (cont'd): Circular Polarized Azimuth Pattern Tabulations

### Relative Field Tabulation(Azimuth)

Azimuth Heading	Relative Field(dB)	Azimuth Heading	Relative Field(dB)
0	.8910 (-0.99 )	180	1.0000 ( 0.01 )
5	.7995 (-1.93 )	185	.9455 (-0.48 )
10	.7080 (-2.99 )	190	.8910 (-0.99 )
15	.6350 (-3.93 )	195	.8705 (-1.19 )
20	.5620 (-4.99 )	200	.8500 (-1.4 )
25	.5045 (-5.93 )	205	.8940 (-0.96 )
30	.4470 (-6.97 )	210	.9380 (-0.55 )
35	.4010 (-7.92 )	215	.9545 (-0.4 )
40	.3550 (-8.97 )	220	.9710 (-0.25 )
45	.3280 (-9.66 )	225	.9855 (-0.12 )
50	.3010 (-10.4 )	230	1.0000 ( 0.01 )
55	.2955 (-10.56 )	235	1.0000 ( 0.01 )
60	.2900 (-10.72 )	240	1.0000 ( 0.01 )
65	.3275 (-9.67 )	245	1.0000 ( 0.01 )
70	.3650 (-8.73 )	250	1.0000 ( 0.01 )
75	.4125 (-7.67 )	255	1.0000 ( 0.01 )
80	.4600 (-6.73 )	260	1.0000 ( 0.01 )
85	.5195 (-5.67 )	265	1.0000 ( 0.01 )
90	.5790 (-4.73 )	270	1.0000 ( 0.01 )
95	.6320 (-3.97 )	275	.9915 (-0.07 )
100	.6850 (-3.27 )	280	.9830 (-0.14 )
105	.6865 (-3.25 )	285	.9730 (-0.23 )
110	.6880 (-3.24 )	290	.9630 (-0.32 )
115	.6860 (-3.26 )	295	.9495 (-0.44 )
120	.6840 (-3.29 )	300	.9360 (-0.57 )
125	.6610 (-3.58 )	305	.9060 (-0.85 )
130	.6380 (-3.89 )	310	.8760 (-1.14 )
135	.6380 (-3.89 )	315	.8385 (-1.52 )
140	.6380 (-3.89 )	320	.8010 (-1.92 )
145	.7210 (-2.83 )	325	.8350 (-1.56 )
150	.8040 (-1.88 )	330	.8690 (-1.21 )
155	.9020 (-0.89 )	335	.9345 (-0.58 )
160	1.0000 ( 0.01 )	340	1.0000 ( 0.01 )
165	1.0000 ( 0.01 )	345	1.0000 ( 0.01 )
170	1.0000 ( 0.01 )	350	1.0000 ( 0.01 )
175	1.0000 ( 0.01 )	355	.9455 (-0.48 )

### Systems With Reliability

CLIENT: *WBHL*

Date: 8/28/2012

ANTENNA TYPE: FM3/4-DA

FREQUENCY: 90.7 MHz

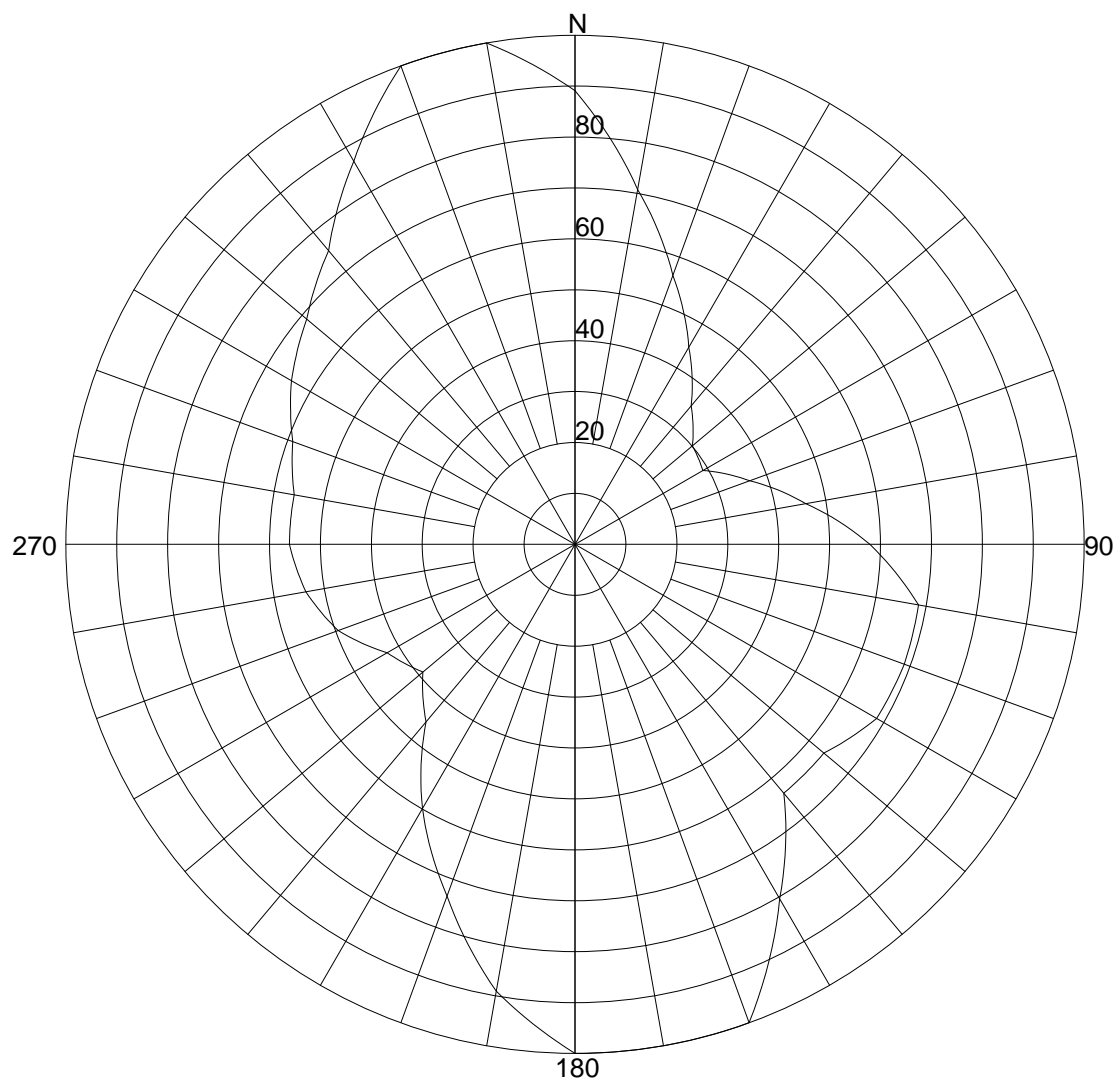
PATTERN POL.: Circular

CIRCULARITY(+/-dB):

AZ. DIRECTIVITY: 1.50669 / 1.78dB

PATTERN RMS: 0.815

## Exhibit 2: Measured Horizontal Polarized Azimuth Pattern



### Azimuth Pattern

## Systems With Reliability

Scale: Linear

Unit: Relative Field

CLIENT: *WBHL*

Date: 8/28/2012

ANTENNA TYPE: FM3/4-DA

FREQUENCY: 90.7 MHz

PATTERN POL.: Horizontal

CIRCULARITY(+/-dB):

