Application for License to Cover
Construction Permit LMS- 0000202346
Station KKBR (FM) Billings MT
FCC Facility ID 16774

TECHNICAL EXHIBIT

This technical exhibit is prepared on behalf of Townsquare License, LLC Licensee of Station KKBR (FM) Billings MT. Construction has been completed on the new combined antenna system for KCHH (FM), KKBR (FM) and KCTR-FM, all commonly owned by this licensee. Contemporaneous applications are being filed for license to cover on KCHH (FM) and KKBR (FM) and Replacement License application for KCTR-FM which are all affected by this common antenna installation.

Special Operating Conditions:

1. A full Proof of Performance Report is attached with certifies that the operation authorized in this construction permit is in compliance with the spurious emissions requirements of 47 C.F.R. Sections 73.317(b) through 73.317(d). All measurements have been made with all stations simultaneously utilizing the shared antenna.

2. With this application, the licensee is requesting Program Test Authority, based on the documentation submitted herein which meets the Special Operating Conditions attached to the underlying Construction Permit.

3. RF Field strength measurements have been made to demonstrate compliance with FCC guidelines for human exposure to RF fields. A report is attached hereto.

4. These certifications are being submitted with the filing of FCC Form 302-FM

Respectfully,

Jim Turvaville, Owner
Turbo Tech Services
Certified Radio Engineer - Consultant

Attached: -Antenna and Combiner Proof
-RF Exposure Certification

Equipment Performance Measurements

For

Townsquare License, LLC

And Stations

KCTR-FM Billings (FacID 16773)

KKBR Billings (FacID 16774)

KCHH Warden (FacID 1315)

For the

New Three Station Combined Antenna System

Steve Campbell, PE
Entronics
8008 Turtle Cove Ave
Las Vegas, NV 89128-6763

steve@rsclv.com
(702) 360-4051

Executive Summary

Townsquare Media, Inc. has elected to refresh the transmitter installations for its Billings FM stations KCTR-FM, KKBR and KCHH by combining them into a new ERI SHPX-10C6-SP antenna and installing an ERI 783 based Branch Combiner. This installation replaces the existing KCTR-FM antenna system with no significant change in height. In compliance with a condition of the KCHH's Construction Permit File Number 0000176079, with a condition of the KKBR's Construction Permit File Number 0000202346, in support of a 47 CFR 73.1690(c)(1) permitted license modification for KCTR-FM and in compliance with the FCC Rules and Regulations, measurements were taken to demonstrate while all stations were operating at their licensed power and operating into the shared antenna, the system is in compliance with 47CFR 73.317 (b) through (d).

This document demonstrates compliance with 47 CFR 73.317 (b) through (d).

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Measurement Narrative

Upon completion of the installation of a replacement non-directional antenna for KCTR-FM with a new Electronic Research, Inc (ERI) Model SHPX 10-C6-SP antenna designed to accept multiple frequencies but with the same general characteristics for KCTR-FM as the existing ERI built antenna, the installation and confirming of a ERI Model 783 based Branch Combiner that was overseen by Eric Wandel of Wavepoint Research, Inc with the technical support assistance of ERI, the installation of one new transmitter for KCHH and the re-installation of the KKBR and KCTR-FM transmitters by the undersigned, and obtaining the FCC consents for testing, measurements were made by the undersigned during the early morning hours of February 16, 2023 and February 21, 2023 to demonstrate compliance with 47 CFR 73.317 (b) through (d) for the three station system. These measurements were made with each of the three transmitters operating at the powers shown in Appendix 1, the new licensed Transmitter Power Outputs (TPO) that will be requested in the License To Cover a Construction Permit (L2C) for both KCHH [FCC Construction Permit (CP) File Number 0000176079] and KKBR [FCC CP File Number 0000202346] and for the modification of the KCTR-FM main license as permitted under 47 CFR 73.1690(c)(1). These three stations were operating in their final configuration into the shared ERI antenna.

Three sets of measurements were performed on each of the stations. The first measurements were made after proper modulation levels of each transmitter were confirmed with a Deva Band Scanner 2 (S/N BS2JA180). The measurements were made with an Anritsu MS2721B (S/N 1007029) Spectrum Analyzer, known to be in good repair and calibration and which passed all self-tests, connected to the Forward Sample Port B of the common 6" ERI directional coupler on the output of the Branch Combiner. A 20 dB pad was inserted to prevent spectrum analyzer front end overload. The analyzer was centered on each carrier frequency, was set to peak hold with a RBW of 300 Hz and no effective VBW filter. The displayed signal was observed for multiple minutes, until no further growth in the displayed peak hold were observed. The modulation including the pilot and RDS subcarrier were removed to obtain the unmodulated carrier level, and the mask based of 47 CFR 73.317 was referenced to the unmodulated carrier. A record was taken for each observation, one at 2 MHz span and one at 6 MHz span for each frequency. During the preparation of this report, the frequencies that exceed the mask in the in each of these observations, as well as other coherent observations were identified on the record. These observations and records are shown in Figures 5 through 10.

The second set of measurements were taken with the three stations operating as described above. Prior to these measurements, a set of three Microwave Filter Company Tunable Notch Filters Type 6367 (S/N 94, 96, 98) were connected in series. Utilizing the tracking generator in the Anritsu MS2721B used for all measurements herein, these filters were tuned to place an approximately equal notch at the three station's fundamental frequencies. These notches were approximately 20 dB deep for each frequency and the characteristics of the cascaded filters are shown in Figure 2 and 3. This cascaded filter set was placed on the input to the Anritsu Spectrum Analyzer, and the input to the filter cascade was connected to the ERI directional coupler to sample products being sent to the antenna. The expected intermodulation products of two and three frequencies were calculated, and the Anritsu was tuned to each of these frequencies. With the use of the Anritsu Marker system, these frequencies were measured where there was an indication above the noise floor (grass) in the Anritsu display and were logged. Where the indication was not above the noise floor, the level of the noise floor was logged and tagged as in the noise floor. Additionally, a scan for other significant indications across the spectrum was

observed and these observations were logged. Upon the completion of the observations, the cable was disconnected from the ERI Directional Coupler and connected to the Anritsu Tracking Generator which was set to 0 dBm output level. Each frequency observed was again observed, from the tracking generator through the cable/notch filter, and this value was recorded as the filter correction value. During the preparation of this report, the value of coupling obtained from a Directional Coupler Sweep performed by Eric Wandel as part of the confirmation measurements of the ERI combiner was determined for each frequency and this was entered as the Combiner Coupler Value for each observation. The corrections for the filter attenuation and for the coupler coupling value were applied to the observed measurements, and these were then referenced to the appropriate carrier. The results of these measurements and observations are listed in Table 1 through 4.

As the cascaded notch filters had some oddities at higher frequencies (See Figure 3) that while should have been adjusted by the procedure outlined above, a third set of measurements were taken substituting a Crystek CHPFL-0150-BNC (No S/N) 150 MHz High Pass Filter for the cascaded notch filters. The measurements described above were repeated for all frequencies above, and an additional scan for significant other products was performed. The same procedure for measuring the filter characteristic for each frequency was used and the calculations were done as described above. These results are displayed in Table 5 through 8.

Prior to these measurements, and after these measurements were done, the Anritsu self-checks were performed. In addition, a 1 MHz to 1.5 GHz sweep of the tracking generator into the spectrum analyzer was performed and the result showed an approximate 0.5 dB response flatness.

For completeness of the documentation, the Tuning Report from Eric Wandel for the confirmation of the ERI combiner is included in Appendix 2. This report demonstrates that the port-to-port coupling between transmitters is greater than -80 dB making any intermod products from the combined system highly unlikely, as was demonstrated by the undersigned's measurement. A plot of the Directional Coupler response measured by Eric Wandel is included for reference, but the values used herein were taken from the 8000 samples in the sweep that was not included herein due to its length.

Certification

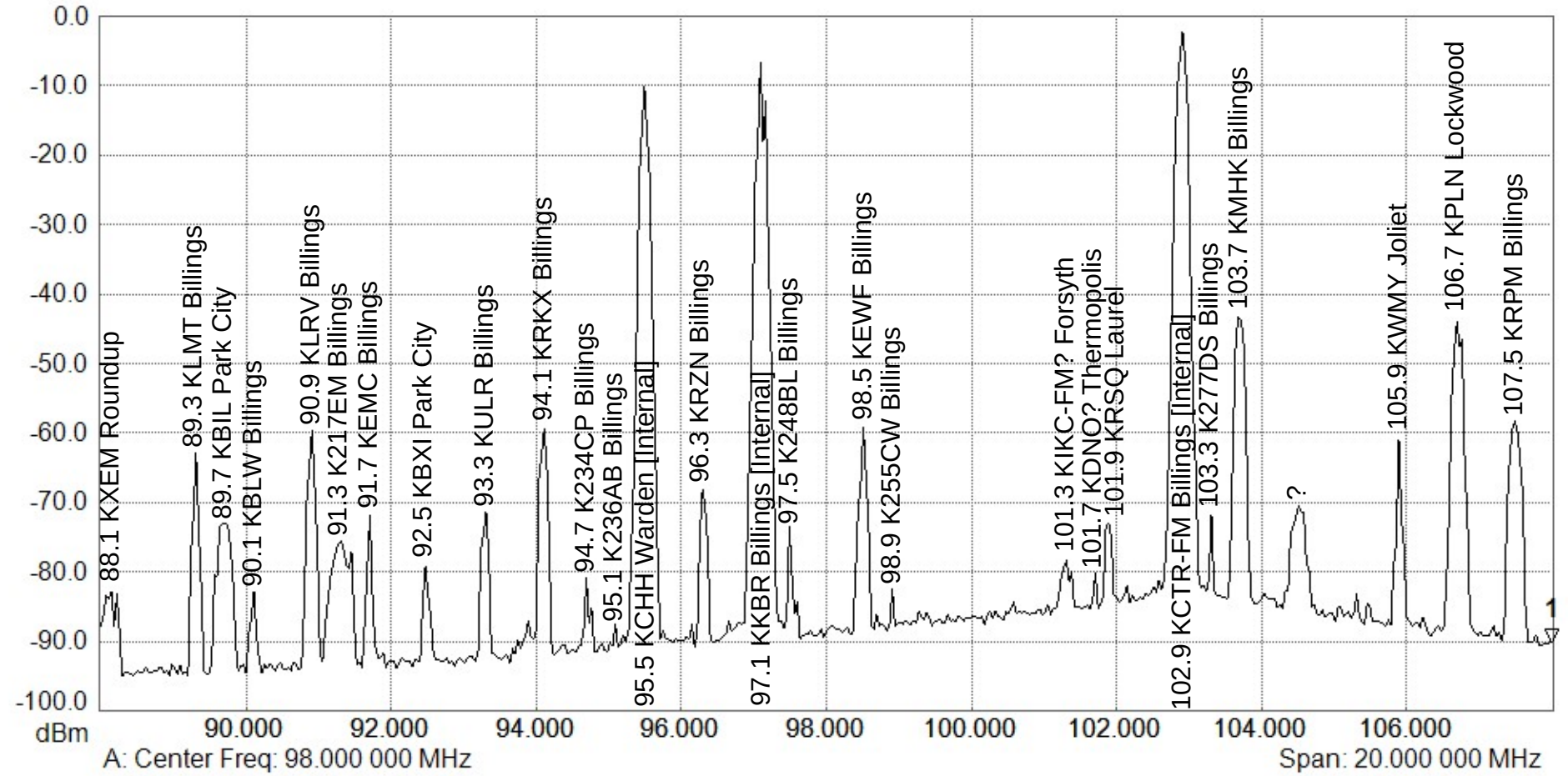
I hereby certify that, except for the work referenced herein and attributed to Eric Wandel, work that I did personally observe, all installation, adjustments to the transmitting equipment and all measurements herein described were performed by the undersigned. All measurements and representations within this report are true and accurate to the best of the undersigned's knowledge and belief.

Steve Campbell

Steve Campbell (NV PE Electrical 16245)
Entronics
June 15, 2023

Figure 1

External Stimulus-Combiner-Coburn Road

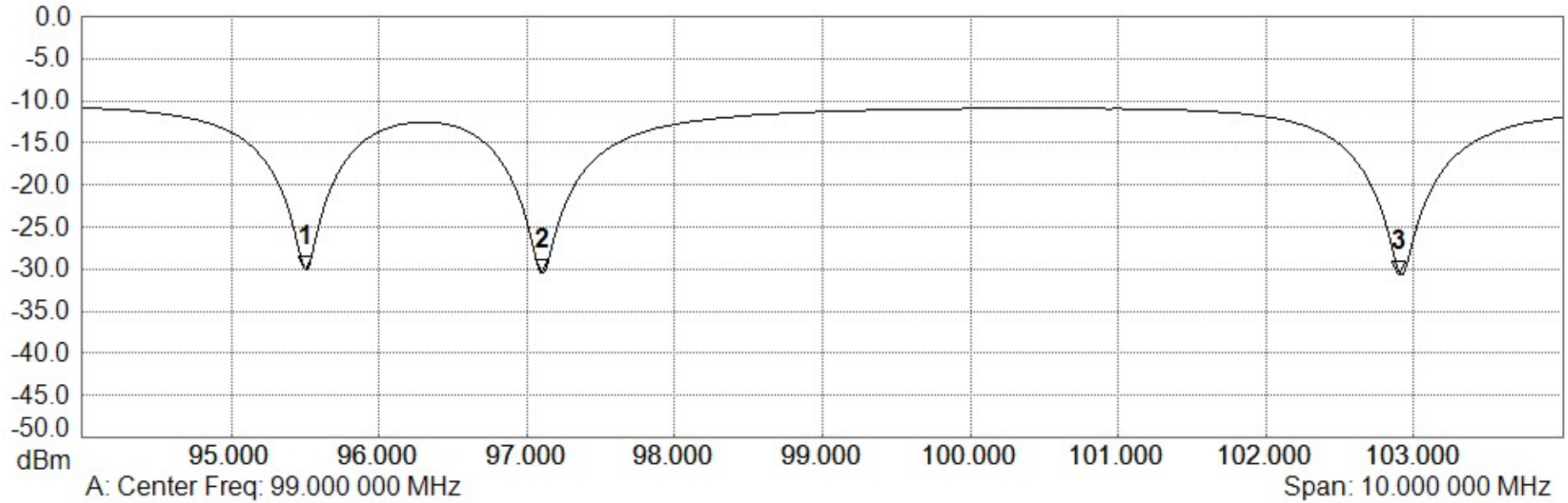


Trace A data:	Detection = Peak	Base Ver. = V5.71
Trace Mode = Max Hold	Center Frequency = 98.000 000 MHz	App Ver. = V5.73
Preamp = OFF	Start Frequency = 88.000 000 MHz	Model = MS2721B
Min Sweep Time = 0.001 S	Stop Frequency = 108.000 000 MHz	Options = 20
Reference Level Offset = 0 dB	Frequency Span = 20.000 000 MHz	Date = 2/15/2023 9:01:22 PM
Input Attenuation = 20.0 dB	Reference Level = 0.000 dBm	Device Name = Entronics_MS2712B_SN-100
RBW = 300.0 Hz	Scale = 10.0 dB/div	
VBW = 3.0 MHz	Serial Number = 1007029	

Figure 2

Cascaded Notch Filter Narrow Characteristic

Generator: Tracking



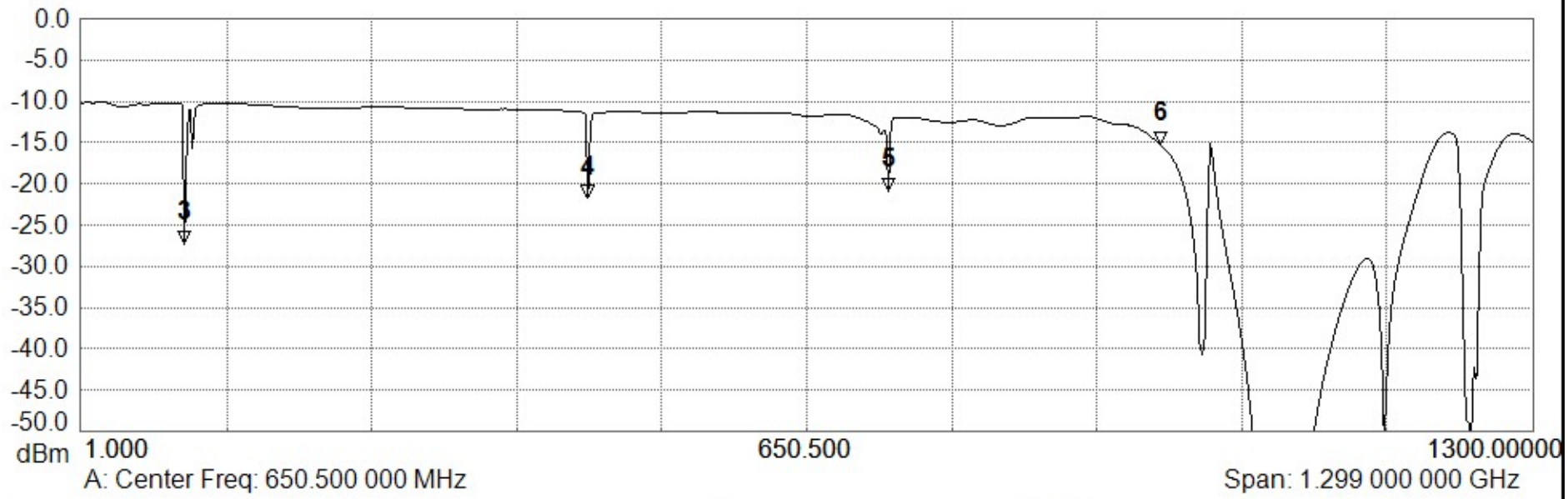
Mkr	Ref	Delta	Ref Freq	Ref Amp	Delta Freq	Delta Amp
1	■	□	95.500 000 MHz	-30.11 dBm		
2	■	□	97.100 000 MHz	-30.35 dBm		
3	■	□	102.900 000 MHz	-30.69 dBm		
4						
5						
6						

Trace A data:	Detection = Sample	Base Ver. = V5.71
Trace Mode = Normal	Center Frequency = 99.000 000 MHz	App Ver. = V5.73
Preamp = OFF	Start Frequency = 94.000 000 MHz	Model = MS2721B
Min Sweep Time = 0.001 S	Stop Frequency = 104.000 000 MHz	Options = 20
Reference Level Offset = 0 dB	Frequency Span = 10.000 000 MHz	Date = 5/2/2023 8:31:23 PM
Input Attenuation = 20.0 dB	Reference Level = 0.000 dBm	Device Name = Entronics_MS2712B_SN-100
RBW = 3.0 kHz	Scale = 5.0 dB/div	
VBW = 3.0 MHz	Serial Number = 1007029	

