

Report Of Intermodulation Product Findings

OKLAHOMA CITY, OKLAHOMA

**K225BN – 92.9 MHz.
K276EX – 103.1 MHz.
KMGL – 104.1 MHz.**

Project# 32592

August 19, 2014

**Electronics Research Inc.
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TABLE OF CONTENTS

Report of Findings for Intermodulation Product Measurements

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

Exhibits Accompanying This Report

EXHIBIT A.....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

EXHIBIT B-1.....Intermodulation Product Measurement Equipment Layout
B-2.....Broadcasting Scheme of the Multiplexed System

REPORT OF FINDINGS OKLAHOMA CITY, OKLAHOMA BROADCAST FACILITY

Introduction: This report of findings is based on data collected at the FM broadcast facility located in Oklahoma City, OK. The report includes measurements offered as proof that the combined operations of K225BN (92.9 MHz.) and K276EX (103.1 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). Several other stations operate into another antenna that is collocated on the tower structure within close proximity to the 92.9 MHz. and 103.1 MHz. antenna. Their effects on the stations operating from this system have been considered in this report. The table of the other frequencies can be found on page 5 of this report. In brief, the collection of measurements presented in this report shows that all possible third order intermodulation (IM) products generated by this multiplexed 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 19, 2014.

The following exhibits are provided:

Exhibit A:

- A-1 Drawing Depicting Antenna.
- A-2 SHP-8AC-HW-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 two of the FM stations operating from the combined antenna system. A second visit will be conducted after the third transmitter installation is completed reserved for an auxiliary station. The K225BN, K276EX, and KMGL multiplexed system is fundamentally comprised of antenna, feed line and multiplexer unit. The SHP-8AC-HW-SP (antenna), 955 Constant Impedance ~ Branch combiner units, and rigid feedline, are products of Electronics Research, Inc while the 3” HJ8-50B Air Heliac is a product of Andrew. Refer to Exhibit B-1, for an illustration of the Broadcasting Scheme of these stations.

To accomplish the aggregation of three transmitter signals into a common antenna feed and provide transmitter-to-transmitter isolation, a multiplexing scheme consisting of (1) 955 Constant Impedance Combiner and (2) 955 Bandpass, filter system were installed. Specifically, the combiner utilizes one ERI Model 955 module for frequency (104.1 MHz.) and two ERI Model 955 Bandpass modules for frequency (92.9 MHz. and 103.1 MHz.). An “Interconnecting T” is used to combine the 92.9 MHz. and 103.1 MHz. into the broad port hybrid of the 104.1 MHz. Constant Impedance module. The multiplexer, fully assembled, exhibited transmitter port-to-port isolation in excess of -67 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 -36 dB directivity and a forward signal sample of -40 dB.

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 Serial # 686 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 Serial # 5362199 signal generator was used. A Rhode & Schwarz ZVL3 Spectrum Analyzer Serial # 100396 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 A-2 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 (dBu)	Scale Reading (dBu)	Carrier Level (dBu)	Notes
92.9	3	120	8.7	114.3	
103.1	3	120	9.7	113.3	
104.1	3				

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		
		92.9	103.1	104.1
KOMA	92.5 MHz.	93.3	113.7	115.7
K225BN	92.9 MHz.	----	113.3	115.3
K243BJ	96.5 MHz.	89.3	109.7	111.7
K276EX	103.1 MHz.	82.7	----	105.1
KMGL	104.1 MHz.	81.7	102.1	----
K238BW	104.5 MHz.	81.3	101.7	103.7
KRXO	107.7 MHz.	78.1	98.5	100.5

