FM Combiner Proof

for the combined operation of:

KKLU-FM / KVCE-FM Main Facilities

KKLU 215C2 / 90.9 MHz, Lubbock, TX / FID 5174
KVCE 224C1 / 92.7 MHz, Slaton, TX / FID 72773

Location Address:
2416 74th St, Lubbock, TX

Tower Coordinates:
33-31-33.8 N 101-52-08.6 W (NAD 83)
ASRN: 1054347

Measurements Recorded
January 17, 2024

Prepared By	Prepared For
Wavepoint Research, Inc. Wavepoint Research, Inc. PO Box 680521 Franklin, TN 37068 Eric Wandel, PE eric@wavepointresearch.com 812-453-2544 (mobile)	**KVCE-FM – VCY America** Point of contact: Roger Taylor Email: rogertee1966@gmail.com Mobile: 806-535-7004 **KKLU-FM – Educational Media Foundation** Point of contact: Garth Powell Email: GPowell@kloveair1.com Mobile: 432-638-4140

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1 Introduction

This report of findings provides evidence to show that the operation of the combined FM facility for KKLU-FM (90.9 MHz) and KVCE-FM (92.7 MHz) located at 2416 74th St, Lubbock, Texas, is in compliance with the FCC Rules and Regulations as required by the Code of Federal Regulations (CFR) Title 47 Sections 73.317 (a) thru (d) (attached as Exhibit A), and specifically as related to potential intermodulation products that may occur and must typically be below the limit specified by 73.317 paragraph (d).

Intermodulation (IM) products can potentially violate section 73.317 paragraph (d) requirements and may be generated from radio stations operating into multiplexed facilities and at congested antenna broadcast sites when inadequate transmitter-to-transmitter isolation is provided. 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 the most likely occurrence of this phenomenon is “third order product” denoted by the mathematical expression [2(F1)-(F2)], where F1 signifies the frequency of the transmitter that is generating the intermodulation product, and F2 signifies the frequency causing the interference. The installed filter / combiner system for the combined operation of KKLU and KVCE was designed to provide adequate isolation between transmitters as well as to provide filtering of potential outgoing intermodulation products to ensure compliance with section 73.317.

The present combiner proof has been commissioned by VCY America due to a planned increase in power, specifically to increase the effective radiated power (ERP) of KVCE from 51 kW to 100 kW.

In brief, the collection of measurements presented in this report establishes that IM products generated by the operation of these stations are less than the maximum allowable level as required by section 73.317(d), and additional exhibits are provided to also show compliance with sections 73.317(b) and (c). During measurements, both KKLU and KVCE were operating at full ERP simultaneously utilizing the shared antenna as described herein.

2 Transmission System

The combined system is comprised of main FM transmitters and bandpass filters for both stations, with the filter outputs combined in a tee and feeding a common side mounted FM antenna.

The installed filter/combiner system is designed to provide adequate isolation to ensure that interfering signals and any resulting intermodulation products are sufficiently attenuated to satisfy the section 73.317 paragraph (d) requirement. The combiner system consists of two 3-cavity filter modules (one module per station) combined with a tee combiner into a common antenna.

The transmitter and filter module information is provided in Table 1 along with power levels for each station. A sketch of the combiner layout and RF flow is shown in Figure 1. The current configuration of the combiner output tee is shown in Figure 2. All stations operated at listed TPO for the duration of compliance measurements.

Table 1 – Combiner System Information, Station Power Levels

Call Sign	**KKLU-FM**	**KVCE-FM**
Channel / Frequency (MHz)	**215C2 / 90.9**	**224C1 / 92.7**
FCC Facility ID	5174	72773
Transmitter	BE FM10S / FX50 Exiter S/N: 109088-001	Nautel GV40 S/N: 10031026
Filter Information	Make: Shively Model #: 2516-3A Part #: 2516-3A-1-1 S/N; 30135-1 S/O: 30135	Make: AAT Model: AAT-IR-BP-3-35K S/N: 1343P Fans added
Input / Output Connectors	3-1/8”	3-1/8”
ERP (kW)	25	100
TPO (kW)	9.4	36.0

The Bird directional coupler line section installed near the output of the tee combiner system is shown in Figure 3. This directional coupler is the sample location for all spectral compliance measurements recorded in this report.

