Report of Inter-Modulation Product Measurements

Radio FM Media
Combined FM Translator Facility
for the Operation of:

K224FD(FX), 92.7 MHz
K233CY(FX), 94.5 MHz
K245BY(FX), 96.9 MHz

Antenna Model: Shively Model 6842-2P
Filter Model: Shively BR-06(3)F-06(3)F-06(3)F

Location Address: 4000 S. University Drive, Fargo, ND 58104
Tower Coordinates: 46-49-03.0 N 96-48-08.0 W (NAD 83)
ASRN: 1038763

Measurements Recorded
August 1, 2022

Prepared By	Prepared For
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1 Introduction

This report of findings provides evidence to show that the operation of the combined FM facility at ASRN 1025239 located at 4000 S. University Drive, Fargo, North Dakota, by Radio FM Media is in compliance with the FCC Rules and Regulations as required by the Code of Federal Regulations (CFR) Title 47 Section 73.317 (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 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 Shively branch combiner consisting of 3-pole bandpass filters with feedback loops for each station was designed to provide adequate isolation between stations as well as to provide suppression of potential outgoing intermodulation products to ensure compliance with section 73.317.

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). Additional exhibits further show compliance with sections 73.317(b) and (c).

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

- Anritsu SiteMaster S332E, S/N 1104062
- Copper Mountain SC5065 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
- Various attenuators and test cables
- ERI directional coupler permanently installed in the system: 7/8" EIA P/N CD108-2-NS-2 (Ports DC2), S/N 39374-031822-1.

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 August 1, 2022, at the commission of Radio FM Media.

2 Transmission System

The Shively 6842-2P antenna is shown in Figure 1.

Figure 1 – Photo of Shively 6842-2P (2-Bay) Antenna, As Installed

The Shively branch combiner model BR-06(3)F-06(3)F-06(3)F is shown in Figure 2 along with the directional coupler that was used for data collection.

Figure 2 – Photo of Shively Branch Combiner and Directional Coupler

A close-up photo of the directional coupler is shown in Figure 3. The port labeled "DC2" was used for spectral compliance measurements and was factory calibrated with a nominal coupling of -55.01 dB at 108 MHz and with a directivity of greater than 38 dB. The coupling level was chosen to ensure signal levels can be adequately measured within the dynamic range of the spectrum analyzer.

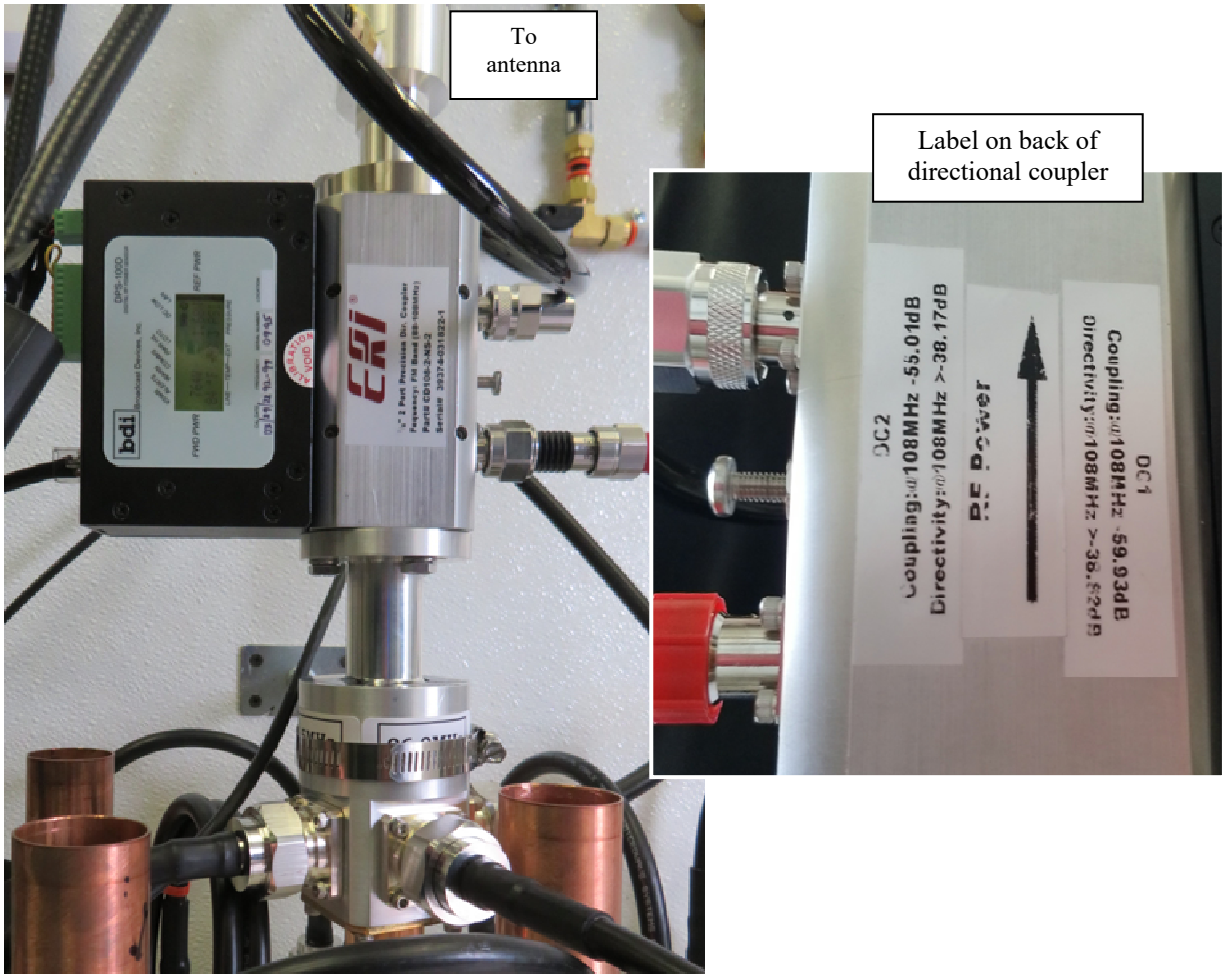


Figure 3 – Directional Coupler at Output of Combiner System

The forward sampling port on the directional coupler "DC2" with Type N connectors was used for measurements, including sampling all outgoing carrier levels, IM products and harmonic frequencies. The sampled signal was fed by shielded cable into the spectrum analyzer for measurements.

