

# **Report Of Intermodulation Product Findings**

**Minot, N.D.  
ERI Antenna: SHPX-12AC6-SP  
ERI: 783-3 Constant Impedance  
and 973-3 “T” Combiner**

<b>KIZZ</b>	<b>93.7 MHz.</b>
<b>KMXA</b>	<b>99.9 MHz.</b>
<b>KZPR</b>	<b>105.3 MHz.</b>

*August 15, 2020*

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**Minot, N.D.**

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## **REPORT OF FINDINGS**

### **KIZZ~KMXA~KZPR**

93.7 MHz. ~ 99.9 MHz. ~ 105.3 MHz.

**Introduction:** This report of findings is based on data collected at the KIZZ, KMXA, and KZPR broadcast facility located in Minot, North Dakota. The report includes measurements offered as proof that the combined operations of KIZZ (93.7 MHz.), KMXA (99.9 MHz.), and KZPR (105.3 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). Jeff Taylor of Electronics Research, Inc. located in Chandler, Indiana performed the measurements summarized herein on August 15, 2020.

#### **The following exhibits are provided:**

##### Exhibit A:

- A-1 Drawing Depicting Antenna.
- A-2 SHPX-12AC6-SP Antenna Specification Sheet.
- A-3 Drawing Depicting Multiplexing Scheme.
- A-4 ERI Constant Impedance and “T” Combiner 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 KIZZ, KMXA, and KZPR combined system is fundamentally comprised of antenna, feed line and constant impedance and “T” combiner units. The SHPX-12AC-SP (antenna), (3) ERI combiner units and rigid feedline are products of Electronics Research, Inc. while the HJ9-50 air cable is a product of Andrew.

To accomplish the aggregation of three transmitter signals into a common antenna feed and provide transmitter-to-transmitter isolation, a multiplexing scheme consisting of a 783-3 “T” Combiner and one Constant Impedance Module was installed. Specifically, the Multiplexer utilizes two ERI Model 783-3 band pass modules with an interconnecting “T” for 93.7 and 105.3 MHz. inserted into the broad port of one 783-6 constant impedance module for 99.9 MHz. The multiplexer, fully assembled, exhibited transmitter port-to-port isolation in excess of -87 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 -43 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 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 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.**

<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>KIZZ 93.7 MHz.</b>	<b>3</b>	<b>-</b>	<b>16.73</b>	<b>19.73</b>	
<b>KMXA 99.9 MHz.</b>	<b>3</b>	<b>-</b>	<b>12.69</b>	<b>15.69</b>	
<b>KZPR 105.3 MHz.</b>	<b>3</b>	<b>-</b>	<b>17.54</b>	<b>20.54</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>93.7</b>	<b>99.9</b>	<b>105.3</b>
KIZZ 93.7 MHz.	----	106.1	116.9
KMXA 99.9 MHz.	87.5	----	110.7
KZPR 105.3 MHz.	82.1	94.5	----

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

IM Measurements Taken in Minot, North Dakota										
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*
<b>Transmitter Mixes</b>										
	<b>93.7</b>	<b>Ref.</b>	3		3	16.73	19.73	<b>19.73</b>		
	<b>99.9</b>	<b>Ref.</b>	3		3	12.69	15.69	<b>15.69</b>		
	<b>105.3</b>	<b>Ref.</b>	3		3	17.54	20.54	<b>20.54</b>		
82.1	93.7	105.3	3	13.6	16.6	-85.45	-68.85	19.73	<b>-88.58</b>	
87.5	93.7	99.9	3	13.4	16.4	-83.7	-67.3	19.73	<b>-87.03</b>	
94.5	99.9	105.3	3	14.9	17.9	-84.55	-66.65	15.69	<b>-82.34</b>	
106.1	99.9	93.7	3	14.2	17.2	-85.43	-68.23	15.69	<b>-83.92</b>	
110.7	105.3	99.9	3	10.1	16.7	-85.56	-68.86	20.54	<b>-89.4</b>	
116.9	105.3	93.7	3	13.6	16.6	-85.23	-68.63	20.54	<b>-89.17</b>	

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.

