ELECTRONICS RESEARCH, INC.
7777 Gardner Road • Chandler, Indiana 47610 • (812) 925-6000 • Fax: (812) 925-4030 • Home Page: www.ERIinc.com

Report Of Intermodulation Product Findings

KBPQ ~ WJJY FM BROADCAST FACILITY
BRAINERD, MINNESOTA

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Electronics Research Inc.
7777 Gardner Road
Chandler, Indiana 47610
Phone (812) 925-6000 Fax (812) 925- 4030

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REPORT OF FINDINGS
KBPQ / WJJY BROADCAST FACILITY
BRAINERD, MINNESOTA

Introduction : This report of findings is based on data collected at the KBPQ / WJJY FM broadcast facility located in Brainerd, MN. The report includes measurements offered as proof that the operations of KBPQ and WJJY 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 second 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 Steapleton of Electronics Research, Inc. located in Chandler, Indiana performed the measurements summarized herein on December 2, 2001.

The following exhibits are provided:

Exhibit A:
- A-1 Drawing Depicting Antenna.
- A-2 SHPX 10AC-SP Antenna Specification Sheet.
- A-3 Drawing Depicting Multiplexing Scheme.
- A-4 TB-6/6 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 Second 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 second 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 second 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 my measurements two FM stations were operating from the combined antenna system. The KBPQ, and WJJY multiplexed system is fundamentally comprised of antenna, feed line and multiplexer unit. The SHPX 10AC-SP antenna and TB-6/6 multiplexer units are products of Electronics Research, Inc, whereas the feed line is manufactured by Myat, Refer to Exhibit B-2, for an illustration of the Broadcasting Scheme of these stations.

To accomplish the aggregation of transmitter signals into a common antenna feed and provide transmitter-to-transmitter isolation, a multiplexing scheme consisting of a Tee Combiner module was installed. Specifically, the Multiplexer utilizes three ERI Model 963 Bandpass filters for each transmitter. An interconnecting TEE is required to complete the multiplexer module. The combiner is illustrated in the attached Exhibit A-3. 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 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 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 -60 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 FIM71 to ensure an adequate signal level for measurements without overloading the measurement equipment. A Potomac Instruments FIM-71 Field Strength Receiver 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 signal generator was used. An Anritsu Model S114B 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-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)	Full Scale Range (dBμ)	Scale Reading (dB)	Adjusted Level (dBμ)	Notes
KBPQ (93.3)	---	---	120	-1.2	**118.8**	
WJJY (106.7)	---	---	140	-19.5	**120.5**	

Predictable second-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 - Second order Products.

	Carrier Frequency (MHz)	
Interfering Frequency (MHz)	**KBPQ 93.3**	**WJJY 106.7**
KBPQ 93.3	**93.3**	**120.1**
WJJY 106.7	**79.9**	**106.7**

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 for a layout of the measurement equipment.

Table 3 Intermodulation Measurements

Product Frequency (MHz)	Carrier Frequency (MHz)	Interfering Frequency (MHz)	Pad (dB)	Bandpass Filter Loss (dB)	Full Scale Range (dBμ)	Scale reading (dB)	Adjusted Level (dBμ)	Carrier Reference Level (dBμ) (See Table 1)	**Level Referenced to Carrier (dB)**	Notes *
79.9	93.3	106.7	---	9.1	20	> -20.0	> 9.1	118.8	**> - 109.7**	
120.1	106.7	93.3	---	6.2	20	> -20.0	> 6.2	120.5	**> -114.3**	

*** NOTES**