Report Of
Intermodulation Product Findings

WEST TIGER #2

KQMV	92.5 MHz.
KMPS	94.1 MHz.
KJAQ	96.5 MHz.
KNUC	98.9 MHz.
KZOK	102.5 MHz.
KBKS	106.1 MHz.

July 27, 2020

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TABLE OF CONTENTS

Seattle, Washington

Report of Findings for Intermodulation Product Measurements

Exhibits Accompanying This Report

REPORT OF FINDINGS
ATC BROADCAST FACILITY

Introduction: This report of findings is based on data collected at the American Tower broadcast facility. The report includes measurements offered as proof that the combined operations of KQMV (92.5 MHz.), KMPS (94.1MHz.), KJAQ (96.5 MHz.), KNUC (98.9 MHz.), KZOK (102.5 MHz.), and KBKS (106.1 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). 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). Troy Knotts and Zach Condi of Electronics Research, Inc. located in Chandler, Indiana performed the measurements summarized herein on July 20, 2020.

The following exhibits are provided:

Exhibit A:
- A-1 Drawing Depicting Antenna.
- A-2 1084-8CP Antenna Specification Sheet.
- A-3 Drawing Depicting Multiplexing Scheme.
- A-4 963 Series Constant Impedance Combiner Specification Sheet.

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 F2 signifies the frequency causing the interference.

The Multiplexed System: These measurements were taken with all seven FM stations operating from the combined antenna system. The multiplexed system is fundamentally comprised of antenna, feed line and multiplexer unit. The SHPXA-16BC-HW-SP (AXIOM) antenna, Constant Impedance combiner units, and portions of the 6 1/8" rigid feedline are products of Electronics Research, Inc, whereas the majority of the 6 1/8" rigid feedline is manufactured by Myat. Refer to Exhibit B-1, for an illustration of the Broadcasting Scheme of these stations.

To accomplish the aggregation of multiple transmitter signals into a common antenna feed and provide transmitter-to-transmitter isolation, a multiplexing scheme consisting of a "Constant Impedance" combiner was installed. Specifically, the combiner utilizes ERI Model 963 series filter modules for each transmitter. The multiplexer, fully assembled, exhibited transmitter port-to-port isolation in excess of -60 dB. Other performance measurements, such as match, loss, group-delay, etc, revealed that the multiplexer unit was in proper working condition. Refer to page 13 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 -30 dB directivity and a forward signal sample of -45 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 tunable 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. An IFR Spectrum Analyzer (Model #2399A; Serial #02113071) was employed to record the level of all signals investigated. A Copper Mountain VNA (Model #S5048; Serial #15077025) was used for selective tuning of the Band Pass Filter. The IFR 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.

Carrier Frequency (MHz)	Pad One (dB)	Bandpass Filter Loss (dB)	Measured Level (dBm)	**Adjusted Level (dBm)**	Notes
92.5	6	-	19.1	**25.1**	
94.1	6	-	19.5	**25.5**	
96.5	6	-	19.8	**25.8**	
98.9	6	-	19.5	**25.5**	
102.5	6	-	20.3	**26.3**	
106.1	6	-	19.9	**25.9**	

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	94.1	96.5	98.9	102.5	106.1
92.5	---	95.7	100.5	105.3	112.5	119.7
94.1	90.9	---	98.9	103.7	110.9	118.1
96.5	88.5	91.7	---	101.3	108.5	115.7
98.9	86.1	89.3	94.1	---	106.1	113.3
102.5	82.5	85.7	90.5	95.3	---	109.7
106.1	78.9	82.1	86.9	91.7	98.9	---

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 Tiger #2

Product Frequency (MHz)	Transmitter Frequency (MHz)	Interfering Frequency (MHz)	Pad (dB)	Bandpass Filter Loss (dB)	Total Loss	Measured Level (dB)	Adjusted Level (dB)	Carrier Reference Level (dB)	Level Referenced to Carrier (dB)	Notes*

