

Report Of Intermodulation Product Findings

***Terre Haute, IN.
Main System***

**WTHI-FM – 99.9 MHz.
WMGI – 100.7 MHz.**

Project# 39175C

May 10, 2023

**Electronics Research Inc.
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REPORT OF FINDINGS TERRE HAUTE, INDIANA BROADCAST FACILITY

Introduction: This report of findings is based on data collected at the FM broadcast facility located in Terre Haute, IN. The report includes measurements offered as proof that the combined operations of WTHI-FM (99.9 MHz.) and WMGI (100.7 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 multiplexed system is less than the maximum allowable level as required by section 73.317 (b) through (d). Jeff Taylor of Electronics Research, Inc. located in Chandler, Indiana performed the measurements summarized herein on May 10, 2023.

The following exhibits are provided:

Exhibit A:

- A-1 Drawing Depicting Antenna.
- A-2 SHPX-6AC Antenna Specification Sheet.
- A-3 Drawing Depicting Diplexed Scheme.
- A-4 Diplexer 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 both FM stations operating from the antenna system. The WTHI-FM and WMGI, diplexed system is fundamentally comprised of antenna, feed line and diplexer unit. The SHPX-6AC antenna, 783-4 combiner units, and 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 two transmitter signals into a common feed and provide transmitter-to-transmitter isolation, a diplexed scheme consisting of a 783-4 “TEE” Combiner” was installed. Specifically, the combiner uses one 783-4 module for frequency (99.9 MHz.), and one 783-4 module for frequency (100.7 MHz.), both non-adjacent coupled. An interconnecting “T” is required to complete the combiner. The “T” combiner, fully assembled, exhibited transmitter port-to-port isolation in excess of -53 dB. Other performance measurements, such as match, loss, group-delay, etc, revealed that the “T” combiner 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 -38 dB directivity and a forward signal sample of -46 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. A Rohde & Schwarz Spectrum Analyzer ZPH.12 serial# 103096 was employed to record the level of all signals investigated. A Rohde & Schwarz Network Analyzer serial# 100396 was used for selective tuning of the Band Pass Filter. The Rohde & Schwarz 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 all transmitters were operating at full licensed 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)	Full Scale Range (dB)	Scale Reading (dBm)	Carrier Level (dBm)	Notes
WTHI-FM 99.9	3	---	14.83	17.83	
WMGI 100.7	3	---	9.05	12.05	

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.

	Carrier Frequencies	
Interfering Frequencies	99.9	100.7
99.9 MHz.	----	101.5
100.7 MHz.	99.1	----

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 Terre Haute, Indiana										
Product Frequency (MHz)	Transmitter Frequency (MHz)	Interfering Frequency (MHz)	Pad (dB)	Bandpass Filter Loss (dB)	Total Loss	Measured Level (dBm)	Adjusted Level (dB)	Carrier Reference Level (dBm)	Level Referenced to Carrier (dBm)	Notes*
Transmitter Mixes										
	99.9	Ref.	6		6	17.8	23.8	23.8		
	100.7	Ref.	6		6	19.7	25.7	25.7		
99.1	99.9	100.7	6	12.1	18.1	-102.2	-84.1	23.8	-107.9	
101.5	100.7	99.9	6	11.9	17.9	-100.5	-82.6	25.7	-108.3	

The Spectrum Analyzer was used to check the close in spectral attenuation of the carrier to confirm the operation of the transmitter, 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 on May 10, 2023 as summarized in this document, I, Jeff Taylor, find the subject system, specifically the transmitters and filter systems for the operation of WTHI-FM and WMGI 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 WTHI-FM and WMGI, 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

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 :

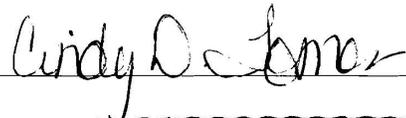
- 1.) I am a Field Technician for Electronics Research, Inc (“ERI “) and have been employed by ERI for 26 years. I am familiar with and have assisted in the design, manufacturing and installation of FM Antennas and FM Multiplexers in my long tenure with ERI.
- 2.) I have either prepared and/or directly 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 Midwest Communications, Inc., on behalf of radio Stations WTHI-FM and WMGT in Terre Haute, IN., to prepare this Report Of Findings.