A diagram of the test equipment setup is shown in Figure 4. This is a general drawing showing the location of the test system filtering between the directional coupler sample port and the spectrum analyzer if filtering is needed to isolate signals of interest.

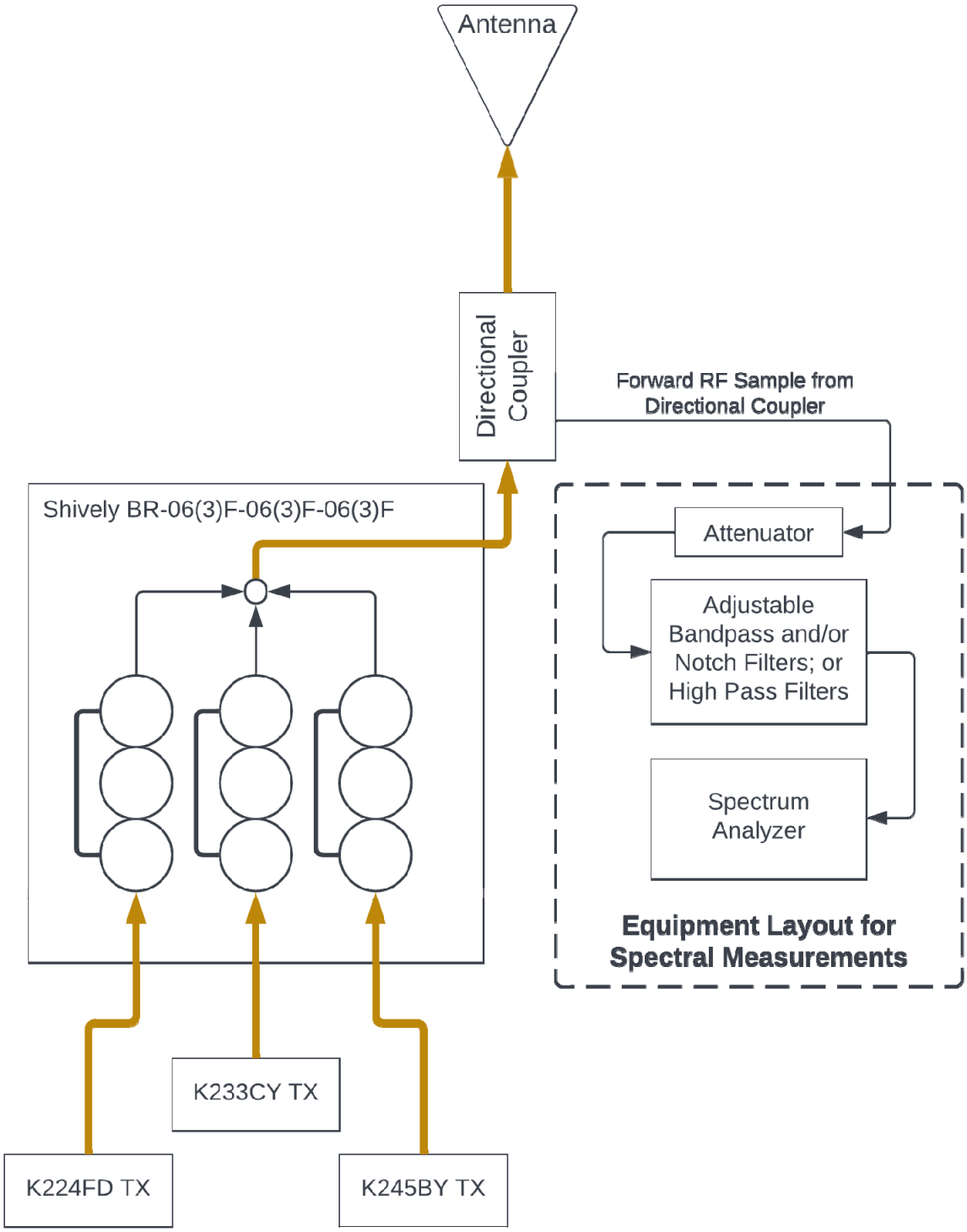


Figure 4 –Test Equipment Layout for IM Measurements

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 has the objective of showing that all possible third order inter-modulation (IM) products generated by the operation of any one of the system stations are less than the maximum allowable level as required by section 73.317(d).

There are three other FM facilities on the same tower – K222DF, K226CL and K252GC, so these are also considered for potential third order products. A matrix showing calculations of the possible third order products is shown in Table 1.

Table 1 - Third Order IM Product Table, Considering Same-Tower Frequencies

F1 MHz (Transmitter Frequency)		F2 MHz (Interfering Frequency)					
		K224FD	**K233CY**	**K245BY**	**K222DF**	**K226CL**	**K252GC**
		92.7	**94.5**	**96.9**	**92.3**	**93.1**	**98.3**
K224FD	**92.7**		90.9	88.5	93.1	92.3	87.1
K233CY	**94.5**	96.3		92.1	96.7	95.9	90.7
K245BY	**96.9**	101.1	99.3		101.5	100.7	95.5

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 level for each system carrier is 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.

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

The reference signal level for each transmitter as recorded at the output directional coupler is listed in Table 2; these values are used as the reference level for possible IM products.