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 Oklahoma City, OK.											
Product Frequency (MHz)	Transmitter Frequency (MHz)	Interfering Frequency (MHz)	Pad (dB)	Bandpass Filter Loss (dB)	Total Loss	Full Scale Range (dBμ)	Scale Reading (dBμ)	Adjusted Level (dBμ)	Carrier Reference Level (dBμ)	Level Referenced to Carrier (dB)	Notes*
Transmitter Mixes											
	92.9	Ref.	3		3	120	8.7		114.3		3 Station System
	103.1	Ref.	3		3	120	9.7		113.3		3 Station System
	104.1	Ref.	3		3	120	0		123		Reserved for Aux
	92.5	Ref.	3		3	120	9.8		113.2		4 Station System
	96.5	Ref.	3		3	120	7.1		115.9		4 Station System
	104.5	Ref.	3		3	120	3.3		119.7		4 Station System
	107.7	Ref.	3		3	120	3.3		117.1		4 Station System
78.1	92.9	107.7	3	10.8	13.8	20	20	13.8	114.3	-100.5	
81.3	92.9	104.5	3	10.7	13.7	20	20	13.7	114.3	-100.6	
82.7	92.9	103.1	3	10.6	13.6	20	20	13.6	114.3	-100.7	
89.3	92.9	96.5	3	10.3	13.3	20	6.1	27.2	114.3	-87.1	
93.3	92.9	92.5	3	10.2	13.2	60	9.2	64	114.3	-50.3	Local KJKE
98.5	103.1	107.7	3	10.1	13.1	20	14.5	18.6	113.3	-94.7	
101.7	103.1	104.5	3	9.8	12.8	40	15.9	36.9	113.3	-76.4	Local KKZU 104.5 Off
109.7	103.1	96.5	3	9.2	12.2	20	20	12.2	113.3	-101.1	
113.3	103.1	92.9	3	9.1	12.1	20	20	12.1	113.3	-101.2	
113.7	103.1	92.5	3	8.9	11.9	20	20	11.9	113.3	-101.4	
81.9	92.5	103.1	3	10.7	13.7	20	20	13.7	113.2	-99.5	
89.9	96.5	103.1	3	10.3	13.3	20	13.8	19.5	115.9	-96.4	
92.1	92.5	92.9	3	10.3	13.3	20	17.5	15.8	113.2	-97.4	
100.1	96.5	92.9	3	9.9	12.9	20	19.2	13.7	115.9	-102.2	
105.9	104.5	103.1	3	9.6	12.6	20	20	12.6	119.7	-107.1	
112.3	107.7	103.1	3	9.1	12.1	20	20	12.1	117.1	-105	
116.1	104.5	92.9	3	8.9	11.9	20	20	11.9	119.7	-107.8	
122.5	107.7	92.9	3	8.9	11.9	20	20	11.9	117.1	-105.2	

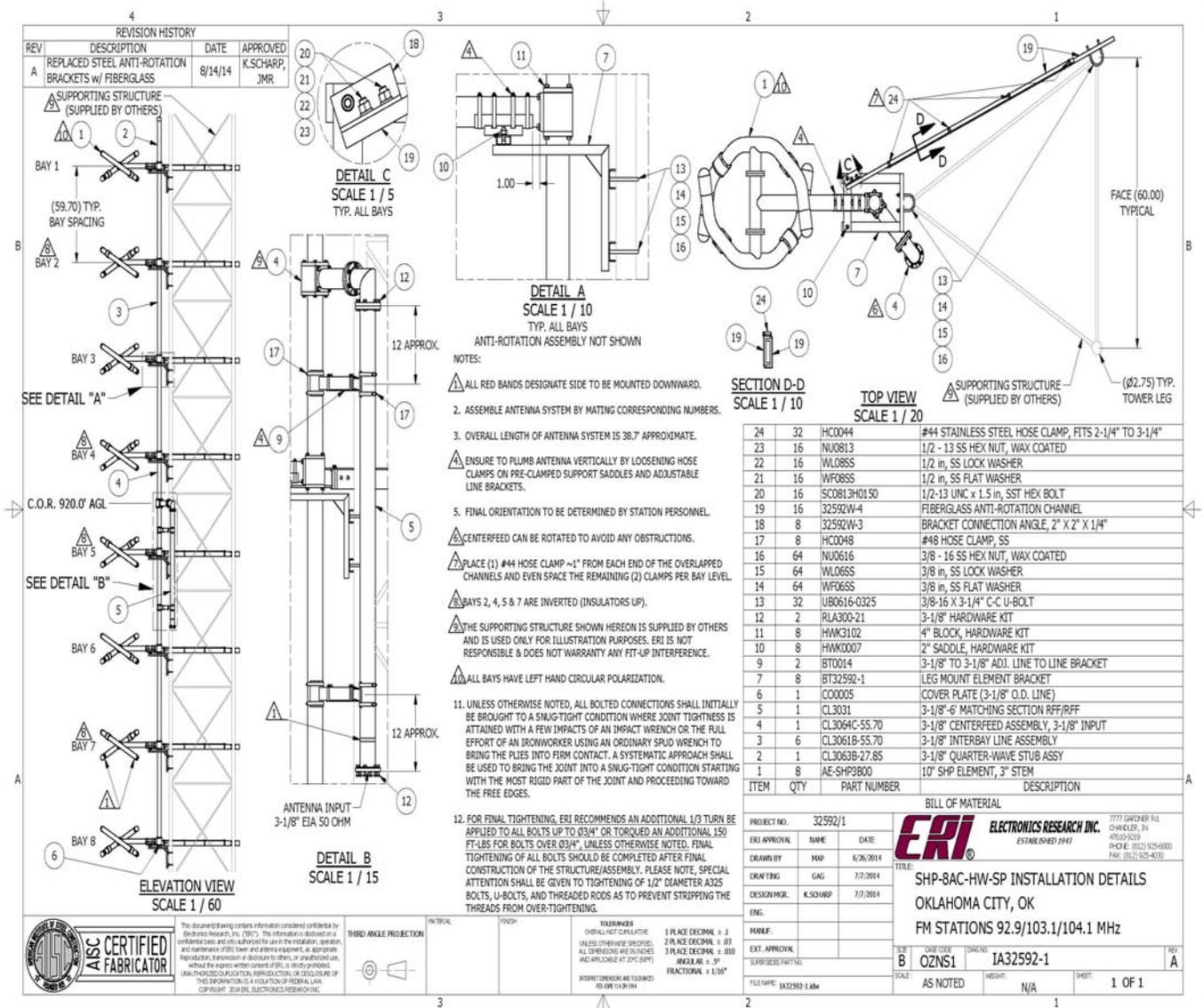
The Spectrum Analyzer was used to check the close in spectral attenuation of the carrier to confirm the operation of the transmitter is in compliance with Sections (b) and (c) of the FCC Rules and Regulations.

