

Report Of Intermodulation Product Findings

**WDRQ 93.1 MHz. Detroit, MI.
WDVD 96.3 MHz. Detroit, MI.
WDZH 98.7 MHz. Detroit, MI.
WYCD 99.5 MHz. Detroit, MI.**

Project# 34866

May 17, 2019

**Electronics Research Inc.
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REPORT OF FINDINGS
WDRQ / WDVD / WZDH / WYCD
93.1 MHz. / 96.3 MHz. / 98.7 MHz. / 99.5 MHz.

Introduction: This report of findings is based on data collected at the WDRQ, WDVD, WZDH and WYCD broadcast facility located in Detroit, Michigan. The report includes measurements offered as proof that the combined operations of WDRQ (93.1 MHz.), WDVD (96.3 MHz.), WZDH (98.7 MHz.), and WYCD (99.5 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 third order inter-modulation (IM) products generated by this multiplexed system are less than the maximum allowable level as required by section 73.317 (b) through (d). At this time, WZDH (98.7 MHz.), does not have a transmitter for intermodulation measurements. Measurements pertaining to the operation of WZDH 98.7 MHz., will be conducted at a later date. Jeff Taylor of Electronics Research, Inc. located in Chandler, Indiana performed the measurements summarized herein on May 17, 2019.

The following exhibits are provided:

Exhibit A:

- A-1 Drawing Depicting Antenna.
- A-2 1183-2CP-2 Antenna Specification Sheet.
- A-3 Drawing Depicting Multiplexed 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 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: These measurements were taken with three of the four FM stations operating from the combined antenna system. The WDRQ, WDVD, WDZH, and WYCD multiplexed system is fundamentally comprised of antenna, feed line and multiplexer unit. The 1183-2CP-2 (antenna), combiner units, and the feedline are products of Electronics Research, Inc. Refer to Exhibit B-1, for an illustration of the Broadcasting Scheme of these stations.

To accomplish the aggregation of four transmitter signals into a common antenna feed and provide transmitter-to-transmitter isolation, a multiplexing scheme consisting of a 783 “T” Combiner and (2)783 Constant Impedance Combiners were installed. Specifically, the combiner uses one ERI 783-3A Band Pass module for frequency (93.1 MHz.), one 783-4A Band Pass Module for frequency (98.7 MHz.), one 783-6 Constant Impedance module for frequency (96.3 MHz.), and one 783-8 Constant Impedance module for frequency (99.5 MHz.). The 93.1 MHz. and 98.7 MHz. is the portion of the “T” combiner which is injected to the broad port of the 96.3 Constant Impedance module. An interconnecting “u-link” is required to connect 96.3 MHz. to the 99.5 MHz. Constant Impedance module to complete the combiner circuit which is illustrated in the attached Exhibit A-3. The multiplexer, fully assembled, exhibited transmitter port-to-port isolation in excess of -59 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 multiplexer’s 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 ensure 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 -57 dB directivity and a forward signal sample of -37 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 Spectrum Analyzer to ensure an adequate signal level for measurements without overloading the measurement equipment. An IFR 2399A Spectrum Analyzer serial# 02113071 was employed to record the level of all signals investigated. A Copper Mountain S5048 Network Analyzer serial# 15077029 was used for selective tuning of the Band Pass Filter. The IFR Spectrum Analyzer was also 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 both transmitters were operating at maximum power. 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)	Scale Range (dBm)	Scale Reading (dBm)	Adjusted Level (dBm)	Notes
93.1	3		6.33	9.33	
96.3	3		6.81	9.81	
98.7					
99.5	3		6.86	9.86	

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.

Interfering Frequencies	Carrier Frequencies			
	93.1	96.3	98.7	99.5
WDRQ 93.1 MHz.	----	99.5		105.9
WDVD 96.3 MHz.	89.9	----		102.7
WDZH 98.7 MHz.			----	
WYCD 99.5 MHz.	86.7	93.1		----

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-2 for a layout of the measurement equipment.

Table 3 – Intermodulation Measurements

IM Measurements Taken in Detroit, Michigan										
Product Frequency (MHz)	Transmitter Frequency (MHz)	Interfering Frequency (MHz)	Pad (dB)	Bandpass Filter Loss (dB)	Total Loss	Measured Level (dBm)	Adjusted Level (dBm)	Carrier Reference Level (dBm)	Level Referenced to Carrier (dB)	Notes*
Transmitter Mixes										
	93.1	Ref.	3		3	6.33	9.33	9.33		
	96.3	Ref.	3		3	6.81	9.81	9.81		
	99.5	Ref.	3		3	6.86	9.86	9.86		
86.7	93.1	99.5	3	12.8	15.8	-98.13	-82.33	9.33	-91.66	
89.9	93.1	96.3	3	11.7	14.7	-94.22	-79.52	9.33	-88.85	
93.1	96.3	99.5	3	11.9	14.9	-97.41	-82.51	9.81	-92.32	93.1 Off
99.5	96.3	93.1	3	12.4	15.4	-98.08	-82.68	9.81	-92.49	99.5 Off
102.7	99.5	96.3	3	11.4	14.4	-98.19	-83.79	9.86	-93.65	
105.9	99.5	93.1	3	10.9	13.9	-97.14	-83.24	9.86	-93.10	