Table 2 - 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)	Transmitter Output Power (W)	73.317(d) Requirement (dB)*
K224FD	92.7	-12.91	-56.33	10	0.13	53.5	373	68.7
K233CY	94.5	-13.24	-56.17	10	0.13	53.1	301	67.8
K245BY	96.9	-11.88	-55.95	10	0.13	54.2	432	69.4

*73.317(d) requirement is lesser of 80 dB or [43 + 10xlog10(Power,W)]

The spectral compliance measurements recorded are listed in the following tables and include the predicable third order products as well as the harmonic frequencies for each station. Two tables are provided for each of the three stations that might operate on this system. The signal level referenced to the carrier level is shown in the third to last data column, and the margin is shown in the last column.

All third order product levels for the current system under investigation meet requirements.

Table 3 - Product Measurements

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)*	Adjusted Reading (dBm)	Carrier Reference Level (dBm)	Level Referenced to Carrier (dB)	73.317(d) Requirement (dB)	Level Relative to Requirement (dB)
92.7	98.3	**87.1**	-56.80	10	-0.12	0.00	-105.4	-38.48	53.5	**-92.0**	68.7	**-23.3**
92.7	96.9	**88.5**	-56.74	10	-0.12	0.00	-104.0	-37.09	53.5	**-90.6**	68.7	**-21.9**
94.5	98.3	**90.7**	-56.52	10	-0.12	0.00	-100.1	-33.42	53.1	**-86.5**	67.8	**-18.7**
92.7	94.5	**90.9**	-56.51	10	-0.12	0.00	-102.1	-35.51	53.5	**-89.1**	68.7	**-20.3**
94.5	96.9	**92.1**	-56.40	10	-0.12	0.00	-100.5	-33.99	53.1	**-87.0**	67.8	**-19.3**
92.7	93.1	**92.3**	-56.37	10	-0.12	0.00	-98.4	-31.86	53.5	**-85.4**	68.7	**-16.7**
92.7	92.3	**93.1**	-56.30	10	-0.13	0.00	-99.2	-32.77	53.5	**-86.3**	68.7	**-17.6**
96.9	98.3	**95.5**	-56.08	10	-0.13	0.00	-99.9	-33.64	54.2	**-87.8**	69.4	**-18.5**
94.5	93.1	**95.9**	-56.04	10	-0.13	0.00	-99.8	-33.65	53.1	**-86.7**	67.8	**-18.9**
94.5	92.7	**96.3**	-56.01	10	-0.13	0.00	-99.2	-33.09	53.1	**-86.1**	67.8	**-18.4**
94.5	92.3	**96.7**	-55.97	10	-0.13	0.00	-98.4	-32.30	53.1	**-85.4**	67.8	**-17.6**
96.9	94.5	**99.3**	-55.74	10	-0.13	0.00	-101.7	-35.81	54.2	**-90.0**	69.4	**-20.7**
96.9	93.1	**100.7**	-55.62	10	-0.13	0.00	-103.2	-37.45	54.2	**-91.6**	69.4	**-22.3**
96.9	92.7	**101.1**	-55.58	10	-0.13	0.00	-103.8	-38.07	54.2	**-92.3**	69.4	**-22.9**
96.9	92.3	**101.5**	-55.55	10	-0.13	0.00	-104.5	-38.86	54.2	**-93.1**	69.4	**-23.7**

