ELECTRONICS RESEARCH, INC.
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Report Of Intermodulation Product Findings

WNNX,WKHX BROADCAST FACILITY
ATLANTA, GEORGIA

May 2003

Electronics Research Inc.
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REPORT OF FINDINGS
WNNX / WKHX COMBINED BROADCAST FACILITY
ATLANTA, GEORGIA

Introduction: This report of findings is based on data collected at the WNNX and WKHX combined FM broadcast facility located in Atlanta, Ga.. The report includes measurements offered as proof that the combined operations of WNNX (99.7 MHz.) and WKHX (101.5 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 second 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). WLTM (94.9 MHz), and WKLS (96.1 MHz), operate into a separate antenna located on another tower approximately 500' from the multiplexed antenna. Their effects on the stations operating from the multiplexed system has been considered in this report. Jeff Taylor of Electronics Research, Inc. located in Chandler, Indiana performed the measurements summarized herein on May 9, 2003.

The following exhibits are provided:

Exhibit A:
- A-1 Drawing Depicting Antenna.
- A-2 1083-10CP Antenna Specification Sheet.
- A-3 Drawing Depicting Multiplexing Scheme.
- A-4 Multiplexer Specification Sheet.
- A-5 Theoretical Vertical Plane Relative Field Antenna Plots.

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 Second 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 second 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 second 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 : These measurements were taken with two FM stations operating from the combined antenna system. The WNNX, and WKHX multiplexed system is fundamentally comprised of antenna, feed line and multiplexer unit. The 1083-10CP antenna and 963-8GD "Constant Z" multiplexer unit are products of Electronics Research, Inc, whereas the feed line is manufactured by Myat Corp., Refer to Exhibit B-2, for an illustration of the Broadcasting Scheme of these stations.

To accomplish the aggregation of two 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 963-8 Constant impedance combiner modules with Group Delay Compensation were installed. All combiner components are natural convection cooled (except for Group Delay, which is forced air cooled). The combiner is illustrated in the attached Exhibit A-3. The multiplexer, fully assembled, exhibited transmitter port-to-port isolation in excess of -81dB. 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 31 dB directivity and a forward signal sample of -51 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 Anritsu Model S114B 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-1 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
WNNX (99.7)	3	--	140	-13.1	**129.9**	
WKHX (101.5)	3	--	140	-13.2	**129.8**	

Predictable second-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 - Second order Products.

	Carrier Frequency (MHz)	
Interfering Frequency (MHz)	**WNNX 99.7**	**WKHX 101.5**
WNNX 99.7	**---**	**103.3**
WKHX 101.5	**97.9**	**—**
WLTM 94.9	**104.5**	**108.1**
WKLS 96.1	**103.3**	**106.9**

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*
97.9	99.7	101.5	3	7.9	20	-8.3	22.6	129.9	**-107.3**	
103.3	101.5	99.7	6	7.7	20	-3.9	29.8	129.8	**-100.0**	
103.3	99.7	96.1	6	7.7	20	-3.9	29.8	129.9	**-100.1**	
104.5	99.7	94.9	3	7.3	20	<-20.0	<10.3	129.9	**< -119.6**	
106.9	101.5	96.1	3	7.3	20	<-20.0	<10.3	129.8	**< -119.5**	
108.1	101.5	94.9	3	7.2	20	<-20.0	<10.2	129.8	**< -119.6**	

*** NOTES**

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 May 9th. 2003, as summarized in this document, I, Jeff Taylor, find the subject multiplexed system- specifically the transmitters and combiner system for the operation of the WNNX and WKHX into the 1083-10CP 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 WNNX and WKHX 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 Jeff Taylor
Jeff Taylor Field Technician

State of Indiana)
) SS:
County of Warrick)

AFFIDAVIT

I, Jeff Taylor, 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 8 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 Richland Tower on behalf of radio Stations WNNX and WKHX in Atlanta, Ga. to prepare this Report Of Findings.

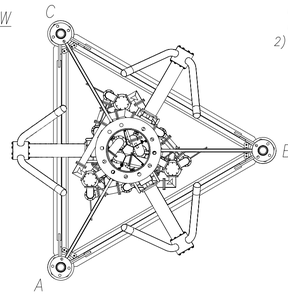
Jeff Taylor
Jeff Taylor; Field Technician

Subscribed and sworn to before me on this 13th. day of May 2003.

