

***Directional Antenna System  
for  
WKNC, Raleigh, North Carolina***

April 29, 2016

Electronics Research Inc. is providing modification to an existing directional antenna system that is specially designed to meet the FCC requirements and the general needs of radio station WKNC.

The antenna is the ERI model MP-4E-DA-HW configuration. The circular polarized system consists of 4 half-wavelength spaced bays using one driven circular polarized radiating element per bay and two vertical parasitic elements interleaved between alternate bay pairs. The antenna was mounted on the North 345 degrees East tower face with bracketry to provide an antenna orientation of North 6.5 degrees East. The antenna was tested on an 8' 6 3/4" face tower, which is the structure the station plans to use to support the array. All tests were performed on a frequency of 88.1 megahertz, which is the center of the FM broadcast channel assigned to WKNC.

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 WKNC, Raleigh, North Carolina

(Continued)

## DESCRIPTION OF THE TEST PROCEDURE

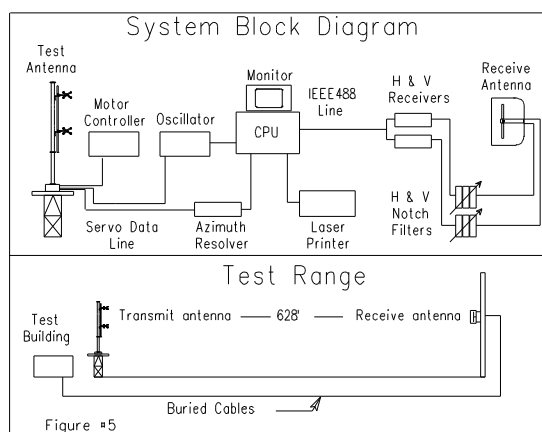
The test antenna consisted of two bay levels of the circular polarized system with the associated vertical parasitic elements. The elements and brackets that were used in this test are electrically equivalent to those that will be supplied with the antenna. A section of 3 1/8 inch o.d. rigid coaxial 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 8' 6 3/4" 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.

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 88.1 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.



# Directional Antenna System For WKNC, Raleigh, North Carolina

(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 Heliac 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 per bay and two vertical parasitic elements 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 MP-4E-DA-HW array is to be mounted on the North 345 degrees East tower face of the 8' 6 3/4" face tower at a bearing of North 6.5 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 25 kilowatts (13.979 dBk).

The power at North 170-240 degrees East does not exceed 2.993 kilowatts (4.761 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 than 85% of the filed composite pattern.

The clear vertical length of the structure required to support the antenna is 36 feet 8 inches.

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 black ink, appearing to read "Tom Schaefer". The signature is fluid and cursive, with a large initial "T" and a long, sweeping underline.