Transmitter Carrier Reference Levels

92.5	**Ref.**	6		6	19.1	25.1	**25.1**
94.1	**Ref.**	6		6	19.5	25.5	**25.5**
96.5	**Ref.**	6		6	19.8	25.8	**25.8**
98.9	**Ref.**	6		6	19.5	25.5	**25.5**
102.5	**Ref.**	6		6	20.3	26.3	**26.3**
106.1	**Ref.**	6		6	19.9	25.9	**25.9**

IM Products and Transmitter Mixes

78.9	92.5	106.1	6	12.2	18.2	-84.7	-66.5	25.1	-91.6	
82.1	94.1	106.1	6	11.8	17.8	-84.5	-66.7	25.5	-92.2	
82.5	92.5	102.5	6	11.8	17.8	-84	-66.2	25.1	-91.3	
85.7	94.1	102.5	6	11.5	17.5	-84.4	-66.9	25.5	-92.4	
86.1	92.5	98.9	6	11.4	17.4	-84.2	-66.8	25.1	-91.9	
86.9	96.5	106.1	6	11.4	17.4	-83.9	-66.5	25.8	-92.3	
88.5	92.5	96.5	6	11.3	17.3	-79.7	-62.4	25.1	-87.5	KNKX on Tiger #1
89.3	94.1	98.9	6	11.3	17.3	-83.5	-66.2	25.5	-91.7	
90.5	96.5	102.5	6	11.2	17.2	-84.9	-67.7	25.8	-93.5	
90.9	92.5	94.1	6	11.2	17.2	-84.1	-66.9	25.1	-92	
91.7	94.1	96.5	6	11.2	17.2	-84	-66.8	25.5	-92.3	
91.7	98.9	106.1	6	11.2	17.2	-84	-66.8	25.5	-92.3	
94.1	96.5	98.9	6	11.2	17.2	-84.17	-84.17	25.8	-92.77	94.1 was turned off
95.3	98.9	102.5	6	11.1	17.1	-83.6	-66.5	25.5	-92	
95.7	94.1	92.5	6	11.1	17.1	-83.7	-66.6	25.5	-92.1	
98.9	96.5	94.1	6	11.2	17.2	-83.79	-66.59	25.8	-92.39	98.9 was turned off
98.9	102.5	106.1	6	11.2	17.2	-83.79	-66.59	26.3	-92.89	98.9 was turned off
100.5	96.5	92.5	6	10.8	16.8	-83.7	-66.9	25.8	-92.7	
101.3	98.9	96.5	6	10.7	16.7	-83.4	-66.7	25.5	-92.2	
103.7	98.9	94.1	6	10.7	16.7	-80.6	-63.9	25.5	-89.4	KHTP on Tiger #1
105.3	98.9	92.5	6	10.6	16.6	-83.1	-66.5	25.5	-92	
106.1	102.5	98.9	6	10.9	16.9	-84.25	-67.35	26.3	-93.65	106.1 was turned off

Product Frequency (MHz)	Transmitter Frequency (MHz)	Interfering Frequency (MHz)	Pad (dB)	Bandpass Filter Loss (dB)	Total Loss	Measured Level (dB)	Adjusted Level (dB)	Carrier Reference Level (dB)	Level Referenced to Carrier (dB)	Notes*
108.5	102.5	96.5	6	10.6	16.6	-83.2	-66.6	26.3	-92.9	
109.7	106.1	102.5	6	10.5	16.5	-83.7	-67.2	25.9	-93.1	
110.9	102.5	94.1	6	10.4	16.4	-83.7	-67.3	26.3	-93.6	
112.5	102.5	92.5	6	10.5	16.5	-83.5	-67	26.3	-93.3	
113.3	106.1	98.9	6	10.6	16.6	-84.5	-67.9	25.9	-93.8	
115.7	106.1	96.5	6	10.4	16.4	-83.4	-67	25.9	-92.9	
118.1	106.1	94.1	6	10.4	16.4	-83.4	-67	25.9	-92.9	
119.7	106.1	92.5	6	10.4	16.4	-84.3	-67.9	25.9	-93.8	

** The IM product levels were limited to -93 dB noise floor of the IFR Spectrum Analyzer. Actual product levels listed above are lower than the levels shown on the above table.

