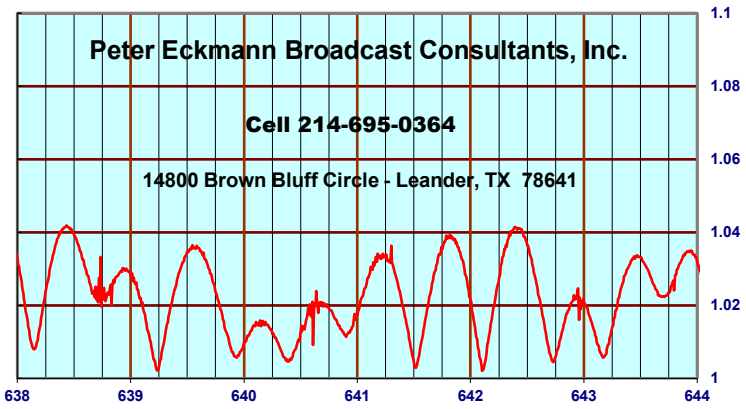


Intermodulation Study Field Report

Date: July 22, 2021
Station Call Sign: KPBS, KMYI, KBZT, KXSN, KFBG, KLVJ, KIOZ
Location: KFMB Master FM antenna, San Diego, CA (Mount Soledad)
Frequencies: 89.5, 94.1, 94.9, 98.1, 100.7, 102.1, 105.3
Antenna: New Dielectric DCRU12DC50T075
Transmission Line: New Dielectric, 6-1/8" Rigid
Work Description: Intermodulation study

Prepared for Dielectric Communications

Prepared by Peter Eckmann

Peter Eckmann Broadcast Consultants, Inc.

Introduction:

Introduction

This report is based on data collected at the site mentioned above. The report includes measurements offered as proof that the combined operations of the above 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 around 6-13 dB for tube type transmitters and around 20dB for solid-state 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 or 20dB 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 Description:

Test equipment used: Keysight Field Fox, Model N9913A, Spectrum Analyzer. Band pass filters, band stop filters, and notch filters were utilized as needed to reduce signal levels of adjacent frequencies. The network analyzer mode was used to tune band pass filters as needed

All measurements were made from the forward directional coupler at the output of the combiner. 50 db coupling with >30 db directivity

All relevant stations were on the air at full power.

The 7-station combiner was supplied by Dielectric. All filters are 5 pole bandpass constant impedance filters except 94.9 and 105.3. These are 4 pole filters. The sequence of the combiners is 88.5, 98.1, 94.9, 94.1, 100.7, 102.1, and 105.3. 105.3 is at the output of the combiner.

Two IM frequencies did not meet the FCC criteria, 95.7 MHz and 95.5 MHz. IM frequency 95.5 is derived from 98.1 and 100.7. When either of these frequencies are turned off there was no change in the magnitude of the 95.5 IM which indicates that this is some interference from another source and is unassociated with 98.1 or 100.7 transmissions.

IM frequency 95.7 is derived from 94.9 and 94.1 and is wide enough to encompass IM frequency 95.5. When IM 94.9 is turned off, the IM at 95.7 drops to the noise floor as does the 95.5 IM. After consultation with other engineers and studying the combiner test data, it seems unlikely that the 95.7 IM is generated from the combiner. It is possible that it is being generated from the tower or appurtenances in the aperture of the antenna. Calculations from combiner measured data show that it is not likely from the combiner. No interference is reported from this site.

IMD Suppression Pt	Worse Case	Mid-Band	Integrated
Isolation of 94.1 to 94.9	52dB	58dB	57dB
Turn Around Loss	20dB	20dB	20dB
IMD Attenuation though 94.9	4dB	14dB	12dB
SUM	76dB*	92dB	89dB

*Worse case is at band edge (+/-200kHz) where it IBOC is -10dB down, therefore, 76dB should be 86dB

At mid-band frequency there is clearly enough attenuation that IMD levels at 95.7 should be attenuated implying compliance. Using the measured 73dB, the turn around loss would be ~0dB. Supporting graphs on pages 14 and 15

An added complexity is that 95.7 broadcasts from an adjacent tower a few hundred feet away. 95.7 was turned off as needed to obtain the 95.7 and 95.5 IM measurement. There are several other FM broadcasters on adjacent towers adding more RF energy and interference making the task even more complex.

All other IM products meet the FCC criteria.

Conclusions:

Based upon my observations and measurement data collected on July 22, 2021, I Peter Eckmann, find the subject combined system operating with stations KPBS, KMYI, KBZT, KXSN, KFBG, KLVJ, KIOZ to be compliant with the requirements of Section 73.317 paragraph (b) through (d) of the FCC Rules and Regulations.