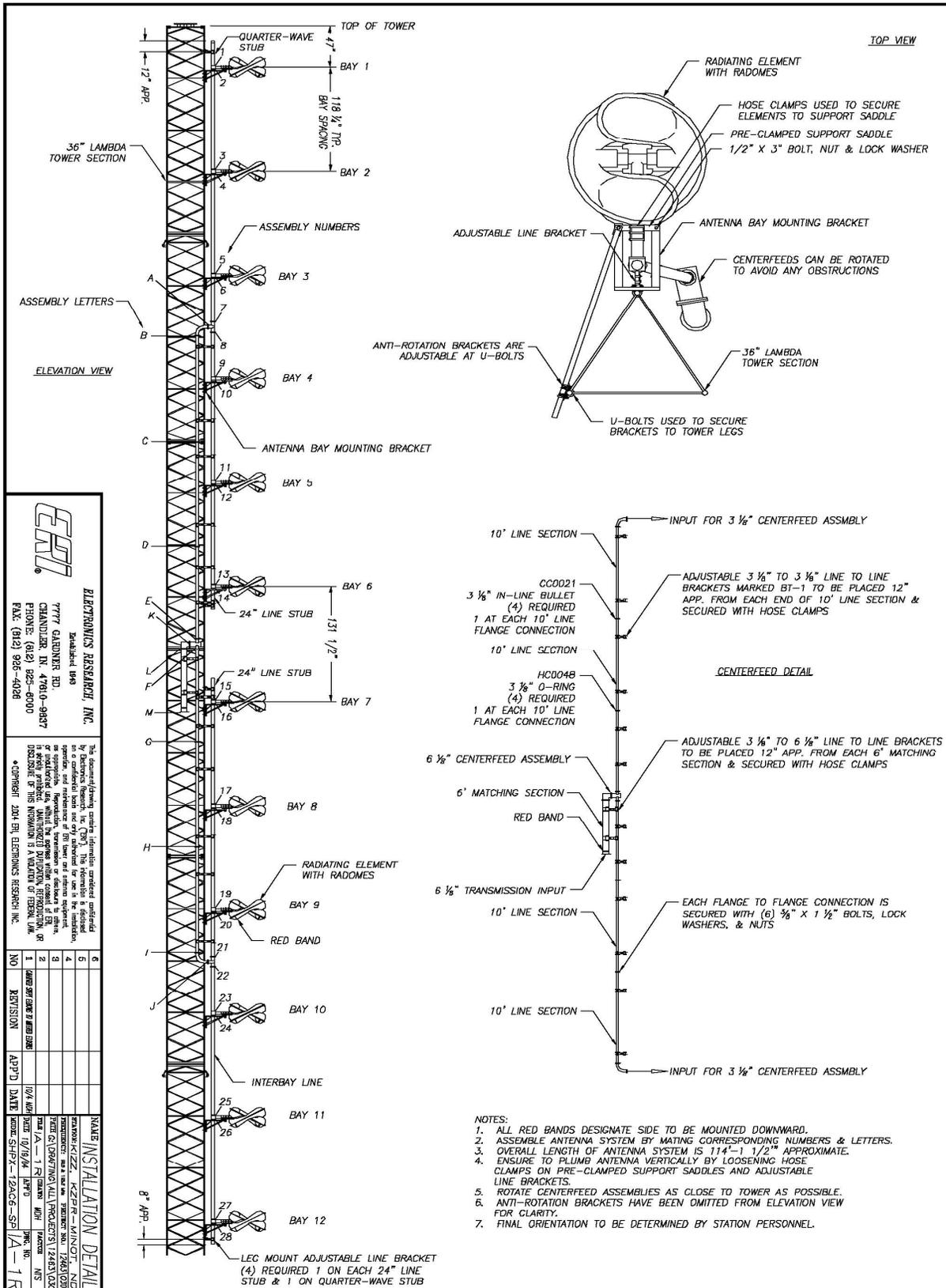
As a final proof of the systems IM Product performance, a wide band search was undertaken using the Spectrum Analyzer. The purpose for this measurement was to look for suspicious anomalies that may warrant further investigation. My search ranged the complete frequency span of the receiver and resulted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