** Many of the displayed readings were at the noise floor of the spectrum analyzer, so actual levels may be lower.*

Table 4 - Harmonic Levels

Carrier Frequency (MHz)	Harmonic #	Harmonic Frequency (MHz)	Directional Coupler Coupling Level at Product Frequency (dB)	External Attenuator (dB)	Cable Loss (dB)	(Double) High Pass Attenuation at Product Frequency (dB) (max)	Max Level Displayed, 1 kHz RBW (dBm)**	Adjusted Reading (dBm)	Carrier Reference Level (dBm)	Level Referenced to Carrier (dB)	73.317(d) Requirement (dB)	Level Relative to Requirement (dB)
92.7	2	**185.4**	-50.3	10	-0.18	-0.80	-105.5	-44.18	53.5	**-97.7**	68.7	**-29.0**
94.5	2	**189.0**	-50.2	10	-0.18	-0.80	-105.3	-44.14	53.1	**-97.2**	67.8	**-29.4**
96.9	2	**193.8**	-50.0	10	-0.18	-0.80	-105.6	-44.65	54.2	**-98.8**	69.4	**-29.5**
92.7	3	**278.1**	-46.9	10	-0.22	-0.80	-105.5	-47.56	53.5	**-101.1**	68.7	**-32.4**
94.5	3	**283.5**	-46.8	10	-0.22	-0.80	-104.9	-47.12	53.1	**-100.2**	67.8	**-32.4**
96.9	3	**290.7**	-46.5	10	-0.23	-0.80	-105.3	-47.73	54.2	**-101.9**	69.4	**-32.6**
92.7	4	**370.8**	-44.5	10	-0.25	-0.80	-105	-49.44	53.5	**-103.0**	68.7	**-34.3**
94.5	4	**378.0**	-44.4	10	-0.25	-0.80	-105.3	-49.90	53.1	**-103.0**	67.8	**-35.2**
96.9	4	**387.6**	-44.2	10	-0.25	-0.80	-105.4	-50.20	54.2	**-104.4**	69.4	**-35.0**
92.7	5	**463.5**	-42.7	10	-0.28	-0.80	-105.7	-51.89	53.5	**-105.4**	68.7	**-36.7**
94.5	5	**472.5**	-42.6	10	-0.28	-0.80	-106	-52.34	53.1	**-105.4**	67.8	**-37.6**
96.9	5	**484.5**	-42.4	10	-0.28	-0.80	-105.3	-51.83	54.2	**-106.0**	69.4	**-36.7**
92.7	6	**556.2**	-41.3	10	-0.31	-0.80	-105	-52.56	53.5	**-106.1**	68.7	**-37.4**
94.5	6	**567.0**	-41.2	10	-0.31	-0.80	-105.4	-53.10	53.1	**-106.2**	67.8	**-38.4**
96.9	6	**581.4**	-41.0	10	-0.31	-0.80	-104.7	-52.59	54.2	**-106.8**	69.4	**-37.4**
92.7	7	**648.9**	-40.2	10	-0.33	-0.80	-105	-53.69	53.5	**-107.2**	68.7	**-38.5**
94.5	7	**661.5**	-40.0	10	-0.33	-0.80	-105.2	-54.03	53.1	**-107.1**	67.8	**-39.3**
96.9	7	**678.3**	-39.9	10	-0.35	-0.80	-105.4	-54.38	54.2	**-108.6**	69.4	**-39.2**
92.7	8	**741.6**	-39.3	10	-0.37	-0.80	-105.7	-55.27	53.5	**-108.8**	68.7	**-40.1**
94.5	8	**756.0**	-39.1	10	-0.36	-0.80	-105.8	-55.51	53.1	**-108.6**	67.8	**-40.8**
96.9	8	**775.2**	-39.0	10	-0.34	-0.80	-105.7	-55.58	54.2	**-109.8**	69.4	**-40.4**
92.7	9	**834.3**	-38.5	10	-0.36	-0.80	-105.1	-55.43	53.5	**-109.0**	68.7	**-40.3**
94.5	9	**850.5**	-38.4	10	-0.37	-0.80	-104.9	-55.32	53.1	**-108.4**	67.8	**-40.6**
96.9	9	**872.1**	-38.2	10	-0.38	-0.80	-104.9	-55.48	54.2	**-109.7**	69.4	**-40.3**
92.7	10	**927.0**	-37.9	10	-0.40	-0.80	-104.7	-55.62	53.5	**-109.2**	68.7	**-40.5**
94.5	10	**945.0**	-37.8	10	-0.39	-0.80	-104.4	-55.44	53.1	**-108.5**	67.8	**-40.7**
96.9	10	**969.0**	-37.6	10	-0.41	-0.80	-104.4	-55.56	54.2	**-109.8**	69.4	**-40.4**
92.7	11	**1019.7**	-37.5	10	-0.39	-0.80	-104.3	-55.63	53.5	**-109.2**	68.7	**-40.5**
94.5	11	**1039.5**	-37.5	10	-0.39	-0.80	-104.5	-55.83	53.1	**-108.9**	67.8	**-41.1**
96.9	11	**1065.9**	-37.5	10	-0.39	-0.80	-103.7	-55.03	54.2	**-109.2**	69.4	**-39.9**

** Many of the displayed readings were at the noise floor of the spectrum analyzer, so actual levels may be lower.*

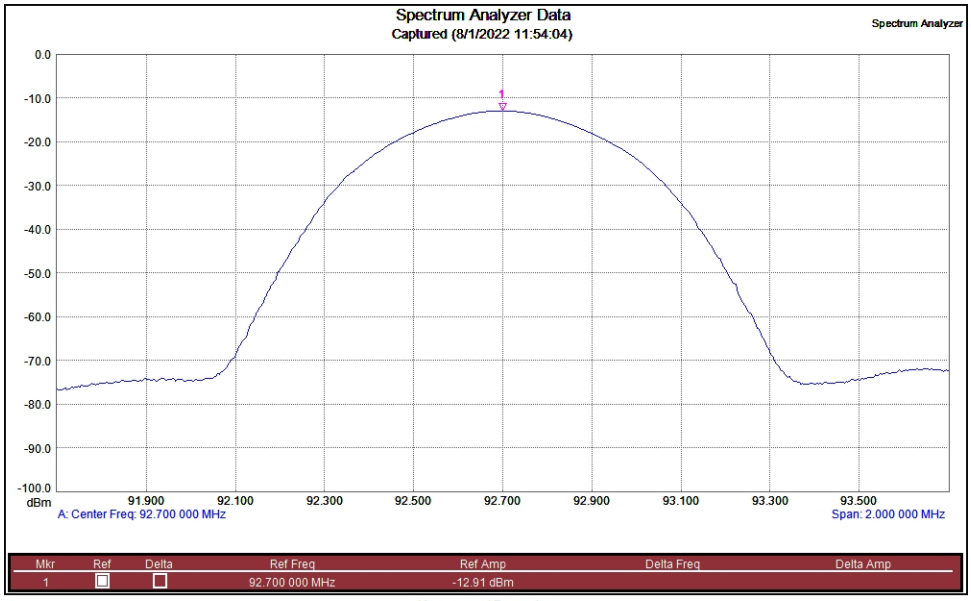
4 Occupied Bandwidth / Mask Measurements

Measurements to show compliance with 73.317(b) and (c) are presented in this section.

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.

In the series of figures that follow, the forward measurement in 300 kHz and 1 kHz resolution bandwidth are shown in the native format of the spectrum analyzer followed by a composite plot of the exported data overlaid on a single plot (normalized to a peak of 0 dB) with the spectral mask outline included.