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

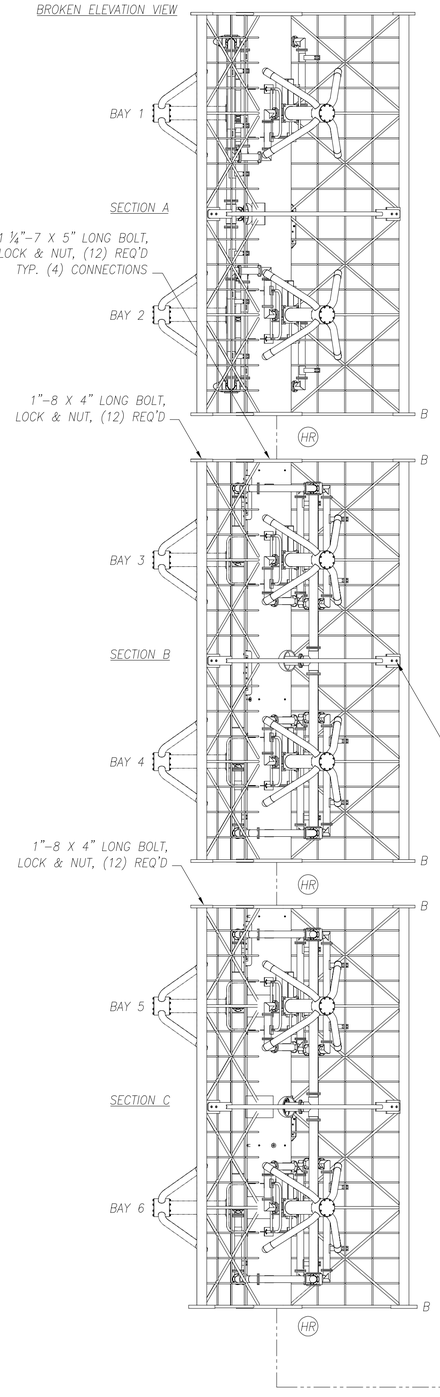
NOTARY PUBLIC * INDIANA

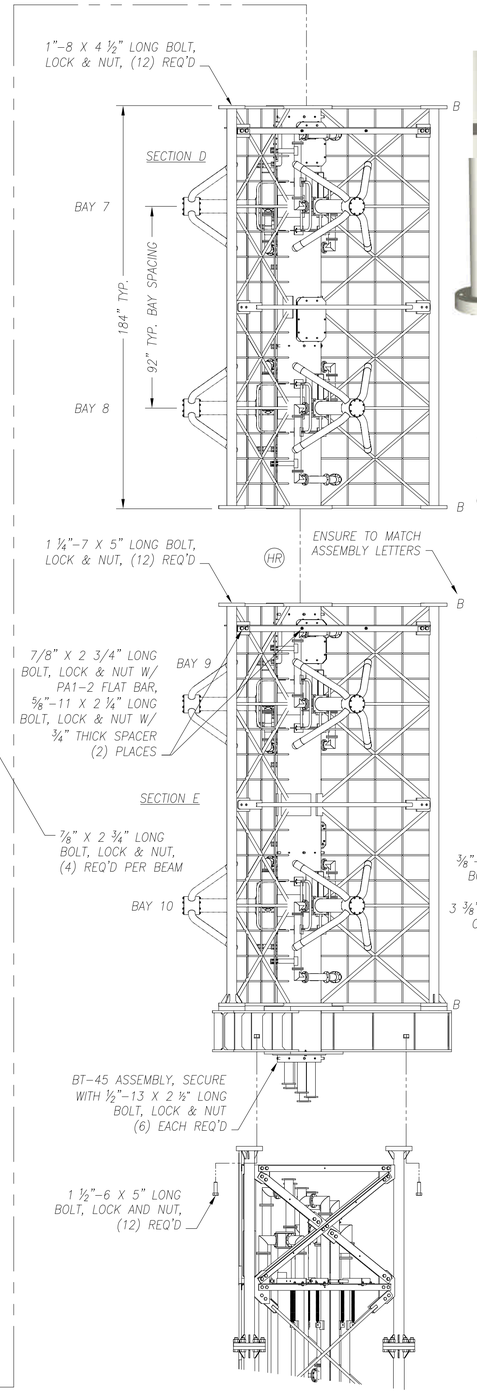
TOP VIEW

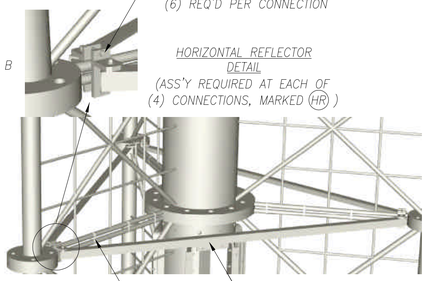


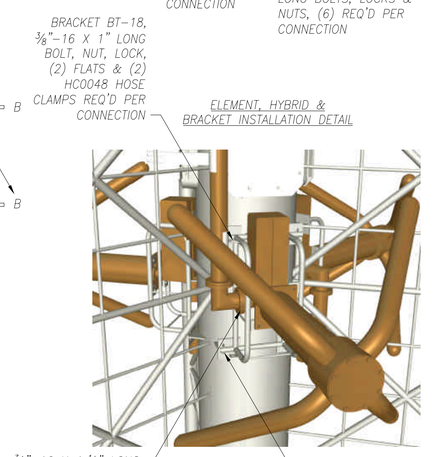
NOTES:
1) THE (10) ELEMENT/HYBRID ASSEMBLIES THAT MUST BE INSTALLED ARE SHOWN WITH PHANTOM LINES BELOW. THE HYBRID FLANGES, AS WELL AS THE FLANGES ON THE ELBOWS IN WHICH THEY CONNECT ARE NUMBERED, EX. 1,A,1, 2,B,1, ETC. MATCH NUMBERS FOR PLACEMENT. (SEE FEED HARNESS DETAIL & NUMBERING SCHEME, IC–2 FOR FULL DETAIL)
2) SUGGESTED INSTALLMENT PROCEDURES:
   1. PREP COGWHEEL FOR INSTALLATION: INSTALL MISSING ELEMENTS (SEE ELEMENT/HYBRID AND BRACKET INSTALLATION DETAIL), REMOVE SHIPPING PACKAGING, ATTACH CENTERFEED ELBOWS AND STUB SECTIONS TO TEE (SEE DETAIL 3 ON RIGHT) AND PLACE SPRING HANGER SADDLES IN CORRECT LOCATION (SEE SADDLE PLACEMENT ON RIGHT).
   2. ENSURE THAT (FOR PICKING ORIENTATION PURPOSES) LADDER BRACKET ON TRANSITION IS ON THE SAME FACE AS THE EXISTING LADDER.
   3. HOIST SECTION "E" UP AND VERY CAREFULLY BOLT TO TRANSITION. ENSURE THAT LETTERS A,B,&C ON COG SECTION LEGS MATCH THOSE ON THE TRANSITION SECTION.
   4. ENSURE TO INSTALL PIPE W/FLANGE MARKED BT–45, ALONG WITH STAR CONFIGURATION AND TEFLON ALIGNMENT PINS AS SHOWN ON TRANSITION ASSEMBLY.
