



ELECTRONICS RESEARCH, INC.

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Report Of Intermodulation Product Findings

*EMPIRE STATE BUILDING MASTER FM BROADCAST FACILITY
NEW YORK, NEW YORK*

<i>WXRK</i>	<i>WNEW</i>
<i>WQXR</i>	<i>WKTU</i>
<i>WSKQ</i>	<i>WAXQ</i>
<i>WRKS</i>	<i>WWPR</i>
<i>WBAI</i>	<i>WCAA</i>
<i>WHTZ</i>	<i>WLTW</i>
<i>WQCD</i>	<i>WBLS</i>

April 2003

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Empire State Building

New York, NY.

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REPORT OF FINDINGS

EMPIRE STATE BUILDING MASTER FM BROADCAST FACILITY NEW YORK, NEW YORK

Introduction : This report of findings is based on data collected at the Empire State Building ERI Master FM broadcast facility located in New York, NY. The report includes out of the FM band measurements offered as evidence that the combined operations of WXRK (92.3 MHz.), WQXR (96.3 MHz.), WSKQ (97.9 MHz.), WRKS (98.7 MHz.), WBAI (99.5 MHz.), WHTZ (100.3 MHz.), WQCD (101.9 MHz.), WNEW (102.7 MHz.), WKTU (103.5 MHz.), WAXQ (104.3 MHz.), WWPR (105.1 MHz.), WCAA (105.9 MHz.), WLTW (106.7 MHz.) and WBLS (107.5 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 (d). In brief, the collection of measurements presented in this report considered only the products that fall outside the FM frequency band. At the time of these measurements, the system users were unable to not interrupt operation, in order to allow measuring the level of any emissions being generated on this system inside the FM frequency band (88 MHz. - 108 MHz). All measured third order inter-modulation (IM) products generated by this multiplex system are less than the maximum allowable level as required by section 73.317 paragraph (d). WPLJ (95.5 MHz.), WQHT (97.1 MHz.) and WCBS (101.1 MHz.) operate into separate side mounted antennas located on top of the Empire State Building. Their effects on the stations operating from the multiplexed system are considered in this report. Mark Steapleton and Jeff Taylor of Electronics Research, Inc. located in Chandler, Indiana performed the measurements summarized herein on April 27, 2003.

The following exhibits are provided:

Exhibit A:

A-1 Drawing Depicting Antenna.

A-2 Drawing Depicting Multiplexing Scheme.

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 were measured that could 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 : At the time of the measurements 14 FM stations were operating from the combined antenna system. The Master FM multiplexed system is fundamentally comprised of antenna, feed line and multiplexer unit. The COG 1084-2 CP antenna and 963 Constant Impedance Modules are products of Electronics Research, Inc, whereas the feed line is manufactured by Dielectric. Refer to Exhibit B-1, for an illustration of the Broadcasting Scheme of these stations.

To accomplish the aggregation of 14 transmitter signals into a common antenna feed and provide transmitter-to-transmitter isolation, a multiplexing scheme consisting of Combiner modules is used. Specifically, fourteen ERI 963-8 combiner modules with Group Delay Compensation are used. The combiner is illustrated in the attached Exhibit A-2. Performance measurements, such as match, insertion loss, group-delay, etc, revealed that the multiplexer unit was in proper working condition.

The IM Investigation : Directional Couplers were placed at key locations throughout the combiner to monitor and maintain the multiplexers 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 combiner 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 -47 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 the Spectrum Analyzer to ensure an adequate signal level for measurements without overloading the measurement equipment. An IFR 2399A Spectrum Analyzer was employed to record the level of all signals investigated. To facilitate the selective tuning of the Band Pass Filter the Tracking Generator option built into the Spectrum analyzer was used. Also, the Spectrum Analyzer 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-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 stations of concern were operating at their full licensed power level. From the equipment setup described above, the relative output signal level of each station's 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
WXRK (92.3)	10	---	-3.91	6.09	
WQXR (96.3)	10	---	-3.25	6.75	
WSKQ (97.9)	10	---	-4.5	5.50	
WRKS (98.7)	10	---	-3.33	6.67	
WBAI (99.5)	10	---	-5.13	4.87	
WHTZ (100.3)	10	---	-3.61	6.39	
WQCD (101.9)	10	---	-3.19	6.81	
WNEW (102.7)	10	---	-3.58	6.42	
WKTU (103.5)	10	---	-4.08	5.92	
WAXQ (104.3)	10	---	-4.00	6.00	
WWPR (105.1)	10	---	-2.75	7.25	
WCAA (105.9)	10	---	-15.83	-5.83	
WLTW (106.7)	10	---	-2.77	7.23	
WBLS (107.5)	10	---	-4.16	5.84	

