



**ELECTRONICS RESEARCH INC.**

7777 Gardner Rd. Chandler, In 47810 Phone (912) 925-8000 Fax (912) 925-4030

## Directional Antenna System For WRUW, Cleveland, OH

September 15, 1998

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 WRUW.

The antenna is the ERI model LP-4E-DA-HW configuration. The circular polarized system consists of 4 half-wavelength spaced bays using one driven circular polarized radiating element per bay, three horizontal parasitic elements per bay and two vertical parasitic elements interleaved between alternate bay pairs. The antenna was mounted on the North 328 degrees East tower face with bracketry to provide an antenna orientation of North 328 degrees East. The antenna was tested on a **ERI**®  $\lambda$  MOUNTING SYSTEM, which is the structure recommended to support the array. All tests were performed on a frequency of 91.1 megahertz which is the center of the FM broadcast channel assigned to WRUW.

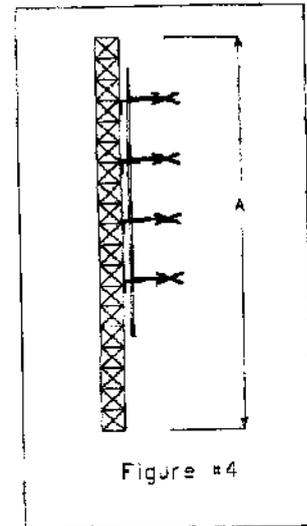


Figure #4

Pattern measurements were made on a sixty-acre antenna pattern range which 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 WRUW, Cleveland, OH

(Continued)

## DESCRIPTION OF THE TEST PROCEDURE

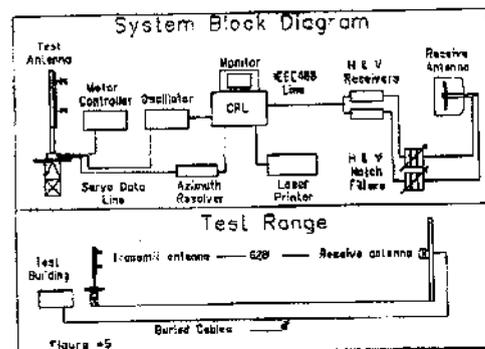
The test antenna consisted of two bay levels of the circular polarized system with the associated horizontal and vertical parasitic elements. The elements and brackets that were used in this test are electrically equivalent to those that will be supplied with the antenna. A section of 1 5/8 inch o.d. rigid coaxial line was used to feed the test antenna, and a section of 1 5/8 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 pattern for both horizontal and vertical polarization components.

The proof-of-performance was accomplished using a supporting structure of identical dimension and configuration as the **ERI®**  $\lambda$  **MOUNTING SYSTEM**, 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 91.1 MHz and was constantly monitored by an Anritsu Model ML521B measuring receiver.



# Directional Antenna System For WRUW, Cleveland, OH

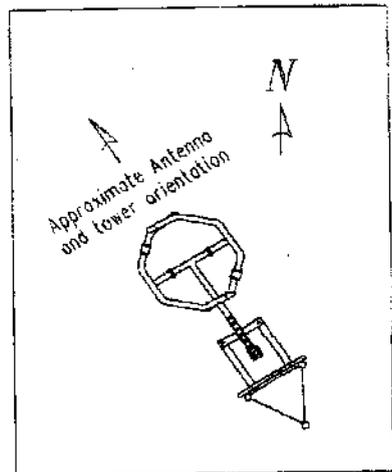
(Continued)

A broad-band horizontal and vertical dipole system, located approximately 628 feet from the test antenna, and mounted at the same height above terrain as the center of the antenna under test, was used to receive the emitted test signals. The signals received by the dipole system were fed to the test building by way of two buried Heliac cables to an Anritsu Model ML521B measuring receiver. 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 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 per bay, three horizontal parasitic elements per bay and two vertical parasitic elements interleaved between alternate bay pairs. The antenna was mounted on the North 328 degrees East tower face with bracketry to provide an antenna orientation of North 328 degrees East. 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 LP-4E-DA-HW array is to be oriented on the **ERI**<sup>®</sup>  $\lambda$  **MOUNTING SYSTEM** at a bearing of North 328 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.

Directional Antenna System  
For  
WRUW, Cleveland, OH

(Continued)

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. 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 130-170 degrees East does not exceed 1 kilowatts (0 dBk).

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

The clear vertical length of the structure required to support the antenna is 32 feet if the antenna is to be top mounted.

