

***Directional Antenna System  
for  
WFCM-FM-FM, Murfreesboro, Tennessee***

June 18, 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 WFCM-FM.

The antenna is the ERI model 1093-1CP-DA configuration. The circular polarized system consists of one level using three driven circular polarized radiating elements, one horizontal parasitic element placed one quarter wave above and below the bay and two vertical parasitic elements at bay level. The antenna was mounted on the tower with bracketry to provide an antenna orientation of North 274 degrees East. The antenna was tested on a 48" face tower, which is the structure the station plans to use to support the array. All tests were performed on a frequency of 91.7 megahertz, which is the center of the FM broadcast channel assigned to WFCM-FM.

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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(Continued)

## DESCRIPTION OF THE TEST PROCEDURE

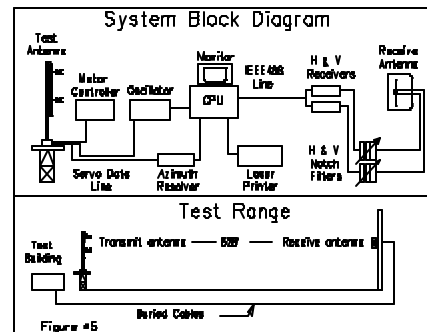
The test antenna consisted of a full-scale model of the complete circular polarized system with the associated horizontal and vertical parasitic elements. The elements and brackets that were used in this test are electrically equivalent to those that will be supplied with the antenna. The lines were 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 48" 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 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 91.7 MHz and was constantly monitored by an Anritsu Model ML521B 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. 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.



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(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 one level using three driven circular polarized radiating element, one horizontal parasitic element placed one quarter wave above and below the bay and two vertical parasitic elements at bay level. 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 1093-1CP-DA array is to be mounted on the 48" face tower at a bearing of North 274 degrees East. Blue prints provided with the antenna will show the proper antenna orientation alignment. The surveyor's alignment is 90 degrees counter clockwise from the antenna orientation described in this report. 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 2.5 kilowatts (3.979 dBk).

The power at North 30 degrees East does not exceed 0.529 kilowatts (-2.765 dBk).

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

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(Continued)

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 20 feet.

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 Sheaf", is written in dark ink.