AZ. DIRECTIVITY: 2.17383 / 3.37dB

PATTERN RMS: 0.678

## Relative Field Tabulation(Azimuth)

Azimuth Heading	Relative Field(dB)	Azimuth Heading	Relative Field(dB)
0	.8910 (-0.99 )	180	1.0000 ( 0.01 )
5	.7995 (-1.93 )	185	.9455 (-0.48 )
10	.7080 (-2.99 )	190	.8910 (-0.99 )
15	.6350 (-3.93 )	195	.8130 (-1.79 )
20	.5620 (-4.99 )	200	.7350 (-2.66 )
25	.5045 (-5.93 )	205	.6670 (-3.5 )
30	.4470 (-6.97 )	210	.5990 (-4.44 )
35	.4010 (-7.92 )	215	.5270 (-5.55 )
40	.3550 (-8.97 )	220	.4550 (-6.82 )
45	.3280 (-9.66 )	225	.4225 (-7.46 )
50	.3010 (-10.4 )	230	.3900 (-8.16 )
55	.2955 (-10.56 )	235	.4080 (-7.77 )
60	.2900 (-10.72 )	240	.4260 (-7.39 )
65	.3275 (-9.67 )	245	.4605 (-6.72 )
70	.3650 (-8.73 )	250	.4950 (-6.09 )
75	.4125 (-7.67 )	255	.5160 (-5.73 )
80	.4600 (-6.73 )	260	.5370 (-5.38 )
85	.5195 (-5.67 )	265	.5490 (-5.19 )
90	.5790 (-4.73 )	270	.5610 (-5.01 )
95	.6320 (-3.97 )	275	.5605 (-5.01 )
100	.6850 (-3.27 )	280	.5600 (-5.02 )
105	.6865 (-3.25 )	285	.5750 (-4.79 )
110	.6880 (-3.24 )	290	.5900 (-4.57 )
115	.6860 (-3.26 )	295	.6165 (-4.19 )
120	.6840 (-3.29 )	300	.6430 (-3.82 )
125	.6610 (-3.58 )	305	.6655 (-3.52 )
130	.6380 (-3.89 )	310	.6880 (-3.24 )
135	.6380 (-3.89 )	315	.7205 (-2.84 )
140	.6380 (-3.89 )	320	.7530 (-2.45 )
145	.7210 (-2.83 )	325	.8110 (-1.81 )
150	.8040 (-1.88 )	330	.8690 (-1.21 )
155	.9020 (-0.89 )	335	.9345 (-0.58 )
160	1.0000 ( 0.01 )	340	1.0000 ( 0.01 )
165	1.0000 ( 0.01 )	345	1.0000 ( 0.01 )
170	1.0000 ( 0.01 )	350	1.0000 ( 0.01 )
175	1.0000 ( 0.01 )	355	.9455 (-0.48 )

## Systems With Reliability

CLIENT: *WBHL*

Date: 8/28/2012

ANTENNA TYPE: FM3/4-DA

FREQUENCY: 90.7 MHz

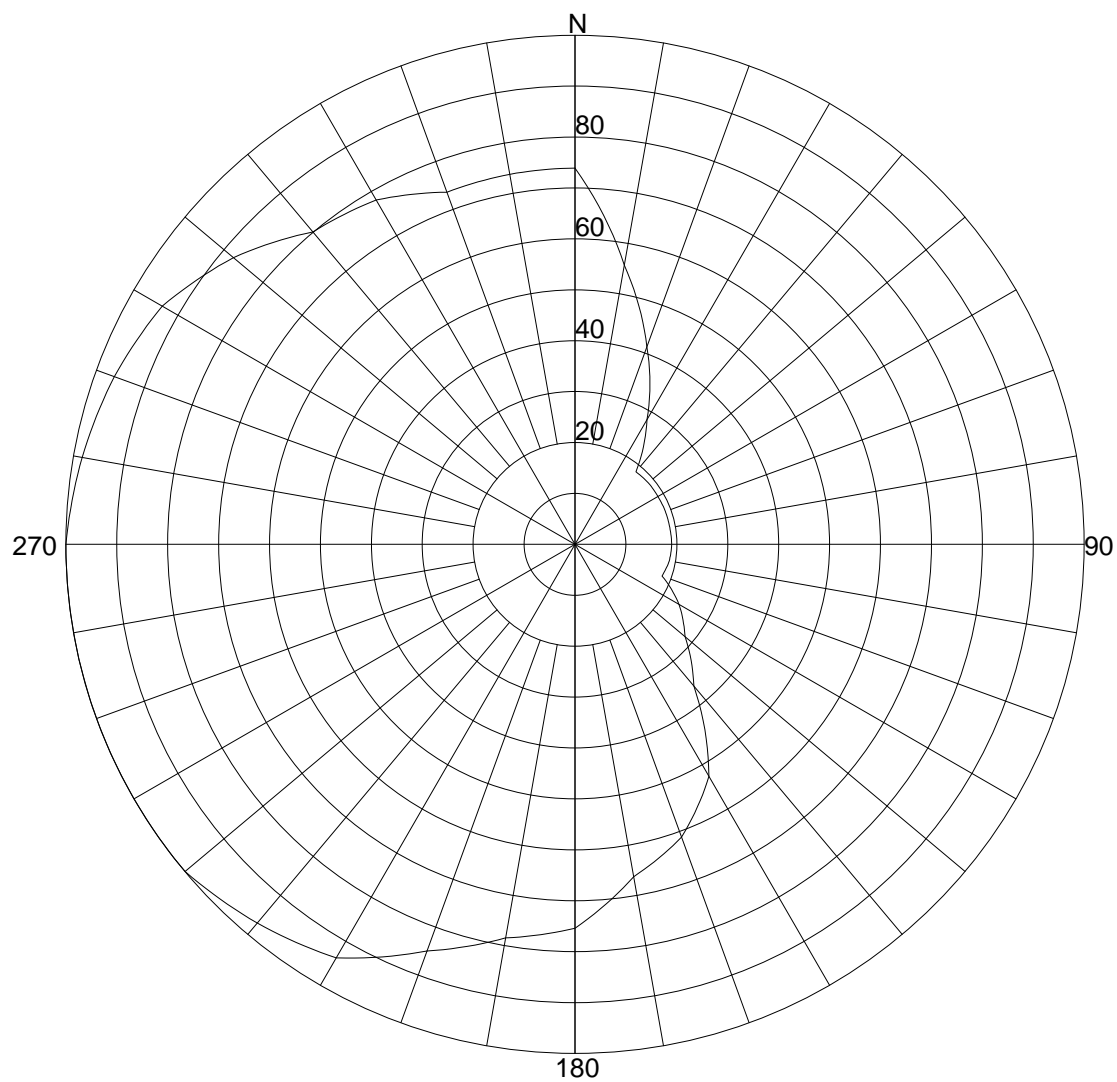
PATTERN POL.: Horizontal

CIRCULARITY(+/-dB):

AZ. DIRECTIVITY: 2.17383 / 3.37dB

PATTERN RMS: 0.678

## Exhibit 3: Measured Vertical Polarized Azimuth Pattern



### Azimuth Pattern

## Systems With Reliability

Scale: Linear

Unit: Relative Field

CLIENT: *WBHL*

Date: 8/28/2012

ANTENNA TYPE: FM3/4-DA

FREQUENCY: 90.7 MHz

PATTERN POL.: Vertical

CIRCULARITY(+/-dB):