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 19, 2014 as summarized in this document, I, Jeff Taylor, find the subject system, specifically the transmitter and filter system for the operation of K225BN and K276EX 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 K225BN and K276EX 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



A-2 ERI Antenna Specification Sheet

TRANSMISSION SITE

OKLAHOMA CITY, OKLAHOMA

General Specifications

Antenna Type High Power FM-Broadcast, Suitable for Multiplexing
 Model Number SHPX-8AC-HW-SP
 Number of Bay Levels Eight
 Polarization Left Hand Circular

Electrical Specifications

Antenna Input Power Capability 11 kW Max ⁽¹⁾
 Operating Frequency Band 92.9 ~ 103.1 ~ 104.1 Megahertz.
 VSWR <1.01:1 @ 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>
92.9	200 Watts	0°	14 %	0 %	2.300	-1.1365 dB	-0.500 dB	127 Watts
103.1	99 Watts	0°	11 %	0 %	2.563	-1.2017 dB	-0.516 dB	57 Watts
104.1	17.225 KW	0°	14 %	0 %	2.555	-1.2075 dB	-0.504 dB	10 kW

Mechanical Specifications

Antenna Feed System Single Input
 Input Connector 3 1/8"-50 Ohm EIA Flanged
 Element Deicing None
 Interbay Spacing 59.6875" Center to Center
 Array Length 37.31 Feet
 Construction Material (Antenna) Galvanized Plated Steel and Stainless Steel
 Construction Material (Mounting) Leg

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 371 Feet of MACXLine-350 3 1/8" Rigid and 582 Feet of Andrew HJ8-50B 3" Heliax.
 4) Losses Taken From Actual Combiner.

EXHIBIT A-3

NOTES:
 1 SERIAL NUMBER IS 32592-071514-1
 2 FLANGE ADAPTER, 1-5/8" EIA TO 1-5/8" UNFLG., IS PART OF THE CAVITY ASSEMBLY FM NOTCH FILTER, AND IS SHOWN MOVED TO THE INPUT & OUTPUT FOR AN UN-FLANGED CONNECTION. ADAPTER WILL NOT BE USED IF A FLANGED CONNECTION IS REQUIRED.

92.9 MHz INPUT 1-5/8" SINGLE PORT DIRECTIONAL COUPLER
 103.1 MHz INPUT 1-5/8" SINGLE PORT DIRECTIONAL COUPLER
 104.1 MHz INPUT 1-5/8" SINGLE PORT DIRECTIONAL COUPLER

SCALE 1 / 24

REVISION HISTORY			
REV	DESCRIPTION	DATE	APPROVED
A	ADDED SERIAL # AND LABELS, ITEM #4 WAS 9.50" LG.	7/16/2014	NP, K. SCHARP

