American Towers Corporation

Cedar Hill North

Master FM System

Intermodulation Study Report

Prepared For

KERA 90.1, KKXT 91.7
North Texas Public Broadcasting Inc
KBFB 97.9 Radio One
&
KJKK 100.3, KRLD 105.3 KMVK 107.5
CBS Radio

Equipment

Shively 6014-8-9SS-5BT-NF Panel Antenna
With Dual Inputs and Reverse-fed IBOC
Dual 6-50 Transmission Line
Three (3) Shively CIF Combiner Modules
Three (3) Dielectric CIF Combiner Modules

Measurement Data Taken on
4 – 5 May 2014

Submitted By

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Introduction

This report is based on data collected at the KERA, KKXT, KBFB, KJKK, KRLD & KMVK combined FM broadcast facility located in Cedar Hill, TX. The report includes measurements offered as proof that the combined operations of KERA (90.1), KKXT (91.7), KBFB (97.9), KJKK (100.3), KRLD (105.3) and KMVK (107.5) 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

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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. All combiner modules employed are 4-pole constant impedance design and exhibit >50dB input to input isolation.

Measurement Technique

All transmitters operated at their normal power levels. Two precision incident couplers, at the combiner output, were utilized for all measurements presented in this report. The coupling is -40dB with >30dB directivity. These two couplers were combined through a Mini Circuits ZMSCQ-2-120+ quadrature coupler to indicate composite legacy analogue as well as digital IBOC signals. 17dB of attenuation was inserted on both samples 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 9913 FieldFox RF analyzer was used to tune the bandpass filter and to measure the insertion loss. Reference and product levels were also measured on the Agilent 9913 RF Analyzer.

