



ELECTRONICS RESEARCH, INC.

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Report Of Intermodulation Product Findings

**AMERICAN TOWER COMBINED BROADCAST FACILITY
BOSTON, MASSACHUSETTS**

WBOS	92.9
WJMN	94.5
WTKK	96.9
WBMX	98.5
WCRB	102.5
WROR	105.7
WMJX	106.7
WXKS	107.9

October 2003

**Electronics Research Inc.
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BOSTON, MASSACHUSETTS

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REPORT OF FINDINGS
WBOS / WJMN / WTKK / WBMX / WCRB / WROR / WMJX / WXKS
AMERICAN TOWER COMBINED BROADCAST FACILITY
BOSTON, MASSACHUSETTS

Introduction : This report of findings is based on data collected at the American Tower FM broadcast facility located in Boston, MA. The report includes measurements offered as proof that the upgrade of the WMJX and the addition of WXKS to the combined operations of WBOS (92.9 MHz.), WJMN (94.5 MHz.), WTKK (96.9 MHz.), WBMX (98.5 MHz.), WCRB (102.5 MHz.), WROR (105.7 MHz.), WMJX (106.7 MHz.) and WXKS (106.7 MHz.) transmitters are in compliance with the FCC Rules and Regulations as required by the Code of Federal Regulations (CFR) Title 47 section 73.317 paragraph (b) through (d). In brief, the collection of measurements presented in this report shows that all possible third order inter-modulation (IM) products generated by this multiplex system are less than the maximum allowable level as required by section 73.317 (b) through (d). WBUR (90.9 MHz.) and WODS (103.3 MHz.) operate into separate side mounted antennas located lower on the same tower. Their effects on the stations operating from the multiplexed system has been considered in this report. Mark Steapleton and Jeff Taylor of Electronics Research, Inc. located in Chandler, Indiana performed the measurements summarized herein on October 15, 2003.

The following exhibits are provided:

Exhibit A:

- A-1 Drawing Depicting Antenna.
- A-2 COG 1084-2CP Antenna Specification Sheet.
- A-3 Drawing Depicting Multiplexing Scheme.
- A-4 963 Constant Impedance Multiplexer Specification Sheet.
- A-5 Theoretical Vertical Plane Relative Field Antenna Plot

Exhibit B:

- B-1 Equipment Employed In Intermodulation Product Measurement.
 - B-2 Broadcasting Scheme of the Multiplexed Systems.
- Table 1. Carrier Reference Levels.
- Table 2. Calculated Third Order Products.
- Table 3. Intermodulation Analysis Measurements.

Exhibits Accompanying Report: Exhibit A, provides comprehensive information on both antenna and filters used by these radio stations. Exhibit B, illustrates the broadcasting scheme of each station, the layout of the equipment used to isolate and measure potential intermodulation products and forward carrier reference levels. Found within Table 1 are the narrow band carrier frequency measurements that provide relative output signal levels for the IM analysis. Table 2 lists the calculated third order products that can be generated from FM transmitters broadcasting from the multiplexed system. The IM Analysis Measurements, in Table 3, provides detailed information obtained from the product frequency investigation.

The Nature Of Intermodulation Products (IM) : Intermodulation products result from inadequate transmitter-to-transmitter isolation. Intermodulation products are commonly generated from radio stations operating into multiplexed facilities and congested antenna broadcast sites. The mechanics associated with the phenomenon have been well documented. When two or more transmitters are coupled to each other, new spectral components are produced by the mixing of the station frequencies in the active circuits of each transmitter. The common term used to describe this phenomenon is third order product denoted by the mathematical expression $[2(F_1)-(F_2)]$, where F_1 signifies the frequency of the transmitter that is generating the intermodulation product, and F_2 signifies the frequency causing the interference.

The Multiplexed System : At the time of my measurements eight (8) FM stations were operating from the combined antenna system. The WBOS, WJMN, WTKK, WBMX, WCRB, WROR, WMJX and WXKS multiplexed system is fundamentally comprised of antenna, feed line and multiplexer unit. The COG 1084-2CP antenna and 963 Constant Impedance multiplexer units are products of Electronics Research, Inc, whereas the feed line is manufactured by Dielectric, Inc., Refer to Exhibit B-1, for an illustration of the Broadcasting Scheme of these stations.

To accomplish the aggregation of eight transmitter signals into a common antenna feed and provide transmitter-to-transmitter isolation, a multiplexing scheme consisting of Combiner modules is used. Specifically, two ERI 963 bandpass filters were added to the existing 963-6 constant impedance module for WMJX and one ERI 963-8 combiner module was installed for WXKS. Both modules operate into the broad port of the existing six (6) combiner modules that were previously operating into the multiplexed antenna system. The combiner is illustrated in the attached Exhibit A-3. The multiplexer, fully assembled, exhibited transmitter port-to-port isolation in excess of - 58 dB. Other performance measurements, such as match, loss, group-delay, etc, revealed that the multiplexer unit was in proper working condition. Refer to Exhibit A-4 for the Combiner Specification Sheet.

The IM Investigation : Directional Couplers were placed at key locations throughout the combiner to monitor and maintain the multiplexers performance. All couplers furnished with the system are factory calibrated and capable of delivering accurate and repeatable RF measurements. To facilitate the taking of the measurements, the coupler located at the antenna output of the multiplexed system was used. Care was taken in the selection of the measurement location to insure that the measurements would be made far removed from transmitters and any filtering used to reduce broadcast emissions. The coupler selected would normally be used for antenna reflection measurements and thus would provide greater than 33 dB directivity and a forward signal sample of -47 dB.