Peter Eckmann

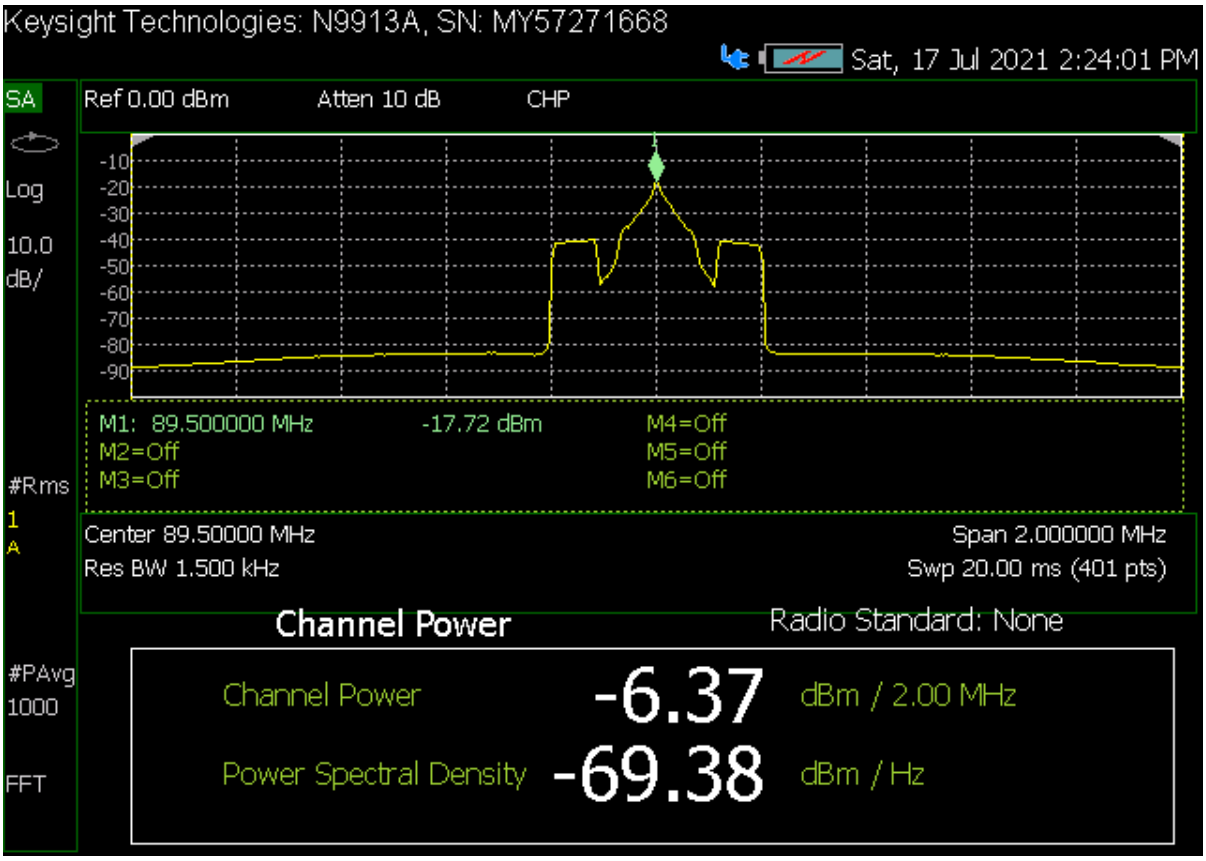
Peter Eckmann Broadcast Consultants, Inc.