The directional antenna should not be mounted on the top of an antenna tower which 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.

The calculated maximum power gain of the horizontally polarized component is 2.645 (4.223 dB).

The calculated maximum power gain of the vertically polarized component is 2.645 (4.223 dB).

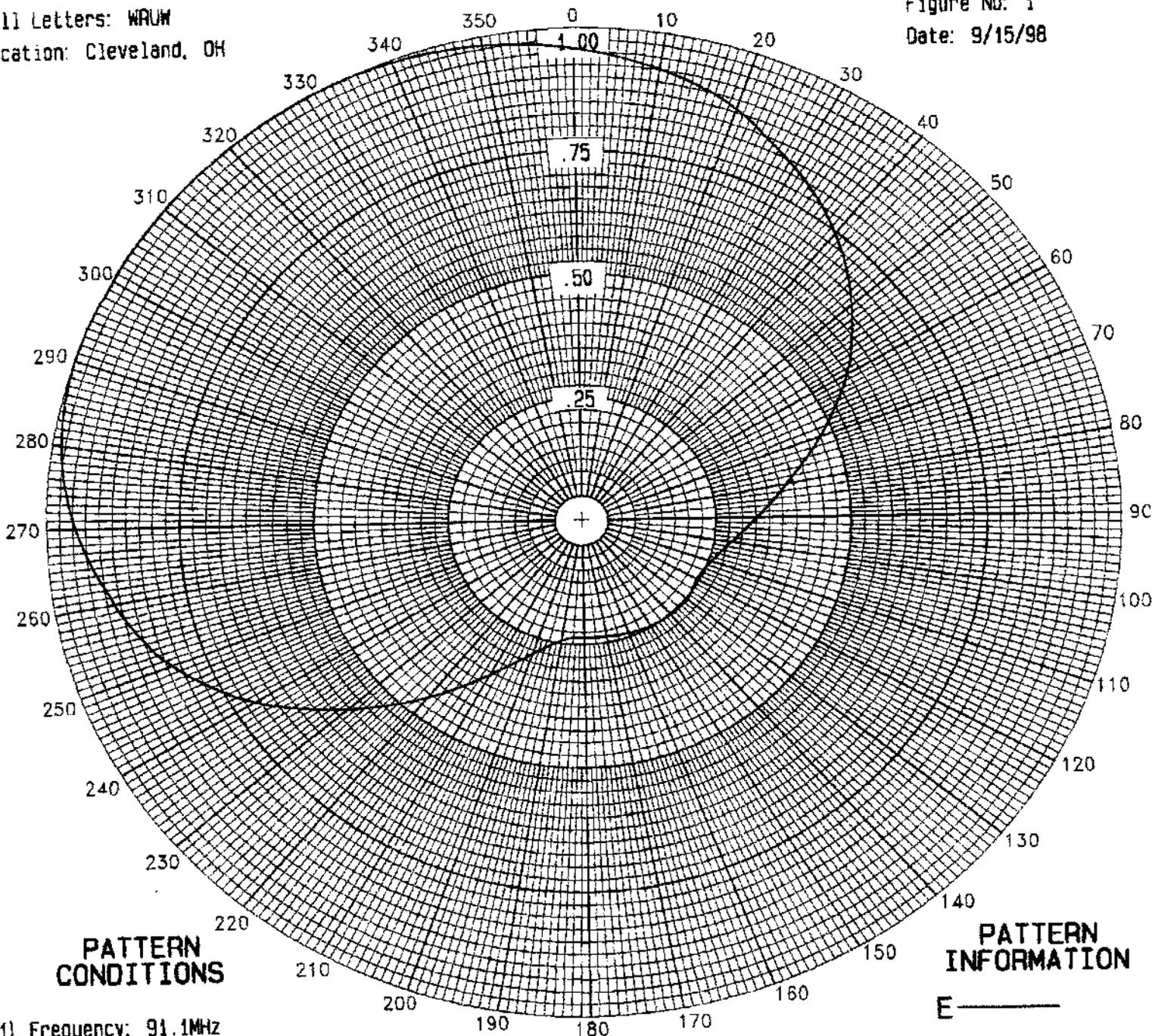
The calculated input power to the antenna input flange is 5.672 kilowatts (7.537 dBk) to provide a maximum horizontal ERP of 15 kilowatts (11.761 dBk) and a maximum vertical ERP of 15 kilowatts (11.761 dBk). The input flange to the antenna is 1 5/8 inch male.

