

# **Report Of Intermodulation Product Findings**

**WMEE 97.3 MHz. Fort Wayne, Indiana  
WQHK-FM 105.1 MHz. Hometown, Indiana**

**Project# 28677A**

*February 28, 2012*

**Electronics Research Inc.  
7777 Gardner Road  
Chandler, Indiana 47610  
Phone (812) 925-6000 Fax (812) 925- 4030**

# TABLE OF CONTENTS

## Report of Findings for Intermodulation Product Measurements

|                |  |
|----------------|--|
| Page 3-4 ..... | Introduction                           |
| Page 5 .....   | Carrier Reference Levels               |
| Page 5 .....   | Table of Third order Products Expected |
| Page 6 .....   | Intermodulation Product Measurements   |
| Page 7 .....   | Conclusion                             |
| Page 8 .....   | Affidavit                              |

## Exhibits Accompanying This Report

|                          |   |
|--------------------------|---|
| <b>EXHIBIT A</b> .....   | Antenna and Combiner Specification Sheet and Drawing    |
| A-1 .....                | Drawing Depicting Antenna                               |
| A-2 .....                | ERI Antenna Specification Sheet                         |
| A-3 .....                | Drawing Depicting Combiner Module                       |
| A-4 .....                | ERI Combiner Specification Sheet                        |
| A-5 .....                | Theoretical Vertical Plane Relative Field Antenna Plots |
| <b>EXHIBIT B-1</b> ..... | Intermodulation Product Measurement Equipment Layout    |
| B-2 .....                | Broadcasting Scheme of the Multiplexed System           |

## REPORT OF FINDINGS

### WMEE / WQHK-FM

97.3 MHz. / 105.1 MHz.

**Introduction:** This report of findings is based on data collected at the WMEE and WQHK-FM broadcast facility located in Fort Wayne, Indiana. The report includes measurements offered as proof that the combined operations of WMEE (97.3 MHz.) and WQHK-FM (105.1) 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). WFWI (92.3 MHz.) operates into separate antenna on the same tower within 200' of the combined antenna. The effects on the stations operating from the multiplexed system have been considered in this report. In brief, the collection of measurements presented in this report shows that all possible third order inter-modulation (IM) products generated by this duplex system are 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 February 28, 2012.

**The following exhibits are provided:**

Exhibit A:

- A-1 Drawing Depicting Antenna.
- A-2 SHPX-4AC-SP 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 all FM stations operating from the combined antenna system. The WMEE and WQHK-FM multiplexed system is fundamentally comprised of antenna, feed line and multiplexer unit. The SHPX-4AC-SP antenna, rigid 3 1/8" feedline, and combiner units are products of Electronics Research, Inc., while the flex air cable is a Cablewave. 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 antenna feed and provide transmitter-to-transmitter isolation, a multiplexing scheme consisting of a 780-3 and 783-3 "TEE" Combiner was installed. Specifically, the combiner uses one ERI Model 780-3 for 105.1 MHz. and one ERI Model 783-3 97.3 MHz. An interconnecting "T" is required to complete the combiner which is illustrated in the attached Exhibit A-3. The multiplexer, fully assembled, exhibited transmitter port-to-port isolation in excess of -81 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 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 -54 dB directivity and a forward signal sample of -40 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 ZVL Vector Network Analyzer with Spectrum Analyzer serial# 100396 was employed to record the level of all signals investigated. The Rohde & Schwarz was also used for selective tuning of the Band Pass Filter. The Spectrum Analyzer portion of the Rohde & Schwarz 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 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.**

| <b>Carrier Frequency (MHz)</b> | <b>Pad One (dB)</b> | <b>Bandpass Filter Loss (dB)</b> | <b>Measured Level (dBm)</b> | <b>Adjusted Level (dBm)</b> | <b>Notes</b> |
|--------------------------------|---------------------|----------------------------------|-----------------------------|-----------------------------|--------------|
| <b>97.3</b>                    | <b>3</b>            | <b>-</b>                         | <b>12.52</b>                | <b>15.52</b>                |              |
| <b>105.1</b>                   | <b>3</b>            | <b>-</b>                         | <b>6.27</b>                 | <b>9.27</b>                 |              |

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.**

| <b>Interfering Frequencies</b> | <b>Carrier Frequencies</b> |              |
|--------------------------------|----------------------------|--------------|
|                                | <b>97.3</b>                | <b>105.1</b> |
| 92.3 MHz.                      | 102.3                      | 117.9        |
| 97.3 MHz.                      | ----                       | 112.9        |
| 105.1 MHz.                     | 89.5                       | ----         |

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-2 for a layout of the measurement equipment.