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 July 20, 2020 as summarized in this document, I, Troy Knotts, find the subject system- specifically the transmitter and filter system for the operation of KQMV, KMPS, KJAQ, KNUC, KZOK and KBKS 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 KQMV, KMPS, KJAQ, KNUC, KZOK and KBKS 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.

Troy Knotts, Field Technician

State of Indiana)
) SS:
County of Warrick)

AFFIDAVIT

I, Troy Knotts, 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 13 years. I am familiar with and have assisted in the installation of FM Antennas and FM Multiplexers in my tenure with ERI.

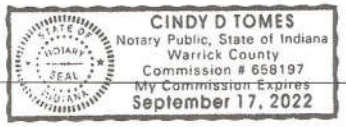
2.) I have either prepared and/or directly supervised the preparation of all technical information contained in this Report of Findings and to my knowledge to be accurate and true.

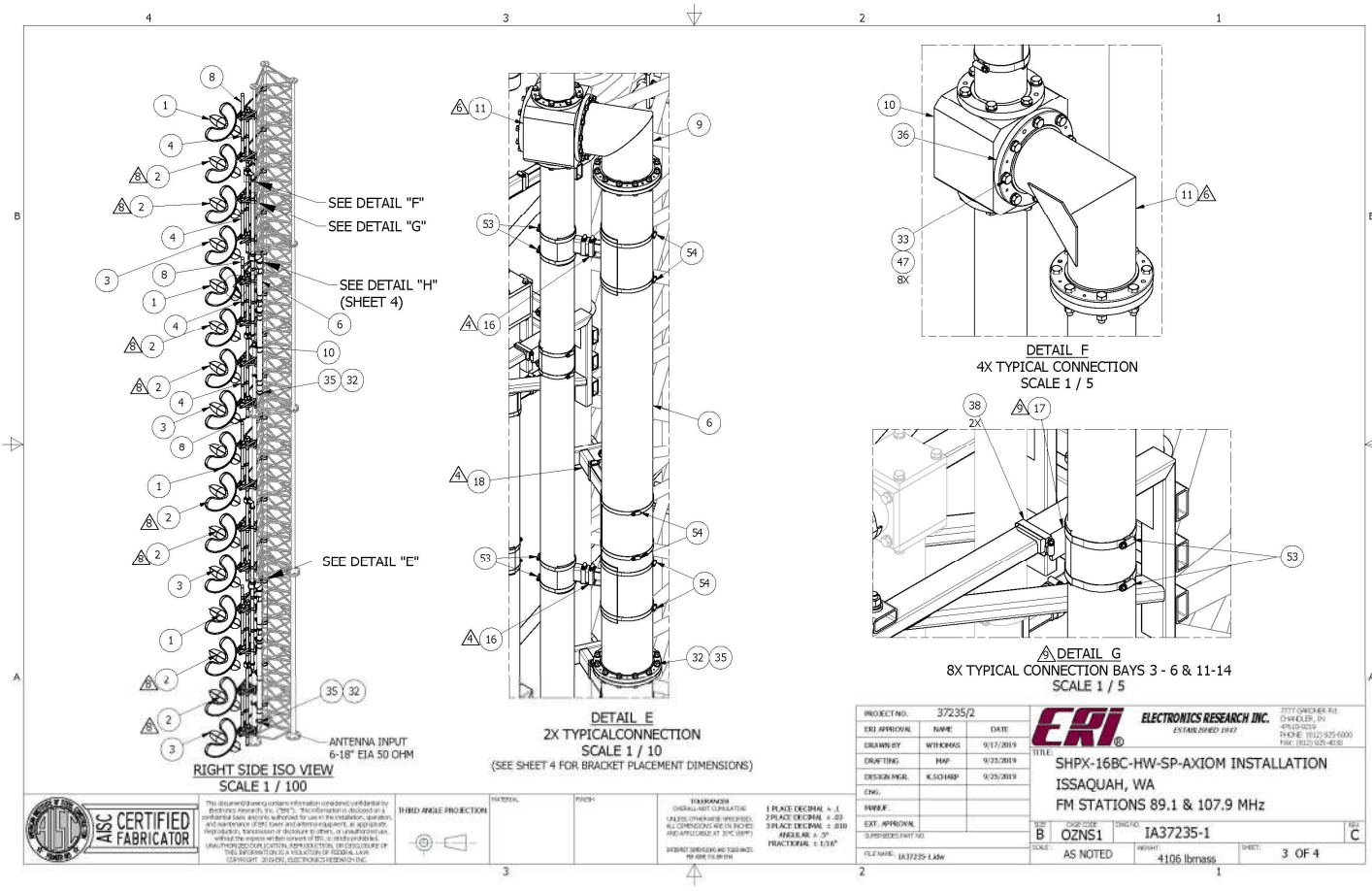
3.) ERI has been requested by American Tower on behalf of the radio stations KQMV, KMPS, KJAQ, KNUC, KZOK, and KBKS to prepare this Report of Findings.

