ELECTRONICS RESEARCH, INC. ERI®

Electronics Research, Inc. 7777 Gardner Rd. Chandler, IN 47610 Phone (812) 925-6000 Fax (812) 925-4030 http://www.eriinc.com/

Directional Antenna System for WNFN, Franklin, Tennessee

March 4, 2019

Electronics Research Inc. is providing a custom fabricated antenna system that is specially designed to meet the FCC requirements and the general needs of radio station WNFN.

The antenna is the ERI model SHP-4AE-DA-HW configuration. The circular polarized system consists of 4 half-wavelength spaced bays using one driven circular polarized radiating element, one horizontal parasitic element per bay and one vertical parasitic element interleaved between alternate bay pairs. The antenna was mounted on the North 80 degrees East tower leg with bracketry to provide an antenna orientation of North 76 degrees East. The antenna was tested on a 7' face tower, which is the structure the station plans to use to support the array. All tests were performed on a frequency of 106.7 megahertz, which is the center of the FM broadcast channel assigned to WNFN.

Pattern measurements were made on a sixty-acre antenna pattern range that is owned and operated by Electronics Research, Inc. The tests were performed under the direction of Thomas B. Silliman, president of Electronics Research, Inc. Mr. Silliman has the Bachelor of Electrical Engineering and the Master of Electrical Engineering degrees from Cornell University and is a registered professional engineer in the states of Indiana, Maryland and Minnesota.

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For
WNFN, Franklin, Tennessee

(Continued)

DESCRIPTION OF THE TEST PROCEDURE

The test antenna consisted of two bay levels of the circular polarized system with the associated horizontal and vertical parasitic elements. The elements and brackets that were used in this test are electrically equivalent to those that will be supplied with the antenna. A section of 3 1/8 inch o.d. rigid coaxial line was used to feed the test antenna, and a section of 3 1/8 inch o.d. rigid outer conductor only was attached above the test antenna. The lines were properly grounded during all tests.

The power distribution and phase relationship to the antenna elements was adjusted in order to achieve the directional radiation patterns for both horizontal and vertical polarization components.

The proof-of-performance was accomplished using a 7' face tower with identical dimension and configuration including all braces, ladders, conduits, coaxial lines and other appurtenances that are included in the actual aperture at which the antenna will be installed. The structure was erected vertically on a turntable mounted on a non-metallic building with the antenna centered vertically on the structure, making the center of radiation of the test approximately 30 feet above ground. The turntable is equipped with a motor drive and a US Digital angle position indicator. The resolution of this angle position indicator is one-hundredth of a degree.

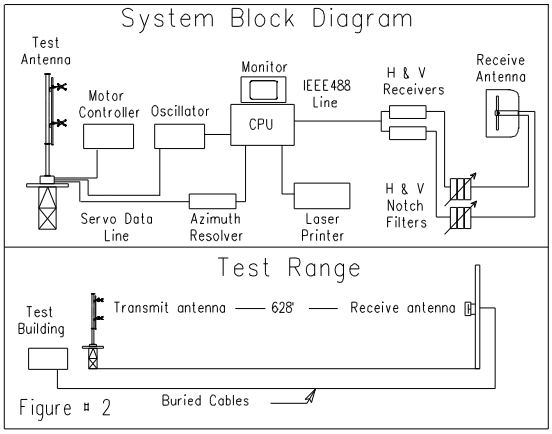

Figure # 2

The antenna under test was operated in the transmitting mode and fed from a HP8657D signal generator. The frequency of the signal source was set at 106.7 MHz and was constantly monitored by a Rohde & Schwarz ESVD measuring receiver.

A broadband horizontal and vertical dipole system, located approximately 628 feet from the test antenna, was used to receive the emitted test signals.

(Continued)

The dipole system was mounted at the same height above terrain as the center of the antenna under test. The signals received by the dipole system were fed to the test building by way of two buried Heliax cables to a Rohde & Schwarz measuring receiver. This data was interfaced to a laser jet printer by means of a computer system. Relative field strength was plotted as a function of azimuth.