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.

Mix Freq.	Carrier Frequency (MHz)													
	92.3	96.3	97.9	98.7	99.5	100.3	101.9	102.7	103.5	104.3	105.1	105.9	106.7	107.5
92.3	---	100.3	103.5	105.1	106.7	108.3	111.5	113.1	114.7	116.3	117.9	119.5	121.1	122.7
95.5	89.1	97.1	100.3	101.9	103.5	105.1	108.3	109.9	111.5	113.1	114.7	116.3	117.9	119.5
96.3	88.3	---	99.5	101.1	102.7	104.3	107.5	109.1	110.7	112.3	113.9	115.5	117.1	118.7
97.1	87.5	95.5	98.7	100.3	101.9	103.5	106.7	108.3	109.9	111.5	113.1	114.7	116.3	117.9
97.9	86.7	94.7	---	99.5	101.1	102.7	105.9	107.5	109.1	110.7	112.3	113.9	115.5	117.1
98.7	85.9	93.9	97.1	---	100.3	101.9	105.1	106.7	108.3	109.9	111.5	113.1	114.7	116.3
99.5	85.1	93.1	96.3	97.9	---	101.1	104.3	105.9	107.5	109.1	110.7	112.3	113.9	115.5
100.3	84.3	92.3	95.5	97.1	98.7	---	103.5	105.1	106.7	108.3	109.9	111.5	113.1	114.7
101.1	83.5	91.5	94.7	96.3	97.9	99.5	102.7	104.3	105.9	107.5	109.1	110.7	112.3	113.9
101.9	82.7	90.7	93.9	95.5	97.1	98.7	---	103.5	105.1	106.7	108.3	109.9	111.5	113.1
102.7	81.9	89.9	93.1	94.7	96.3	97.9	101.1	---	104.3	105.9	107.5	109.1	110.7	112.3
103.5	81.1	89.1	92.3	93.9	95.5	97.1	100.3	101.9	---	105.1	106.7	108.3	109.9	111.5
104.3	80.3	88.3	91.5	93.1	94.7	96.3	99.5	101.1	102.7	---	105.9	107.5	109.1	110.7
105.1	79.5	87.5	90.7	92.3	93.9	95.5	98.7	100.3	101.9	103.5	---	106.7	108.3	109.9
105.9	78.7	86.7	89.9	91.5	93.1	94.7	97.9	99.5	101.1	102.7	104.3	---	107.5	109.1
106.7	77.9	85.9	89.1	90.7	92.3	93.9	97.1	98.7	100.3	101.9	103.5	105.1	---	108.3
107.5	77.1	85.1	88.3	89.9	91.5	93.1	96.3	97.9	99.5	101.1	102.7	104.3	105.9	---

Using the equipment previously described the IM product measurements were recorded and are listed in Table 3 for the predictable products falling outside the FM band. The signal levels referenced to the carriers are calculated and listed in the column labeled "Level Referenced to Carrier". Refer to Exhibit B for a layout of the measurement equipment.