SCALE 1 / 32

23	24	WL05SS	5/16 in, SS LOCK WASHER
22	24	NLJ0518	5/16 - 18 SS HEX NUT, WAX COATED
21	24	SCD518H0125	5/16-18 UNC x 1.25 in, SST HEX BOLT
20	16	WL04SS	1/4 in, SS LOCK WASHER
19	16	WF04SS	1/4 in, SS FLAT WASHER
18	16	SCD420S0100	1/4-20 x 1 SOCKET HEAD CAP SCREW, Stainless Steel
17	1	RLA150-NF-AL	1-5/8" * 50 OHM X "N" FEMALE REDUCER
16	1	ICK0002-N001	CIRCULATOR KIT CABLE ASSEMBLY
15	8	FK0001	SINGLE FAN AND THERMO SWITCH KIT 955
14	1	CT1016	Ø1-5/8" ALUMINUM TEE ASSY.
13	1	CL032	LOAD 500 W, TYPE "N" BIRD #8201
12	2	CH210	HYBRID, 1-5/8 FM, PF
11	4	CFZ30-04NA	955-4 NON-ADJACENT BANDPASS FILTER
10	3	CD235	COUPLER SINGLE PORT FM EIA AL 8.00 LONG
9	1	CD227	1 5/8 DIR COUPLER 2 PORT ALUM
8	3	ACK150-20	1-5/8" STD INNER CONN 50 OHM
7	8	1329150-39	1-5/8" UNPRESSURIZED ALUMINUM COUPLING
6	1	1329150-29-5-53.50	1-5/8" VAR LINE SECTION UNFLG UP TO 60°
5	1	1329150-29-5-4.69	1-5/8" VAR LINE SECTION UNFLG UP TO 60°
4	1	1329150-29-5-3.75	1-5/8" VAR LINE SECTION UNFLG UP TO 60°
3	1	1329150-29-5-3.00	1-5/8" VAR LINE SECTION UNFLG UP TO 60°
2	4	1329150-10SE-3	90° ALUMINUM UNFLANGED ELBOW ASSEMBLY
1	4	1329100-38	1-5/8" ALUMINUM CLAMP TYPE FLANGE ADAPTER

ITEM	QTY	PART NUMBER	DESCRIPTION
1	4	1329100-38	1-5/8" ALUMINUM CLAMP TYPE FLANGE ADAPTER
2	4	1329150-10SE-3	90° ALUMINUM UNFLANGED ELBOW ASSEMBLY
3	1	1329150-29-5-3.00	1-5/8" VAR LINE SECTION UNFLG UP TO 60°
4	1	1329150-29-5-3.75	1-5/8" VAR LINE SECTION UNFLG UP TO 60°
5	1	1329150-29-5-4.69	1-5/8" VAR LINE SECTION UNFLG UP TO 60°
6	1	1329150-29-5-53.50	1-5/8" VAR LINE SECTION UNFLG UP TO 60°
7	8	1329150-39	1-5/8" UNPRESSURIZED ALUMINUM COUPLING
8	3	ACK150-20	1-5/8" STD INNER CONN 50 OHM
9	1	CD227	1 5/8 DIR COUPLER 2 PORT ALUM
10	3	CD235	COUPLER SINGLE PORT FM EIA AL 8.00 LONG
11	4	CFZ30-04NA	955-4 NON-ADJACENT BANDPASS FILTER
12	2	CH210	HYBRID, 1-5/8 FM, PF
13	1	CL032	LOAD 500 W, TYPE "N" BIRD #8201
14	1	CT1016	Ø1-5/8" ALUMINUM TEE ASSY.
15	8	FK0001	SINGLE FAN AND THERMO SWITCH KIT 955
16	1	ICK0002-N001	CIRCULATOR KIT CABLE ASSEMBLY
17	1	RLA150-NF-AL	1-5/8" * 50 OHM X "N" FEMALE REDUCER
18	16	SCD420S0100	1/4-20 x 1 SOCKET HEAD CAP SCREW, Stainless Steel
19	16	WF04SS	1/4 in, SS FLAT WASHER
20	16	WL04SS	1/4 in, SS LOCK WASHER
21	24	SCD518H0125	5/16-18 UNC x 1.25 in, SST HEX BOLT
22	24	NLJ0518	5/16 - 18 SS HEX NUT, WAX COATED
23	24	WL05SS	5/16 in, SS LOCK WASHER

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ENG.	NP 7/14/2014
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BILL OF MATERIAL	
PROJECT NO.	32592/3
ERI APPROVAL	NAME DATE
DRAWN BY	DLB 7/8/2014
DESIGN MGR.	K. SCHARP 7/14/2014
ENG.	NP 7/14/2014
MANUF.	
EXT. APPROVAL	
SUPPLIES PART NO.	
FILE NAME:	32592-0M1.dwg

