

***Directional Antenna System  
for  
WCEN, Hemlock, Michigan***

September 23, 2004

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 WCEN.

The antenna is the ERI model MP-8AC-DA configuration. The circular polarized system consists of 8 full-wavelength spaced bays using one driven circular polarized radiating element, one horizontal parasitic elements placed one quarter wave above and below each bay and two vertical parasitic elements per bay. The antenna was tested on a stepped pole, which is the structure the station plans to use to support the array. All tests were performed on a frequency of 94.5 megahertz, which is the center of the FM broadcast channel assigned to WCEN.

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.

# Directional Antenna System For WCEN, Hemlock, Michigan

(Continued)

## DESCRIPTION OF THE TEST PROCEDURE

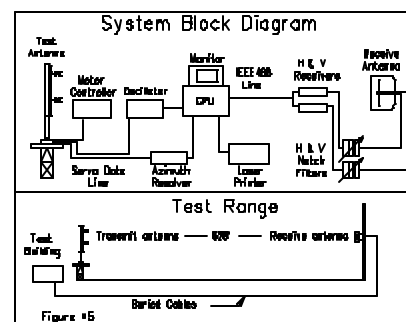
The test antenna consisted of two bay levels of the circular polarized system with the associated horizontal and vertical parasitic elements. The elements and brackets that were used in this test are electrically equivalent to those that will be supplied with the antenna. A section of 3 1/8 inch o.d. 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 stepped pole 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 azimuth indicating mechanism, resolution of this azimuth measuring device is one-tenth of a degree.

The antenna under test was operated in the transmitting mode and fed from a Wavetek Model 3000 signal generator. The frequency of the signal source was set at 94.5 MHz and was constantly monitored by an Anritsu Model ML521B measuring receiver.

A broad-band horizontal and vertical dipole system, located approximately 628 feet from the test antenna, was used to receive the emitted test signals. 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 an Anritsu Model ML521B measuring receiver.



# Directional Antenna System For WCEN, Hemlock, Michigan

(Continued)

This data was interfaced to a Hewlett-Packard Laser Jet 4P printer by means of a Pentium 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 coordinated graph paper in a clockwise direction. Both horizontal and vertical components were recorded separately.

## CONCLUSIONS

The circular polarized system consists of 8 full-wavelength spaced bays using one driven circular polarized radiating element, one horizontal parasitic elements placed one quarter wave above and below each bay and two vertical parasitic elements per bay. The power distribution and phase relationship will be fixed when antenna is manufactured. Proper maintenance of the elements should be all that is required to maintain the pattern in adjustment.

The MP-8AC-DA array is to be mounted on the stepped pole at a bearing of North 65 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 maximum value of either the horizontal or vertical component at any azimuth. The measured horizontal plane relative field pattern, for both the horizontal and vertical polarization components, is shown on Figure #2 attached. 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 100 kilowatts (20 dBk).

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 than 85% of the filed composite pattern.

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(Continued)

The clear vertical length of the structure required to support the antenna is 87 feet 7 in, if the antenna is to be top mounted.

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.

A handwritten signature in cursive script, appearing to read "Tom St. Louis".