ELECTRONICS RESEARCH, INC.

# ERI HORIZONTAL PLANE RELATIVE FIELD ENVELOPE PATTERN

Call Letters: WRAUW  
 Location: Cleveland, OH

Figure No: 1  
 Date: 9/15/98



### PATTERN CONDITIONS

- 1) Frequency: 91.1MHz
- 2) Antenna Type: LP-4E-DA-HW
- 3) Antenna Orientation: North 328 Deg. East
- 4) Antenna Mounting: Standard
- 5) Tower Type: Lambda
- 6) Comments: Envelope Pattern: A composite maximum of either H or V azimuth values.

### PATTERN INFORMATION

**ENVELOPE**  
 RMS .6911  
 Maximum: 1 @ 292°  
 Minimum: .2376 @ 183°



# Horizontal Plane Relative Field & dBk List

Radio Station WRUW  
List For Figure# 1

Frequency: 91.1MHz  
Date 9/15/98

AZIMUTH	RELATIVE FIELD	dBk	POWER kW	POLARIZATION	AZIMUTH	RELATIVE FIELD	dBk	POWER kW	POLARIZATION
0°	0.958	11.389	13.770	HORIZONTAL	180°	0.238	-0.717	0.848	HORIZONTAL
5°	0.943	11.254	13.347	HORIZONTAL	185°	0.239	-0.687	0.854	HORIZONTAL
10°	0.926	11.095	12.867	HORIZONTAL	190°	0.247	-0.401	0.912	HORIZONTAL
15°	0.907	10.911	12.335	HORIZONTAL	195°	0.263	0.145	1.034	HORIZONTAL
20°	0.882	10.668	11.664	HORIZONTAL	200°	0.287	0.904	1.231	HORIZONTAL
25°	0.847	10.316	10.756	VERTICAL	205°	0.318	1.823	1.522	HORIZONTAL
30°	0.817	10.000	10.001	VERTICAL	210°	0.358	2.850	1.927	HORIZONTAL
35°	0.783	9.638	9.199	VERTICAL	215°	0.406	3.941	2.478	HORIZONTAL
40°	0.747	9.222	8.361	VERTICAL	220°	0.462	5.061	3.207	HORIZONTAL
45°	0.707	8.748	7.495	VERTICAL	225°	0.519	6.061	4.037	HORIZONTAL
50°	0.664	8.204	6.614	VERTICAL	230°	0.582	7.061	5.083	HORIZONTAL
55°	0.619	7.595	5.748	HORIZONTAL	235°	0.646	7.961	6.253	HORIZONTAL
60°	0.575	6.951	4.956	HORIZONTAL	240°	0.711	8.803	7.591	HORIZONTAL
65°	0.525	6.156	4.127	HORIZONTAL	245°	0.767	9.461	8.833	HORIZONTAL
70°	0.476	5.313	3.399	HORIZONTAL	250°	0.818	10.012	10.027	HORIZONTAL
75°	0.430	4.437	2.778	HORIZONTAL	255°	0.856	10.411	10.992	HORIZONTAL
80°	0.389	3.561	2.270	HORIZONTAL	260°	0.887	10.721	11.807	HORIZONTAL
85°	0.356	2.789	1.901	HORIZONTAL	265°	0.918	11.015	12.632	VERTICAL
90°	0.327	2.058	1.606	HORIZONTAL	270°	0.945	11.269	13.392	VERTICAL
95°	0.303	1.386	1.376	HORIZONTAL	275°	0.967	11.467	14.017	VERTICAL
100°	0.283	0.792	1.200	HORIZONTAL	280°	0.983	11.612	14.495	VERTICAL
105°	0.267	0.297	1.071	HORIZONTAL	285°	0.994	11.708	14.818	VERTICAL
110°	0.256	-0.079	0.982	HORIZONTAL	290°	0.999	11.755	14.980	VERTICAL
115°	0.249	-0.318	0.929	HORIZONTAL	295°	1.000	11.761	15.000	VERTICAL
120°	0.246	-0.410	0.910	HORIZONTAL	300°	1.000	11.760	14.998	VERTICAL
125°	0.250	-0.295	0.934	HORIZONTAL	305°	0.999	11.755	14.979	VERTICAL
130°	0.254	-0.147	0.967	HORIZONTAL	310°	0.999	11.754	14.977	HORIZONTAL
135°	0.254	-0.147	0.967	HORIZONTAL	315°	1.000	11.761	15.000	HORIZONTAL
140°	0.253	-0.175	0.960	HORIZONTAL	320°	1.000	11.761	15.000	HORIZONTAL
145°	0.252	-0.224	0.950	HORIZONTAL	325°	1.000	11.761	15.000	HORIZONTAL
150°	0.250	-0.293	0.935	HORIZONTAL	330°	1.000	11.761	15.000	HORIZONTAL
155°	0.247	-0.383	0.915	HORIZONTAL	335°	0.999	11.749	14.960	HORIZONTAL
160°	0.244	-0.488	0.894	HORIZONTAL	340°	0.995	11.718	14.852	HORIZONTAL
165°	0.242	-0.576	0.876	HORIZONTAL	345°	0.989	11.667	14.678	HORIZONTAL
170°	0.240	-0.644	0.862	HORIZONTAL	350°	0.981	11.595	14.438	HORIZONTAL
175°	0.238	-0.691	0.853	HORIZONTAL	355°	0.971	11.503	14.135	HORIZONTAL