The forward port of the coupler was used for sampling the outgoing carrier levels and IM products. The IM sampled signal was fed by shielded cable into a Band Pass Filter where all extraneous energy was steeply attenuated. Various attenuation pads were used, when needed, on the band pass filter and/or the FIM71 to ensure an adequate signal level for measurements without overloading the measurement equipment. A Potomac Instruments FIM-71 Field Strength Receiver was employed to record the level of all signals investigated. To facilitate the selective tuning of the Receiver and Band Pass Filter a Wavetek Model 3000 signal generator was used. An IFR 2399A Spectrum Analyzer was used to measure the close in spectral attenuation of each carrier and wide band search for any anomalies that may need further investigation. See attached Exhibit B-2 for an illustration of the measurement equipment.

Prior to recording measurements, all pertinent broadcasting equipment including Transmitters, Multiplexer, Feed Line and Antenna were adjusted to optimal performance. Also, it was confirmed before taking any measurements that all stations of concern were operating at their full licensed power level. From the equipment setup described above, the relative output signal level of each stations forward carrier was made. The resulting signal levels of these measurements are listed in Table 1, column labeled "Adjusted Level". This level will be used as the reference level for possible IM products of each carrier and was necessary to confirm that no significant levels of spurious energy, referenced to each carrier, were present from any transmitter operating from the multiplexed system.

Table 1 - Carrier Reference Levels

Carrier Frequency (MHz)	Pad One (dB)	Bandpass Filter Loss (dB)	Full Scale Range (dB:)	Scale Reading (dB)	Adjusted Level (dB:)	Notes
WBOS (92.9)	3	---	140	-19.1	123.9	
WJMN (94.5)	3	---	140	-11.8	131.2	
WTKK (96.9)	3	---	140	-17.2	125.8	
WBMX (98.5)	3	---	140	-10.9	132.1	
WCRB (102.5)	3	---	140	-10.9	132.1	
WROR (105.7)	3	---	140	-16.3	126.7	
WMJX (106.7)	3	---	140	-16.8	126.2	
WXKS (107.9)	3	---	140	-18.8	124.2	

Predictable third-order products due to system harmonics mixed with all on-site interfering frequencies that could be generated from the multiplexed system are calculated and listed in Table 2.

Table 2 - Third Order Products.

Mix Freq.	Carrier Frequency (MHz)							
	92.9	94.5	96.9	98.5	102.5	105.7	106.7	107.9
90.9	94.9	98.1	102.9	106.1	114.1	120.5	122.5	124.9
92.9	---	96.1	100.9	104.1	112.1	118.5	120.5	122.9
94.5	91.3	---	99.3	102.5	110.5	116.9	118.9	121.3
96.9	88.9	92.1	---	100.1	108.1	114.5	116.5	118.9
98.5	87.3	90.5	95.3	---	106.5	112.9	114.9	117.3
102.5	83.3	86.5	91.3	94.5	---	108.9	110.9	113.3
103.3	82.5	85.7	90.5	93.7	101.7	108.1	110.1	112.5
105.7	80.1	83.3	88.1	91.3	99.3	---	107.7	110.1
106.7	79.1	82.3	87.1	90.3	98.3	104.7	---	109.1
107.9	77.9	81.1	85.9	89.1	97.1	103.5	105.5	---

Using the equipment previously described the IM product measurements were recorded and are listed in Table 3. The signal levels referenced to the carriers are calculated and listed in the column labeled "Level Referenced to Carrier". Refer to Exhibit B for a layout of the measurement equipment.

Table 3 Intermodulation Measurements

Product Frequency (MHz)	Carrier Frequency (MHz)	Interfering Frequency (MHz)	Pad (dB)	Bandpass Filter Loss (dB)	Full Scale Range (dBμ)	Scale reading (dB)	Adjusted Level (dBμ)	Carrier Reference Level (dBμ) (See Table 1)	Level Referenced to Carrier (dB)	Notes*
77.9	92.9	107.9	13	—	20	-8.1	24.9	123.9	-99.0	
79.1	92.9	106.7	13	12.2	20	-20.0	25.2	123.9	-98.7	
80.1	92.9	105.7	13	12.2	20	-20.0	25.2	123.9	-98.7	
81.1	94.5	107.9	13	12.1	20	-20.0	25.1	131.2	-106.1	
82.3	94.5	106.7	13	11.8	20	-20.0	24.8	131.2	-106.4	
82.5	92.9	103.3	3	11.5	20	-20.0	14.5	123.9	-109.4	
83.3	94.5	105.7	3	11.8	20	-20.0	14.8	131.2	-116.4	
83.3	92.9	102.5	3	11.8	20	-20.0	14.8	123.9	-109.1	
85.7	94.5	103.3	3	11.1	20	-20.0	14.1	131.2	-117.1	
85.9	96.9	107.9	3	11.1	20	-20.0	14.1	125.8	-111.7	
86.5	94.5	102.5	3	11.1	20	-20.0	14.1	131.2	-117.1	
87.1	96.9	106.7	3	11.0	20	-20.0	14.0	125.8	-111.8	
87.3	92.9	98.5	3	11.0	20	-20.0	14.0	123.9	-109.9	
88.1	96.9	105.7	3	11.0	20	-20.0	14.0	125.8	-111.8	
88.9	92.9	96.9	3	10.6	20	-20.0	13.6	123.9	-110.3	
89.1	98.5	107.9	3	10.5	20	-20.0	13.5	132.1	-118.6	
90.3	98.5	106.7	3	10.4	20	-18.2	15.2	132.1	-116.9	
90.5	94.5	98.5	3	10.2	20	-20.0	13.2	131.2	-118.0	
90.5	96.9	103.3	3	10.2	20	-20.0	13.2	125.8	-112.6	
91.3	98.5	105.7	3	10.1	20	-18.5	14.6	132.1	-117.5	
91.3	92.9	94.5	3	10.1	20	-18.5	14.6	123.9	-109.3	
91.3	96.9	102.5	3	10.1	20	-18.5	14.6	125.8	-111.2	
92.1	94.5	96.9	3	10.1	20	-20.0	13.1	131.2	-118.1	
93.7	98.5	103.3	3	9.8	20	-12.9	19.9	132.1	-112.2	
94.5	98.5	102.5	3	9.6	20	-20.0	12.6	132.1	-119.5	1
94.9	92.9	90.9	9	9.6	20	-20.0	18.6	123.9	-105.3	1
95.3	96.9	98.5	3	9.5	20	-11.2	21.3	125.8	-104.5	
96.1	94.5	92.9	9	9.2	20	-9.7	28.5	131.2	-102.7	