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

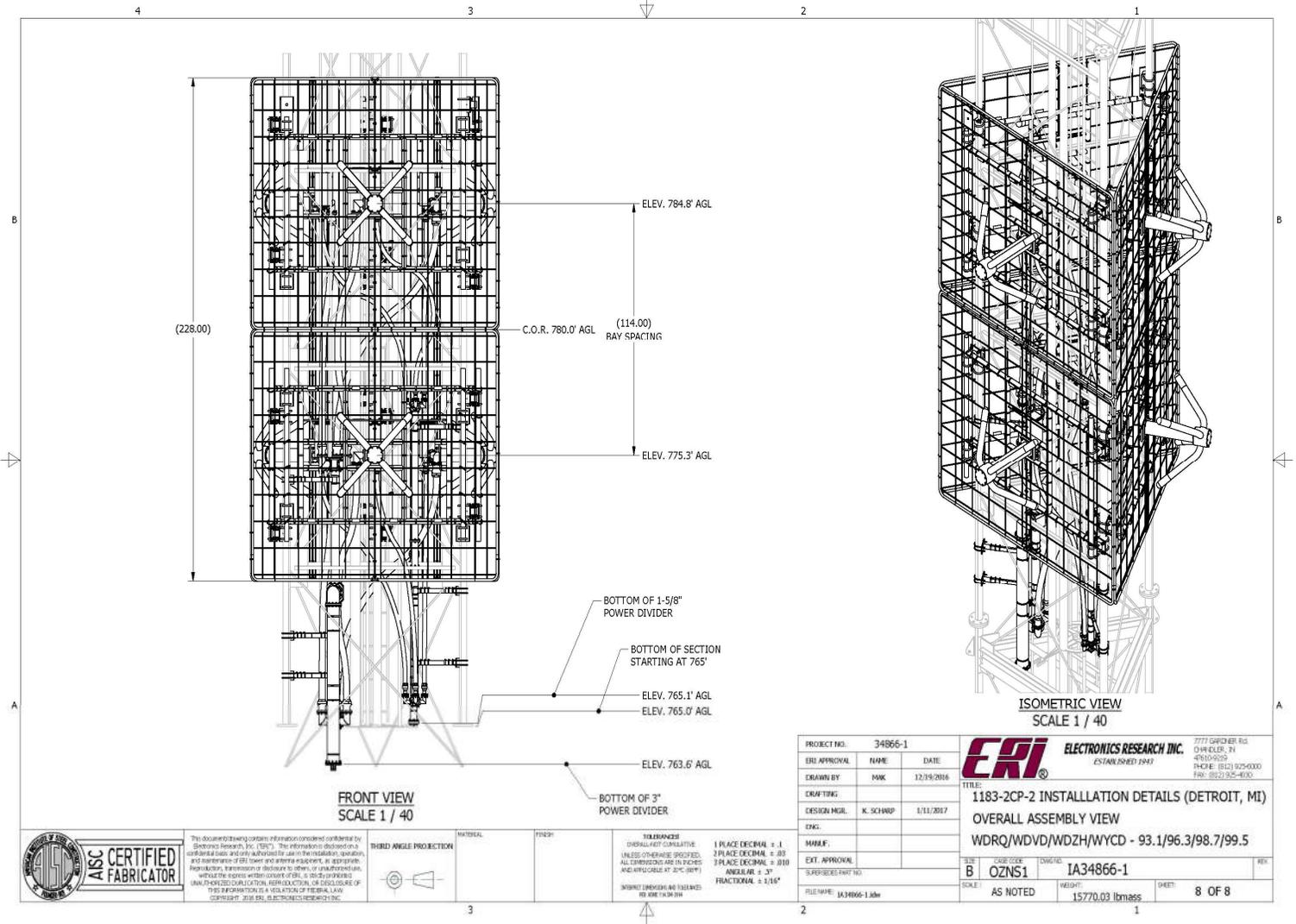
As a final proof of the systems IM Product performance, a wide band search was undertaken using the Spectrum Analyzer. The purpose for this measurement was to look for suspicious anomalies that may warrant further investigation. My search ranged the complete frequency span of the receiver and resulted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

Conclusion: Based upon my observations and measurements taken on May 17, 2019 as summarized in this document, I, Jeff Taylor, find the subject system, specifically the transmitter and filter system for the operation of WDRQ, WDVD, and WYCD into the 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 station operating on the installed system. Based on this recorded data, I conclude that WDRQ, WDVD, and WYCD 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.

