# Report Of Intermodulation Product Findings

**Prepared for**

**Citadel Broadcasting Stations**
**WWLS (98.1 MHz.) & KATT (100.5 MHz.)**

**Oklahoma City, Oklahoma**

**Job # 18120KK**

**March 14th, 2008**

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## Oklahoma City, Oklahoma

## Report of Findings for Intermodulation Product Measurements



## Exhibits Accompanying This Report

# REPORT OF FINDINGS
# for

## Citadel Broadcasting Stations
## WWLS 98.1 MHz. & KATT 100.5 MHz.

**Introduction:** This report of findings is based on the addition of WWLS and KATT being added to an existing multiplexed system. The data collected at the WWLS (98.1 MHz.), KYIS (98.9 MHz.), & KATT (100.5 MHz.) of Citadel Broadcasting Stations and KOMA (92.5 MHz.), KMGL (104.1 MHz.), & KRXO (107.7 MHz.) of Renda Broadcasting Stations broadcast facility located in Oklahoma City, Oklahoma. The report includes measurements offered as proof that the addition of WWLS and KATT to the combined operations of the above stations transmitters comply 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). Mark Garrison of Electronics Research, Inc. located in Chandler, Indiana performed the measurements summarized herein on March 14, 2008.

**The following exhibits are provided:**

Exhibit A:
- A-1 Drawing Depicting Antenna.
- A-2 COG-20P-12-240-2 Panel Antenna Specification Sheet.
- A-3 Drawing Depicting Multiplexing Scheme.
- A-4 973-8 Series Constant Impedance Combiner Multiplexer Specification Sheet.
- A-5 Theoretical Vertical Plane Relative Field Antenna Plots

Exhibit B:
- B-1 Equipment Employed In Intermodulation Product Measurement.

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 F2 signifies the frequency causing the interference.

**The Multiplexed System:** These measurements were taken with six FM stations operating from the combined antenna system. The multiplexed system is fundamentally comprised of antenna, feed line and diplexer unit. The COG-20P-12-240-2 (antenna), 973-8 Series Constant Impedance combiner system, and 1660 feet of 6 1/8"MACXLINE 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 six transmitter signals into a common antenna feed and provide transmitter-to-transmitter isolation, a multiplexing scheme consisting of six 973-8 series Constant Impedance Combiner was installed. Specifically, the multiplexer utilizes one ERI Model 973-8 series constant impedance combiner for each station, which is illustrated in the attached Exhibit A-3. The multiplexer, fully assembled, exhibited transmitter port-to-port isolation in excess of -60dB. 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 -33 dB directivity and a forward signal sample of -63 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 FIM-71 to ensure an adequate signal level for measurements without overloading the measurement equipment. A Potomac Instruments FIM-71 Field Strength Receiver Serial # 242 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 # 7512028-signal generator was used. An IFR Spectrum Analyzer Serial #02113071 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, Diplexer, Feed Line and Antenna were adjusted to optimal performance. In addition, 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.

| Transmitter Frequency (MHz) | Interfering Frequency (MHz) | Pad (dB) | Total Loss | Full Scale Range (dBµ) | Scale Reading (dBµ) | Carrier Reference Level (dBµ) |
|---|---|---|---|---|---|---|
| **92.5** | **Ref.** | **6** | **6** | **120** | **10** | **116** |
| **98.1** | **Ref.** | **6** | **6** | **120** | **14** | **112** |
| **98.9** | **Ref.** | **6** | **6** | **120** | **10** | **116** |
| **100.5** | **Ref.** | **6** | **6** | **120** | **14.9** | **111.1** |
| **104.1** | **Ref.** | **6** | **6** | **120** | **9.2** | **116.8** |
| **107.7** | **Ref.** | **6** | **6** | **120** | **9.3** | **116.7** |

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.

| | 92.5 | 98.1 | 98.9 | 100.5 | 104.1 | 107.7 |
|---|---|---|---|---|---|---|
| 92.5 | --- | 103.7 | 105.3 | 108.5 | 115.7 | 122.9 |
| 98.1 | 86.9 | --- | 99.7 | 102.9 | 110.1 | 117.3 |
| 98.9 | 86.1 | 97.3 | --- | 102.1 | 109.3 | 116.5 |
| 100.5 | 84.5 | 95.7 | 97.3 | --- | 107.7 | 114.9 |
| 104.1 | 80.9 | 92.1 | 93.7 | 96.9 | --- | 111.3 |
| 107.7 | 77.3 | 88.5 | 90.1 | 93.3 | 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.

