Oklahoma City, Oklahoma

Master FM Broadband System

Intermodulation Study Report

Prepared For

KOMA 92.5, KMGL 104.1 & KRXO 107.7
Renda Broadcasting
&
KYIS 98.9 Citidel Broadcasting

Equipment

ERI COG-20P-12-240-2 Panel Antenna
with Dual Inputs and Reverse-fed IBOC
1660′ Dual ERI 6″- 50Ω Maxline & Dual 3″ Heliax Transmission Line
ERI 973-8 Four Channel Constant Impedance Combiner with Circulator
Isolated IBOC

Measurement Data Taken on
30 August – 1 September 2007

Submitted By

Todd R Loney
Senior RF Engineer

400 North Ashley Drive, Suite 3010, Tampa, FL 33602
813.286.4140 ● Fax 813.286.4130
www.richlandtowers.com

Introduction

This report is based on data collected at the KOMA, KYIS, KMGL & KRXO combined FM broadcast facility located in Okalahoma City, OK. The report includes measurements offered as proof that the combined operations of KOMA (92.5 MHz.), KYIS (98.7 MHz.), KMGL (104.1) and KRXO (107.7) 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).

TITLE 47--TELECOMMUNICATION

CHAPTER I--FEDERAL COMMUNICATIONS

COMMISSION (CONTINUED)

PART 73_RADIO BROADCAST SERVICES--Table of Contents

Subpart B_FM Broadcast Stations

Sec. 73.317 FM transmission system requirements.

(b) Any emission appearing on a frequency removed from the carrier by between 120 kHz and 240 kHz inclusive must be attenuated at least 25 dB below the level of the unmodulated carrier. Compliance with this requirement will be deemed to show the occupied bandwidth to be 240 kHz or less.

(c) Any emission appearing on a frequency removed from the carrier by more than 240 kHz and up to and including 600 kHz must be attenuated at least 35 dB below the level of the unmodulated carrier.

(d) Any emission appearing on a frequency removed from the carrier by more than 600 kHz must be attenuated at least 43 + 10 Log10 (Power, in watts) dB below the level of the unmodulated carrier, or 80 dB, whichever is the lesser attenuation.

In brief, the collection of measurements presented in this report demonstrate that all possible third order intermodulation (IM) products generated by this multiplex system are less than the maximum allowable level as required by section 73.317 (b) through (d).

Discussion of Intermodulation

When two or more transmitters are coupled to each other, new spectral components are produced by mixing of the fundamental and harmonic terms of each of the desired output frequencies. For example, if only two transmitters are involved, the third order intermodulation terms could be generated in the following way.

The output of the first transmitter (f1) is coupled into the non-linear output stage of the second transmitter (f2) because there is not complete isolation between the two output stages. (f2) will mix with the second harmonic of (f1) producing an in-band 3rd order term with a frequency of [2(f1)-(f2)]. In a similar fashion the other 3rd order term will be produced at a frequency of [2(f2)-(f1)]. This implies that the second harmonic content within each transmitter's output stage along with the specific nonlinear characteristics of the output stage will have an effect on the value of the mixing loss. It is possible however to generate these same 3rd order terms in another way. If the difference frequency between the two transmitters [(f2)-(fl)] which is an out-of-band frequency, re-mixes with either (fl) or (f2), the same 3rd order intermodulation frequencies are produced.

Experience has shown that to prevent spurious emissions, each transmitter must be isolated from all others in the system by a minimum of 40 dB, with 46 to 50 dB ensuring regulatory compliance. IM product attenuation is accomplished by a combination of transmitter turn-around loss and filtering. Turn-around losses are intrinsic to the way IM products are created in the transmitter. These losses typically run ≈6-13 dB for tube type transmitters. An off-frequency signal is attenuated ≈40 dB, as it passes through the bandpass filters, of the combiner module, toward the transmitter with the IM product it creates exiting the transmitter an additional 6-13 dB below the level the signal entered. This product is then attenuated an additional 40 dB as it passes back through the combiner bandpass filters. The result is IM product attenuation of at least 80 dB, with 100 dB or more possible.