Jeff Taylor, Field Technician

EXHIBIT, A-1



PROJECT NO.	34866-1	ERI ELECTRONICS RESEARCH INC. <small>ESTABLISHED 1993</small> 7771 GROVER RD CHICAGO, IL 60650 PHONE: (815) 925-0000 FAX: (815) 925-4000
ERI APPROVAL	NAME DATE	
DRAWN BY	MMK 12/19/2016	TITLE:
DRAFTING		1183-2CP-2 INSTALLATION DETAILS (DETROIT, MI)
DESIGN MGR.	K. SCHWAP 1/11/2017	OVERALL ASSEMBLY VIEW
ENG.		WDRQ/WDVD/WDZH/WYCD - 93.1/96.3/98.7/99.5
MANUF.		REV:
EXT. APPROVAL		REV. B
SUPPLIER PART NO.		DATE CODE
FILENAME: IA34866-1.dwg		OZNS1
		ISSUE NO.
		IA34866-1
		SCALE:
		AS NOTED
		WEIGHT:
		15770.03 lbmass
		SHEET:
		8 OF 8



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THIRD ANGLE PROJECTION

TOLERANCES UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE IN INCHES AND DECIMALS ARE TO 0.001 ANGLES ARE ± 30° FRACTIONAL ± 1/16"

1 PLACE DECIMAL = .1
 2 PLACE DECIMAL = .03
 3 PLACE DECIMAL = .010
 ANGLES ARE ± 30°
 FRACTIONAL = 1/16"

A-2 ERI Antenna Specification Sheet

MULTIPLEXED TRANSMISSION SITE

DETROIT, MICHIGAN

General Specifications

Antenna Type High Power FM-Broadcast, Suitable For Multiplexing
 Model Number 1183-2CP-2
 Number of Bay Levels Two
 Polarization Circular Polarized

Electrical Specifications

Antenna Input Power Capability 82 kW Max ⁽¹⁾
 Operating Frequency Band..... 93.1 ~ 99.5 Megahertz.
 VSWR <1.08:1 @ Operating Frequencies⁽²⁾
 Azimuthal Pattern Circularity Better Than +/- 1dB From RMS (Free Space)
 Power Split 50/50 (Horizontal & Vertical)
 Frequency Specific Information:

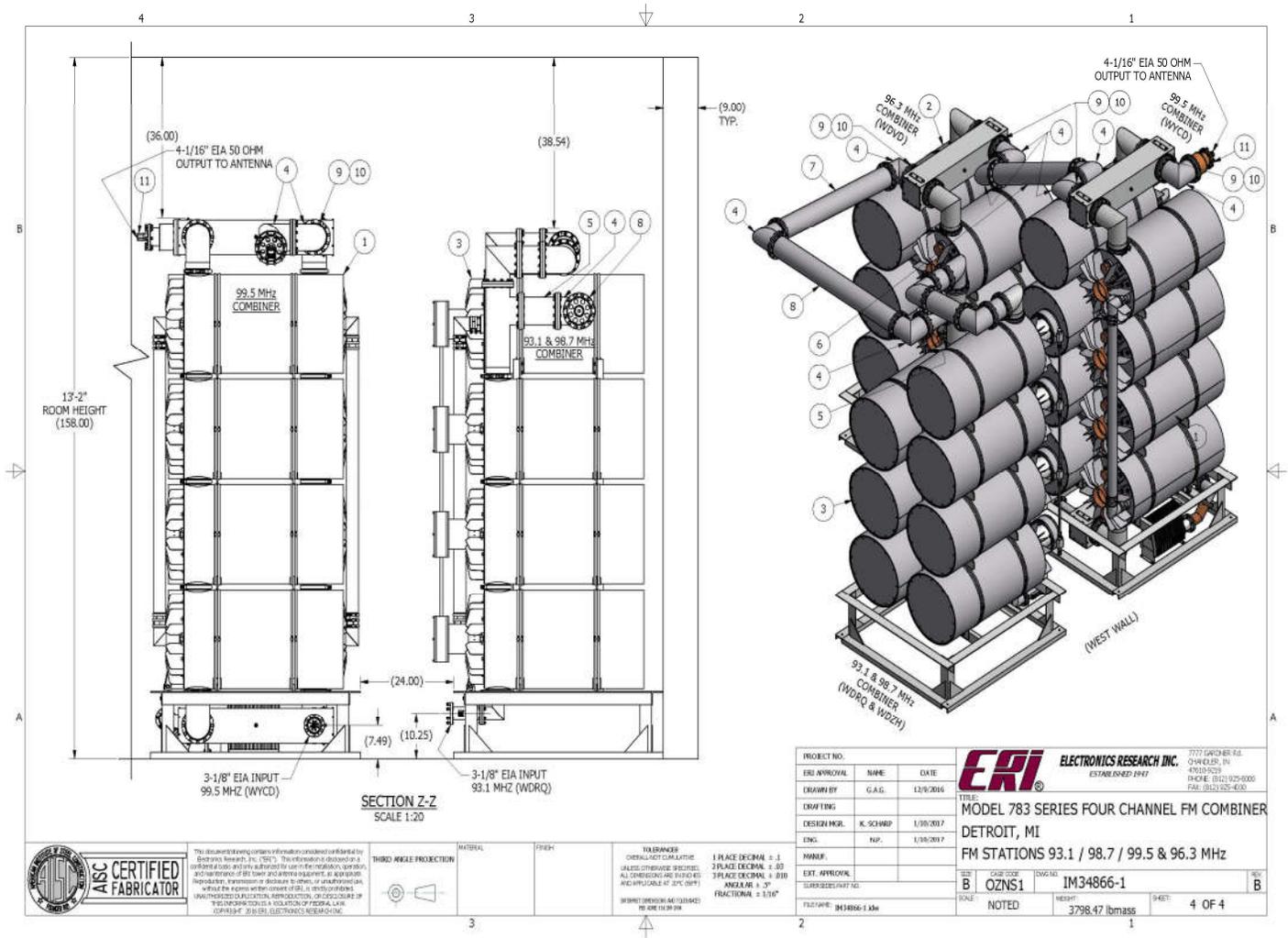
<u>Frequency</u>	<u>Station ERP</u>	<u>Beam Tilt</u>	<u>First Null Fill</u>	<u>Second Null Fill</u>	<u>Power Gain</u>	<u>Line Loss</u> ⁽³⁾	<u>Filter Loss</u> ⁽⁴⁾	<u>Computed Filter Input</u>
93.1	5 kW	0.0°	0 %	0 %	.955	-0.655 dB	-205 dB	6.403 kW
96.3	20 kW	0.0°	0 %	0 %	.955	-0.664 dB	-212 dB	25.70 kW
98.7	20 kW	0.0°	0 %	0%	.954	-0.673 dB	-396 dB	26.90 kW
99.5	17.5 kW	0.0°	0 %	0%	.953	-0.673 dB	-307 dB	23.08 kW