| IM Measurements Taken in Oklahoma City, Oklahoma | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Product Frequency (MHz)** | **Transmitter Frequency (MHz)** | **Interfering Frequency (MHz)** | **Pad (dB)** | **Band pass 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*** |
| 77.3 | 92.5 | 107.7 | 6 | 12.1 | 18.1 | 40 | 10.5 | 47.6 | 116.0 | -68.4 | KOCO-5 TV |
| 80.9 | 92.5 | 104.1 | 6 | 11.9 | 17.9 | 20 | 16.0 | 21.9 | 116.0 | -94.1 | |
| 84.5 | 92.5 | 100.5 | 6 | 11.9 | 17.9 | 20 | 20.0 | 17.9 | 116.0 | -98.1 | |
| 86.1 | 92.5 | 98.9 | 6 | 12.0 | 18.0 | 20 | 20.0 | 18.0 | 116.0 | -98.0 | |
| 86.9 | 92.5 | 98.1 | 6 | 12.0 | 18.0 | 20 | 20.0 | 18.0 | 116.0 | -98.0 | |
| 88.5 | 98.1 | 107.7 | 6 | 11.8 | 17.8 | 20 | 20.0 | 17.8 | 112.0 | -94.2 | |
| 90.1 | 98.9 | 107.7 | 6 | 12.2 | 18.2 | 20 | 4.0 | 34.2 | 116.0 | -81.8 | KCSC 90.1 |
| 92.1 | 98.1 | 104.1 | 6 | 12.2 | 18.2 | 40 | 6.0 | 52.2 | 112.0 | -59.8 | KFXI 92.1 |
| 93.3 | 100.5 | 107.7 | 6 | 12.2 | 18.2 | 20 | 10.0 | 28.2 | 111.1 | -82.9 | |
| 93.7 | 98.9 | 104.1 | 6 | 11.5 | 17.5 | 20 | 16.0 | 21.5 | 116.0 | -94.5 | |
| 95.7 | 98.1 | 100.5 | 6 | 11.6 | 17.6 | 20 | 14.0 | 23.6 | 112.0 | -88.4 | |
| 96.9 | 100.5 | 104.1 | 6 | 11.8 | 17.8 | 20 | 15.0 | 22.8 | 111.1 | -88.3 | |
| 97.3 | 98.1 | 98.9 | 6 | 12.0 | 18.0 | 20 | 16.3 | 21.7 | 112.0 | -90.3 | |
| 97.3 | 98.9 | 100.5 | 6 | 12.0 | 18.0 | 20 | 16.3 | 21.7 | 116.0 | -94.3 | |
| 99.7 | 98.9 | 98.1 | 6 | 11.2 | 17.2 | 20 | 9.0 | 28.2 | 116.0 | -87.8 | |
| 100.5 | 104.1 | 107.7 | 6 | 11.5 | 17.5 | 20 | 17.5 | 20.0 | 116.8 | -96.8 | |
| 102.1 | 100.5 | 98.9 | 6 | 10.0 | 16.0 | 20 | 6.0 | 30.0 | 111.1 | -81.1 | |
| 102.9 | 100.5 | 98.1 | 6 | 10.8 | 16.8 | 20 | 5.5 | 31.3 | 111.1 | -79.8 | KJYO 102.7 |
| 103.7 | 98.1 | 92.5 | 6 | 10.9 | 16.9 | 40 | 16.0 | 40.9 | 112.0 | -71.1 | KOCD 103.7 |
| 105.3 | 98.9 | 92.5 | 6 | 12.3 | 18.3 | 20 | 19.0 | 19.3 | 116.0 | -96.7 | |
| 107.7 | 104.1 | 100.5 | 6 | 12.0 | 18.0 | 60 | 13.0 | 6.0 | 116.8 | -110.8 | |
| 108.5 | 100.5 | 92.5 | 6 | 11.0 | 17.0 | 20 | 10.5 | 26.5 | 111.1 | -84.6 | |
| 109.3 | 104.1 | 98.9 | 6 | 10.1 | 16.1 | 20 | 20.0 | 16.1 | 116.8 | -100.7 | |
| 110.1 | 104.1 | 98.1 | 6 | 10.0 | 16.0 | 20 | 20.0 | 16.0 | 116.8 | -100.8 | |
| 111.3 | 107.7 | 104.1 | 6 | 10.7 | 16.7 | 20 | 20.0 | 16.7 | 116.7 | -100.0 | |
| 114.9 | 107.7 | 100.5 | 6 | 10.9 | 16.9 | 20 | 20.0 | 16.9 | 116.7 | -99.8 | |
| 115.7 | 104.1 | 92.5 | 6 | 10.7 | 16.7 | 20 | 20.0 | 16.7 | 116.8 | -100.1 | |
| 116.5 | 107.7 | 98.9 | 6 | 11.0 | 17.0 | 20 | 20.0 | 17.0 | 116.7 | -99.7 | |
| 117.3 | 107.7 | 98.1 | 6 | 10.4 | 16.4 | 20 | 20.0 | 16.4 | 116.7 | -100.3 | |
| 122.9 | 107.7 | 92.5 | 6 | 10.8 | 16.8 | 20 | 20.0 | 16.8 | 116.7 | -99.9 | |