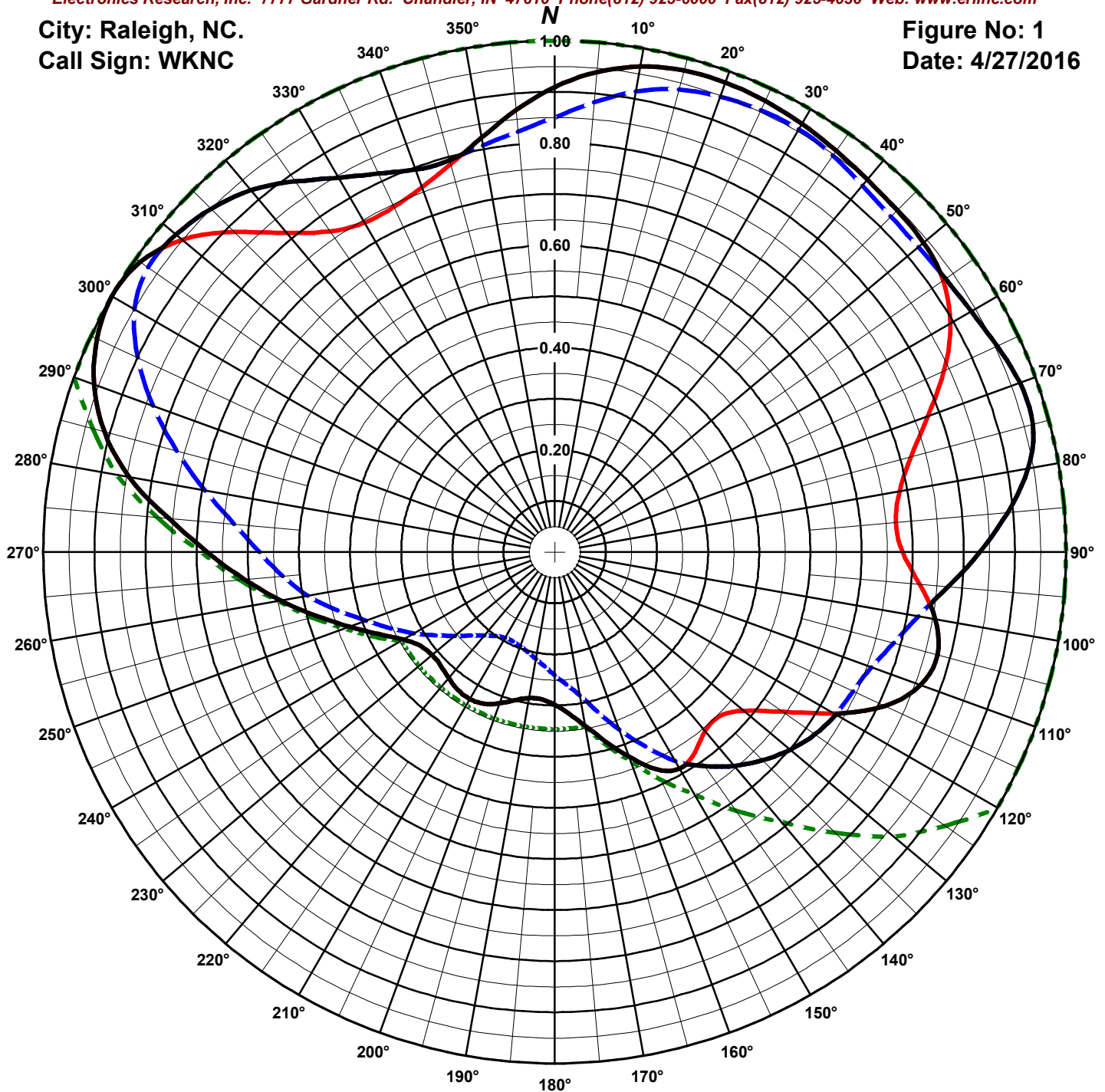
The Microsoft Word document on file electronically at Electronic Research, Inc. governs the specifications, scope, and configuration of the product described. All other representations whether verbal, printed, or electronic are subordinate to the master copy of this document on file at ERI.

# 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

City: Raleigh, NC.  
Call Sign: WKNC

Figure No: 1  
Date: 4/27/2016



Frequency: 88.1 MHz

Antenna Type: MP-4E-DA-HW

Antenna Mounting: Custom

Tower Type: 8' 6" Tower

## HORIZONTAL

RMS: .706

Maximum: 1 @ 300°

Minimum: .288 @ 187°

## VERTICAL

RMS: .706

Maximum: .971 @ 306°

Minimum: .193 @ 206°

## COMPOSITE

RMS: .739

Maximum: 1 @ 300°

Minimum: .288 @ 187°

## FCC ENVELOPE

RMS: .823

Maximum: 1 @ 0°

Minimum: .346 @ 170°

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 BPED-20140117ANA.

# ERI<sup>®</sup> 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

Station: WKNC

Location: Raleigh, NC.