Table 3 Intermodulation Measurements

Product Frequency (MHz)	Carrier Freq. (MHz)	Interferin g Freq. (MHz)	Pad (dB)	Bandpass Filter Loss (dB)	Measured Level (dBm)	Carrier Reference Level (dBm) (See Table 1)	Level Referenced to Carrier (dB)	Notes
77.1	92.3	107.5	3	8.8	-113.5	6.09	-107.8	
77.9	92.3	106.7	3	9.3	-116.0	6.09	-109.8	
78.7	92.3	105.9	3	8.3	-111.2	6.09	-106.0	
79.5	92.3	105.1	3	8.0	-114.0	6.09	-109.1	
80.3	92.3	104.3	3	7.8	-113.1	6.09	-108.4	
81.1	92.3	103.5	3	7.8	-117.3	6.09	-112.6	
81.9	92.3	102.7	3	7.5	-111.9	6.09	-107.5	
82.7	92.3	101.9	3	7.1	-115.1	6.09	-111.1	
83.5	92.3	101.1	3	6.7	-113.0	6.09	-109.4	
84.3	92.3	100.3	3	6.4	-113.0	6.09	-109.7	
85.1	92.3 96.3	99.5 107.5	3	6.1	-108.6	6.09	-105.6	1
85.9	92.3 96.3	98.7 106.7	3	6.0	-112.9	6.09	-110.0	1
86.7	92.3 96.3	97.9 105.9	3	5.8	-108.2	6.09	-105.5	1
87.5	92.3 96.3	97.1 105.1	3	5.75	-112.2	6.09	-109.5	1
108.3	105.1 100.3 103.5 104.3 107.5 101.9 102.7 105.9 106.7	101.9 92.3 98.7 100.3 106.7 95.5 97.1 103.5 105.1	19	7.0	-110.6	-5.83	-78.8	1 & 2
109.1	103.5 104.3 105.1 107.5 102.7 105.9 106.7	97.9 99.5 101.1 105.9 96.3 102.7 104.3	9	7.2	-112.6	-5.83	-90.6	1
109.9	104.3 105.1 102.7 103.5 105.9 106.7 107.5	98.7 100.3 95.5 97.1 101.9 103.5 105.1	3	7.3	-109.3	-5.83	-93.2	1
110.7	104.3 105.1 103.5 106.7 107.5 105.9	97.9 99.5 96.3 102.7 104.3 101.1		7.3	-113.9	-5.83	-100.8	1

Product Frequency (MHz)	Carrier Freq. (MHz)	Interferin g Freq. (MHz)	Pad (dB)	Bandpass Filter Loss (dB)	Measured Level (dBm)	Carrier Reference Level (dBm) (See Table 1)	Level Referenced to Carrier (dB)	Notes
111.5	105.1 103.5 104.3 106.7 107.5 101.9 105.9	98.7 95.5 97.1 101.9 103.5 92.9 100.3		7.4	-111.4	-5.83	-98.2	1
112.3	105.1 104.3 107.5 105.9 106.7	97.9 96.3 102.7 99.5 101.1		7.4	-110.9	-5.83	-97.7	1
113.1	104.3 105.1 107.5 102.7 105.9 106.7	95.5 97.1 101.9 92.3 98.7 100.3		7.35	-111.0	-5.83	-97.8	1
113.9	105.1 105.9 106.7 107.5	96.3 97.9 99.5 101.1		7.4	-110.9	-5.83	-97.7	1
114.7	105.1 103.5 106.7 107.5 105.9	95.5 92.3 98.7 100.3 97.1		7.3	-111.7	-5.83	-98.6	1
115.5	106.7 107.5 105.9	97.9 99.5 96.3		7.3	-108.1	-5.83	-95.0	1
116.3	104.3 107.5 105.9 106.7	92.3 98.7 95.5 97.1		7.2	-108.0	-5.83	-95.0	1
117.1	107.5 106.7	97.9 96.3		7.2	-111.8	5.84	-110.4	1
117.9	105.1 106.7 107.5	92.3 95.5 97.1		7.3	-116.0	5.84	-114.5	1
118.7	107.5	96.3		7.1	-117.3	5.84	-116.0	
119.5	107.5 105.9	95.5 92.3		7.0	-116.8	-5.83	-104.0	1
121.1	106.7	92.3		6.8	-116.3	5.84	-115.3	
122.7	107.5	92.3		6.3	-118.1	5.84	-117.6	

*** NOTES**

- 1) The Level Referenced to Carrier was calculated using the lowest Carrier Reference level (Bold) for this IM product.
- 2) This Level is less than $43 + 10 \text{ Log (Power in Watts)}$ when referenced to 105.9 MHz. Carrier Reference Level, and is less than -80 dB below all other carrier reference levels.