The Spectrum Analyzer was used to check the close in spectral attenuation of the carrier to confirm the operation of the transmitter complies 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 March 14, 2008 and summarized in this document. I, Mark Garrison, find the subject system- specifically the transmitter and filter system for the operation of WWLS (98.1 MHz.), KYIS (98.9 MHz.), & KATT (100.5 MHz.) of Citadel Broadcasting and KOMA (92.5 MHz.), KMGL (104.1 MHz.), & KRXO (107.7 MHz.) of Renda Broadcasting 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 the above stations comply with the requirements of Section 73.317 paragraph (b) through (d) of the FCC Rules and Regulations.

Respectfully submitted,
Electronics Research, Inc.

Mark Garrison, Field Technician

State of Indiana

County of Warrick SS:

## AFFIDAVIT

I, Mark Garrison, 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 6 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 Citadel Communications Corp. on behalf of radio Stations WWLS (98.1 MHz.) and KATT (100.5 MHz.) in Oklahoma City, Oklahoma. to prepare this Report Of Findings.

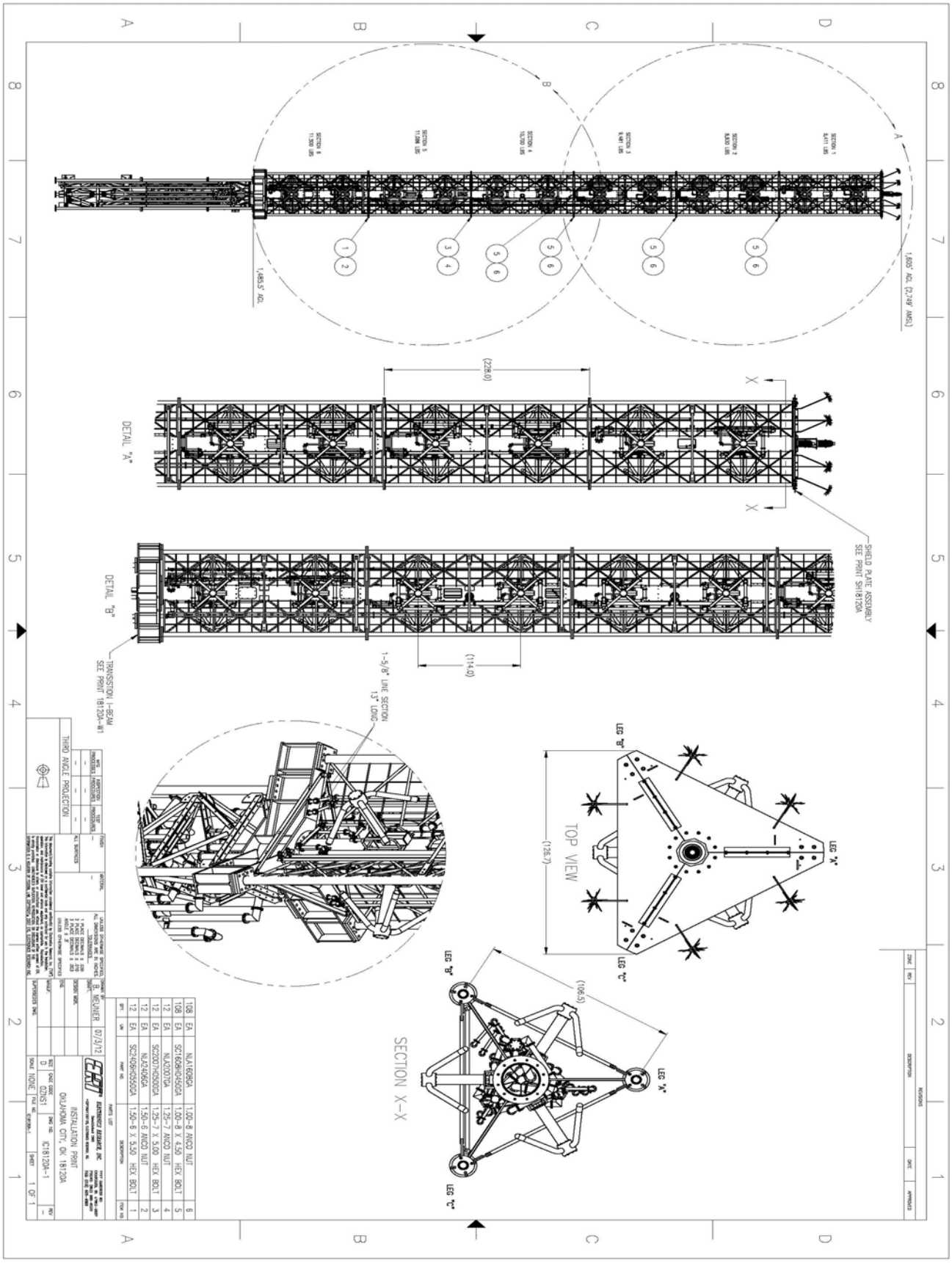
Mark Garrison; Field Technician

*Subscribed and sworn to before me on this 18th. day of March, 2008.*

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

JACQUELYN S. KINNEY
Notary Public, State of Indiana
Vanderburgh County
My Commission Expires
July 05, 2015

# EXHIBIT A-1


DETAIL "A"
DETAIL "B"
SECTION X-X
TOP VIEW
SHIELD PLATE ASSEMBLY SEE PRINT SH181204
TRANSITION I-BEAM SEE PRINT 181204-M1
1-5/8" LINE SECTION 13' LONG
INSTALLATION PRINT
OKLAHOMA CITY, OK 181204
IC181204-1

# A-2 ERI Antenna Specification Sheet

Oklahoma City. Oklahoma

## *General Specifications*

Antenna Type……High Power FM-Broadcast, Suitable for Multiplexing
Model Number ..... COG3-20P-12-240-2
Number of Bay ..... 12
Polarization Analog..... Right Hand Circular
Polarization Digital ..... Left Hand Circular