The measurements were performed by rotating the test antenna in a counter-clockwise direction and plotting the received signal on polar co-ordinated graph paper in a clockwise direction. Both horizontal and vertical components were recorded separately.

CONCLUSIONS

The circular polarized system consists of 4 half-wavelength spaced bays using one driven circular polarized radiating element, one horizontal parasitic element per bay and one vertical parasitic element interleaved between alternate bay pairs. The power distribution and phase relationship will be fixed when the antenna is manufactured. Proper maintenance of the elements should be all that is required to maintain the pattern in adjustment.

The SHP-4AE-DA-HW array is to be mounted on the North 80 degrees East tower leg of the 7' face tower at a bearing of North 76 degrees East. Blue prints provided with the antenna will show the proper antenna orientation alignment. The antenna alignment procedure should be directed by a licensed surveyor as prescribed by the FCC.

Figure #1 represents the measured individual horizontal and vertical components, the composite maximum of either the horizontal or vertical component at any azimuth and the FCC filed envelope pattern. The horizontal plane relative field list for the composite pattern and the individual H & V components are shown as Figure #1 & 1A respectively. The actual measured pattern does not exceed the authorized FCC composite pattern at any azimuth. A calculated vertical plane relative field pattern is shown on Figure #3 attached. The power in the maximum will reach 15 kilowatts (11.761 dBk).

The power at North 320-330 degrees East does not exceed 7.4 kilowatts (8.692 dBk).

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(Continued)

The RMS of the vertically polarized horizontal plane component does not exceed the RMS of the horizontally polarized horizontal plane component.

The composite horizontal and vertical maximum relative field pattern obtained from the measured data as shown on Figure #1 has an RMS that is greater that 85% of the filed composite pattern.

The clear vertical length of the structure required to support the antenna is 33 feet 9 in.

The directional antenna should not be mounted on the top of an antenna tower that includes a top-mounted platform larger than the cross-sectional area of the tower in the horizontal plane. No obstructions other than those that are specified by the blue prints supplied with the antenna are to be mounted within 75 ft. horizontally of the system. The vertical distance to the nearest obstruction should be a minimum of 10 ft. from the directional antenna. Metallic guy wires should be a minimum distance of forty feet horizontally from the antenna.

ELECTRONICS RESEARCH, INC.