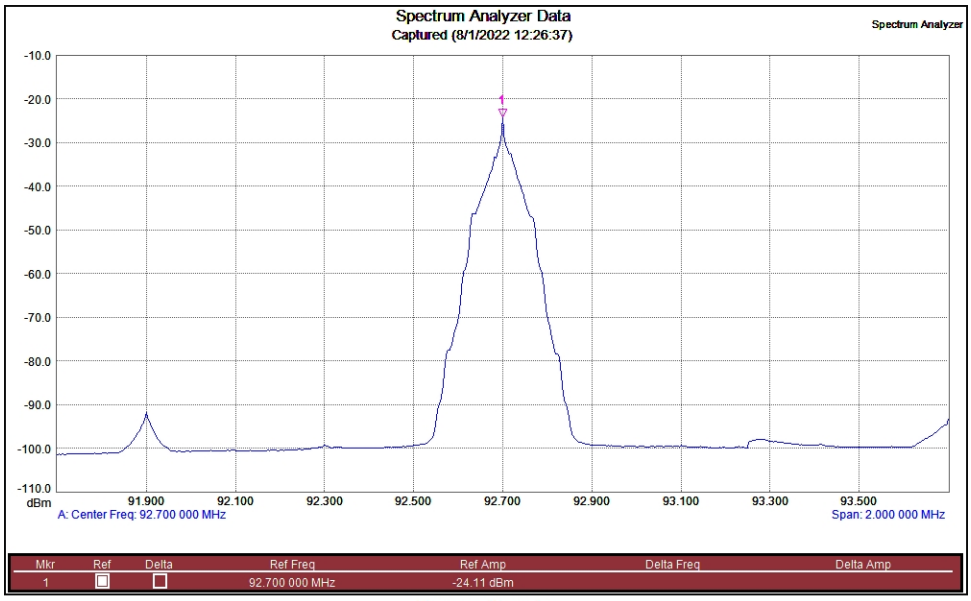
As shown in the composite plots, operation at each of the frequencies is in compliance with 73.317(b) and (c) – that is, the blue line 1 kHz spectrum recording is under the red line FCC mask.



Measurement Parameters

Trace A data:Trace Average	128	Stop Frequency	93.700 000 MHz
Trace Mode	Average	Frequency Span	2.000 000 MHz
Preamp	OFF	Reference Level	0.000 dBm
Min Sweep Time	0.001 S	Scale	10.0 dB/div
Reference Level Offset	0 dB	Serial Number	1104062
Input Attenuation	10.0 dB	Base Ver.	V6.01
RBW	300.0 kHz	App Ver.	V7.24
VBW	100.0 kHz	Model	S332E
Detection	RMS	Options	
Center Frequency	92.700 000 MHz	Date	8/1/2022 11:54:04
Start Frequency	91.700 000 MHz	Device Name	

Figure 5 – K224FD(FX) Forward Carrier Reference Level Measurement, 300 kHz RBW



Measurement Parameters

Trace A data:Trace Average	128	Stop Frequency	93.700 000 MHz
Trace Mode	Average	Frequency Span	2.000 000 MHz
Preamp	OFF	Reference Level	-10.000 dBm
Min Sweep Time	0.001 S	Scale	10.0 dB/div
Reference Level Offset	0 dB	Serial Number	1104062
Input Attenuation	15.0 dB	Base Ver.	V6.01
RBW	1.0 kHz	App Ver.	V7.24
VBW	300.0 Hz	Model	S332E
Detection	RMS	Options	
Center Frequency	92.700 000 MHz	Date	8/1/2022 12:26:37
Start Frequency	91.700 000 MHz	Device Name	

Figure 6 – K224FD(FX) Spectrum Profile, 1 kHz RBW

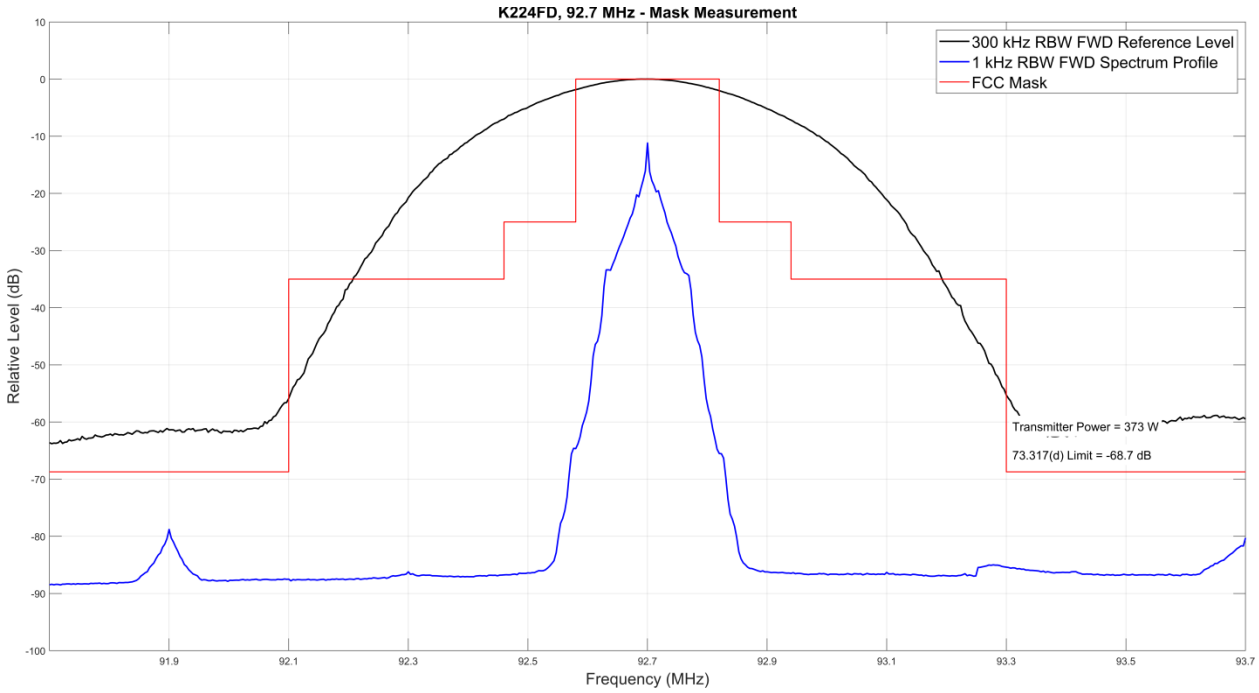
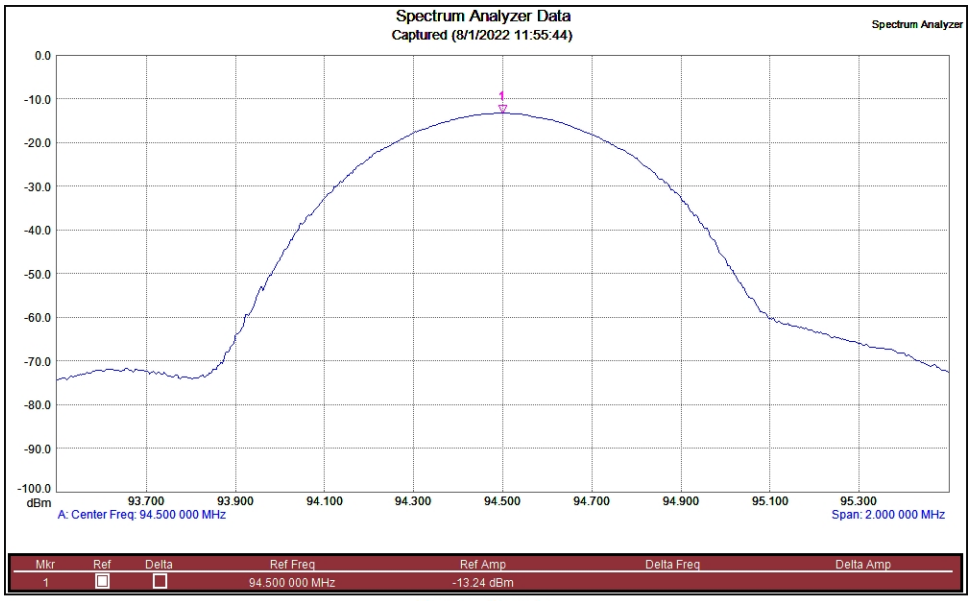