Product Frequency (MHz)	Carrier Frequency (MHz)	Interfering Frequency (MHz)	Pad (dB)	Bandpass Filter Loss (dB)	Full Scale Range (dBμ)	Scale reading (dB)	Adjusted Level (dBμ)	Carrier Reference Level (dBμ) (See Table 1)	Level Referenced to Carrier (dB)	Notes*
97.1	102.5	107.9	9	9.2	20	-20.0	18.2	132.1	-113.9	2
98.1	94.5	90.9	9	9.2	20	-15.2	23.0	131.2	-108.2	
98.3	102.5	106.7	9	9.2	20	-20.0	18.2	132.1	-113.9	3
99.3	102.5	105.7	3	9.2	20	-11.1	21.1	132.1	-111.0	
99.3	96.9	94.5	3	9.2	20	-11.1	21.1	125.8	-104.7	
100.1	98.5	96.9	3	9.2	20	-6.8	25.4	132.1	-106.7	
100.9	96.9	92.9	3	9.2	20	-5.8	26.4	125.8	-99.4	
101.7	102.5	103.3	3	9.1	20	-7.9	24.2	132.1	-107.9	
102.5	98.5	94.5	3	9.1	20	-16.1	16.0	132.1	-116.1	4
102.9	96.9	90.9	9	9.1	20	-20.0	18.1	125.8	-107.7	
103.5	105.7	107.9	3	9.1	20	-14.8	17.3	126.7	-109.4	
104.1	98.5	92.9	3	9.0	20	-2.1	29.9	132.1	-102.2	
104.7	105.7	106.7	9	9.1	20	-15.6	22.5	126.7	-104.2	
105.5	106.7	107.9	9	9.0	20	-20.0	18.0	126.2	-108.2	5
106.1	98.5	90.9	9	9.0	20	-1.2	36.8	132.1	-95.3	
106.5	102.5	98.5	9	9.0	20	-17.2	20.8	132.1	-111.3	6
107.7	106.7	105.7	9	9.0	20	-14.0	24.0	126.2	-102.2	7
108.1	102.5	96.9	9	9.0	20	-20.0	18.0	132.1	-114.1	7
108.1	105.7	103.3	3	9.0	20	-20.0	12.0	126.7	-114.7	
108.9	105.7	102.5	3	9.0	20	-1.8	30.2	126.7	-96.5	
109.1	107.9	106.7	9	9.0	20	-19.8	18.2	124.2	-106.0	
110.1	106.7	103.3	3	8.9	20	-20.0	11.9	126.2	-114.3	
110.1	107.9	105.7	3	8.9	20	-20.0	11.9	124.2	-112.3	
110.5	102.5	94.5	3	8.9	20	-20.0	11.9	132.1	-120.2	
110.9	106.7	102.5	3	9.2	20	-20.0	12.2	126.2	-114.0	
112.1	102.5	92.9	3	9.0	20	-20.0	12.0	132.1	-120.1	
112.5	107.9	103.3	3	8.9	20	-20.0	11.9	124.2	-112.3	
112.9	105.7	98.5	3	8.9	20	-20.0	11.9	126.7	-114.8	
113.3	107.9	102.5	3	8.8	20	-20.0	11.8	124.2	-112.4	
114.1	102.5	90.9	3	8.9	20	-20.0	11.9	132.1	-120.2	
114.5	105.7	96.9	3	8.5	20	-20.0	11.5	126.7	-115.2	
114.9	106.7	98.5	3	8.4	20	-20.0	11.4	126.2	-114.8	