5. ENSURE THAT LINES ARE ADJUSTED TO PROTRUDE OUT OF THE PIPE AS DIMENSIONED IN DETAIL BELOW BY LOOSENING HOSE CLAMPS ON SPRING HANGERS AND RIGID LINE BRACKETS. LINE SECTIONS ARE ALIGNED WITH TEFLON PINS IN STAR CONFIGURATIONS. (SEE DETAIL 1 ON RIGHT). ENSURE THAT LINE TENSION IS HANGING EVENLY FROM SPRINGS, IT IS IMPORTANT TO MAINTAIN PROTRUSION DIMENSIONS ON LINES AS SECTIONS ARE ADDED.
6. ONCE ALL SECTIONS ARE STACKED, STAINLESS & FIBERGLASS HORIZONTAL TIE BEAMS & REFLECTORS MAY BE ADDED, AS WELL AS HOSE CLAMPS BETWEEN SECTIONS (SHOWN BELOW). FIBERGLASS ANGLES SECURE ONLY TO THE TOP OF SECTIONS "E"&"D".

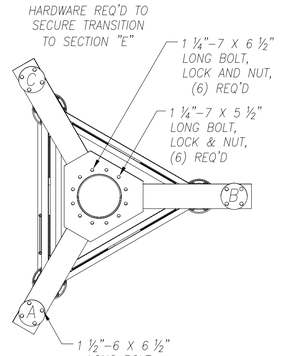
BROKEN ELEVATION VIEW





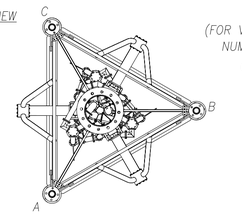




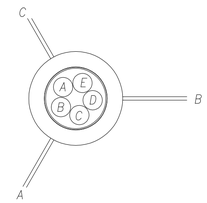


NOTES:
1) PARTS ARE STAMPED FOR ASSEMBLY PURPOSES.
2) RIGID LINE BRACKETS (BT–29 & BT–30) ARE USED DIRECTLY AND EXCLUSIVELY ON LINES THAT ROUTE THROUGH CENTERFEED ENTRANCE PORTS AS SHOWN IN DETAIL 3 AND IN RED ON DETAIL (1).
3) POLE WALL THICKNESS CHANGES FROM ½" ON THE LOWER (3) SECTIONS TO ⅜" ON THE TOP (2) SECTIONS, ENSURE TO USE BRACKET BT–30 ON THE LOWER (3) SECTIONS AND BRACKET BT–29 ON THE UPPER (2) SECTIONS.
   IN ADDITION, THERE ARE (2) SIZES OF STAR CONFIGURATIONS. USE BT–24 BRACKETS ON LOWER (3) SECTIONS AND BT–27 BRACKETS ON THE UPPER (2) SECTIONS.
4) SPRING HANGERS ARE PLACED ONLY AT THE TOP OF EACH SECTION AS SHOWN IN DETAIL 2.

TOP VIEW

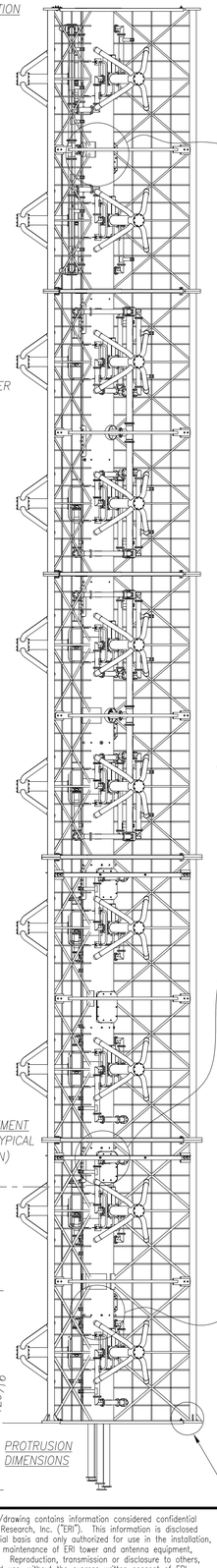


LINE PLACEMENT DETAIL
(FOR VERTICAL REFERENCE, SEE FEED LINE NUMBERING AND AND LENGTH DETAIL)