**Conclusion:** Based upon my observations and measurements taken on August 15, 2020 as summarized in this document, I, Jeff Taylor, find the subject system-specifically the transmitter and filter system for the operation of KIZZ, KMXA, and KZPR 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. Based on this recorded data, I conclude that KIZZ, KMXA, and KZPR 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





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NO.	REVISION	APPROV. DATE	NAME
1	ISSUE FOR DRAWING	10/14/87	INSTALLATION DETAIL
2			
3			
4			
5			

**A-2 ERI Antenna Specification Sheet**

Minot, North Dakota

**General Specifications**

Antenna Type . . . . . High Power FM-Broadcast, Suitable for Multiplexing  
 Model Number . . . . . SHPX-12AC6-SP  
 Number of Bay Levels . . . . . Twelve  
 Polarization . . . . . Right Hand Circular

**Electrical Specifications**

Antenna Input Power Capability . . . . . 45.5 KW Max <sup>(1)</sup>  
 Operating Frequency Band . . . . . 93.7 ~ 105.3 Megahertz.  
 VSWR . . . . . <1.07:1 @ Operating Frequencies <sup>(2)</sup>  
 Azimuthal Pattern Circularity . . . . . Better Than +/- 1.5dB 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> <sup>(3)</sup>	<u>Filter Loss</u> <sup>(4)</sup>	<u>Computed TPO</u>
93.7	100 kW	0°	0.1 %	20.1%	6.114	.3427 dB	.157 dB	18.34 kW
99.9	42 kW	0°	0.1 %	2.4%	6.844	.3556 dB	.188 dB	6.95 kW
105.3	100 kW	0°	0.1 %	22.1 %	5.657	.3647 dB	.144 dB	19.86 kW