**Table 3 – Intermodulation Measurements**[illegible]

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 February 28, 2012 as summarized in this document, I, Jeff Taylor, find the subject system, specifically the transmitter and filter system for the operation of WMEE and WQHK-FM 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 WMEE and WQHK-FM 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 :

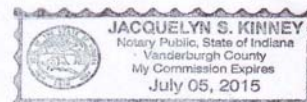
- 1.) I am a Field Technician for Electronics Research, Inc ("ERI ") and have been employed by ERI for 15 years. I am familiar with and have assisted in the design, manufacturing and installation of FM Antennas and FM Multiplexers in my long tenure with ERI.
- 2.) I have either prepared and/or directly 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 Federated Media on behalf of radio Stations WMEE and WQHK-FM in Fort Wayne, Indiana to prepare this Report of Findings.

Jeff Taylor; Field Technician

*Jeff Taylor*

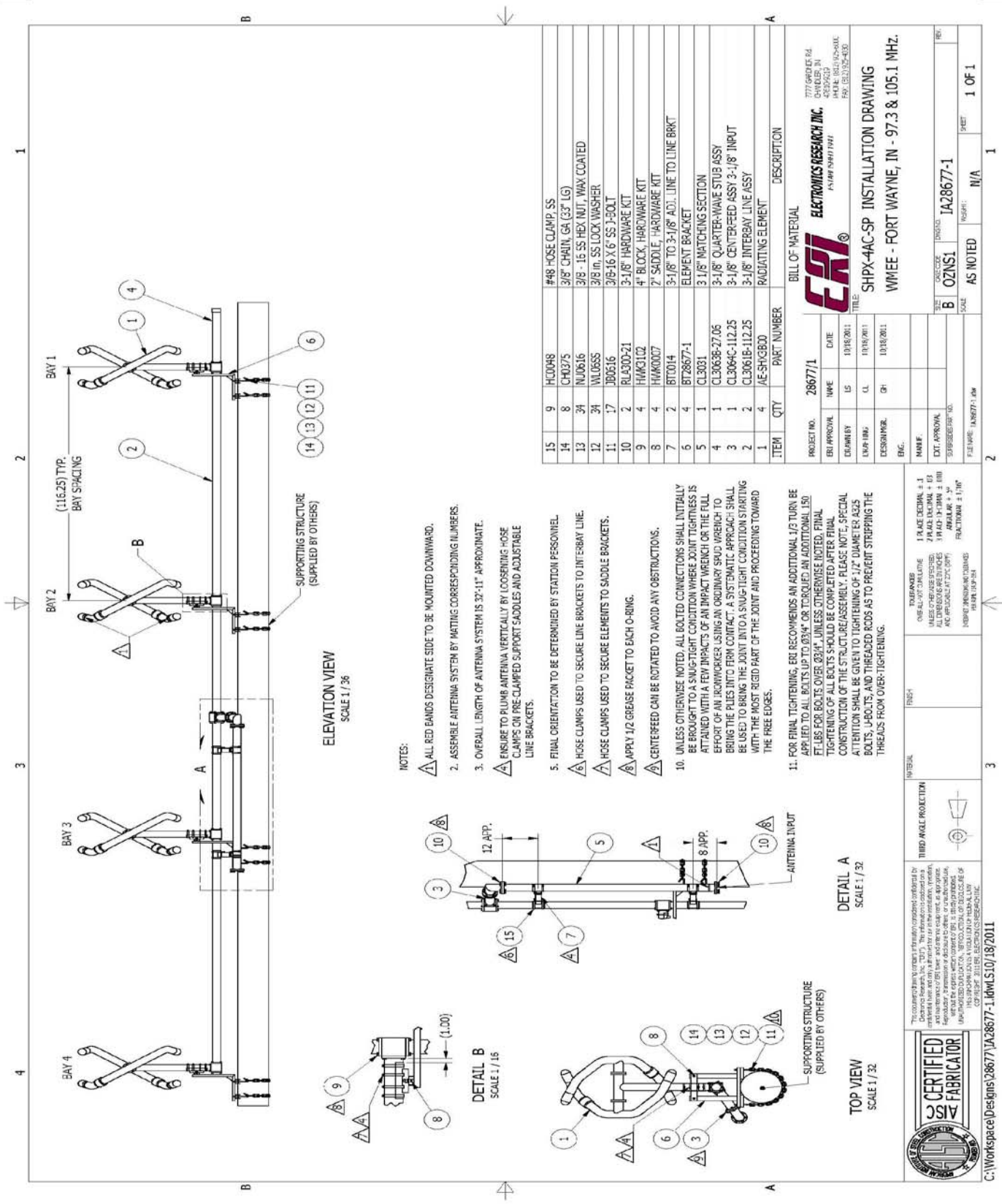
*Subscribed and sworn to before me on this 29th, day of February, 2012.*