# **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: WFCM-FM

LOCATION: MURFREESBORO, TN

ANTENNA TYPE: 1093-1CP-DA

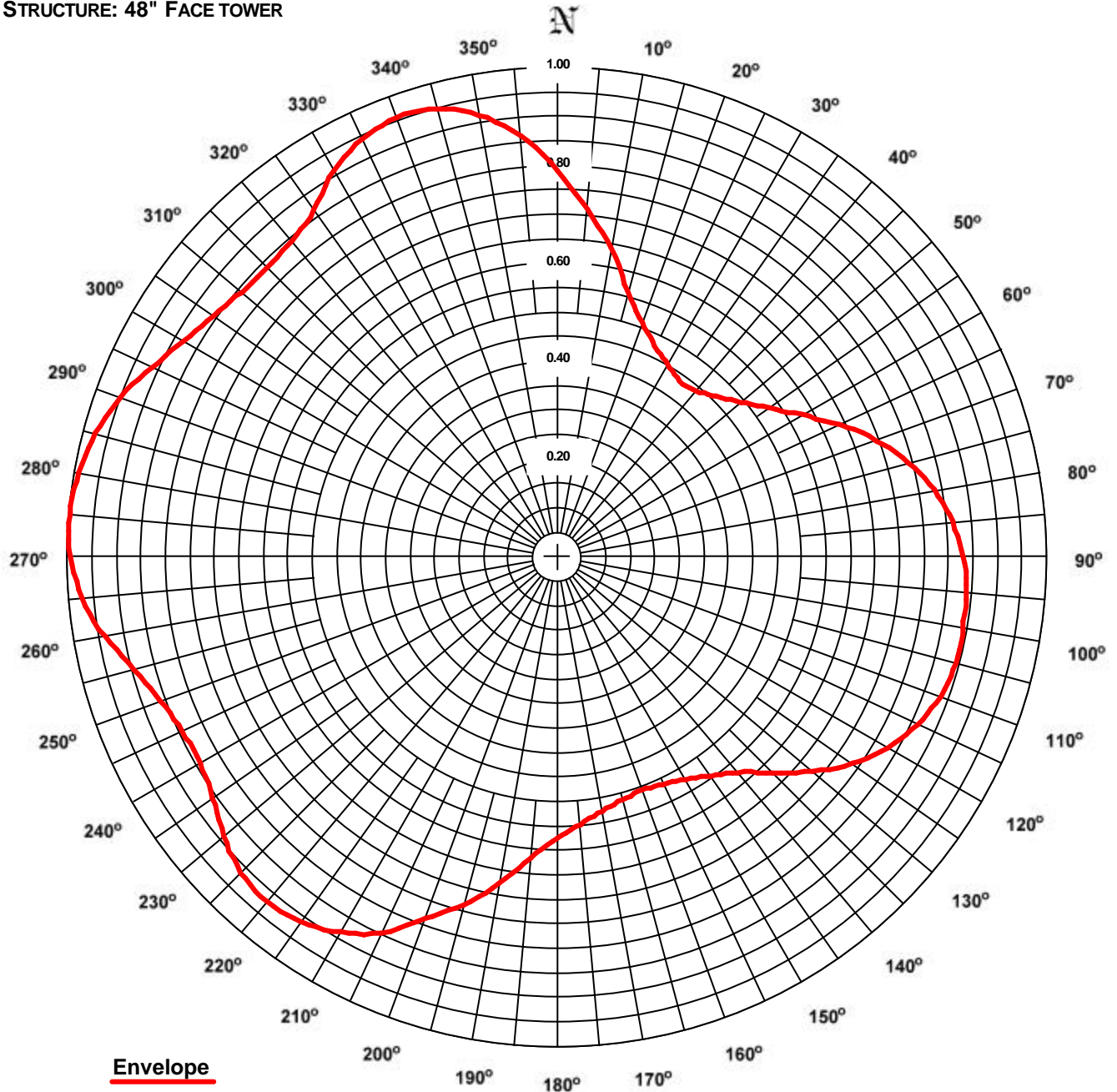
STRUCTURE: 48" FACE TOWER

DATE: 6/18/04

FREQUENCY: 91.7 MHz

ORIENTATION: 274° TRUE

MOUNTING: CUSTOM



RMS: 0.773

Maximum: 1.000 @ 274° True

Minimum: 0.435 @ 36° 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 BPED-20000703ADU.

# **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: WFCM-FM**  
**Location: Murfreesboro, TN**  
**Frequency: 91.7 MHz**

**Antenna: 1093-1CP-DA**  
**Orientation: 274° True**  
**Tower: 48" Face tower**

**Figure: 1**  
**Date: 6/18/2004**  
**Reference: WFCM-FM3m.fig**

Angle	Envelope			Polarization	Angle	Envelope			Polarization
	Field	kW	dBk			Field	kW	dBk	
0°	0.789	1.56	1.92	Vertical	180°	0.576	0.83	-0.82	Vertical
5°	0.711	1.26	1.02	Vertical	185°	0.619	0.96	-0.18	Horizontal
10°	0.641	1.03	0.12	Vertical	190°	0.678	1.15	0.60	Horizontal
15°	0.560	0.79	-1.05	Horizontal	195°	0.736	1.35	1.31	Horizontal
20°	0.509	0.65	-1.89	Horizontal	200°	0.788	1.55	1.91	Horizontal
25°	0.474	0.56	-2.51	Horizontal	205°	0.848	1.80	2.55	Vertical
30°	0.453	0.51	-2.91	Horizontal	210°	0.886	1.96	2.93	Horizontal
35°	0.437	0.48	-3.21	Horizontal	215°	0.912	2.08	3.18	Horizontal
40°	0.442	0.49	-3.10	Vertical	220°	0.922	2.13	3.27	Horizontal
45°	0.462	0.53	-2.73	Vertical	225°	0.913	2.08	3.19	Horizontal
50°	0.491	0.60	-2.20	Vertical	230°	0.888	1.97	2.95	Horizontal
55°	0.530	0.70	-1.54	Vertical	235°	0.858	1.84	2.65	Horizontal