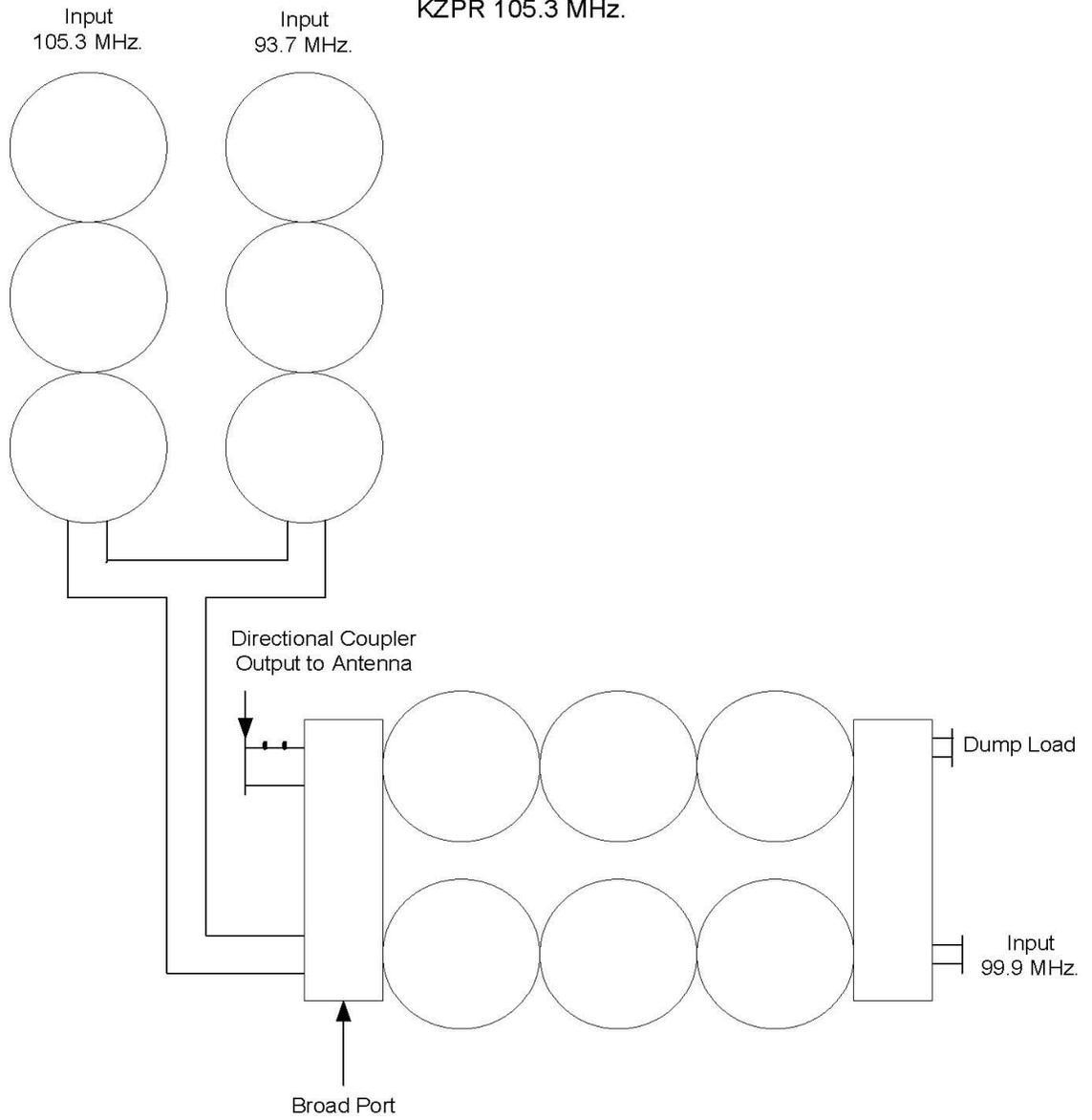
**Mechanical Specifications**

Antenna Feed System . . . . . Fed with One Line  
 Input Connector . . . . . 6 1/8"-50 Ohm EIA Flanged  
 Element Deicing . . . . . Radomes  
 Interbay Spacing . . . . . 118.25" Center to Center  
 Array Length . . . . . 114.4 Feet  
 Construction Material (Antenna) . . . . . All Noncorrosive  
 Construction Material (Mounting) . . . . . All 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 77 Feet, 4 1/16" ERI Macxline and 378 Feet of HJ9-50 Andrew Flex.  
 4) Losses Taken from Actual Combiner.

Combiner Drawing  
Minot, N.D.

KIZZ 93.7 MHz.  
KMXA 99.9 MHz.  
KZPR 105.3 MHz.



**A-4 ERI Combiner Specification Sheet**

Ft. Walton Beach, Florida

**General Specifications:**

Multiplexer Type ..... "T" and Constant Impedance Combiner  
 Number of Combining Units ..... Three  
 Injected Port to Injected Port Isolation..... > - 87 dB  
 Output Connector..... 6 1/8 "50 Ohm EIA (Flanged)  
 Output Power (Designed) ..... 45.5 kW <sup>(1)</sup>