SECTION	LINE LENGTH
A	9 ¾"
B	13 ¾"
C	7 ½"
D	11 ¾"
E	5 ½"

ELEVATION



FEED LINE NUMBERING AND LENGTH DETAIL

FEED LINES ARE COLORED AS FOLLOWS:

BAYS 1 & 2 – YELLOW (A)

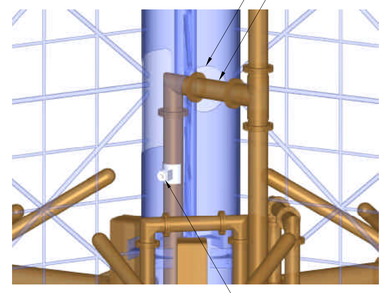
BAYS 3 & 4 – BLUE (B)

BAYS 5 & 6 – GREEN (C)

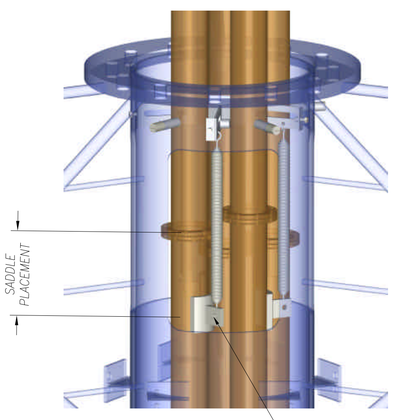
BAYS 7 & 8 – ORANGE (D)

BAYS 9 & 10 – BROWN (E)

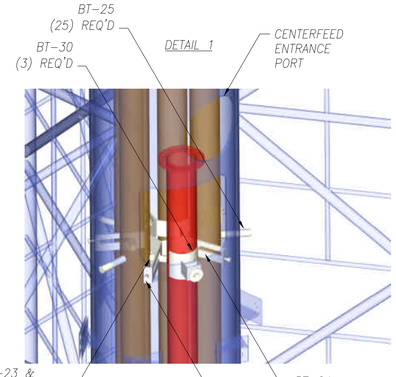
DETAIL 3



DETAIL 2



DETAIL 1



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NO	REVISION	APP'D	DATE
6			
5			
4			
3			
2			
1			

NAME SECTION INSTALLATION/LINE DETAILS
STATION: 09545–ATLANTA, GA
FREQUENCY: 101.5&99.7MHz PROJECT NO.: 09545
PATH G:\DRAFTING\ALL\PROJECTS\09545
FILE IC — 4 DRAWN B.L.V. FACTOR NTS
DATE 1/6/03 APP'D DWG. NO.
MODEL COG3–20P–10–140–2 IC — 4

A-2 ERI Antenna Specification Sheet
ATLANTA, GEORGIA

General Specifications

Antenna Type . . . . . High Power FM-Broadcast, Suitable For Multiplexing
Model Number COG-1083-10CP
Number Of Bay Levels . . . . . Ten
Polarization . . . . . Right Hand Circular