Jacquelyn Kinney; Notary Public  
My commission expires July 5, 2015



*Jacquelyn S. Kinney*





**A-2 ERI Antenna Specification Sheet****MULTIPLEXED TRANSMISSION SITE****Fort Wayne, IN.****General Specifications**

Antenna Type ..... High Power FM-Broadcast, Suitable For Multiplexing  
 Model Number ..... SHPX-4AC-SP  
 Number of Bay Levels ..... Four  
 Polarization ..... Right Hand Circular

**Electrical Specifications**

Antenna Input Power Capability ..... 19 kW Max <sup>(1)</sup>  
 Operating Frequency Band ..... 97.3 ~ 105.1 Megahertz.  
 VSWR ..... <1.02:1 @ Operating Frequencies <sup>(2)</sup>  
 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<br/>Null Fill</u> | <u>Second<br/>Null Fill</u> | <u>Power Gain</u> | <u>Line Loss</u> <sup>(3)</sup> | <u>Filter Loss</u> <sup>(4)</sup> | <u>Computed<br/>TPO</u> |
|------------------|--------------------|------------------|----------------------------|-----------------------------|-------------------|---------------------------------|-----------------------------------|-------------------------|
| 97.3             | 26 KW              | 0°               | 8.0 %                      | 0.0 %                       | 2.114             | -0.642 dB                       | .162 dB                           | 14.80 kW                |
| 105.1            | 5.7 KW             | 0°               | 8.0 %                      | 0.0 %                       | 2.051             | -0.682 dB                       | .309 dB                           | 3.492 kW                |

**Mechanical Specifications**

Antenna Feed System ..... Fed with One 3 1/8" Line  
 Input Connector ..... 3 1/8"-50 Ohm EIA Flanged  
 Element Deicing ..... None  
 Interbay Spacing ..... 116.25" Center to Center  
 Array Length ..... 31.6 Feet  
 Construction Material ( Antenna ) ..... Galvanized Plated Steel and Stainless Steel  
 Construction Material ( Mounting ) ..... Leg Mount

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 74.5 Feet of 3 1/8" ERI Macxline (17.5' sections) and 614 Feet of Cablewave Flexwell 3 1/2" Air Cable.

4) Losses Taken From Actual Feedline.



**A-4 ERI Combiner Specification Sheet****MULTIPLEXED TRANSMISSION SITE****Fort Wayne, Indiana****General Specifications:**

Multiplexer Type ..... “TEE” Combiner  
Number of Combining Units ..... Two  
Injected Port to Injected Port Isolation ..... < -80 dB  
Output Connector ..... 3 1/8 “50 Ohm EIA (Flanged)  
Output Power (Designed) ..... 19 kW<sup>(1)</sup>

Heat Removal ..... Convection Cooled  
Physical Arrangement ..... All Components Rack Mounted