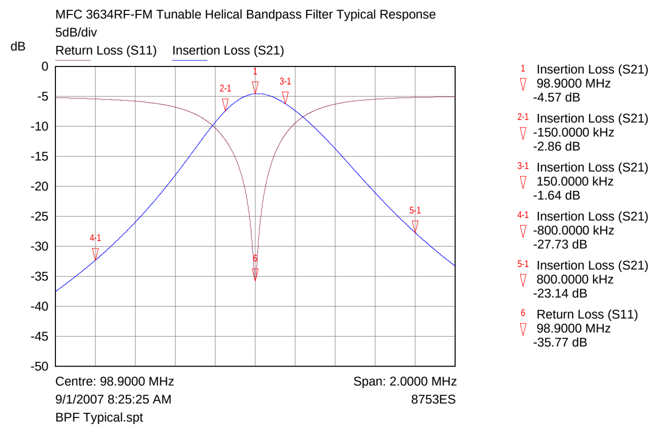


Figure 1

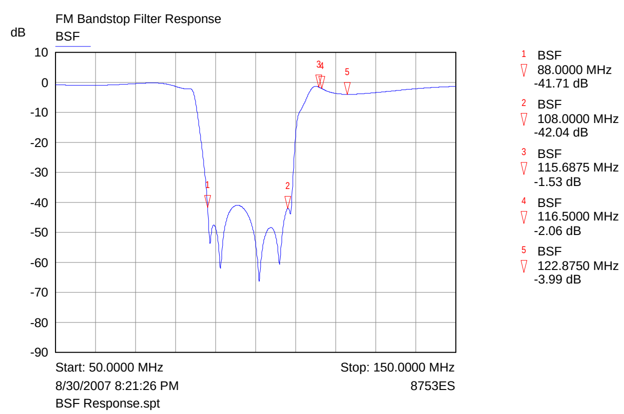


Figure 2

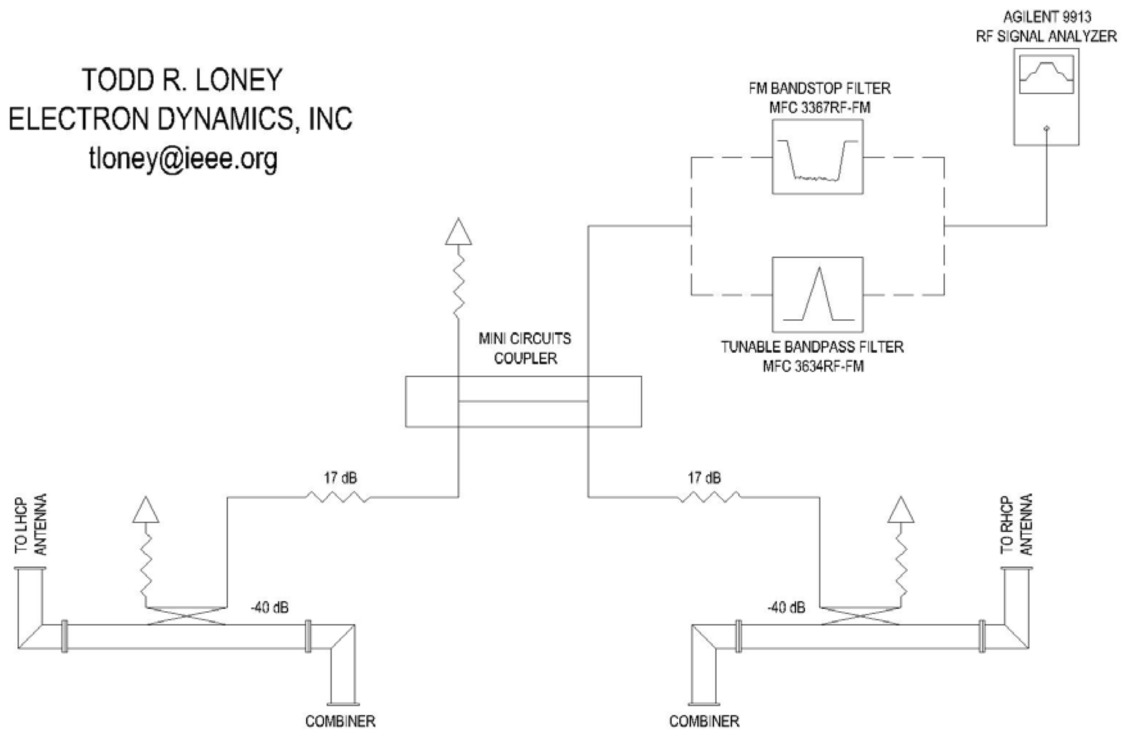


Figure 3

Measurement Results

Most products measured into the noise floor of the spectrum analyzer. Due to significant fundamental energy at 105.3, the measured result at product 105.7 was only -86.5dBc. The tunable bandpass filter is not able to adequately attenuate energy only 400kHz away. This measurement still exceeds the -80dBc specification and based on all other measurements, I am confident that this IM product also exceeds -100dBc

Product Frequencies

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

	F2					
F1	**90.1**	**91.7**	**97.9**	**100.3**	**105.3**	**107.5**
90.1	-	88.5	82.3	79.9	74.9	72.7
91.7	93.3	-	85.5	83.1	78.1	75.9
97.9	105.7	104.1	-	95.5	90.5	88.3
100.3	110.5	108.9	102.7	-	95.3	93.1
105.3	120.5	118.9	112.7	110.3	-	103.1
107.5	124.9	123.3	117.1	114.7	109.7	-

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

Table of Measurements

Where:

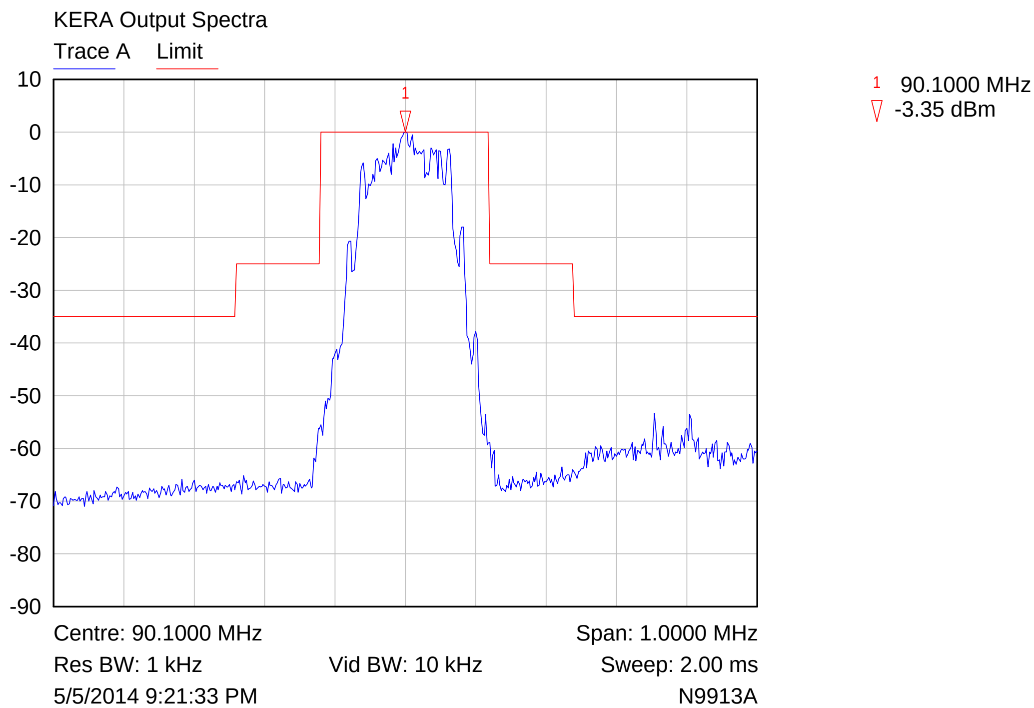
$$\text{IM Level} = (f1_{ref} - f1_{filter\ loss}) - (IM_{product} - IM_{filter\ loss})$$