2(f1)-f2

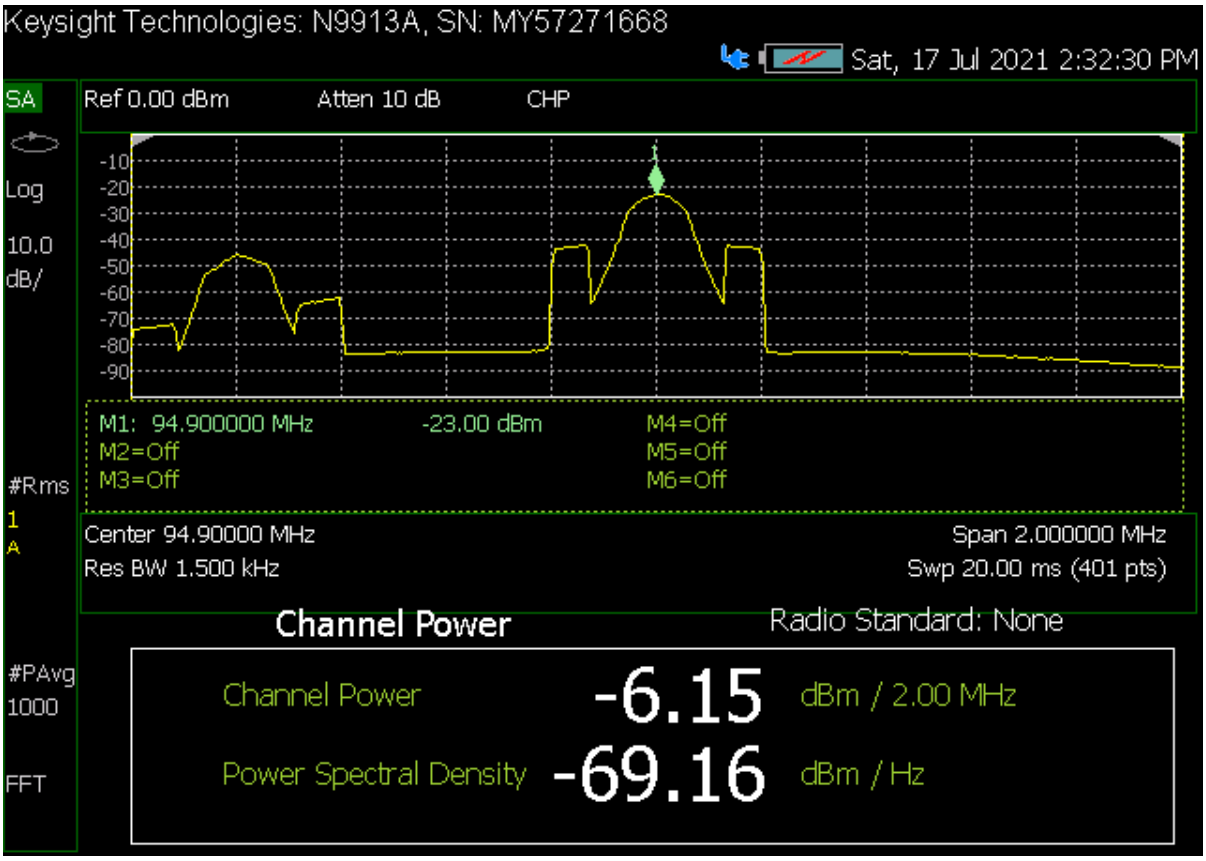
	f2						
f1	89.5	94.9	98.1	100.7	94.1	105.3	102.1
89.5		84.1	80.9	78.3	84.9	73.7	76.9
94.9	100.3		91.7	89.1	95.7	84.5	87.7
98.1	106.7	101.3		95.5	102.1	90.9	94.1
100.7	111.9	106.5	103.3		107.3	96.1	99.3
94.1	98.7	93.3	90.1	87.5		82.9	86.1
105.3	121.1	115.7	112.5	109.9	116.5		108.5
102.1	114.7	109.3	106.1	103.5	110.1	98.9	

Yellow indicates frequencies in the FM band.