Tom Schaaf

ERI® Horizontal Plane Relative Field Pattern

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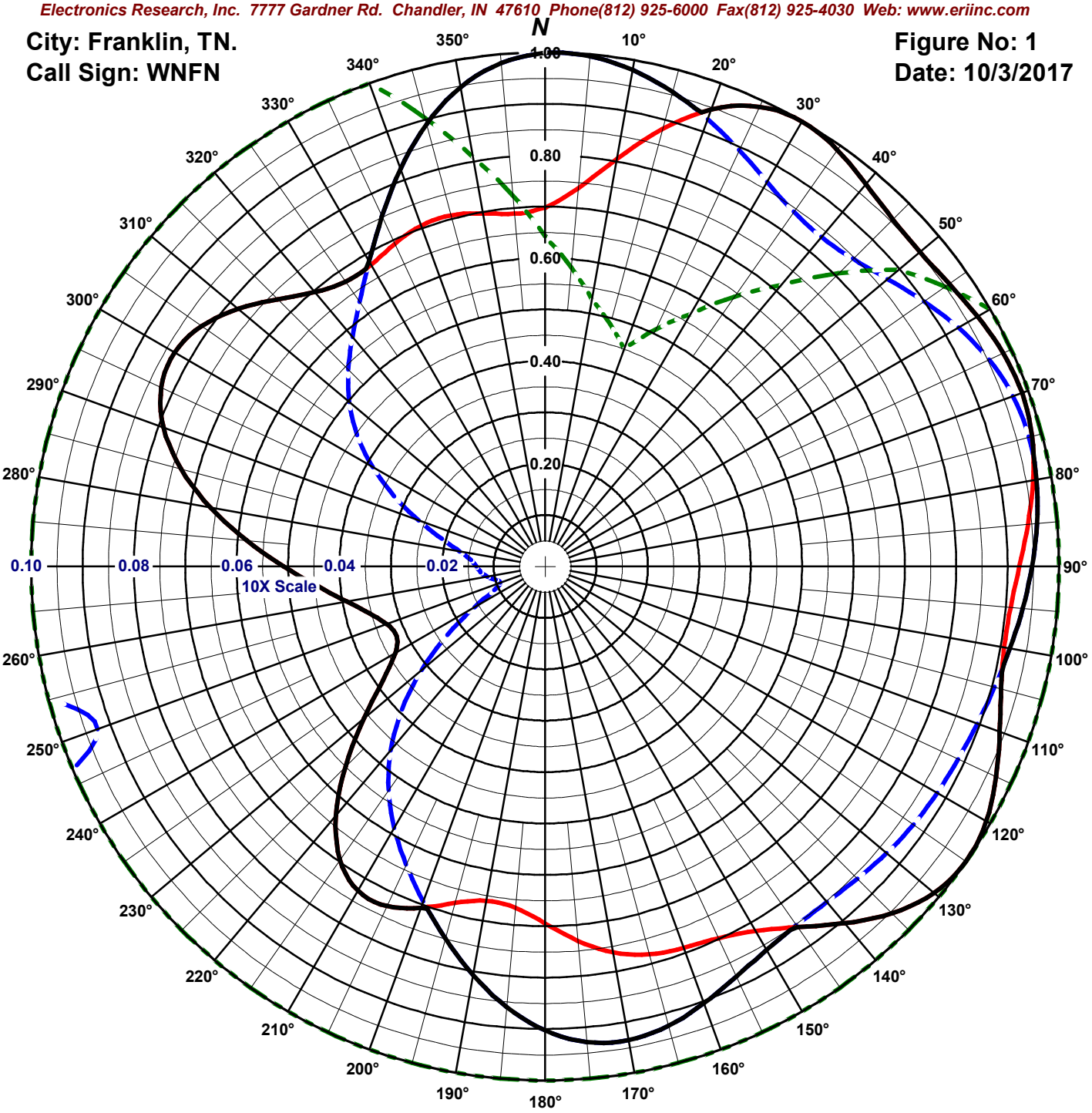
City: Franklin, TN.
Call Sign: WNFN

Figure No: 1
Date: 10/3/2017



Antenna Orientation: 76° True

Frequency: 106.7 MHz
Antenna Type: SHP-4AE-DA-HW

Antenna Mounting: Custom
Tower Type: 7' Tower

HORIZONTAL	VERTICAL	COMPOSITE	FCC ENVELOPE
RMS: .789	RMS: .755	RMS: .834	RMS: .945
Maximum: 1 @ 125°	Maximum: 1 @ 2°	Maximum: 1 @ 2°	Maximum: 1 @ 60°
Minimum: .319 @ 246°	Minimum: .093 @ 250°	Minimum: .319 @ 246°	Minimum: .45 @ 20°

Measured patterns of the horizontal and vertical components. The composite pattern shows the maximum of either the H or V azimuth values. This patterns is greater than 85% of the FCC filed composite pattern BPH-20170627AAL.

ERI® Horizontal Plane Relative Field Pattern

Electronics Research, Inc. 7777 Gardner Rd. Chandler, IN 47610 Phone(812) 925-6000 Fax(812) 925-4030 Web: www.eriinc.com

Figure# 1 **Date: 10/3/2017**
Station: WNFN **Antenna: SHP-4AE-DA-HW**
Location: Franklin, TN. **Antenna Orientation: 76° True**
Frequency: 106.7 MHz **Number of Bays: 4**