Product Frequency (MHz)	Carrier Frequency (MHz)	Interfering Frequency (MHz)	Pad (dB)	Bandpass Filter Loss (dB)	Full Scale Range (dBμ)	Scale reading (dB)	Adjusted Level (dBμ)	Carrier Reference Level (dBμ) (See Table 1)	Level Referenced to Carrier (dB)	Notes*
116.5	106.7	96.9	3	8.5	20	-20.0	11.5	126.2	-114.7	
116.9	105.7	94.5	3	8.4	20	-20.0	11.4	126.7	-115.3	
117.3	107.9	98.5	3	8.3	20	-20.0	11.3	124.2	-112.9	
118.5	105.7	92.9	3	8.3	20	-20.0	11.3	126.7	-115.4	
118.9	106.7	94.5	3	8.2	20	-20.0	11.2	126.2	-115.0	
118.9	107.9	96.9	3	8.2	20	-20.0	11.2	124.2	-113.0	
120.5	105.7	90.9	3	8.2	20	-20.0	11.2	126.7	-115.5	
120.5	106.7	92.9	3	8.2	20	-20.0	11.2	126.2	-115.0	
121.3	107.9	94.5	3	8.1	20	-20.0	11.1	124.2	-113.1	
122.5	106.7	90.9	3	8.0	20	-20.0	11.0	126.2	-115.2	
122.9	107.9	92.9	3	8.0	20	-20.0	11.0	124.2	-113.2	
124.9	107.9	90.9	23	---	20	-20.0	23.0	124.2	-101.2	

*** NOTES**

- 1) The 94.5 MHz. System carrier was turned OFF for this measurement.
- 2) The 96.9 MHz. System carrier was turned OFF for this measurement
- 3) The 98.5 MHz. System carrier was turned OFF for this measurement
- 4) The 102.5 MHz. System carrier was turned OFF for this measurement
- 5) The 105.7 MHz. System carrier was turned OFF for this measurement
- 6) The 106.7 MHz. System carrier was turned OFF for this measurement
- 7) The 107.9 MHz. System carrier was turned OFF for this measurement

The Spectrum Analyzer was used to check the close in spectral attenuation of each carrier to confirm the operation of these transmitters are in compliance with Sections (b) and (c) of the FCC Rules and Regulations.

As a final proof of the systems IM Product performance, a wide band search was undertaken using the Spectrum Analyzer. The purpose for this measurement was to look for suspicious anomalies that may warrant further investigation. My search ranged the complete frequency span of the receiver and resulted in no additional investigations

Conclusion : Based upon my observations and measurements taken October 15, 2003 as summarized in this document, I, Mark Steapleton, find the subject multiplexed system- specifically the transmitters and combiner system for the operation of the WBOS, WJMN, WTKK, WBMX, WCRB, WROR, WMJX and WXKS into the COG 1084-2CP antenna- to be in proper working order. Furthermore, based on the measured data, it is my opinion that there are no inter-modulation products in excess of 80 dB below carrier levels generated from or within the stations operating on the installed system. Also, based on this recorded data. I conclude that WBOS, WJMN, WTKK, WBMX, WCRB, WROR, WMJX and WXKS are in compliance with the requirements of Section 73.317 paragraph (b) through (d) of the FCC Rules and Regulations.

Respectfully submitted,
Electronics Research, Inc.

By 
Mark Steapleton Field Technician

WARRICK COUNTY)
) SS:
STATE OF INDIANA)

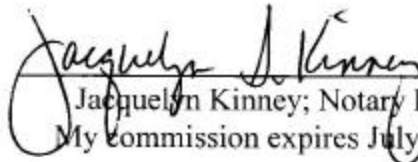
AFFIDAVIT

I, Mark Steapleton, hereby declare that the following statements are true and correct to the best of my knowledge and belief :