AZ. DIRECTIVITY: 2.07805 / 3.18dB

PATTERN RMS: 0.694



## Relative Field Tabulation(Azimuth)

Azimuth Heading	Relative Field(dB)	Azimuth Heading	Relative Field(dB)
0	.7390 (-2.62 )	180	.7540 (-2.44 )
5	.6480 (-3.76 )	185	.7695 (-2.26 )
10	.5570 (-5.07 )	190	.7850 (-2.09 )
15	.4850 (-6.27 )	195	.8175 (-1.74 )
20	.4130 (-7.66 )	200	.8500 (-1.4 )
25	.3480 (-9.14 )	205	.8940 (-0.96 )
30	.2830 (-10.93 )	210	.9380 (-0.55 )
35	.2345 (-12.56 )	215	.9545 (-0.4 )
40	.1860 (-14.56 )	220	.9710 (-0.25 )
45	.1870 (-14.52 )	225	.9855 (-0.12 )
50	.1880 (-14.47 )	230	1.0000 ( 0.01 )
55	.1880 (-14.47 )	235	1.0000 ( 0.01 )
60	.1880 (-14.47 )	240	1.0000 ( 0.01 )
65	.1885 (-14.45 )	245	1.0000 ( 0.01 )
70	.1890 (-14.42 )	250	1.0000 ( 0.01 )
75	.1890 (-14.42 )	255	1.0000 ( 0.01 )
80	.1890 (-14.42 )	260	1.0000 ( 0.01 )
85	.1895 (-14.4 )	265	1.0000 ( 0.01 )
90	.1900 (-14.38 )	270	1.0000 ( 0.01 )
95	.1890 (-14.42 )	275	.9915 (-0.07 )
100	.1880 (-14.47 )	280	.9830 (-0.14 )
105	.1850 (-14.61 )	285	.9730 (-0.23 )
110	.1820 (-14.75 )	290	.9630 (-0.32 )
115	.2090 (-13.56 )	295	.9495 (-0.44 )
120	.2360 (-12.51 )	300	.9360 (-0.57 )
125	.2590 (-11.7 )	305	.9060 (-0.85 )
130	.2820 (-10.96 )	310	.8760 (-1.14 )
135	.3225 (-9.8 )	315	.8385 (-1.52 )
140	.3630 (-8.78 )	320	.8010 (-1.92 )
145	.4445 (-7.02 )	325	.7910 (-2.03 )
150	.5260 (-5.56 )	330	.7810 (-2.14 )
155	.5690 (-4.88 )	335	.7585 (-2.39 )
160	.6120 (-4.25 )	340	.7360 (-2.65 )
165	.6375 (-3.9 )	345	.7370 (-2.64 )
170	.6630 (-3.56 )	350	.7380 (-2.63 )
175	.7085 (-2.98 )	355	.7385 (-2.62 )

## Systems With Reliability

CLIENT: *WBHL*

Date: 8/28/2012

ANTENNA TYPE: FM3/4-DA

FREQUENCY: 90.7 MHz

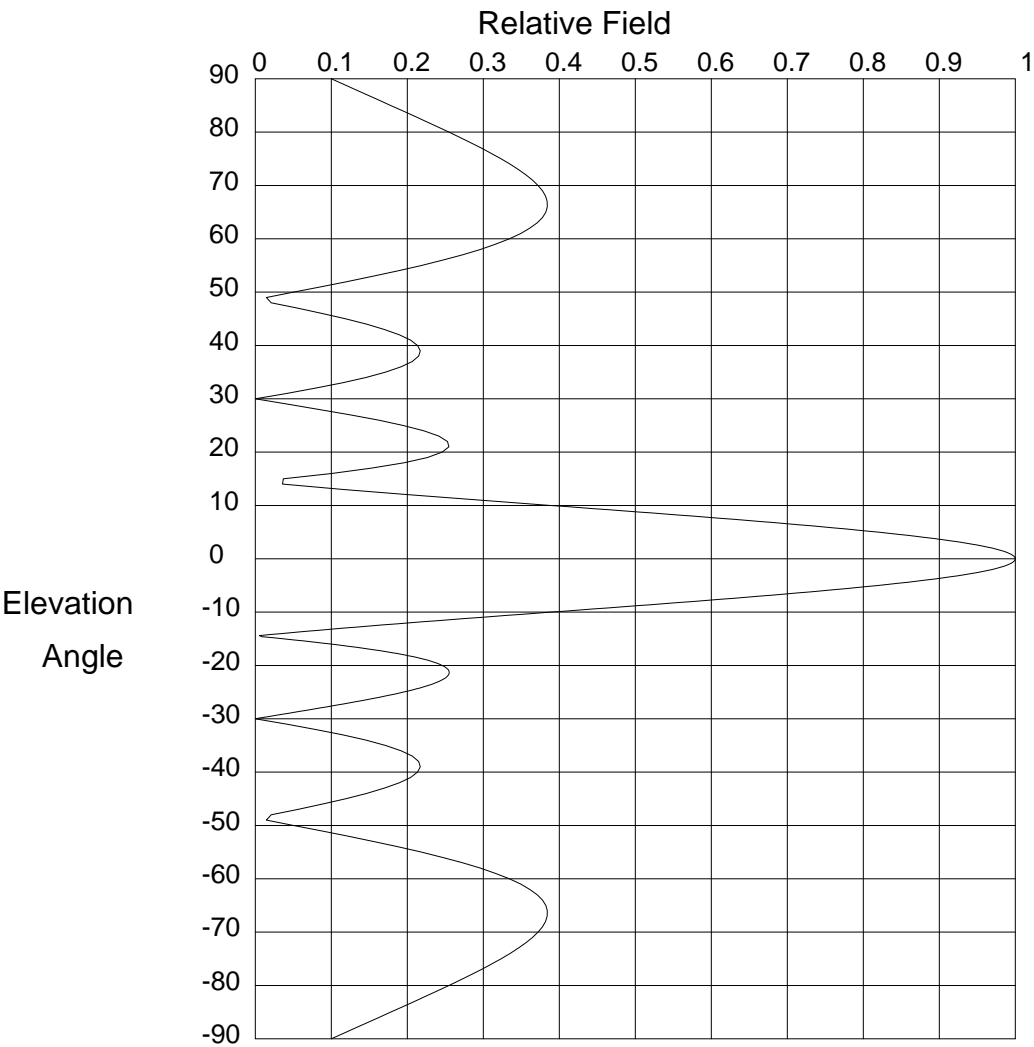
PATTERN POL.: Vertical

CIRCULARITY(+/-dB):