Electrical Specifications

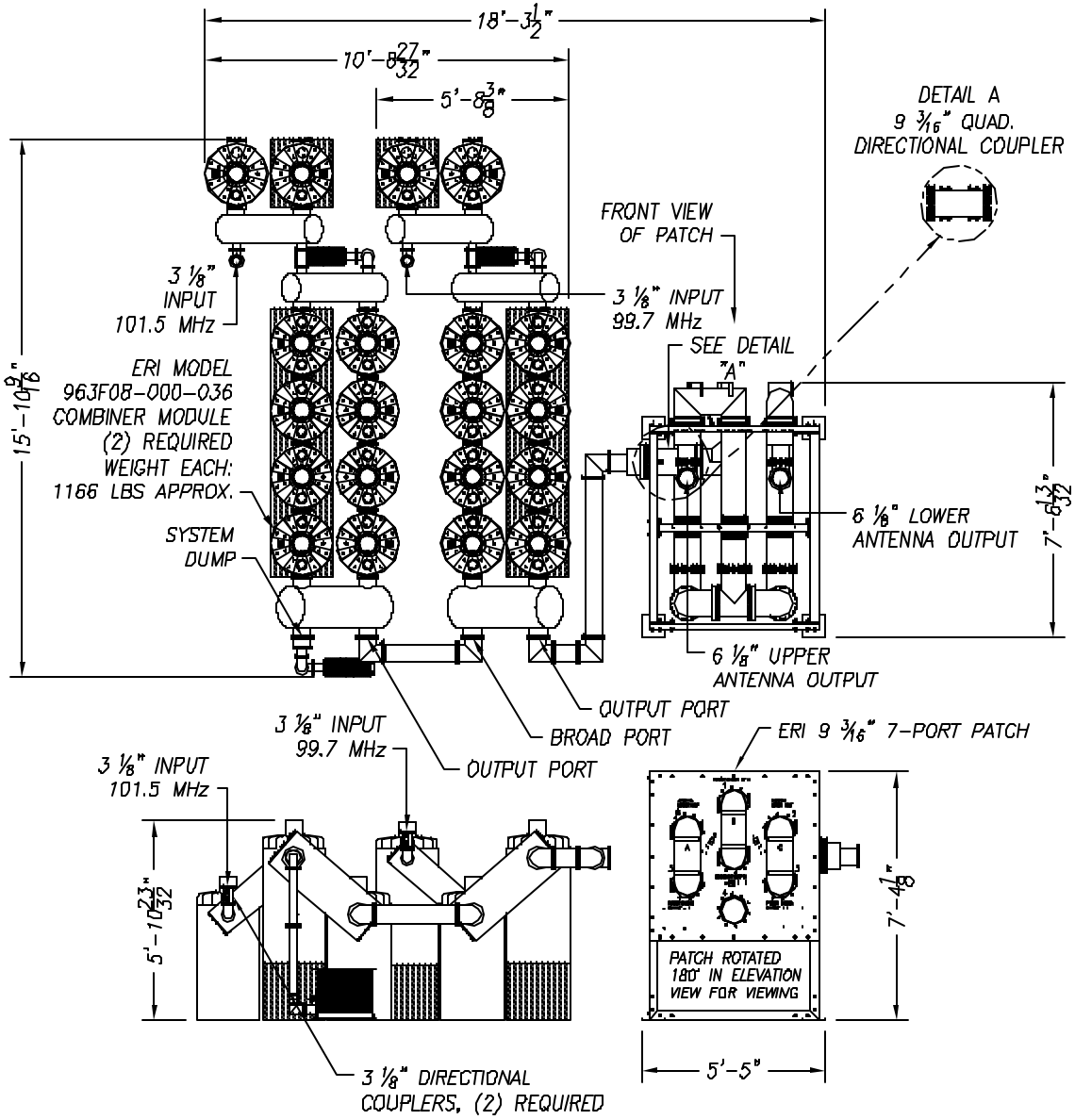
Antenna Input Power Capability (Designed) . . . . . 250 KW. Maximum (1)
Operating Frequency Band . . . . . All FM Frequencies
VSWR . . . . . 1.15 : 1 (2)
Azimuthal Pattern Circularity . . . . . +/- 2dB From RMS (Free Space)
Power Split . . . . . 50/50 (Horizontal & Vertical)
Quarter Wave Shorting Stub . . . . . NA
Frequency Specific Information:

Frequency	Station ERP	Beam Tilt	First Null Fill	Second Null Fill	Power Gain (MAXIMUM)	Line Loss (3)	Filter Loss (4)	Computed TPO (5)
99.7	**100 (KW)**	**-0.76°**	**10 %**	**5%**	**4.412**	**.577 dB**	**.461 dB**	**28.78 (KW)**
101.5	**100 (KW)**	**-0.76°**	**10 %**	**5%**	**4.482**	**.582 dB**	**.452 dB**	**28.30 (KW)**

Mechanical Specifications

Antenna Feed System . . . . . Fed With Dual Feed Lines
Input Connectors . . . . . 6-1/8" 50- Ohm EIA Flanged
Element Deicing . . . . . Not Ordered (6)
Interbay Spacing . . . . . 92.00 Inch Center to Center
Array Length . . . . . 119.6 Feet
Construction Material (Antenna) . . . . . All Noncorrosive
Construction Material (Mounting) . . . . . Galvanized Plated Steal and All Stainless Steel
Mounting . . . . . Integral Arrangement (Antenna Preassembled To Mast)

1) Power Capability Has Been Rated Assuming An Operating Transmission VSWR Of 1.5:1
2) VSWR Specification Achieved After On Site Tuning For User Specific Frequencies.
3) Line Loss Assumes A Feed Run Of 1193 Feet, Myat Type 601 Rigid 6 1/8" Coax.
4) Losses Taken From Actual Multiplexer Measurements Taken At The Factory.
5) TPO Calculations Are Figured As Combiner Input Power.
6) With Low Q Element Design, Moderate Icing Will Not Cause Appreciable VSWR Rise.



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NO	REVISION	APP'D	DATE
8			
6			
4			
3			
2			
1			

NAME IM REPORT
STATION: ATLANTA, GA.
FREQUENCY: N/A PROJECT NO.: 09545/3
PATH G:\DRAFTING\ALL\PROJECTS\09545\3
FILE IM-5 DRAWN S.DEOM FACTOR 1/64=1
DATE 4/11/03 APP'D DWG. NO.
MODEL (8) 963F08-000-036 IM-5

Two 963-8GD ERI Constant Impedance Combiner Specification Sheet
Atlanta, Georgia

General Specifications:

Multiplexer Type . . . . . 963-8 Constant Impedance With Group Delay Compensation
Number Of Combining Units . . . . . Two
Injected Port to Injected Port Isolation . . . . . - 81 dB
Output Connector . . . . . 6 1/8 " 50 Ohm EIA (Flanged)
Output Power (Designed) . . . . . 140 KW(1)
Combiner Units, Size and Weight :

Type 963-8GD Tuned To 99.7 MHz. . . . . 58" ht. X 48" wd. X 16' lg. & 2000 Lbs.
Type 963-8GD Tuned To 101.5 MHz. . . . . 58" ht. X 48" wd. X 16' lg. & 2000 Lbs.