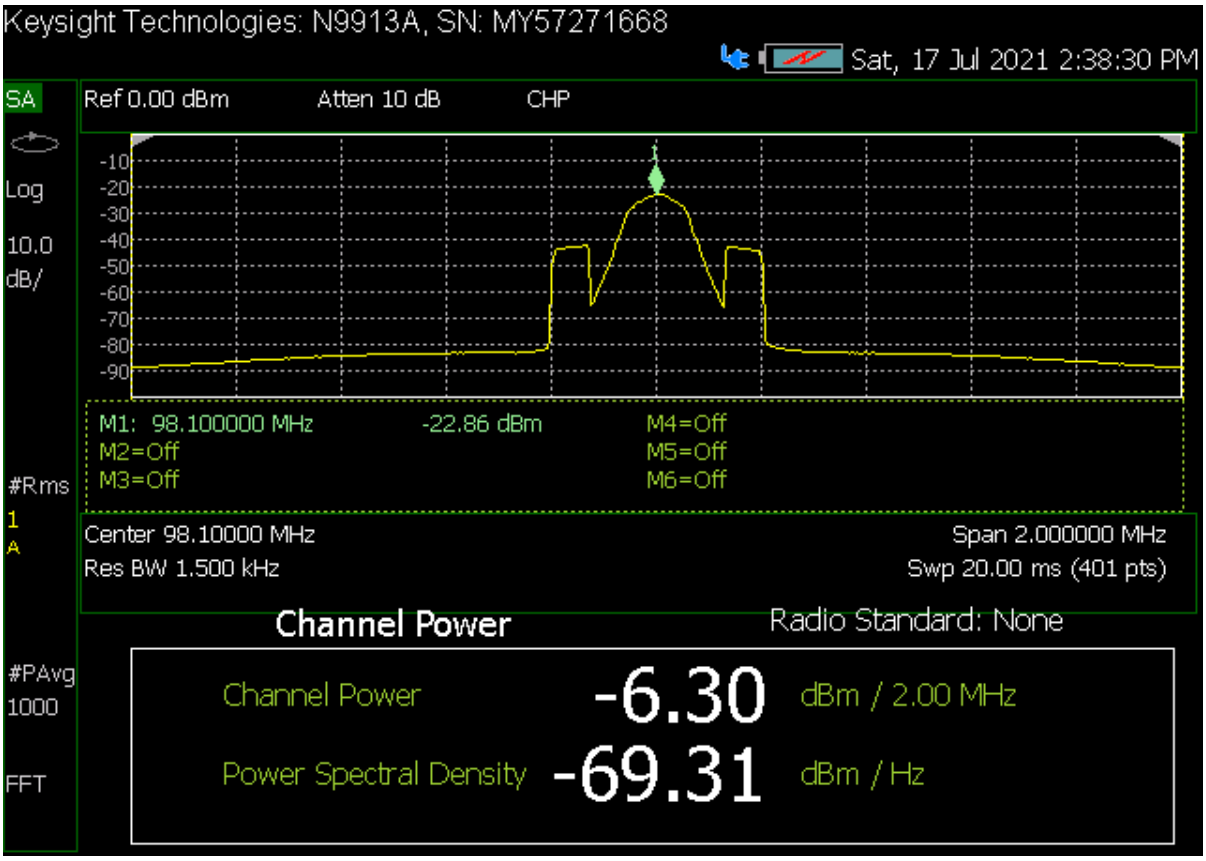
f1	f2	IM freq	F1 measured level	added attn	F1 filter loss	measured value	IM filter loss	F1 level	notch filter loss at IM Freq	calculated IM level	Notes:
89.5			-17.72	20	4.6			6.88			
	94.9	84.1				-112.1	4.85			-114.13	
	98.1	80.9				-112.1	4.91			-114.07	
	100.7	78.3				-92.4	1.06			-98.22	used fm band stop filter
	94.1	84.9				-112.8	4.78			-114.9	
	105.3	73.7				-97.74	0.51			-104.11	used fm band stop filter
	102.1	76.9				-91.91	0.84			-97.95	used fm band stop filter
94.9			-23	20	4.16			1.16			
	89.5	100.3				-98.76	7.88		2.48	-89.56	need to turn off 100.7
	98.1	91.7				-105.3	3.99			-102.47	
	100.7	89.1				-112.2	4.64			-108.72	89.5 was off air during measurement
	94.1	95.7				-72.1	9.67		0.78	-62.81	95.7 off, triple bandpass filters for 95.7 , notch 94.9
	105.3	84.5				-112.9	4.81			-109.25	
	102.1	87.7				-112.5	4.51			-109.15	
98.1			-22.86	20	4.4			1.54			
	89.5	106.7				-105.3	4.01			-102.83	
	94.9	101.3				-106.8	8.06		1.42	-98.86	used double tuned bandpass filters and notch @ 100.7
	100.7	95.5				-79.18	8.27			-72.45	94.9, 95.7, 96.5 off, double bp filter 95.5
	94.1	102.1				-112.5	8			-106.04	102.1 turned off for measurement, used double filters for 102.1
	105.3	90.9				-109.2	4.49			-106.25	
	102.1	94.1				-105.2	8.88			-97.86	turned off 94.1 for measuremenmt, used double bandpass filters set for 94.1
100.7			-22.18	20	3.68			1.5			
	89.5	111.9				-112	3.48			-110.02	
	94.9	106.5				-93.97	4.24			-91.23	
	98.1	103.3				-99.01	3.81			-96.7	
	94.1	107.3				-106.7	3.55			-104.65	
	105.3	96.1				-97	4.33			-94.17	
	102.1	99.3				-103.2	3.8			-100.9	
94.1			-19.5	20	4.4			4.9			
	89.5	98.7				-99.72	8.09		1.29	-95.24	notched 98.1, double bandpass filters for 98.7
	94.9	93.3				-89.64	4.04			-90.5	
	98.1	90.1				-89.71	4.52			-90.09	
	100.7	87.5				-111.9	4.61			-112.19	
	105.3	82.9				112.2	4.96			112.26	
	102.1	86.1				-112.7	4.32			-113.28	
105.3			-21.4	20	3.65			2.25			
	89.5	121.1				-104.2	0.62			-105.83	
	94.9	115.7				-92.96	1.14			-94.07	
	98.1	112.5				-112.2	3.83			-110.62	
	100.7	109.9				-112	3.49			-110.76	
	94.1	116.5				-90.53	1.04			-91.74	
	102.1	108.5				-111.9	3.91			-110.24	
102.1			-22.7	20	4.14			1.44			
	89.5	114.7				-102.2	1.31			-102.33	
	94.9	109.3				-111.9	3.51			-109.83	
	98.1	106.1				-86.34	3.97			-83.81	
	100.7	103.5				-103.1	3.62			-100.92	
	94.1	110.1				-112	3.91			-109.53	
	105.3	98.9				-89.11	3.74			-86.81	