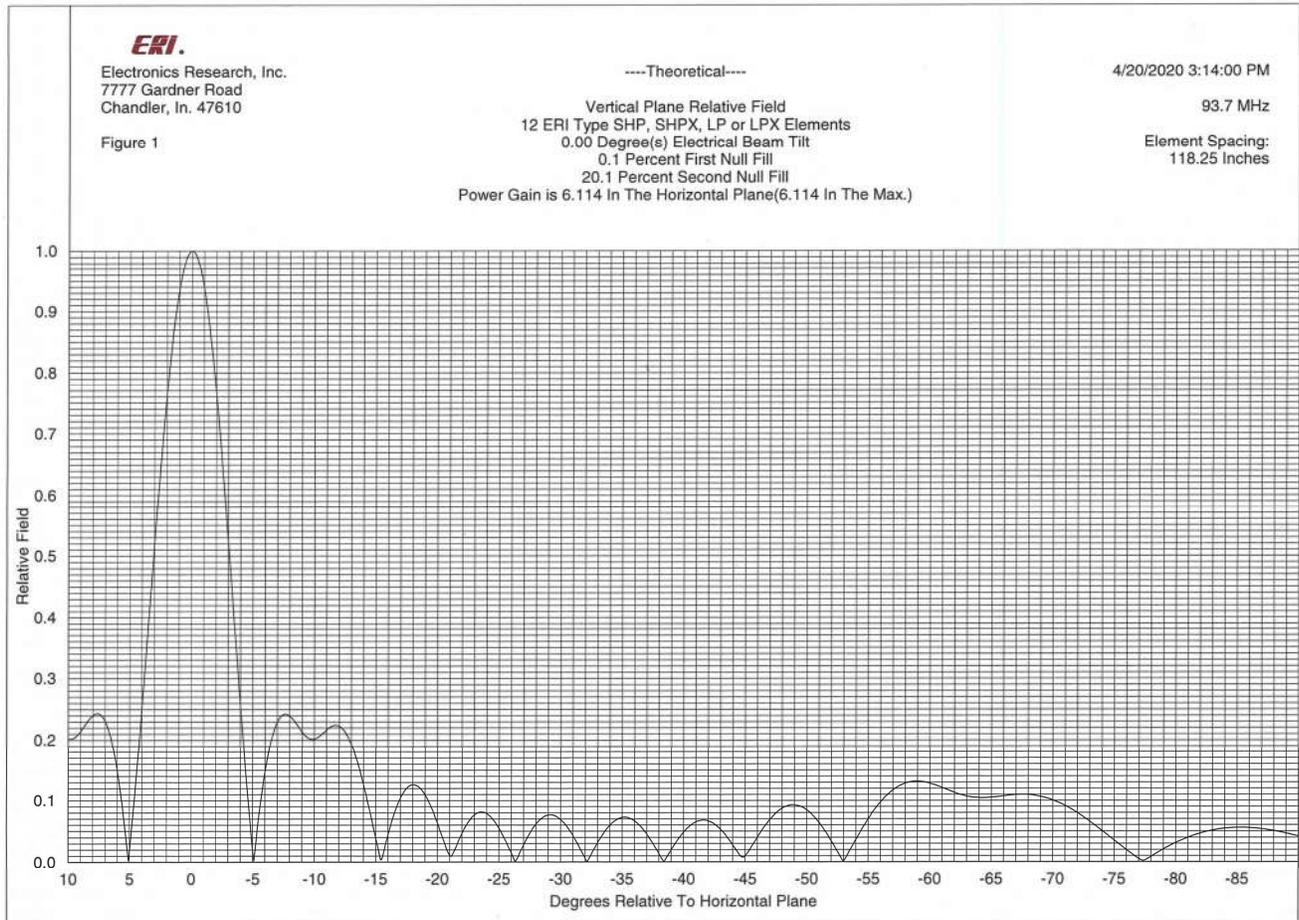
Heat Removal..... 93.7 MHz. and 105.3 MHz. Forced Air Colling  
 Heat Removal.....96.5 MHz. Natural Convection  
 Physical Arrangement .....All Components Floor standing