Figure 3

Cascaded Notch Filter Wide Characteristic

Generator: Tracking



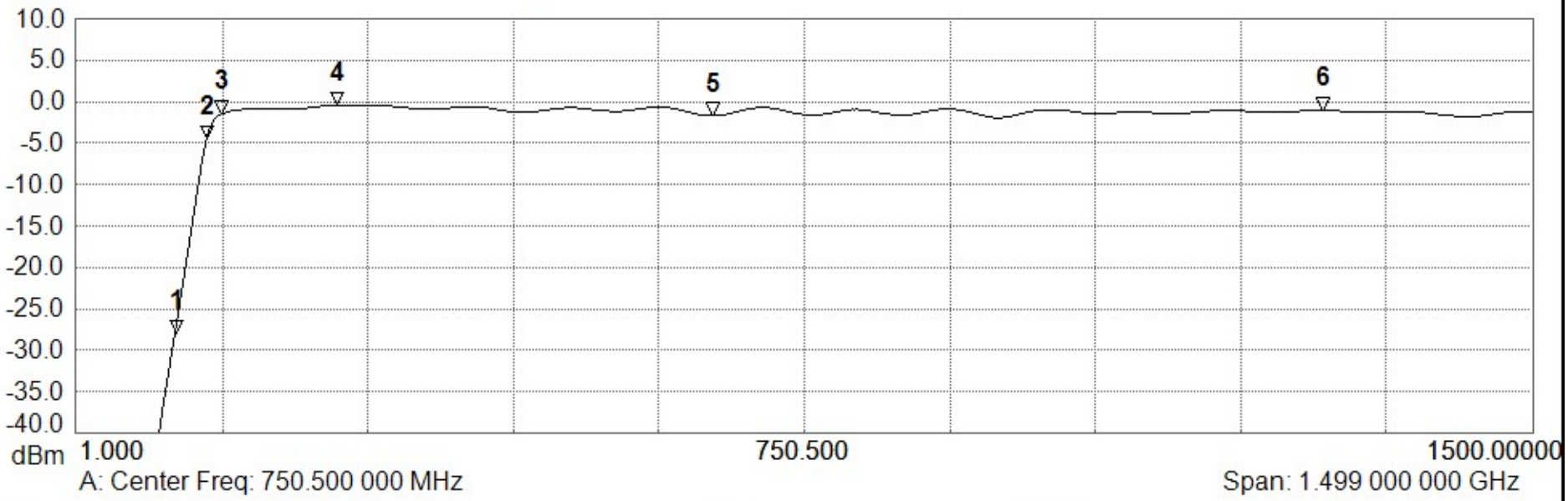
Mkr	Ref	Delta	Ref Freq	Ref Amp	Delta Freq	Delta Amp
1						
2						
3	■	□	93.110 909 MHz	-27.28 dBm		
4	■	□	454.469 091 MHz	-21.80 dBm		
5	■	□	723.716 364 MHz	-20.86 dBm		
6	■	□	966.983 636 MHz	-15.23 dBm		

Trace A data:	Detection = Sample	Base Ver. = V5.71
Trace Mode = Normal	Center Frequency = 650.500 000 MHz	App Ver. = V5.73
Preamp = OFF	Start Frequency = 1.000 000 MHz	Model = MS2721B
Min Sweep Time = 0.001 S	Stop Frequency = 1.300 000 000 GHz	Options = 20
Reference Level Offset = 0 dB	Frequency Span = 1.299 000 000 GHz	Date = 5/2/2023 8:37:18 PM
Input Attenuation = 20.0 dB	Reference Level = 0.000 dBm	Device Name = Entronics_MS2712B_SN-100
RBW = 3.0 kHz	Scale = 5.0 dB/div	
VBW = 3.0 MHz	Serial Number = 1007029	

Figure 4

Crystek 150 MHz HPF Characteristic

Generator: Tracking



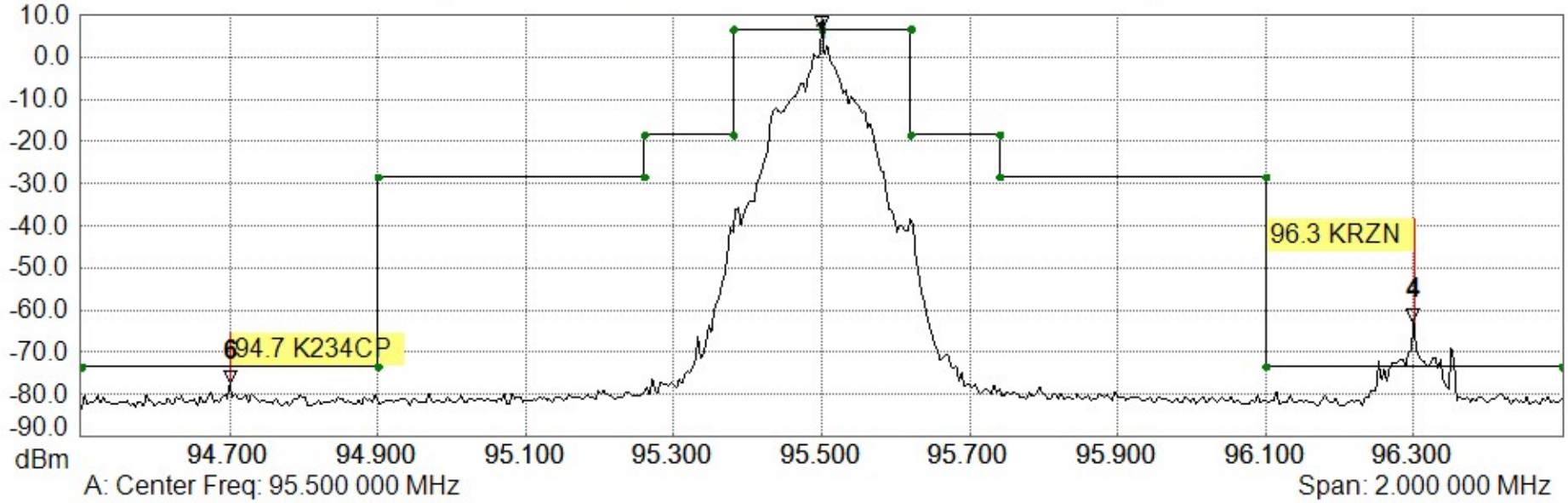
Mkr	Ref	Delta	Ref Freq	Ref Amp	Delta Freq	Delta Amp
1	■	□	102.900 002 MHz	-27.96 dBm		
2	■	□	134.500 000 MHz	-4.47 dBm		
3	■	□	150.000 000 MHz	-1.44 dBm		
4	■	□	268.891 861 MHz	-0.38 dBm		
5	■	□	655.372 795 MHz	-1.70 dBm		
6	■	□	1.284 689 091 GHz	-1.06 dBm		

Trace A data:	Detection = Sample	Base Ver. = V5.71
Trace Mode = Normal	Center Frequency = 750.500 000 MHz	App Ver. = V5.73
Preamp = OFF	Start Frequency = 1.000 000 MHz	Model = MS2721B
Min Sweep Time = 0.001 S	Stop Frequency = 1.500 000 000 GHz	Options = 20
Reference Level Offset = 0 dB	Frequency Span = 1.499 000 000 GHz	Date = 5/2/2023 9:00:41 PM
Input Attenuation = 30.0 dB	Reference Level = 10.000 dBm	Device Name = Entronics_MS2712B_SN-100
RBW = 3.0 kHz	Scale = 5.0 dB/div	
VBW = 3.0 MHz	Serial Number = 1007029	

Figure 5

Spectrum Analyzer

95.5 KCHH (FacID 1315) Occupied Bandwidth Measurements (Narrow)



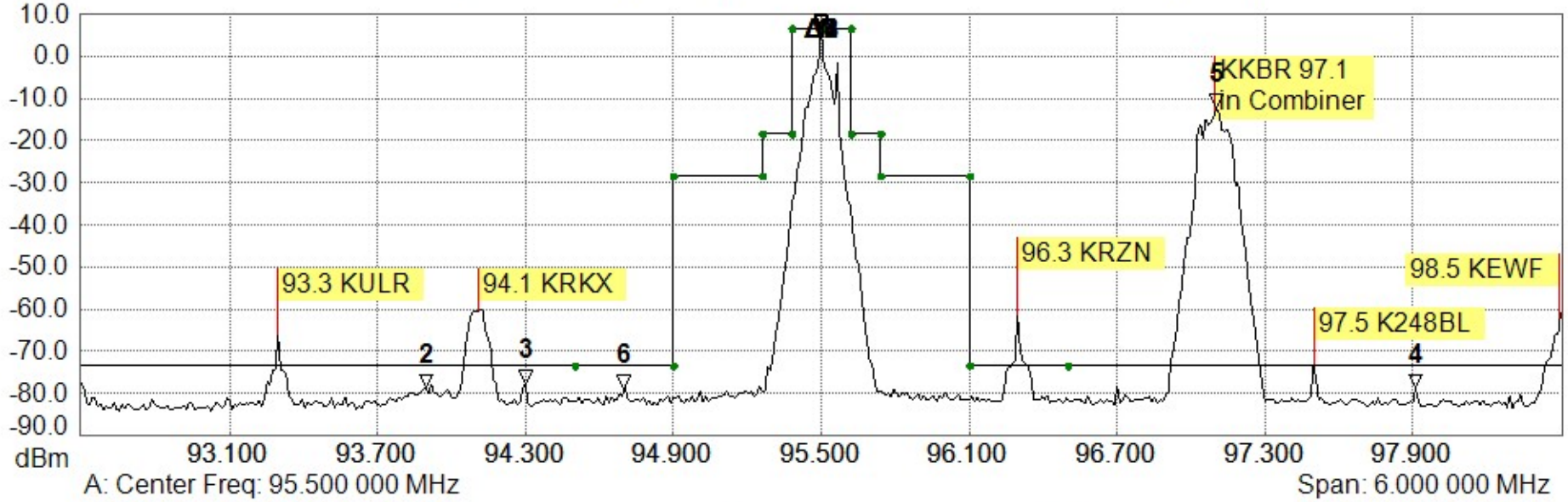
Mkr	Ref	Delta	Ref Freq	Ref Amp	Delta Freq	Delta Amp
1	■	□	95.500 000 MHz	6.33 dBm		
2						
3						
4	■	□	96.300 000 MHz	-62.82 dBm		
5						
6	■	□	94.700 000 MHz	-77.51 dBm		

Trace A data:	Detection = Peak	Base Ver. = V5.71
Trace Mode = Max Hold	Center Frequency = 95.500 000 MHz	App Ver. = V5.73
Preamp = OFF	Start Frequency = 94.500 000 MHz	Model = MS2721B
Min Sweep Time = 0.001 S	Stop Frequency = 96.500 000 MHz	Options = 20
Reference Level Offset = 0 dB	Frequency Span = 2.000 000 MHz	Date = 2/15/2023 11:18:30 PM
Input Attenuation = 30.0 dB	Reference Level = 10.000 dBm	Device Name = Entronics_MS2712B_SN-100
RBW = 300.0 Hz	Scale = 10.0 dB/div	
VBW = 3.0 MHz	Serial Number = 1007029	

Figure 6

Spectrum Analyzer

95.5 KCHH (FacID 1315) Occupied Bandwidth Measurements (Wide)



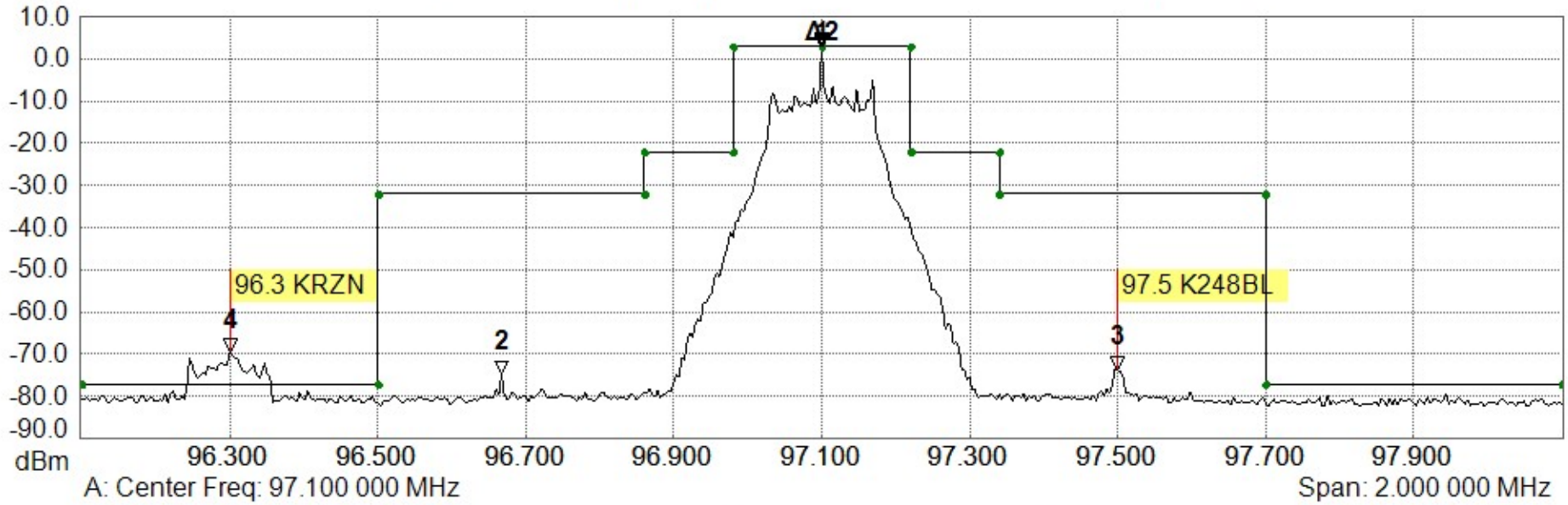
Mkr	Ref	Delta	Ref Freq	Ref Amp	Delta Freq	Delta Amp
1	■	□	95.500 000 MHz	6.64 dBm		
2	■	■	93.900 000 MHz	-78.58 dBm	1.600 000 MHz	85.22 dB
3	■	■	94.300 003 MHz	-77.64 dBm	1.200 000 MHz	84.28 dB
4	■	■	97.913 010 MHz	-78.65 dBm	**-2.413 010 MHz**	**85.29 dB**
5	■	□	97.100 000 MHz	-12.22 dBm		
6	■	■	94.700 000 MHz	-78.81 dBm	800.000 kHz	85.45 dB

Trace A data:	Detection = Peak	Base Ver. = V5.71
Trace Mode = Max Hold	Center Frequency = 95.500 000 MHz	App Ver. = V5.73
Preamp = OFF	Start Frequency = 92.500 000 MHz	Model = MS2721B
Min Sweep Time = 0.001 S	Stop Frequency = 98.500 000 MHz	Options = 20
Reference Level Offset = 0 dB	Frequency Span = 6.000 000 MHz	Date = 2/15/2023 11:12:57 PM
Input Attenuation = 30.0 dB	Reference Level = 10.000 dBm	Device Name = Entronics_MS2712B_SN-100
RBW = 300.0 Hz	Scale = 10.0 dB/div	
VBW = 3.0 MHz	Serial Number = 1007029	

Figure 7

Spectrum Analyzer

97.1 KKBR (FacID 16774) Occupied Bandwidth Measurements (Narrow)



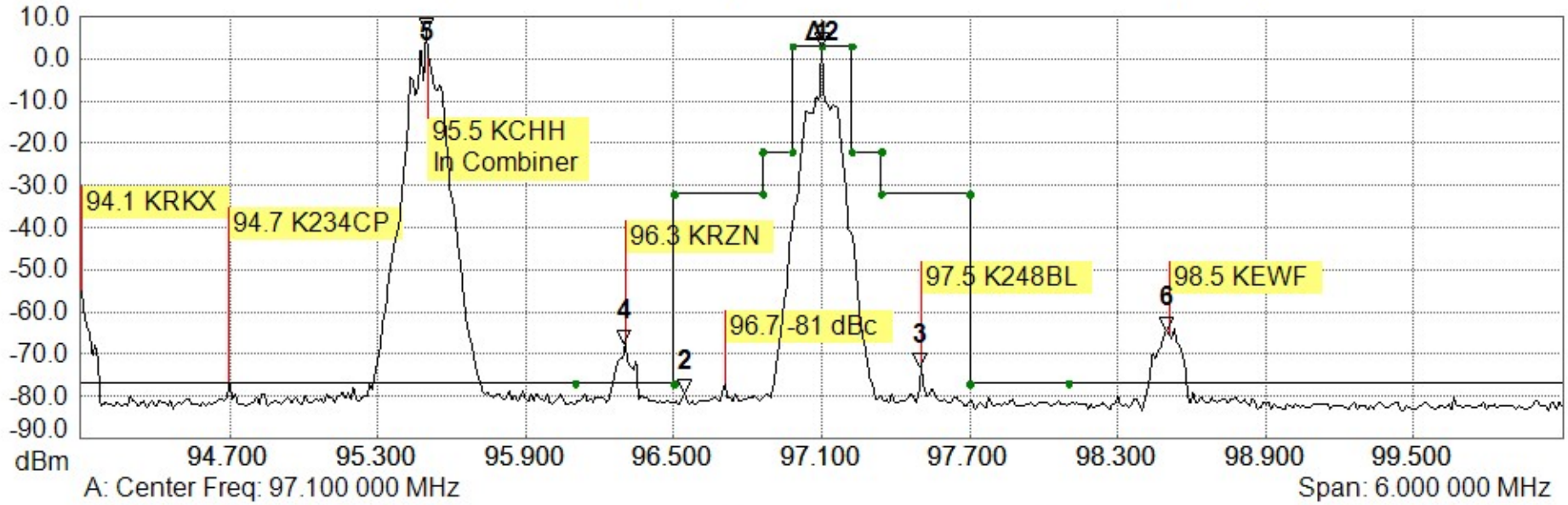
Mkr	Ref	Delta	Ref Freq	Ref Amp	Delta Freq	Delta Amp
1	■	□	97.100 000 MHz	2.95 dBm		
2	■	■	96.667 273 MHz	-74.73 dBm	**432.730 kHz**	**77.68 dB**
3	■	□	97.500 000 MHz	-73.78 dBm		
4	■	□	96.300 000 MHz	-69.63 dBm		
5						
6						

Trace A data:	Detection = Peak	Base Ver. = V5.71
Trace Mode = Max Hold	Center Frequency = 97.100 000 MHz	App Ver. = V5.73
Preamp = OFF	Start Frequency = 96.100 000 MHz	Model = MS2721B
Min Sweep Time = 0.001 S	Stop Frequency = 98.100 000 MHz	Options = 20
Reference Level Offset = 0 dB	Frequency Span = 2.000 000 MHz	Date = 2/16/2023 12:07:20 AM
Input Attenuation = 30.0 dB	Reference Level = 10.000 dBm	Device Name = Entronics_MS2712B_SN-100
RBW = 300.0 Hz	Scale = 10.0 dB/div	
VBW = 3.0 MHz	Serial Number = 1007029	