The combined output feeds a single side mounted FM antenna, ERI model SHPX-6AC-SP. A photo of the antenna is shown in Figure 4.

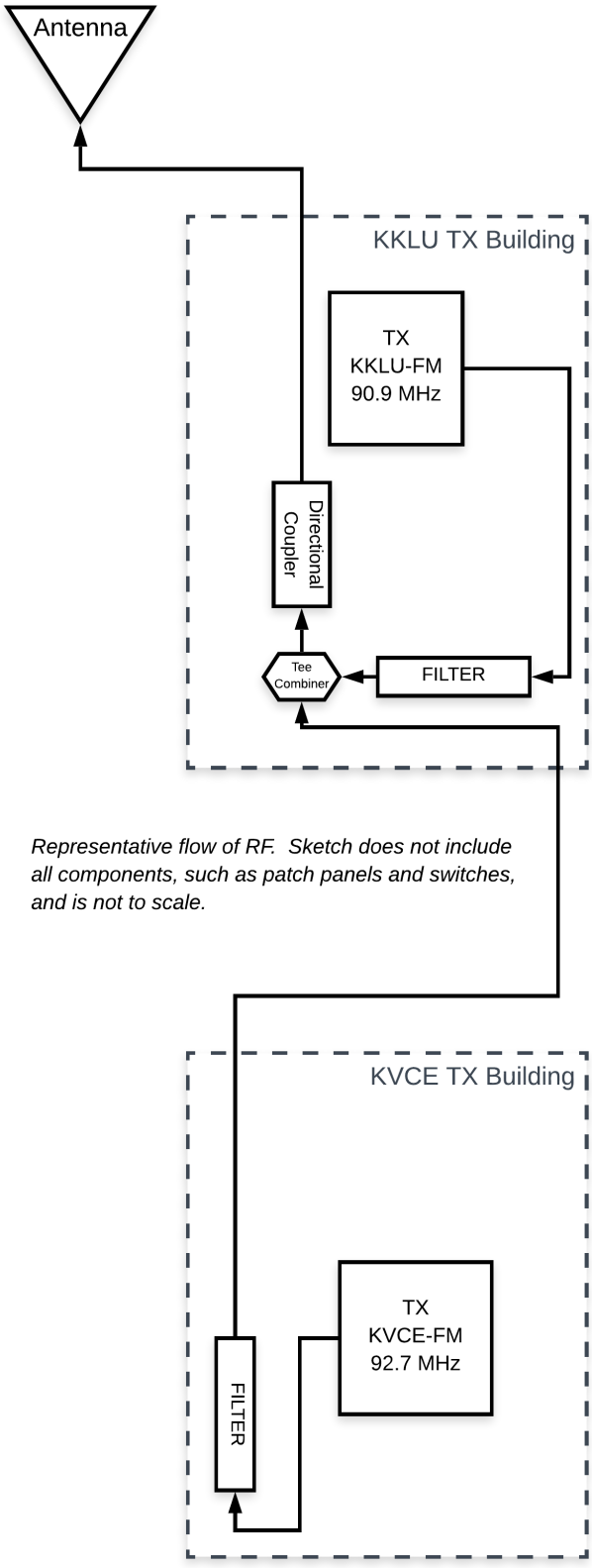

Figure 1 – Combiner System Layout and RF Flow

Figure 2 – Configuration of Combiner Tee

Figure 3 – Directional Coupler at Output of Combiner System

Figure 4 – Combined System Antenna, ERI Model SHPX-6AC-SP

A variety of equipment was employed to collect the data recorded herein, including:

- Rohde & Schwarz FSH20 Spectrum Analyzer
  - ID: 1314.2000K80 – 150165 – Ac
  - Calibration date: 2020-02-21
- Copper Mountain SC5090 Vector Network Analyzer, S/N 20089230, for adjusting band pass / notch filters used for testing
- Band pass / notch filters with high selectivity, used to isolate measured signals and to suppress carrier signals
- Mini Circuits High Pass Filters
- Various attenuators and shielded test cables
- Bird Model directional coupler line section, installed at the combiner system output to the antenna, labeled as Line Section 7006A003-0, bar code 1138518, EMF Tag # 800-525-6373 / 1031239.
- Bird Directional Coupler Elements, characterized with the installed Bird line section:
  - 553-75, SN 1482326, used in this study for measurements in range 75 – 125 MHz
  - 553-125, SN 1567209, used in this study for measurements in range 125 – 250 MHz
  - 553-401, SN 1567208, used in this study for measurements in range 250 – 1100 MHz

Measurements to verify compliance with section 73.317 were made at the directional coupler listed above. Eric Wandel, P.E., made the measurements summarized herein on January 17, 2024, at the commission of VCY America.

The Bird directional coupler line section accommodates RF sampling with the use of the Bird directional coupler elements listed above. These elements have a nominal coupling level of -55 dB and a nominal minimum directivity of 30 dB. The coupling level of -55 dB is adequate to ensure signal levels can be measured within the dynamic range of the spectrum analyzer equipment. Prior to conducting the combined systems measurements, the elements listed above were characterized in the Bird line section in this system; this study applies correction factors based on the actual measured values of coupling level per frequency. The sampled signal was fed by shielded cable into the spectrum analyzer with additional attenuators added as needed to prevent overloading the analyzer.

A diagram of the test equipment setup is shown in Figure 5.