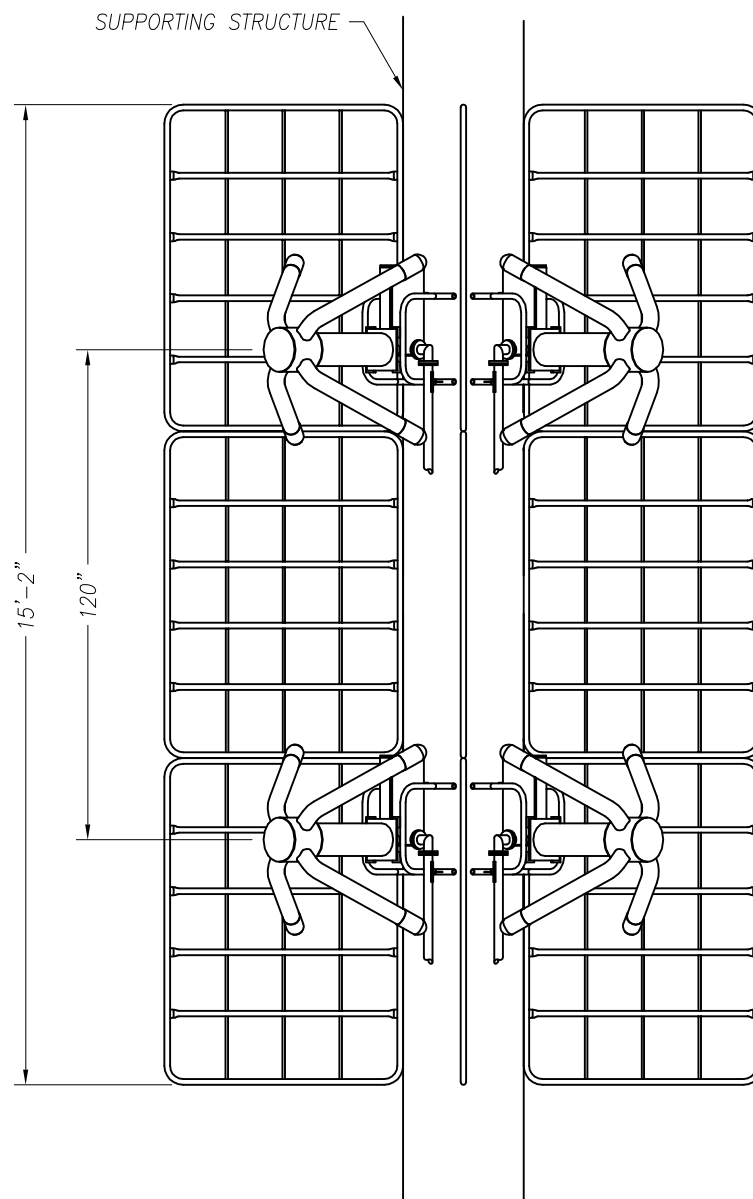
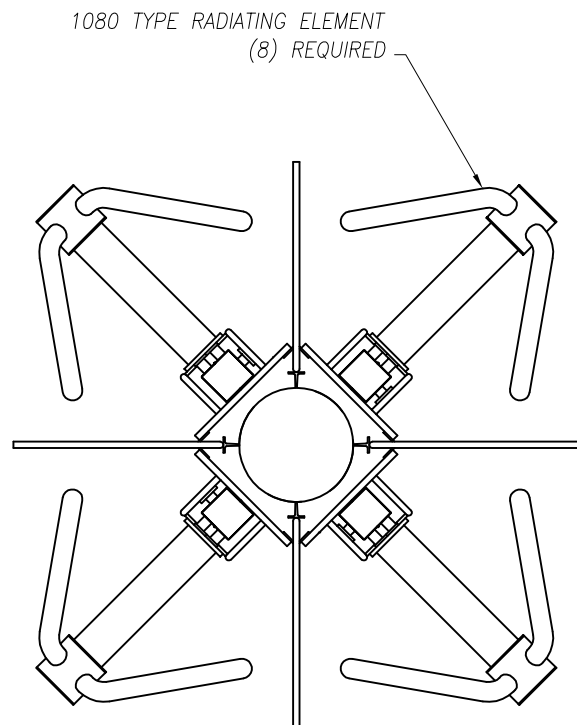
- 1.) I am a Field Technician for Electronics Research, Inc ("ERI ") and have been employed by ERI for 23 years. I am familiar with and have assisted in the design, manufacturing and installation of FM Antennas and FM Multiplexers in my long tenure with ERI.
- 2.) I have either prepared and/or directly supervised the preparation of all technical information contained in this Report Of Findings and to my knowledge to be accurate and true.
- 3.) ERI has been requested by American Tower Inc, on behalf of radio Stations WBOS, WJMN, WTKK, WBMX, WCRB, WROR, WMJX and WXKS, in Boston, MA. to prepare this Report Of Findings.


Mark Steapleton; Field Technician

Subscribed and sworn to before me on this 23rd. day of October 2003.


Jacquelyn Kinney; Notary Public
My commission expires July 5, 2007





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6				NAME	INTER-MODULATION REPORT		
5				STATION:	AMERICAN TOWER / NEWTON, MA SITE		
4				FREQUENCY:	PROJECT NO.: 10092		
3				PATH G:	\DRAFTING\ALL\PROJECTS\10092		
2				FILE	IR - 1	DRAWN	BAM
1				DATE	7/29/03	APP'D	FACTOR NTS
NO	REVISION	APP'D	DATE	MODEL	COG1084-2CP	DWG. NO.	IR - 1

EXHIBIT A-1

A-2 ERI Antenna Specification Sheet

BOSTON, MASSACHUSETTS

General Specifications

Antenna Type High Power FM-Broadcast, Suitable For Diplexing
 Model Number COG1084-2CP (Cogwheel)
 Number Of Bay Levels Two
 Polarization Right Hand Circular

Electrical Specifications

Antenna Input Power Capability 72 KW. Maximum
 Operating Frequency Band 88 ~ 108 Megahertz.
 VSWR 1.15 : 1 @ Operating Frequencies.⁽¹⁾
 Azimuthal Pattern Circularity Better Than +/- 2 From RMS
 Power Split 50/50 (Horizontal & Vertical)
 Frequency Specific Information:

<u>Frequency</u>	<u>Station ERP</u>	<u>Beam Tilt</u>	<u>First Null Fill</u>	<u>Power Gain</u>	<u>Line Loss</u> ⁽²⁾	<u>Filter Loss</u> ⁽³⁾	<u>Computed TPO</u>
107.9(MHz.)	1.80 KW	-0.0°	0 %	0.957	-0.948 dB	-0.429 dB	2.58 KW