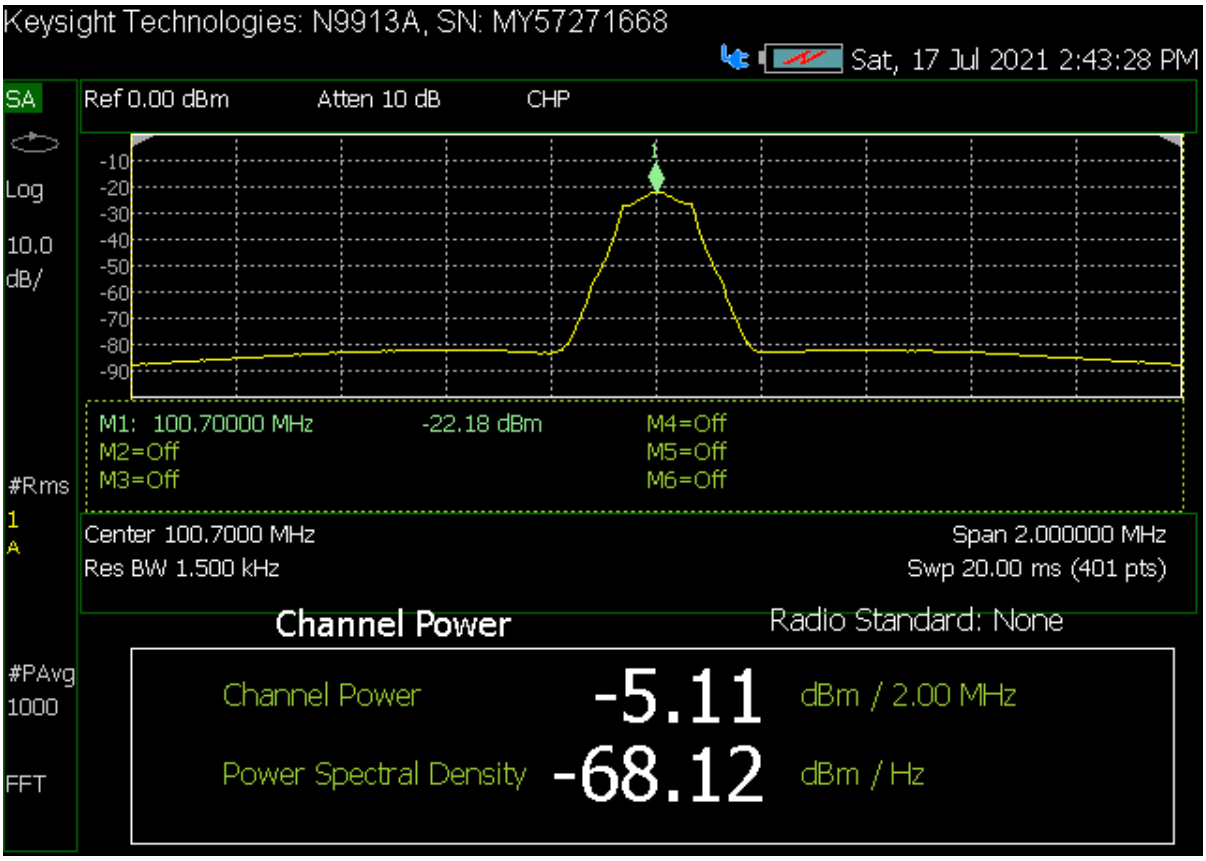
89.5 occupied bandwidth



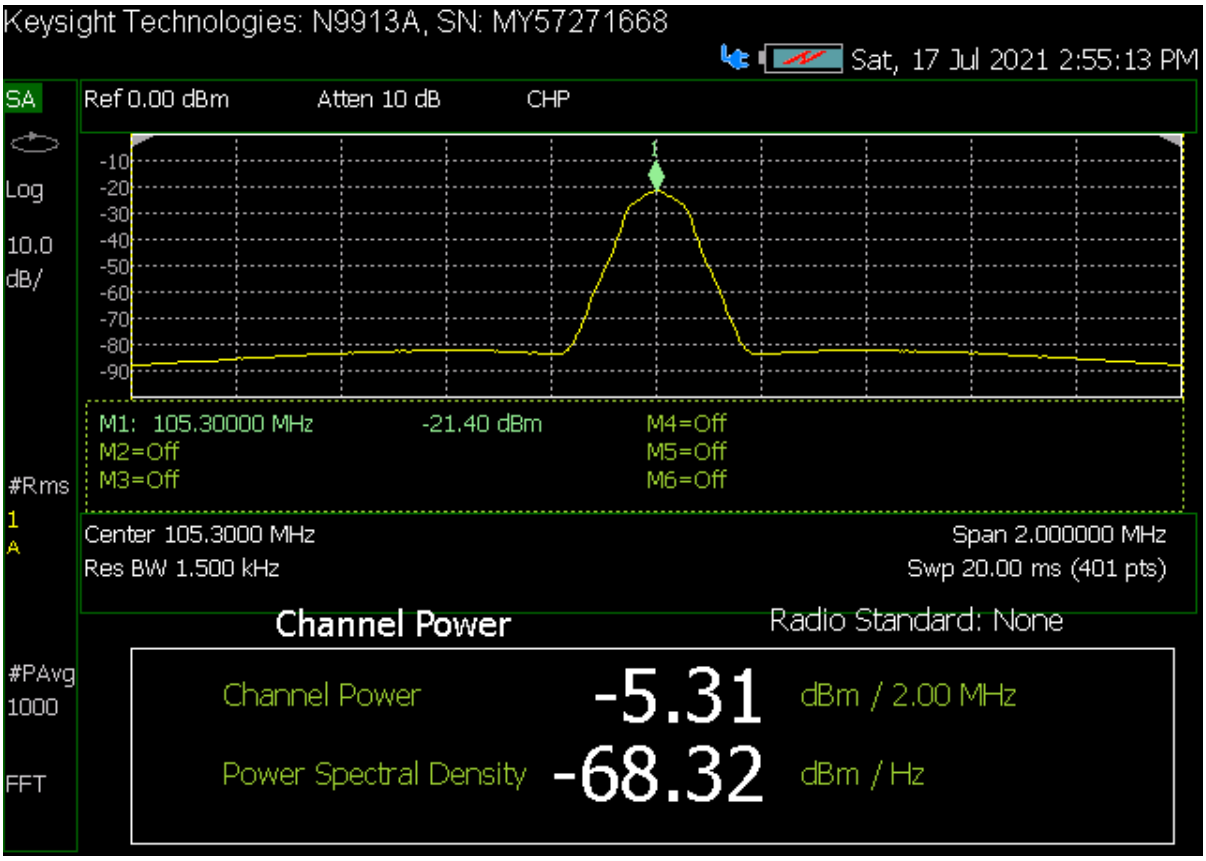
94.9 occupied bandwidth



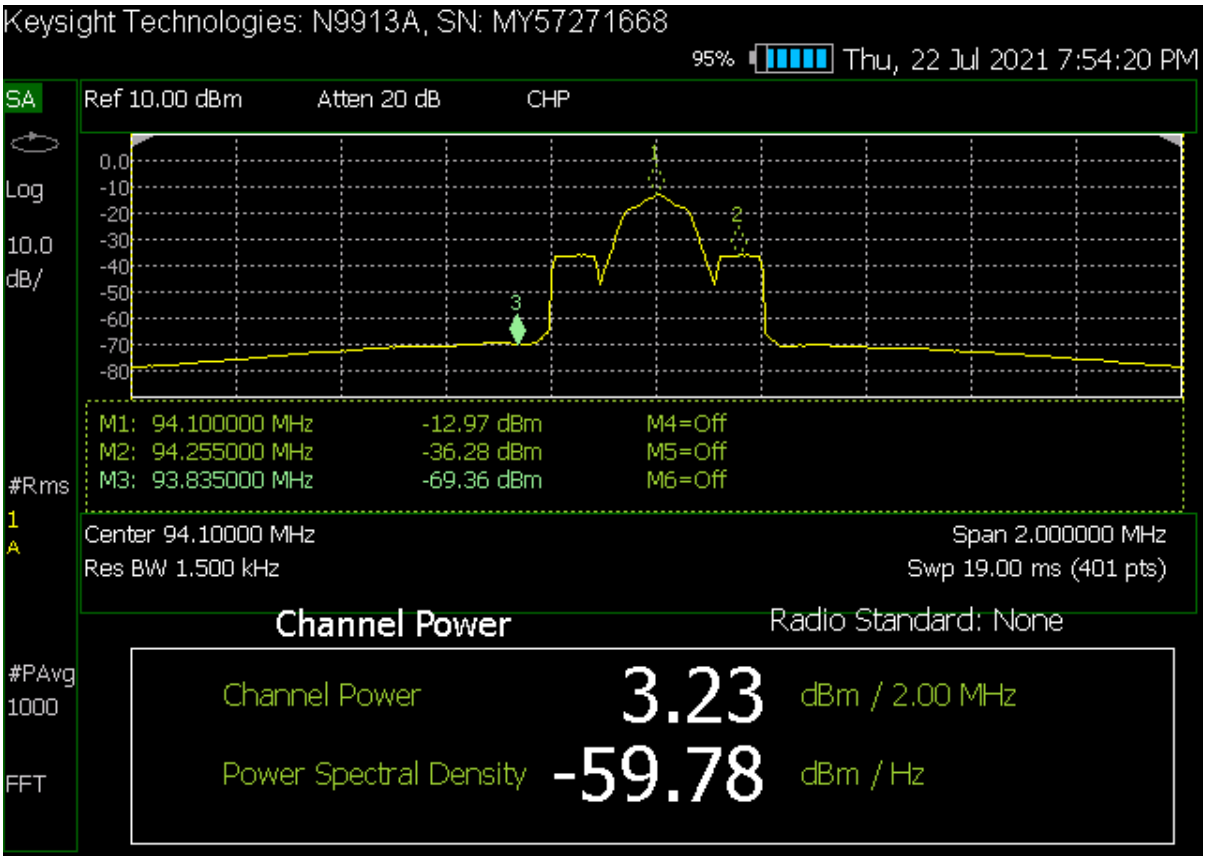