Frequency: 88.1 MHz

Date: 4/27/2016

Antenna: MP-4E-DA-HW

Antenna Orientation: 6.5° True

Number of Bays: 4

| Azimuth | Envelope |        |        | Polarization | Azimuth | Envelope |        |        | Polarization |
|---------|----------|--------|--------|--------------|---------|----------|--------|--------|--------------|
|         | Field    | kW     | dBk    |              |         | Field    | kW     | dBk    |              |
| 0°      | 0.909    | 20.677 | 13.155 | Horizontal   | 180°    | 0.299    | 2.228  | 3.478  | Horizontal   |
| 5°      | 0.942    | 22.183 | 13.460 | Horizontal   | 185°    | 0.289    | 2.093  | 3.208  | Horizontal   |
| 10°     | 0.964    | 23.225 | 13.660 | Horizontal   | 190°    | 0.290    | 2.102  | 3.226  | Horizontal   |
| 15°     | 0.975    | 23.758 | 13.758 | Horizontal   | 195°    | 0.300    | 2.246  | 3.514  | Horizontal   |
| 20°     | 0.977    | 23.853 | 13.775 | Horizontal   | 200°    | 0.315    | 2.479  | 3.942  | Horizontal   |
| 25°     | 0.974    | 23.696 | 13.747 | Horizontal   | 205°    | 0.327    | 2.674  | 4.272  | Horizontal   |
| 30°     | 0.967    | 23.374 | 13.687 | Horizontal   | 210°    | 0.332    | 2.753  | 4.399  | Horizontal   |
| 35°     | 0.958    | 22.962 | 13.610 | Horizontal   | 215°    | 0.329    | 2.711  | 4.332  | Horizontal   |
| 40°     | 0.951    | 22.605 | 13.542 | Horizontal   | 220°    | 0.322    | 2.589  | 4.131  | Horizontal   |
| 45°     | 0.946    | 22.376 | 13.498 | Horizontal   | 225°    | 0.315    | 2.474  | 3.934  | Horizontal   |
| 50°     | 0.942    | 22.164 | 13.457 | Horizontal   | 230°    | 0.313    | 2.443  | 3.879  | Horizontal   |
| 55°     | 0.932    | 21.734 | 13.371 | Vertical     | 235°    | 0.320    | 2.562  | 4.085  | Horizontal   |
| 60°     | 0.941    | 22.133 | 13.450 | Vertical     | 240°    | 0.342    | 2.927  | 4.665  | Horizontal   |
| 65°     | 0.954    | 22.771 | 13.574 | Vertical     | 245°    | 0.380    | 3.603  | 5.566  | Horizontal   |
| 70°     | 0.968    | 23.427 | 13.697 | Vertical     | 250°    | 0.427    | 4.554  | 6.584  | Horizontal   |
| 75°     | 0.968    | 23.417 | 13.695 | Vertical     | 255°    | 0.483    | 5.822  | 7.650  | Horizontal   |
| 80°     | 0.940    | 22.098 | 13.443 | Vertical     | 260°    | 0.544    | 7.404  | 8.695  | Horizontal   |
| 85°     | 0.889    | 19.762 | 12.958 | Vertical     | 265°    | 0.609    | 9.285  | 9.678  | Horizontal   |
| 90°     | 0.832    | 17.287 | 12.377 | Vertical     | 270°    | 0.680    | 11.562 | 10.631 | Horizontal   |
| 95°     | 0.773    | 14.926 | 11.740 | Vertical     | 275°    | 0.758    | 14.347 | 11.568 | Horizontal   |
| 100°    | 0.756    | 14.280 | 11.547 | Horizontal   | 280°    | 0.845    | 17.847 | 12.516 | Horizontal   |
| 105°    | 0.775    | 15.012 | 11.764 | Horizontal   | 285°    | 0.912    | 20.772 | 13.175 | Horizontal   |
| 110°    | 0.761    | 14.484 | 11.609 | Horizontal   | 290°    | 0.958    | 22.950 | 13.608 | Horizontal   |
| 115°    | 0.712    | 12.668 | 11.027 | Horizontal   | 295°    | 0.988    | 24.379 | 13.870 | Horizontal   |
| 120°    | 0.635    | 10.069 | 10.030 | Vertical     | 300°    | 1.000    | 25.000 | 13.979 | Horizontal   |
| 125°    | 0.621    | 9.656  | 9.848  | Vertical     | 305°    | 0.989    | 24.446 | 13.882 | Horizontal   |
| 130°    | 0.601    | 9.031  | 9.557  | Vertical     | 310°    | 0.966    | 23.338 | 13.681 | Vertical     |
| 135°    | 0.576    | 8.284  | 9.183  | Vertical     | 315°    | 0.950    | 22.543 | 13.530 | Vertical     |
| 140°    | 0.546    | 7.450  | 8.722  | Vertical     | 320°    | 0.924    | 21.330 | 13.290 | Vertical     |
| 145°    | 0.511    | 6.529  | 8.148  | Vertical     | 325°    | 0.885    | 19.572 | 12.916 | Vertical     |
| 150°    | 0.489    | 5.970  | 7.760  | Horizontal   | 330°    | 0.845    | 17.865 | 12.520 | Vertical     |
| 155°    | 0.468    | 5.484  | 7.391  | Horizontal   | 335°    | 0.816    | 16.665 | 12.218 | Vertical     |
| 160°    | 0.426    | 4.542  | 6.572  | Horizontal   | 340°    | 0.796    | 15.829 | 11.994 | Vertical     |
| 165°    | 0.383    | 3.667  | 5.643  | Horizontal   | 345°    | 0.793    | 15.732 | 11.968 | Vertical     |
| 170°    | 0.345    | 2.974  | 4.733  | Horizontal   | 350°    | 0.823    | 16.917 | 12.283 | Horizontal   |
| 175°    | 0.317    | 2.511  | 3.998  | Horizontal   | 355°    | 0.867    | 18.809 | 12.744 | Horizontal   |