CITY OF LICENSE: Cleveland, OH

MOUNTING STRUCTURE: Lambda

ANTENNA TYPE: LP-4E-DA-HW NUMBER OF BAYS:4

ENVELOPE MAXIMUM RELATIVE FIELD=1.0000 AZIMUTH=292°

ENVELOPE MINIMUM RELATIVE FIELD=0.2376 AZIMUTH=183°

ENVELOPE RMS = .6911

MAXIMUM HORIZONTAL E.R.P. = 15.000kW MAXIMUM VERTICAL E.R.P. = 15.000kW

TOTAL POWER INPUT= 5.6721kW

MAXIMUM HORIZONTAL POWER GAIN OF THE COMPLETE ARRAY= 2.645( 4.223dB)

MAXIMUM VERTICAL POWER GAIN OF THE COMPLETE ARRAY= 2.645( 4.223dB)

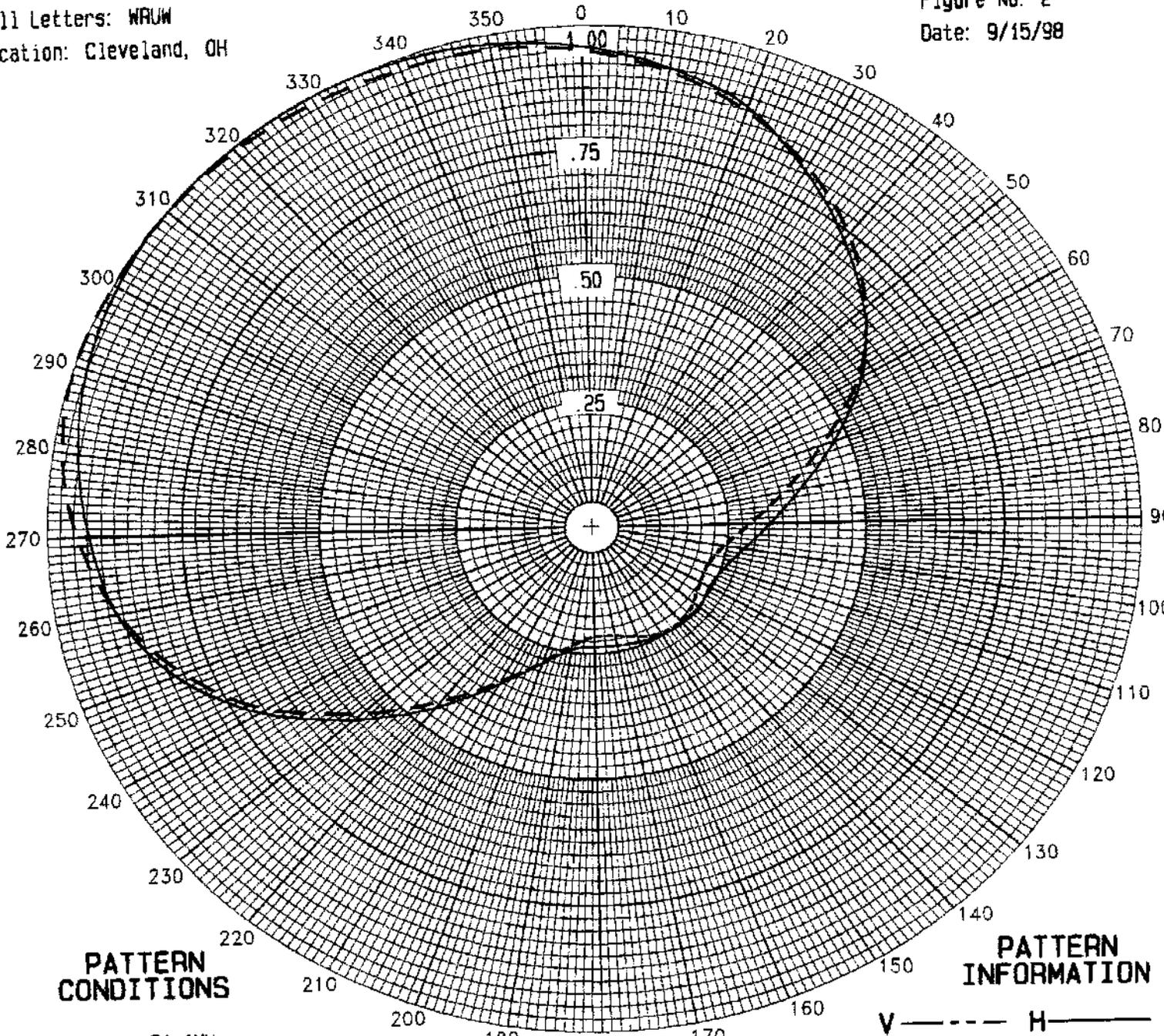
ANTENNA ORIENTATION: North 328 degrees East