98.1 occupied bandwidth



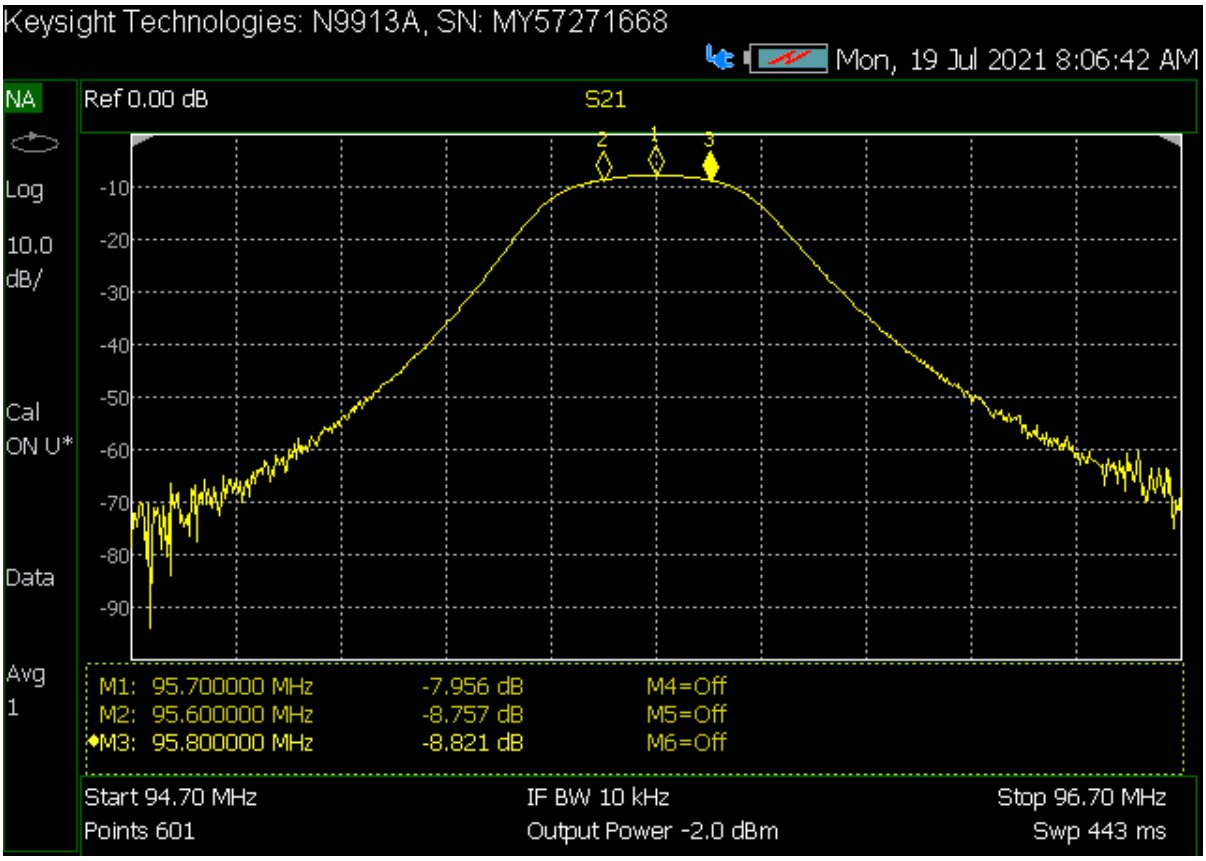
100.7 occupied bandwidth



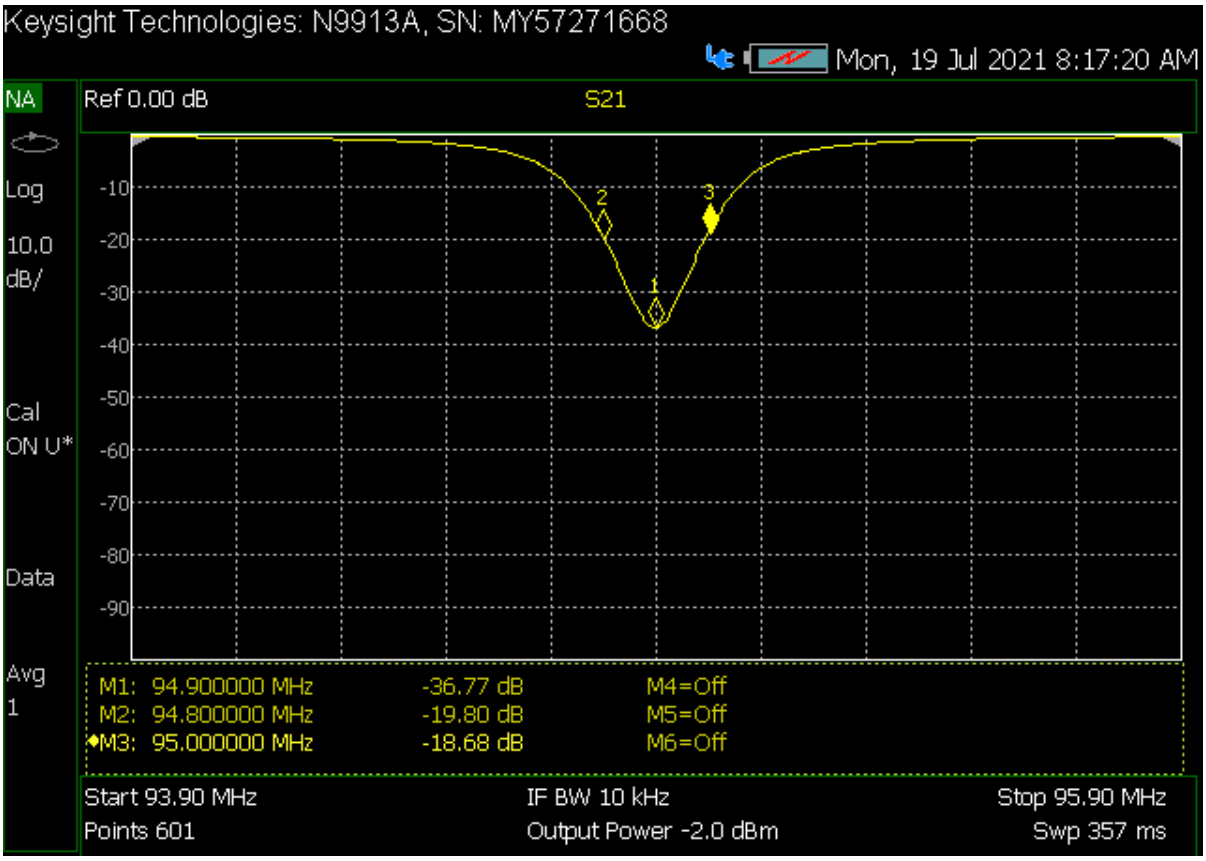