f1	f2	IM	f1 Ref Lvl dBm	f1 Filter Loss	Offset Ref	Measured dBm	IM Filter Loss	Measured Offset	Calculated IM Level	
90.1	107.5	**72.7**	-7.2	-4.1	-3.1	-110.0	-0.5	-109.5	**-106.4**	
90.1	105.3	**74.9**	-7.2	-4.1	-3.1	-110.0	-0.2	-109.8	**-106.7**	
91.7	107.5	**75.9**	-9.6	-4.5	-5.1	-110.0	-0.1	-109.9	**-104.8**	
91.7	105.3	**78.1**	-9.6	-4.5	-5.1	-110.0	-0.3	-109.7	**-104.6**	
90.1	100.3	**79.9**	-7.2	-4.1	-3.1	-110.0	-1.4	-108.6	**-105.5**	
90.1	97.9	**82.3**	-7.2	-4.1	-3.1	-110.0	-4.5	-105.5	**-102.4**	
91.7	100.3	**83.1**	-9.6	-4.5	-5.1	-110.0	-4.4	-105.6	**-100.5**	
91.7	97.9	**85.5**	-9.6	-4.5	-5.1	-110.0	-4.2	-105.8	**-100.7**	
97.9	107.5	**88.3**	-1.6	-4.3	2.7	-110.0	-4.2	-105.8	**-108.5**	
90.1	91.7	**88.5**	-7.2	-4.1	-3.1	-110.0	-4.1	-105.9	**-102.8**	
97.9	105.3	**90.5**	-1.6	-4.3	2.7	-100.0	-4.1	-95.9	**-98.6**	*
100.3	107.5	**93.1**	-2.2	-4.8	2.6	-110.0	-4.1	-105.9	**-108.5**	
91.7	90.1	**93.3**	-9.6	-4.5	-5.1	-110.0	-4.0	-106.0	**-100.9**	
100.3	105.3	**95.3**	-2.2	-4.8	2.6	-110.0	-4.1	-105.9	**-108.5**	
97.9	100.3	**95.5**	-1.6	-4.3	2.7	-110.0	-4.1	-105.9	**-108.6**	
100.3	97.9	**102.7**	-2.2	-4.8	2.6	-110.0	-4.3	-105.7	**-108.3**	
105.3	107.5	**103.1**	-1.4	-4.4	3.0	-110.0	-4.3	-105.7	**-108.7**	
97.9	91.7	**104.1**	-1.6	-4.3	2.7	-110.0	-4.3	-105.7	**-108.4**	
97.9	90.1	**105.7**	-1.6	-4.3	2.7	-88.0	-4.2	-83.8	**-86.5**	*
100.3	91.7	**108.9**	-2.2	-4.8	2.6	-110.0	-4.1	-105.9	**-108.5**	
107.5	105.3	**109.7**	-8.0	-4.3	-3.7	-110.0	-4.1	-105.9	**-102.2**	
105.3	100.3	**110.3**	-1.4	-4.4	3.0	-110.0	-4.1	-105.9	**-108.9**	
100.3	90.1	**110.5**	-2.2	-4.8	2.6	-110.0	-4.1	-105.9	**-108.5**	
105.3	97.9	**112.7**	-1.4	-4.4	3.0	-110.0	-5.3	-104.7	**-107.7**	
107.5	100.3	**114.7**	-8.0	-4.3	-3.7	-110.0	-1.3	-108.7	**-105.0**	
107.5	97.9	**117.1**	-8.0	-4.3	-3.7	-110.0	-2.2	-107.8	**-104.1**	
105.3	91.7	**118.9**	-1.4	-4.4	3.0	-110.0	-3.6	-106.4	**-109.4**	
105.3	90.1	**120.5**	-1.4	-4.4	3.0	-110.0	-4.4	-105.6	**-108.6**	
107.5	91.7	**123.3**	-8.0	-4.3	-3.7	-110.0	-5.1	-104.9	**-101.2**	
107.5	90.1	**124.9**	-8.0	-4.3	-3.7	-110.0	-5.3	-104.7	**-101.0**	