Jeff Taylor; Field Technician



Subscribed and sworn to before me on this 11th, day of May, 2023.

Cindy D Tomes; Notary Public
My commission expires September 17, 2030





EXHIBIT, A-1

SHP/SHPX ANTENNA TABLE		
ANTENNA PART NUMBER	FREQUENCY	ITEM #1 PART NUMBER
AA-SHP06AC-A00	107.9 - 103.0 MHz	AE-SHP3A00
AA-SHP06AC-B00	102.9 - 98.0 MHz	AE-SHP3B00
AA-SHP06AC-C00	97.9 - 93.0 MHz	AE-SHP3C00
AA-SHP06AC-D00	92.9 - 88.1 MHz	AE-SHP3D00
AA-SHPX06AC-A00	107.9 - 103.0 MHz	AE-SHX3A00
AA-SHPX06AC-B00	102.9 - 98.0 MHz	AE-SHX3B00
AA-SHPX06AC-C00	97.9 - 93.0 MHz	AE-SHX3C00
AA-SHPX06AC-D00	92.9 - 88.1 MHz	AE-SHX3D00

HEATERS / DEICERS	
ITEM #1 PART NUMBER*	
AE-SHP3A0H	
AE-SHP3B0H	
AE-SHP3C0H	
AE-SHP3D0H	
AE-SHX3A0H	
AE-SHX3B0H	
AE-SHX3C0H	
AE-SHX3D0H	

*ADD QTY. 25, P/N CP0032

DETAIL A

DETAIL B
(SOME ITEMS NOT SHOWN FOR CLARITY)

NOTES: (RIGHT HAND LOOPS SHOWN)

- ALL RED BANDS DESIGNATE SIDE TO BE MOUNTED DOWNWARD.
- ASSEMBLE ANTENNA SYSTEM BY MATING CORRESPONDING NUMBERS.
- OVERALL LENGTH OF ANTENNA SYSTEM RANGE FROM 59.8 FT. @ 88.1 MHz TO 49.1 FT. @ 107.9 MHz.
- ENSURE TO PLUMB ANTENNA VERTICALLY BY LOOSENING HOSE CLAMPS ON PRE-CLAMPED SUPPORT SADDLES AND ADJUSTABLE LINE BRACKETS. TIGHTEN HOSE CLAMPS WHEN PLUMB.
- FINAL ORIENTATION TO BE DETERMINED BY STATION PERSONNEL.
- CENTERFEED CAN BE ROTATED TO AVOID ANY OBSTRUCTIONS.
- THE SUPPORTING STRUCTURE SHOWN HEREON IS SUPPLIED BY OTHERS AND IS USED ONLY FOR ILLUSTRATION PURPOSES. ERI IS NOT RESPONSIBLE & DOES NOT WARRANT ANY FIT-UP INTERFERENCE.
- UNLESS OTHERWISE NOTED, ALL BOLTED CONNECTIONS SHALL INITIALLY BE BROUGHT TO A SNUG-TIGHT CONDITION WHERE JOINT TIGHTNESS IS ATTAINED WITH A FEW IMPACTS OF AN IMPACT WRENCH OR THE FULL EFFORT OF AN IRONWORKER USING AN ORDINARY SPUD WRENCH TO BRING THE PLIES INTO FIRM CONTACT. A SYSTEMATIC APPROACH SHALL BE USED TO BRING THE JOINT INTO A SNUG-TIGHT CONDITION STARTING WITH THE MOST RIGID PART OF THE JOINT AND PROCEEDING TOWARD THE FREE EDGES.
- FOR FINAL TIGHTENING, ERI RECOMMENDS AN ADDITIONAL 1/3 TURN BE BROUGHT TO ALL BOLTS UP TO Ø3/4" OR TORQUED AN ADDITIONAL 150 FT-LBS FOR BOLTS OVER Ø3/4". UNLESS OTHERWISE NOTED, FINAL TIGHTENING OF ALL BOLTS SHOULD BE COMPLETED AFTER FINAL CONSTRUCTION OF THE STRUCTURE/ASSEMBLY. PLEASE NOTE, SPECIAL ATTENTION SHALL BE GIVEN TO TIGHTENING OF 1/2" DIAMETER A325 BOLTS, U-BOLTS, AND THREADED RODS AS TO PREVENT STRIPPING THE THREADS FROM OVER-TIGHTENING.