Measurement Technique

A precision incident coupler, at the combiner output, was utilized for all measurements presented in this report. The coupling valve value is -53dB with >30 directivity. Double screened cables were utilized. A 16dB attenuator pad was inserted for all measurements. To achieve adequate dynamic measurement range, a high Q, tunable, bandpass filter was inserted for all F1 reference levels as well as most IM product frequencies. For frequencies out of the tunable range of the filter, an FM bandstop filter was inserted. The filter(s) loss was measured at each frequency and used as an offset for the measured levels. Figure 1 shows the typical match and response of the tunable bandpass filter. Figure 2 shows the response of the FM bandstop filter. Figure 3 is a drawing of the test configuration.
An Agilent 8753ES network analyzer was used to tune the bandpass filter and measure the insertion loss. Reference and product levels were measured on an Agilent ESA 4402B spectrum analyzer. Wideband measurements were also performed to identify any other anomalous energy. To obtain baseline data, a wideband sweep was taken prior to the transmitters be energized. The data was again taken with the transmitters operating. The FM bandstop filter was inserted to prevent analyzer overload and allow measurement level to -100dBc.

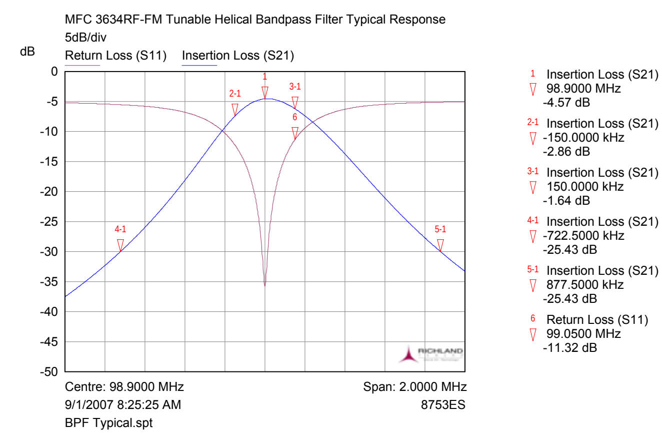


Figure 1

Figure 2

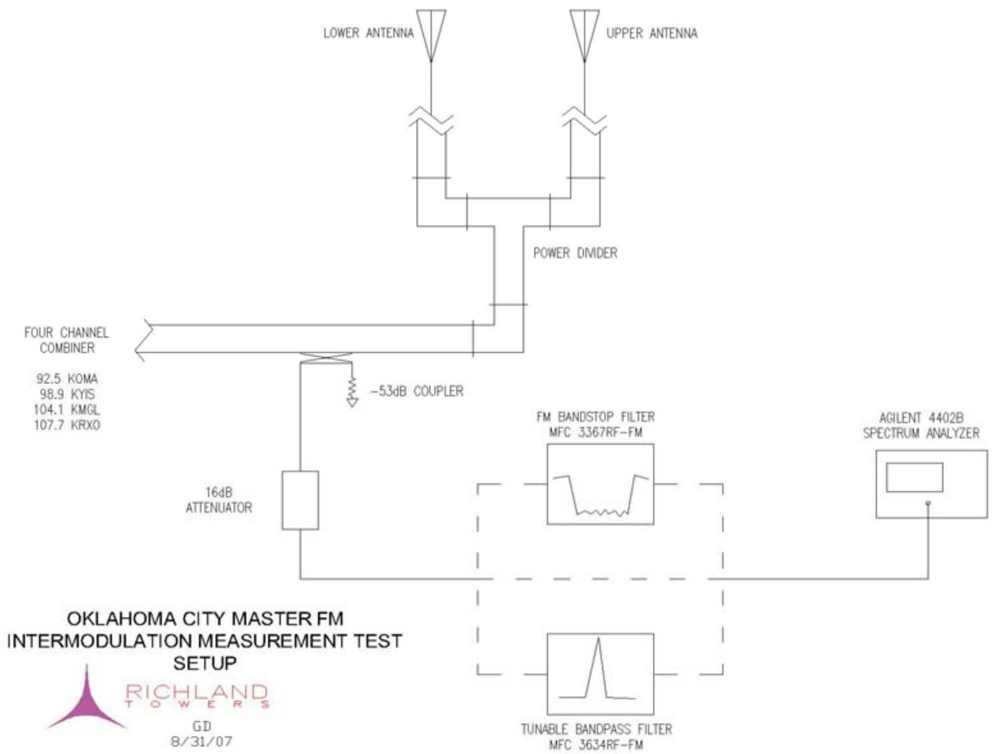


Figure 3

Measurement Results

Most products measured into the noise floor of the spectrum analyzer. Due to ingress from nearby stations on or near three of the product frequencies (77.25MHz, 90.1MHz & 100.5MHz), some results are erroneous. However, based on the results of the remaining frequencies and the documented input to input isolations of >75dB I am confident that all spurious emissions are in compliance.