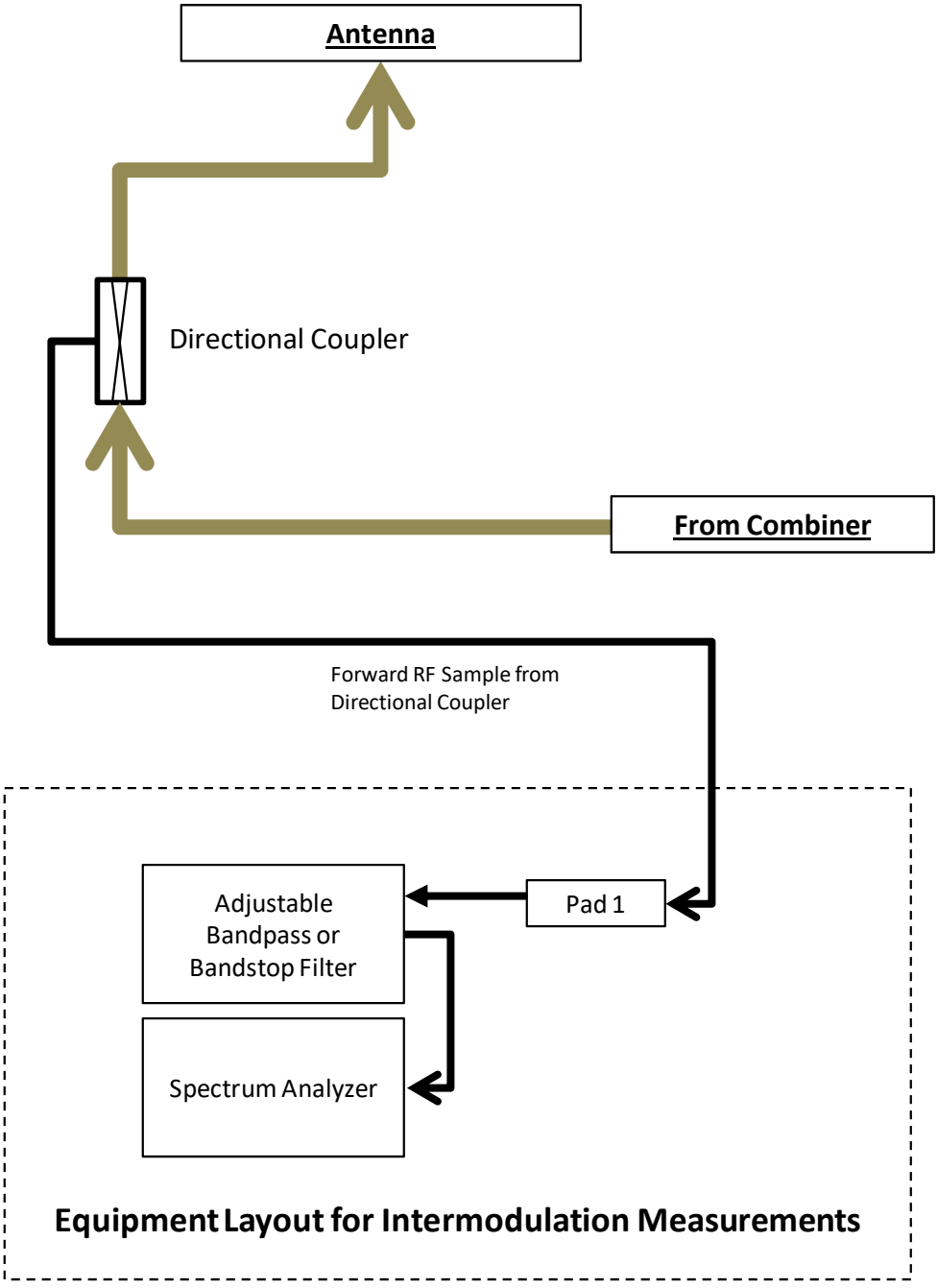

Figure 5 –Test Equipment Layout for IM Measurements

3 Product Measurements

Measurements were made to assess the level of potential intermodulation products that might exist at the output of the combined system with specific attention given to third order IM products (of the type $2F_1 - F_2$). The collection of measurements presented in this report shows that all possible third order inter-modulation (IM) products generated by the operation of the present combined stations are less than the maximum allowable level as required by section 73.317(d).

Key isolation characteristics of the filter / combiner system as previously measured are listed in Table 2.

Table 2 – Measured Filter / Combiner Isolation Characteristics

Module	Characteristic	Value
KKLU-FM 90.9 MHz	Input to output suppression greater than 40 dB	<88.6 MHz >92.4 MHz
KVCE-FM 92.7 MHz	Input to output suppression greater than 40 dB	Varies, see port-to-port value below >99.8 MHz
	KVCE input to KKLU input notch @ 92.7 MHz	-57 dB <-40 dB: -140 kHz / +100 kHz

Calculations of the possible system-generated third order products are shown in Table 3. The potential interfering frequencies include other nearby FM stations that have the potential to couple into the system transmitters and cause third order products.

Table 3 - Third Order IM Product Table

F1 MHz (TX Frequency)		F2 MHz (Interfering Frequency)									
		KKLU 90.9	KVCE 92.7	KAMY 90.1	K218DI 91.5	K222CQ 92.3	K226CH 93.1	KLBB 93.7	K231BE 94.1	KFMX 94.5	K236CP 95.1
KKLU	90.9		89.1	91.7	90.3	89.5	88.7	88.1*	87.7*	87.3*	86.7*
KVCE	92.7	94.5		95.3	93.9	93.1	92.3	91.7	91.3	90.9	90.3

**These potential products fall beyond the 40-dB suppression level of the KKLU filter and so were not measured.*

As stated in CFR Title 47, Section 73.317, measurements of spectral emissions are compared to the level of the unmodulated carrier, so the relative output signal levels for the system carriers are measured first to establish reference levels for other measurements.

It is sometimes inconvenient to establish this carrier reference level using the actual unmodulated carrier during operation of the station. As an approximation to this, it is generally accepted that the power of the transmitter output can be estimated from the modulated signal using a 300 kHz resolution bandwidth (RBW)[1] which serves to integrate the power in the modulated signal. This method of establishing the carrier reference level is used here as a basis for comparing the potential IM product levels.

The reference signal level for each transmitter as recorded at the output directional coupler are listed in Table 4 and are used as the reference level for possible IM products.

Table 4 - Transmitter Forward Power Reference Levels

Call Sign	Carrier Frequency (MHz)	Carrier Level Displayed, 300 kHz RBW (dBm)	Probe Coupling Level (dB)	External Attenuator (dB)	Cable Loss (dB)	Adjusted Carrier Forward Reference Level (dBm)
KKLU	90.9	-6.6	-54.8	-20	-0.12	68.4
KVCE	92.7	-0.3	-54.8	-20	-0.13	74.6

The IM product measurements recorded are listed in Table 5. The signal level referenced to the carrier level is shown in the third-to-last column, and the margin is shown in the last column.