## *Electrical Specifications*

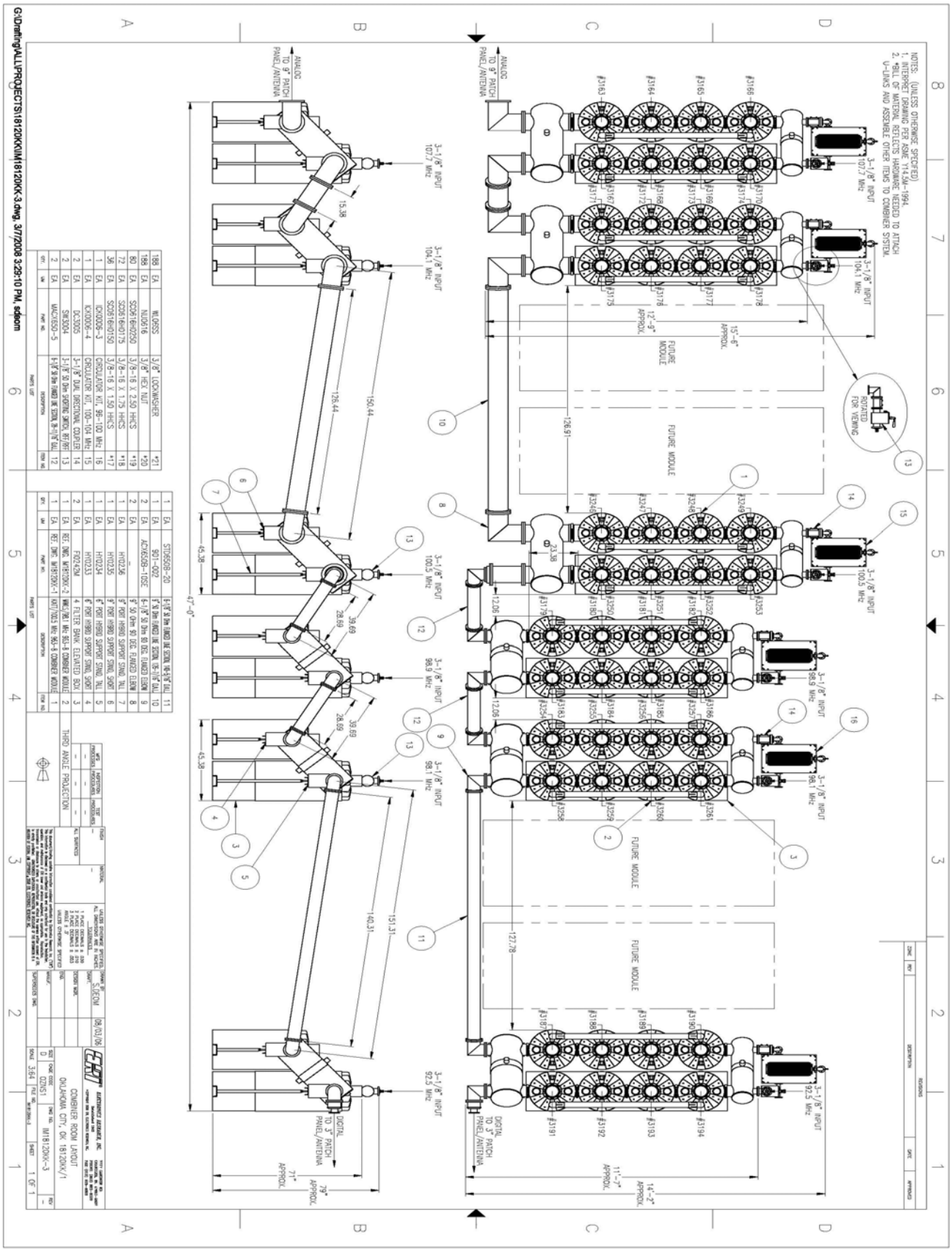
Antenna Input Power Capability . . . . . .... 240 KW Max (1).
Operating Frequency Band..... 88 ~ 108 Megahertz.
VSWR. . . . . <1.06:1 @ Operating Frequencies(2)
Azimuthal Pattern Circularity ..... Better Then +/- 2dB from RMS (Free Space)
Power Split ..... 50/50 ( Horizontal & Vertical )
Frequency Specific Information:

| Frequency | Station ERP | Beam Tilt | First Null Fill | Second Null Fill | Power Gain | Line Loss (3) | Filter Loss (4) | Computed TPO |
|---|---|---|---|---|---|---|---|---|
| 98.1 | 31kW | -0.75 | 10% | 5% | 6.102 | -0.7968 | -0.357 | 6.7kW |
| 100.5 | 31kW | -0.75 | 10% | 5% | 6.157 | -0.276 | -0.276 | 6.5kW |

## *Mechanical Specifications*

Antenna Feed System.....Fed With Two 6 1/8” Line
Input Connector ……...6 1/8”-50 Ohm EIA Flanged
Element Deicing..... None
Interbay Spacing..... 114” Center to Center
Array Length ..... 114’
Construction Material (Antenna) ..... All Noncorrosive
Construction Material (Mounting) ..... 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 1660 feet of 6 1/8” ERI MAXLINE Rigid.**
**4) Losses Taken From Actual Combiner.**



# A-4 ERI Combiner Specification Sheet

Oklahoma City. Oklahoma

## *General Specifications:*

**Multiplexer Type ..... 973-8 Series**
**Number of Combining Units ..... Six**
**Injected Port to Injected Port Isolation..... < -60 dB**
**Output Connector ..... 6 1/8 "50 Ohm EIA (Flanged)**
**Output Power (Designed) ..... 28 KW (1)**

**Heat Removal..... Natural Convection**
**Physical Arrangement..... All Components floor standing**

## *Injected Port Specifications:*

**Frequency Assignment ..... 98.1 & 100.5 MHz.**
**Power Rating, Each Injected Port (Designed) ..... 10 KW**
**Input Connector ..... 3-1/8" 50 Ohm EIA (Flanged)**
**VSWR..... < 1.1:1 @ +/-150 KHz.(2**
**Group Delay..... Less than 250ns Overall Variation, Carrier @ +/- 150 KHz.**
**Insertion Loss (Measured):**

**98.1 MHz. ……... - 0.-0.357 dB**
**100.5 MHz. ..... - 0.276 dB**

**1) Power Rating Listed is as Designed Only. Actual Power Capabilities May Vary.**
**2) When Terminated in 50 Ohm Resistive Load.**