Product Frequencies

IM Product Frequency (MHz) = [2(f1) – (f2)]

	f2 (MHz)			
f1 (MHz)	92.5	98.9	104.1	107.7
92.5	-	86.1	80.9	77.3
98.9	105.3	-	93.7	90.1
104.1	115.7	109.3	-	100.5
107.7	122.9	116.5	111.3	-

Note: Yellow highlight indicates an IM product in the FM band

Table of Measurements

Where:

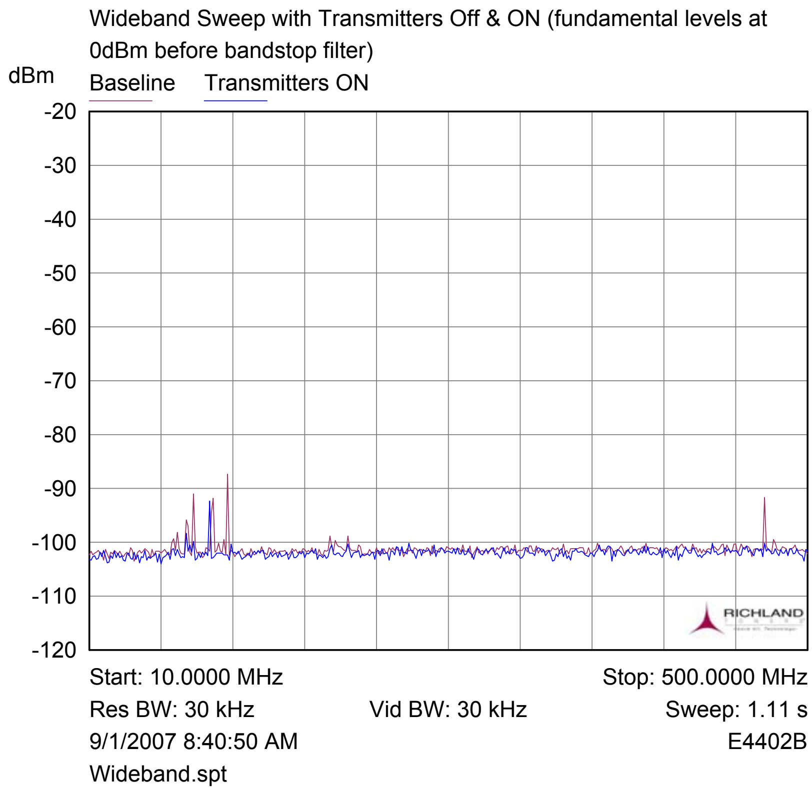
$$\text{IM Level} = (f1_{ref} + f1_{filter\ loss}) - (IM_{product} + IM_{filter\ loss})$$

f1	f2	IM	f1 Ref Level	f1 Filter Loss	Offset Ref	Measured	IM Filter Loss	Measured Offset	Calculated IM Level	
92.5	107.7	**77.3**	-1.00	4.5	3.50	-85.00	5.15	-79.85	**83.35**	†
92.5	104.1	**80.9**	-1.00	4.5	3.50	-101.00	5.40	-95.60	**99.10**	
92.5	98.9	**86.1**	-1.00	4.5	3.50	-102.00	6.68	-95.32	**98.82**	
98.9	107.7	**90.1**	-0.07	4.3	4.23	-89.00	5.70	-83.30	**87.53**	†
98.9	104.1	**93.7**	-0.07	4.3	4.23	-101.00	4.36	-96.64	**100.87**	
104.1	107.7	**100.5**	0.08	4.8	4.88	-72.00	5.20	-66.80	**71.68**	†
98.9	92.5	**105.3**	-0.07	4.3	4.23	-104.00	4.16	-99.84	**104.07**	
104.1	98.9	**109.3**	0.08	4.8	4.88	-104.00	4.66	-99.34	**104.22**	
107.7	104.1	**111.3**	0.52	4.5	5.02	-103.00	4.30	-98.70	**103.72**	
104.1	92.5	**115.7**	0.08	4.8	4.88	-103.00	1.50	-101.50	**106.38**	
107.7	98.9	**116.5**	0.52	4.5	5.02	-103.00	2.00	-101.00	**106.02**	
107.7	92.5	**122.9**	0.52	4.5	5.02	-103.00	4.00	-99.00	**104.02**	