All third order product levels for the combined system meet requirements.

Measurements of station harmonic levels through the eleventh harmonics were also recorded using two high pass filters in the test setup to suppress the carrier signals as seen by the spectrum analyzer. The recorded levels are provided in Table 6.

All harmonic levels met the CFR Title 47, Section 73.317(d) requirements.

[1] *NRSC-G201-A, NRSC-5 RF Mask Compliance: Measurement Methods and Practice,* National Radio Systems Committee, April 2010.

Table 5 - Product Measurements – KKLU / KVCE Combined System

Carrier Frequency (MHz)	Interfering Frequency (MHz)	Product Frequency (MHz)	Directional Coupler Coupling Level at Product Frequency (dB)	External Attenuator (dB)	Cable Loss (dB)	Notch or Band Pass Attenuation at Product Frequency (dB)	IM Level Displayed, 1 kHz RBW (dBm) [Note 1]	Adjusted Reading (dBm)	Carrier Reference Level (dBm)	Level Referenced to Carrier (dB)	73.317(d) Requirement (dB)	Level Relative to Requirement (dB)
90.9	92.7	**89.1**	-54.9	0	-0.12	-1.07 (2 notch)	-60.8	-4.75	68.4	**-73.1**	80.0	**6.9 [Note 2]**
90.9	92.7	**89.1**	-54.9	0	-0.12	-1.07 (2 notch)	-59.8	-3.76	68.4	**-72.1**	80.0	**7.9 [Note 2]**
92.7	90.9	**94.5**	-54.7	0	-0.13	-1.91 (2 notch)	-61.1	-4.33	74.6	**-78.9**	80.0	**1.1 [Note 3]**
92.7	90.9	**94.5**	-54.7	0	-0.13	-1.91 (2 notch)	-58.8	-2.08	74.6	**-76.7**	80.0	**3.3 [Note 3]**
92.7	90.9	**94.5**	-54.7	0	-0.13	-1.91 (2 notch)	-89.3	-32.57	74.6	**-107.1**	80.0	**-27.1 [Note 3]**
90.9	93.1	**88.7**	-54.9	0	-0.12	-0.73 (2 notch)	-117.0	-61.32	68.4	**-129.7**	80.0	**-49.7**
90.9	92.3	**89.5**	-54.8	0	-0.12	-1.83 (2 notch)	-113.2	-56.45	68.4	**-124.8**	80.0	**-44.8**
90.9	91.5	**90.3**	-54.8	20	-0.12	0	-98.7	-23.72	68.4	**-92.1**	80.0	**-12.1**
92.7	95.1	**90.3**	-54.8	20	-0.12	0	-98.7	-23.72	74.6	**-98.3**	80.0	**-18.3**
92.7	94.5	**90.9**	-54.8	20	-0.12	0	-105.4	-30.50	74.6	**-105.1**	80.0	**-25.1**
92.7	94.1	**91.3**	-54.8	20	-0.12	0	-92.1	-17.13	74.6	**-91.7**	80.0	**-11.7**
92.7	94.1	**91.3**	-54.8	0	-0.12	-5.10 (band pass)	-102.1	-42.03	74.6	**-116.6**	80.0	**-36.6**
92.7	93.7	**91.7**	-54.8	20	-0.12	0	-97.2	-22.29	74.6	**-96.9**	80.0	**-16.9**
90.9	90.1	**91.7**	-54.8	20	-0.12	0	-97.2	-22.29	68.4	**-90.6**	80.0	**-10.6**
92.7	93.1	**92.3**	-54.8	20	-0.12	0	-85.7	-10.81	74.6	**-85.4**	80.0	**-5.4**
92.7	93.1	**92.3**	-54.8	0	-0.12	-5.11 (band pass)	-98.2	-38.15	74.6	**-112.7**	80.0	**-32.7**
92.7	92.3	**93.1**	-54.7	20	-0.13	0	-86.6	-11.73	74.6	**-86.3**	80.0	**-6.3**
92.7	92.3	**93.1**	-54.7	0	-0.13	-5.03 (band pass)	-99.0	-39.13	74.6	**-113.7**	80.0	**-33.7**
92.7	91.5	**93.9**	-54.7	20	-0.13	0	-98.8	-23.93	74.6	**-98.5**	80.0	**-18.5**
92.7	90.1	**95.3**	-54.7	0	-0.13	-0.88 (2 notch)	-112.7	-56.99	74.6	**-131.6**	80.0	**-51.6**

NOTES: 1) In many cases, the measured signal was at the noise floor of the spectrum analyzer. All measurements were adequate to show that each potential product level is lower than the limit, but the actual level may in general be even lower than the level recorded here.