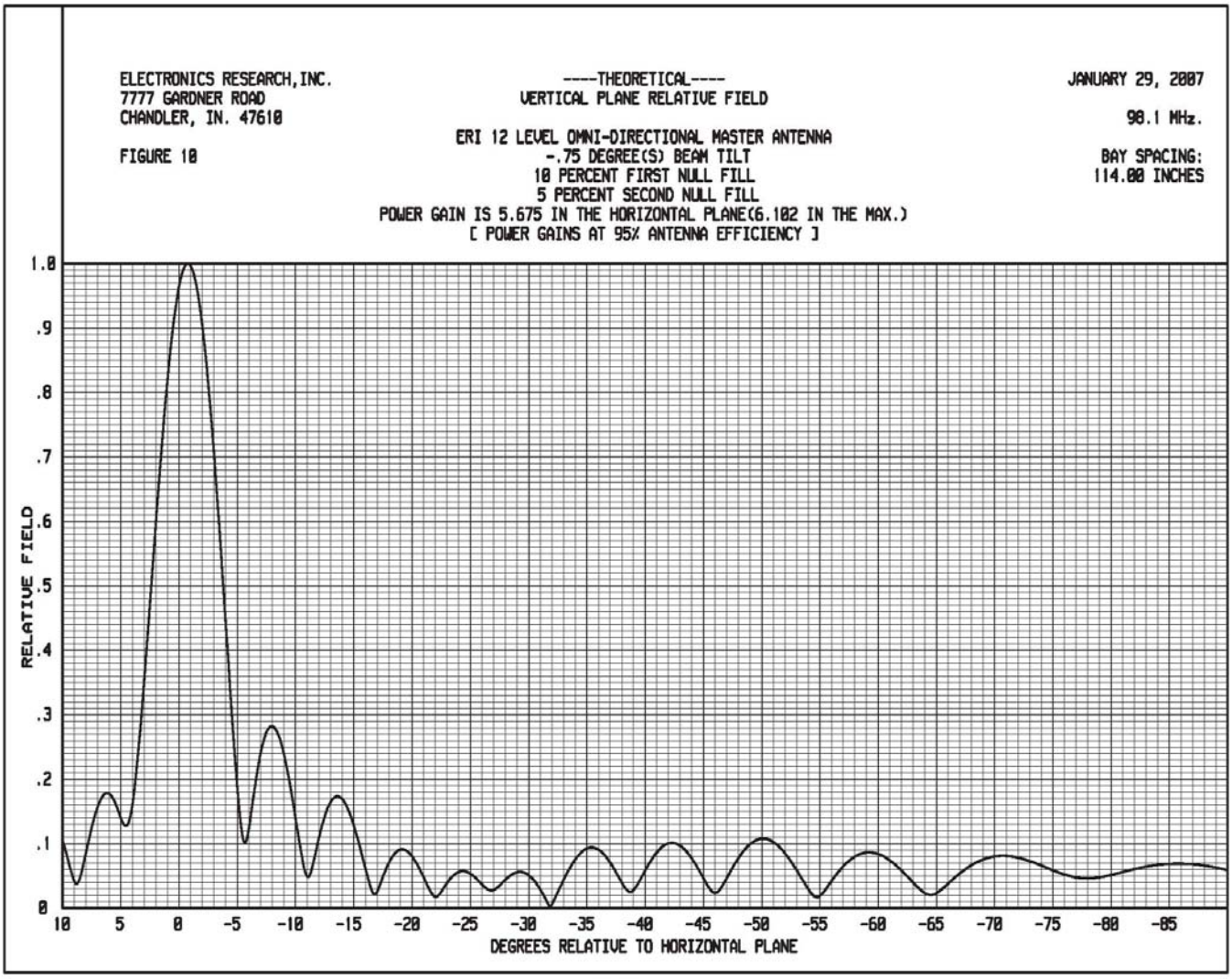