60°	0.578	0.84	-0.78	Vertical	240°	0.843	1.78	2.49	Horizontal
65°	0.636	1.01	0.05	Vertical	245°	0.845	1.78	2.51	Horizontal
70°	0.695	1.21	0.81	Vertical	250°	0.862	1.86	2.69	Horizontal
75°	0.743	1.38	1.40	Vertical	255°	0.894	2.00	3.01	Horizontal
80°	0.782	1.53	1.84	Vertical	260°	0.939	2.20	3.43	Horizontal
85°	0.811	1.64	2.16	Vertical	265°	0.974	2.37	3.75	Horizontal
90°	0.830	1.72	2.37	Vertical	270°	0.994	2.47	3.93	Horizontal
95°	0.840	1.76	2.47	Vertical	275°	1.000	2.50	3.98	Horizontal
100°	0.843	1.78	2.50	Horizontal	280°	0.992	2.46	3.91	Horizontal
105°	0.845	1.78	2.51	Horizontal	285°	0.975	2.38	3.76	Horizontal
110°	0.834	1.74	2.40	Horizontal	290°	0.949	2.25	3.53	Horizontal
115°	0.812	1.65	2.18	Horizontal	295°	0.914	2.09	3.20	Horizontal
120°	0.780	1.52	1.82	Horizontal	300°	0.881	1.94	2.88	Horizontal
125°	0.737	1.36	1.33	Horizontal	305°	0.856	1.83	2.63	Horizontal
130°	0.683	1.17	0.67	Horizontal	310°	0.842	1.77	2.48	Horizontal
135°	0.624	0.97	-0.12	Horizontal	315°	0.836	1.75	2.42	Horizontal
140°	0.576	0.83	-0.81	Vertical	320°	0.843	1.78	2.49	Horizontal
145°	0.547	0.75	-1.26	Vertical	325°	0.865	1.87	2.72	Vertical
150°	0.526	0.69	-1.60	Vertical	330°	0.910	2.07	3.16	Vertical
155°	0.513	0.66	-1.82	Vertical	335°	0.941	2.21	3.45	Vertical
160°	0.508	0.65	-1.90	Vertical	340°	0.954	2.28	3.57	Vertical
165°	0.515	0.66	-1.79	Vertical	345°	0.946	2.24	3.50	Vertical
170°	0.528	0.70	-1.56	Vertical	350°	0.916	2.10	3.21	Vertical
175°	0.549	0.75	-1.24	Vertical	355°	0.863	1.86	2.70	Vertical