**Horizontal Polarization:**

**Maximum: 2.491 (3.964 dB)**

**Horizontal Plane: 2.491 (3.964 dB)**

**Maximum ERP: 25.000 kW**

**Vertical Polarization:**

**Maximum: 2.350 (3.711 dB)**

**Horizontal Plane: 2.350 (3.711 dB)**

**Maximum ERP: 23.584 kW**

**Total Input Power: 10.035 kW**

**Reference: WKNC2M.FIG**

**This list shows the the maximum azimuth values of either the horizontal or vertical components.**

# ERI<sup>®</sup> 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# 2A

Date: 4/27/2016

Station: WKNC

Antenna: MP-4E-DA-HW

Location: Raleigh, NC.

Antenna Orientation: 6.5° True

Frequency: 88.1 MHz

Number of Bays: 4

| Azimuth | Horizontal |        |        | Vertical |        |        | Azimuth | Horizontal |        |        | Vertical |        |        |
|---------|------------|--------|--------|----------|--------|--------|---------|------------|--------|--------|----------|--------|--------|
|         | Field      | kW     | dBk    | Field    | kW     | dBk    |         | Field      | kW     | dBk    | Field    | kW     | dBk    |
| 0°      | 0.909      | 20.677 | 13.155 | 0.850    | 18.070 | 12.570 | 180°    | 0.299      | 2.228  | 3.478  | 0.241    | 1.449  | 1.611  |
| 5°      | 0.942      | 22.183 | 13.460 | 0.883    | 19.476 | 12.895 | 185°    | 0.289      | 2.093  | 3.208  | 0.225    | 1.263  | 1.013  |
| 10°     | 0.964      | 23.225 | 13.660 | 0.914    | 20.906 | 13.203 | 190°    | 0.290      | 2.102  | 3.226  | 0.212    | 1.123  | 0.504  |
| 15°     | 0.975      | 23.758 | 13.758 | 0.936    | 21.922 | 13.409 | 195°    | 0.300      | 2.246  | 3.514  | 0.202    | 1.024  | 0.101  |
| 20°     | 0.977      | 23.853 | 13.775 | 0.947    | 22.436 | 13.509 | 200°    | 0.315      | 2.479  | 3.942  | 0.196    | 0.960  | -0.178 |
| 25°     | 0.974      | 23.696 | 13.747 | 0.954    | 22.733 | 13.567 | 205°    | 0.327      | 2.674  | 4.272  | 0.193    | 0.929  | -0.321 |
| 30°     | 0.967      | 23.374 | 13.687 | 0.955    | 22.791 | 13.578 | 210°    | 0.332      | 2.753  | 4.399  | 0.194    | 0.940  | -0.269 |
| 35°     | 0.958      | 22.962 | 13.610 | 0.948    | 22.446 | 13.511 | 215°    | 0.329      | 2.711  | 4.332  | 0.201    | 1.007  | 0.029  |
| 40°     | 0.951      | 22.605 | 13.542 | 0.936    | 21.893 | 13.403 | 220°    | 0.322      | 2.589  | 4.131  | 0.213    | 1.135  | 0.549  |
| 45°     | 0.946      | 22.376 | 13.498 | 0.929    | 21.574 | 13.339 | 225°    | 0.315      | 2.474  | 3.934  | 0.231    | 1.335  | 1.254  |
| 50°     | 0.942      | 22.164 | 13.457 | 0.928    | 21.536 | 13.332 | 230°    | 0.313      | 2.443  | 3.879  | 0.255    | 1.622  | 2.101  |
| 55°     | 0.927      | 21.467 | 13.318 | 0.932    | 21.734 | 13.371 | 235°    | 0.320      | 2.562  | 4.085  | 0.284    | 2.016  | 3.046  |
| 60°     | 0.893      | 19.957 | 13.001 | 0.941    | 22.133 | 13.450 | 240°    | 0.342      | 2.927  | 4.665  | 0.318    | 2.529  | 4.030  |
| 65°     | 0.840      | 17.656 | 12.469 | 0.954    | 22.771 | 13.574 | 245°    | 0.380      | 3.603  | 5.566  | 0.353    | 3.115  | 4.935  |