Mechanical Specifications

Antenna Feed System.....Fed with One 4 1/16” Line
 Input Connector6 1/8”-50 Ohm Flanged
 Element Deicing..... None
 Interbay Spacing..... 114” Center to Center
 Array Length 228 Inches
 Construction Material (Antenna) Brass and Stainless Steel
 Construction Material (Mounting) Custom Mounting

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 910 Feet of 4 1/16” ERI Maxcline.
 4) Losses Taken From Actual Combiner.

EXHIBIT A-3



PROJECT NO.	ERI	ELECTRONICS RESEARCH INC.	7777 GARWOOD RD. CHARLOTTE, NC 28226-1629 PHONE: (704) 924-6000 FAX: (704) 924-4000
ERI APPROVAL	NAME	DATE	
DRAWN BY	G.A.G.	12/9/2006	
DRAFTING			
DESIGN MGR.	K. SCHWEP	1/19/2007	
ENG.	N.P.	1/19/2007	
MANUF.			
EXT. APPROVAL			
DATE REVISIONS STARTED			
FILE NAME	IM34866-1.kbr		
TITLE:	MODEL 783 SERIES FOUR CHANNEL FM COMBINER		
	DETROIT, MI		
	FM STATIONS 93.1 / 98.7 / 99.5 & 96.3 MHz		
REV. B	CAB CODE: OZNS1	ENG. NO: IM34866-1	REV. B
SCALE: NOTED	WEIGHT: 3798.47 lbmass	SHEET: 4 OF 4	



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THIRD ANGLE PROJECTION

TOLERANCES UNLESS OTHERWISE SPECIFIED: ALL DIMENSIONS ARE IN INCHES AND UNLESS OTHERWISE SPECIFIED: FRACTIONAL = 1/32"

A-4 ERI Combiner Specification Sheet

MULTIPLEXED TRANSMISSION SITE

DETROIT, MICHIGAN

General Specifications:

Multiplexer Type783 “T” and Constant Impedance Combiner
Number of Combining Units Four
Injected Port to Injected Port Isolation < -59 dB
Output Connector 6 1/8 “50 Ohm EIA (Flanged)
Output Power (Designed) 82 kW⁽¹⁾

Heat RemovalConvection Cooling for 96.3 and 99.5 Forced Air for 93.1 and 98.7 MHz.
Physical ArrangementAll Components Rack Mounted

Injected Port Specifications:

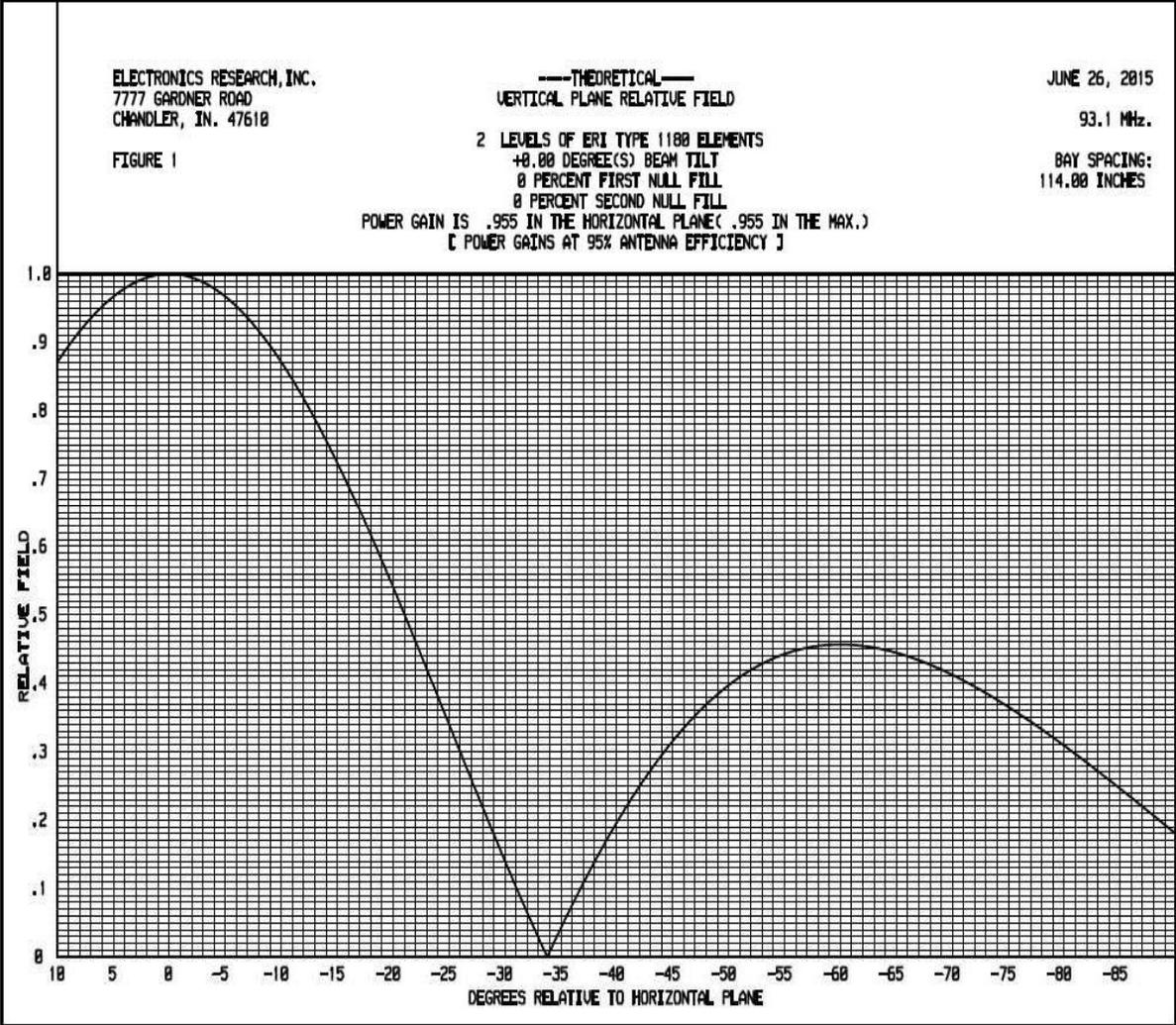
Frequency Assignment93.1 ~ 96.3 ~ 98.7 ~ 99.5 MHz.
Power Rating, Each Injected Port (Designed) 6.4 kW for 93.1 MHz., & 25.7 kW for 96.3 MHz.
Power Rating, Each Injected Port (Designed) 26.9 kW for 98.7 MHz., & 23.0 kW for 99.5 MHz.
Input Connector3-1/8" 50 Ohm EIA (Flanged).
VSWR.....< 1.10:1 @ +/-200 KHz.⁽²⁾
Group DelayLess than 250 ns Overall Variation, Carrier @ +/- 150 KHz.
Insertion Loss (Measured):