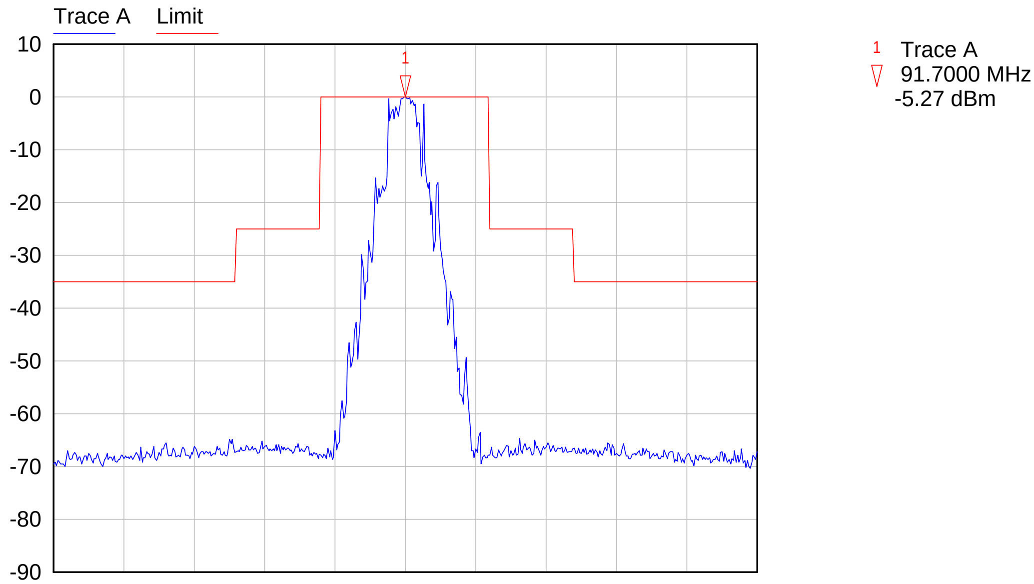
*decreased dynamic range due to fundamental carrier out of combiner system inside skirt of BP filter

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 has Left Hand (LHCP) and Right Circular (RHCP) Polarized inputs and operates under the following conditions:

- KERA 90.1 is analogue only and is normally LHCP
- KKXT 91.7 is analogue only and is normally LHCP
- KBFB 97.9 normally operates analogue LHCP and IBOC is RHCP
- KJKK 100.3 normally operates analogue RHCP and is IBOC RHCP
- KRLD 105.3 normally operates analogue RHCP and is IBOC RHCP
- KMVK 107.5 normally operated low level combined and is LHCP