# **ERI**® *Horizontal Plane Relative Field Pattern*

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

FIGURE: 1

STATION: WCEN

LOCATION: HEMLOCK, MI

ANTENNA TYPE: MP-8AC-DA

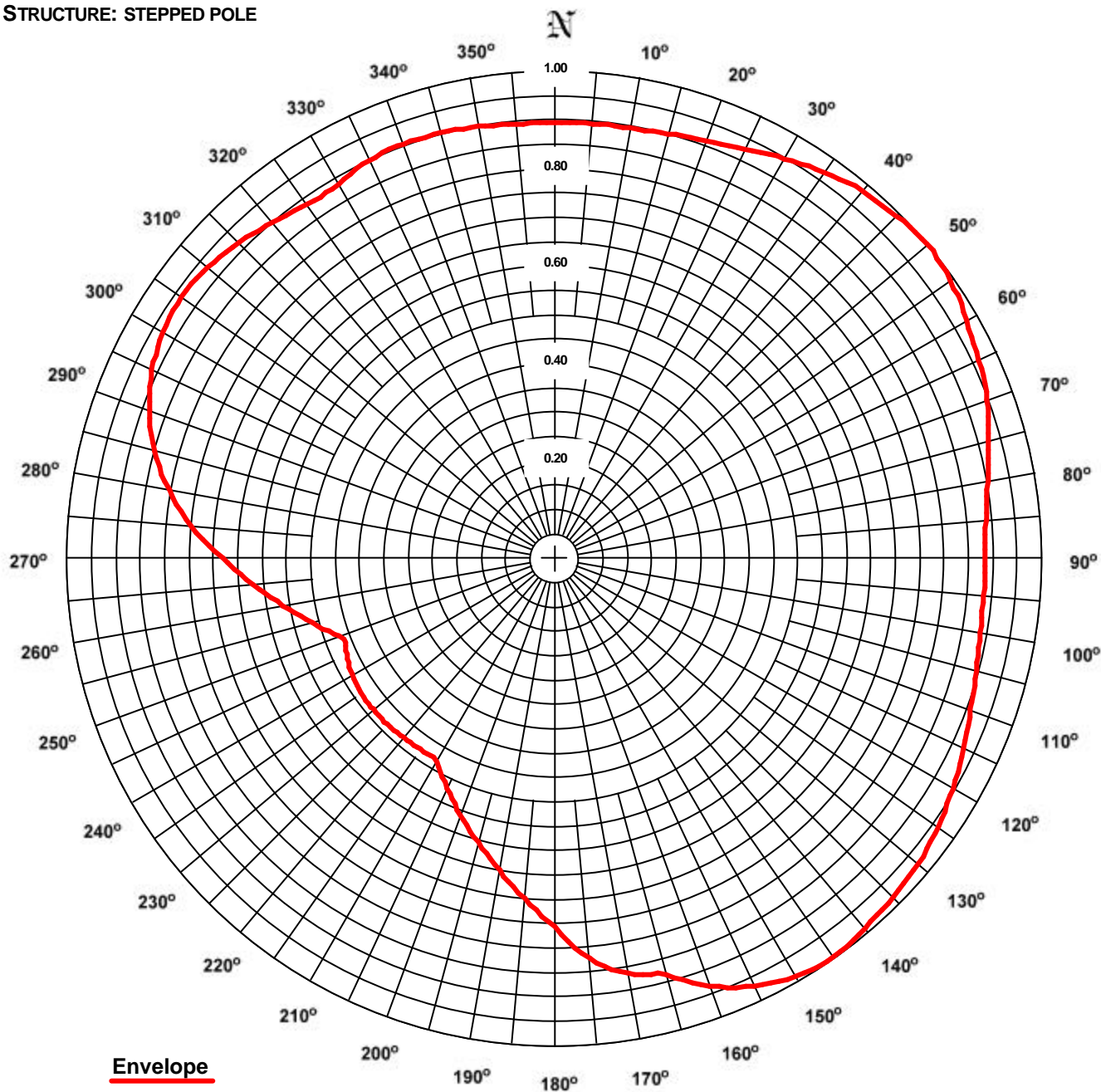
STRUCTURE: STEPPED POLE

DATE: 9/23/2004

FREQUENCY: 94.5 MHz

ORIENTATION: 65° TRUE

MOUNTING: STANDARD



RMS: 0.840

Maximum: 1.000 @ 50° True

Minimum: 0.462 @ 249° True

COMMENTS: COMPOSITE PATTERN: THIS PATTERN SHOWS THE MAXIMUM OF EITHER THE H OR V AZIMUTH VALUES. THIS PATTERN DOES NOT EXCEED THE FCC FILED COMPOSITE PATTERN AT ANY AZIMUTH. THE RMS OF THIS PATTERN IS GREATER THAN 85% OF THE FILED FCC COMPOSITE PATTERN BMLH-20011121AAX ..