AZ. DIRECTIVITY: 2.07805 / 3.18dB

PATTERN RMS: 0.694

Exhibit 4: Elevation Pattern



Elevation Pattern

Systems With Reliability

Scale: Linear  
Units: Field, Relative

CLIENT: <i>WBHL</i>		Date: 9/11/2012
ANTENNA TYPE: FM3/4-DA		
FREQUENCY: 90.7 MHz		
PATTERN POL.: Circular		
DIRECTIVITY(Peak): 4.088/6.115 dBd	Beam Tilt (Deg.) :	0
DIRECTIVITY(Horiz): 4.088/6.115 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	.10 (-20)	52.0	.122 (-18.296)	14.0	.036 (-28.925 )
89.0	.116 (-18.733)	51.0	.087 (-21.259)	13.0	.116 (-18.677 )
88.0	.131 (-17.628)	50.0	.051 (-25.907)	12.0	.203 (-13.829 )
87.0	.147 (-16.648)	49.0	.015 (-36.679)	11.0	.295 (-10.601 )
86.0	.163 (-15.769)	48.0	.021 (-33.591)	10.0	.389 (-8.198 )
85.0	.178 (-14.973)	47.0	.055 (-25.123)	9.8	.408 (-7.785 )
84.0	.194 (-14.247)	46.0	.088 (-21.083)	9.6	.427 (-7.391 )
83.0	.209 (-13.581)	45.0	.119 (-18.507)	9.4	.446 (-7.015 )
82.0	.225 (-12.967)	44.0	.146 (-16.7)	9.2	.465 (-6.656 )
81.0	.24 (-12.4)	43.0	.17 (-15.39)	9.0	.484 (-6.311 )
80.0	.255 (-11.875)	42.0	.19 (-14.446)	8.8	.502 (-5.981 )
79.0	.269 (-11.39)	41.0	.204 (-13.798)	8.6	.521 (-5.665 )
78.0	.284 (-10.941)	40.0	.214 (-13.409)	8.4	.539 (-5.362 )
77.0	.298 (-10.528)	39.0	.217 (-13.261)	8.2	.558 (-5.071 )
76.0	.311 (-10.149)	38.0	.215 (-13.353)	8.0	.576 (-4.792 )
75.0	.323 (-9.803)	37.0	.207 (-13.7)	7.8	.594 (-4.524 )
74.0	.335 (-9.491)	36.0	.192 (-14.331)	7.6	.612 (-4.266 )
73.0	.346 (-9.212)	35.0	.172 (-15.306)	7.4	.63 (-4.019 )
72.0	.356 (-8.968)	34.0	.146 (-16.728)	7.2	.647 (-3.782 )
71.0	.365 (-8.759)	33.0	.115 (-18.8)	7.0	.664 (-3.554 )
70.0	.372 (-8.587)	32.0	.08 (-21.983)	6.8	.681 (-3.335 )
69.0	.378 (-8.453)	31.0	.041 (-27.75)	6.6	.698 (-3.125 )
68.0	.382 (-8.359)	30.0	.00 (-50)	6.4	.714 (-2.924 )
67.0	.384 (-8.309)	29.0	.042 (-27.509)	6.2	.73 (-2.731 )
66.0	.384 (-8.305)	28.0	.084 (-21.504)	6.0	.746 (-2.546 )
65.0	.382 (-8.352)	27.0	.125 (-18.095)	5.8	.761 (-2.368 )
64.0	.378 (-8.452)	26.0	.162 (-15.813)	5.6	.776 (-2.199 )
63.0	.371 (-8.611)	25.0	.195 (-14.205)	5.4	.791 (-2.036 )
62.0	.362 (-8.836)	24.0	.222 (-13.076)	5.2	.805 (-1.881 )
61.0	.349 (-9.134)	23.0	.242 (-12.335)	5.0	.819 (-1.733 )
60.0	.334 (-9.515)	22.0	.253 (-11.938)	4.8	.833 (-1.591 )
59.0	.317 (-9.989)	21.0	.255 (-11.878)	4.6	.846 (-1.457 )
58.0	.296 (-10.571)	20.0	.246 (-12.177)	4.4	.858 (-1.329 )
57.0	.273 (-11.282)	19.0	.226 (-12.899)	4.2	.87 (-1.207 )
56.0	.247 (-12.148)	18.0	.196 (-14.173)	4.0	.882 (-1.092 )
55.0	.219 (-13.205)	17.0	.153 (-16.282)	3.8	.893 (-0.983 )
54.0	.188 (-14.511)	16.0	.10 (-19.974)	3.6	.904 (-0.88 )
53.0	.156 (-16.155)	15.0	.037 (-28.661)	3.4	.914 (-0.783 )

## Systems With Reliability

Page 1 of 3

CLIENT: *WBHL*

Date: 9/11/2012

ANTENNA TYPE: FM3/4-DA

FREQUENCY: 90.7 MHz

PATTERN POL.: Circular

DIRECTIVITY(Peak): 4.088/6.115 dBd

Beam Tilt (Deg.) : 0

DIRECTIVITY(Horiz): 4.088/6.115 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	.923 (-0.692)	-4.4	.858 (-1.329)	-12.0	.203 (-13.829 )
3.0	.933 (-0.607)	-4.6	.846 (-1.457)	-12.2	.186 (-14.626 )
2.8	.941 (-0.528)	-4.8	.833 (-1.591)	-12.4	.168 (-15.493 )
2.6	.949 (-0.454)	-5.0	.819 (-1.733)	-12.6	.151 (-16.444 )
2.4	.956 (-0.386)	-5.2	.805 (-1.881)	-12.8	.133 (-17.497 )
2.2	.963 (-0.324)	-5.4	.791 (-2.036)	-13.0	.116 (-18.677 )
2.0	.97 (-0.268)	-5.6	.776 (-2.199)	-13.2	.10 (-20.021 )
1.8	.975 (-0.216)	-5.8	.761 (-2.368)	-13.4	.083 (-21.584 )
1.6	.981 (-0.171)	-6.0	.746 (-2.546)	-13.6	.067 (-23.455 )
1.4	.985 (-0.131)	-6.2	.73 (-2.731)	-13.8	.051 (-25.792 )
1.2	.989 (-0.096)	-6.4	.714 (-2.924)	-14.0	.036 (-28.925 )
1.0	.992 (-0.067)	-6.6	.698 (-3.125)	-14.2	.021 (-33.736 )
.8	.995 (-0.043)	-6.8	.681 (-3.335)	-14.4	.006 (-44.914 )
.6	.997 (-0.024)	-7.0	.664 (-3.554)	-14.6	.009 (-41.043 )
.4	.999 (-0.011)	-7.2	.647 (-3.782)	-14.8	.023 (-32.742 )
.2	1.00 (-0.003)	-7.4	.63 (-4.019)	-15.0	.037 (-28.661 )
.0	1.00 (0)	-7.6	.612 (-4.266)	-15.2	.05 (-25.959 )
-.2	1.00 (-0.003)	-7.8	.594 (-4.524)	-15.4	.063 (-23.954 )
-.4	.999 (-0.011)	-8.0	.576 (-4.792)	-15.6	.076 (-22.37 )
-.6	.997 (-0.024)	-8.2	.558 (-5.071)	-15.8	.088 (-21.07 )
-.8	.995 (-0.043)	-8.4	.539 (-5.362)	-16.0	.10 (-19.974 )
-1.0	.992 (-0.067)	-8.6	.521 (-5.665)	-16.2	.112 (-19.034 )
-1.2	.989 (-0.096)	-8.8	.502 (-5.981)	-16.4	.123 (-18.214 )
-1.4	.985 (-0.131)	-9.0	.484 (-6.311)	-16.6	.133 (-17.493 )
-1.6	.981 (-0.171)	-9.2	.465 (-6.656)	-16.8	.144 (-16.854 )
-1.8	.975 (-0.216)	-9.4	.446 (-7.015)	-17.0	.153 (-16.282 )
-2.0	.97 (-0.268)	-9.6	.427 (-7.391)	-17.2	.163 (-15.77 )
-2.2	.963 (-0.324)	-9.8	.408 (-7.785)	-17.4	.172 (-15.308 )
-2.4	.956 (-0.386)	-10.0	.389 (-8.198)	-17.6	.18 (-14.891 )
-2.6	.949 (-0.454)	-10.2	.37 (-8.63)	-17.8	.188 (-14.514 )
-2.8	.941 (-0.528)	-10.4	.351 (-9.085)	-18.0	.196 (-14.173 )
-3.0	.933 (-0.607)	-10.6	.333 (-9.563)	-18.2	.203 (-13.864 )
-3.2	.923 (-0.692)	-10.8	.314 (-10.068)	-18.4	.209 (-13.584 )
-3.4	.914 (-0.783)	-11.0	.295 (-10.601)	-18.6	.215 (-13.331 )
-3.6	.904 (-0.88)	-11.2	.276 (-11.166)	-18.8	.221 (-13.103 )
-3.8	.893 (-0.983)	-11.4	.258 (-11.767)	-19.0	.226 (-12.899 )
-4.0	.882 (-1.092)	-11.6	.24 (-12.407)	-19.2	.231 (-12.716 )
-4.2	.87 (-1.207)	-11.8	.222 (-13.092)	-19.4	.236 (-12.553 )