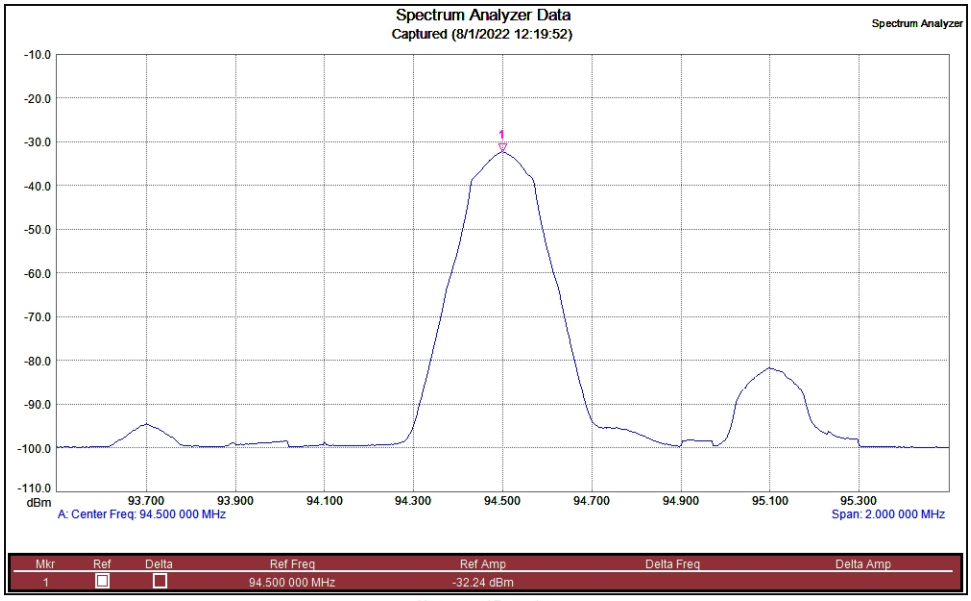
Figure 7 – K224FD(FX) Mask Compliance, Normalized Data Plots, 2 MHz Span



Measurement Parameters

Trace A data:Trace Average	128	Stop Frequency	95.500 000 MHz
Trace Mode	Average	Frequency Span	2.000 000 MHz
Preamp	OFF	Reference Level	0.000 dBm
Min Sweep Time	0.001 S	Scale	10.0 dB/div
Reference Level Offset	0 dB	Serial Number	1104062
Input Attenuation	10.0 dB	Base Ver.	V6.01
RBW	300.0 kHz	App Ver.	V7.24
VBW	100.0 kHz	Model	S332E
Detection	RMS	Options	
Center Frequency	94.500 000 MHz	Date	8/1/2022 11:55:44
Start Frequency	93.500 000 MHz	Device Name	

Figure 8 – K233CY(FX) Forward Carrier Reference Level Measurement, 300 kHz RBW



Measurement Parameters

Trace A data:Trace Average	128	Stop Frequency	95.500 000 MHz
Trace Mode	Average	Frequency Span	2.000 000 MHz
Preamp	OFF	Reference Level	-10.000 dBm
Min Sweep Time	0.001 S	Scale	10.0 dB/div
Reference Level Offset	0 dB	Serial Number	1104062
Input Attenuation	15.0 dB	Base Ver.	V6.01
RBW	1.0 kHz	App Ver.	V7.24
VBW	300.0 Hz	Model	S332E
Detection	RMS	Options	
Center Frequency	94.500 000 MHz	Date	8/1/2022 12:19:52
Start Frequency	93.500 000 MHz	Device Name	