BILL OF MATERIAL	
PROJECT NO.	32592/3
ERI APPROVAL	NAME DATE
DRAWN BY	DLB 7/8/2014
DESIGN MGR.	K. SCHARP 7/14/2014
ENG.	NP 7/14/2014
MANUF.	
EXT. APPROVAL	
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MANUF.	
EXT. APPROVAL	
SUPPLIES PART NO.	
FILE NAME:	32592-0M1.dwg

BILL OF MATERIAL	
PROJECT NO.	32592/3
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DESIGN MGR.	K. SCHARP 7/14/2014
ENG.	NP 7/14/2

A-4 ERI Combiner Specification Sheet

TRANSMISSION SITE

OKLAHOMA CITY, OKLAHOMA

General Specifications:

Multiplexer Type Band Pass and Constant Impedance
Number of Combining Units Three
Injected Port to Injected Port Isolation < - 67 dB
Output Connector 1 5/8 "50 Ohm EIA (Flanged)
Output Power (Designed) 11 kW⁽¹⁾

Heat Removal Forced Air cooling
Physical Arrangement All Components Floor Standing

Injected Port Specifications:

Frequency Assignment92.9 ~ 103.1, and 104.1 MHz.
Power Rating, Each Injected Port (Designed).....127 Watts 92.9 ~ 57 Watts 103.1 ~ 10.0 kW 104.1
Input Connector1-5/8" 50 Ohm EIA (Flanged).
VSWR.....< 1.15:1 @ +/-200 KHz.⁽²⁾
Group DelayLess than 250 ns Overall Variation, Carrier @ +/- 150 KHz.
Insertion Loss (Measured):

92.9 MHz. - 0.500 dB
103.1 MHz. - 0.516 dB
104.1 MHz. - 0.504 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

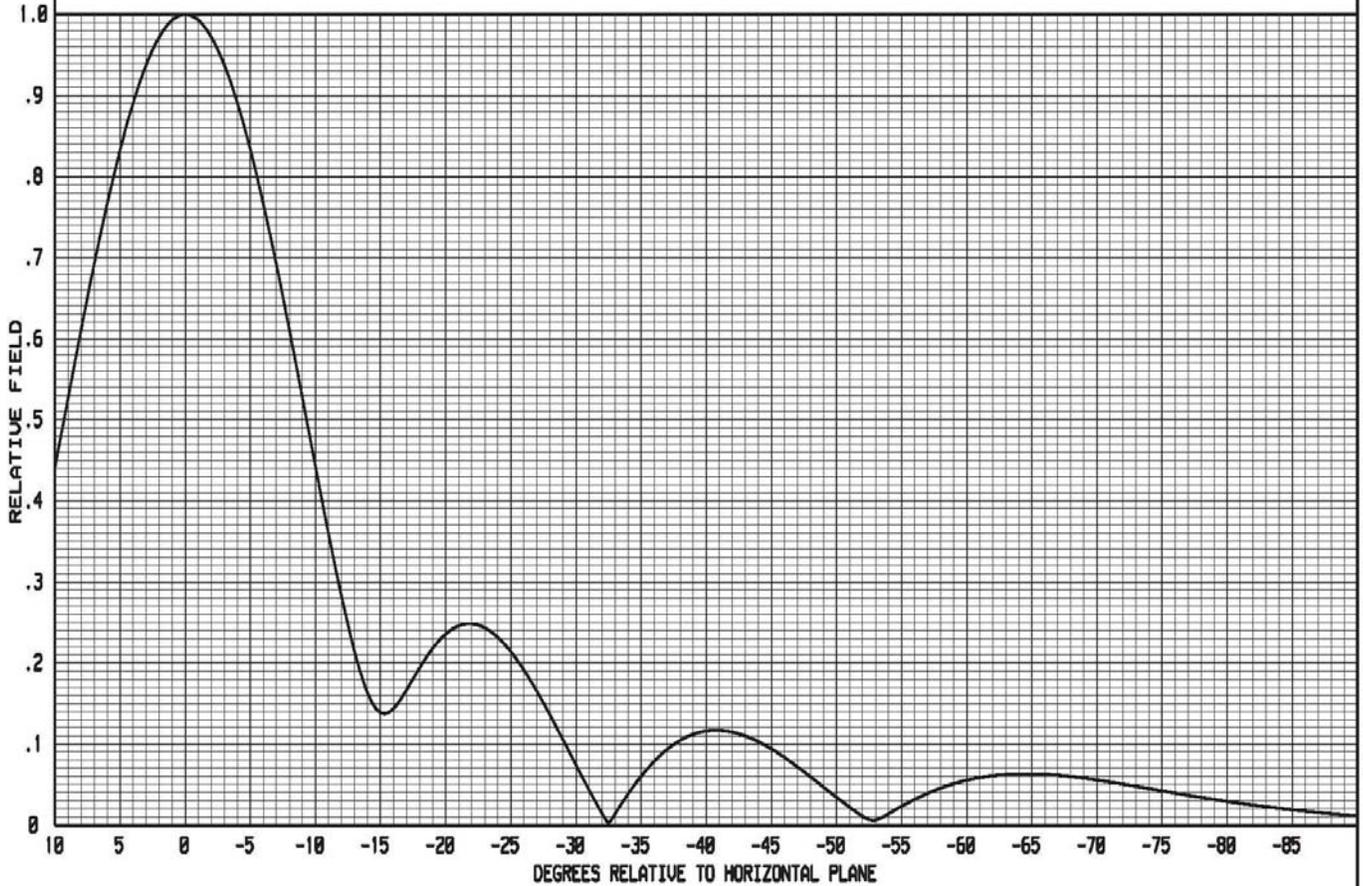
-----THEORETICAL-----
VERTICAL PLANE RELATIVE FIELD