**Injected Port Specifications:**

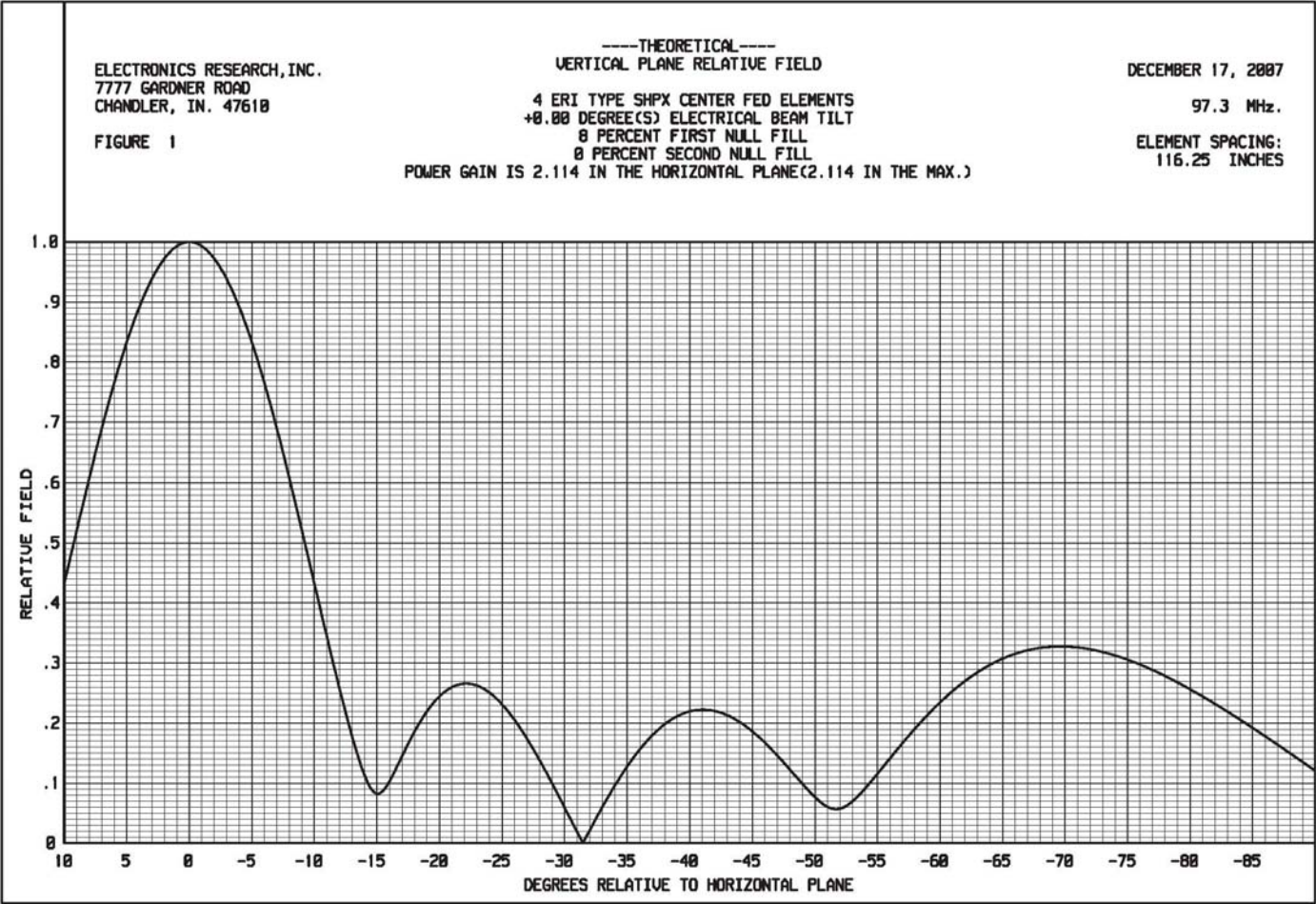
Frequency Assignment ..... 97.3 ~ 105.1 MHz.  
Power Rating, Each Injected Port (Designed).....14.8 kW for 97.3 MHz. ~ 3.492 kW for 105.1 MHz.  
Input Connector .....3-1/8" 50 Ohm EIA (Flanged).  
VSWR.....< 1.06 @ +/-150 KHz.<sup>(2)</sup>  
Group Delay .....Less than 75 ns Overall Variation, Carrier @ +/- 150 KHz.  
Insertion Loss (Measured):