Azimuth	Envelope			Polarization	Azimuth	Envelope			Polarization
	Field	kW	dBk	Maximum		Field	kW	dBk	Maximum
0°	0.999	14.976	11.754	Vertical	180°	0.903	12.223	10.872	Vertical
5°	0.997	14.899	11.732	Vertical	185°	0.860	11.099	10.453	Vertical
10°	0.981	14.431	11.593	Vertical	190°	0.807	9.766	9.897	Vertical
15°	0.956	13.710	11.370	Vertical	195°	0.749	8.425	9.256	Vertical
20°	0.946	13.417	11.277	Horizontal	200°	0.707	7.490	8.745	Horizontal
25°	0.987	14.609	11.646	Horizontal	205°	0.729	7.969	9.014	Horizontal
30°	1.000	14.985	11.757	Horizontal	210°	0.728	7.955	9.007	Horizontal
35°	0.990	14.703	11.674	Horizontal	215°	0.696	7.264	8.612	Horizontal
40°	0.971	14.151	11.508	Horizontal	220°	0.633	6.009	7.788	Horizontal
45°	0.956	13.715	11.372	Horizontal	225°	0.549	4.522	6.553	Horizontal
50°	0.952	13.601	11.336	Horizontal	230°	0.460	3.177	5.020	Horizontal
55°	0.959	13.801	11.399	Horizontal	235°	0.385	2.219	3.461	Horizontal
60°	0.972	14.166	11.512	Horizontal	240°	0.336	1.697	2.296	Horizontal
65°	0.983	14.499	11.613	Horizontal	245°	0.319	1.530	1.846	Horizontal
70°	0.988	14.629	11.652	Horizontal	250°	0.328	1.611	2.071	Horizontal
75°	0.981	14.429	11.592	Horizontal	255°	0.353	1.874	2.728	Horizontal
80°	0.971	14.141	11.505	Vertical	260°	0.392	2.307	3.630	Horizontal
85°	0.961	13.853	11.416	Vertical	265°	0.444	2.953	4.703	Horizontal
90°	0.948	13.471	11.294	Vertical	270°	0.508	3.877	5.885	Horizontal
95°	0.933	13.056	11.158	Vertical	275°	0.583	5.099	7.075	Horizontal
100°	0.918	12.653	11.022	Vertical	280°	0.661	6.557	8.167	Horizontal
105°	0.919	12.658	11.023	Horizontal	285°	0.733	8.068	9.067	Horizontal
110°	0.941	13.290	11.235	Horizontal	290°	0.790	9.359	9.712	Horizontal
115°	0.968	14.067	11.482	Horizontal	295°	0.824	10.179	10.077	Horizontal
120°	0.991	14.738	11.684	Horizontal	300°	0.832	10.386	10.164	Horizontal
125°	1.000	15.000	11.761	Horizontal	305°	0.815	9.975	9.989	Horizontal
130°	0.988	14.636	11.654	Horizontal	310°	0.780	9.115	9.598	Horizontal
135°	0.954	13.656	11.353	Horizontal	315°	0.735	8.112	9.091	Horizontal
140°	0.906	12.318	10.906	Horizontal	320°	0.697	7.287	8.626	Horizontal
145°	0.857	11.008	10.417	Horizontal	325°	0.677	6.867	8.368	Horizontal
150°	0.862	11.134	10.467	Vertical	330°	0.685	7.033	8.472	Vertical
155°	0.880	11.624	10.653	Vertical	335°	0.751	8.456	9.272	Vertical
160°	0.904	12.265	10.887	Vertical	340°	0.823	10.148	10.064	Vertical
165°	0.926	12.849	11.089	Vertical	345°	0.891	11.903	10.756	Vertical
170°	0.936	13.133	11.184	Vertical	350°	0.946	13.436	11.283	Vertical
175°	0.929	12.937	11.118	Vertical	355°	0.983	14.496	11.612	Vertical

Horizontal Polarization:
Maximum: 2.080 (3.181 dB)
Horizontal Plane: 2.080 (3.181 dB)
Maximum ERP: 15.000 kW

Vertical Polarization:
Maximum: 2.080 (3.181 dB)
Horizontal Plane: 2.080 (3.181 dB)
Maximum ERP: 15.000 kW

Total Input Power: 7.211 kW
Reference: WNFN1M.FIG
This list shows the the maximum azimuth values of either the horizontal or vertical components.