| 70°     | 0.776      | 15.074 | 11.782 | 0.968    | 23.427 | 13.697 | 250°    | 0.427      | 4.554  | 6.584  | 0.392    | 3.839  | 5.842  |
| 75°     | 0.721      | 13.014 | 11.144 | 0.968    | 23.417 | 13.695 | 255°    | 0.483      | 5.822  | 7.650  | 0.439    | 4.823  | 6.833  |
| 80°     | 0.685      | 11.725 | 10.691 | 0.940    | 22.098 | 13.443 | 260°    | 0.544      | 7.404  | 8.695  | 0.490    | 6.011  | 7.789  |
| 85°     | 0.670      | 11.209 | 10.496 | 0.889    | 19.762 | 12.958 | 265°    | 0.609      | 9.285  | 9.678  | 0.534    | 7.129  | 8.530  |
| 90°     | 0.680      | 11.574 | 10.635 | 0.832    | 17.287 | 12.377 | 270°    | 0.680      | 11.562 | 10.631 | 0.577    | 8.332  | 9.208  |
| 95°     | 0.716      | 12.824 | 11.080 | 0.773    | 14.926 | 11.740 | 275°    | 0.758      | 14.347 | 11.568 | 0.629    | 9.892  | 9.953  |
| 100°    | 0.756      | 14.280 | 11.547 | 0.722    | 13.037 | 11.152 | 280°    | 0.845      | 17.847 | 12.516 | 0.694    | 12.039 | 10.806 |
| 105°    | 0.775      | 15.012 | 11.764 | 0.686    | 11.776 | 10.710 | 285°    | 0.912      | 20.772 | 13.175 | 0.765    | 14.631 | 11.653 |
| 110°    | 0.761      | 14.484 | 11.609 | 0.659    | 10.859 | 10.358 | 290°    | 0.958      | 22.950 | 13.608 | 0.836    | 17.468 | 12.422 |
| 115°    | 0.712      | 12.668 | 11.027 | 0.644    | 10.356 | 10.152 | 295°    | 0.988      | 24.379 | 13.870 | 0.900    | 20.235 | 13.061 |
| 120°    | 0.631      | 9.939  | 9.973  | 0.635    | 10.069 | 10.030 | 300°    | 1.000      | 25.000 | 13.979 | 0.948    | 22.491 | 13.520 |
| 125°    | 0.544      | 7.411  | 8.699  | 0.621    | 9.656  | 9.848  | 305°    | 0.989      | 24.446 | 13.882 | 0.970    | 23.545 | 13.719 |
| 130°    | 0.483      | 5.826  | 7.654  | 0.601    | 9.031  | 9.557  | 310°    | 0.950      | 22.581 | 13.537 | 0.966    | 23.338 | 13.681 |
| 135°    | 0.455      | 5.172  | 7.136  | 0.576    | 8.284  | 9.183  | 315°    | 0.885      | 19.590 | 12.920 | 0.950    | 22.543 | 13.530 |
| 140°    | 0.458      | 5.238  | 7.192  | 0.546    | 7.450  | 8.722  | 320°    | 0.815      | 16.593 | 12.199 | 0.924    | 21.330 | 13.290 |
| 145°    | 0.478      | 5.714  | 7.570  | 0.511    | 6.529  | 8.148  | 325°    | 0.766      | 14.660 | 11.661 | 0.885    | 19.572 | 12.916 |
| 150°    | 0.489      | 5.970  | 7.760  | 0.472    | 5.564  | 7.454  | 330°    | 0.744      | 13.828 | 11.408 | 0.845    | 17.865 | 12.520 |
| 155°    | 0.468      | 5.484  | 7.391  | 0.419    | 4.397  | 6.431  | 335°    | 0.744      | 13.850 | 11.415 | 0.816    | 16.665 | 12.218 |
| 160°    | 0.426      | 4.542  | 6.572  | 0.369    | 3.413  | 5.332  | 340°    | 0.759      | 14.407 | 11.586 | 0.796    | 15.829 | 11.994 |
| 165°    | 0.383      | 3.667  | 5.643  | 0.323    | 2.613  | 4.172  | 345°    | 0.785      | 15.421 | 11.881 | 0.793    | 15.732 | 11.968 |
| 170°    | 0.345      | 2.974  | 4.733  | 0.285    | 2.024  | 3.063  | 350°    | 0.823      | 16.917 | 12.283 | 0.807    | 16.289 | 12.119 |
| 175°    | 0.317      | 2.511  | 3.998  | 0.260    | 1.691  | 2.281  | 355°    | 0.867      | 18.809 | 12.744 | 0.826    | 17.036 | 12.314 |