8 ERI ROTOTILLER(TM) CENTER FED ELEMENTS
+0.00 DEGREE(S) ELECTRICAL BEAM TILT
14 PERCENT FIRST NULL FILL
0 PERCENT SECOND NULL FILL
POWER GAIN IS 2.300 IN THE HORIZONTAL PLANE(2.300 IN THE MAX.)

SEPTEMBER 16, 2013

92.9 MHz.

ELEMENT SPACING:
59.6875 INCHES



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

FIGURE 3

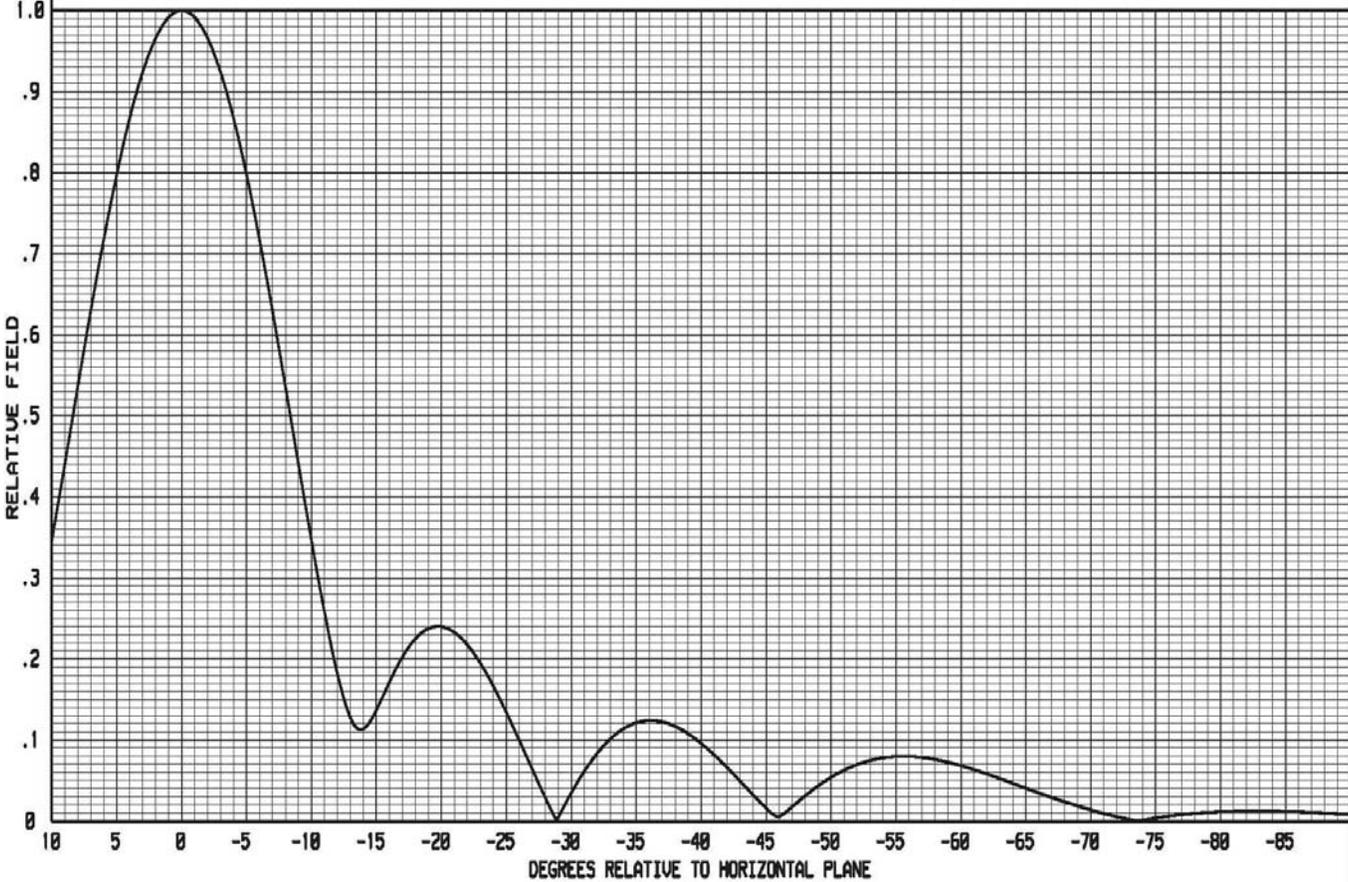
-----THEORETICAL-----
VERTICAL PLANE RELATIVE FIELD