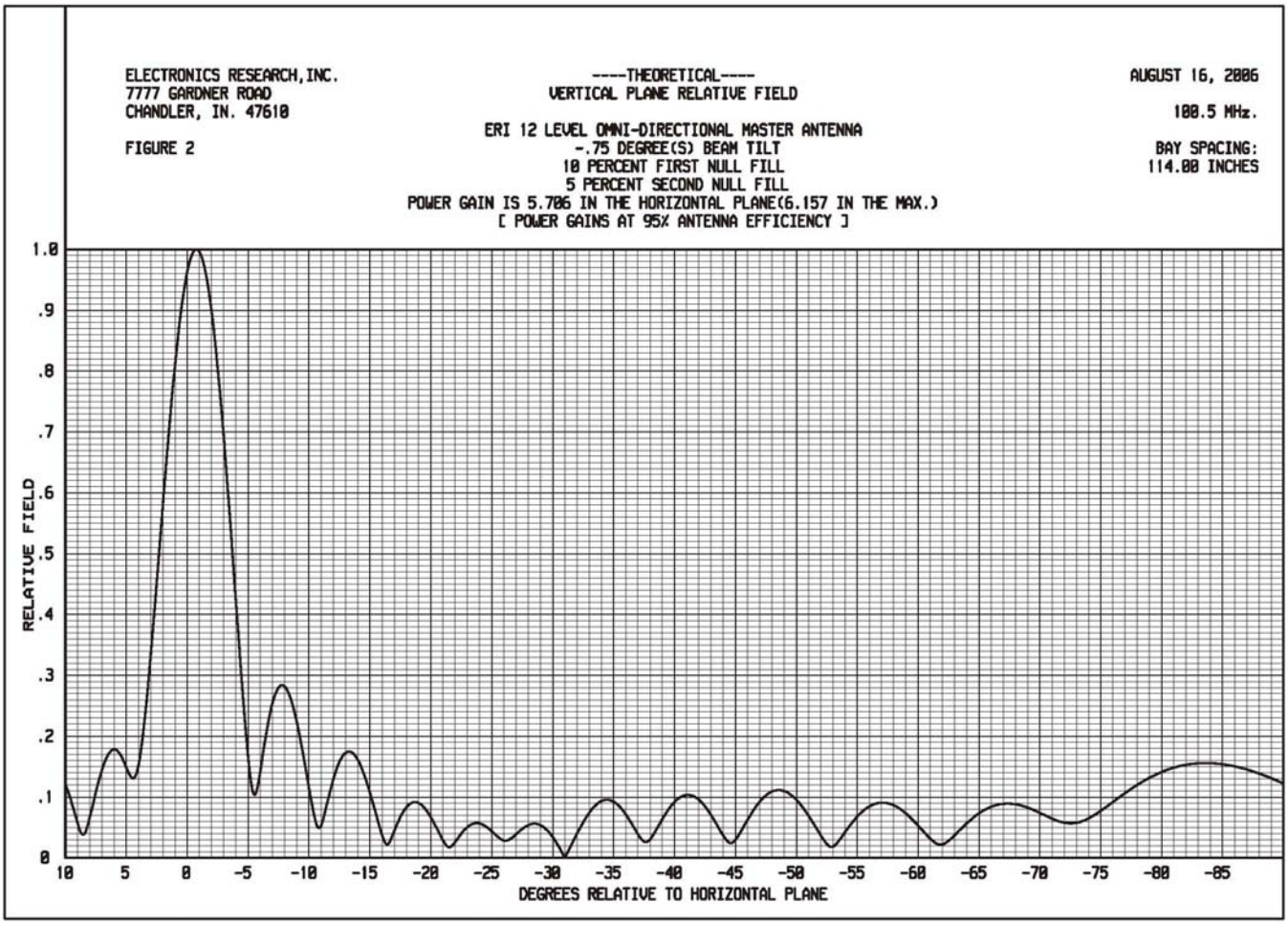