Figure 8

Spectrum Analyzer

97.1 KKBR (FacID 16774) Occupied Bandwidth Measurements (Wide)



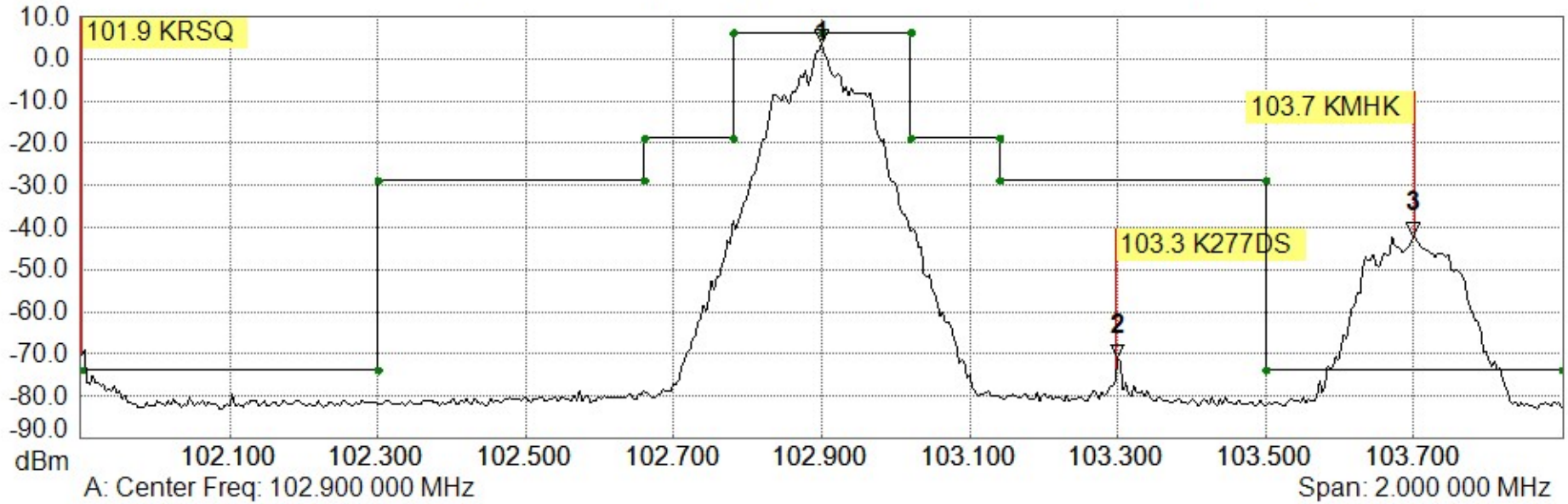
Mkr	Ref	Delta	Ref Freq	Ref Amp	Delta Freq	Delta Amp
1	■	□	97.100 000 MHz	3.02 dBm		
2	■	■	96.542 000 MHz	-79.30 dBm	560.000 kHz	82.32 dB
3	■	□	97.500 000 MHz	-73.13 dBm		
4	■	□	96.300 000 MHz	-67.49 dBm		
5	■	□	95.500 000 MHz	6.48 dBm		
6	■	□	98.500 000 MHz	-64.43 dBm		

Trace A data:	Detection = Peak	Base Ver. = V5.71
Trace Mode = Max Hold	Center Frequency = 97.100 000 MHz	App Ver. = V5.73
Preamp = OFF	Start Frequency = 94.100 000 MHz	Model = MS2721B
Min Sweep Time = 0.001 S	Stop Frequency = 100.100 000 MHz	Options = 20
Reference Level Offset = 0 dB	Frequency Span = 6.000 000 MHz	Date = 2/16/2023 12:16:23 AM
Input Attenuation = 30.0 dB	Reference Level = 10.000 dBm	Device Name = Entronics_MS2712B_SN-100
RBW = 300.0 Hz	Scale = 10.0 dB/div	
VBW = 3.0 MHz	Serial Number = 1007029	

Figure 9

Spectrum Analyzer

102.9 KCTR-FM(FacID 16773) Occupied Bandwidth Measurements (Narrow)



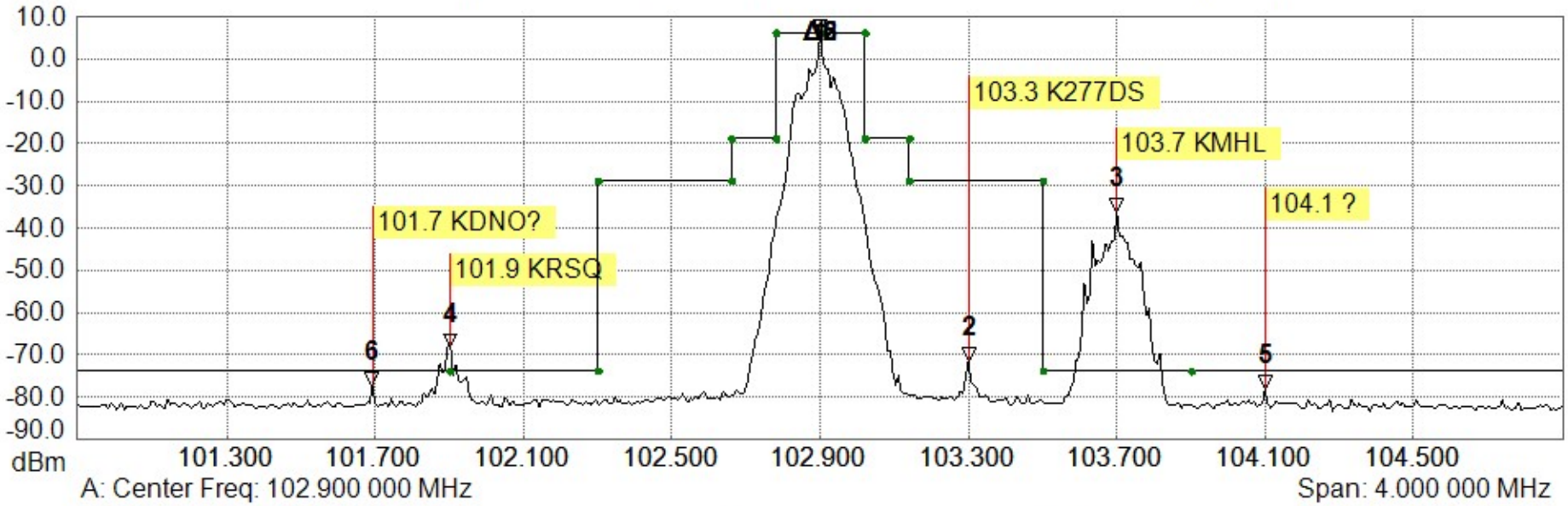
Mkr	Ref	Delta	Ref Freq	Ref Amp	Delta Freq	Delta Amp
1	■	□	102.900 000 MHz	3.63 dBm		
2	■	□	103.300 000 MHz	-70.86 dBm		
3	■	□	103.700 000 MHz	-41.96 dBm		
4						
5						
6						

Trace A data:	Detection = Peak	Base Ver. = V5.71
Trace Mode = Max Hold	Center Frequency = 102.900 000 MHz	App Ver. = V5.73
Preamp = OFF	Start Frequency = 101.900 000 MHz	Model = MS2721B
Min Sweep Time = 0.001 S	Stop Frequency = 103.900 000 MHz	Options = 20
Reference Level Offset = 0 dB	Frequency Span = 2.000 000 MHz	Date = 5/2/2023 6:06:08 PM
Input Attenuation = 30.0 dB	Reference Level = 10.000 dBm	Device Name = Entronics_MS2712B_SN-100
RBW = 300.0 Hz	Scale = 10.0 dB/div	
VBW = 3.0 MHz	Serial Number = 1007029	

Figure 10

Spectrum Analyzer

102.9 KCTR-FM(FacID 16773) Occupied Bandwidth Measurements (Wide)



Mkr	Ref	Delta	Ref Freq	Ref Amp	Delta Freq	Delta Amp
1	■	□	102.900 000 MHz	6.26 dBm		
2	■	■	103.300 000 MHz	-71.46 dBm	-398.842 kHz	77.73 dB
3	■	□	103.700 000 MHz	-36.26 dBm		
4	■	□	101.900 000 MHz	-68.11 dBm		
5	■	■	104.099 998 MHz	-78.01 dBm	-1.200 000 MHz	84.28 dB
6	■	■	101.689 809 MHz	-77.26 dBm	1.210 000 MHz	83.53 dB

Trace A data:	Detection = Peak	Base Ver. = V5.71
Trace Mode = Max Hold	Center Frequency = 102.900 000 MHz	App Ver. = V5.73
Preamp = OFF	Start Frequency = 100.900 000 MHz	Model = MS2721B
Min Sweep Time = 0.001 S	Stop Frequency = 104.900 000 MHz	Options = 20
Reference Level Offset = 0 dB	Frequency Span = 4.000 000 MHz	Date = 5/2/2023 6:08:12 PM
Input Attenuation = 30.0 dB	Reference Level = 10.000 dBm	Device Name = Entronics_MS2712B_SN-100
RBW = 300.0 Hz	Scale = 10.0 dB/div	
VBW = 3.0 MHz	Serial Number = 1007029	

Table 1

Combiner Output
KCHH Principals
Notch Filter Measurements

IM Order	*Freq A*	*Freq B*	*Freq C*	*Resultant Product*	*SA Measured Value (via SA Markers Measurements)*	*Noise Floor*	*Test Setup*	*Filter Measured Value*	*Observation Corrected for Filter Loss*	*Combiner Coupler Value (Shaded Extrapolated)*	*Observation Corrected for Directional Coupler Coupling*	*Relative to Carrier*	*Notes*
A-B	95.5 MHz	97.1 MHz		1.600 MHz	-66.1 dBm		Notch	-0.28 dB	-65.86 dBm	-58.00 dB	-7.86 dBm	**-84.5 dBc**	
A-B	95.5 MHz	102.9 MHz		7.400 MHz	-64.9 dBm		Notch	-0.39 dB	-64.51 dBm	-58.00 dB	-6.51 dBm	**-83.1 dBc**	
A-B	95.5 MHz	103.7 MHz		8.200 MHz	-78.4 dBm	1	Notch	-1.07 dB	-77.37 dBm	-58.00 dB	-19.37 dBm	**[SANF] <-96.0 dBc**	
A+B	95.5 MHz	97.1 MHz		192.600 MHz	-64.9 dBm		Notch	-1.74 dB	-63.16 dBm	-40.38 dB	-22.78 dBm	**-99.4 dBc**	
A+B	95.5 MHz	102.9 MHz		198.400 MHz	-64.5 dBm		Notch	-1.85 dB	-62.62 dBm	-40.16 dB	-22.46 dBm	**-99.1 dBc**	
A+B	95.5 MHz	103.7 MHz		199.200 MHz	-76.9 dBm		Notch	-1.87 dB	-75.01 dBm	-40.12 dB	-34.89 dBm	**-111.5 dBc**	
2A-B	95.5 MHz	97.1 MHz		93.900 MHz	-67.3 dBm		Notch	-1.80 dB	-65.53 dBm	-46.48 dB	-19.05 dBm	**-95.7 dBc**	
2A-B	95.5 MHz	102.9 MHz		88.100 MHz	-65.9 dBm		Notch	-1.05 dB	-64.81 dBm	-47.03 dB	-17.78 dBm	**-94.4 dBc**	
2A-B	95.5 MHz	103.7 MHz		87.300 MHz	-77.2 dBm	1	Notch	-1.06 dB	-76.15 dBm	-47.11 dB	-29.04 dBm	**[SANF] <-105.7 dBc**	
2A+B	95.5 MHz	97.1 MHz		288.100 MHz	-67.0 dBm		Notch	-2.10 dB	-64.90 dBm	-37.12 dB	-27.78 dBm	**-104.4 dBc**	
2A+B	95.5 MHz	102.9 MHz		293.900 MHz	-67.9 dBm		Notch	-2.22 dB	-65.65 dBm	-36.98 dB	-28.67 dBm	**-105.3 dBc**	
2A+B	95.5 MHz	103.7 MHz		294.700 MHz	-76.7 dBm	1	Notch	-2.24 dB	-74.41 dBm	-36.96 dB	-37.45 dBm	**[SANF] <-114.1 dBc**	
1A Reference	95.5 MHz			95.500 MHz	8.2 dBm		Notch	-22.10 dB	30.29 dBm	-46.34 dB	76.63 dBm	**0.0 dBc**	KCHH (FacID 1315)
2A	95.5 MHz			191.000 MHz	-65.9 dBm		Notch	-1.72 dB	-64.13 dBm	-40.46 dB	-23.67 dBm	**-100.3 dBc**	
3A	95.5 MHz			286.500 MHz	-70.5 dBm		Notch	-2.06 dB	-68.40 dBm	-37.16 dB	-31.24 dBm	**-107.9 dBc**	
4A	95.5 MHz			382.000 MHz	-77.9 dBm	1	Notch	-2.55 dB	-75.35 dBm	-35.03 dB	-40.32 dBm	**[SANF] <-116.9 dBc**	
5A	95.5 MHz			477.500 MHz	-75.3 dBm	1	Notch	-2.96 dB	-72.30 dBm	-33.55 dB	-38.75 dBm	**[SANF] <-115.4 dBc**	
6A	95.5 MHz			573.000 MHz	-76.6 dBm	1	Notch	-3.26 dB	-73.31 dBm	-32.57 dB	-40.74 dBm	**[SANF] <-117.4 dBc**	
7A	95.5 MHz			668.500 MHz	-76.6 dBm	1	Notch	-3.90 dB	-72.66 dBm	-31.97 dB	-40.69 dBm	**[SANF] <-117.3 dBc**	
8A	95.5 MHz			764.000 MHz	-73.3 dBm		Notch	-4.48 dB	-68.80 dBm	-31.75 dB	-37.05 dBm	**-113.7 dBc**	
9A	95.5 MHz			859.500 MHz	-74.8 dBm	1	Notch	-4.48 dB	-70.28 dBm	-31.83 dB	-38.45 dBm	**[SANF] <-115.1 dBc**	
10A	95.5 MHz			955.000 MHz	-76.4 dBm	1	Notch	-5.60 dB	-70.81 dBm	-31.83 dB	-38.98 dBm	**[SANF] <-115.6 dBc**	
11A	95.5 MHz			1050.500 MHz	-73.3 dBm	1	Notch	-44.78 dB	-28.49 dBm	-31.83 dB	3.34 dBm	**[SANF] <-73.3 dBc**	Notch Filter Oddity-See LPF Section
12A	95.5 MHz			1146.000 MHz	-75.5 dBm	1	Notch	-25.13 dB	-50.35 dBm	-31.83 dB	-18.52 dBm	**[SANF] <-95.1 dBc**	

Table 2

Combiner Output
KKBR Principals
Notch Filter Measurements

IM Order	*Freq A*	*Freq B*	*Freq C*	*Resultant Product*	*SA Measured Value (via SA Markers Measurements)*	*Noise Floor*	*Test Setup*	*Filter Measured Value*	*Observation Corrected for Filter Loss*	*Combiner Coupler Value (Shaded Extrapolated)*	*Observation Corrected for Directional Coupler Coupling*	*Relative to Carrier*	*Notes*
A-B	97.1 MHz	95.5 MHz		1.600 MHz	-64.1 dBm		Notch	-0.30 dB	-63.82 dBm	-58.00 dB	-5.82 dBm	**-80.0 dBc**	
A-B	97.1 MHz	102.9 MHz		5.800 MHz	-65.4 dBm		Notch	-0.35 dB	-65.00 dBm	-58.00 dB	-7.00 dBm	**-81.2 dBc**	
A-B	97.1 MHz	103.7 MHz		6.600 MHz	-77.7 dBm	1	Notch	-0.37 dB	-77.28 dBm	-58.00 dB	-19.28 dBm	**[SANF] <-93.5 dBc**	
A+B	97.1 MHz	95.5 MHz		192.600 MHz	-64.1 dBm		Notch	-1.72 dB	-62.34 dBm	-40.38 dB	-21.96 dBm	**-96.1 dBc**	
A+B	97.1 MHz	102.9 MHz		200.000 MHz	-66.6 dBm		Notch	-1.89 dB	-64.74 dBm	-40.08 dB	-24.66 dBm	**-98.8 dBc**	
A+B	97.1 MHz	103.7 MHz		200.800 MHz	-76.8 dBm	1	Notch	-1.90 dB	-74.87 dBm	-40.04 dB	-34.83 dBm	**[SANF] <-109.0 dBc**	
2A-B	97.1 MHz	95.5 MHz		98.700 MHz	-71.3 dBm		Notch	-2.18 dB	-69.15 dBm	-46.08 dB	-23.07 dBm	**-97.3 dBc**	
2A-B	97.1 MHz	102.9 MHz		91.300 MHz	-67.6 dBm		Notch	-1.10 dB	-66.50 dBm	-46.73 dB	-19.77 dBm	**-94.0 dBc**	Check-Translator
2A-B	97.1 MHz	103.7 MHz		90.500 MHz	-75.3 dBm	1	Notch	-1.06 dB	-74.24 dBm	-46.81 dB	-27.43 dBm	**[SANF] <-101.6 dBc**	
2A+B	97.1 MHz	95.5 MHz		289.700 MHz	-72.7 dBm		Notch	-2.15 dB	-70.55 dBm	-37.12 dB	-33.43 dBm	**-107.6 dBc**	
2A+B	97.1 MHz	102.9 MHz		297.100 MHz	-73.7 dBm		Notch	-2.22 dB	-71.44 dBm	-36.91 dB	-34.53 dBm	**-108.7 dBc**	
2A+B	97.1 MHz	103.7 MHz		297.900 MHz	-75.5 dBm	1	Notch	-2.18 dB	-73.29 dBm	-36.89 dB	-36.40 dBm	**[SANF] <-110.6 dBc**	
1A Reference	97.1 MHz			97.100 MHz	5.6 dBm		Notch	-22.42 dB	27.98 dBm	-46.21 dB	74.19 dBm	**0.0 dBc**	KKBR (FacID 16774)
2A	97.1 MHz			194.200 MHz	-72.2 dBm		Notch	-1.77 dB	-70.39 dBm	-40.31 dB	-30.08 dBm	**-104.3 dBc**	Noise floor increase, -90
3A	97.1 MHz			291.300 MHz	-75.1 dBm	1	Notch	-2.20 dB	-72.86 dBm	-37.05 dB	-35.81 dBm	**[SANF] <-110.0 dBc**	
4A	97.1 MHz			388.400 MHz	-76.2 dBm	1	Notch	-2.58 dB	-73.65 dBm	-34.90 dB	-38.75 dBm	**[SANF] <-112.9 dBc**	
5A	97.1 MHz			485.500 MHz	-77.1 dBm	1	Notch	-3.06 dB	-74.02 dBm	-33.43 dB	-40.59 dBm	**[SANF] <-114.8 dBc**	Noise floor increase, -90
6A	97.1 MHz			582.600 MHz	-76.1 dBm	1	Notch	-3.41 dB	-72.64 dBm	-32.49 dB	-40.15 dBm	**[SANF] <-114.3 dBc**	
7A	97.1 MHz			679.700 MHz	-75.4 dBm	1	Notch	-3.98 dB	-71.45 dBm	-31.95 dB	-39.50 dBm	**[SANF] <-113.7 dBc**	
8A	97.1 MHz			776.800 MHz	-77.2 dBm	1	Notch	-4.43 dB	-72.72 dBm	-31.76 dB	-40.96 dBm	**[SANF] <-115.2 dBc**	
9A	97.1 MHz			873.900 MHz	-73.6 dBm	1	Notch	-4.36 dB	-69.21 dBm	-31.83 dB	-37.38 dBm	**[SANF] <-111.6 dBc**	
10A	97.1 MHz			971.000 MHz	-73.0 dBm		Notch	-7.47 dB	-65.50 dBm	-31.83 dB	-33.67 dBm	**-107.9 dBc**	
11A	97.1 MHz			1068.100 MHz	-73.6 dBm		Notch	-43.79 dB	-29.81 dBm	-31.83 dB	2.02 dBm	**-72.2 dBc**	Notch Filter issues above 1 GHz, see LPF measurements
12A	97.1 MHz			1165.200 MHz	-72.2 dBm		Notch	-26.81 dB	-45.38 dBm	-31.83 dB	-13.55 dBm	**-87.7 dBc**	
				97.069 MHz	-66.6 dBm		Notch	-20.60 dB	-46.01 dBm	-46.22 dB	0.21 dBm	**-74.0 dBc**	TX Power Dependant-Symentical about 97.1 MHz
				97.130 MHz	-69.3 dBm		Notch	-22.35 dB	-46.90 dBm	-46.21 dB	-0.69 dBm	**-74.9 dBc**	Exciter Caps??
				97.193 MHz	-64.8 dBm		Notch	-22.42 dB	-42.38 dBm	-46.21 dB	3.83 dBm	**-70.4 dBc**	
				97.007 MHz	-64.8 dBm		Notch	-22.42 dB	-42.42 dBm	-46.22 dB	3.80 dBm	**-70.4 dBc**	