97.3 MHz. .... - 0.162 dB  
105.1 MHz. .... - 0.309 dB

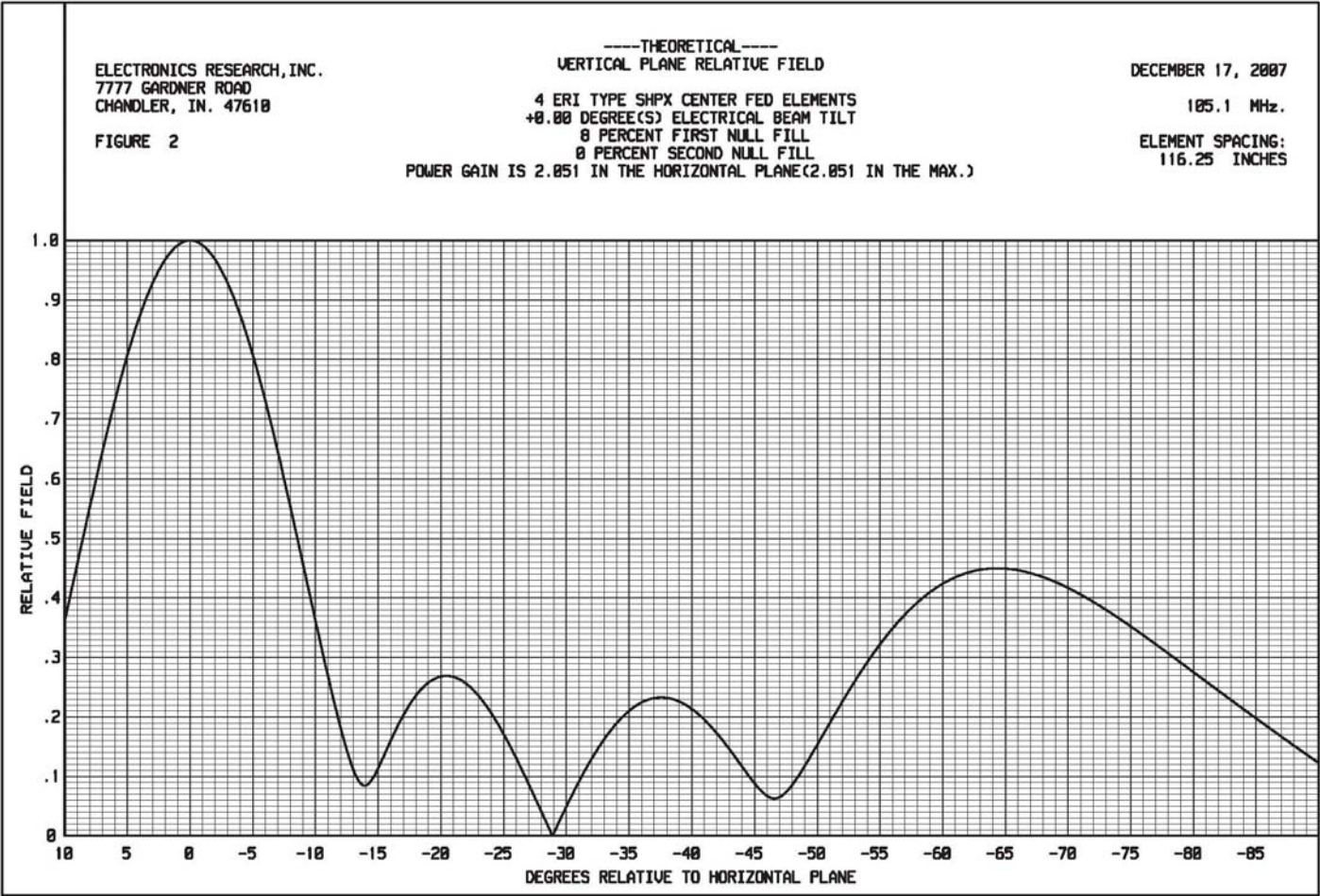
1) Power Rating Listed is as Designed Only. Actual Power Capabilities May Vary.

2) When Terminated in 50 Ohm Resistive Load.

3) Losses Taken From Actual Feedline.







## Broadcasting Scheme and Equipment Employed in Intermodulation Measurements