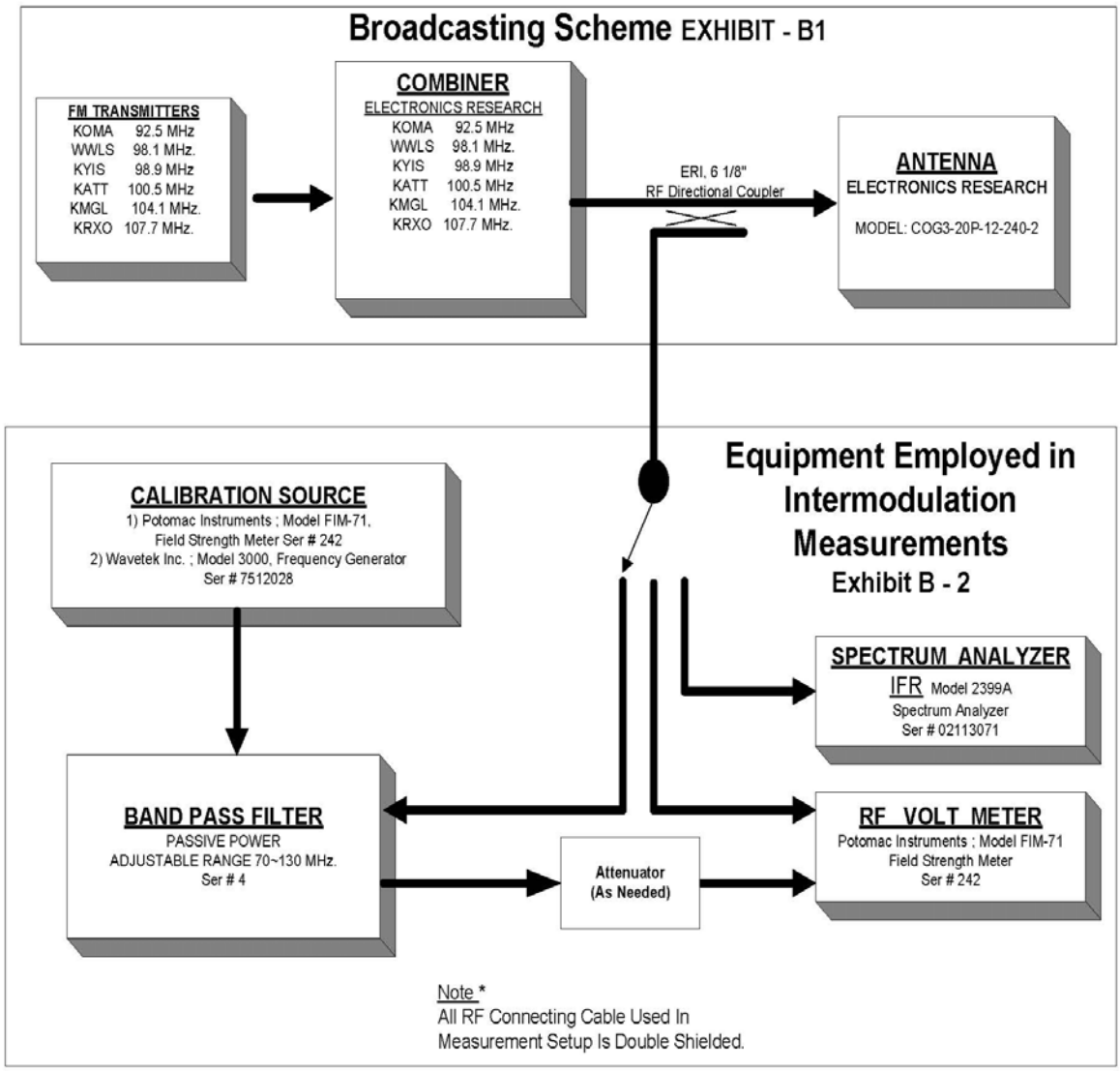