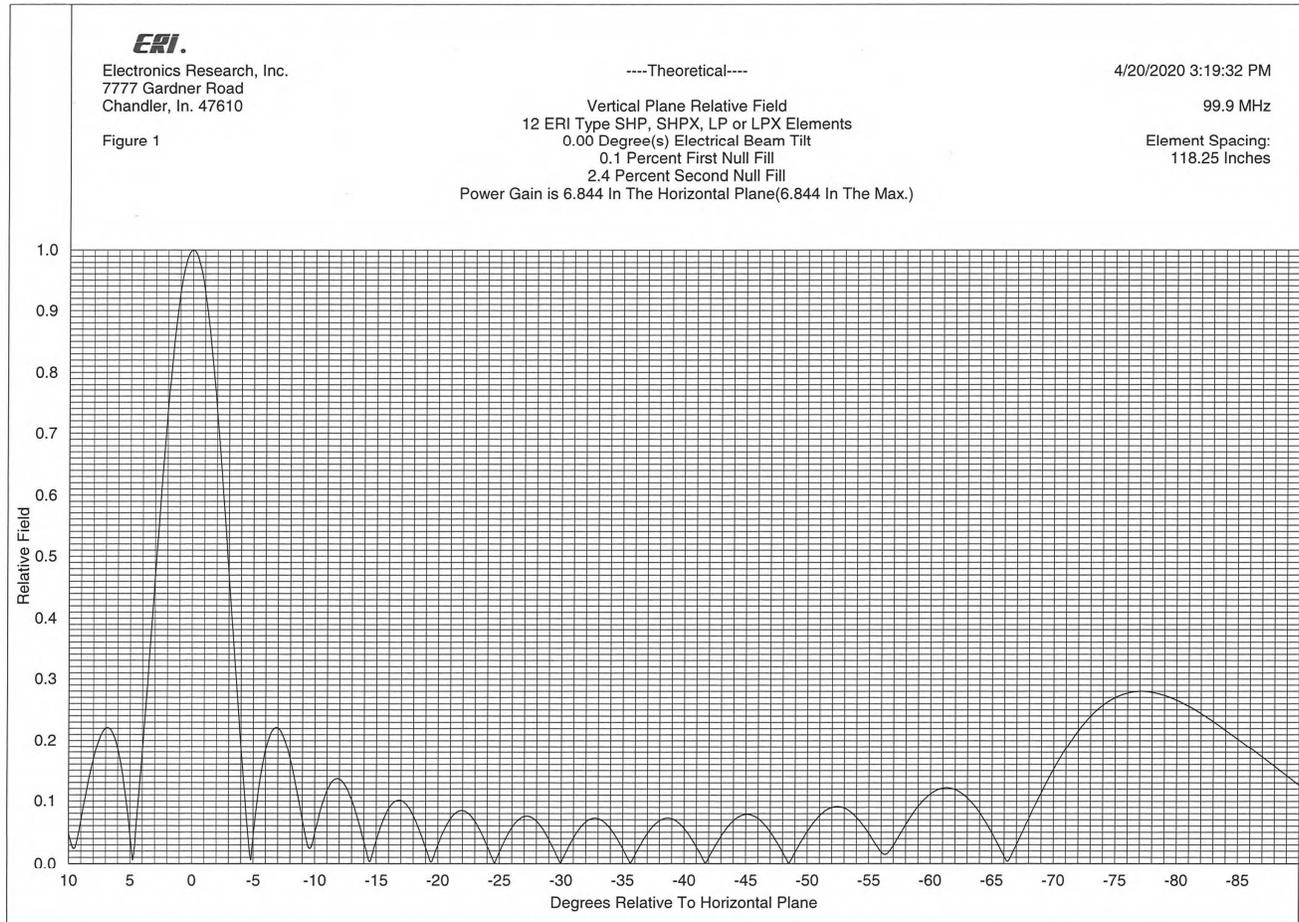
**Injected Port Specifications:**

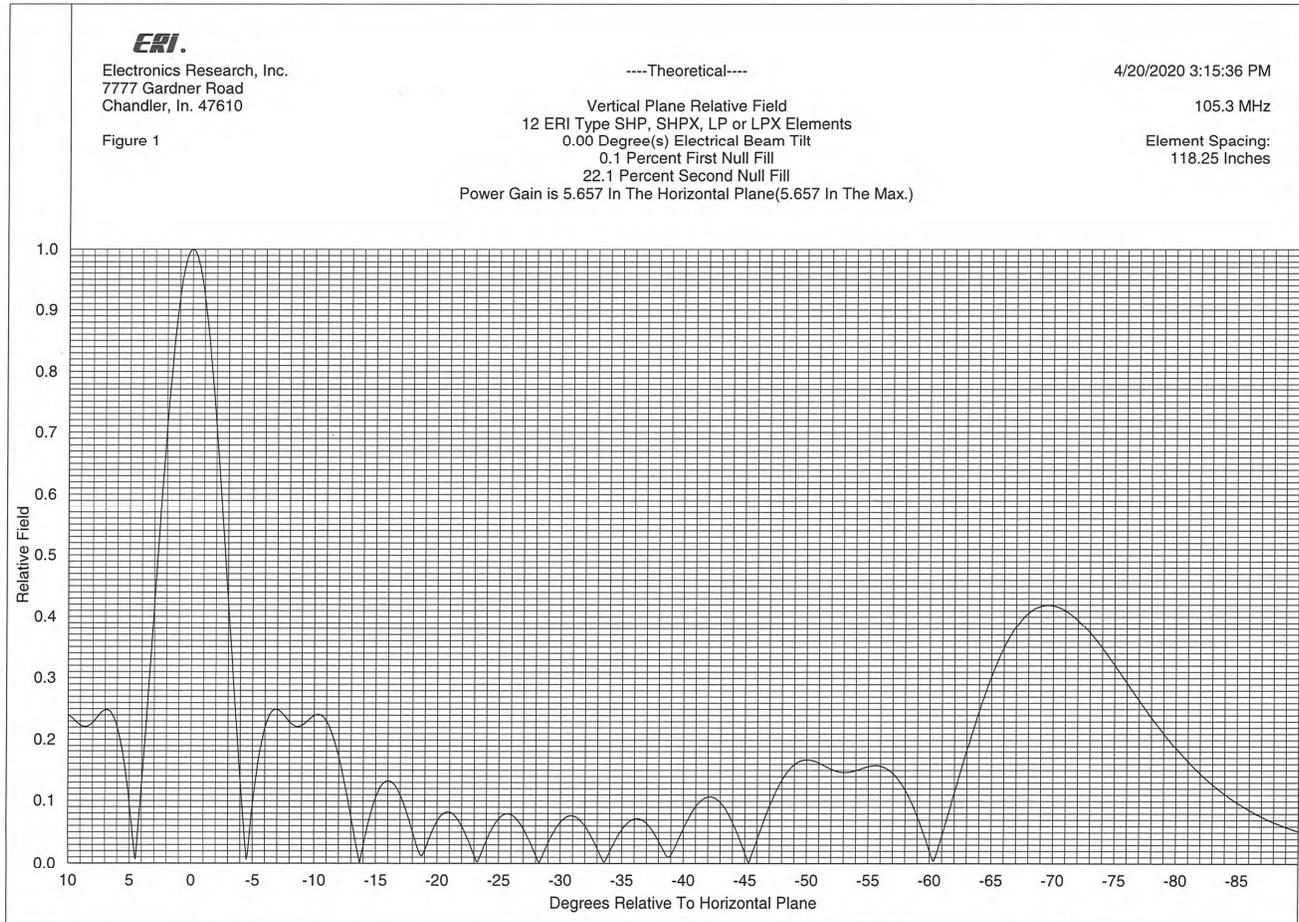
Frequency Assignment ..... 93.7, 99.9, and 105.3 MHz.  
 Power Rating, Each Injected Port ..... 18.34 kW for 93.7 MHz.  
 Power Rating, Each Injected Port .....6.95 kW for 99.9 and 19.86 kW for 105.3 MHz.  
 Input Connector ..... 3-1/8" 50 Ohm EIA (Flanged)  
 VSWR..... < 1.06:1 @ +/-150 KHz. <sup>(2)</sup>  
 Group Delay..... Less than 75 ns Overall Variation, Carrier @ +/- 150 KHz.  
 Insertion Loss (Measured):