Heat Removal (Except Group Delay which is Forced Air) . . . . . Natural Convection
Physical Arrangement . . . . . All Components Floor Standing

Injected Port Specifications:

Frequency Assignment . . . . . 99.7 MHz. And 101.5 MHz.
Power Rating, Each Injected Port (Maximum) . . . . . 40 KW
Input Connector . . . . . 3-1/8" 50 Ohm EIA (Flanged)
VSWR . . . . . Less than 1.08:1 @ +/-150 KHz(2
Group Delay . . . . . Less than 50 ns Overall Variation, Carrier @ +/- 150 KHz
Insertion Loss (Measured):

99.7 MHz. . . . . - 0.461 dB
101.5 MHz. . . . . - 0.452 dB

1) Power Rating Listed is as Designed Only. Actual Power Capabilities May Vary.
2) When Terminated in 50 Ohm Resistive Load.

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

FIGURE 1

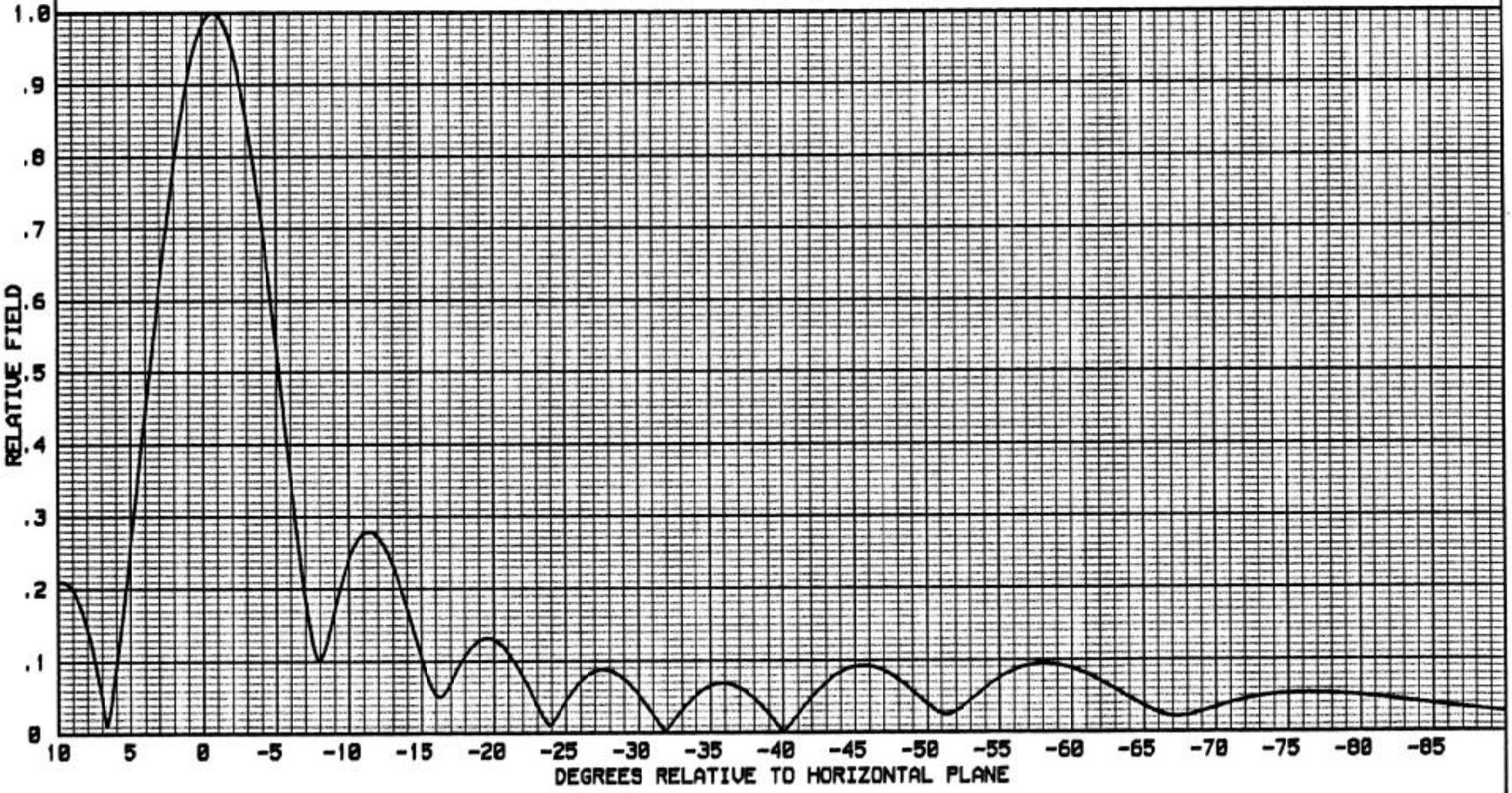
----THEORETICAL----
VERTICAL PLANE RELATIVE FIELD