# **ERI**® *Horizontal Plane Relative Field List*

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

**Station: WCEN**  
**Location: Hemlock, MI**  
**Frequency: 94.5 MHz**

**Antenna: MP-8AC-DA**  
**Orientation: 65° True**  
**Tower: stepped pole**

**Figure: 1**  
**Date: 9/23/2004**  
**Reference: wcen1m.fig**

Angle	Envelope			Polarization	Angle	Envelope			Polarization
	Field	kW	dBk			Field	kW	dBk	
0°	0.893	79.79	19.02	Horizontal	180°	0.758	57.46	17.59	Horizontal
5°	0.895	80.02	19.03	Horizontal	185°	0.702	49.35	16.93	Horizontal
10°	0.895	80.14	19.04	Vertical	190°	0.651	42.38	16.27	Horizontal
15°	0.901	81.22	19.10	Vertical	195°	0.605	36.59	15.63	Horizontal
20°	0.910	82.80	19.18	Vertical	200°	0.562	31.58	14.99	Horizontal
25°	0.925	85.56	19.32	Horizontal	205°	0.521	27.14	14.34	Horizontal
30°	0.946	89.53	19.52	Horizontal	210°	0.483	23.33	13.68	Horizontal
35°	0.966	93.25	19.70	Horizontal	215°	0.480	23.01	13.62	Vertical
40°	0.984	96.87	19.86	Horizontal	220°	0.482	23.23	13.66	Vertical
45°	0.992	98.41	19.93	Horizontal	225°	0.484	23.42	13.70	Vertical
50°	1.000	100.00	20.00	Horizontal	230°	0.485	23.51	13.71	Vertical
55°	0.993	98.60	19.94	Horizontal	235°	0.484	23.43	13.70	Vertical
60°	0.977	95.42	19.80	Horizontal	240°	0.479	22.95	13.61	Vertical
65°	0.962	92.52	19.66	Vertical	245°	0.470	22.10	13.44	Vertical
70°	0.946	89.45	19.52	Vertical	250°	0.470	22.09	13.44	Horizontal
75°	0.923	85.22	19.31	Vertical	255°	0.516	26.59	14.25	Horizontal
80°	0.903	81.54	19.11	Vertical	260°	0.566	32.00	15.05	Horizontal
85°	0.890	79.13	18.98	Vertical	265°	0.621	38.59	15.87	Horizontal
90°	0.886	78.43	18.94	Horizontal	270°	0.682	46.55	16.68	Horizontal
95°	0.884	78.20	18.93	Horizontal	275°	0.748	55.94	17.48	Horizontal
100°	0.888	78.82	18.97	Vertical	280°	0.804	64.59	18.10	Horizontal
105°	0.897	80.41	19.05	Vertical	285°	0.849	72.15	18.58	Horizontal
110°	0.910	82.75	19.18	Vertical	290°	0.885	78.37	18.94	Horizontal
115°	0.927	85.97	19.34	Vertical	295°	0.911	83.01	19.19	Horizontal
120°	0.945	89.30	19.51	Vertical	300°	0.927	85.94	19.34	Horizontal
125°	0.961	92.42	19.66	Vertical	305°	0.933	87.05	19.40	Horizontal
130°	0.978	95.65	19.81	Vertical	310°	0.928	86.20	19.36	Horizontal
135°	0.984	96.92	19.86	Vertical	315°	0.916	83.96	19.24	Horizontal
140°	0.991	98.21	19.92	Vertical	320°	0.898	80.72	19.07	Horizontal
145°	1.000	100.00	20.00	Vertical	325°	0.886	78.56	18.95	Horizontal
150°	0.992	98.38	19.93	Vertical	330°	0.887	78.75	18.96	Vertical
155°	0.970	94.11	19.74	Vertical	335°	0.900	80.92	19.08	Vertical
160°	0.935	87.39	19.41	Vertical	340°	0.904	81.74	19.12	Vertical
165°	0.886	78.48	18.95	Vertical	345°	0.903	81.48	19.11	Vertical
170°	0.866	74.93	18.75	Horizontal	350°	0.899	80.77	19.07	Vertical
175°	0.825	68.00	18.33	Horizontal	355°	0.894	79.92	19.03	Vertical