The Spectrum Analyzer was used to check the close-in spectral attenuation of each carrier to investigate that the operation of the transmitters are in compliance with Sections (b) and (c) of the FCC Rules and Regulations. Because of limits in the measurement setup, the accuracy of the occupied bandwidth of the transmitters were within +/- 1dB of the FCC requirements.

As a final proof of the system's 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. The search ranged the complete frequency span of the receiver and resulted in no additional investigations

Conclusion : Based upon my observations and measurements taken April 27, 2003 as summarized in this document, I, Mark Steapleton, find the subject multiplexed system- specifically the transmitters and combiner system for the operation of the WXRK, WQXR, WSKQ, WRKS, WBAI, WHTZ, WQCD, WNEW, WKTU, WAXQ, WWPR, WCAA, WLTW and WBLS into the COG 1084-2 CP antenna- to be in proper working order. Based on this recorded data. I conclude that WXRK, WQXR, WSKQ, WRKS, WBAI, WHTZ, WQCD, WNEW, WKTU, WAXQ, WWPR, WCAA, WLTW and WBLS are in compliance with the requirements of Section 73.317 paragraph (d) of the FCC Rules and Regulations. The measured data shows that no IM products in excess of the allowable levels exist outside the FM band. By analysis of previously measured characteristics of the filter / combiner system, it is my opinion that the transmitter to transmitter isolation is sufficient to ensure IM products within the FM band are below the allowable levels. These predictable IM products within the FM band were not able to be measured, however, as previously stated.

Respectfully submitted,
Electronics Research, Inc.