105.3 occupied bandwidth



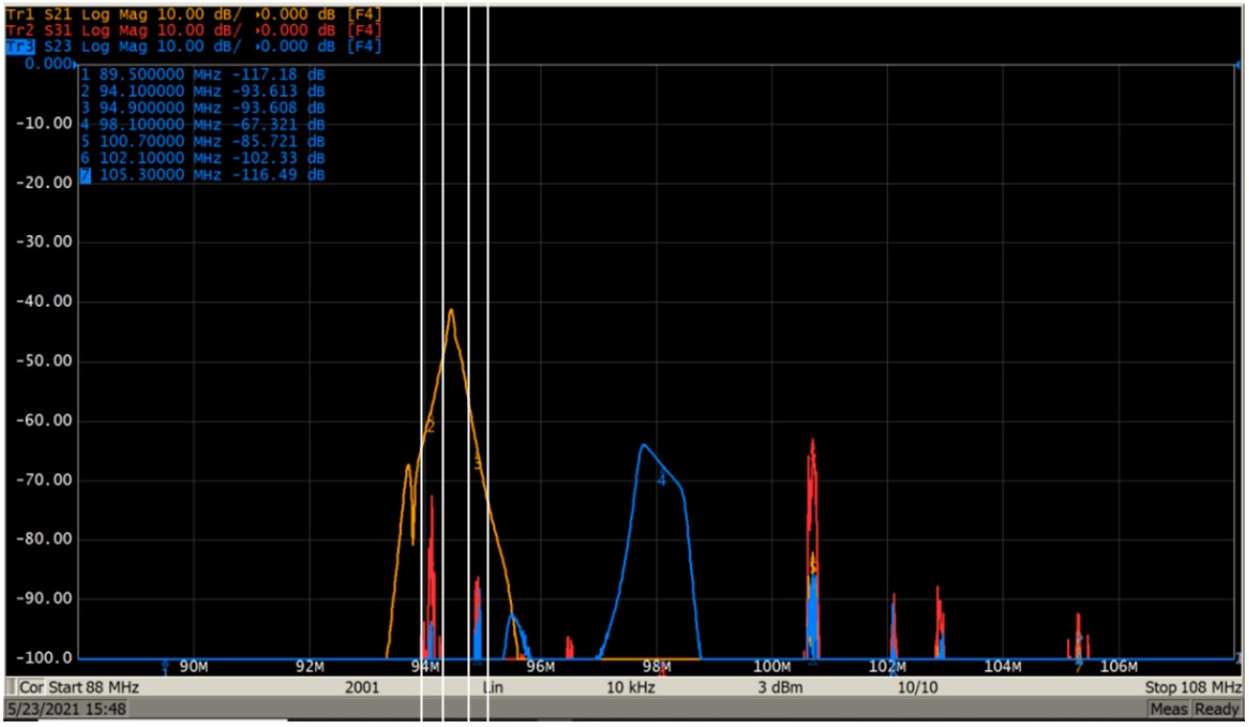
94.1 occupied bandwidth



Typical bandpass filter, two in series as needed.



Typical notch filter as needed



-52dB (-57dB integrated) isolation, 94.1 to 94.9

-14dB (-12dB integrated) attenuation of 95.7MHz IMD passing back through 94.9 filter