Horizontal Polarization:

Maximum: 2.491 (3.964 dB)

Horizontal Plane: 2.491 (3.964 dB)

Maximum ERP: 25.000 kW

Vertical Polarization:

Maximum: 2.350 (3.711 dB)

Horizontal Plane: 2.350 (3.711 dB)

Maximum ERP: 23.584 kW

Total Input Power: 10.035 kW

Reference: WKNC2M.FIG

This list shows the azimuth values for the horizontal and vertical components.



# ERI<sup>®</sup> Vertical 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 No: 3

Call Sign: WKNC

Location: Raleigh, NC.

Frequency: 88.1 MHz

Antenna: 4 bay MP-4E-DA-HW

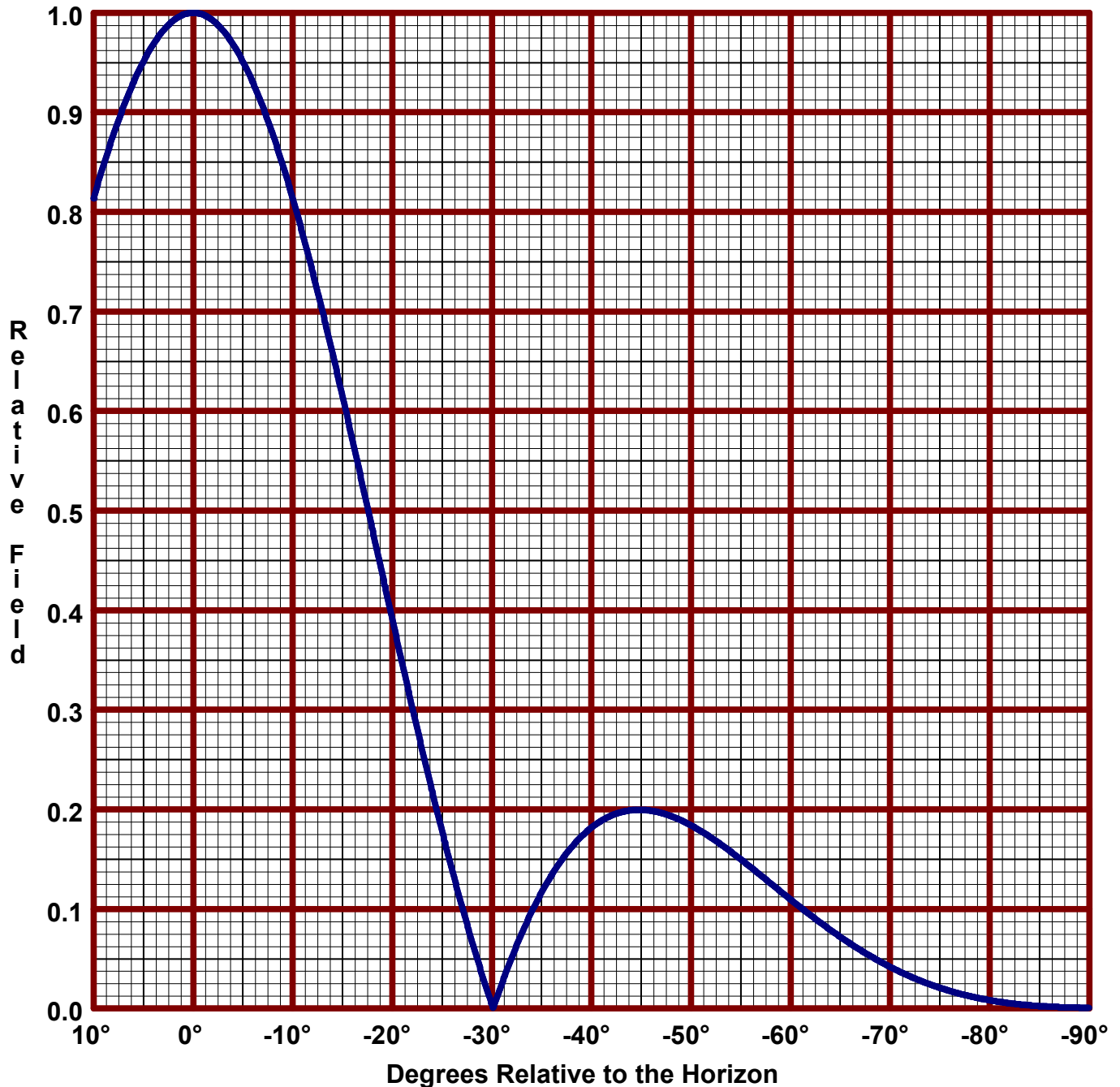
Date: 4/27/2016

H/V Power Ratio: 1

.5 Wave-length Spacing

0° Beam Tilt

0% First Null Fill



Horizontal Polarization:

Maximum: 2.491 (3.964 dB)

Horizontal Plane: 2.491 (3.964 dB)

Maximum ERP: 25.000 kW

Vertical Polarization:

Maximum: 2.350 (3.711 dB)

Horizontal Plane: 2.350 (3.711 dB)

Maximum ERP: 23.584 kW



# Directional Antenna System for WKNC, Raleigh, North Carolina

(Continued)

## ANTENNA SPECIFICATIONS

|                 |          |
|-----------------|----------|
| Antenna Type:   | MP-4E-DA |
| Frequency:      | 88.1 MHz |
| Number of Bays: | Four     |

## MECHANICAL SPECIFICATIONS

|  |            |
|--|------------|
| Mounting:                                  | Custom     |
| System length:                             | 25 ft 8 in |
| Aperture length required:                  | 36 ft 8 in |
| Orientation:                               | 6.5° true  |
| Input flange to the antenna 3 1/8" female. |            |

## ELECTRICAL SPECIFICATIONS

(For directional use)

|                                |                        |
|--------------------------------|------------------------|
| Maximum horizontal ERP:        | 25.000 kW (13.979 dBk) |
| Horizontal maximum power gain: | 2.491 (3.964 dB)       |
| Maximum vertical ERP:          | 23.584 (13.726 dB)     |
| Vertical maximum power gain:   | 2.350 (3.711 dB)       |
| Total input power:             | 10.035 kW (10.015 dBk) |