93.1 MHz. - 0.205 dB
96.3 MHz. - 0.212 dB
98.7 MHz. - 0.396 dB
99.5 MHz. - 0.307 dB

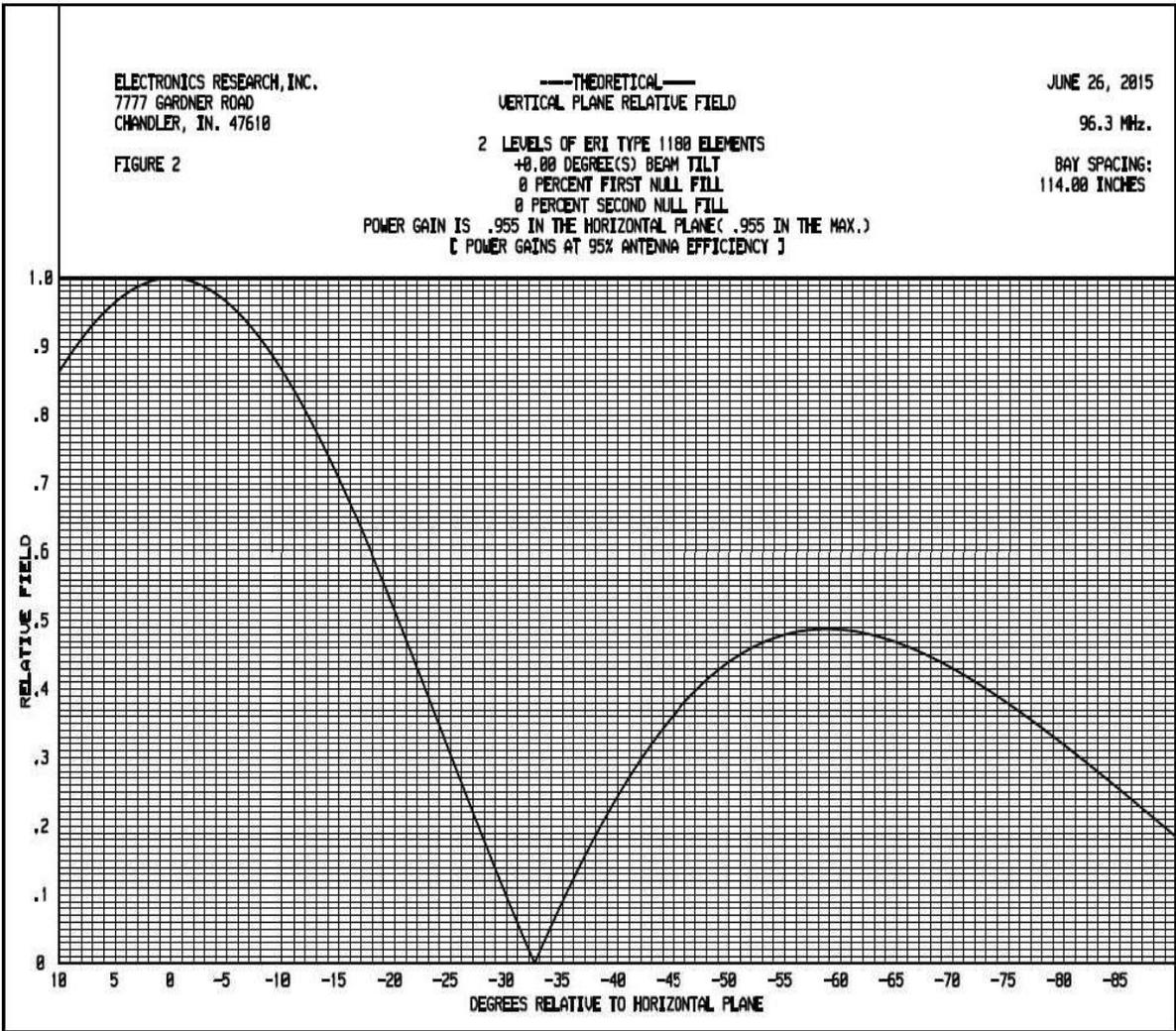
1) Power Rating Listed is as Designed Only. Actual Power Capabilities May Vary.