ERI® Horizontal Plane Relative Field Pattern

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Figure# 1A | **Date: 10/3/2017**

Station: WNFN | **Antenna: SHP-4AE-DA-HW**

Location: Franklin, TN. | **Antenna Orientation: 76° True**

Frequency: 106.7 MHz | **Number of Bays: 4**

Azimuth	Horizontal			Vertical			Azimuth	Horizontal			Vertical		
	Field	kW	dBk	Field	kW	dBk		Field	kW	dBk	Field	kW	dBk
0°	0.698	7.312	8.641	0.999	14.976	11.754	180°	0.694	7.231	8.592	0.903	12.223	10.872
5°	0.739	8.188	9.132	0.997	14.899	11.732	185°	0.666	6.663	8.237	0.860	11.099	10.453
10°	0.805	9.722	9.878	0.981	14.431	11.593	190°	0.661	6.545	8.159	0.807	9.766	9.897
15°	0.880	11.628	10.655	0.956	13.710	11.370	195°	0.678	6.894	8.385	0.749	8.425	9.256
20°	0.946	13.417	11.277	0.926	12.861	11.093	200°	0.707	7.490	8.745	0.693	7.205	8.576
25°	0.987	14.609	11.646	0.894	11.980	10.785	205°	0.729	7.969	9.014	0.640	6.137	7.880
30°	1.000	14.985	11.757	0.864	11.194	10.490	210°	0.728	7.955	9.007	0.587	5.172	7.137
35°	0.990	14.703	11.674	0.843	10.658	10.277	215°	0.696	7.264	8.612	0.531	4.231	6.265
40°	0.971	14.151	11.508	0.837	10.500	10.212	220°	0.633	6.009	7.788	0.467	3.274	5.151
45°	0.956	13.715	11.372	0.847	10.753	10.315	225°	0.549	4.522	6.553	0.394	2.329	3.672
50°	0.952	13.601	11.336	0.870	11.350	10.550	230°	0.460	3.177	5.020	0.314	1.476	1.692
55°	0.959	13.801	11.399	0.900	12.138	10.841	235°	0.385	2.219	3.461	0.232	0.807	-0.931
60°	0.972	14.166	11.512	0.929	12.943	11.120	240°	0.336	1.697	2.296	0.159	0.379	-4.217
65°	0.983	14.499	11.613	0.953	13.628	11.344	245°	0.319	1.530	1.846	0.110	0.180	-7.448
70°	0.988	14.629	11.652	0.969	14.082	11.487	250°	0.328	1.611	2.071	0.093	0.129	-8.903
75°	0.981	14.429	11.592	0.974	14.243	11.536	255°	0.353	1.874	2.728	0.100	0.149	-8.258
80°	0.964	13.941	11.443	0.971	14.141	11.505	260°	0.392	2.307	3.630	0.114	0.196	-7.070
85°	0.943	13.342	11.252	0.961	13.853	11.416	265°	0.444	2.953	4.703	0.126	0.237	-6.244
90°	0.923	12.781	11.066	0.948	13.471	11.294	270°	0.508	3.877	5.885	0.134	0.268	-5.718
95°	0.909	12.403	10.935	0.933	13.056	11.158	275°	0.583	5.099	7.075	0.145	0.316	-5.009
100°	0.907	12.340	10.913	0.918	12.653	11.022	280°	0.661	6.557	8.167	0.168	0.426	-3.707
105°	0.919	12.658	11.023	0.906	12.299	10.899	285°	0.733	8.068	9.067	0.208	0.649	-1.876
110°	0.941	13.290	11.235	0.895	12.010	10.795	290°	0.790	9.359	9.712	0.262	1.027	0.115
115°	0.968	14.067	11.482	0.887	11.795	10.717	295°	0.824	10.179	10.077	0.324	1.572	1.963
120°	0.991	14.738	11.684	0.881	11.640	10.660	300°	0.832	10.386	10.164	0.387	2.251	3.523
125°	1.000	15.000	11.761	0.875	11.485	10.601	305°	0.815	9.975	9.989	0.446	2.988	4.754
130°	0.988	14.636	11.654	0.867	11.287	10.526	310°	0.780	9.115	9.598	0.497	3.710	5.693
135°	0.954	13.656	11.353	0.859	11.068	10.441	315°	0.735	8.112	9.091	0.541	4.395	6.430
140°	0.906	12.318	10.906	0.853	10.903	10.375	320°	0.697	7.287	8.626	0.583	5.098	7.074
145°	0.857	11.008	10.417	0.852	10.898	10.373	325°	0.677	6.867	8.368	0.629	5.936	7.735
150°	0.819	10.053	10.023	0.862	11.134	10.467	330°	0.678	6.889	8.382	0.685	7.033	8.472
155°	0.798	9.555	9.802	0.880	11.624	10.653	335°	0.692	7.188	8.566	0.751	8.456	9.272
160°	0.790	9.354	9.710	0.904	12.265	10.887	340°	0.706	7.467	8.732	0.823	10.148	10.064
165°	0.781	9.157	9.618	0.926	12.849	11.089	345°	0.707	7.500	8.751	0.891	11.903	10.756
170°	0.762	8.720	9.405	0.936	13.133	11.184	350°	0.697	7.297	8.632	0.946	13.436	11.283
175°	0.731	8.015	9.039	0.929	12.937	11.118	355°	0.689	7.116	8.522	0.983	14.496	11.612