Table 3

Combiner Output
KCTR Principals
Notch Filter Measurements

IM Order	*Freq A*	*Freq B*	*Freq C*	*Resultant Product*	*SA Measured Value (via SA Markers Measurements)*	*Noise Floor*	*Test Setup*	*Filter Measured Value*	*Observation Corrected for Filter Loss*	*Combiner Coupler Value (Shaded Extrapolated)*	*Observation Corrected for Directional Coupler Coupling*	*Relative to Carrier*	*Notes*
A-B	102.9 MHz	95.5 MHz		7.400 MHz	-63.3 dBm		Notch	-0.39 dB	-62.91 dBm	-58.00 dB	-4.91 dBm	**-80.4 dBc**	
A-B	102.9 MHz	97.1 MHz		5.800 MHz	-66.1 dBm		Notch	-0.35 dB	-65.79 dBm	-58.00 dB	-7.79 dBm	**-83.2 dBc**	
A-B	102.9 MHz	103.7 MHz		0.800 MHz	-76.9 dBm	1	Notch	-0.25 dB	-76.65 dBm	-58.00 dB	-18.65 dBm	**[SANF] <-94.1 dBc**	
A+B	102.9 MHz	95.5 MHz		198.400 MHz	-63.7 dBm		Notch	-1.85 dB	-61.83 dBm	-40.16 dB	-21.67 dBm	**-97.1 dBc**	
A+B	102.9 MHz	97.1 MHz		200.000 MHz	-67.5 dBm		Notch	-1.89 dB	-65.62 dBm	-40.08 dB	-25.54 dBm	**-101.0 dBc**	
A+B	102.9 MHz	103.7 MHz		206.600 MHz	-76.6 dBm	1	Notch	-1.90 dB	-74.68 dBm	-39.81 dB	-34.87 dBm	**[SANF] <-110.3 dBc**	
2A-B	102.9 MHz	95.5 MHz		110.300 MHz	-67.3 dBm		Notch	-1.32 dB	-65.97 dBm	-45.09 dB	-20.88 dBm	**-96.3 dBc**	-97.38 with Fax 20 off
2A-B	102.9 MHz	97.1 MHz		108.700 MHz	-70.5 dBm		Notch	-1.37 dB	-69.13 dBm	-45.22 dB	-23.91 dBm	**-99.4 dBc**	
2A-B	102.9 MHz	103.7 MHz		102.100 MHz	-77.0 dBm	1	Notch	-3.38 dB	-73.61 dBm	-45.75 dB	-27.86 dBm	**[SANF] <-103.3 dBc**	
2A+B	102.9 MHz	95.5 MHz		301.300 MHz	-71.2 dBm		Notch	-2.17 dB	-69.05 dBm	-36.78 dB	-32.27 dBm	**-107.7 dBc**	
2A+B	102.9 MHz	97.1 MHz		302.900 MHz	-73.6 dBm		Notch	-2.15 dB	-71.42 dBm	-36.73 dB	-34.69 dBm	**-110.1 dBc**	
2A+B	102.9 MHz	103.7 MHz		309.500 MHz	-77.2 dBm	1	Notch	-2.22 dB	-74.96 dBm	-36.58 dB	-38.38 dBm	**[SANF] <-113.8 dBc**	
1A Reference	102.9 MHz			102.900 MHz	7.2 dBm		Notch	-22.60 dB	29.76 dBm	-45.68 dB	75.44 dBm	**0.0 dBc**	KCTR-FM (FacID 16772)
2A	102.9 MHz			205.800 MHz	-70.9 dBm		Notch	-1.85 dB	-69.02 dBm	-39.84 dB	-29.18 dBm	**-104.6 dBc**	
3A	102.9 MHz			308.700 MHz	-76.1 dBm	1	Notch	-2.21 dB	-73.90 dBm	-36.60 dB	-37.30 dBm	**[SANF] <-112.7 dBc**	
4A	102.9 MHz			411.600 MHz	-76.7 dBm	1	Notch	-2.73 dB	-74.01 dBm	-34.51 dB	-39.50 dBm	**[SANF] <-114.9 dBc**	
5A	102.9 MHz			514.500 MHz	-76.7 dBm	1	Notch	-3.27 dB	-73.40 dBm	-33.12 dB	-40.28 dBm	**[SANF] <-115.7 dBc**	
6A	102.9 MHz			617.400 MHz	-76.0 dBm	1	Notch	-3.78 dB	-72.21 dBm	-32.25 dB	-39.96 dBm	**[SANF] <-115.4 dBc**	
7A	102.9 MHz			720.300 MHz	-75.4 dBm	1	Notch	-5.99 dB	-69.42 dBm	-31.79 dB	-37.63 dBm	**[SANF] <-113.1 dBc**	
8A	102.9 MHz			823.200 MHz	-75.0 dBm	1	Notch	-4.60 dB	-70.36 dBm	-31.78 dB	-38.58 dBm	**[SANF] <-114.0 dBc**	
9A	102.9 MHz			926.100 MHz	-75.9 dBm	1	Notch	-5.01 dB	-70.90 dBm	-31.83 dB	-39.07 dBm	**[SANF] <-114.5 dBc**	
10A	102.9 MHz			1029.000 MHz	-76.2 dBm	1	Notch	-23.59 dB	-52.63 dBm	-31.83 dB	-20.80 dBm	**[SANF] <-96.2 dBc**	
11A	102.9 MHz			1131.900 MHz	-76.4 dBm	1	Notch	-30.73 dB	-45.64 dBm	-31.83 dB	-13.81 dBm	**[SANF] <-89.2 dBc**	
12A	102.9 MHz			1234.800 MHz	-75.0 dBm		Notch	-6.38 dB	-68.63 dBm	-31.83 dB	-36.80 dBm	**-112.2 dBc**	
				102.815 MHz	-63.8 dBm		Notch		-63.83 dBm	-45.69 dB	-18.14 dBm	**-93.6 dBc**	
				102.800 MHz	-66.6 dBm		Notch		-66.61 dBm	-45.69 dB	-20.92 dBm	**-96.4 dBc**	
				102.985 MHz	-62.0 dBm		Notch		-61.99 dBm	-45.68 dB	-16.31 dBm	**-91.8 dBc**	
				103.000 MHz	-70.9 dBm		Notch		-70.94 dBm	-45.67 dB	-25.27 dBm	**-100.7 dBc**	

Table 4

Combiner Output
Three Frequency IM Products
Notch Filter Measurements

Ref KKBR, lowest

IM Order	*Freq A*	*Freq B*	*Freq C*	*Resultant Product*	*SA Measured Value (via SA Markers Measurements)*	*Noise Floor*	*Test Setup*	*Filter Measured Value*	*Observation Corrected for Filter Loss*	*Combiner Coupler Value (Shaded Extrapolated)*	*Observation Corrected for Directional Coupler Coupling*	*Relative to Carrier*	*Notes*
A+B-C	103.7 MHz	102.9 MHz	97.1 MHz	109.500 MHz	-78.7 dBm	1	Notch	-1.33 dB	-77.34 dBm	-45.15 dB	-32.19 dBm	**[SANF] <-106.4 dBc**	Reference carrier is 97.1 MHz, it is the lowest carrier.
A+C-B	103.7 MHz	102.9 MHz	97.1 MHz	97.900 MHz	-76.0 dBm	1	Notch	-4.12 dB	-71.88 dBm	-46.14 dB	-25.74 dBm	**[SANF] <-99.9 dBc**	
B+C-A	103.7 MHz	102.9 MHz	97.1 MHz	96.300 MHz	-58.0 dBm		Notch	-3.80 dB	-54.17 dBm	-46.27 dB	-7.90 dBm	**-82.1 dBc**	Station Modulation, ours are dead carrier
A+B+C	103.7 MHz	102.9 MHz	97.1 MHz	303.700 MHz	-76.2 dBm	1	Notch	-2.15 dB	-74.00 dBm	-36.71 dB	-37.29 dBm	**[SANF] <-111.5 dBc**	
A+B-C	102.9 MHz	97.1 MHz	95.5 MHz	104.500 MHz	-62.8 dBm		Notch	-2.18 dB	-60.64 dBm	-45.56 dB	-15.08 dBm	**-89.3 dBc**	
A+C-B	102.9 MHz	97.1 MHz	95.5 MHz	101.300 MHz	-66.4 dBm		Notch	-1.81 dB	-64.58 dBm	-45.82 dB	-18.76 dBm	**-92.9 dBc**	
B+C-A	102.9 MHz	97.1 MHz	95.5 MHz	89.700 MHz	-57.1 dBm		Notch	-1.06 dB	-56.03 dBm	-46.89 dB	-9.14 dBm	**-83.3 dBc**	Full Modulation, Station, no hard carrier seen
A+B+C	102.9 MHz	97.1 MHz	95.5 MHz	295.500 MHz	-66.5 dBm		Notch	-2.21 dB	-64.25 dBm	-36.95 dB	-27.30 dBm	**-101.5 dBc**	
A+B-C	97.1 MHz	95.5 MHz	103.7 MHz	88.900 MHz	-75.1 dBm	1	Notch	-1.04 dB	-74.10 dBm	-46.96 dB	-27.14 dBm	**[SANF] <-101.3 dBc**	
A+C-B	97.1 MHz	95.5 MHz	103.7 MHz	105.300 MHz	-77.3 dBm	1	Notch	-1.72 dB	-75.57 dBm	-45.49 dB	-30.08 dBm	**[SANF] <-104.3 dBc**	
B+C-A	97.1 MHz	95.5 MHz	103.7 MHz	102.100 MHz	-74.0 dBm		Notch	-3.38 dB	-70.57 dBm	-45.75 dB	-24.82 dBm	**-99.0 dBc**	
A+B+C	97.1 MHz	95.5 MHz	103.7 MHz	296.300 MHz	-77.1 dBm	1	Notch	-2.21 dB	-74.88 dBm	-36.93 dB	-37.95 dBm	**[SANF] <-112.1 dBc**	
A+B-C	95.5 MHz	103.7 MHz	102.9 MHz	96.300 MHz	-58.2 dBm		Notch	-3.80 dB	-54.36 dBm	-46.28 dB	-8.08 dBm	**-82.3 dBc**	Full Station Modulation No hard carrier
A+C-B	95.5 MHz	103.7 MHz	102.9 MHz	94.700 MHz	-70.9 dBm		Notch	-3.46 dB	-67.48 dBm	-46.41 dB	-21.07 dBm	**-95.3 dBc**	Modulation, very weak, no hard carrier
B+C-A	95.5 MHz	103.7 MHz	102.9 MHz	111.100 MHz	-78.9 dBm	1	Notch	-1.29 dB	-77.64 dBm	-45.03 dB	-32.61 dBm	**[SANF] <-106.8 dBc**	
A+B+C	95.5 MHz	103.7 MHz	102.9 MHz	302.100 MHz	-76.9 dBm	1	Notch	-2.18 dB	-74.69 dBm	-36.75 dB	-37.94 dBm	**[SANF] <-112.1 dBc**	

Table 5

Combiner Output
KCHH Principle Measurements
Low Pass Filter

IM Order	*Freq A*	*Freq B*	*Freq C*	*Resultant Product*	*SA Measured Value (via SA Markers Measurements)*	*Noise Floor*	*Test Setup*	*Filter Measured Value*	*Observation Corrected for Filter Loss*	*Combiner Coupler Value (Shaded Extrapolated)*	*Observation Corrected for Directional Coupler Coupling*	*Relative to Carrier*	*Notes*
A-B	95.5 MHz	97.1 MHz		1.600 MHz			HPF	-90.00 dBm	90.0 dBm	-58.00 dB	148.00 dBm		
A-B	95.5 MHz	102.9 MHz		7.400 MHz			HPF	-92.00 dBm	92.0 dBm	-58.00 dB	150.00 dBm		
A-B	95.5 MHz	103.7 MHz		8.200 MHz			HPF		0.0 dBm	-58.00 dB	58.00 dBm		
A+B	95.5 MHz	97.1 MHz		192.600 MHz	-82.26 dBm	1	HPF	-1.86 dBm	-80.4 dBm	-40.38 dB	-40.02 dBm	[SANF] <-113.3 dBc	
A+B	95.5 MHz	102.9 MHz		198.400 MHz	-77.94 dBm		HPF	-1.84 dBm	-76.1 dBm	-40.16 dB	-35.94 dBm	-109.3 dBc	
A+B	95.5 MHz	103.7 MHz		199.200 MHz	-77.18 dBm	1	HPF	-1.91 dBm	-75.3 dBm	-40.12 dB	-35.15 dBm	[SANF] <-108.5 dBc	
2A-B	95.5 MHz	97.1 MHz		93.900 MHz	-76.81 dBm	1	HPF	-36.54 dBm	-40.3 dBm	-46.48 dB	6.21 dBm	[SANF] <-67.1 dBc	
2A-B	95.5 MHz	102.9 MHz		88.100 MHz	-79.38 dBm	1	HPF	-42.19 dBm	-37.2 dBm	-47.03 dB	9.84 dBm	[SANF] <-63.5 dBc	
2A-B	95.5 MHz	103.7 MHz		87.300 MHz	-79.34 dBm	1	HPF	-42.92 dBm	-36.4 dBm	-47.11 dB	10.69 dBm	[SANF] <-62.6 dBc	
2A+B	95.5 MHz	97.1 MHz		288.100 MHz	-77.41 dBm	1	HPF	-1.83 dBm	-75.6 dBm	-37.12 dB	-38.46 dBm	[SANF] <-111.8 dBc	
2A+B	95.5 MHz	102.9 MHz		293.900 MHz	-75.26 dBm	1	HPF	-1.85 dBm	-73.4 dBm	-36.98 dB	-36.43 dBm	[SANF] <-109.7 dBc	
2A+B	95.5 MHz	103.7 MHz		294.700 MHz	-77.67 dBm	1	HPF	-1.87 dBm	-75.8 dBm	-36.96 dB	-38.84 dBm	[SANF] <-112.1 dBc	
1A Reference	95.5 MHz			95.500 MHz	-8.32 dBm		HPF	-35.29 dBm	27.0 dBm	-46.34 dB	73.31 dBm	0.0 dBc	KCHH (FacID 1315)
2A	95.5 MHz			191.000 MHz	-77.56 dBm	1	HPF	-1.95 dBm	-75.6 dBm	-40.46 dB	-35.15 dBm	[SANF] <-108.5 dBc	
3A	95.5 MHz			286.500 MHz	-75.18 dBm	1	HPF	-1.81 dBm	-73.4 dBm	-37.16 dB	-36.21 dBm	[SANF] <-109.5 dBc	
4A	95.5 MHz			382.000 MHz	-77.74 dBm	1	HPF	-2.15 dBm	-75.6 dBm	-35.03 dB	-40.56 dBm	[SANF] <-113.9 dBc	
5A	95.5 MHz			477.500 MHz	-74.36 dBm	1	HPF	-2.15 dBm	-72.2 dBm	-33.55 dB	-38.66 dBm	[SANF] <-112.0 dBc	
6A	95.5 MHz			573.000 MHz	-77.38 dBm	1	HPF	-2.44 dBm	-74.9 dBm	-32.57 dB	-42.37 dBm	[SANF] <-115.7 dBc	
7A	95.5 MHz			668.500 MHz	-76.69 dBm	1	HPF	-2.50 dBm	-74.2 dBm	-31.97 dB	-42.22 dBm	[SANF] <-115.5 dBc	
8A	95.5 MHz			764.000 MHz	-76.05 dBm	1	HPF	-3.23 dBm	-72.8 dBm	-31.75 dB	-41.07 dBm	[SANF] <-114.4 dBc	
9A	95.5 MHz			859.500 MHz	-73.96 dBm	1	HPF	-3.64 dBm	-70.3 dBm	-31.83 dB	-38.49 dBm	[SANF] <-111.8 dBc	
10A	95.5 MHz			955.000 MHz	-76.20 dBm	1	HPF	-3.90 dBm	-72.3 dBm	-31.83 dB	-40.47 dBm	[SANF] <-113.8 dBc	
11A	95.5 MHz			1050.500 MHz	-73.32 dBm	1	HPF	-4.02 dBm	-69.3 dBm	-31.83 dB	-37.47 dBm	[SANF] <-110.8 dBc	
12A	95.5 MHz			1146.000 MHz	-73.21 dBm	1	HPF	-3.84 dBm	-69.4 dBm	-31.83 dB	-37.54 dBm	[SANF] <-110.8 dBc	
?				198.310 MHz	-66.43 dBm		HPF	-1.84 dBm	-64.6 dBm	-40.16 dB	-24.43 dBm	-97.7 dBc	