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

**Envelope**  
**1.000 @ 274° True**  
**0.435 @ 36° True**  
**0.773**  
**2.500 kW**  
**0.759 (-1.199 dB)**

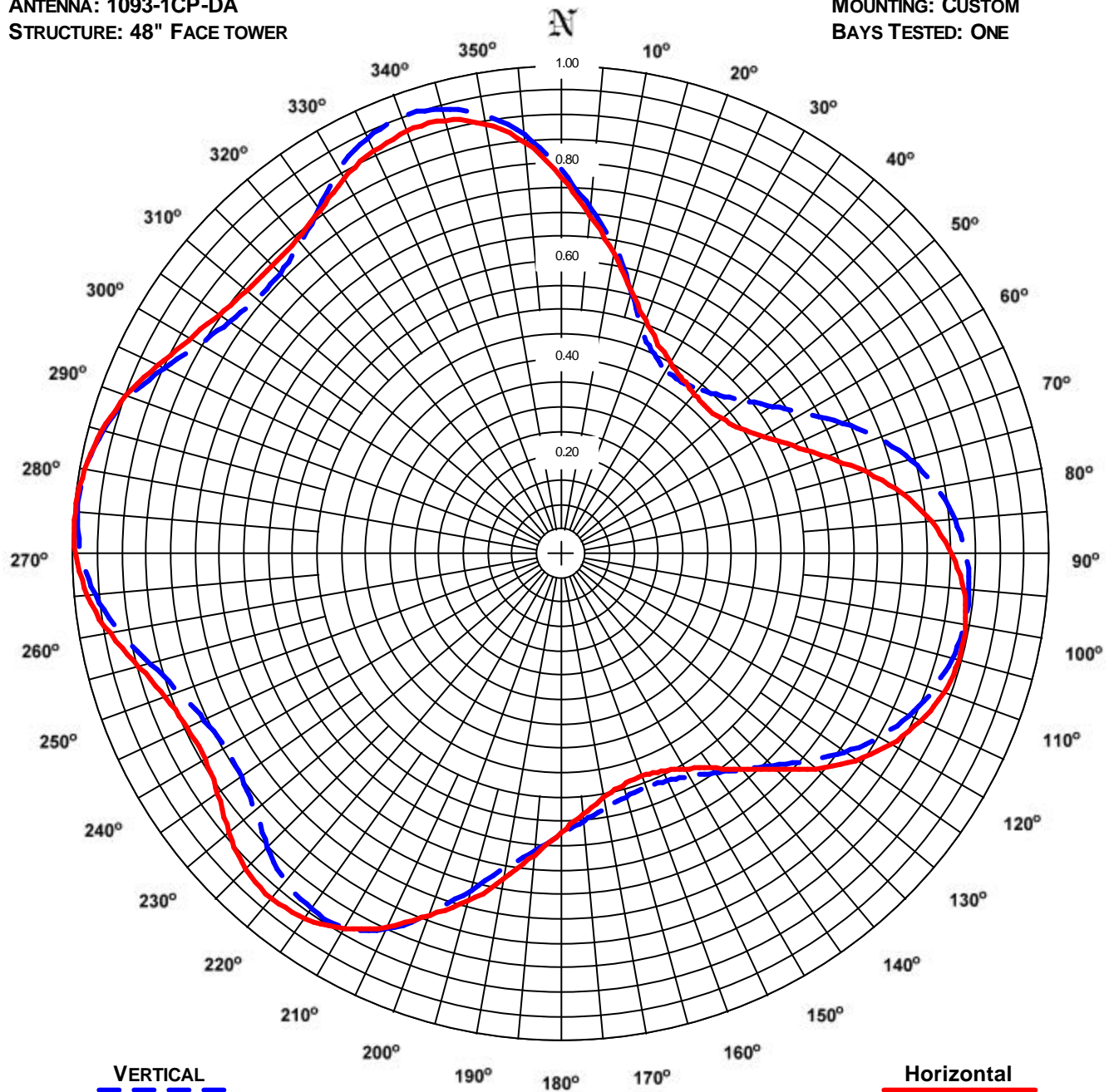
**Total Input Power: 3.295 kW**

# **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: WFCM-FM  
LOCATION: MURFREESBORO, TN  
ANTENNA: 1093-1CP-DA  
STRUCTURE: 48" FACE TOWER

DATE: 6/18/2004  
FREQUENCY: 91.7 MHz  
ORIENTATION: 274° TRUE  
MOUNTING: CUSTOM  
BAYS TESTED: ONE



VERTICAL  
RMS: 0.760  
MAXIMUM: 0.995 @ 276° TRUE  
MINIMUM: 0.432 @ 33° TRUE

Horizontal  
RMS: 0.760  
Maximum: 1.000 @ 274° True  
Minimum: 0.424 @ 45° True

COMMENTS: MEASURED PATTERNS OF THE HORIZONTAL AND VERTICAL COMPONENTS.

# **ERI<sup>®</sup>** *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: WFCM-FM**  
**Location: Murfreesboro, TN**  
**Frequency: 91.7 MHz**