†Notes:

1. IM measurement frequency at 77.3 is contaminated by ingress from KOCO-TV channel 5 vision carrier located <1 mile from transmitter site. Both 92.5 & 107.7 transmitters were switched off and product remained unchanged.
2. IM measurement frequency at 90.1 is contaminated by ingress from KCSC located <1 mile from transmitter site. Both 98.9 & 107.7 transmitters were switched off and product remained unchanged.
3. IM measurement frequency at 100.5 is contaminated by ingress from KATT located <1 mile from transmitter site. Both 104.1 & 107.7 transmitters were switched off and product remained unchanged.

Wideband sweep data indicated no out of band emissions above the noise floor of the analyzer. Figure 4 shows baseline data with no stations operating into the combined system. For the 'Transmitter ON' trace, an FM bandstop filter was inserted to remove the fundamental tones and increase dynamic range for the measurement.



Transmitters ON FM Bandstop Filter Inserted (88-108)

Figure 4

To demonstrate compliance with sections 73.317 (b) & (c) of FCC rules, the spectra of each station were analyzed by selecting a narrow span and resolution bandwidth and utilizing the max hold function. Since the stations were modulated with programming, the spectrum analyzer was allowed to 'build' before data was taken. This system operates with the IBOC signals (-20dB relative to analogue) excited left hand circular polarized (LHCP) while the analogue signals are excited right hand circular polarized (RHCP). The antenna / combiner system yield 25dB isolation, consequently there is some IBOC energy seen on the analogue output spectra (-45dB). Figures 5 – 8 are the plots of KOMA, KYIS, KMGL and KRXO spectra.