**Polarization:**  
**Maximum Field:**  
**Minimum Field:**  
**RMS:**  
**Maximum ERP:**  
**Maximum Power Gain:**

**Envelope**  
**1.000 @ 50° True**  
**0.462 @ 249° True**  
**0.840**  
**100.000 kW**  
**6.547 (8.160 dB)**

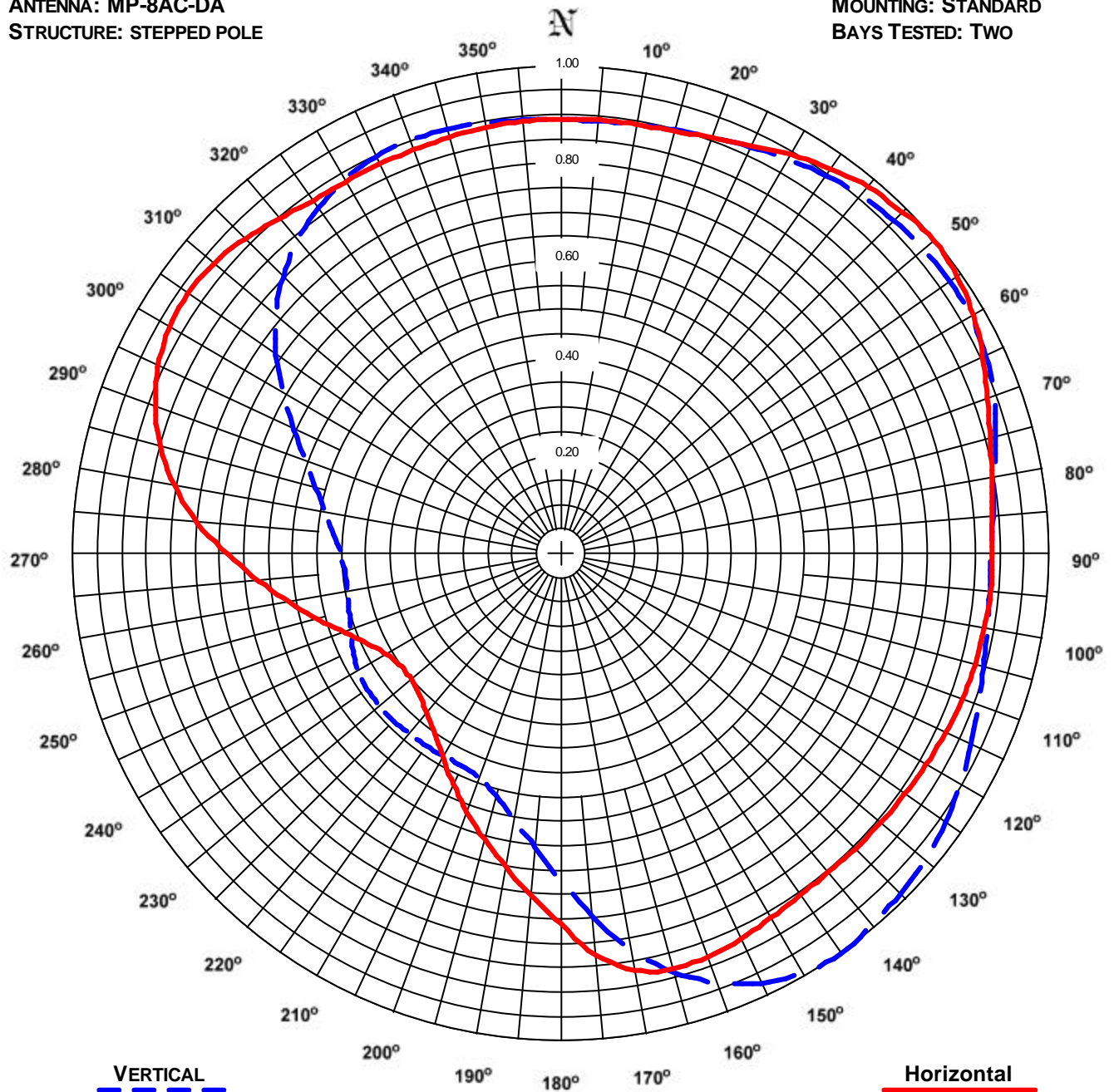
**Total Input Power: 15.275 kW**

# **ERI**® *Horizontal Plane Relative Field Pattern*

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

FIGURE NO: 2  
STATION: WCEN  
LOCATION: HEMLOCK, MI  
ANTENNA: MP-8AC-DA  
STRUCTURE: STEPPED POLE

DATE: 9/23/2004  
FREQUENCY: 94.5 MHz  
ORIENTATION: 65° TRUE  
MOUNTING: STANDARD  
BAYS TESTED: TWO



VERTICAL  
RMS: 0.796  
MAXIMUM: 1.000 @ 145° TRUE  
MINIMUM: 0.443 @ 263° TRUE

Horizontal  
RMS: 0.818  
Maximum: 1.000 @ 50° True  
Minimum: 0.399 @ 233° True

COMMENTS: MEASURED PATTERNS OF THE HORIZONTAL AND VERTICAL COMPONENTS.

# **ERI<sup>®</sup>** *Horizontal Plane Relative Field List*

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**Station: WCEN**  
**Location: Hemlock, MI**  
**Frequency: 94.5 MHz**

**Antenna: MP-8AC-DA**  
**Orientation: 65° True**  
**Tower: stepped pole**

**Figure: 2**  
**Date: 9/23/2004**  
**Reference: wcen1m.fig**

Angle	Horizontal			Vertical			Angle	Horizontal			Vertical		
	Field	kW	dBk	Field	kW	dBk		Field	kW	dBk	Field	kW	dBk
0°	0.893	79.79	19.02	0.892	79.48	19.00	180°	0.758	57.46	17.59	0.669	44.72	16.50