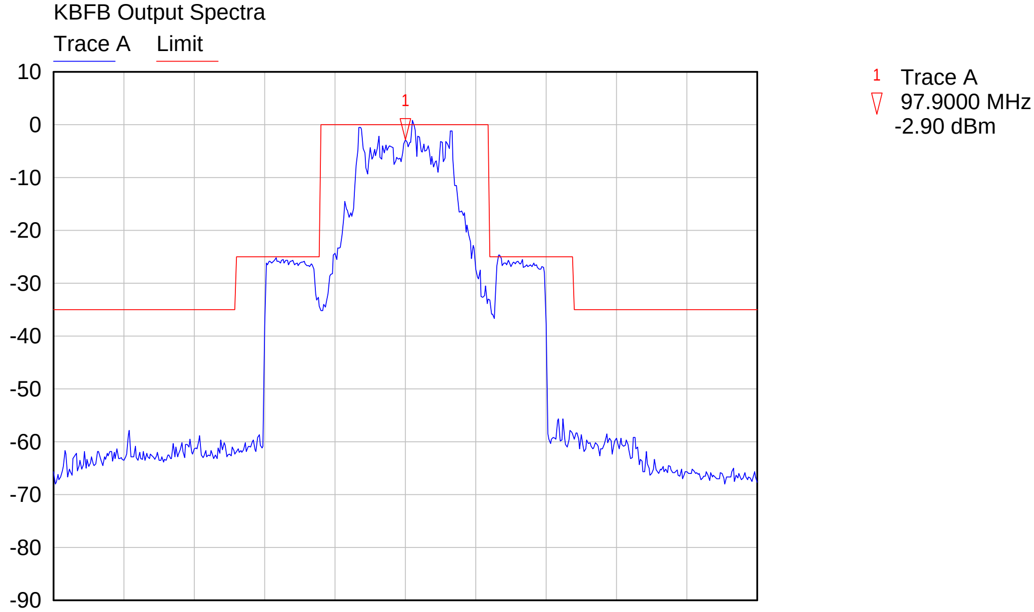


KKXT Ouput Spectra



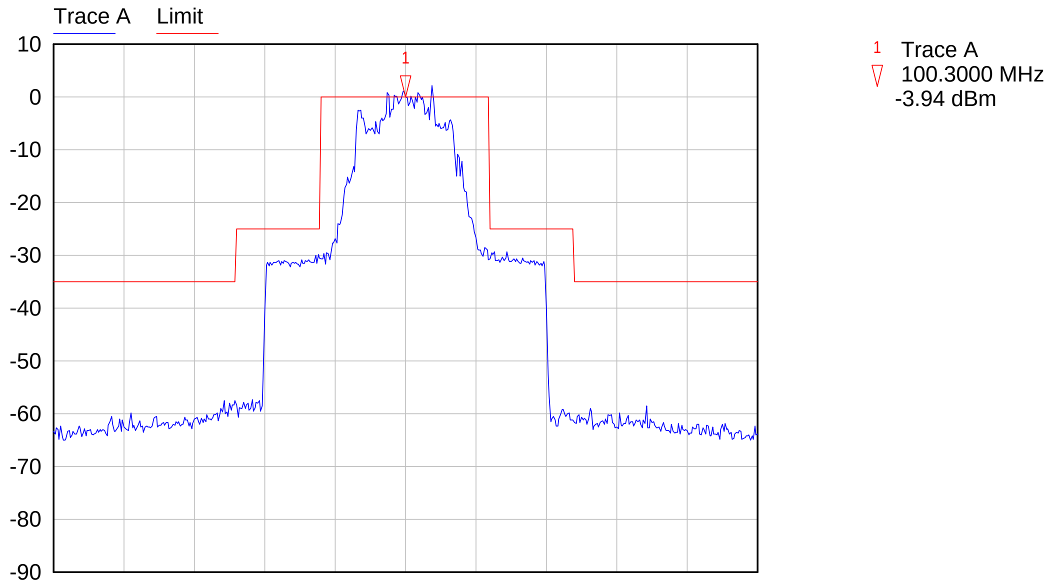
Centre: 91.7000 MHz | Span: 1.0000 MHz
Res BW: 1 kHz | Vid BW: 10 kHz | Sweep: 2.00 ms
5/5/2014 9:26:14 PM | N9913A

KBFB Output Spectra



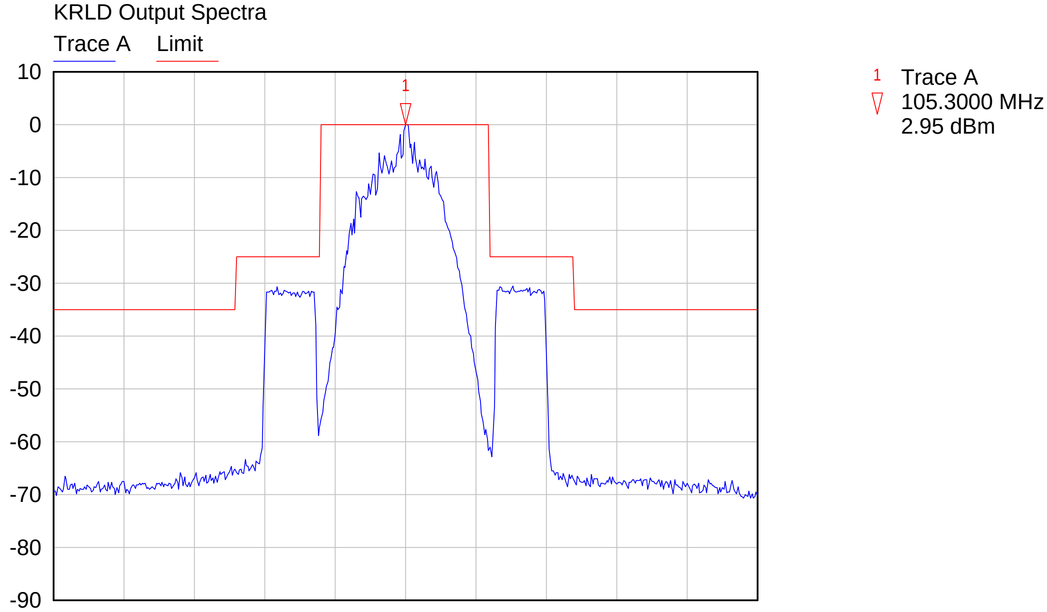
Centre: 97.9000 MHz | Span: 1.0000 MHz
Res BW: 1 kHz | Vid BW: 10 kHz | Sweep: 2.00 ms
5/5/2014 9:31:34 PM | N9913A