TOP VIEW

SEE ELEMENT BRACKET DRAWING FOR DETAILS.

NOTE:
ANTI-ROTATION BRACKETS ARE REQUIRED WHEN LEG MOUNTING TO DIAMETER Ø3.00" & UNDER.

ITEM	QTY	PART NUMBER	DESCRIPTION
13	32	HC0048	#48 HOSE CLAMP, SS (FITS 2-1/2" TO 3-1/2")
12	2	BT0207-33-10.00	3-1/8" LINE TO 3-1/8" LINE BRACKET
11	6	BT0011Y	STEM SUPPORT
10	2	RLA300-Z1	3-1/8" HARDWARE KIT
9	6	HWK3102	4" BLOCK, HARDWARE KIT
8	6	HWK0007	2" SADDLE, HARDWARE KIT
7	6	SEE DRAWING	ELEMENT BRACKET
6	1	CO0005	COVER PLATE (3-1/8" O.D. LINE)
5	1	CL3031	3-1/8" 50 OHM, 6" MATCHING SECTION ASSEMBLY
4	1	CL3064C-FREQUENCY	3-1/8" CENTERFEED ASSEMBLY
3	4	CL3061B-FREQUENCY	3-1/8" INTERBAY LINE ASSEMBLY
2	1	CL3063B-FREQUENCY	3-1/8" QUARTER-WAVE STUB ASSEMBLY
1	6	SEE TABLE	SHP/SHPX ELEMENT

THIRD ANGLE PROJECTION

SCALE: 1/8" = 1'-0"

DATE: 11/22/2017

FILE NAME: AA-SHP-SHPX06C.dwg

PROJECT NO.: ERI STOCK

DATE: 11/22/2017

DATE: 11/22/2017

DATE: 11/22/2017

ERI ELECTRONICS RESEARCH INC.
ESTABLISHED 1941

7777 GARDNER RD
GARDNER, MA 01459
PHONE: (978) 925-0000
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TITLE: SHP/SHPX ANTENNA INSTALLATION DETAILS
SIX BAY, CENTERFEED, NO RADOMES
FU 07 5 95 3 104 5 107 7 NG

SCALE: NTS **DATE:** N/A **SHEET:** 1 OF 1

A-2 ERI Antenna Specification Sheet

**TRANSMISSION SITE
TERRE HAUTE, INDIANA**

General Specifications

Antenna TypeHigh Power FM-Broadcast, Suitable For Diplexing
 Model Number SHPX-6AC
 Number of Bay Levels Six
 Polarization..... Right Hand Circular

Electrical Specifications

Antenna Input Power Capability 31.8 kW Max ⁽¹⁾
 Operating Frequency Band 99.9 ~ 100.7 Megahertz.
 VSWR. <1.02:1 @ Operating Frequencies⁽²⁾
 Azimuthal Pattern Circularity Better Than +/- 2dB From RMS (Free Space)
 Power Split 50/50 (Horizontal & Vertical)
 Frequency Specific Information:

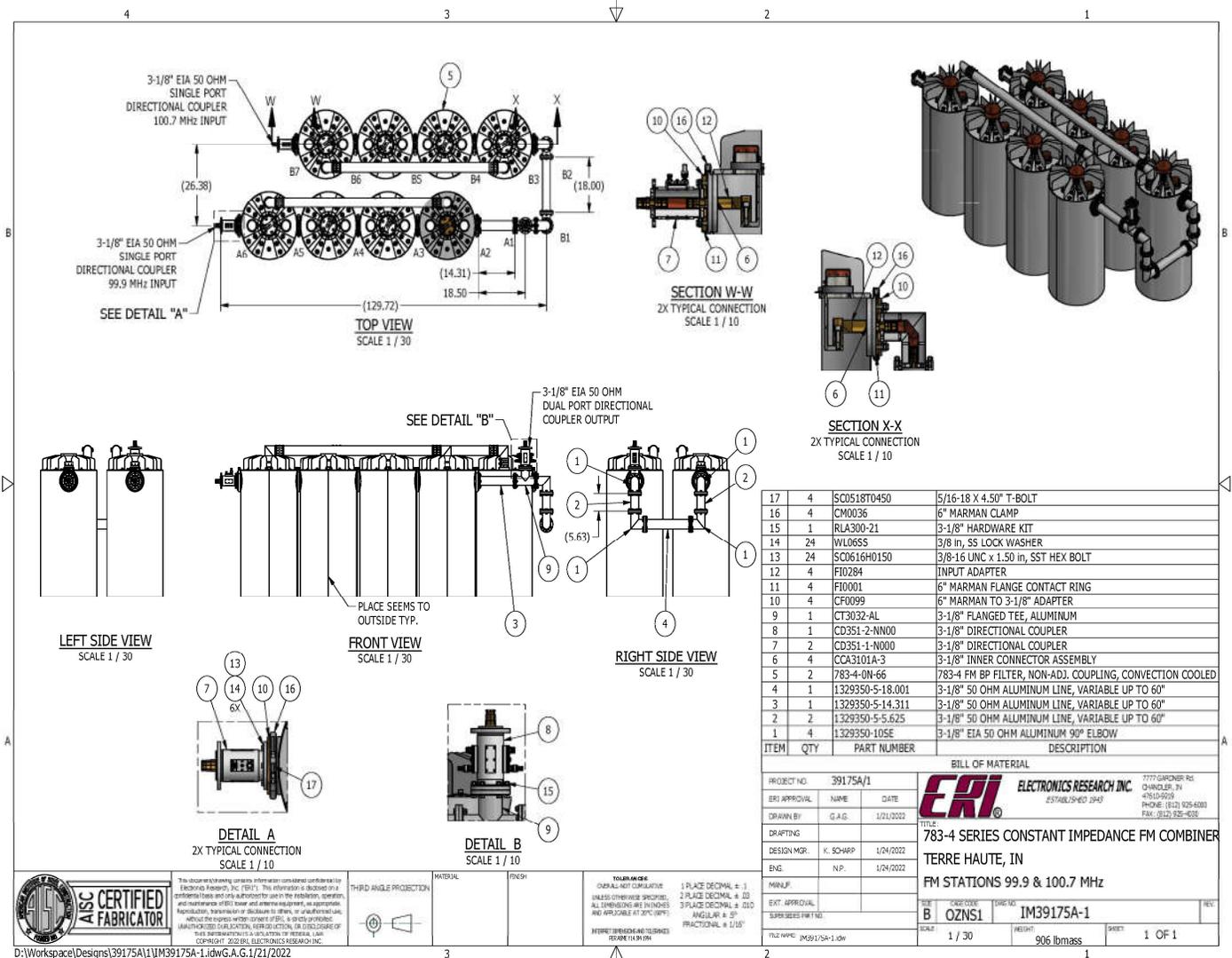
<u>Frequency</u>	<u>Station ERP</u>	<u>Beam Tilt</u>	<u>First Null Fill</u>	<u>Second Null Fill</u>	<u>Power Gain</u>	<u>Line Loss</u> ⁽³⁾	<u>Filter Loss</u> ⁽⁴⁾	<u>Computed TPO</u>
99.9	38.0 KW	0.0°	1.4 %	0.0 %	3.307	-0.486 dB	-0.255 dB	13.70 kW
100.7	50.0 KW	0.0°	1.4 %	0.0 %	3.294	-0.487 dB	-0.278 dB	18.10 kW

Mechanical Specifications

Antenna Feed System.....Single Input
 Input Connector3 1/8"50-Ohm EIA Flanged
 Element Deicing.....None
 Interbay Spacing..... 117.25" Center to Center
 Array Length 51.4 Feet
 Construction Material (Antenna)..... Brass and Stainless Steel

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 507 Feet of ERI MACXLine 350.
 4) Losses Taken from Actual Combiner.