Troy Knotts; Field Technician

Subscribed and sworn to before me on this 27th, day of July, 2020.

My commission expires 09/17/2022




SEE DETAIL "F"
SEE DETAIL "G"
SEE DETAIL "H"
(SHEET 4)
SEE DETAIL "E"
ANTENNA INPUT
6-18" EIA 50 OHM
RIGHT SIDE ISO VIEW
SCALE 1 / 100
DETAIL E
2X TYPICALCONNECTION
SCALE 1 / 10
(SEE SHEET 4 FOR BRACKET PLACEMENT DIMENSIONS)
DETAIL F
4X TYPICAL CONNECTION
SCALE 1 / 5
DETAIL G
8X TYPICAL CONNECTION BAYS 3 - 6 & 11-14
SCALE 1 / 5
AISC CERTIFIED FABRICATOR
ELECTRONICS RESEARCH INC.
ESTABLISHED 1947
SHPX-16BC-HW-SP-AXIOM INSTALLATION
ISSAQUAH, WA
FM STATIONS 89.1 & 107.9 MHz
IA37235-1
AS NOTED
4106 lbmass
3 OF 4

ELECTRONICS RESEARCH, INC. ERI

EXHIBIT, A - 2

A-2 ERI Antenna Specification Sheet

American Tower West Tiger #2
Seattle, Washington

General Specifications

Antenna Type .....High Power ERI AXIOM®0 FM-Broadcast, Suitable For Multiplexing
Model Number .....SHPXA-16BC-HW-SP (AXIOM)
Number of Bay Levels.....Sixteen
Polarization ..... Circular

Electrical Specifications

Antenna Input Power Capability..... Each half 120 KW Max (1)
Operating Frequency Band ..... 88 ~ 108 Megahertz.
VSWR. .....<1.25:1 @ Operating Frequencies (2)
Azimuthal Pattern Circularity ..... Better Then +/- 2dB From RMS (Free Space)
Power Split ..... 50/50 (Horizontal & Vertical)
Frequency Specific Information:

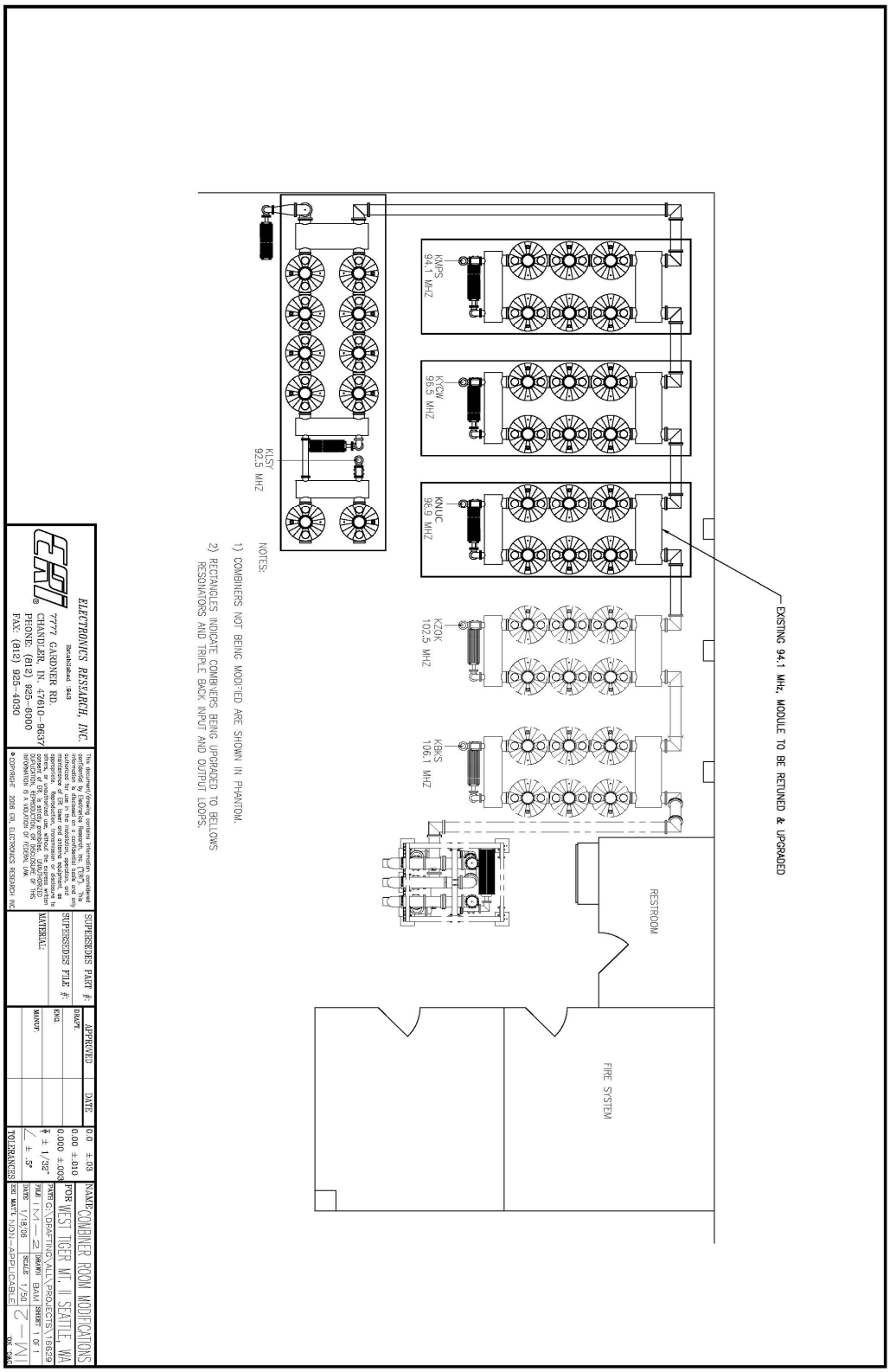
Frequency	Station ERP	Beam Tilt	First Null Fill	Second Null Fill	Power Gain	Line Loss (3)	Filter Loss (4)	Computed Analog TPO
92.5	**60 KW**	**-0.99°**	**10.1 %**	**5%**	**4.398**	**.156 dB**	**.414 dB**	**15.55 KW**
94.1	**73 KW**	**-0.99°**	**10 %**	**5%**	**4.479**	**.157 dB**	**.284 dB**	**18.04 KW**
96.5	**70 KW**	**-0.99°**	**10 %**	**5%**	**4.595**	**.159 dB**	**.223 dB**	**16.63 KW**
98.9	**68 KW**	**-0.99°**	**9.9 %**	**5%**	**4.701**	**.161 dB**	**.236 dB**	**18.85 KW**
102.5	**73 KW**	**-0.99°**	**9.9 %**	**5%**	**4.840**	**.164 dB**	**.297 dB**	**16.77 KW**
106.1	**73 KW**	**-0.99°**	**9.8 %**	**5%**	**4.951**	**.167 dB**	**.254 dB**	**16.24 KW**