5°	0.895	80.02	19.03	0.892	79.55	19.01	185°	0.702	49.35	16.93	0.604	36.42	15.61
10°	0.895	80.10	19.04	0.895	80.14	19.04	190°	0.651	42.38	16.27	0.552	30.46	14.84
15°	0.899	80.78	19.07	0.901	81.22	19.10	195°	0.605	36.59	15.63	0.514	26.41	14.22
20°	0.909	82.58	19.17	0.910	82.80	19.18	200°	0.562	31.58	14.99	0.489	23.95	13.79
25°	0.925	85.56	19.32	0.921	84.91	19.29	205°	0.521	27.14	14.34	0.479	22.90	13.60
30°	0.946	89.53	19.52	0.936	87.53	19.42	210°	0.483	23.33	13.68	0.478	22.89	13.60
35°	0.966	93.25	19.70	0.949	90.01	19.54	215°	0.451	20.33	13.08	0.480	23.01	13.62
40°	0.984	96.87	19.86	0.959	91.99	19.64	220°	0.426	18.18	12.60	0.482	23.23	13.66
45°	0.992	98.41	19.93	0.967	93.47	19.71	225°	0.410	16.77	12.25	0.484	23.42	13.70
50°	1.000	100.00	20.00	0.972	94.42	19.75	230°	0.400	16.03	12.05	0.485	23.51	13.71
55°	0.993	98.60	19.94	0.974	94.85	19.77	235°	0.400	16.00	12.04	0.484	23.43	13.70
60°	0.977	95.42	19.80	0.971	94.34	19.75	240°	0.412	16.94	12.29	0.479	22.95	13.61
65°	0.954	91.08	19.59	0.962	92.52	19.66	245°	0.435	18.92	12.77	0.470	22.10	13.44
70°	0.930	86.56	19.37	0.946	89.45	19.52	250°	0.470	22.09	13.44	0.458	20.97	13.22
75°	0.911	83.03	19.19	0.923	85.22	19.31	255°	0.516	26.59	14.25	0.449	20.15	13.04
80°	0.897	80.52	19.06	0.903	81.54	19.11	260°	0.566	32.00	15.05	0.444	19.71	12.95
85°	0.889	79.00	18.98	0.890	79.13	18.98	265°	0.621	38.59	15.87	0.444	19.71	12.95
90°	0.886	78.43	18.94	0.883	77.93	18.92	270°	0.682	46.55	16.68	0.451	20.38	13.09