Horizontal Polarization:
Maximum: 2.080 (3.181 dB)
Horizontal Plane: 2.080 (3.181 dB)
Maximum ERP: 15.000 kW

Vertical Polarization:
Maximum: 2.080 (3.181 dB)
Horizontal Plane: 2.080 (3.181 dB)
Maximum ERP: 15.000 kW

Total Input Power: 7.211 kW
Reference: WNFN1M.FIG
This list shows the azimuth values for the horizontal and vertical components.

Vertical Plane Relative Field Pattern

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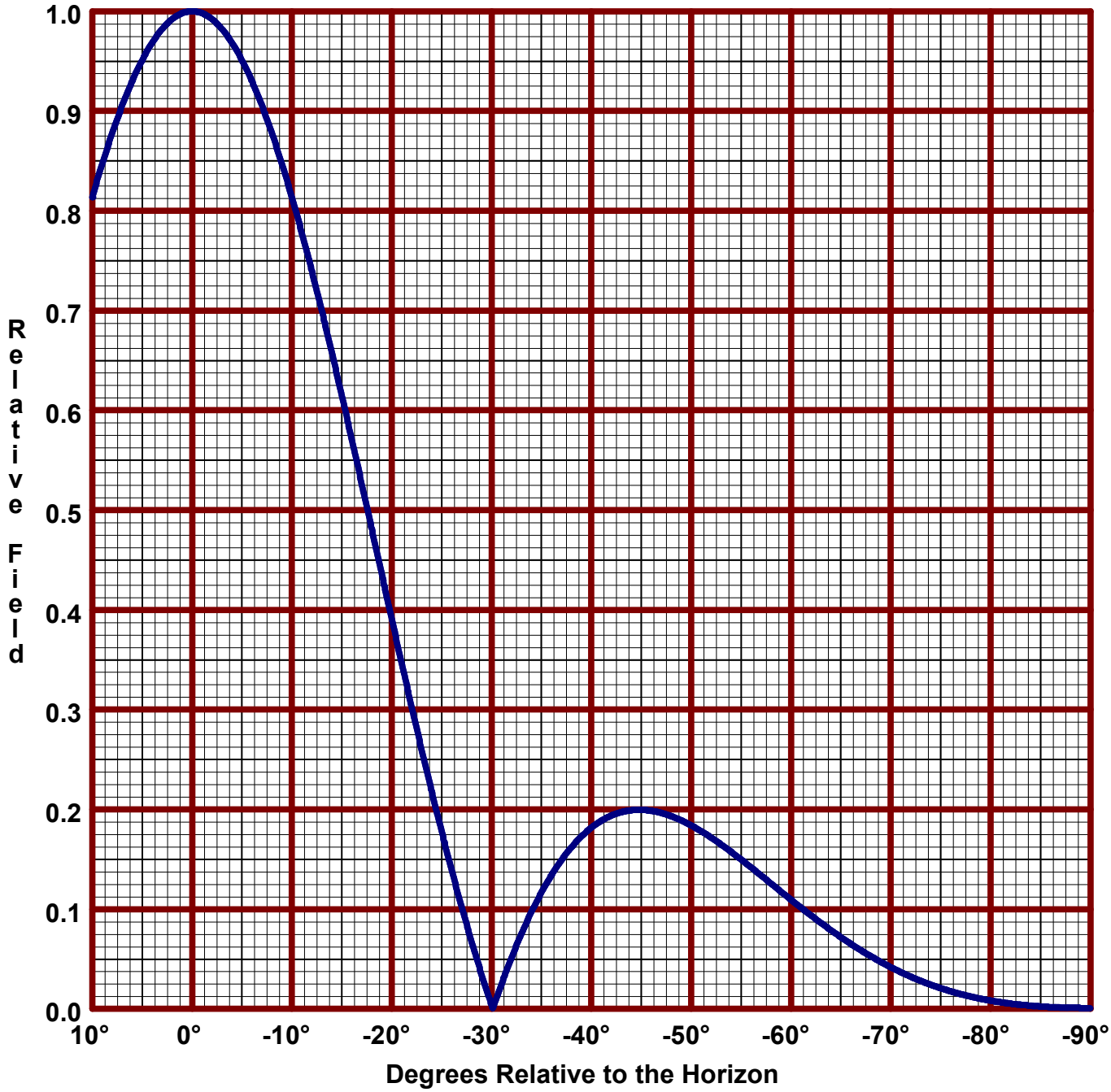
Figure No: 3
Call Sign: WNFN
Location: Franklin, TN.
Frequency: 106.7 MHz
Antenna: 4 bay SHP-4AE-DA-HW