Table 6

Combiner Output
KKBR Principle Measurements
Low Pass Filter

IM Order	*Freq A*	*Freq B*	*Freq C*	*Resultant Product*	*SA Measured Value (via SA Markers Measurements)*	*Noise Floor*	*Test Setup*	*Filter Measured Value*	*Observation Corrected for Filter Loss*	*Combiner Coupler Value (Shaded Extrapolated)*	*Observation Corrected for Directional Coupler Coupling*	*Relative to Carrier*	*Notes*
A-B	97.1 MHz	95.5 MHz		1.600 MHz			HPF		0.0 dBm	-58.00 dB	58.00 dBm		
A-B	97.1 MHz	102.9 MHz		5.800 MHz			HPF		0.0 dBm	-58.00 dB	58.00 dBm		
A-B	97.1 MHz	103.7 MHz		6.600 MHz			HPF		0.0 dBm	-58.00 dB	58.00 dBm		
A+B	97.1 MHz	95.5 MHz		192.600 MHz	-75.20 dBm	1	HPF	-1.88 dBm	-73.3 dBm	-40.38 dB	-32.94 dBm	[SANF] <-102.7 dBc	
A+B	97.1 MHz	102.9 MHz		200.000 MHz	-75.64 dBm	1	HPF	-1.94 dBm	-73.7 dBm	-40.08 dB	-33.62 dBm	[SANF] <-103.4 dBc	
A+B	97.1 MHz	103.7 MHz		200.800 MHz	-75.94 dBm	1	HPF	1.95 dBm	-77.9 dBm	-40.04 dB	-37.85 dBm	[SANF] <-107.6 dBc	
2A-B	97.1 MHz	95.5 MHz		98.700 MHz	-77.23 dBm	1	HPF	-33.13 dBm	-44.1 dBm	-46.08 dB	1.98 dBm	[SANF] <-67.8 dBc	
2A-B	97.1 MHz	102.9 MHz		91.300 MHz	-77.07 dBm	1	HPF	-33.98 dBm	-43.1 dBm	-46.73 dB	3.64 dBm	[SANF] <-66.1 dBc	
2A-B	97.1 MHz	103.7 MHz		90.500 MHz	-77.60 dBm	1	HPF	-39.74 dBm	-37.9 dBm	-46.81 dB	8.95 dBm	[SANF] <-60.8 dBc	
2A+B	97.1 MHz	95.5 MHz		289.700 MHz	-77.53 dBm	1	HPF	-1.90 dBm	-75.6 dBm	-37.12 dB	-38.51 dBm	[SANF] <-108.3 dBc	
2A+B	97.1 MHz	102.9 MHz		297.100 MHz	-77.74 dBm	1	HPF	-1.84 dBm	-75.9 dBm	-36.91 dB	-38.99 dBm	[SANF] <-108.7 dBc	
2A+B	97.1 MHz	103.7 MHz		297.900 MHz	-77.57 dBm	1	HPF	-1.85 dBm	-75.7 dBm	-36.89 dB	-38.83 dBm	[SANF] <-108.6 dBc	
1A Reference	97.1 MHz			97.100 MHz	-10.62 dBm		HPF	-34.17 dBm	23.6 dBm	-46.21 dB	69.76 dBm	0.0 dBc	KKBR (FacID 16774)
2A	97.1 MHz			194.200 MHz	-76.15 dBm	1	HPF	-1.86 dBm	-74.3 dBm	-40.31 dB	-33.98 dBm	[SANF] <-103.7 dBc	
3A	97.1 MHz			291.300 MHz	-76.17 dBm	1	HPF	-1.88 dBm	-74.3 dBm	-37.05 dB	-37.24 dBm	[SANF] <-107.0 dBc	
4A	97.1 MHz			388.400 MHz	-78.02 dBm	1	HPF	-2.28 dBm	-75.7 dBm	-34.90 dB	-40.84 dBm	[SANF] <-110.6 dBc	
5A	97.1 MHz			485.500 MHz	-77.12 dBm	1	HPF	-2.68 dBm	-74.4 dBm	-33.43 dB	-41.01 dBm	[SANF] <-110.8 dBc	
6A	97.1 MHz			582.600 MHz	-74.01 dBm		HPF	-2.91 dBm	-71.1 dBm	-32.49 dB	-38.61 dBm	-108.4 dBc	
7A	97.1 MHz			679.700 MHz	-76.55 dBm	1	HPF	-3.04 dBm	-73.5 dBm	-31.95 dB	-41.56 dBm	[SANF] <-111.3 dBc	
8A	97.1 MHz			776.800 MHz	-76.89 dBm	1	HPF	-3.49 dBm	-73.4 dBm	-31.76 dB	-41.64 dBm	[SANF] <-111.4 dBc	
9A	97.1 MHz			873.900 MHz	-73.70 dBm		HPF	-3.78 dBm	-69.9 dBm	-31.83 dB	-38.09 dBm	-107.8 dBc	
10A	97.1 MHz			971.000 MHz	-75.20 dBm	1	HPF	-3.91 dBm	-71.3 dBm	-31.83 dB	-39.46 dBm	[SANF] <-109.2 dBc	
11A	97.1 MHz			1068.100 MHz	-75.04 dBm	1	HPF	-3.85 dBm	-71.2 dBm	-31.83 dB	-39.36 dBm	[SANF] <-109.1 dBc	
12A	97.1 MHz			1165.200 MHz	-74.48 dBm	1	HPF	-3.85 dBm	-70.6 dBm	-31.83 dB	-38.80 dBm	[SANF] <-108.6 dBc	
				97.069 MHz	-78.28 dBm	0	HPF	-34.16 dBm	-44.1 dBm	-46.22 dB	2.10 dBm	-67.7 dBc	Possible 97.1 Exciter Issues, Caps?. Within 47CFR73.317
				97.130 MHz	-75.08 dBm		HPF	-34.16 dBm	-40.9 dBm	-46.21 dB	5.29 dBm	-64.5 dBc	Possible 97.1 Exciter Issues, Caps?. Within 47CFR73.317
				97.193 MHz	-81.29 dBm	1	HPF	-34.17 dBm	-47.1 dBm	-46.21 dB	-0.91 dBm	[SANF] <-70.7 dBc	
				97.007 MHz	-77.66 dBm	1	HPF	-34.17 dBm	-43.5 dBm	-46.22 dB	2.73 dBm	[SANF] <-67.0 dBc	
				198.310 MHz	-66.12 dBm		HPF	-1.86 dBm	-64.3 dBm	-40.16 dB	-24.10 dBm	-93.9 dBc	

Table 7

Combiner Output
KCTR Principle Measurements
Low Pass Filter

IM Order	*Freq A*	*Freq B*	*Freq C*	*Resultant Product*	*SA Measured Value (via SA Markers Measurements)*	*Noise Floor*	*Test Setup*	*Filter Measured Value*	*Observation Corrected for Filter Loss*	*Combiner Coupler Value (Shaded Extrapolated)*	*Observation Corrected for Directional Coupler Coupling*	*Relative to Carrier*	*Notes*
A-B	102.9 MHz	95.5 MHz		7.400 MHz			HPF		0.0 dBm	-58.00 dB	58.00 dBm		
A-B	102.9 MHz	97.1 MHz		5.800 MHz			HPF		0.0 dBm	-58.00 dB	58.00 dBm		
A-B	102.9 MHz	103.7 MHz		0.800 MHz			HPF		0.0 dBm	-58.00 dB	58.00 dBm		
A+B	102.9 MHz	95.5 MHz		198.400 MHz	-74.22 dBm		HPF	-1.84 dBm	-72.4 dBm	-40.16 dB	-32.22 dBm	-105.9 dBc	
A+B	102.9 MHz	97.1 MHz		200.000 MHz	-72.88 dBm		HPF	-1.92 dBm	-71.0 dBm	-40.08 dB	-30.88 dBm	-104.6 dBc	
A+B	102.9 MHz	103.7 MHz		206.600 MHz	-77.92 dBm	1	HPF	-2.06 dBm	-75.9 dBm	-39.81 dB	-36.05 dBm	[SANF] <-109.7 dBc	
2A-B	102.9 MHz	95.5 MHz		110.300 MHz	-73.30 dBm		HPF	-23.42 dBm	-49.9 dBm	-45.09 dB	-4.79 dBm	-78.5 dBc	Close to SA Noise Floor
2A-B	102.9 MHz	97.1 MHz		108.700 MHz	-76.43 dBm	1	HPF	-24.87 dBm	-51.6 dBm	-45.22 dB	-6.34 dBm	[SANF] <-80.0 dBc	
2A-B	102.9 MHz	103.7 MHz		102.100 MHz	-78.32 dBm	1	HPF	-30.82 dBm	-47.5 dBm	-45.75 dB	-1.75 dBm	[SANF] <-75.4 dBc	
2A+B	102.9 MHz	95.5 MHz		301.300 MHz	-77.38 dBm	1	HPF	-1.80 dBm	-75.6 dBm	-36.78 dB	-38.80 dBm	[SANF] <-112.5 dBc	
2A+B	102.9 MHz	97.1 MHz		302.900 MHz	-78.02 dBm	1	HPF	-1.81 dBm	-76.2 dBm	-36.73 dB	-39.48 dBm	[SANF] <-113.2 dBc	
2A+B	102.9 MHz	103.7 MHz		309.500 MHz	-77.74 dBm	1	HPF	-1.92 dBm	-75.8 dBm	-36.58 dB	-39.24 dBm	[SANF] <-112.9 dBc	
1A Reference	102.9 MHz			102.900 MHz	-2.24 dBm		HPF	-30.23 dBm	28.0 dBm	-45.68 dB	73.67 dBm	0.0 dBc	KCTR-FM (FacID 16772)
2A	102.9 MHz			205.800 MHz	-77.29 dBm	1	HPF	-2.06 dBm	-75.2 dBm	-39.84 dB	-35.39 dBm	[SANF] <-109.1 dBc	
3A	102.9 MHz			308.700 MHz	-75.24 dBm	1	HPF	-1.92 dBm	-73.3 dBm	-36.60 dB	-36.72 dBm	[SANF] <-110.4 dBc	
4A	102.9 MHz			411.600 MHz	-76.48 dBm	1	HPF	-2.20 dBm	-74.3 dBm	-34.51 dB	-39.77 dBm	[SANF] <-113.4 dBc	
5A	102.9 MHz			514.500 MHz	-77.24 dBm	1	HPF	-2.46 dBm	-74.8 dBm	-33.12 dB	-41.66 dBm	[SANF] <-115.3 dBc	
6A	102.9 MHz			617.400 MHz	-75.52 dBm	1	HPF	-2.74 dBm	-72.8 dBm	-32.25 dB	-40.53 dBm	[SANF] <-114.2 dBc	
7A	102.9 MHz			720.300 MHz	-75.78 dBm	1	HPF	-3.36 dBm	-72.4 dBm	-31.79 dB	-40.63 dBm	[SANF] <-114.3 dBc	
8A	102.9 MHz			823.200 MHz	-76.89 dBm	1	HPF	-3.48 dBm	-73.4 dBm	-31.78 dB	-41.63 dBm	[SANF] <-115.3 dBc	
9A	102.9 MHz			926.100 MHz	-76.42 dBm	1	HPF	-3.46 dBm	-73.0 dBm	-31.83 dB	-41.13 dBm	[SANF] <-114.8 dBc	
10A	102.9 MHz			1029.000 MHz	-76.10 dBm	1	HPF	-3.90 dBm	-72.2 dBm	-31.83 dB	-40.37 dBm	[SANF] <-114.0 dBc	
11A	102.9 MHz			1131.900 MHz	-75.79 dBm	1	HPF	-3.81 dBm	-72.0 dBm	-31.83 dB	-40.15 dBm	[SANF] <-113.8 dBc	
12A	102.9 MHz			1234.800 MHz	-73.57 dBm	1	HPF	-3.82 dBm	-69.8 dBm	-31.83 dB	-37.92 dBm	[SANF] <-111.6 dBc	
				102.985 MHz	-66.38 dBm		HPF		-66.4 dBm	-45.68 dB	-20.70 dBm	-94.4 dBc	
				102.815 MHz	-70.24 dBm		HPF		-70.2 dBm	-45.69 dB	-24.55 dBm	-98.2 dBc	

Table 8

Combiner Output
Three Frequency IM Products
Low Pass Filter

IM Order	*Freq A*	*Freq B*	*Freq C*	*Resultant Product*	*SA Measured Value (via SA Markers Measurements)*	*Noise Floor*	*Test Setup*	*Filter Measured Value*	*Observation Corrected for Filter Loss*	*Combiner Coupler Value (Shaded Extrapolated)*	*Observation Corrected for Directional Coupler Coupling*	*Relative to Carrier*	*Notes*
A+B-C	103.7 MHz	102.9 MHz	97.1 MHz	109.500 MHz	-78.56 dBm	1	HPF	-24.87 dBm	-51.6 dBm	-46.14 dB	-5.42 dBm	[SANF] <-75.2 dBc	Reference carrier is 97.1 MHz, it is the lowest carrier.
A+C-B	103.7 MHz	102.9 MHz	97.1 MHz	97.900 MHz	-76.49 dBm	1	HPF	-33.63 dBm	-42.9 dBm	-46.14 dB	3.28 dBm	[SANF] <-66.5 dBc	
B+C-A	103.7 MHz	102.9 MHz	97.1 MHz	96.300 MHz	-76.99 dBm	1	HPF	0.00 dBm	-77.0 dBm	-46.27 dB	-30.72 dBm	[SANF] <-100.5 dBc	
A+B+C	103.7 MHz	102.9 MHz	97.1 MHz	303.700 MHz	-76.87 dBm	1	HPF		-76.9 dBm	-36.71 dB	-40.16 dBm	[SANF] <-109.9 dBc	
A+B-C	102.9 MHz	97.1 MHz	95.5 MHz	104.500 MHz	-77.94 dBm		HPF		-77.9 dBm	-45.56 dB	-32.38 dBm	-102.1 dBc	
A+C-B	102.9 MHz	97.1 MHz	95.5 MHz	101.300 MHz	-76.79 dBm		HPF		-76.8 dBm	-45.82 dB	-30.97 dBm	-100.7 dBc	
B+C-A	102.9 MHz	97.1 MHz	95.5 MHz	89.700 MHz	-76.20 dBm		HPF		-76.2 dBm	-46.89 dB	-29.31 dBm	-99.1 dBc	
A+B+C	102.9 MHz	97.1 MHz	95.5 MHz	295.500 MHz	-76.93 dBm		HPF		-76.9 dBm	-36.95 dB	-39.98 dBm	-109.7 dBc	
A+B-C	97.1 MHz	95.5 MHz	103.7 MHz	88.900 MHz	-77.21 dBm		HPF		-77.2 dBm	-46.96 dB	-30.25 dBm	-100.0 dBc	
A+C-B	97.1 MHz	95.5 MHz	103.7 MHz	105.300 MHz	-75.83 dBm		HPF		-75.8 dBm	-45.49 dB	-30.34 dBm	-100.1 dBc	
B+C-A	97.1 MHz	95.5 MHz	103.7 MHz	102.100 MHz	-77.79 dBm		HPF		-77.8 dBm	-45.75 dB	-32.04 dBm	-101.8 dBc	
A+B+C	97.1 MHz	95.5 MHz	103.7 MHz	296.300 MHz	-79.52 dBm		HPF		-79.5 dBm	-36.93 dB	-42.59 dBm	-112.3 dBc	
A+B-C	95.5 MHz	103.7 MHz	102.9 MHz	96.300 MHz	-76.26 dBm		HPF		-76.3 dBm	-46.28 dB	-29.98 dBm	-99.7 dBc	
A+C-B	95.5 MHz	103.7 MHz	102.9 MHz	94.700 MHz	-77.64 dBm		HPF		-77.6 dBm	-46.41 dB	-31.23 dBm	-101.0 dBc	
B+C-A	95.5 MHz	103.7 MHz	102.9 MHz	111.100 MHz	-78.08 dBm		HPF		-78.1 dBm	-45.03 dB	-33.05 dBm	-102.8 dBc	
A+B+C	95.5 MHz	103.7 MHz	102.9 MHz	302.100 MHz	-76.58 dBm		HPF		-76.6 dBm	-36.75 dB	-39.83 dBm	-109.6 dBc	

Notes-Legend

[SANF] Spectrum Analyzer Noise Floor

Notch Triple Microwave Filter Company Type 6367, no pads, in line with RF Input to Spectrum Analyzer
Notch Oddities noted around 455.9 MHz, 725.4 MHz and above 1 GHz

HPF Crystek CHPFL-0150-BNC High Pass Filter in place of triple Band Pass Filter, Single cable from Sample

Noise Floor 1=no discernable signal above the noise floor grass in the spectrum analyzer, blank or 0 = discernable signal above noise floor.

Tracking Generator Spectrum Analyzer flatness +- 0.5 dB

Townsquare Media Billings – Combined FM System

KCHH / KKBR / KCTR

Appendix 1

System Gains and Losses

TPO CALCULATION SHEET
ERI SHPX-10C6-SP

Station Call Sign	**KCHH**	**KKBR**	**KCTR**
Frequency (MHz)	**95.5**	**97.1**	**102.9**
	Analog	**Analog**	**Analog**
ERP (W)	**100000**	**50000**	**100000**
Antenna Model	ERI SHPX-10C6-SP	ERI SHPX-10C6-SP	ERI SHPX-10C6-SP
Antenna gain elevation **From ERI Tech Quote # 20220303-534**	5.420	5.609	5.350
Antenna azimuth gain	1	1	1
Antenna Gain, peak of beam (multiplier)	5.4200	5.6090	5.3500
Antenna input power (W)	**18450**	**8914**	**18692**
Upper Transmission Line [Rigid Line for Slug Tuning]	4-1/16" Rigid	4-1/16" Rigid	4-1/16" Rigid
Line Length (feet) [17 x 17.5-ft]	297.5	297.5	297.5
Line loss per hundred feet (dB/100')	0.073	0.073	0.075
Vertical Line loss total (dB)	0.2172	0.2172	0.2231
Power Into Rigid Transmission Line (W)	**19396**	**9371**	**19677**
Lower Transmission Line	HJ11-50 4" Heliax	HJ11-50 4" Heliax	HJ11-50 4" Heliax
Line Length (feet) [350-ft less rigid line for tuning]	31	31	31
Line loss per hundred feet (dB/100')	0.111	0.113	0.116
Vertical Line loss total (dB)	0.0344	0.0350	0.0360
Power Into Heliax Transmission Line (W)	**19551**	**9447**	**19841**
Filter Insertion Loss (dB) (measured)	0.197	0.208	0.220
Power Input to Filter (W)	**20458**	**9911**	**20872**
TX to Combiner Line (rigid in KCTR TX Building)			3-1/8" Rigid
Line Length (feet)			10.7
Line loss per hundred feet (dB/100') [from Myat catalog]			-0.0943
Line loss total (dB)			-0.0101
TX to Combiner Line (flex jumper from KCTR TX Building to Combiner Building)			HJ8-50B 3" Heliax
Line Length (feet)			31
Line loss per hundred feet (dB/100')			-0.144
Line loss total (dB)			-0.0446
TX to Combiner Line (Rigid Line in Combiner Building)	3-1/8" Rigid	3-1/8" Rigid	3-1/8" Rigid
Line Length (feet)	25.3	18.2	8.5
Line loss per hundred feet (dB/100') [from Myat catalog]	-0.0908	-0.0916	-0.0943
Line loss total (dB)	-0.0230	-0.0167	-0.0080
TPO (W)	*20566*	*9949*	*20910*
TPO (kW) Rounded per 47CFR73.212	**20.5**	**9.9**	**21.0**

Field Service Report
FM Branch Combiner

For the Combined Operation of:

KCHH-FM 95.5 MHz, Worden, MT
KKBR-FM 97.1 MHz, Billing, MT
KCTR-FM 102.9 MHz, Billings, MT

Location Address: 1736 Coburn Rd, Billings, MT

Tower Coordinates: 45-45-59.0 N 108-27-21.0 W (NAD 83)
ASRN: 1002037

Antenna Model: ERI SHPX-10AC6-SP Side Mounted FM Antenna
Combiner: Reconfigured ERI Branch Combiner
Consisting of 973 Filter Modules Plus ERI Notch Filter 945-2

Measurements Recorded
August 22 – 29, 2022

Submitted by:

Eric Wandel, P.E.
Email: eric@wavepointresearch.com
Mobile: 812-453-2544

LIST OF TABLES

LIST OF FIGURES / MEASUREMENTS

1. Measurements

In August 2022, Townsquare Media of Billings commissioned a new combined FM facility for the combined operation of:

- KCHH-FM 95.5 MHz, Worden, MT
- KKBR-FM 97.1 MHz, Billing, MT
- KCTR-FM 102.9 MHz, Billings, MT

The combined system includes the following components:

- A new ERI SHPX-10AC6-SP Side Mounted FM Antenna with 6-1/8" matching section
- Adapter from 6-1/8" 50 Ohm to 4-1/16" 50 Ohm EIA plus (17) sections of 17.5-ft 4-1/16" 50 Ohm Rigid line (297.5-ft)
- Approximately 30-ft length of HJ11-50 4" Heliax line
- A retuned / reconfigured ERI Branch Combiner consisting of (3) 973 four-cavity bandpass filter modules
- An ERI Notch Filter Model 945-2 between the KCTR transmitter and the main combiner

This report provides a summary of the final performance measurements of the main combiner system plus notch filter. The general layout of the filter / combiner system is shown in Figure 1.