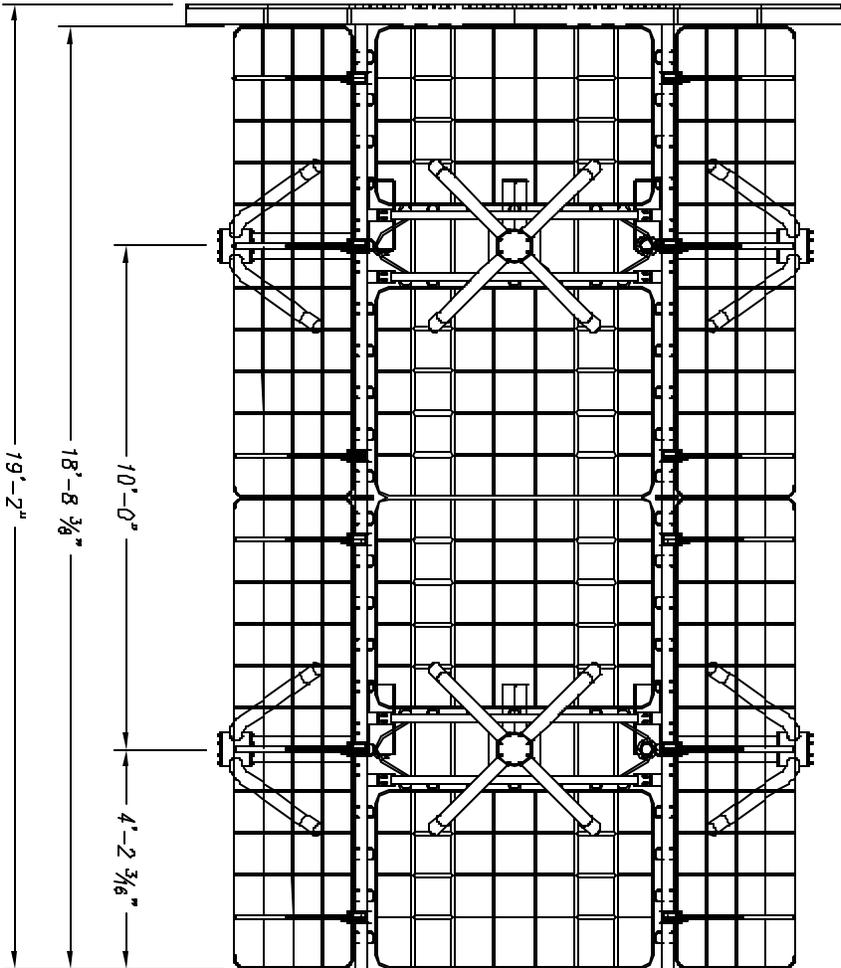
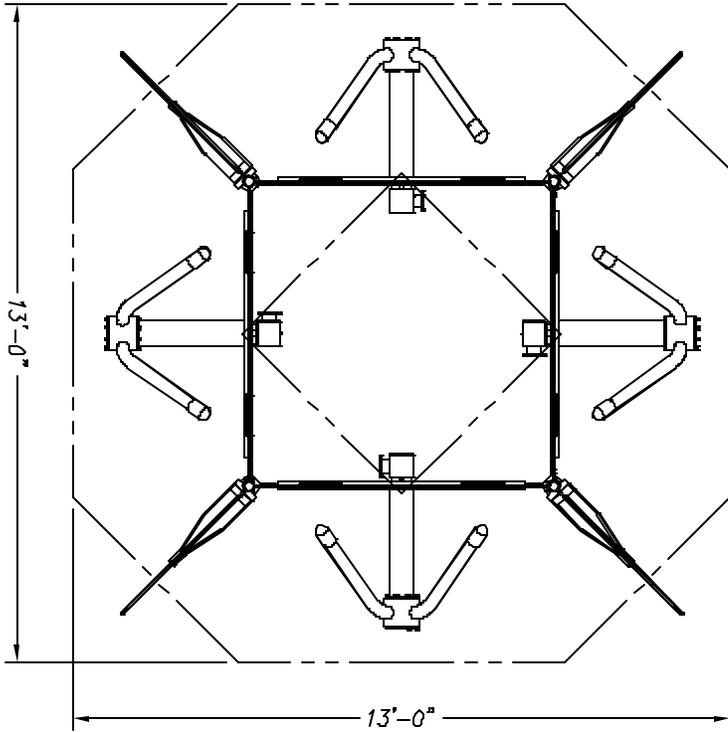
By 
Mark Steapleton Field Technician