Mechanical Specifications

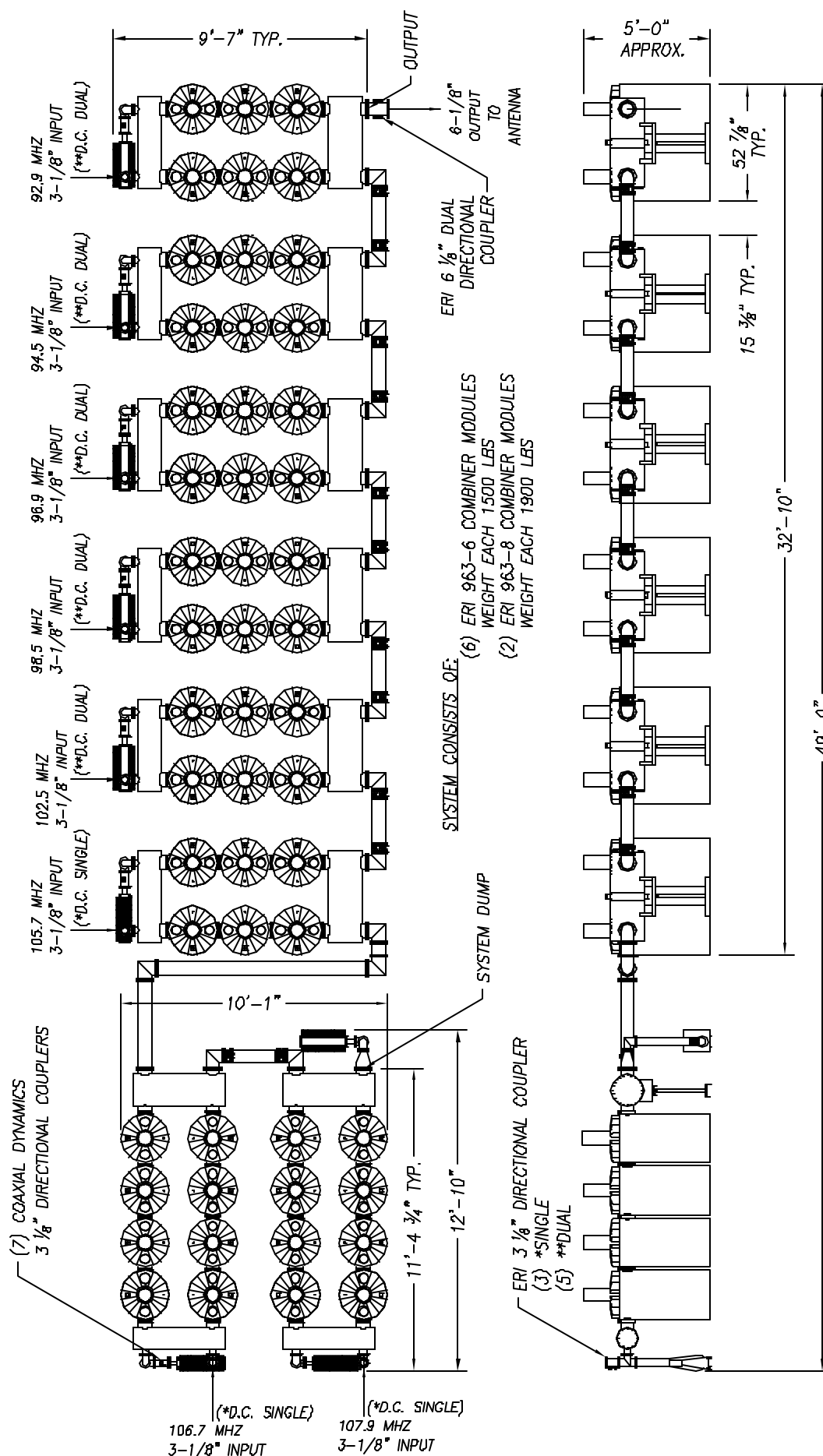
Antenna Feed System Branch Fed Single Input
 Input Connector 6-1/8" 50- Ohm EIA Flanged
 Element Deicing Low Q Element⁽⁴⁾
 Interbay Spacing 120 Inch Center to Center
 Array Length 15 feet 2 inches
 Construction Material (Antenna) All Noncorrosive
 Construction Material (Mounting) Galvanized Plated Steel And Stainless Steel
 Mounting Step Pole

1) VSWR Specification Achieved After On Site Tuning For User Specific Frequencies.

2) Line Loss Assumes A Feed Run Of 1,145 Feet, of Dielectric Type DC-675-004 Rigid 6 1/8 Coax (Output of Multiplexer to Main 3" Power Splitter). Also, 335' of Dielectric Type 375-003 Rigid 3 1/8" Coax (between the main 3" power splitter and antenna bay level power dividers.

3) Losses Taken From Actual Multiplexer Measurements.

4) With Low Q Element Design, Moderate Icing Will Not Cause Appreciable VSWR Rise.



ELECTRONICS RESEARCH, INC.

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ND. 2-

A-4 ERI Combiner Specification Sheet

BOSTON, MASSACHUSETTS

General Specifications

Multiplexer Type Band Pass Constant Impedance
 Number Of Combining Modules Used Eight, Type 963⁽¹⁾
 Injected Port to Injected Port Isolation - 58 dB
 Output Connector 6 1/8 " 50 Ohm EIA (Flanged)
 Output Power (Maximum for combiner only) 140 KW
 Combiner Modules, Size and Weight :
 Type 963-8 Tuned To 106.7 MHZ. 5' ht. X 4.5' wd. X 11' lng. & 1,700 Lbs.
 Type 963-8 Tuned To 107.9 MHZ. 5' ht. X 4.5' wd. X 11' lng. & 1,700 Lbs.

Heat Removal (All Multiplexer Components) Natural Convection
 Physical Arrangement All Components Standing on a mezzanine
 Multiplexer (Emergency) Broad Port Usage Connected to Dump Load

Injected Port Specifications

Frequency Assignment, Listed From Antenna Output 92.9/94.5/96.9/98.5/102.5/105.7/106.7/107.9 MHZ.
 Power Rating, Each Injected Port (Maximum) 40 kW
 Connector 3-1/8" 50 Ohm EIA (Flanged)
 VSWR Less than 1.08:1 @ +/-150 KHz⁽¹⁾
 Group Delay Less than 125 ns Overall Variation, Carrier @ +/- 150 KHz
 Insertion Loss (Measured):
 106.7 MHZ. -.401 dB
 107.9 MHZ. -.429 dB

(1) When Terminated in 50 Ohm Resistive Load.