ERI MODEL COG-1083-10CP ANTENNA
-.76 DEGREE(S) BEAM TILT
10 PERCENT FIRST NULL FILL
5 PERCENT SECOND NULL FILL
POWER GAIN IS 4.261 IN THE HORIZONTAL PLANE(4.412 IN THE MAX.)
[POWER GAINS AT 95% ANTENNA EFFICIENCY]

OCTOBER 9, 2002

99.7 MHz.

BAY SPACING:
92.00 INCHES
(.7771 WAVELENGTH)



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

FIGURE 2

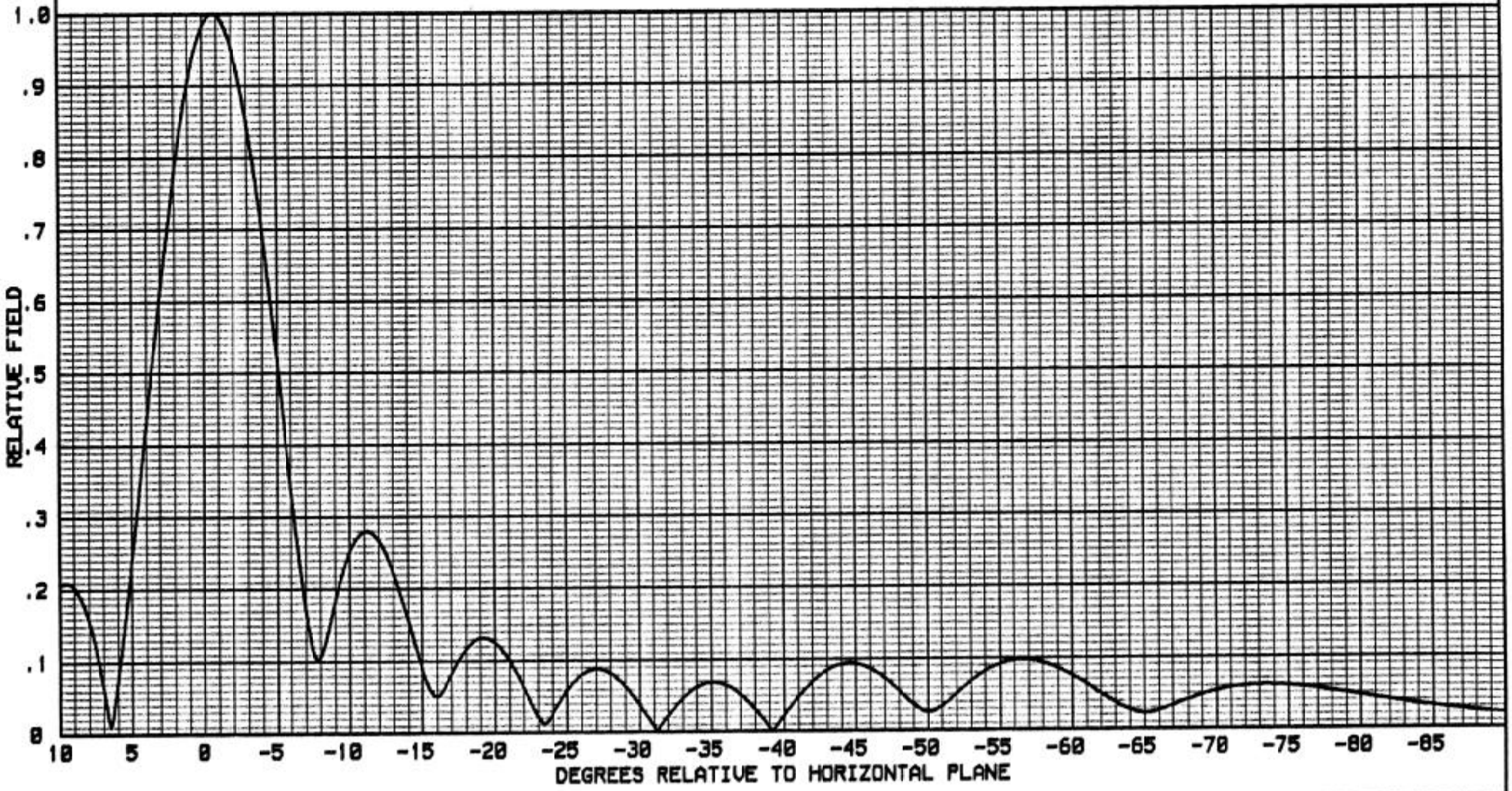
----THEORETICAL----
VERTICAL PLANE RELATIVE FIELD

ERI MODEL COG-1083-10CP ANTENNA
-.76 DEGREE(S) BEAM TILT
10 PERCENT FIRST NULL FILL
5 PERCENT SECOND NULL FILL
POWER GAIN IS 4.323 IN THE HORIZONTAL PLANE(4.482 IN THE MAX.)
[POWER GAINS AT 95% ANTENNA EFFICIENCY]