## Systems With Reliability

Page 2 of 3

CLIENT: *WBHL*

Date: 9/11/2012

ANTENNA TYPE: FM3/4-DA

FREQUENCY: 90.7 MHz

PATTERN POL.: Circular

DIRECTIVITY(Peak): 4.088/6.115 dBd

Beam Tilt (Deg.) : 0

DIRECTIVITY(Horiz): 4.088/6.115 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	.24 (-12.41)	-27.2	.117 (-18.664)	-54.0	.188 (-14.511 )
-19.8	.243 (-12.285)	-27.4	.109 (-19.281)	-55.0	.219 (-13.205 )
-20.0	.246 (-12.177)	-27.6	.101 (-19.954)	-56.0	.247 (-12.148 )
-20.2	.249 (-12.087)	-27.8	.092 (-20.691)	-57.0	.273 (-11.282 )
-20.4	.251 (-12.012)	-28.0	.084 (-21.504)	-58.0	.296 (-10.571 )
-20.6	.253 (-11.952)	-28.2	.076 (-22.408)	-59.0	.317 (-9.989 )
-20.8	.254 (-11.908)	-28.4	.067 (-23.424)	-60.0	.334 (-9.515 )
-21.0	.255 (-11.878)	-28.6	.059 (-24.581)	-61.0	.349 (-9.134 )
-21.2	.255 (-11.862)	-28.8	.051 (-25.921)	-62.0	.362 (-8.836 )
-21.4	.255 (-11.861)	-29.0	.042 (-27.509)	-63.0	.371 (-8.611 )
-21.6	.255 (-11.873)	-29.2	.034 (-29.455)	-64.0	.378 (-8.452 )
-21.8	.254 (-11.899)	-29.4	.025 (-31.965)	-65.0	.382 (-8.352 )
-22.0	.253 (-11.938)	-29.6	.017 (-35.502)	-66.0	.384 (-8.305 )
-22.2	.251 (-11.99)	-29.8	.008 (-41.542)	-67.0	.384 (-8.309 )
-22.4	.25 (-12.056)	-30.0	.00 (-50)	-68.0	.382 (-8.359 )
-22.6	.247 (-12.136)	-31.0	.041 (-27.75)	-69.0	.378 (-8.453 )
-22.8	.245 (-12.228)	-32.0	.08 (-21.983)	-70.0	.372 (-8.587 )
-23.0	.242 (-12.335)	-33.0	.115 (-18.8)	-71.0	.365 (-8.759 )
-23.2	.238 (-12.455)	-34.0	.146 (-16.728)	-72.0	.356 (-8.968 )
-23.4	.235 (-12.588)	-35.0	.172 (-15.306)	-73.0	.346 (-9.212 )
-23.6	.231 (-12.737)	-36.0	.192 (-14.331)	-74.0	.335 (-9.491 )
-23.8	.226 (-12.899)	-37.0	.207 (-13.7)	-75.0	.323 (-9.803 )
-24.0	.222 (-13.076)	-38.0	.215 (-13.353)	-76.0	.311 (-10.149 )
-24.2	.217 (-13.269)	-39.0	.217 (-13.261)	-77.0	.298 (-10.528 )
-24.4	.212 (-13.478)	-40.0	.214 (-13.409)	-78.0	.284 (-10.941 )
-24.6	.206 (-13.703)	-41.0	.204 (-13.798)	-79.0	.269 (-11.39 )
-24.8	.201 (-13.945)	-42.0	.19 (-14.446)	-80.0	.255 (-11.875 )
-25.0	.195 (-14.205)	-43.0	.17 (-15.39)	-81.0	.24 (-12.4 )
-25.2	.189 (-14.484)	-44.0	.146 (-16.7)	-82.0	.225 (-12.967 )
-25.4	.182 (-14.783)	-45.0	.119 (-18.507)	-83.0	.209 (-13.581 )
-25.6	.176 (-15.103)	-46.0	.088 (-21.083)	-84.0	.194 (-14.247 )
-25.8	.169 (-15.446)	-47.0	.055 (-25.123)	-85.0	.178 (-14.973 )
-26.0	.162 (-15.813)	-48.0	.021 (-33.591)	-86.0	.163 (-15.769 )
-26.2	.155 (-16.207)	-49.0	.015 (-36.679)	-87.0	.147 (-16.648 )
-26.4	.147 (-16.629)	-50.0	.051 (-25.907)	-88.0	.131 (-17.628 )
-26.6	.14 (-17.082)	-51.0	.087 (-21.259)	-89.0	.116 (-18.733 )
-26.8	.132 (-17.569)	-52.0	.122 (-18.296)	-90.0	.10 (-20 )
-27.0	.125 (-18.095)	-53.0	.156 (-16.155)	90.0	.00 (-50 )

## Systems With Reliability

Page 3 of 3

CLIENT: *WBHL*

Date: 9/11/2012

ANTENNA TYPE: FM3/4-DA

FREQUENCY: 90.7 MHz

PATTERN POL.: Circular

DIRECTIVITY(Peak): 4.088/6.115 dBd

Beam Tilt (Deg.) : 0

DIRECTIVITY(Horiz): 4.088/6.115 dBd

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

## Exhibit 5: Antenna Data Sheet



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

<b>Customer</b>	WBHL
<b>Contact</b>	David Bolduc
<b>Location</b>	Harrison, MI
<b>Antenna Model</b>	FM3/4-DA
<b>Channel / Frequency</b>	214C3/90.7 MHz

### ELECTRICAL SPECIFICATIONS

#### Antenna Specifications:

	H-POL			V. Pol.	
		<b>dB</b>			<b>dB</b>
License ERP ( KW)	10.000	10.000 <b>dB</b>		10.000	10.000 <b>dB</b>
FCC Limit Pattern Directivity	1.385	1.416 <b>dB</b>		1.385	1.416 <b>dB</b>
Elevation Directivity	4.088	6.115 <b>dB</b>		4.088	6.115 <b>dB</b>
Azimuth Directivity	2.174	3.372 <b>dB</b>		2.078	3.177 <b>dB</b>
Composite Pattern	1.507	1.780 <b>dB</b>		1.507	1.780 <b>dB</b>
Polarization Ratio	0.489	-3.109 <b>dB</b>		0.511	-2.914 <b>dB</b>
<b>RMS Comp./RMS Limit</b>	95.89 %				
Antenna Efficiency %	100	0		100	0
Power Ratio ( Pol. Ratio X Efficiency)	0.4887	0		0.5113	0
Antenna Gain	4.343	6.378 <b>dB</b>		4.343	6.378 <b>dB</b>

<b>Antenna Input Power (KW)</b>	2.302 kW	3.622 (dBK)
---------------------------------	----------	-------------

#### Feed Line Specifications:

Line Type	1 5/8" Air	<b>50 Ω HJ7-50A</b>
Attenuation Per 100 ft (dB)	0.196	<b>dB</b>
Line Length (ft) AGL + 40' Horizontal Run	466.53	<b>ft.</b>
Total Line Attenuation (dB)	0.914	<b>dB</b>
Line Efficiency	81.01	<b>%</b>
<b>Power Input to the Line (KW)</b>	2.842 kW	4.536 (dBK)

### MECHANICAL SPECIFICATIONS

<b>No. Of Bays</b>	4		
<b>Antenna Aperture</b>	32.53	<b>ft.</b>	9.92 <b>meter</b>
<b>Center of Radiation AGL</b>	426.53	<b>ft.</b>	130.00 <b>meter</b>
<b>Antenna Weight w/pole</b>	470.00	<b>lbs.</b>	213.64 <b>kg</b>
<b>Windload (50/33)</b>	748.00	<b>lbs.</b>	<b>Windload CaAc</b> 22.25 <b>ft^2</b>

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

# WBHL Antenna RMS Comparison

### PROPOSED ANTENNA

**Azimuth  
Heading**      **Relative  
Field**

0	0.891
10	0.708
20	0.562
30	0.447
40	0.355
50	0.307
60	0.299
70	0.365
80	0.460
90	0.579
100	0.729
110	0.785
120	0.785
130	0.638
140	0.638
150	0.804
160	1.000
170	1.000
180	1.000
190	1.000
200	1.000
210	1.000
220	1.000
230	1.000
240	1.000
250	1.000
260	1.000
270	1.000
280	1.000
290	1.000
300	1.000
310	1.000
320	1.000
330	1.000
340	1.000
350	1.000

### DESIGNED ANTENNA

**Azimuth  
Heading**      **Relative  
Field**

0	0.891
10	0.708
20	0.562
30	0.447
40	0.355
50	0.301
60	0.290
70	0.365
80	0.460
90	0.579
100	0.685
110	0.688
120	0.684
130	0.638
140	0.638
150	0.804
160	1.000
170	1.000
180	1.000
190	0.891
200	0.850
210	0.938
220	0.971
230	1.000
240	1.000
250	1.000
260	1.000
270	1.000
280	0.983
290	0.963
300	0.936
310	0.876
320	0.801
330	0.869
340	1.000
350	1.000