KJKK Output Spectra

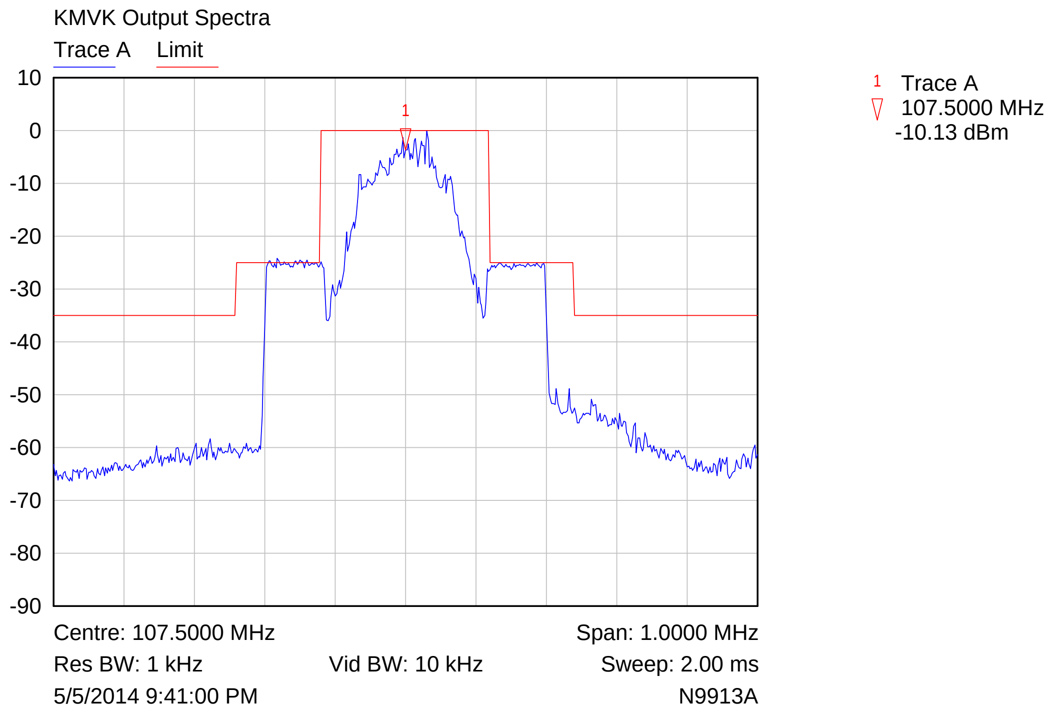


Centre: 100.3000 MHz | Span: 1.0000 MHz
Res BW: 1 kHz | Vid BW: 10 kHz | Sweep: 2.00 ms
5/5/2014 9:33:46 PM | N9913A

KRLD Output Spectra

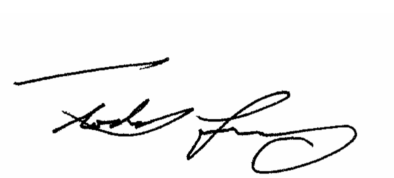


Centre: 105.3000 MHz | Span: 1.0000 MHz
Res BW: 1 kHz | Vid BW: 10 kHz | Sweep: 2.00 ms
5/5/2014 9:36:05 PM | N9913A



Conclusions

Based upon my observations and measurement data collected on 5 May 2014, I Todd Loney, find the subject combined system operating with stations KERA, KKXT, KBFB, KJKK, KVIL & KMVK 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 with and under the observation of David Sanderford of Marsand Inc.



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6 May 2014

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