Key performance parameters of the standalone combiner system are summarized in Table 1. Measurements of the KCTR notch filter were made separately, with the notch filter data also shown in Table 1. Port-to-Port isolation measurements are summarized in Table 2.

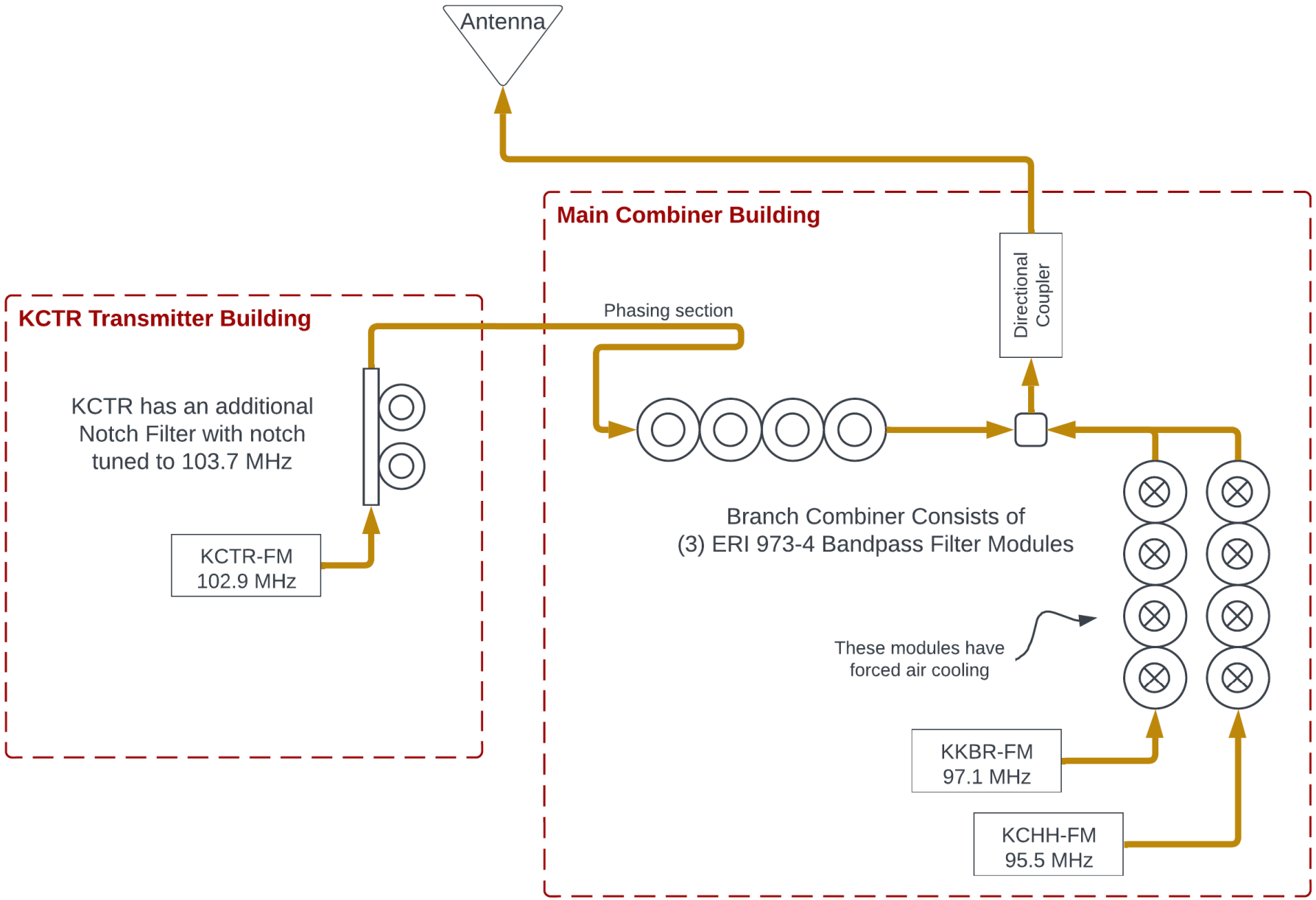


Figure 1 – General Layout of Main Filter / Combiner System

Table 1 – Summary of Filter Key Performance Parameters

Description of Parameter	KCHH-FM 95.5 MHz	KKBR-FM 97.1 MHz	KCTR-FM 102.9 MHz
Match at carrier frequency	-49.3 dB	-44.0 dB	-34.0 dB
Average match in +/-200 kHz	-37.9 dB	-33.6 dB	-37.9 dB
Insertion loss at carrier frequency	-0.1880 dB	-0.2080 dB	-0.2201 dB
Average insertion loss in +/-200 kHz	-0.1970 dB	-0.2185 dB	-0.2251 dB
Group delay variation in +/-200 kHz	189 nsec	168 nsec	84 nsec
Notch Filter – Notch Depth at 103.7 MHz			-56 dB
Notch Filter Match at carrier frequency			-38.3 dB
Notch Filter Insertion loss at carrier frequency			-0.0963 dB
Notch Filter Group delay variation in +/-200 kHz			133.64 nsec

Table 2 – Port-to-Port Isolation, Main Combiner Input Ports

	95.5	97.1	102.9
95.5		95.5 MHz: -56.9 dB 97.1 MHz: -57.5 dB	95.5 MHz: -102.2 dB 102.9 MHz: -86.5 dB
97.1	95.5 MHz: -56.9 dB 97.1 MHz: -57.5 dB		97.1 MHz: -118.6 dB 102.9 MHz: -95.1 dB
102.9	95.5 MHz: -102.2 dB 102.9 MHz: -86.5 dB	97.1 MHz: -118.6 dB 102.9 MHz: -95.1 dB	

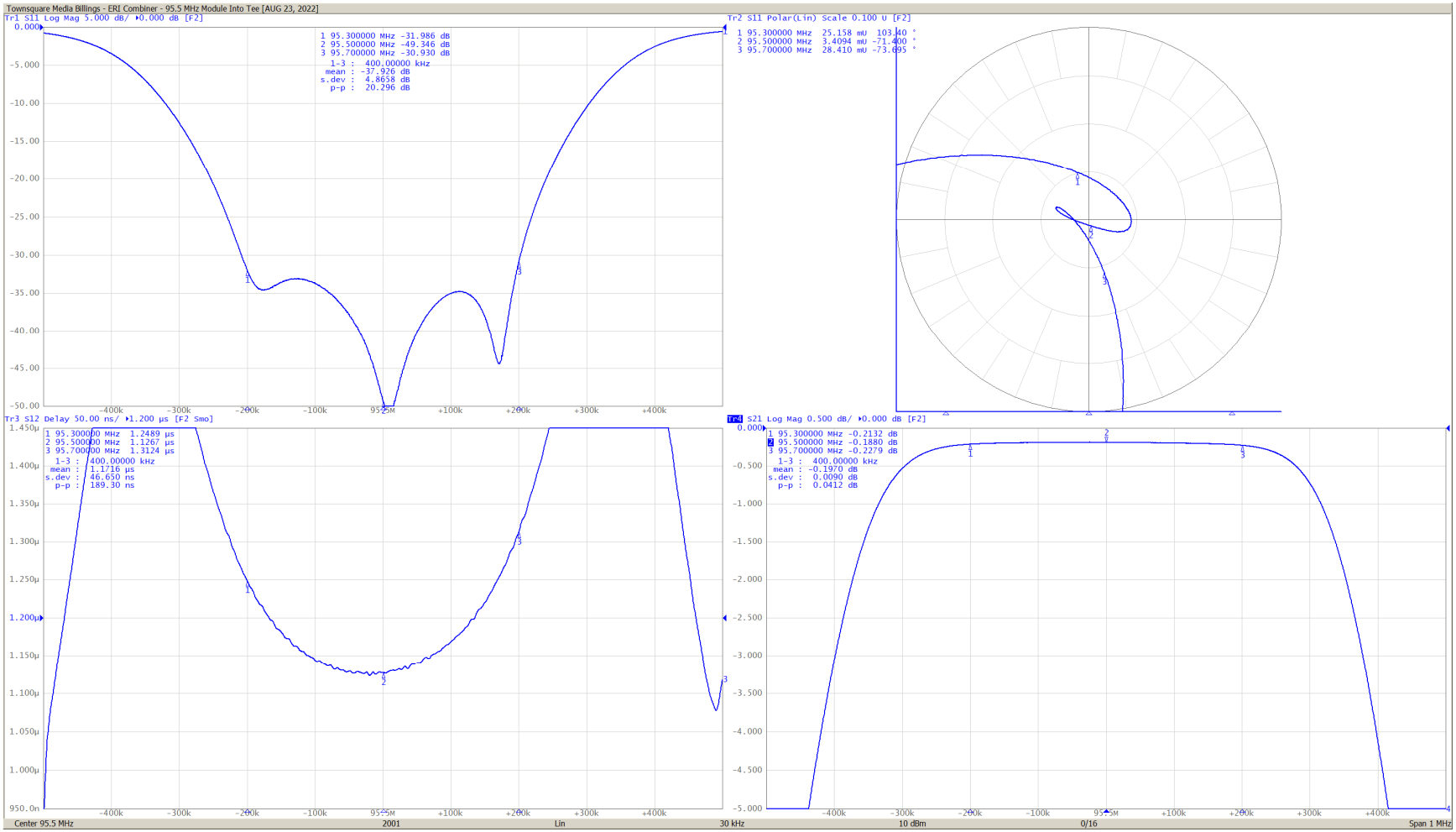


Figure 2 – KCHH-FM 95.5 MHz Combiner Characteristics – Match, Group Delay, and Insertion Loss – 1 MHz Span

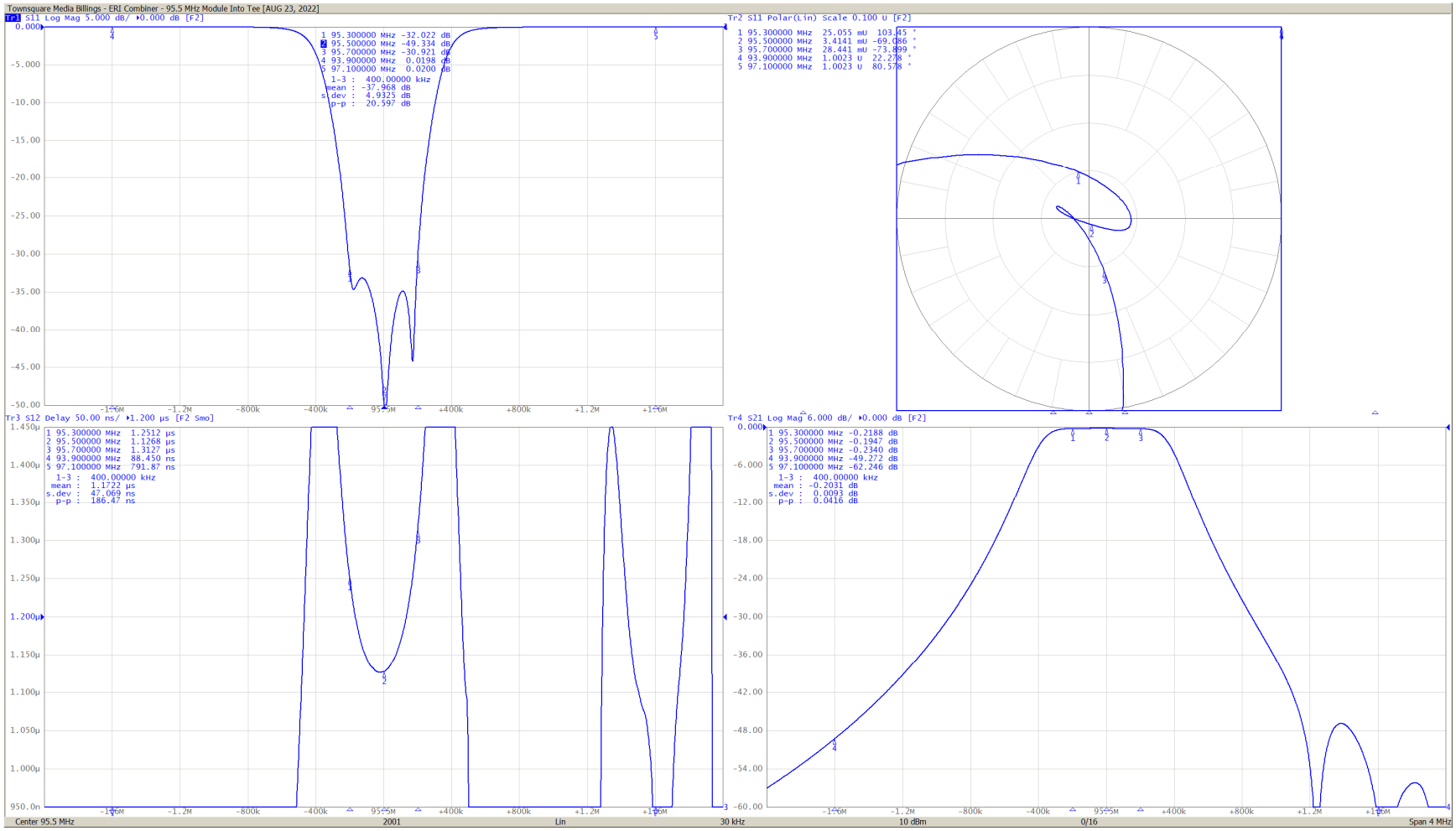


Figure 3 – KCHH-FM 95.5 MHz Combiner Characteristics – Match, Group Delay, and Insertion Loss – 4 MHz Span

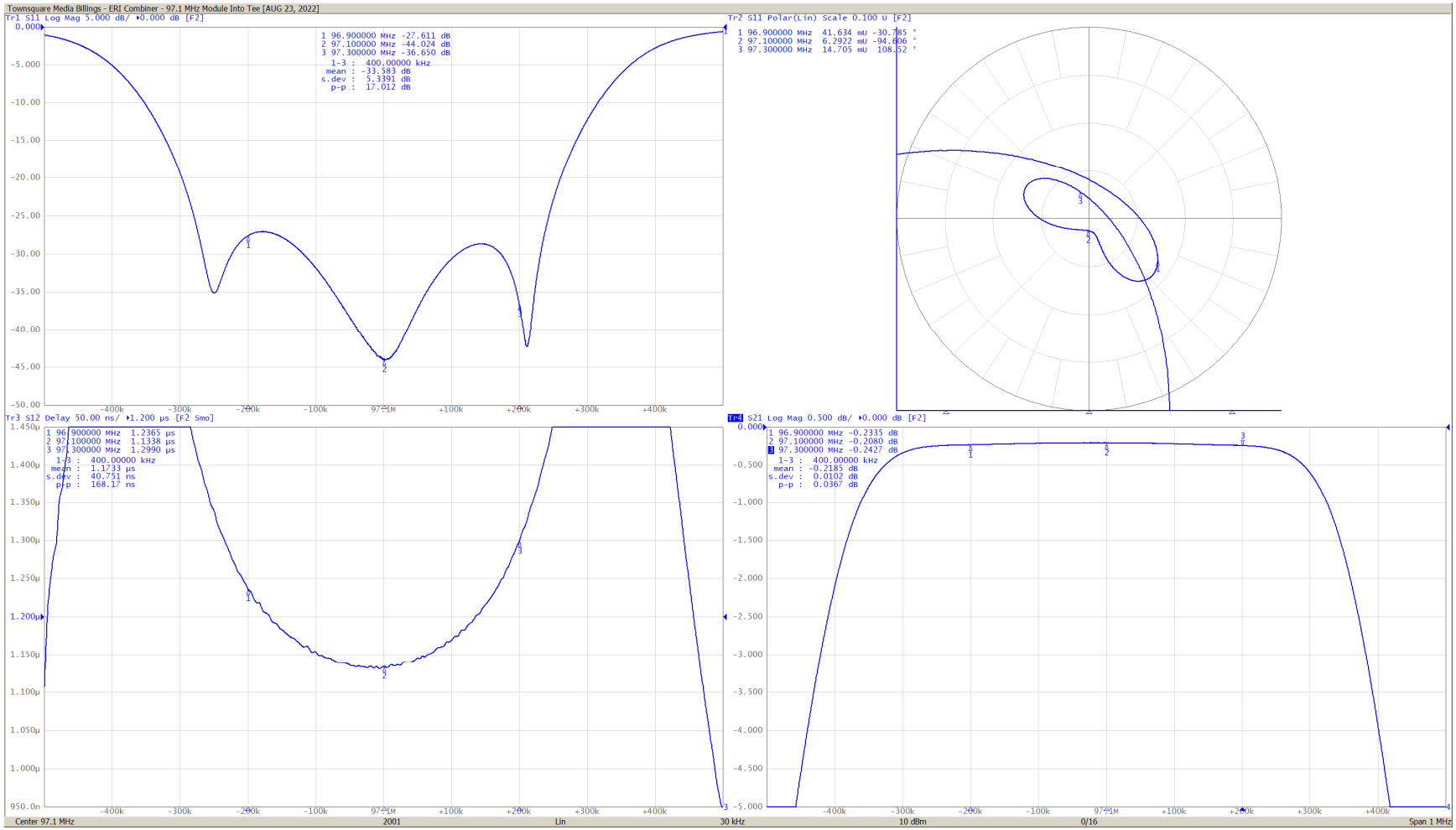


Figure 4 – KKBR-FM 97.1 MHz Combiner Characteristics – Match, Group Delay, and Insertion Loss – 1 MHz Span