Figure 9 – K233CY (FX) Spectrum Profile, 1 kHz RBW

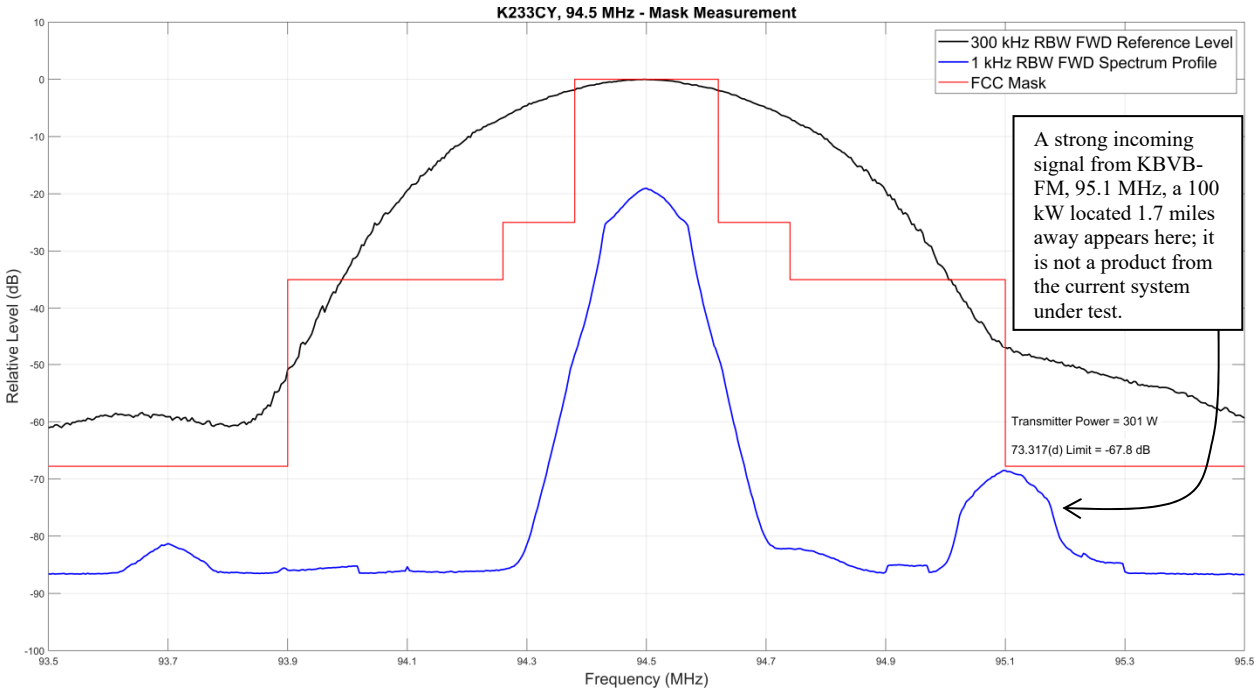
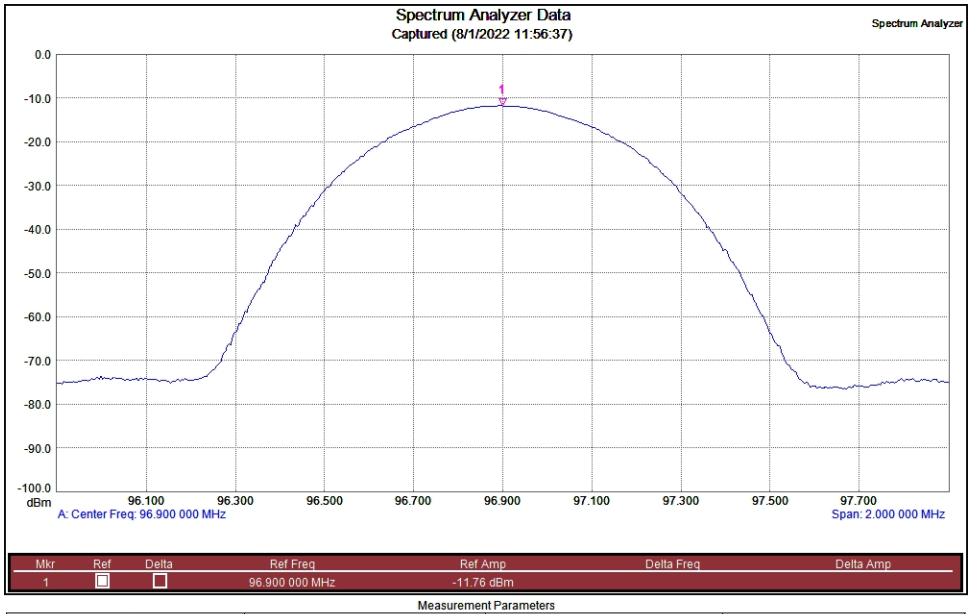


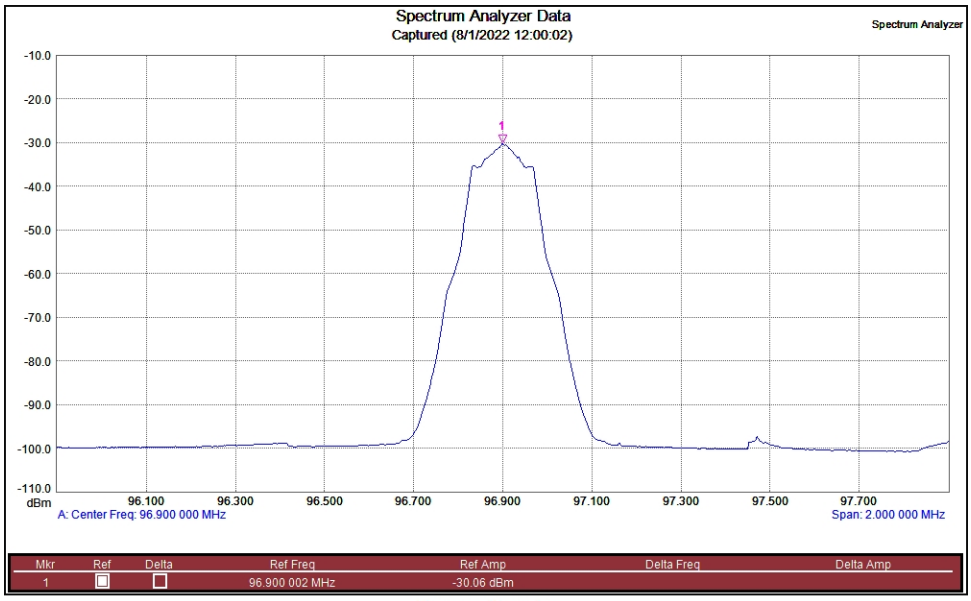
Figure 10 – K233CY (FX) Mask Compliance, Normalized Data Plots, 2 MHz Span