Date: 10/3/2017
H/V Power Ratio: 1
.5 Wave-length Spacing
0° Beam Tilt
0% First Null Fill



Horizontal Polarization:
Maximum: 2.080 (3.181 dB)
Horizontal Plane: 2.080 (3.181 dB)
Maximum ERP: 15.000 kW

Vertical Polarization:
Maximum: 2.080 (3.181 dB)
Horizontal Plane: 2.080 (3.181 dB)
Maximum ERP: 15.000 kW

Directional Antenna System
for
WNFN, Franklin, Tennessee

(Continued)

ANTENNA SPECIFICATIONS

Antenna Type:	SHP-4AE-DA-HW
Frequency:	106.7 MHz
Number of Bays:	Four

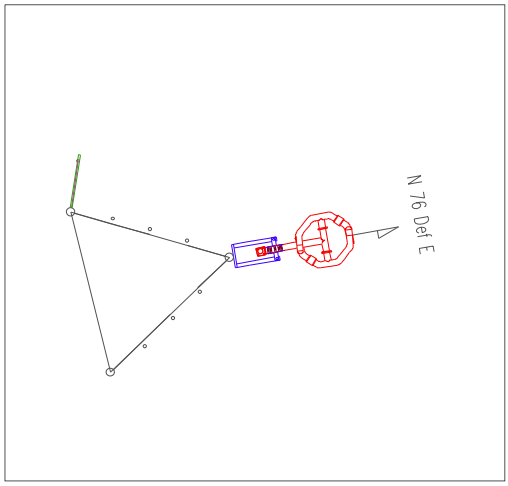
MECHANICAL SPECIFICATIONS

Mounting:	Custom
System length:	17 ft 5 in
Aperture length required:	33 ft 9 in
Orientation:	76° true

Input flange to the antenna 3 1/8" female.

ELECTRICAL SPECIFICATIONS
(For directional use)

Maximum horizontal ERP:	15.000 kW (11.761 dBk)
Horizontal maximum power gain:	2.080 (3.181 dB)
Maximum vertical ERP:	15.000 kW (11.761 dBk)
Vertical maximum power gain:	2.080 (3.181 dB)
Total input power:	7.211 kW (8.58 dBk)



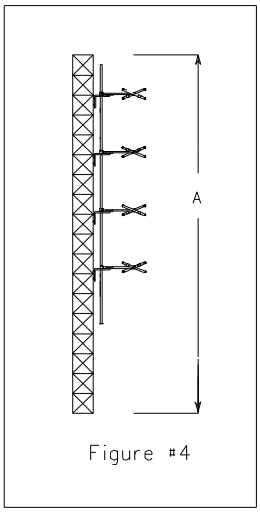


Figure #4