REFERENCE: WRUWV.PAT

# ERI HORIZONTAL PLANE RELATIVE FIELD PATTERN

Call Letters: WRUW  
 Location: Cleveland, OH

Figure No: 2  
 Date: 9/15/98



### PATTERN CONDITIONS

- 1) Frequency: 91.1MHz
- 2) Antenna Type: LP-4E-DA-HW
- 3) Antenna Orientation: North 328 Deg. East
- 4) Antenna Mounting: Standard
- 5) Tower Type: Lambda
- 6) Comments: The measured horizontal and vertical components.

### PATTERN INFORMATION

VERTICAL	HORIZONTAL
RMS .6833	RMS .6871
Maximum: 1 @ 292°	Maximum: 1 @ 314°
Minimum: .2163 @ 177°	Minimum: .2376 @ 183°



# Horizontal Plane Relative Field & dBk List

Radio Station WRUW  
List For Figure# 2

Frequency: 91.1MHz  
Date 9/15/98

AZIMUTH	H POL RELATIVE FIELD	H POL dBk	H POL POWER kW	V POL RELATIVE FIELD	V POL dBk	V POL POWER kW	AZIMUTH	H POL RELATIVE FIELD	H POL dBk	H POL POWER kW	V POL RELATIVE FIELD	V POL dBk	V POL POWER kW
0°	0.958	11.389	13.770	0.951	11.322	13.559	180°	0.238	-0.717	0.848	0.218	-1.481	0.711
5°	0.943	11.254	13.347	0.936	11.189	13.149	185°	0.239	-0.687	0.854	0.225	-1.196	0.739
10°	0.926	11.095	12.867	0.919	11.024	12.658	190°	0.247	-0.401	0.912	0.238	-0.696	0.852
15°	0.907	10.911	12.335	0.898	10.825	12.091	195°	0.263	0.145	1.034	0.258	-0.017	0.996
20°	0.882	10.668	11.664	0.874	10.590	11.455	200°	0.287	0.904	1.231	0.283	0.801	1.203
25°	0.846	10.312	10.745	0.847	10.316	10.756	205°	0.318	1.823	1.522	0.315	1.717	1.485
30°	0.808	9.910	9.794	0.817	10.000	10.001	210°	0.358	2.850	1.927	0.352	2.697	1.861
35°	0.770	9.484	8.901	0.783	9.638	9.199	215°	0.406	3.941	2.478	0.396	3.711	2.350
40°	0.733	9.064	8.061	0.747	9.222	8.361	220°	0.462	5.061	3.207	0.445	4.738	2.977
45°	0.696	8.618	7.274	0.707	8.748	7.495	225°	0.519	6.061	4.037	0.501	5.761	3.768
50°	0.660	8.154	6.537	0.664	8.204	6.614	230°	0.582	7.061	5.083	0.563	6.771	4.785
55°	0.619	7.595	5.748	0.618	7.581	5.729	235°	0.646	7.961	6.253	0.628	7.716	5.910
60°	0.575	6.951	4.956	0.569	6.861	4.854	240°	0.711	8.803	7.591	0.700	8.661	7.347
65°	0.525	6.156	4.127	0.507	5.869	3.863	245°	0.767	9.461	8.833	0.754	9.312	8.534
70°	0.476	5.313	3.399	0.452	4.866	3.066	250°	0.818	10.012	10.027	0.803	9.859	9.680
75°	0.430	4.437	2.778	0.403	3.862	2.433	255°	0.856	10.411	10.992	0.847	10.317	10.758
80°	0.389	3.561	2.270	0.359	2.873	1.938	260°	0.887	10.721	11.807	0.885	10.790	11.748