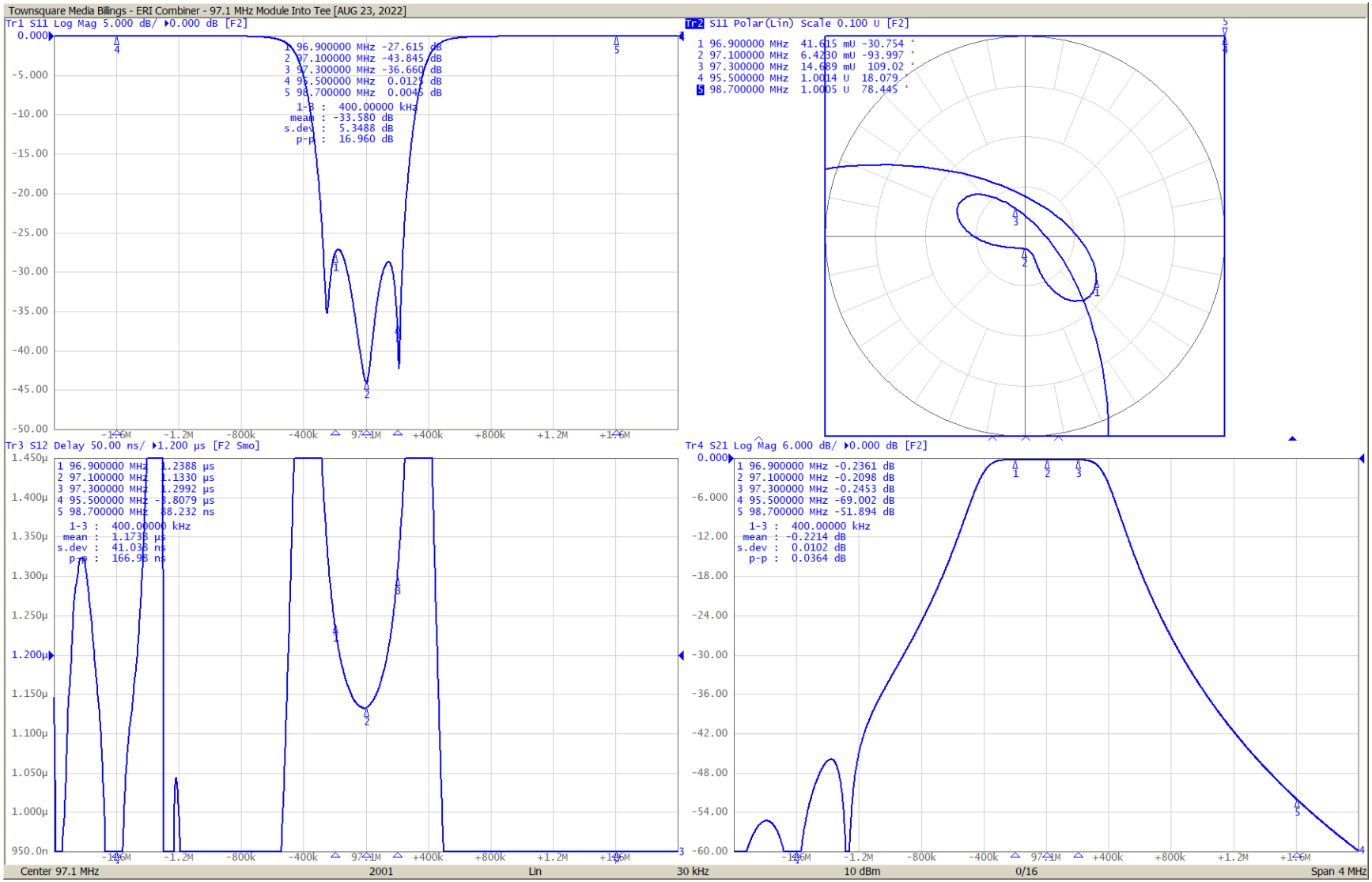


Figure 5 – KKBR-FM 97.1 MHz Combiner Characteristics – Match, Group Delay, and Insertion Loss – 4 MHz Span

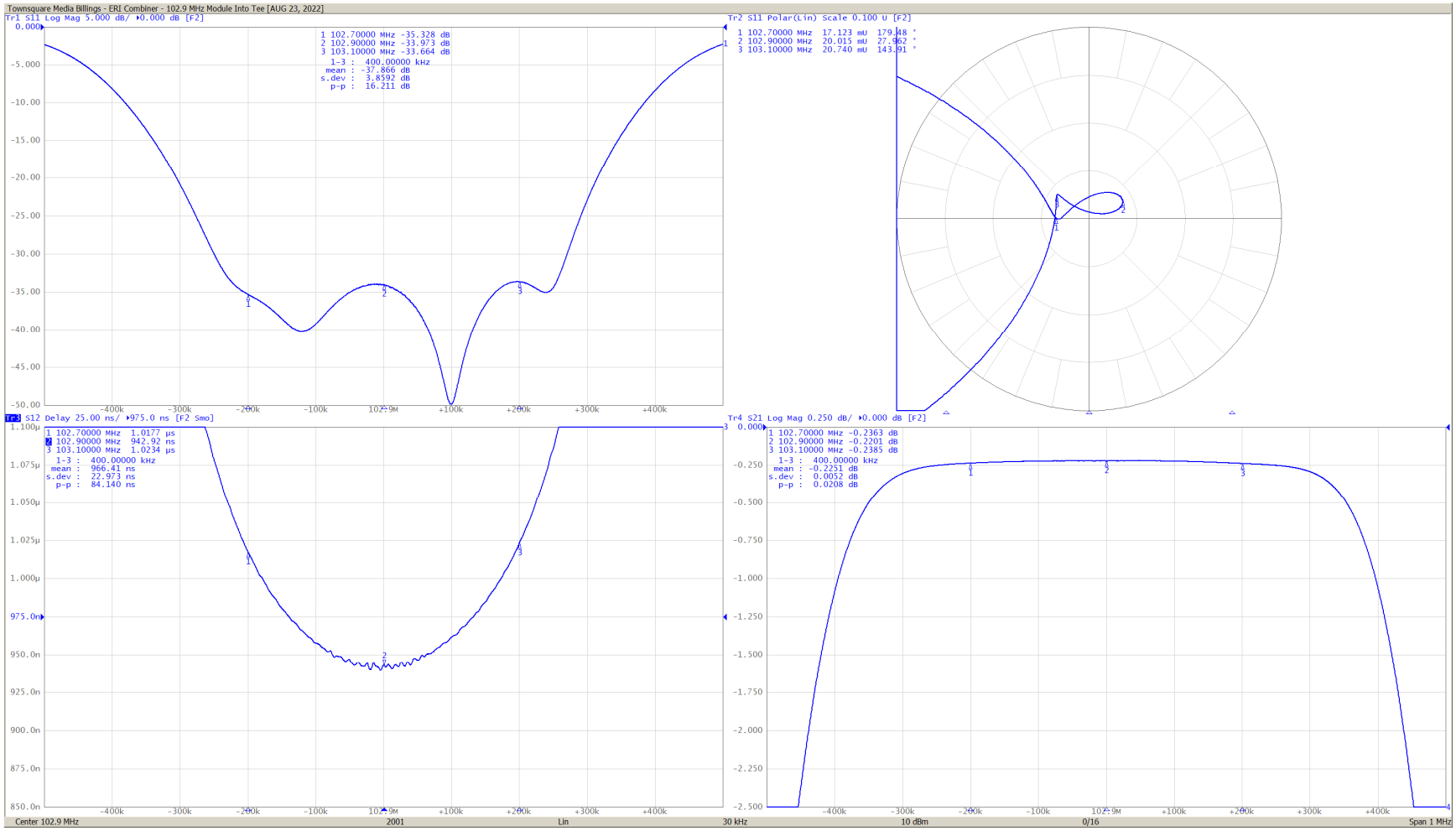


Figure 6 – KCTR-FM 102.9 MHz Combiner Characteristics – Match, Group Delay, and Insertion Loss – 1 MHz Span

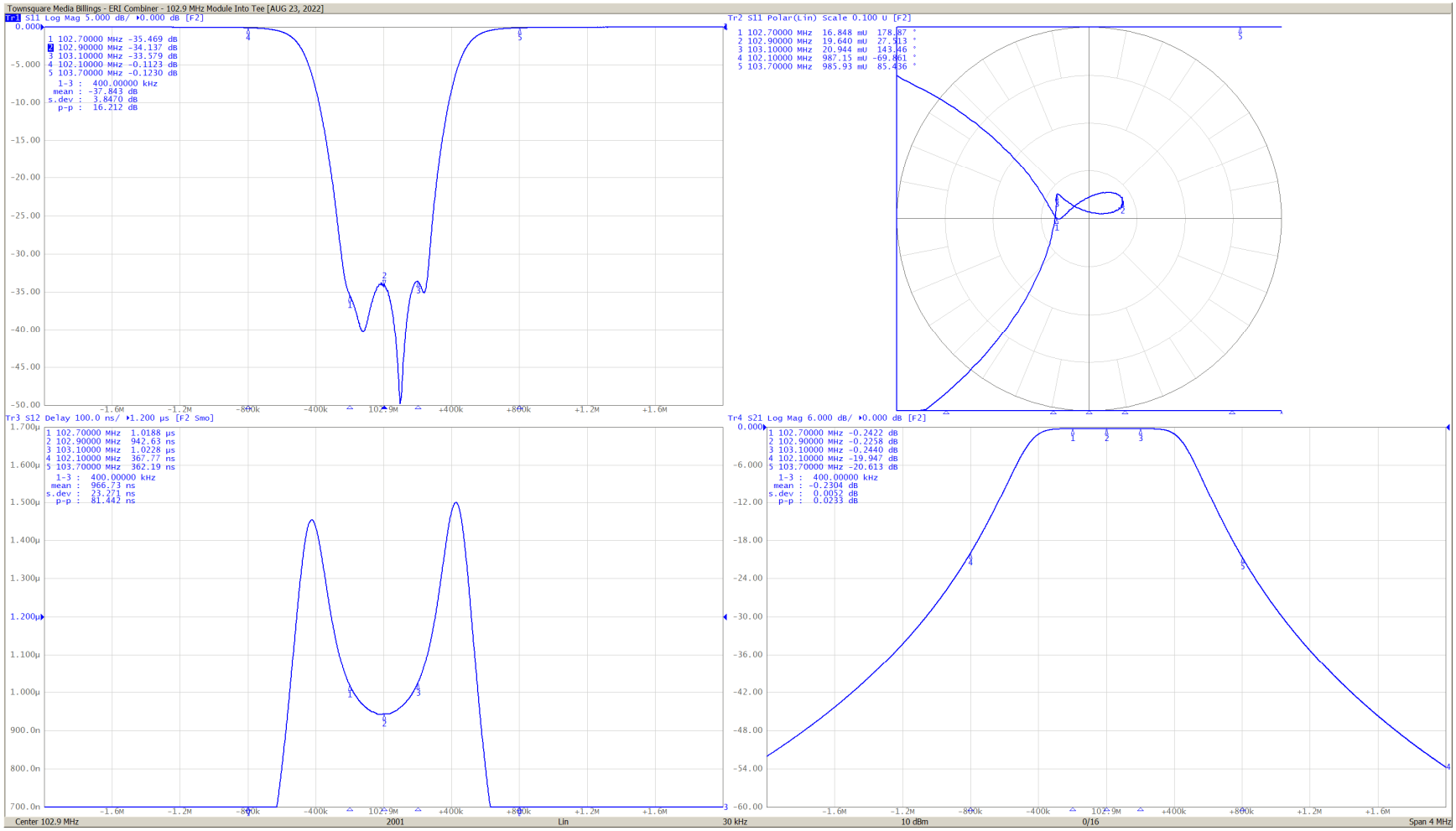


Figure 7 – KCTR-FM 102.9 MHz Combiner Characteristics – Match, Group Delay, and Insertion Loss – 4 MHz Span

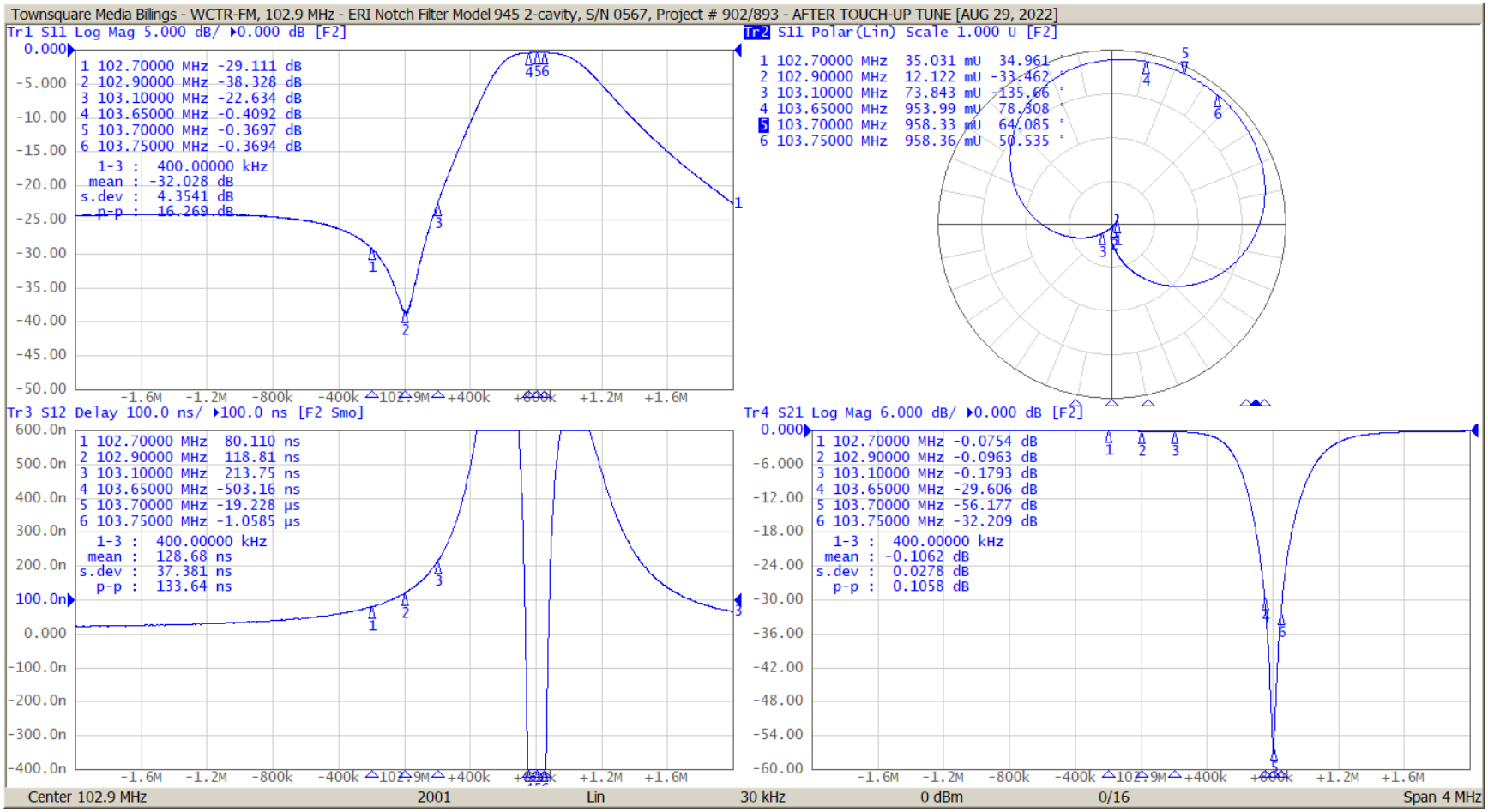


Figure 8 – KCHH-FM 95.5 MHz Notch Filter Characteristics – Match, Group Delay, and Insertion Loss – 4 MHz Span

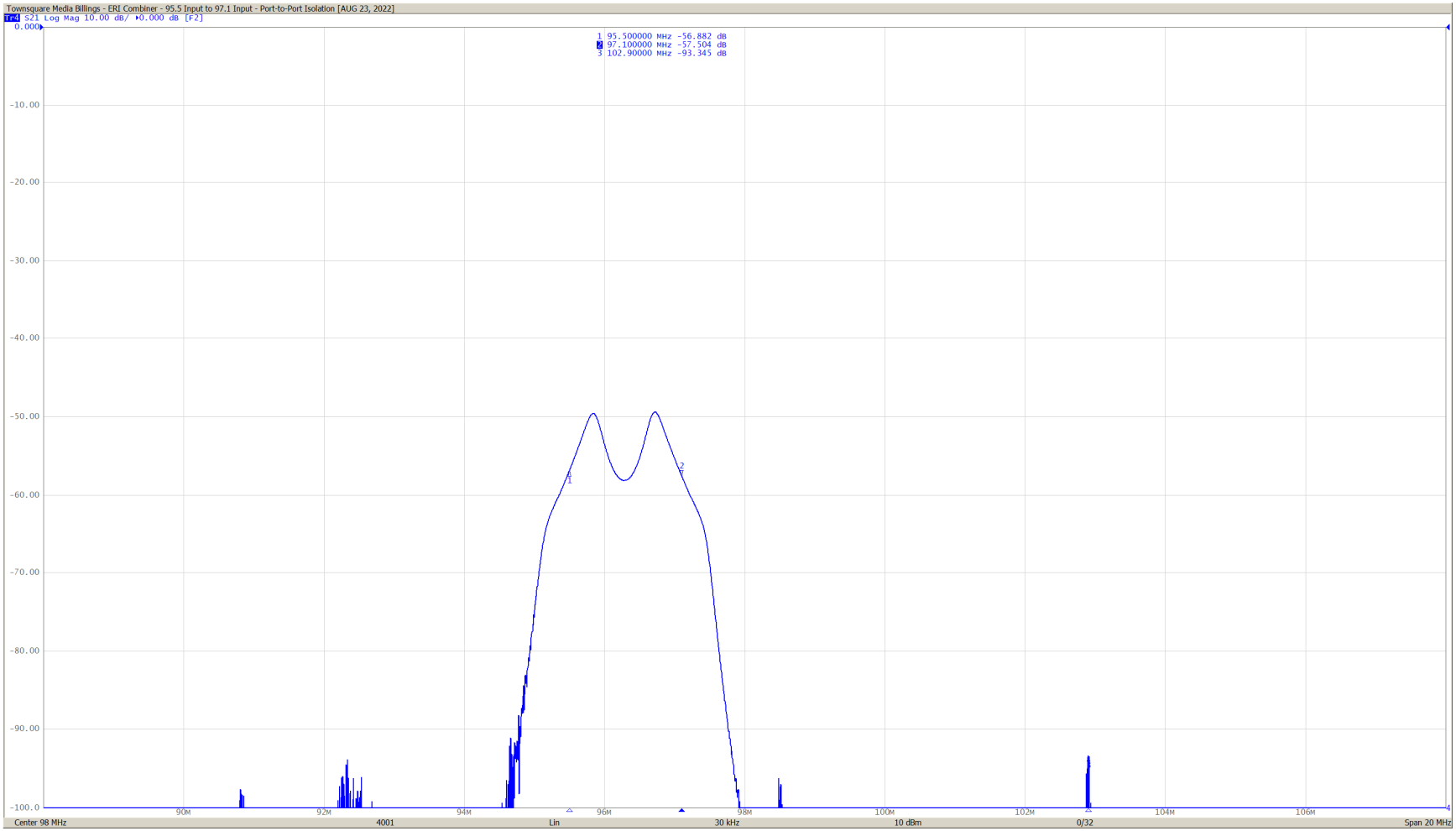


Figure 9 – KCHH-FM 95.5 MHz Input to KKBR-FM 97.1 MHz Input – Port-to-Port Isolation