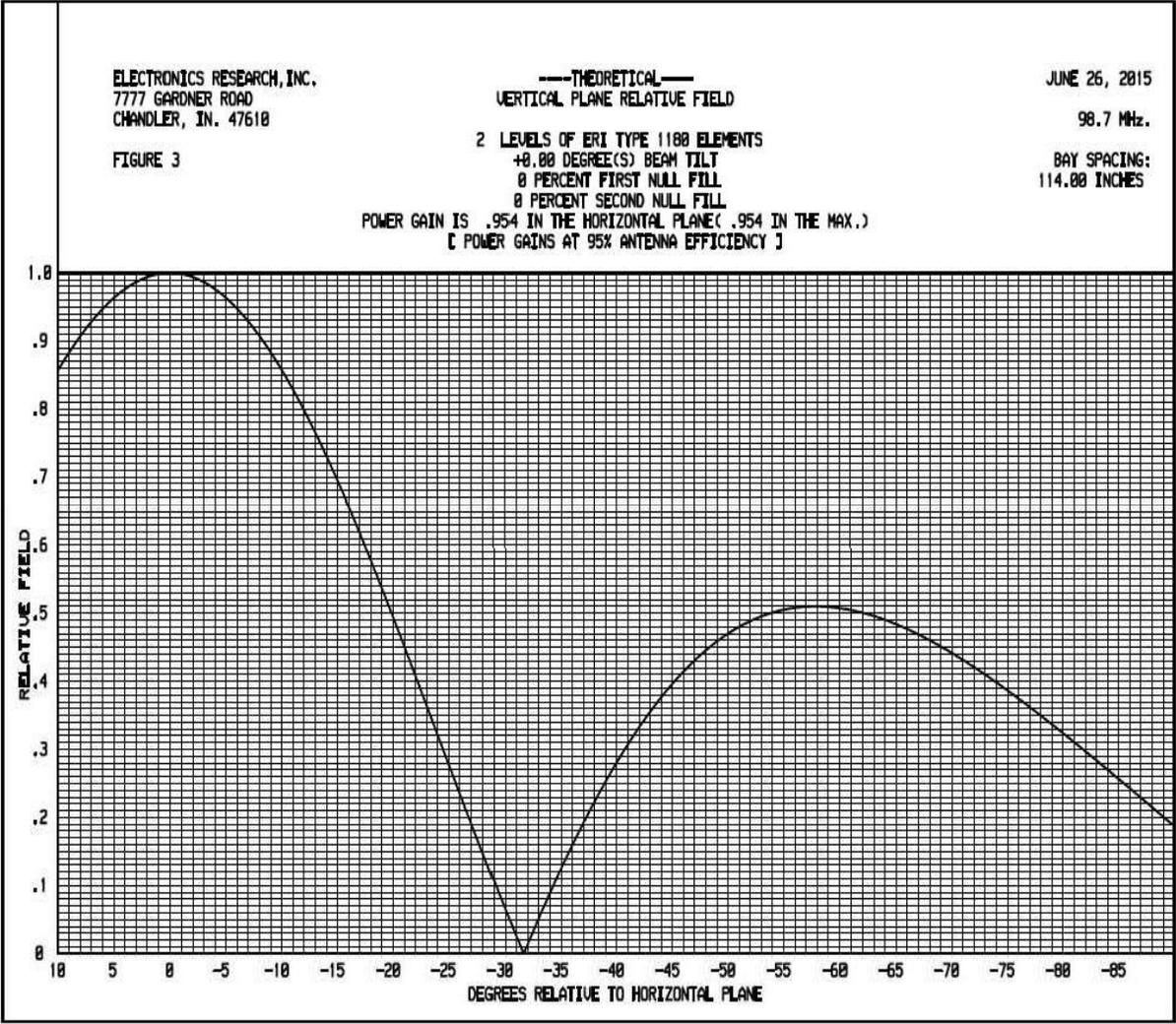
2) When Terminated in 50 Ohm Resistive Load.

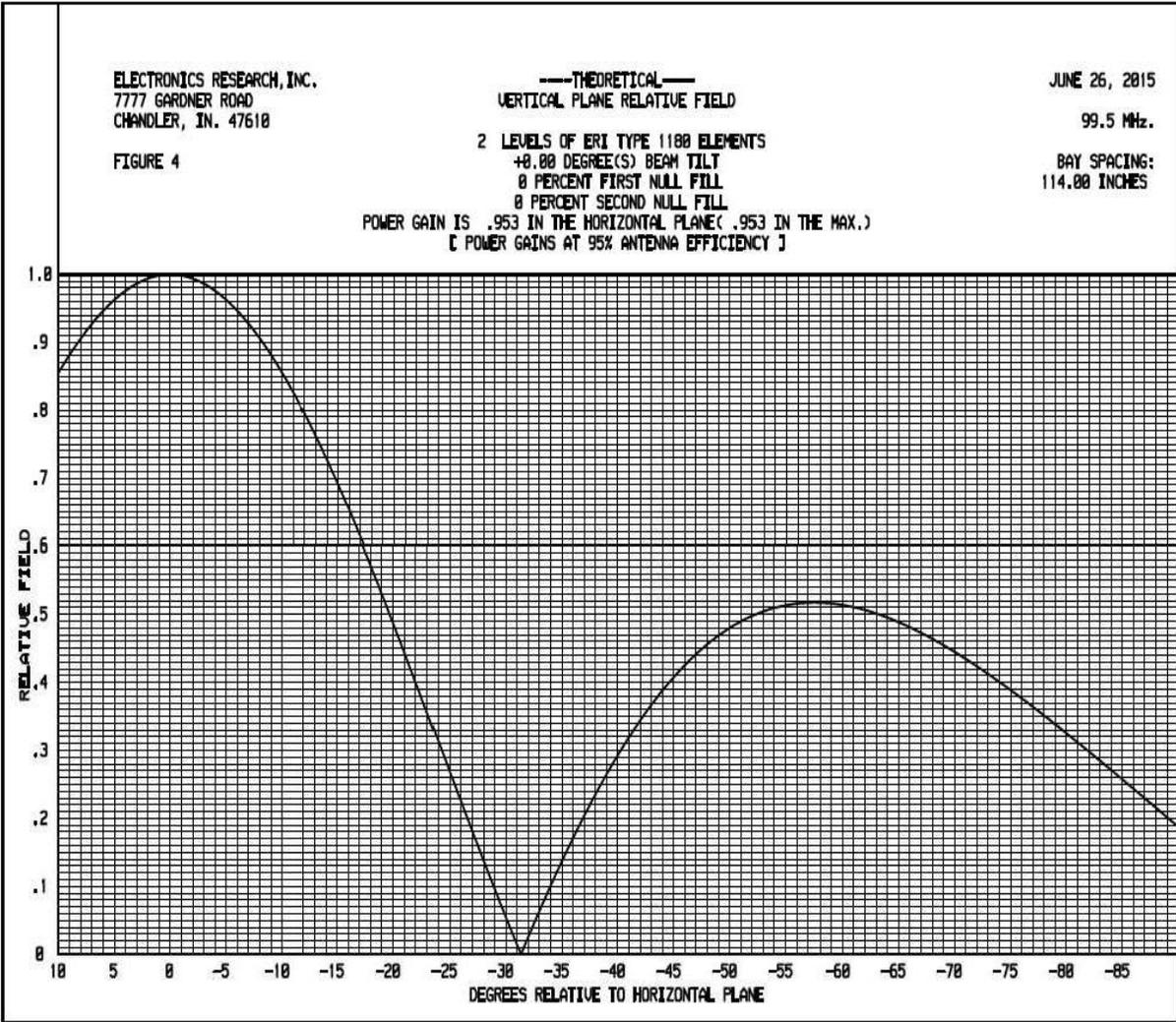
ERI Technical Proposal 20161008-584
CBS Radio/Cumulus Detroit
Master FM Antenna and Combiner for Replacement of the Motower Alan Dick Master FM Antenna System