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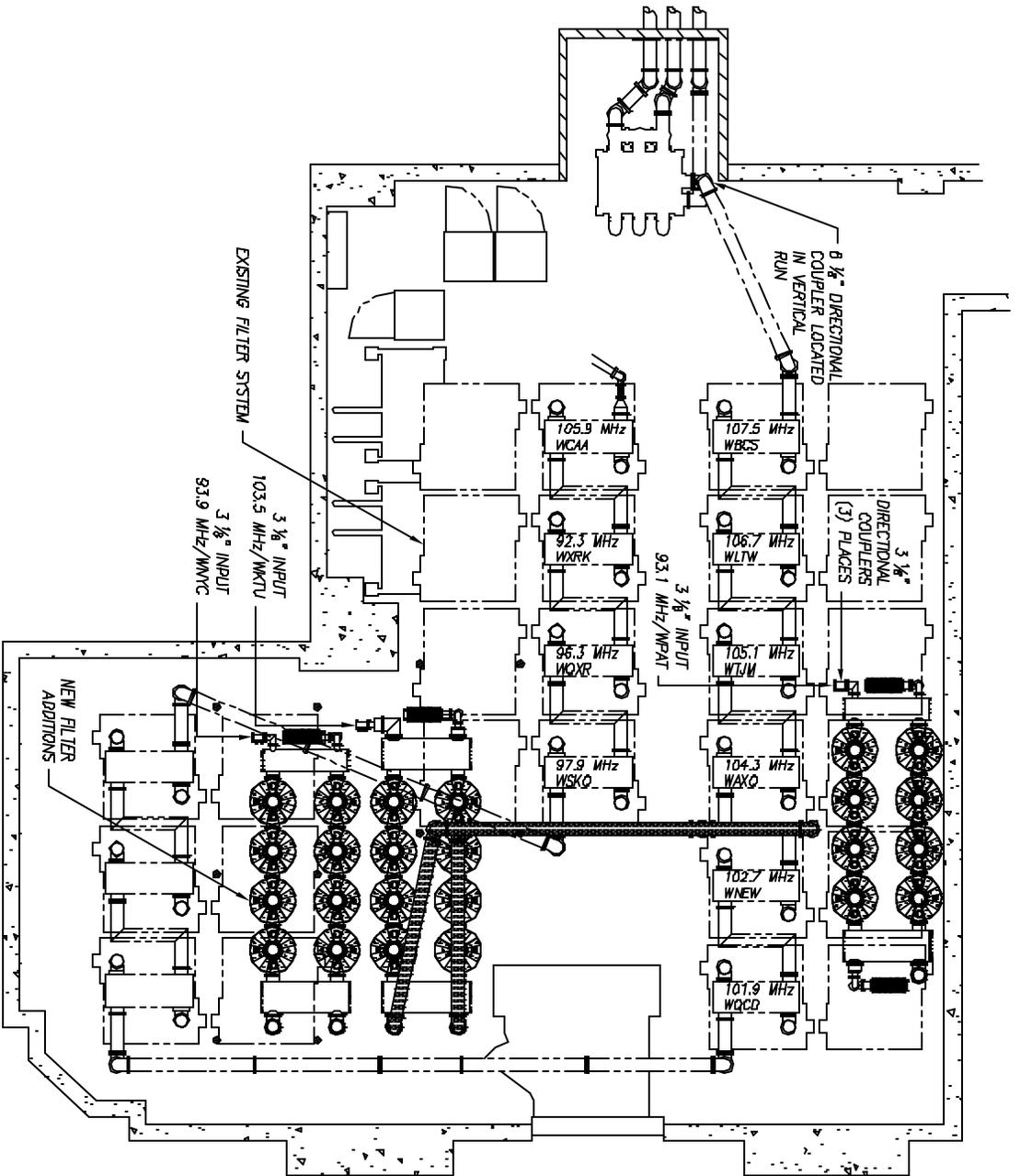
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DATE: 5/12/03	APPROVED:	
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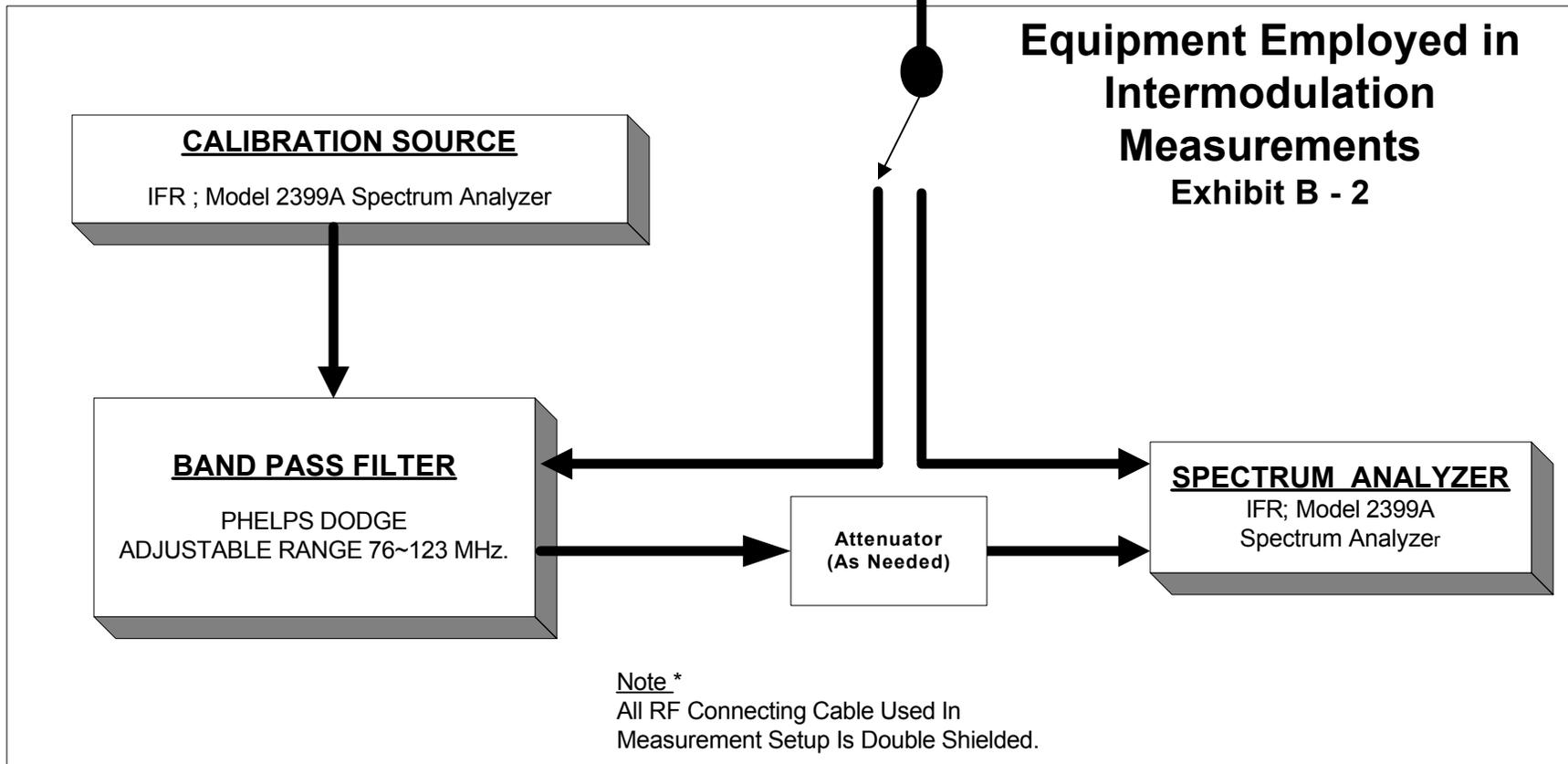