Mechanical Specifications

Antenna Feed System ..... Fed With Two 6 1/8" Lines
Input Connector .....6 1/8"-50 Ohm EIA Flanged
Element Deicing.....Radomes
Interbay Spacing ..... 60" Center to Center
Array Length..... 79.7 ft
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 333 Feet, 6 1/8" Myat/ERI Rigid.
4) Losses Taken From Actual Combiner.

EXHIBIT, A – 3


G:\Drafting\ALL\PROJECTS\16629\IM-2.dwg, 7/5/2006 12:49:44 PM, bmeurier
EXSTING 94.1 MHz, MODULE TO BE RETUNED & UPGRADED
KMPS 94.1 MHZ
KYOW 96.5 MHZ
KNUC 98.9 MHZ
KZOK 102.5 MHZ
KBKS 106.1 MHZ
KLSY 92.5 MHZ
RESTROOM
FIRE SYSTEM
NOTES:
1) COMBINERS NOT BEING MODIFIED ARE SHOWN IN PHANTOM.
2) RECTANGLES INDICATE COMBINERS BEING UPGRADED TO BELLOWS RESONATORS AND TRIPLE BACK INPUT AND OUTPUT LOOPS.
ELECTRONICS RESEARCH, INC.
7777 GARDNER RD.
CHANDLER, IN. 47610-9637
PHONE: (812) 925-6000
FAX: (812) 925-4030
SUPERSEDES PART #:
SUPERSEDES FILE #:
MATERIAL:
NAME COMBINER ROOM MODIFICATIONS
FOR WEST TIGER MT. II SEATTLE, WA
PATH G:\DRAFTING\ALL\PROJECTS\16629
FILE IM1 — 2
DRAWN BAM
SHEET 1 OF 1
DATE 7/18/06
SCALE 1/50
ERI MFR'S NON-APPLICABLE
SIZE D — VAL
TOLERANCES

A-4 ERI Combiner Specification Sheet

American Tower West Tiger #2
Seattle, Washington

General Specifications:

Multiplexer Type ..... Constant Impedance "Series 963"
Number of Combining Units ..... Six
Injected Port to Injected Port Isolation ..... < - 50 dB
Output Connector ..... 6 1/8 "50 Ohm EIA (Flanged)
Output Power (Designed) ..... 140 KW(1)