2) Local station KTTZ-FM operating at 89.1 MHz has an ERP of 70 kW and only 4.1 miles from the KKLU / KVCE site. This signal coupled into the KKLU / KVCE system and the profile of the KTTZ analog plus HD sidebands was evident on the spectrum analyzer display. During the time of measurements, we were not able to coordinate with these stations to temporarily shut off their transmitters, however, the VNA measurements of the filter / combiner system provide sufficient additional evidence that system products above allowable levels do not exist at the output of the KKLU / KVCE system. In the second measurement shown in the table, KKLU 90.9 MHz was shut off, but no significant change in the measured level at 89.1 MHz occurred.

3) In the second measurement of 94.5 MHz, KVCE 92.7 MHz shut off. In the third measurement of 94.5 MHz, local station KFMX-FM operating at 94.5 MHz cooperated to temporarily cease transmission so that this measurement of potential product at 94.5 MHz could be made.

Table 6 - Harmonic Measurements – KKLU / KVCE Combined System

Carrier Frequency (MHz)	Harmonic Number	Harmonic Frequency (MHz)	Directional Coupler Coupling Level at Harmonic Frequency (dB)	External Attenuator (dB)	Cable Loss (dB)	Double High Pass Filter at harmonic frequency (dB)	Harmonic Level Displayed, 1 kHz RBW (dBm) (Note 1)	Adjusted Reading (dBm)	Carrier Reference Level (dBm)	Level Referenced to Carrier (dB)	73.317(d) Requirement (dBc)	Harmonic Level Relative to Requirement (dB)
90.9	2	181.8	-55.2	0	-0.17	-0.69	-120.74	-64.71	68.4	**-133.1**	80.0	**-53.1**
90.9	3	272.7	-55.4	0	-0.21	-0.42	-120.34	-64.30	68.4	**-132.7**	80.0	**-52.7**
90.9	4	363.6	-54.6	0	-0.25	-0.41	-119.95	-64.72	68.4	**-133.1**	80.0	**-53.1**
90.9	5	454.5	-54.2	0	-0.27	-0.60	-119.80	-64.70	68.4	**-133.1**	80.0	**-53.1**
90.9	6	545.4	-54.2	0	-0.30	-0.55	-120.21	-65.19	68.4	**-133.5**	80.0	**-53.5**
90.9	7	636.3	-54.3	0	-0.33	-0.44	-119.48	-64.43	68.4	**-132.8**	80.0	**-52.8**
90.9	8	727.2	-54.5	0	-0.36	-0.42	-120.63	-65.41	68.4	**-133.8**	80.0	**-53.8**
90.9	9	818.1	-54.7	0	-0.35	-0.43	-120.76	-65.29	68.4	**-133.6**	80.0	**-53.6**
90.9	10	909.0	-55.0	0	-0.41	-0.45	-118.28	-62.45	68.4	**-130.8**	80.0	**-50.8**
90.9	11	999.9	-55.3	0	-0.39	-0.47	-119.44	-63.30	68.4	**-131.7**	80.0	**-51.7**
92.7	2	185.4	-55.2	0	-0.18	-0.67	-120.66	-64.64	74.6	**-139.2**	80.0	**-59.2**
92.7	3	278.1	-55.3	0	-0.22	-0.41	-120.02	-64.06	74.6	**-138.6**	80.0	**-58.6**
92.7	4	370.8	-54.5	0	-0.25	-0.42	-120.27	-65.09	74.6	**-139.7**	80.0	**-59.7**
92.7	5	463.5	-54.2	0	-0.28	-0.58	-119.86	-64.79	74.6	**-139.4**	80.0	**-59.4**
92.7	6	556.2	-54.2	0	-0.31	-0.50	-119.71	-64.72	74.6	**-139.3**	80.0	**-59.3**
92.7	7	648.9	-54.3	0	-0.33	-0.42	-119.85	-64.82	74.6	**-139.4**	80.0	**-59.4**
92.7	8	741.6	-54.5	0	-0.37	-0.43	-120.61	-65.33	74.6	**-139.9**	80.0	**-59.9**
92.7	9	834.3	-54.8	0	-0.36	-0.45	-120.27	-64.71	74.6	**-139.3**	80.0	**-59.3**
92.7	10	927.0	-55.0	0	-0.40	-0.46	-118.20	-62.31	74.6	**-136.9**	80.0	**-56.9**
92.7	11	1019.7	-55.3	0	-0.39	-0.47	-118.71	-62.56	74.6	**-137.1**	80.0	**-57.1**