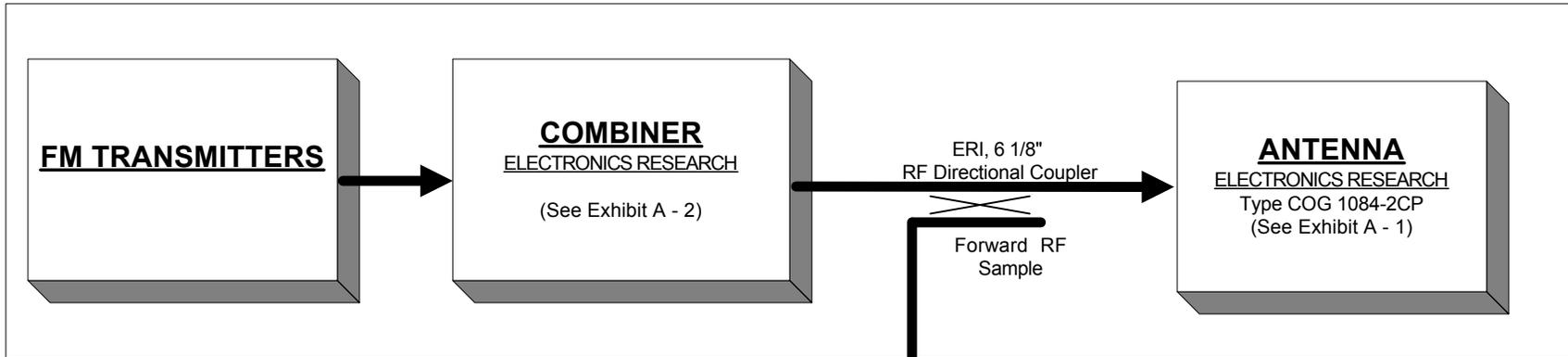
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DATE	5/8/03	APPR	
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Broadcasting Scheme EXHIBIT - B1



Broadcasting Scheme and Equipment Employed in Intermodulation Measurements