8 ERI ROTOTILLER(TM) CENTER FED ELEMENTS
+0.00 DEGREE(S) ELECTRICAL BEAM TILT
11 PERCENT FIRST NULL FILL
0 PERCENT SECOND NULL FILL
POWER GAIN IS 2.563 IN THE HORIZONTAL PLANE(2.563 IN THE MAX.)

SEPTEMBER 16, 2013

103.1 MHz.

ELEMENT SPACING:
59.6875 INCHES



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

FIGURE 4

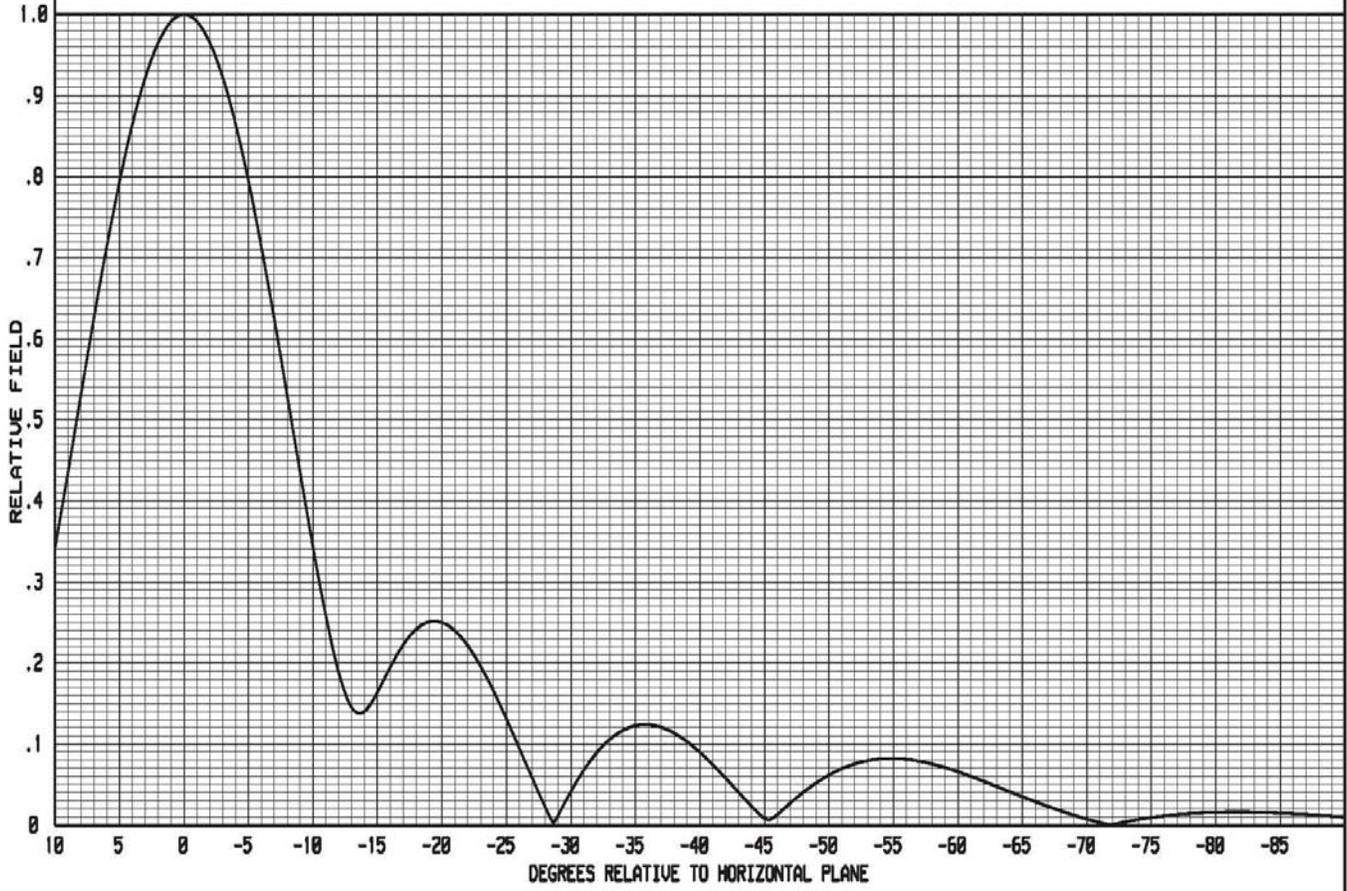
-----THEORETICAL-----
VERTICAL PLANE RELATIVE FIELD