ELECTRONICS RESEARCH, INC.
7777 GARDNER ROAD
CHANDLER, IN. 47610

FIGURE 8

----THEORETICAL----
VERTICAL PLANE RELATIVE FIELD

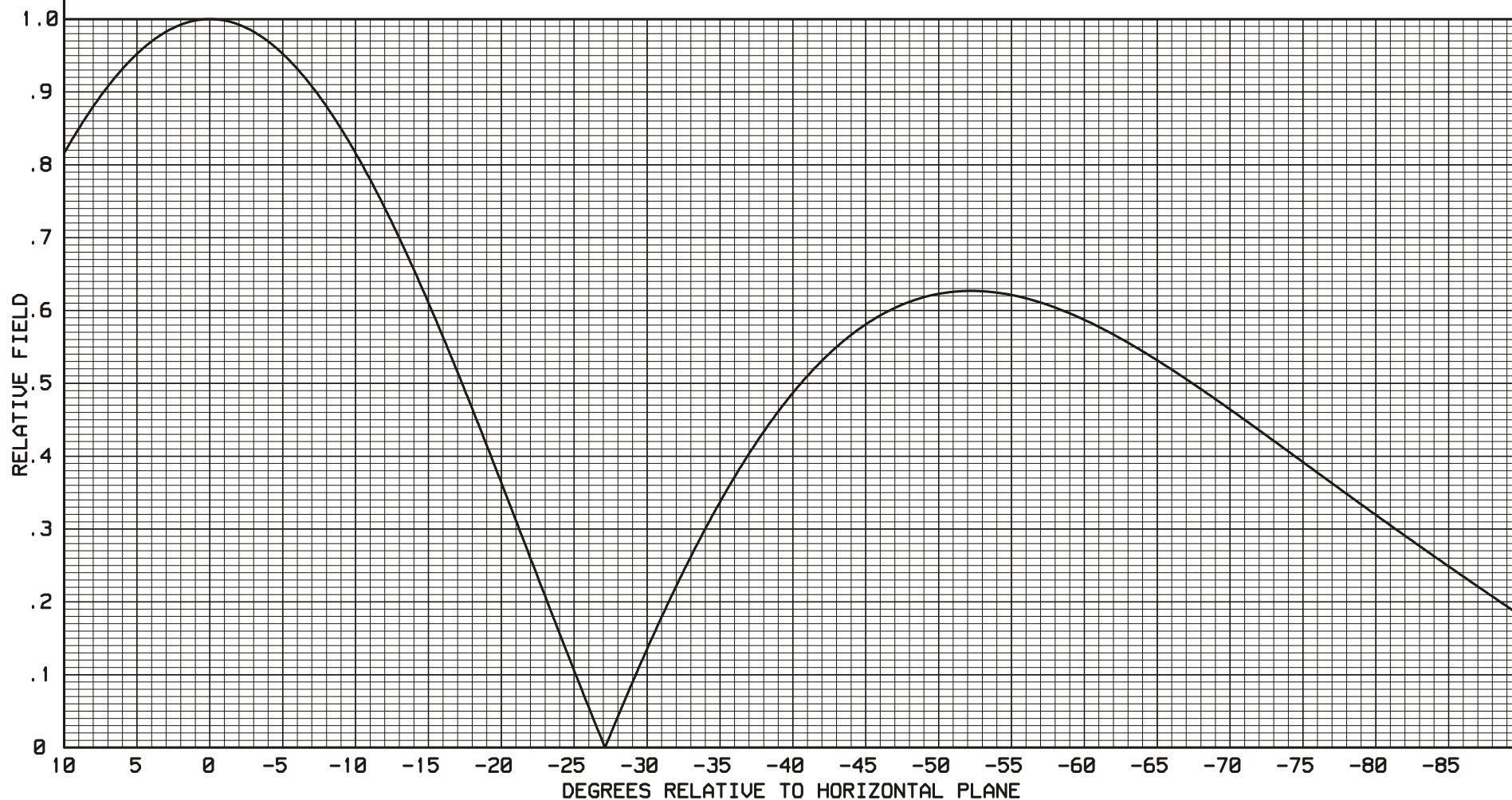
2 LEVELS OF TYPE 1080 ELEMENTS
+0.00 DEGREE(S) BEAM TILT
0 PERCENT FIRST NULL FILL
0 PERCENT SECOND NULL FILL

POWER GAIN IS 0.959 IN THE HORIZONTAL PLANE(0.959 IN THE MAX.)