NOTES: 1) In many cases, the measured signal was at the noise floor of the spectrum analyzer. All measurements were adequate to show that each harmonic level is lower than the limit, but the actual level may in general be even lower than the level recorded here.

4 Occupied Bandwidth / Mask Measurements

Additional measurements of compliance were made to show compliance with 73.317(b) through (d) in the 2 MHz band near the carrier frequency. These occupied bandwidth / mask measurements are presented herein.

In Figure 6 and Figure 7 , verification of compliance with the occupied bandwidth and mask requirements of 73.317(b) through (d) are shown. These measurements were collected using the Rohde & Schwarz FSH20 spectrum analyzer. Both 300 kHz resolution bandwidth and 1 kHz resolution bandwidth data are shown on the same plot along with the FCC 73.317 mask, where all data is normalized to the peak of the 300 kHz RBW plot.

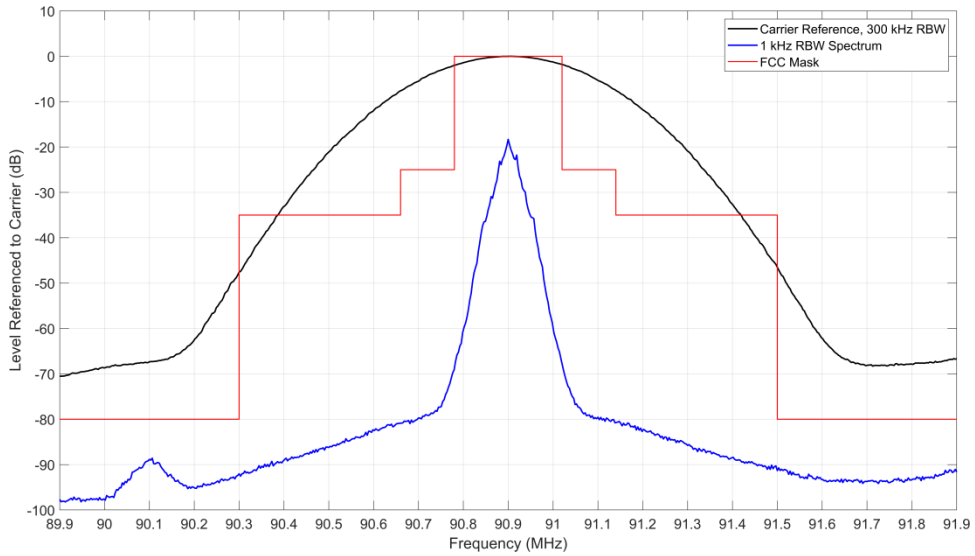

Figure 6 – KKLU-FM 90.9 MHz, 73.317(b) through (d) Mask Compliance

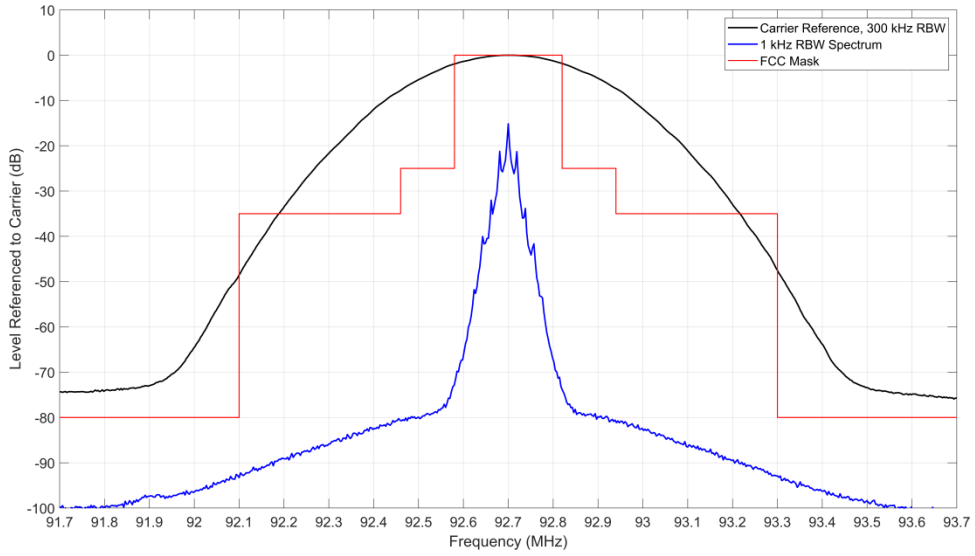

Figure 7 – KVCE-FM 92.7 MHz, 73.317(b) through (d) Mask Compliance

5 Conclusions

Based upon the observations and measurements recorded in this document, I, Eric R. Wandel, find the operation of the combined FM system for stations:

- KKLU 215C2 / 90.9 MHz, Lubbock, TX / FID 5174
- KVCE 224C1 / 92.7 MHz, Slaton, TX / FID 72773

as described herein and located at 2416 74th St, Lubbock, Texas, to be in compliance with the requirements of CFR Title 47, Section 73.317(b) through (d).

Respectfully submitted by Eric R. Wandel, P.E.

AFFIDAVIT

I, Eric R. Wandel, employed by Wavepoint Research, Inc. and under the commission of VCY America, have performed the preparation of all technical information contained in this document and to my knowledge have made no misrepresentations or false claims.

My qualifications to perform this work are supported as follows:

1. Education includes:
   a) The degree of Bachelor of Science in Electrical Engineering from Rose-Hulman Institute of Technology, Terre Haute, Indiana
   b) The degree of Bachelor of Science in Applied Optics from Rose-Hulman Institute of Technology, Terre Haute, Indiana
   c) The degree of Master of Science in Electrical Engineering from Rensselaer Polytechnic Institute, Troy, New York
2. Experience includes:
   a) Over 30 years of experience in systems engineering work related to RF engineering, signal processing, antenna and filter design, including design, installation and field checkout of high power broadcast systems involving combined operation of multiple stations.
3. Licensed Professional Engineer
   a) State of Tennessee, Registration Number: 126598

Eric R. Wandel, P.E. January 25, 2024
Date

Exhibit A – Citation from CFR Title 47, Sections 73.317

Code of Federal Regulations

TITLE 47 - TELECOMMUNICATION
CHAPTER I - FEDERAL COMMUNICATIONS COMMISSION
SUBCHAPTER C - BROADCAST RADIO SERVICES
PART 73 - RADIO BROADCAST SERVICES
Subpart B - FM Broadcast Stations

§ 73.317 FM transmission system requirements.

a) FM broadcast stations employing transmitters authorized after January 1, 1960, must maintain the bandwidth occupied by their emissions in accordance with the specification detailed below. FM broadcast stations employing transmitters installed or type accepted before January 1, 1960, must achieve the highest degree of compliance with these specifications practicable with their existing equipment. In either case, should harmful interference to other authorized stations occur, the licensee shall correct the problem promptly or cease operation.

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 $43 + 10 \text{ Log}_{10}$ (Power, in watts) dB below the level of the unmodulated carrier, or 80 dB, whichever is the lesser attenuation.

e) Preemphasis shall not be greater than the impedance-frequency characteristics of a series inductance resistance network having a time constant of 75 microseconds. (See upper curve of Figure 2 of § 73.333.)