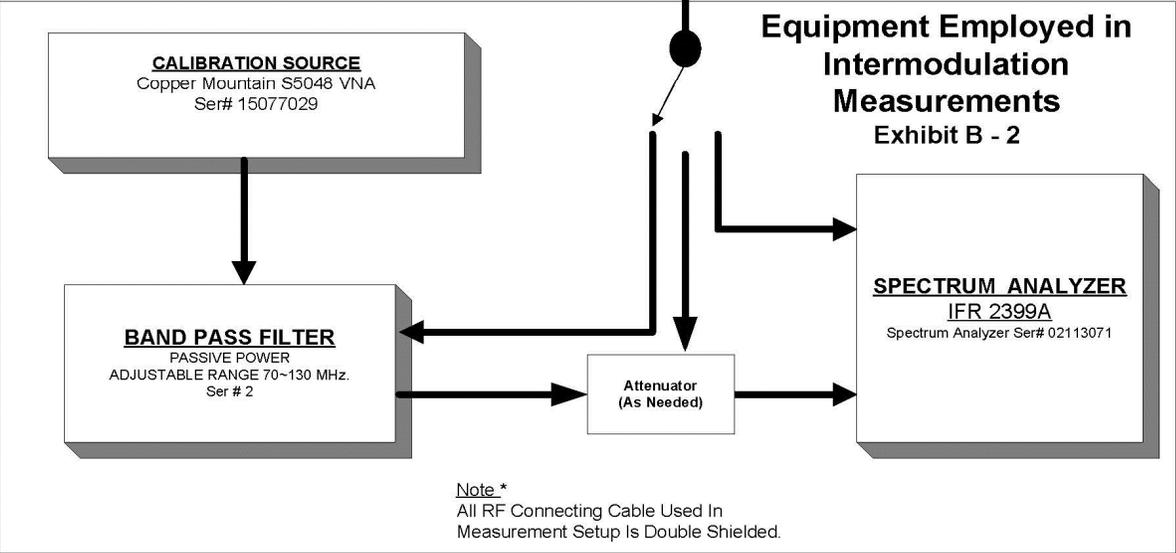
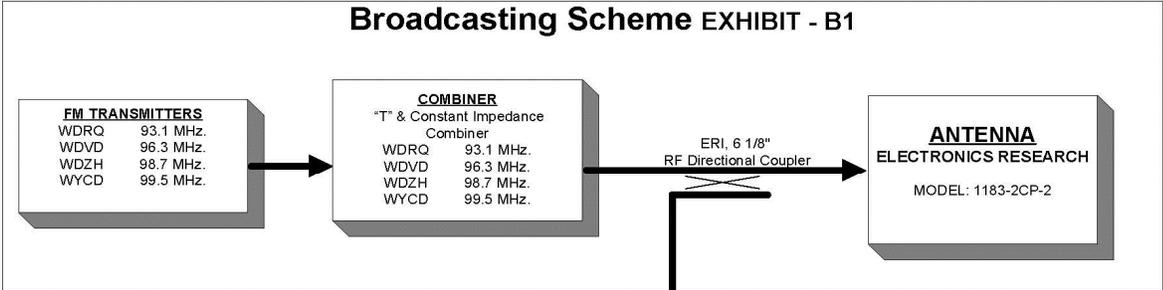


CBS Radio/Cumulus Detroit
Master FM Antenna and Combiner for Replacement of the Motower Alan Dick Master FM Antenna System









Broadcasting Scheme and Equipment Employed in Intermodulation Measurements

EXHIBIT B