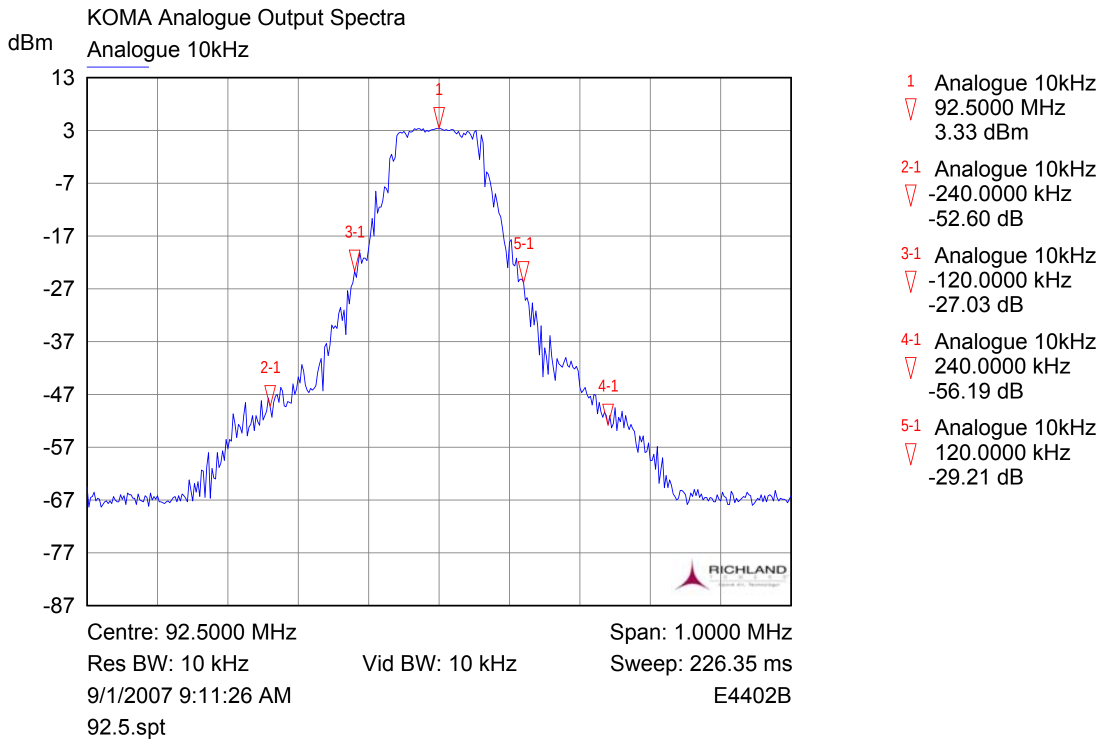


Figure 5

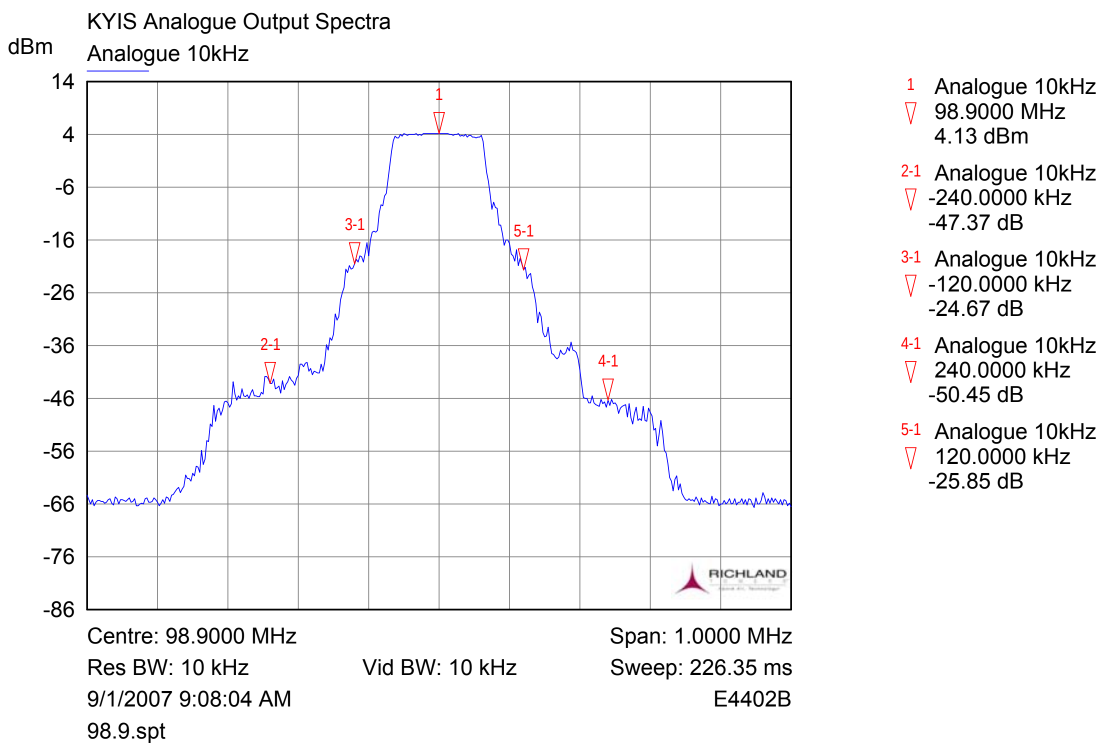


Figure 6

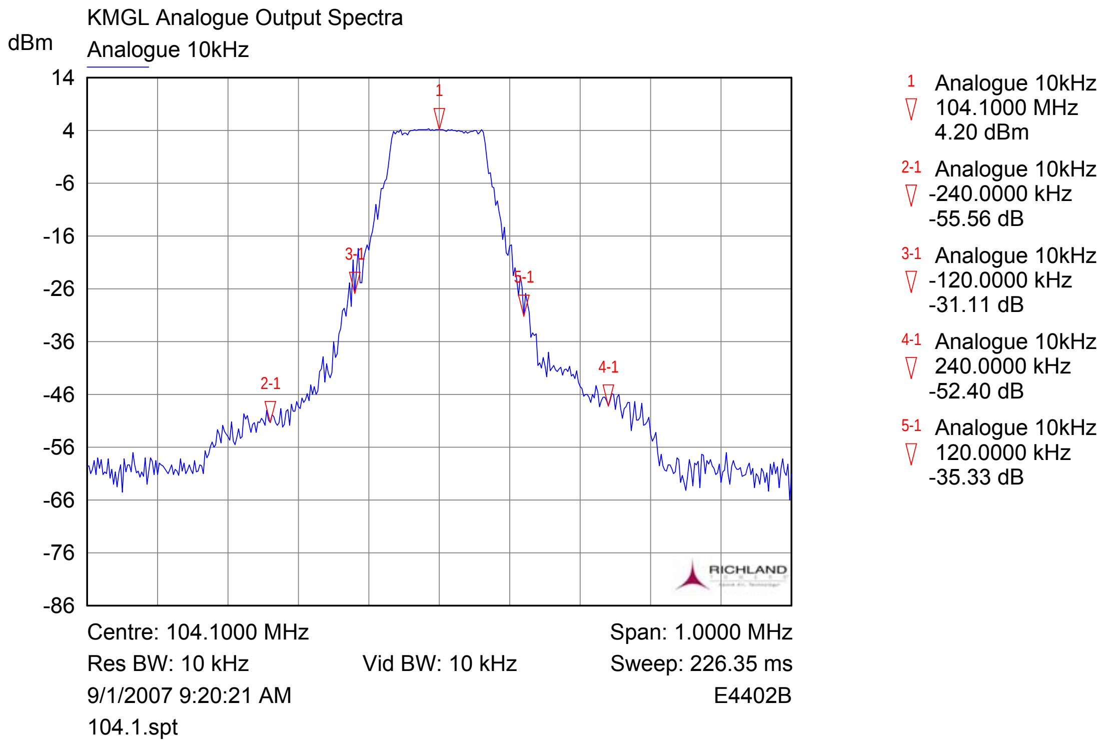


Figure 7

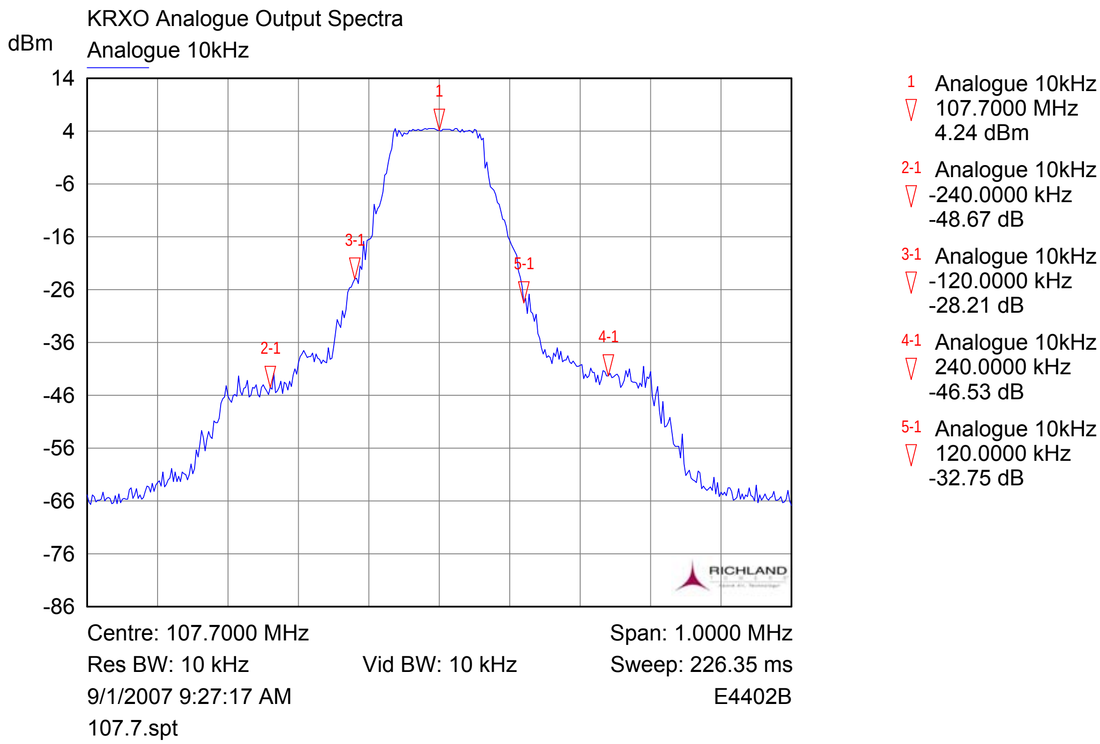


Figure 8

400 North Ashley Drive, Suite 3010, Tampa, FL 33602
813.286.4140 ● Fax 813.286.4130
www.richlandtowers.com

Conclusions

Based upon my observations and measurement data collected on 30 August 2007, I Todd Loney, find the subject combined system operating with stations KOMA, KYIS, KMGL and KRXO to be compliant with the requirements of Section 73.317 paragraph (b) through (d) of the FCC Rules and Regulations. All measurement data was collected under the observation of Citidel (KYIS) Chief Engineer Mike Fields.

Todd R Loney
1 September 2007