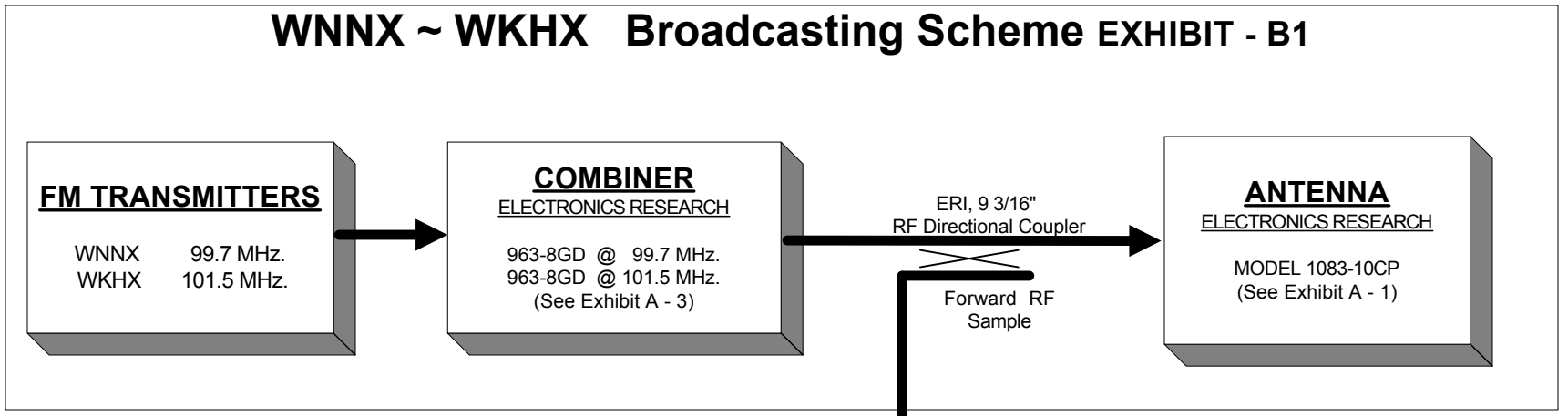
OCTOBER 9, 2002

101.5 MHz.

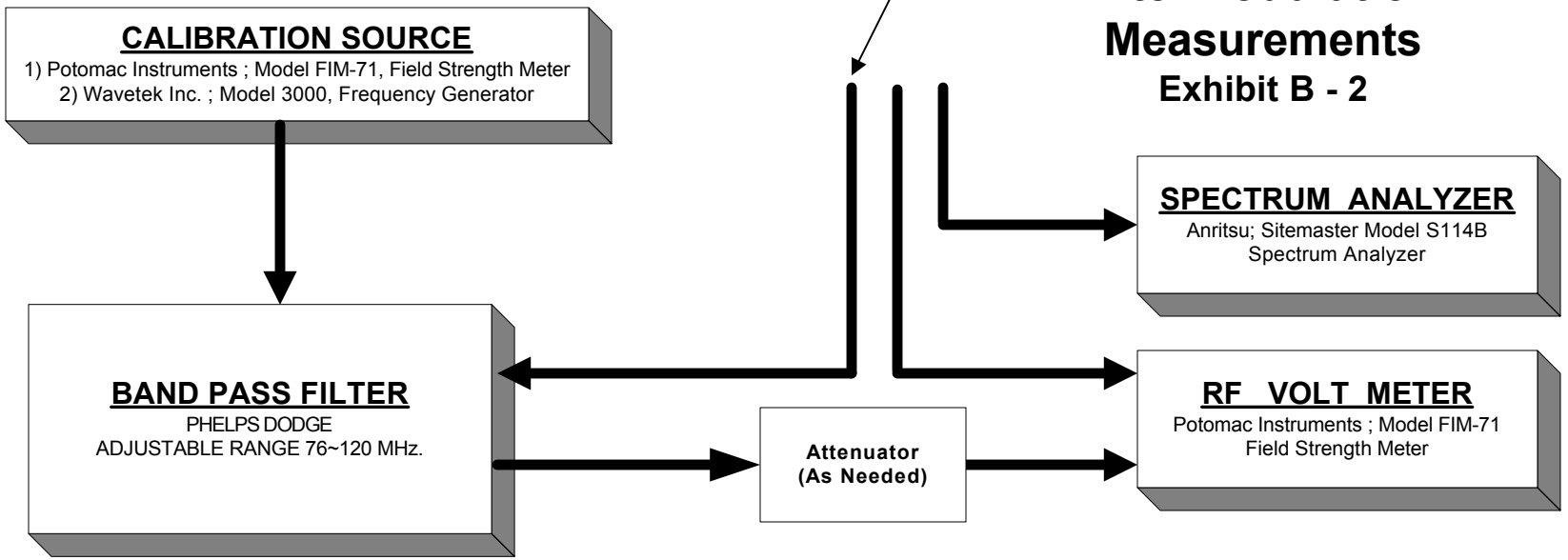
BAY SPACING:
92.00 INCHES
(.7912 WAVELENGTH)



WNNX ~ WKHX Broadcasting Scheme EXHIBIT - B1



Equipment Employed in Intermodulation Measurements
Exhibit B - 2



Note *
All RF Connecting Cable Used In
Measurement Setup Is Double Shielded.

Broadcasting Scheme and Equipment Employed in Intermodulation Measurements

EXHIBIT B