95°	0.884	78.20	18.93	0.883	77.96	18.92	275°	0.748	55.94	17.48	0.467	21.78	13.38
100°	0.882	77.80	18.91	0.888	78.82	18.97	280°	0.804	64.59	18.10	0.489	23.95	13.79
105°	0.879	77.24	18.88	0.897	80.41	19.05	285°	0.849	72.15	18.58	0.520	27.01	14.32
110°	0.875	76.51	18.84	0.910	82.75	19.18	290°	0.885	78.37	18.94	0.558	31.09	14.93
115°	0.870	75.63	18.79	0.927	85.97	19.34	295°	0.911	83.01	19.19	0.603	36.37	15.61
120°	0.864	74.69	18.73	0.945	89.30	19.51	300°	0.927	85.94	19.34	0.656	43.05	16.34
125°	0.860	73.91	18.69	0.961	92.42	19.66	305°	0.933	87.05	19.40	0.713	50.85	17.06
130°	0.856	73.29	18.65	0.978	95.65	19.81	310°	0.928	86.20	19.36	0.763	58.23	17.65
135°	0.853	72.84	18.62	0.984	96.92	19.86	315°	0.916	83.96	19.24	0.806	64.89	18.12
140°	0.852	72.55	18.61	0.991	98.21	19.92	320°	0.898	80.72	19.07	0.840	70.63	18.49
145°	0.854	73.00	18.63	1.000	100.00	20.00	325°	0.886	78.56	18.95	0.868	75.29	18.77
150°	0.861	74.19	18.70	0.992	98.38	19.93	330°	0.882	77.75	18.91	0.887	78.75	18.96
155°	0.871	75.95	18.81	0.970	94.11	19.74	335°	0.882	77.83	18.91	0.900	80.92	19.08
160°	0.878	77.16	18.87	0.935	87.39	19.41	340°	0.883	78.06	18.92	0.904	81.74	19.12
165°	0.881	77.62	18.90	0.886	78.48	18.95	345°	0.886	78.42	18.94	0.903	81.48	19.11
170°	0.866	74.93	18.75	0.823	67.80	18.31	350°	0.888	78.92	18.97	0.899	80.77	19.07
175°	0.825	68.00	18.33	0.747	55.85	17.47	355°	0.891	79.43	19.00	0.894	79.92	19.03