**Antenna: 1093-1CP-DA**  
**Orientation: 274° True**  
**Tower: 48" Face tower**

**Figure: 2**  
**Date: 6/18/2004**  
**Reference: WFCM-  
 FM3m.fig**

Angle	Horizontal			Vertical			Angle	Horizontal			Vertical		
	Field	kW	dBk	Field	kW	dBk		Field	kW	dBk	Field	kW	dBk
0°	0.774	1.50	1.75	0.789	1.56	1.92	180°	0.572	0.82	-0.88	0.576	0.83	-0.82
5°	0.697	1.21	0.84	0.711	1.26	1.02	185°	0.619	0.96	-0.18	0.610	0.93	-0.32
10°	0.627	0.98	-0.08	0.641	1.03	0.12	190°	0.678	1.15	0.60	0.650	1.06	0.24
15°	0.560	0.79	-1.05	0.558	0.78	-1.08	195°	0.736	1.35	1.31	0.713	1.27	1.05
20°	0.509	0.65	-1.89	0.486	0.59	-2.29	200°	0.788	1.55	1.91	0.783	1.53	1.85
25°	0.474	0.56	-2.51	0.453	0.51	-2.90	205°	0.843	1.78	2.50	0.848	1.80	2.55
30°	0.453	0.51	-2.91	0.435	0.47	-3.25	210°	0.886	1.96	2.93	0.884	1.95	2.91
35°	0.437	0.48	-3.21	0.433	0.47	-3.30	215°	0.912	2.08	3.18	0.890	1.98	2.96
40°	0.428	0.46	-3.40	0.442	0.49	-3.10	220°	0.922	2.13	3.27	0.876	1.92	2.83
45°	0.424	0.45	-3.47	0.462	0.53	-2.73	225°	0.913	2.08	3.19	0.850	1.80	2.56
50°	0.431	0.47	-3.32	0.491	0.60	-2.20	230°	0.888	1.97	2.95	0.818	1.67	2.24
55°	0.451	0.51	-2.94	0.530	0.70	-1.54	235°	0.858	1.84	2.65	0.799	1.60	2.03
60°	0.482	0.58	-2.35	0.578	0.84	-0.78	240°	0.843	1.78	2.49	0.795	1.58	1.98
65°	0.526	0.69	-1.60	0.636	1.01	0.05	245°	0.845	1.78	2.51	0.806	1.62	2.10
70°	0.582	0.85	-0.73	0.695	1.21	0.81	250°	0.862	1.86	2.69	0.831	1.73	2.37
75°	0.649	1.05	0.23	0.743	1.38	1.40	255°	0.894	2.00	3.01	0.870	1.89	2.77
80°	0.712	1.27	1.03	0.782	1.53	1.84	260°	0.939	2.20	3.43	0.919	2.11	3.25
85°	0.763	1.46	1.63	0.811	1.64	2.16	265°	0.974	2.37	3.75	0.958	2.30	3.61
90°	0.802	1.61	2.06	0.830	1.72	2.37	270°	0.994	2.47	3.93	0.983	2.42	3.83
95°	0.829	1.72	2.35	0.840	1.76	2.47	275°	1.000	2.50	3.98	0.995	2.47	3.93
100°	0.843	1.78	2.50	0.839	1.76	2.46	280°	0.992	2.46	3.91	0.990	2.45	3.89
105°	0.845	1.78	2.51	0.830	1.72	2.36	285°	0.975	2.38	3.76	0.972	2.36	3.74
110°	0.834	1.74	2.40	0.812	1.65	2.17	290°	0.949	2.25	3.53	0.942	2.22	3.46
115°	0.812	1.65	2.18	0.786	1.54	1.88	295°	0.914	2.09	3.20	0.899	2.02	3.05
120°	0.780	1.52	1.82	0.751	1.41	1.50	300°	0.881	1.94	2.88	0.858	1.84	2.65
125°	0.737	1.36	1.33	0.709	1.26	0.99	305°	0.856	1.83	2.63	0.830	1.72	2.37
130°	0.683	1.17	0.67	0.659	1.09	0.36	310°	0.842	1.77	2.48	0.815	1.66	2.20
135°	0.624	0.97	-0.12	0.614	0.94	-0.26	315°	0.836	1.75	2.42	0.814	1.66	2.19
140°	0.575	0.83	-0.83	0.576	0.83	-0.81	320°	0.843	1.78	2.49	0.831	1.73	2.37
145°	0.536	0.72	-1.44	0.547	0.75	-1.26	325°	0.861	1.85	2.68	0.865	1.87	2.72
150°	0.508	0.64	-1.91	0.526	0.69	-1.60	330°	0.889	1.98	2.96	0.910	2.07	3.16
155°	0.491	0.60	-2.21	0.513	0.66	-1.82	335°	0.912	2.08	3.18	0.941	2.21	3.45
160°	0.484	0.59	-2.32	0.508	0.65	-1.90	340°	0.923	2.13	3.28	0.954	2.28	3.57
165°	0.490	0.60	-2.21	0.515	0.66	-1.79	345°	0.921	2.12	3.27	0.946	2.24	3.50
170°	0.507	0.64	-1.92	0.528	0.70	-1.56	350°	0.897	2.01	3.03	0.916	2.10	3.21
175°	0.534	0.71	-1.47	0.549	0.75	-1.24	355°	0.848	1.80	2.54	0.863	1.86	2.70

<b>Polarization:</b>	<b>Horizontal</b>	<b>Vertical</b>
<b>Maximum Field:</b>	<b>1.000 @ 274° True</b>	<b>0.995 @ 276° True</b>
<b>Minimum Field:</b>	<b>0.424 @ 45° True</b>	<b>0.432 @ 33° True</b>
<b>RMS:</b>	<b>0.760</b>	<b>0.760</b>
<b>Maximum ERP:</b>	<b>2.500 kW</b>	<b>2.475 kW</b>
<b>Maximum Power Gain:</b>	<b>0.759 (-1.199 dB)</b>	<b>0.751 (-1.242 dB)</b>

**Total Input Power: 3.295 kW**



Directional Antenna System  
for  
WFCM-FM, Murfreesboro, Tennessee

(Continued)

ANTENNA SPECIFICATIONS

Antenna Type:	1093-1CP-DA
Frequency:	91.7 MHz
Number of Bays:	one

MECHANICAL SPECIFICATIONS

Mounting:	Custom
System length:	10 ft
Aperture length required:	20 ft.
Orientation:	274° true

Input flange to the antenna 1 5/8 inch female

ELECTRICAL SPECIFICATIONS

(For directional use)

Maximum horizontal ERP:	2.5 kW (3.979 dBk)
Horizontal maximum power gain:	0.759 (-1.199 dB)
Maximum vertical ERP:	2.475 kW (3.937 dBk)
Vertical maximum power gain:	0.751 (-1.242 dB)
Total input power:	3.295 kW (5.179 dBk)