Measurement Parameters

Trace A data:Trace Average	128	Stop Frequency	97.900 000 MHz
Trace Mode	Average	Frequency Span	2.000 000 MHz
Preamp	OFF	Reference Level	0.000 dBm
Min Sweep Time	0.001 S	Scale	10.0 dB/div
Reference Level Offset	0 dB	Serial Number	1104062
Input Attenuation	10.0 dB	Base Ver.	V6.01
RBW	300.0 kHz	App Ver.	V7.24
VBW	100.0 kHz	Model	S332E
Detection	RMS	Options	
Center Frequency	96.900 000 MHz	Date	8/1/2022 11:56:37
Start Frequency	95.900 000 MHz	Device Name	

Figure 11 – K245BY(FX) Forward Carrier Reference Level Measurement, 300 kHz RBW



Measurement Parameters

Trace A data:Trace Average	128	Stop Frequency	97.900 000 MHz
Trace Mode	Average	Frequency Span	2.000 000 MHz
Preamp	OFF	Reference Level	-10.000 dBm
Min Sweep Time	0.001 S	Scale	10.0 dB/div
Reference Level Offset	0 dB	Serial Number	1104062
Input Attenuation	15.0 dB	Base Ver.	V6.01
RBW	1.0 kHz	App Ver.	V7.24
VBW	300.0 Hz	Model	S332E
Detection	RMS	Options	
Center Frequency	96.900 000 MHz	Date	8/1/2022 12:00:02
Start Frequency	95.900 000 MHz	Device Name	

Figure 12 – K245BY (FX) Spectrum Profile, 1 kHz RBW

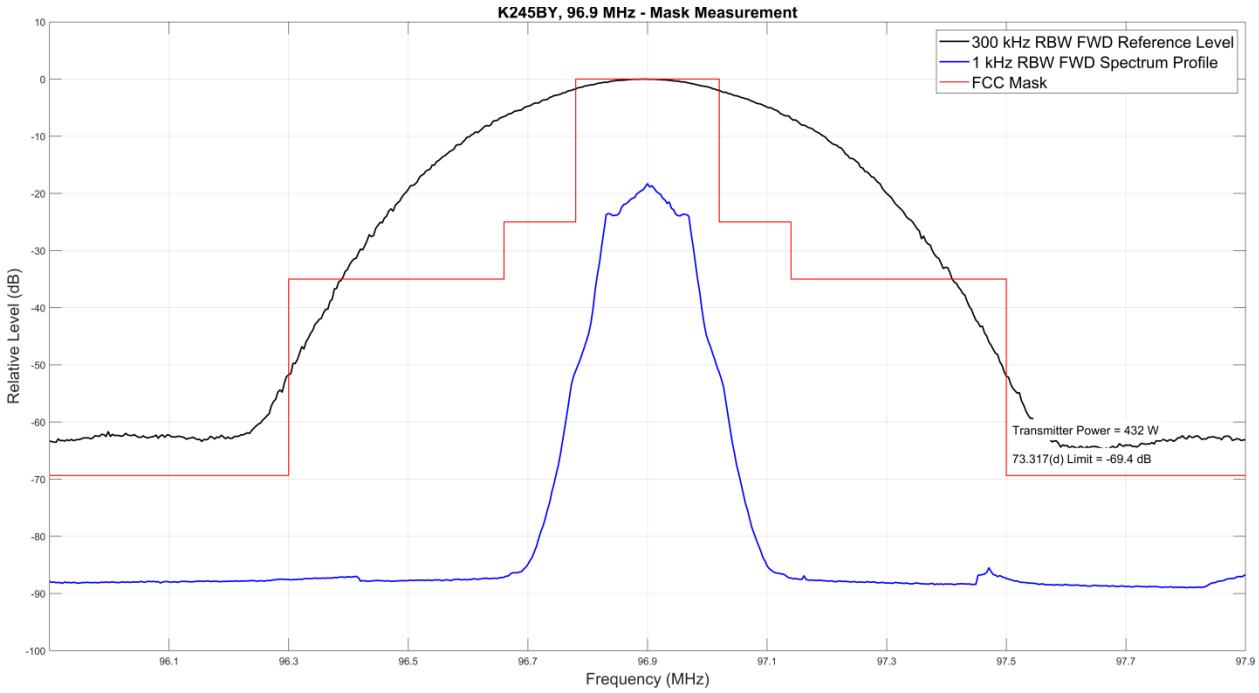


Figure 13 – K245BY (FX) Mask Compliance, Normalized Data Plots, 2 MHz Span

5 Conclusions

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

- K224FD(FX), 92.7 MHz, 373 W TPO
- K233CY(FX), 94.5 MHz, 301 W TPO
- K245BY(FX), 96.9 MHz, 432 W TPO

as described herein 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 Radio FM Media 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) 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 Indiana, Registration No. 19900140
   b) State of Tennessee, Registration No. 126598

Eric R Wandel

Eric R. Wandel, P.E.

August 1, 2022
Date

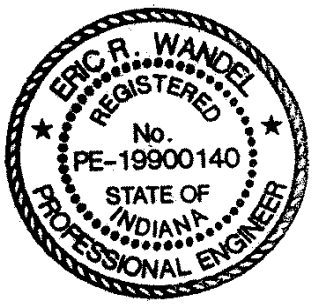


Exhibit A – Citation from CFR Title 47, Section 73.317

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.)