85°	0.356	2.789	1.901	0.322	1.921	1.556	265°	0.907	10.911	12.334	0.918	11.015	12.632
90°	0.327	2.058	1.606	0.291	1.033	1.268	270°	0.923	11.061	12.767	0.945	11.269	13.392
95°	0.303	1.386	1.376	0.266	0.243	1.058	275°	0.939	11.214	13.226	0.967	11.467	14.017
100°	0.283	0.792	1.200	0.246	-0.411	0.910	280°	0.953	11.347	13.636	0.983	11.612	14.495
105°	0.267	0.297	1.071	0.233	-0.891	0.815	285°	0.966	11.460	13.997	0.994	11.708	14.818
110°	0.256	-0.079	0.982	0.226	-1.164	0.765	290°	0.977	11.555	14.304	0.999	11.755	14.980
115°	0.249	-0.318	0.929	0.225	-1.209	0.757	295°	0.985	11.631	14.558	1.000	11.761	15.000
120°	0.246	-0.410	0.910	0.227	-1.112	0.774	300°	0.992	11.689	14.755	1.000	11.760	14.998
125°	0.250	-0.295	0.934	0.232	-0.922	0.809	305°	0.996	11.730	14.895	0.999	11.755	14.979
130°	0.254	-0.147	0.967	0.239	-0.660	0.859	310°	0.999	11.754	14.977	0.998	11.744	14.941
135°	0.254	-0.147	0.967	0.245	-0.462	0.899	315°	1.000	11.761	15.000	0.996	11.727	14.885
140°	0.253	-0.175	0.960	0.248	-0.356	0.921	320°	1.000	11.761	15.000	0.994	11.705	14.809
145°	0.252	-0.224	0.950	0.248	-0.346	0.923	325°	1.000	11.761	15.000	0.990	11.678	14.716
150°	0.250	-0.293	0.935	0.245	-0.439	0.904	330°	1.000	11.761	15.000	0.987	11.645	14.603
155°	0.247	-0.383	0.915	0.240	-0.626	0.866	335°	0.999	11.749	14.960	0.982	11.606	14.473
160°	0.244	-0.488	0.894	0.232	-0.916	0.810	340°	0.995	11.718	14.852	0.977	11.561	14.325
165°	0.242	-0.576	0.876	0.224	-1.216	0.756	345°	0.989	11.667	14.678	0.975	11.544	14.270
170°	0.240	-0.644	0.862	0.219	-1.422	0.721	350°	0.981	11.595	14.438	0.970	11.499	14.122
175°	0.238	-0.691	0.853	0.217	-1.526	0.704	355°	0.971	11.503	14.135	0.962	11.425	13.885

CITY OF LICENSE: Cleveland, OH  
MOUNTING STRUCTURE: Lambda  
ANTENNA TYPE: LP-4E-DA-HW NUMBER OF BAYS:4  
HORIZONTAL MAXIMUM RELATIVE FIELD=1.0000 AZIMUTH=314  
HORIZONTAL MINIMUM RELATIVE FIELD=0.2376 AZIMUTH=183  
VERTICAL MAXIMUM RELATIVE FIELD=1.0000 AZIMUTH=292  
VERTICAL MINIMUM RELATIVE FIELD=0.2163 AZIMUTH=177  
HORIZONTAL RMS=.6871 VERTICAL RMS=.6833  
MAXIMUM HORIZONTAL E.R.P. = 15.000kW MAXIMUM VERTICAL E.R.P. = 15.000kW  
TOTAL POWER INPUT = 5.6721kW  
MAXIMUM HORIZONTAL POWER GAIN OF THE COMPLETE ARRAY = 2.645( 4.223dB)  
MAXIMUM VERTICAL POWER GAIN OF THE COMPLETE ARRAY = 2.645( 4.223dB)  
ANTENNA ORIENTATION: North 328 degrees East  
REFERENCE: WRUWH.PAT WRUWV.PAT