Sum of Relative Field Squared :      26.025  
Sum Divided by 36 (Readings) :      0.723  
Square Root :      0.850

Sum of Relative Field Squared :      23.935  
Sum Divided by 36 (Readings) :      0.665  
Square Root :      0.815

Percentage of Construction Permit Antenna Filled :

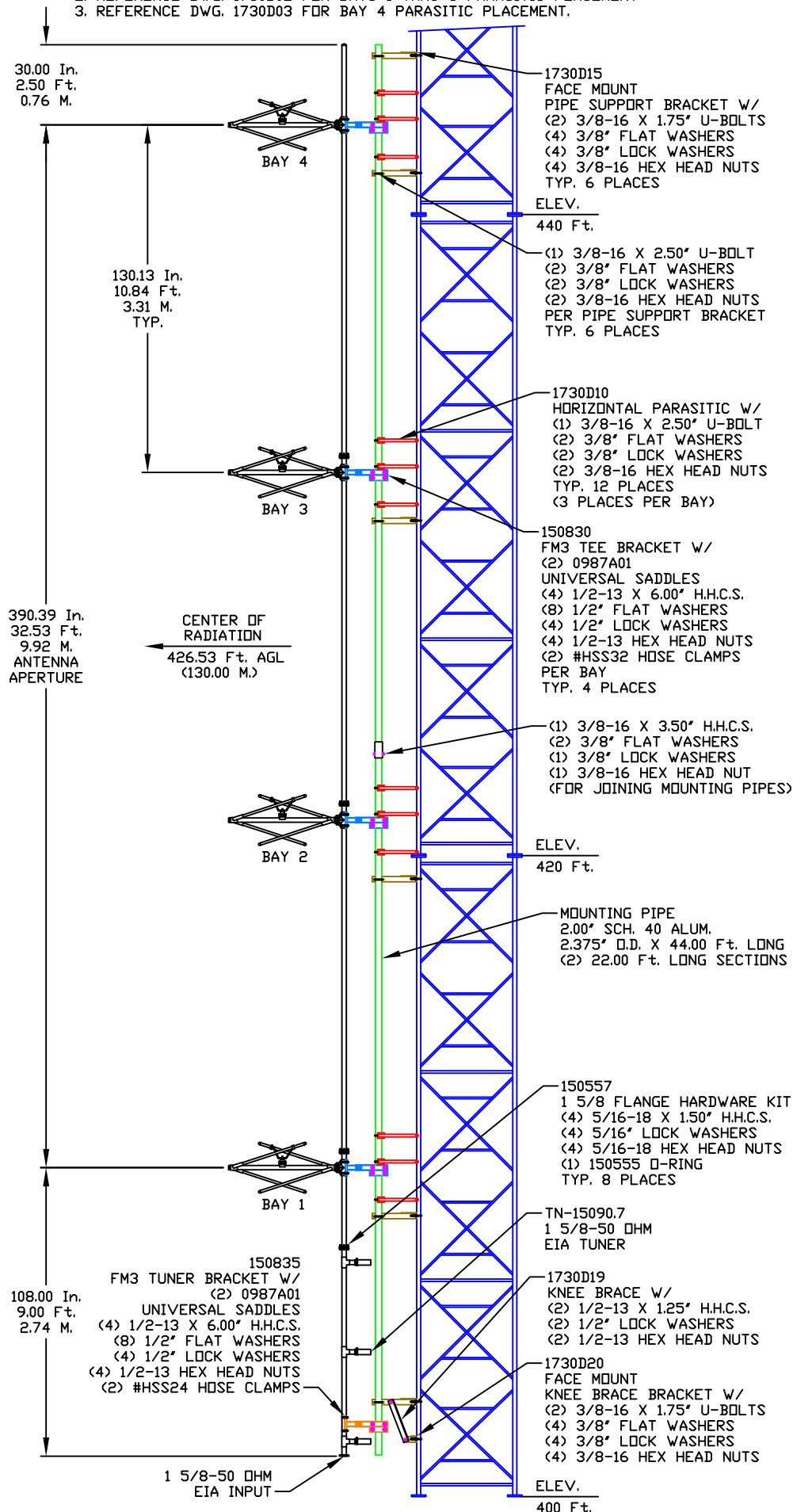
**95.9%**

# Exhibit 7: Drawings

## NOTES:

1. REFERENCE DWG. 1730D01 FOR ANTENNA ORIENTATION.
2. REFERENCE DWG. 1730D02 FOR BAYS 1 THRU 3 PARASITIC PLACEMENT.
3. REFERENCE DWG. 1730D03 FOR BAY 4 PARASITIC PLACEMENT.

DRAWING  
NUMBER: 1730D00



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

TITLE: FM3/4-DA, FREQ. 90.7  
WBHL, HARRISON, MI

MATERIAL:

SIZE REV APPR. DATE  
C 1  
2  
3

ENGINEER:

SCALE: NTS

NAME: RAC

DATE: 9/10/12

SHEET

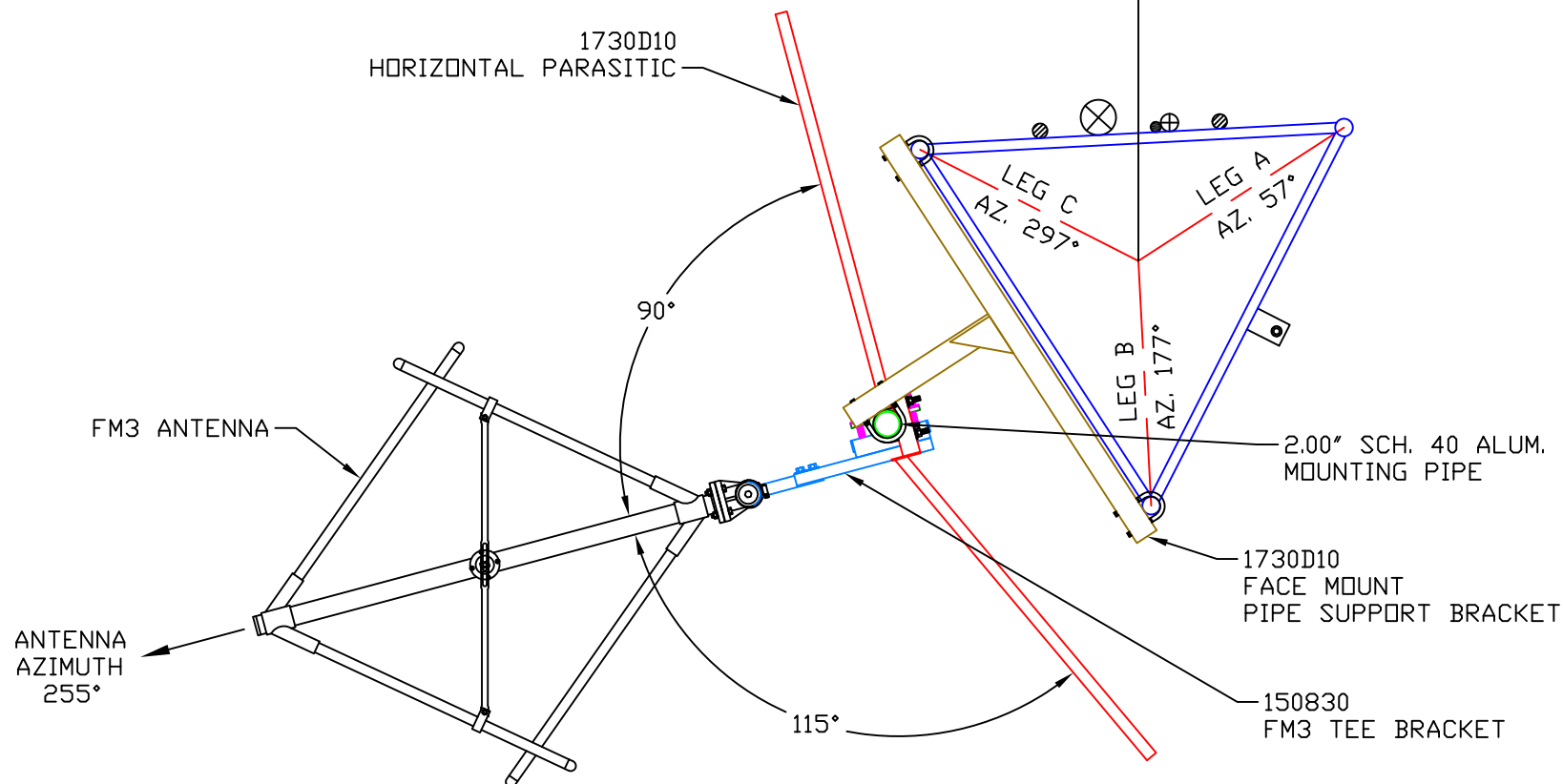
1 OF 1

DRAWING  
NUMBER: 1730D00



DRAWING NUMBER: 1730D01

TRUE  
NORTH



TOP VIEW

<b>TOLERANCES</b> .X ± .015 .XX ± .005 .XXX ± .002 X/X ± 1/32 DEG. ± 1/2 UNLESS OTHERWISE SPECIFIED		<b>REVISION RECORD</b>		
		<b>REV</b>	<b>APPROVAL</b>	<b>DATE</b>
<b>BY THIS DRAWING</b>		<b>DRAWING NUMBER:</b> 1730D01		
<b>NAME:</b> RAC		<b>DATE:</b> 9/10/12 <b>SHEET</b> 1 <b>OF</b> 1		



**SYSTEMS WITH RELIABILITY, INC**  
**619 INDUSTRIAL PARK ROAD**  
**EBensburg, PENNSYLVANIA 15931**

TITLE:	FM3/4-DA, FREQ. 90.7 WBHL, HARRISON, MI
MATERIAL:	ANTENNA ORIENTATION FROM TRUE NORTH

SIZE  
A

PARTS MADE BY THIS DRAWING

SCALE: NTS

NAME: RAC

DATE: 9/10/12

SHEET	1	OF	1
-------	---	----	---

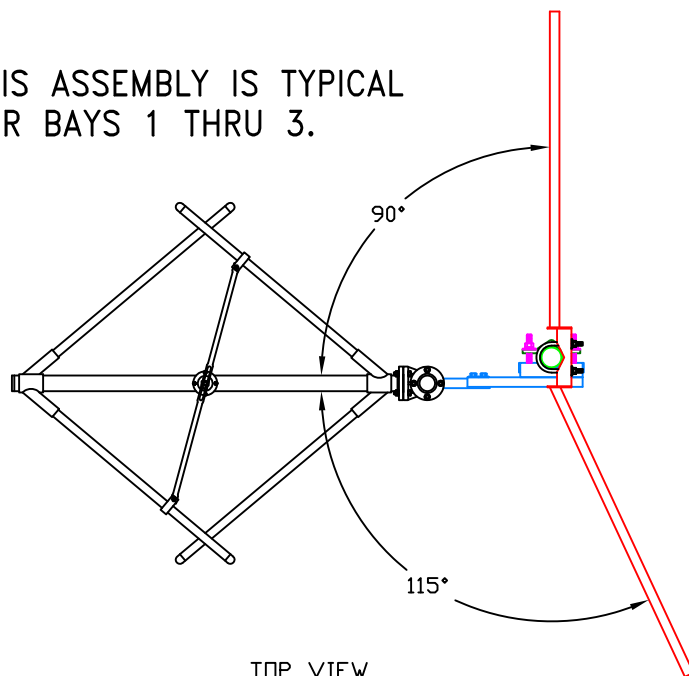
NOTE:

THIS ASSEMBLY IS TYPICAL  
FOR BAYS 1 THRU 3.

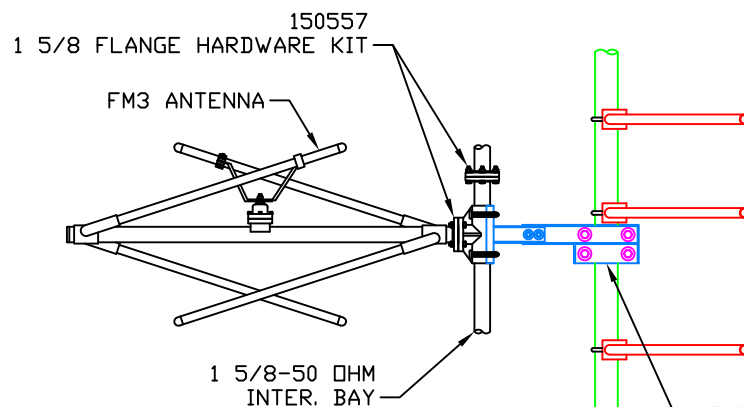
Exhibit 7 (cont'd): Drawings

DRAWING  
NUMBER:

1730D02



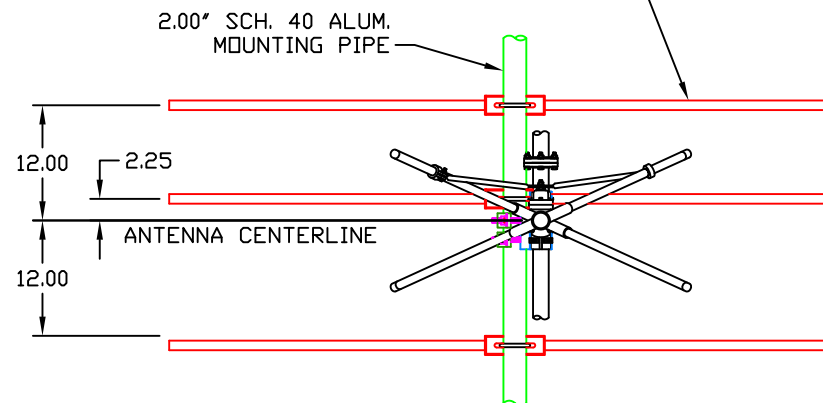
TOP VIEW



SIDE VIEW

- 150830  
FM3 TEE BRACKET W/  
(2) 0987A01 UNIVERSAL SADDLES  
(4) 1/2-13 X 6.00" H.H.C.S.  
(8) 1/2" FLAT WASHERS  
(4) 1/2" LOCK WASHERS  
(4) 1/2-13 HEX HEAD NUTS  
(2) #HSS32 HOSE CLAMPS

- 1730D10  
HORIZONTAL PARASITIC W/  
(1) 3/8-16 X 2.50" U-BOLT  
(2) 3/8" FLAT WASHERS  
(2) 3/8" LOCK WASHERS  
(2) 3/8-16 HEX HEAD NUTS



FRONT VIEW

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

REVISION RECORD		
REV	APPROVAL	DATE
DRAWING NUMBER: 1730D02		
SCALE: NTS	NAME: RAC	DATE: 9/10/12 SHEET 1 OF 1



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

TITLE:

FM3/4-DA, FREQ. 90.7  
WBHL, HARRISON, MI  
PARASITIC PLACEMENT  
BAYS 1 THRU 3

MATERIAL:

SIZE

A

PARTS MADE BY THIS DRAWING

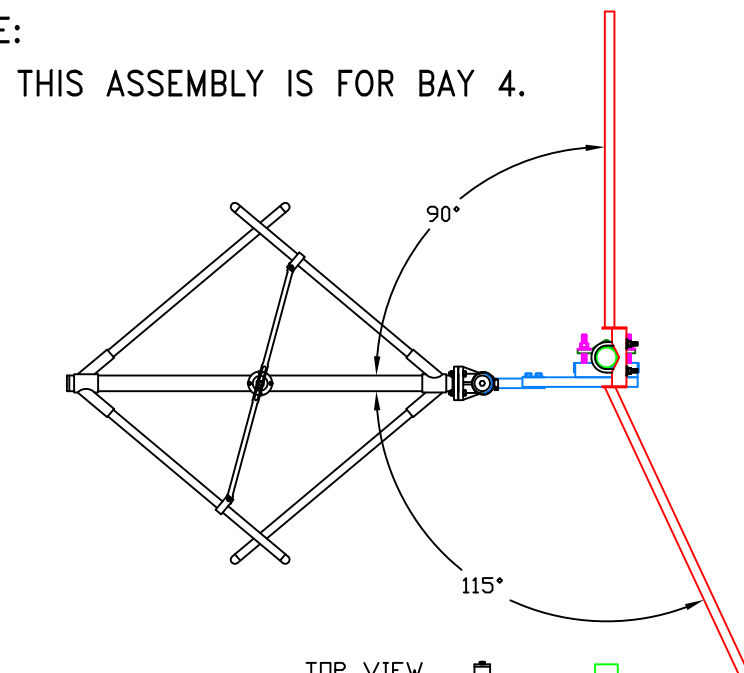
NOTE:

THIS ASSEMBLY IS FOR BAY 4.