APRIL 24, 2003

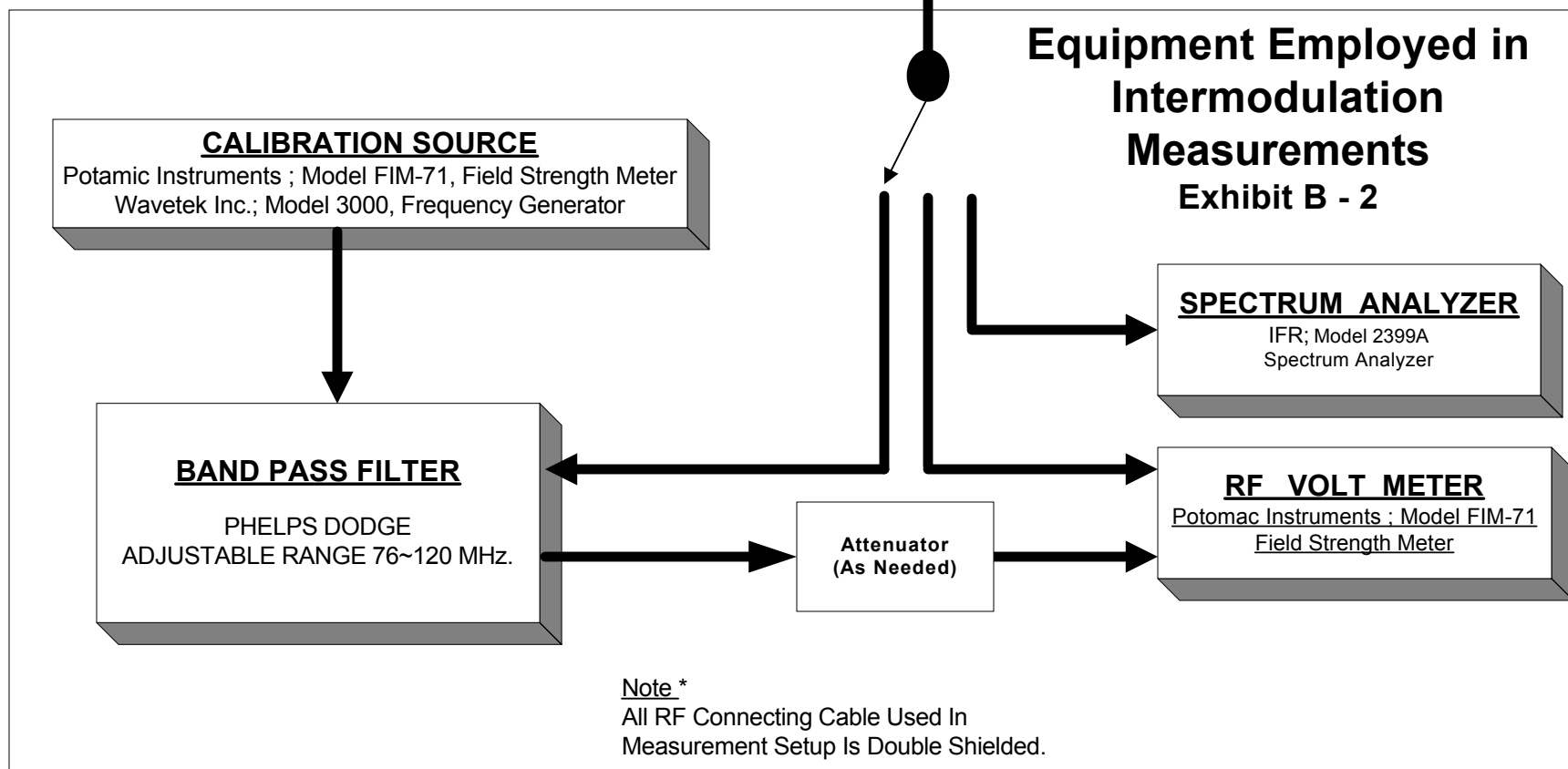
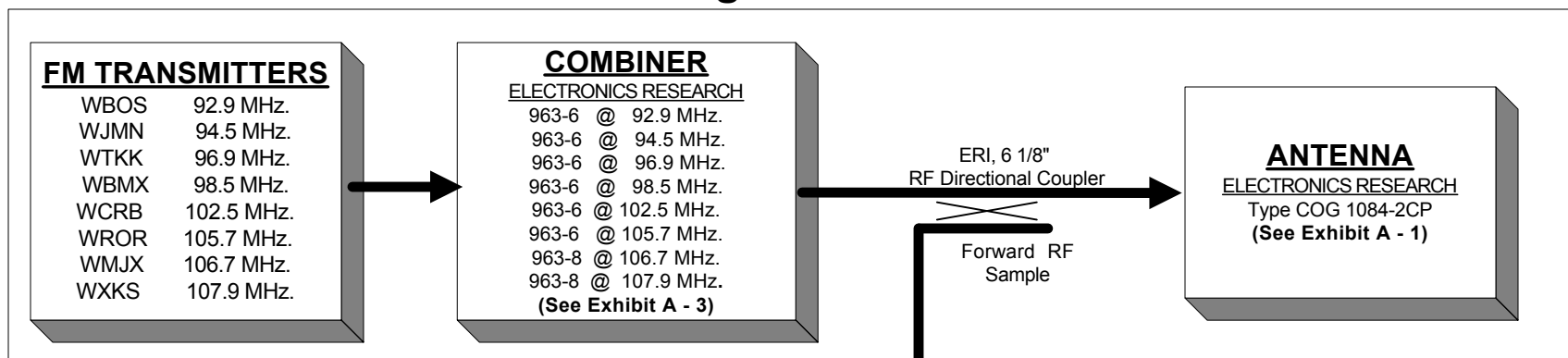
107.9 MHz

BAY SPACING
120.00 INCHES
(1.0970 WAVELENGTH)



WBOS~WJMN~WTKK~WBMX~WCRB~WROR~WMJX~WXKS

Broadcasting Scheme EXHIBIT - B1



Broadcasting Scheme and Equipment Employed in Intermodulation Measurements

EXHIBIT B