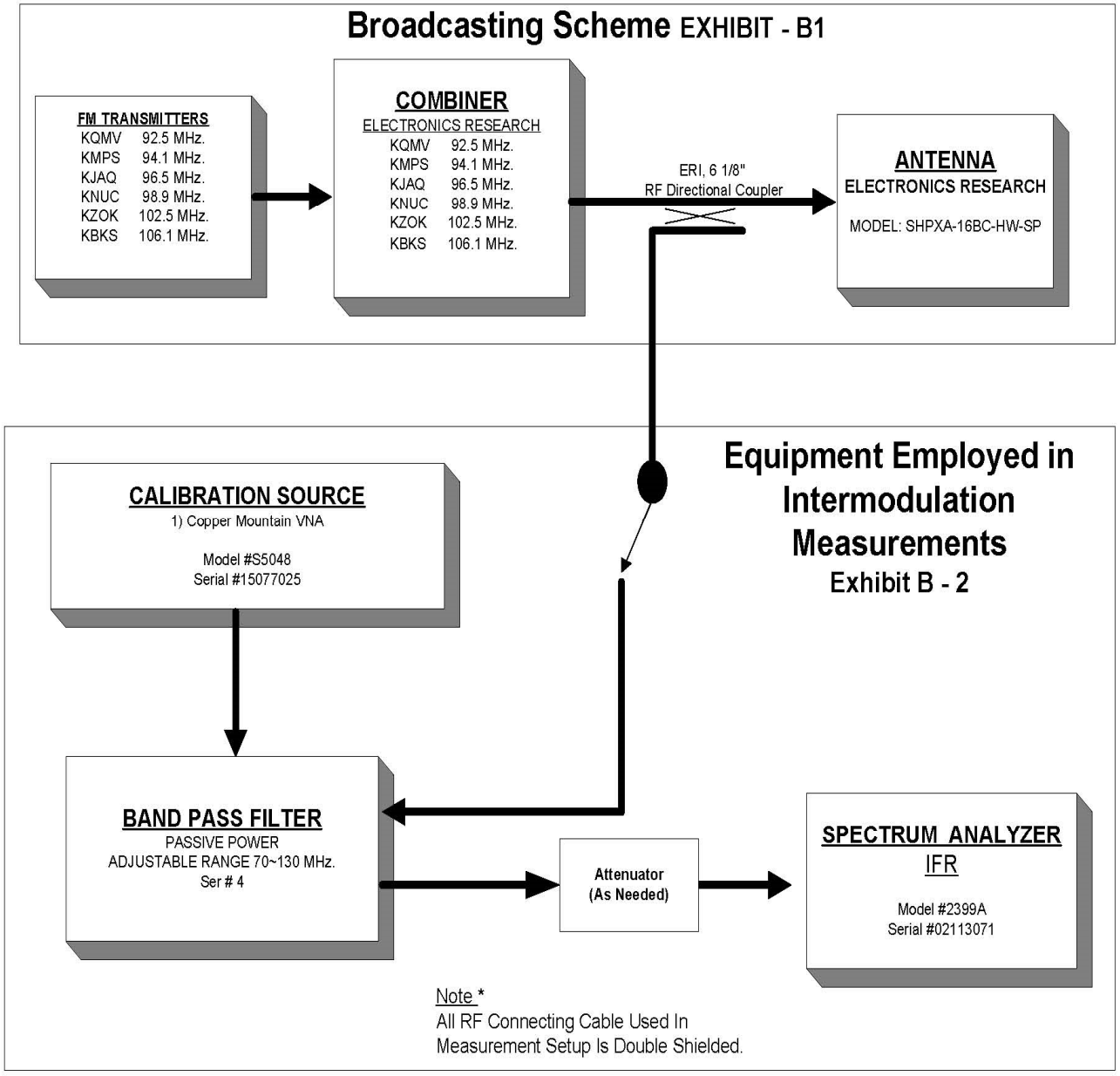
Heat Removal (All Multiplexer Components) ..... Natural Convection
Physical Arrangement ..... All Components floor standing

Injected Port Specifications:

Frequency Assignment .....92.5, 94.1, 96.5, 98.9, 102.5, and 106.1 MHz.
Power Rating, Each Injected Port (Designed) .....26 KW
Input Connector .....3-1/8" 50 Ohm EIA (Flanged)
VSWR..... < 1.08:1 @ +/-150 KHz.(2
Group Delay .....Less than 75 ns Overall Variation, Carrier @ +/- 150 KHz.
Insertion Loss (Measured):

92.5 MHz. ..... - 0.414 dB
94.1 MHz. ..... - 0.284 dB
96.5 MHz. ..... - 0.223 dB
98.9 MHz. ..... - 0.236 dB
102.5 MHz. ..... - 0.297 dB
106.1 MHz. ..... - 0.254 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