Exhibit 7 (cont'd): Drawings

DRAWING  
NUMBER:

1730D03



TOP VIEW

150557  
1 5/8 FLANGE HARDWARE KIT

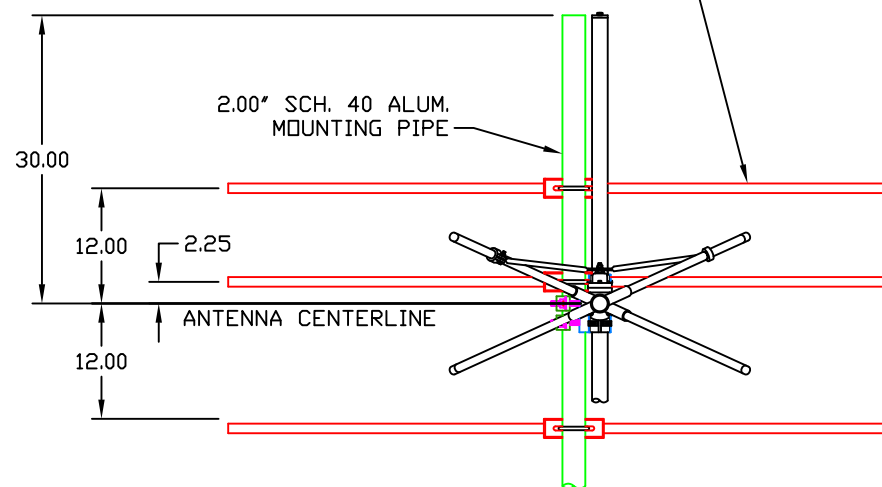
FM3 ANTENNA

1 5/8-50 OHM  
INTER. BAY

SIDE VIEW

150830  
FM3 TEE BRACKET W/  
(2) 0987A01 UNIVERSAL SADDLES  
(4) 1/2-13 X 6.00" H.H.C.S.  
(8) 1/2" FLAT WASHERS  
(4) 1/2" LOCK WASHERS  
(4) 1/2-13 HEX HEAD NUTS  
(2) #HSS32 HOSE CLAMPS

1730D10  
HORIZONTAL PARASITIC W/  
(1) 3/8-16 X 2.50" U-BOLT  
(2) 3/8" FLAT WASHERS  
(2) 3/8" LOCK WASHERS  
(2) 3/8-16 HEX HEAD NUTS



FRONT VIEW

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

REVISION RECORD		
REV	APPROVAL	DATE
DRAWING NUMBER: 1730D03		
SCALE: NTS	NAME: RAC	DATE: 9/10/12 SHEET 1 OF 1



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

TITLE:

FM3/4-DA, FREQ. 90.7  
WBHL, HARRISON, MI  
PARASITIC PLACEMENT  
BAY 4

MATERIAL:

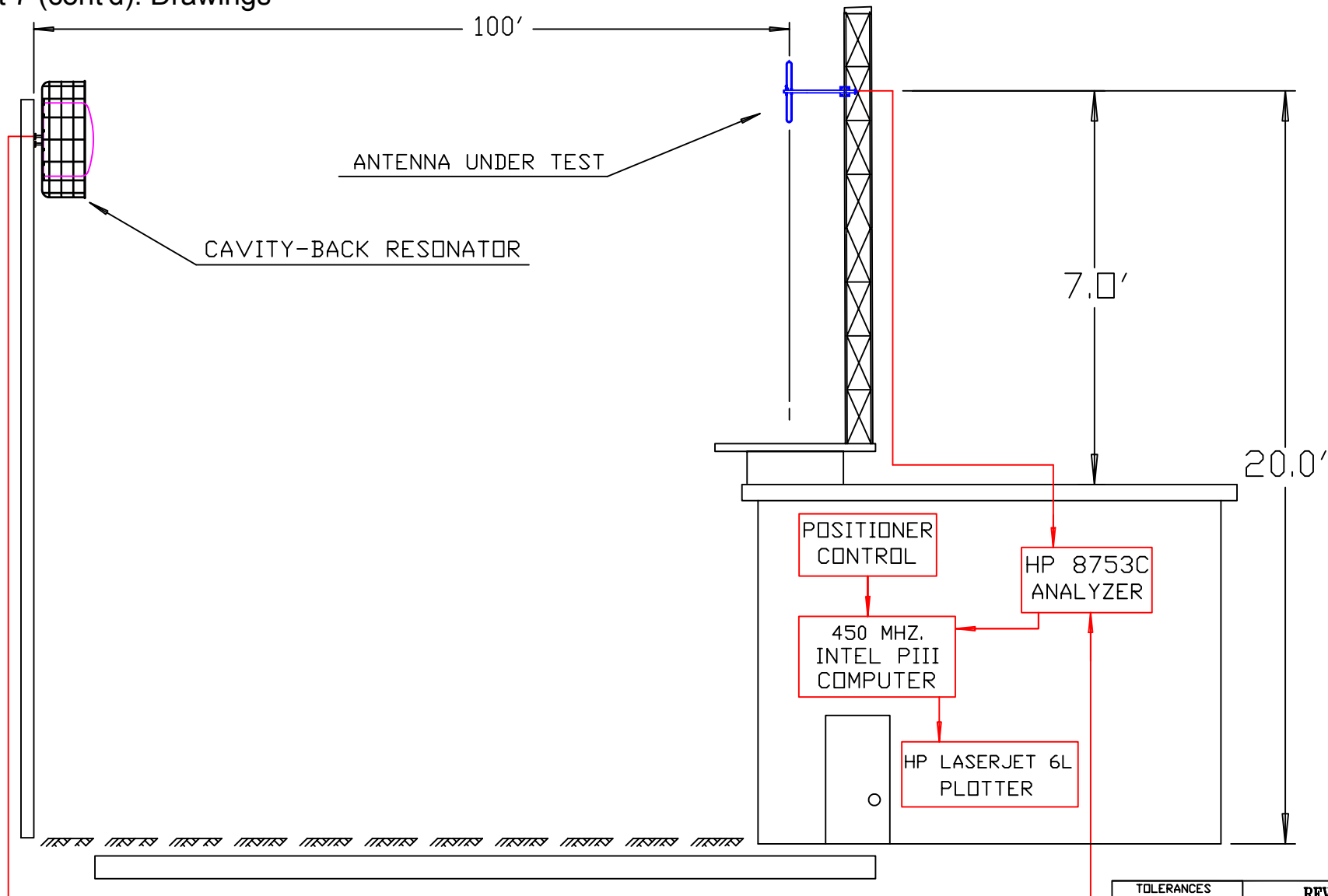
SIZE

A

PARTS MADE BY THIS DRAWING

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
DRAWING NUMBER: 2105A10		
SCALE: NTS	NAME: JRM	DATE: 11/1/98
SHEET 1 OF 1		



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