8 ERI ROTOTILLER(TM) CENTER FED ELEMENTS
+0.00 DEGREE(S) ELECTRICAL BEAM TILT
14 PERCENT FIRST NULL FILL
0 PERCENT SECOND NULL FILL
POWER GAIN IS 2.555 IN THE HORIZONTAL PLANE(2.555 IN THE MAX.)

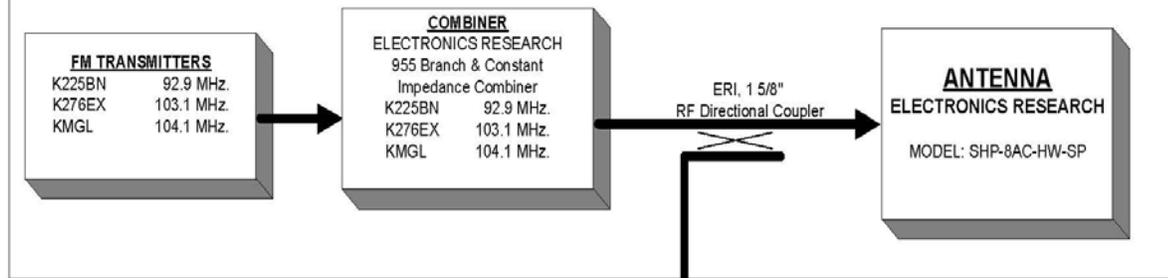
SEPTEMBER 16, 2013

104.1 MHz.

ELEMENT SPACING:
59.6875 INCHES

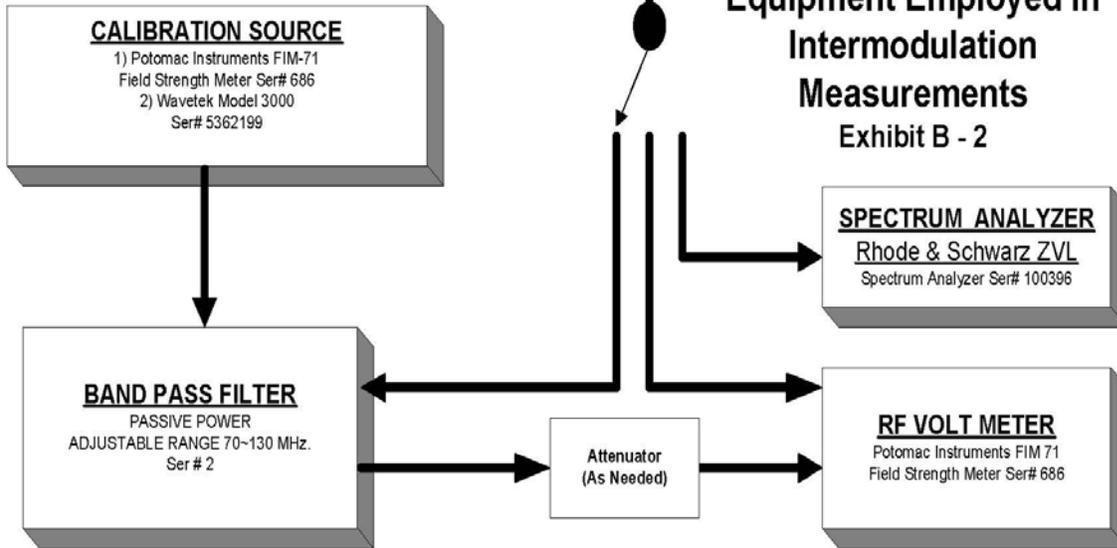


Broadcasting Scheme EXHIBIT - B1



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