ELECTRONICS RESEARCH,INC.
7777 GARDNER ROAD
CHANDLER, IN. 47610
FIGURE 10
----THEORETICAL----
VERTICAL PLANE RELATIVE FIELD
ERI 12 LEVEL OMNI-DIRECTIONAL MASTER ANTENNA
-.75 DEGREE(S) BEAM TILT
10 PERCENT FIRST NULL FILL
5 PERCENT SECOND NULL FILL
POWER GAIN IS 5.675 IN THE HORIZONTAL PLANE(6.102 IN THE MAX.)
[ POWER GAINS AT 95% ANTENNA EFFICIENCY ]
JANUARY 29, 2007
98.1 MHz.
BAY SPACING:
114.00 INCHES
RELATIVE FIELD
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85
DEGREES RELATIVE TO HORIZONTAL PLANE

**EXHIBIT A - 5**


ELECTRONICS RESEARCH,INC.
7777 GARDNER ROAD
CHANDLER, IN. 47610
FIGURE 2
----THEORETICAL----
VERTICAL PLANE RELATIVE FIELD
ERI 12 LEVEL OMNI-DIRECTIONAL MASTER ANTENNA
-.75 DEGREE(S) BEAM TILT
10 PERCENT FIRST NULL FILL
5 PERCENT SECOND NULL FILL
POWER GAIN IS 5.706 IN THE HORIZONTAL PLANE(6.157 IN THE MAX.)
[ POWER GAINS AT 95% ANTENNA EFFICIENCY ]
AUGUST 16, 2006
100.5 MHz.
BAY SPACING:
114.00 INCHES
RELATIVE FIELD
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85
DEGREES RELATIVE TO HORIZONTAL PLANE




Broadcasting Scheme and Equipment Employed in Intermodulation Measurements

EXHIBIT B