<b>Polarization:</b>	<b>Horizontal</b>	<b>Vertical</b>
<b>Maximum Field:</b>	<b>1.000 @ 50° True</b>	<b>1.000 @ 145° True</b>
<b>Minimum Field:</b>	<b>0.399 @ 233° True</b>	<b>0.443 @ 263° True</b>
<b>RMS:</b>	<b>0.818</b>	<b>0.796</b>
<b>Maximum ERP:</b>	<b>100.000 kW</b>	<b>100.000 kW</b>
<b>Maximum Power Gain:</b>	<b>6.547 (8.160 dB)</b>	<b>6.547 (8.160 dB)</b>

**Total Input Power: 15.275 kW**





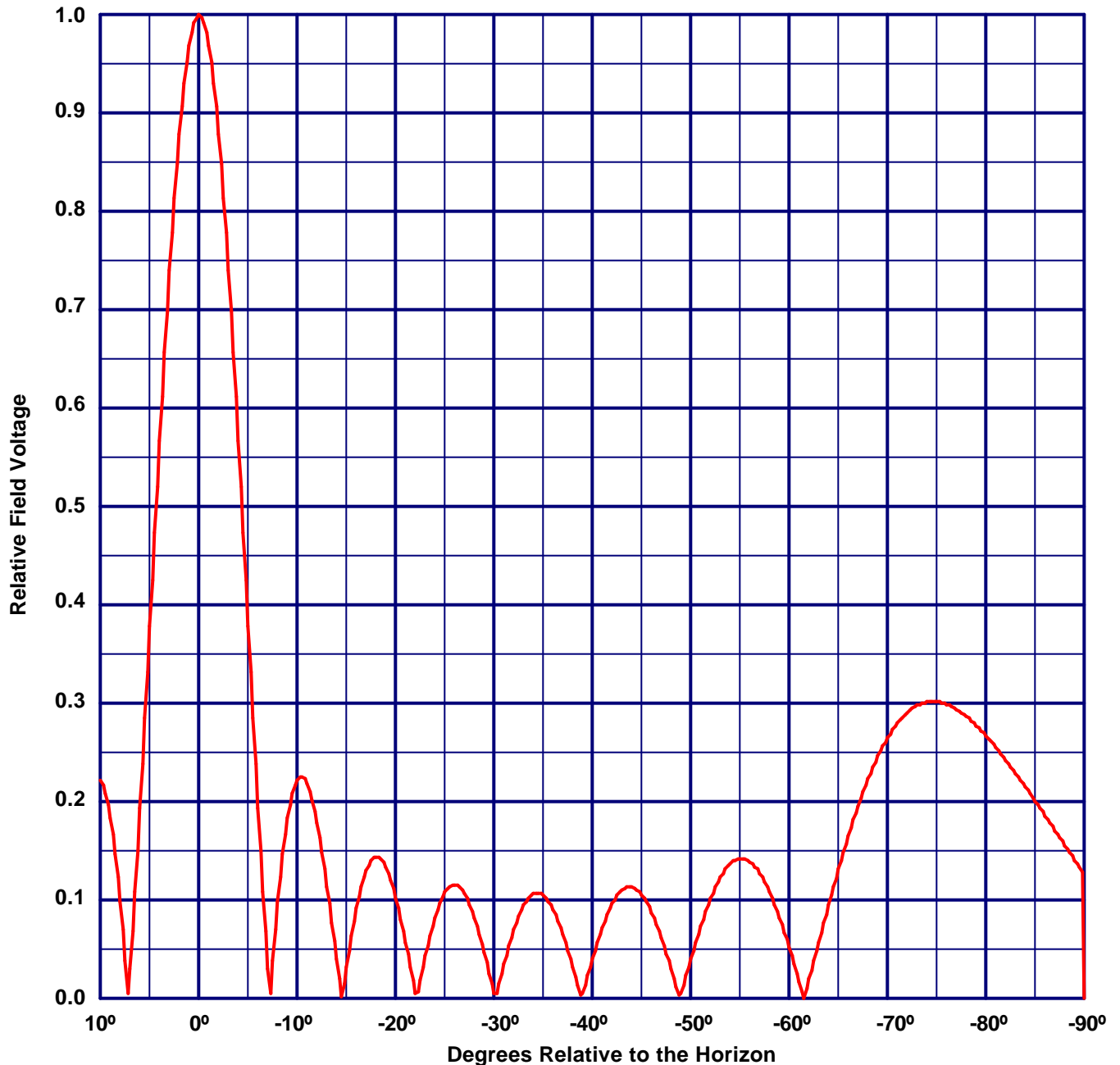
## ***Vertical Plane Relative Field Pattern***

**WCEN, Hemlock, MI, 94.5 MHz**

**Figure#: 3**

**Date: 9/23/2004**

***An 8 level, 1 wave-length spaced MP-8AC-DA directional antenna  
with 0° beam tilt, 0% null fill and a H/V maximum power ratio of 1.000***



**Vertical Polarization Gain:**

**Maximum: 6.547 (8.160 dB)**

**Horizontal Plane: 6.547 (8.160 dB)**

**Horizontal Polarization Gain:**

**Maximum: 6.547 (8.160 dB)**

**Horizontal Plane: 6.547 (8.160 dB)**

# Directional Antenna System for WCEN, Hemlock, Michigan

(Continued)

## ANTENNA SPECIFICATIONS

Antenna Type:	MP-8AC-DA
Frequency:	94.5 MHz
Number of Bays:	8

## MECHANICAL SPECIFICATIONS

Mounting:	Standard
System length:	76 ft 5 in
Aperture length required:	87 ft. 7 in
Orientation:	65° true
Input flange to the antenna 3 1/8 inch female	

## ELECTRICAL SPECIFICATIONS

(For directional use)

Maximum horizontal ERP:	100 kW (20 dBk)
Horizontal maximum power gain:	6.547 (8.160 dB)
Maximum vertical ERP:	100 kW (20 dBk)
Vertical maximum power gain:	6.547 (8.160 dB)
Total input power:	15.275 kW (11.840 dBk)