EXHIBIT A-3



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A-4 ERI "T" Combiner Specification Sheet

**TRANSMISSION SITE
TERRE HAUTE, INDIANA**

General Specifications:

**Multiplexer Type Non-Adjacent Coupled 783-4 "T" Combiner
Number of Combining Units Two
Injected Port to Injected Port Isolation < - 53 dB
Output Connector 3 1/8 "50 Ohm EIA (Flanged)
Output Power (Designed) 31.8 kW⁽¹⁾**

**Heat Removal Natural Convection
Physical Arrangement Floor Standing**

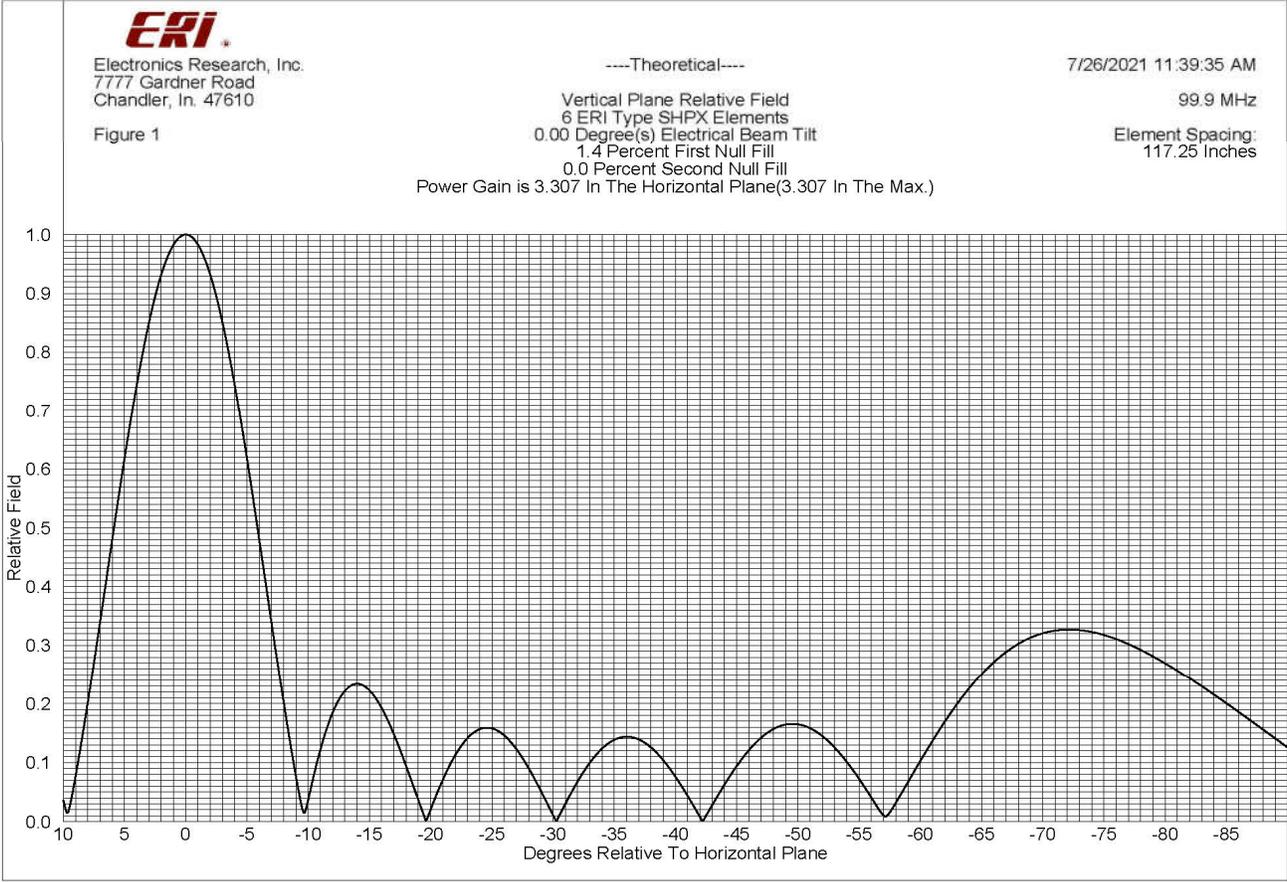
Injected Port Specifications:

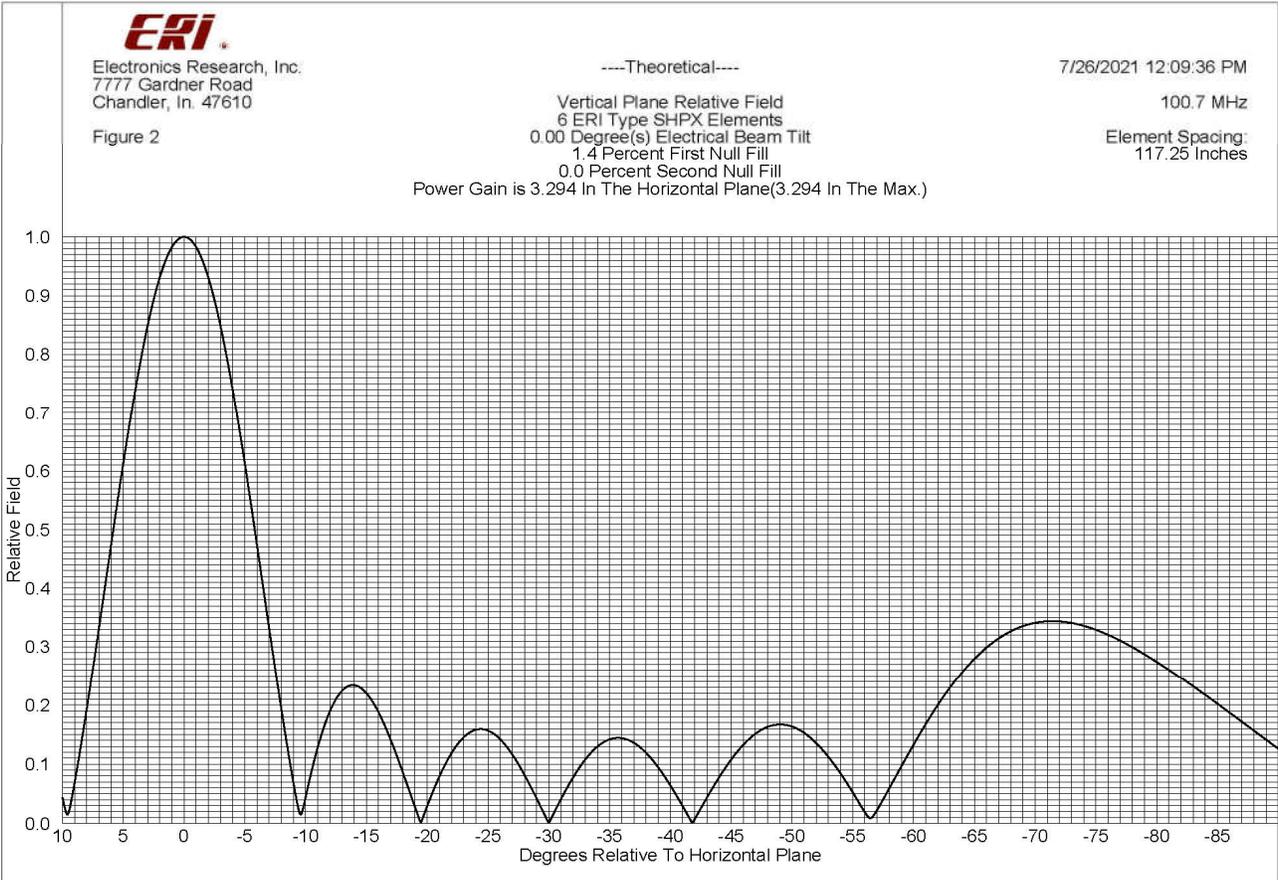
**Frequency Assignment 99.9 ~ 100.7 MHz.
Power Rating, Each Injected Port (Designed)..... 13.70 kW 99.9 MHz, 18.10 kW 100.7 MHz.
Input Connector 3 1/8" 50 Ohm EIA (Flanged).
VSWR.....< 1.06:1 @ +/-200 KHz.⁽²⁾
Group DelayLess than 200 ns Overall Variation, Carrier @ +/- 150 KHz.
Insertion Loss (Measured):**

**99.9 MHz. - 0.255 dB
100.7 MHz. - 0.278 dB**

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

2) When Terminated in 50 Ohm Resistive Load.





Broadcasting Scheme and Equipment Employed in Intermodulation Measurements

EXHIBIT B