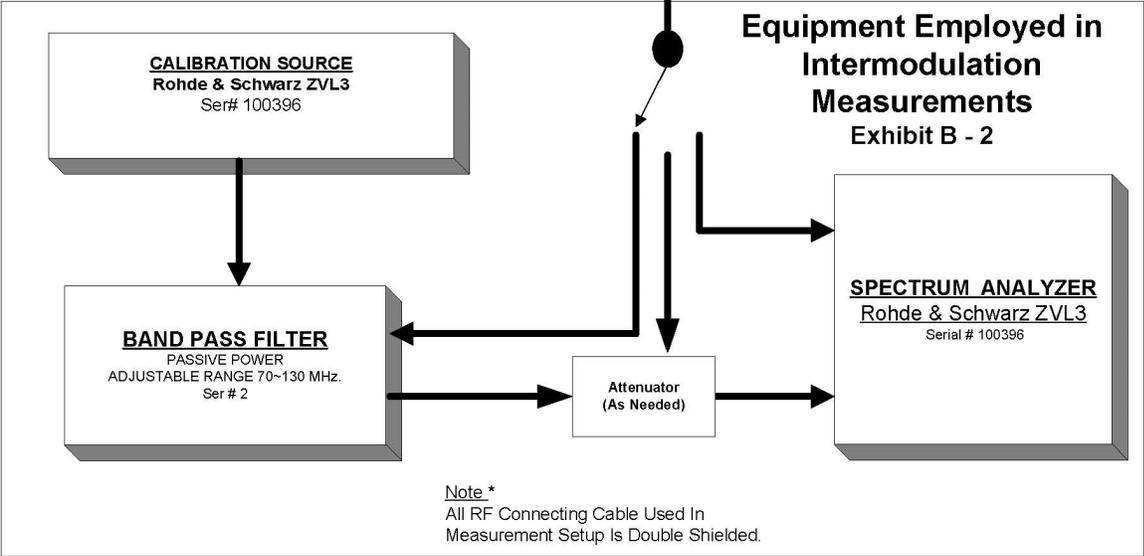
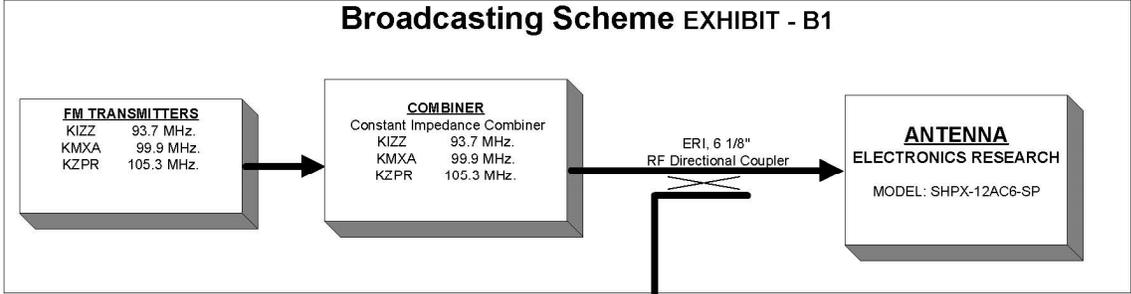
93.7 MHz. .... - 0.157 dB  
 99.9 MHz. .... - 0.188 dB  
 105.3 MHz. .... - 0.144 dB

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**