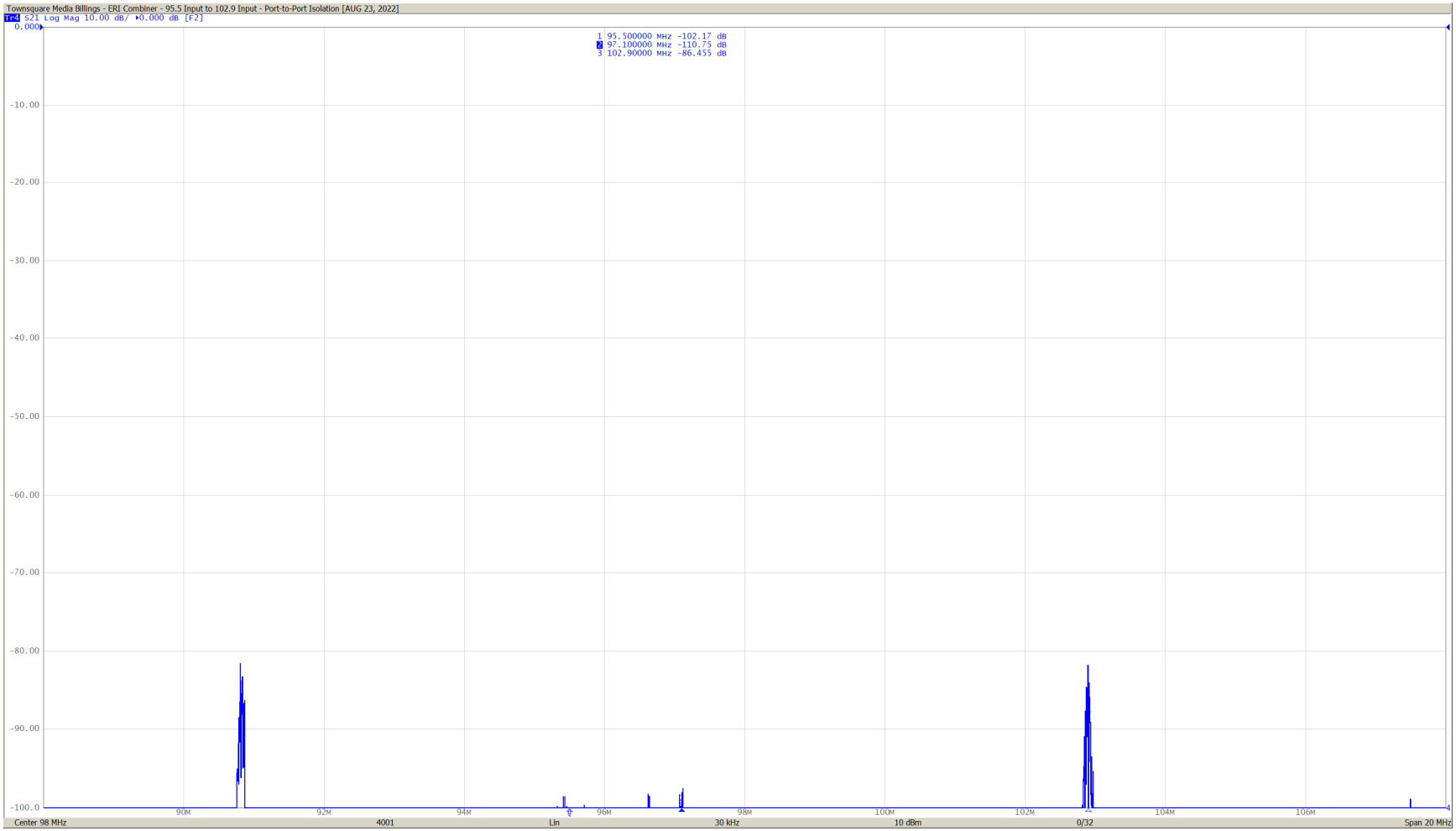


Figure 10 – KCHH-FM 95.5 MHz Input to KCTR-FM 102.9 MHz Input – Port-to-Port Isolation (at combiner input without notch filter)

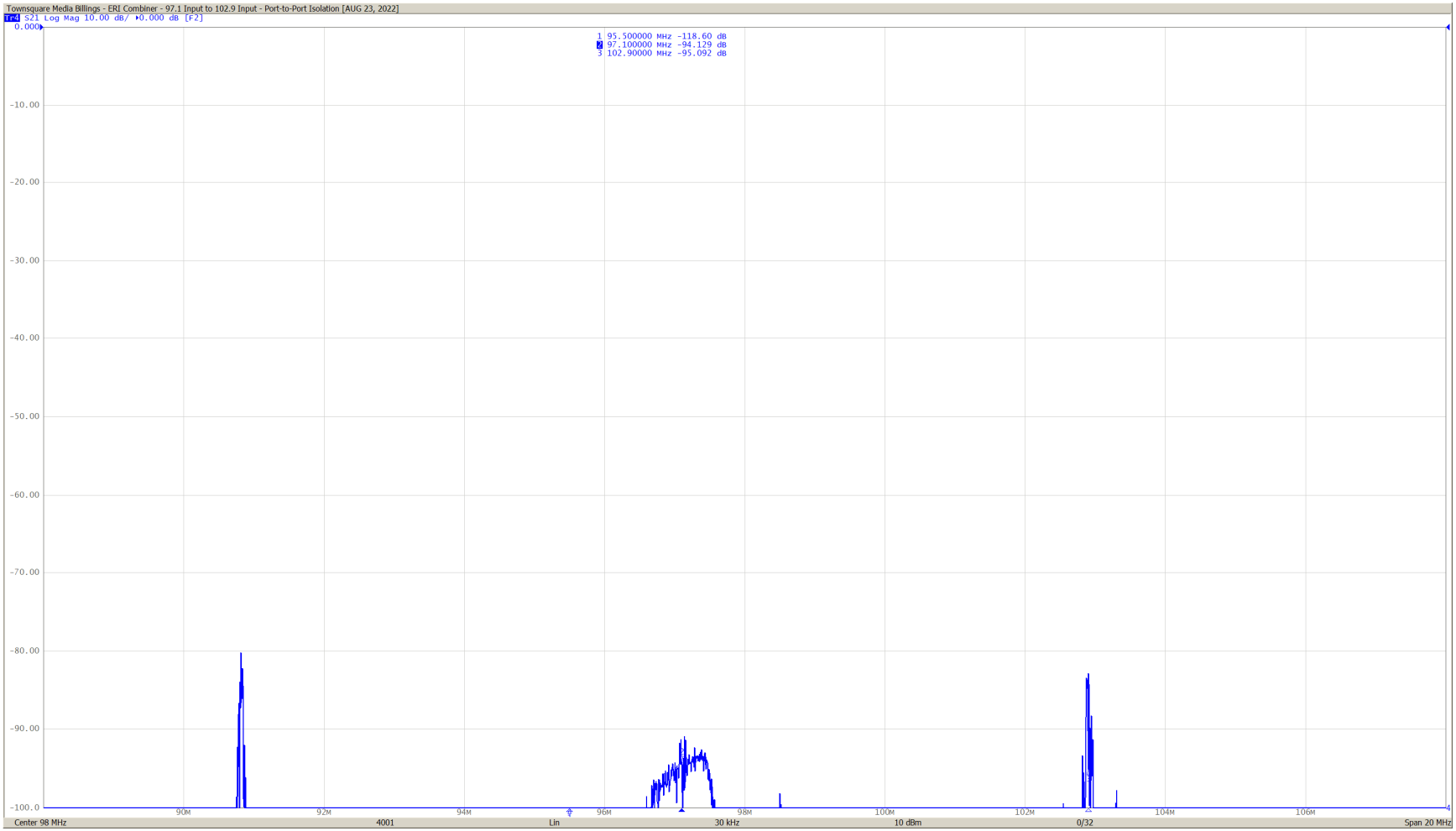


Figure 11 – KKBR-FM 97.1 MHz Input to KCHH-FM 102.9 MHz Input – Port-to-Port Isolation (at combiner input without notch filter)

Non-Ionizing Radiation Measurements

For

Townsquare License, LLC

And Stations

KCTR-FM Billings (FacID 16773)

KKBR Billings (FacID 16774)

KCHH Warden (FacID 1315)

For the

New Three Station Combined Antenna System

Steve Campbell, PE
Entronics
8008 Turtle Cove Ave
Las Vegas, NV 89128-6763

steve@rsclv.com
(702) 360-4051

Executive Summary

Townsquare License, LLC has elected to refresh the transmitter installations for its Billings FM stations KCTR-FM, KKBR and KCHH by combining the three stations into a new ERI SHPX-10C6-SP antenna and installing and an ERI 783 based Branch Combiner. This installation replaces the existing KCTR-FM antenna system with a like non-directional antenna and with no significant change in height. In compliance with;

A) a condition of the KCHH's Construction Permit File Number 0000176079,
B) a condition of the KKBR's Construction Permit File Number 0000202346,
C) in support of a 47 CFR 73.1690(c)(1) permitted license modification for KCTR-FM
D) and in compliance with the FCC Rules and Regulations,

measurements were taken to demonstrate that while all stations were operating at their newly proposed licensed power and operating into the shared antenna, no accessible location exists where the RF Power Density from all contributors is in excess of the FCC Guidelines as defined in OET Bulletin No. 65, Edition 97-01, August 1997 and the instant stations are a significant contributor.

Table of Contents

Site Description

The tower (ASRN 1002037) that hosts the three stations instant to this report is located on a private parcel of land at 1736 Coburn Road, Billings, Montana under the control of Townsquare License, LLC. This parcel is part of the de facto Billings Antenna Farm. The entire parcel of land is fenced with a barbed-wire fence. There is a closed and locked gate to access this parcel. The eastern side of this parcel adjoins a public right of way, Coburn Road. There is only one tower on the parcel. There are two additional parcels abutting the Townsquare parcel, both containing towers with high power users. There are additional parcels of land beyond the abutting parcels, also containing towers with high power users. A list of the towers with high power users is in Table 1.

Measurement Narrative

An initial evaluation of the site from the tower base to 400 meters from the tower base was performed utilizing the FCC FM Model. As the three frequencies of this study are using the same antenna, the interbay spacing (Lambda) for each station was slightly different, the FCC FM Model was executed three times with the specifics for each frequency. These three results were then summed for each distance from the base of the tower. The highest value calculated from the sum of these three frequencies was 176.6 $\mu W/cm^2$ at 36.4 to 38.8 M from the tower base, which is 88.3% of the General Population/Uncontrolled (GP/U) limit of OET--65. This distance is completely on the property of Townsquare License, LLC, property that is fenced with a barbed-wire fence and posted with RFR Warning and no trespassing signs. The nearest point to the tower that is publicly accessible without crossing the fence is approximately 48 meters from the tower base and the power density at that distance from the tower is predicted to be 146 uW/cm2 or 73% of the GP/U limit. The plot of the FCC FM Model predicted RF Field Density for the three stations is shown in Plot 1.

However, this is a multi-user tower site with other high-power users and with uneven terrain. The list of other towers and high-power users is in Table 1. While the FCC FM Model Predictions indicate that by and of themselves the RF fields from the instant antenna use do not impose RF Power Densities of concern, the totals from all contributors must be evaluated.

Upon completion of the installation of a replacement non-directional antenna for KCTR-FM with a new Electronic Research, Inc (ERI) Model SHPX 10-C6-SP antenna designed to accept multiple frequencies but with the same general characteristics for KCTR-FM as the existing ERI built antenna, the installation of a ERI Model 783 based Branch Combiner that overseen by Eric Wandel of Wavepoint Research Inc with the technical support assistance of ERI, the installation of one new transmitter for KCHH and the re-installation of the KKBR and KCTR-FM transmitters by the undersigned, and obtaining the FCC consents for testing, measurements were made by the undersigned with assistance of others working under the undersigned's direction to determine if RF Power Density in excess of FCC Guidelines (OET Bulletin No. 65, Edition 97-01, August 1997) exist at any accessible location to which instant stations are a significant contributor. These measurements were made with each of the three instant transmitters operating at the powers shown in Appendix 1, the newly proposed Transmitter Power Outputs (TPO) that will be requested in the License To Cover a Construction Permit (L2C) for both KCHH [FCC Construction Permit (CP) File Number 0000176079] and KKBR [FCC CP File Number 0000202346] and for the modification of the KCTR-FM main license as permitted under 47 CFR 73.1690(c)(1). These three stations were operating in their final configuration into the shared ERI antenna.

The measurements were taken utilizing a new Narda Model NBM-550 (S/N H-0406, Last Calibrated February 15, 2018) with a shaped probe Model EA5091 (S/N 01269, Last Calibrated August 08, 2018) and equipped with GPS Logging that was used. A rectangular grid of the Townsquare License, LLC property, the KTVQ property to the west of the Townsquare property, the property to the south of the Townsquare property and the public accessible Coburn Road were walked with the Narda equipment in data logging mode. These measurements were made without utilizing special averaging. The unit was set to log a set of points every 2 to 5 seconds (two different times were used based on distance from the tower), and for each point logged, the minimum, average and maximum value [in % of Occupational/Controlled (O/C) limit] of the readings for that period were recorded along with the time and the geographical coordinates. A total of 5,978 measurement points were collected.

These measurements were plotted on a Google Earth plot of Coburn Road Transmitter Farm (see attached) for:

a) levels below 50% General Population/Uncontrolled RF Power Density Limit, [Figure 2]
b) 50% to 100% General Population/Uncontrolled RF Power Density Limits, [Figure 3]
c) Under 100% Occupational/Controlled RF Power Density Limits, [Figure 4]
d) And over 100% Occupational/Controlled RF Power Density Limits. [Figure 5]

The areas found by the logged survey that were above the Occupational/Controlled RF Power Density Limits were re-evaluated by the undersigned and are in compliance with in OET Bulletin No. 65, Edition 97-01, August 1997 as described below.

The areas adjacent to the 6 guy anchors of ASRN 1002037 were found to be above the O/C Limit when the probe was brought very close to the guy wire. Further measurements were taken, and it was determined that these high readings are in part coupling between the guy wire and the Narda probe when in close proximity. It was determined that the RF Power Density dropped to the O/C limits when the probe was moved 4" or greater from the guy wire. It was further determined that the RF Power Density dropped below the GP/U limits when the probe was moved greater than 12" from the inner guy anchor wires and moved greater than 18" from the guy outer guy anchor wires. A spatial average was performed over the size of a 6' body about 12" from the outer guy wires on leg 2 and this average was 22.8% of the O/C Limit or just over the GP/U limit. The high readings shown in figures 4 and 5 are an abnormal coupling with the Narda Probe and do not represent excessive radiation over the special average of a human body.

There is an area along Coburn Road with very high indications on the NARDA Probe. This area is directly under a high-tension commercial power transmission line. Per Narda's manual (see Appendix 2), the Narda NBM-550 is susceptible to the high fields from such high-tension lines. To confirm that this was the case, frequency selective measurements were taken along a run on Coburn Road under and adjacent to the power line. These measurements were taken with a Deva Band Scanner 2 running an uncalibrated antenna (relative measurements) along Coburn Road. Plot 2 shows the relative field strengths versus distance along Coburn Road from a point southeast of the high-tension power lines (show at level 20 on the plot) to well north of the high-tension lines. It can be seen that the relative levels of the instant FM stations do not show an increase near the power lines indicating that the stations are not the cause of these elevated measurements in the area. The conclusion is that the low frequency effects discussed by Narda are the cause of these readings and do not indicate excessive RF Power Density as defined under OET-65.

Within Building 1 and Building 2 (southern building), the Narda test set was used to locate levels of high RF Power Density that could expose workers to energy beyond the OET-65 defined limits. Within Building #1, the areas near the 3" line entrance to the building, and the areas near the elbows at the top of the notch filter were elevated and approaching but not exceeding the Occupational/Controlled limits of OET-65. These areas were small in area and very difficult to access. An area between the notch filter and the FM30T transmitter had RF Power Density in excessive of the Occupational/Controlled limits of OET-65, but it is not possible to get more than a hand in this area. The remainder of the interior of Building #1 was at or below the General Public/Uncontrolled limits set in OET-65.

The highest RF Power Density found within Building #2 was near the trombone tunning stub for KCTR-FM, and this measurement was below the Occupational/Controlled limits of OET-65. The remainder of the interior of Building #2 was below the General Public/Uncontrolled limits of OET-65. The buildings are controlled and restricted access areas but are well in compliance with the requirements of OET-65 for Occupational/Controlled environments.

Certification

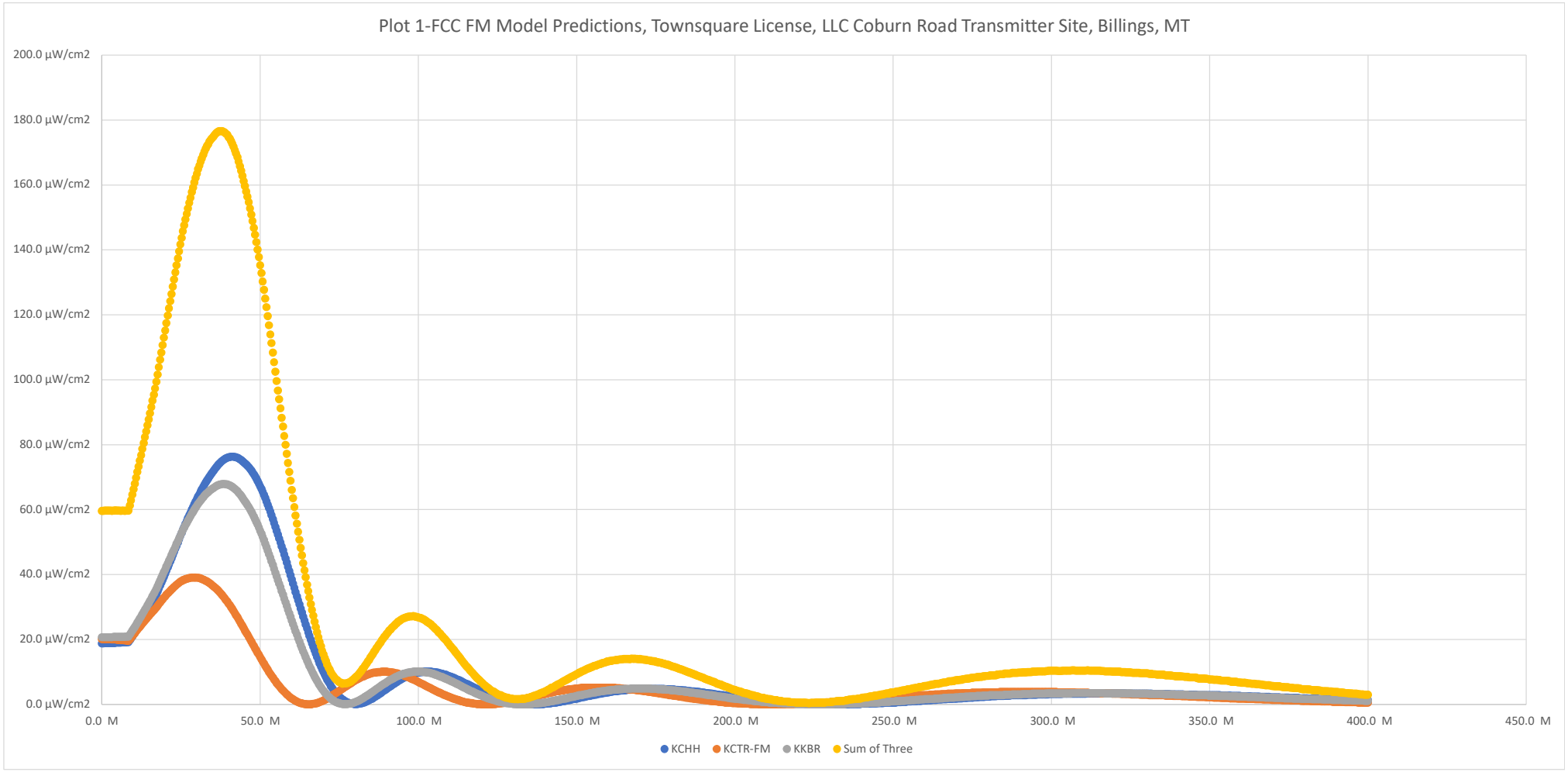
The undersigned hereby certify, except for the work referenced herein and attributed to Eric Wandel, all measurements herein described were performed by the undersigned or under the undersigned's direct supervision. All measurements and representations within this report are true and accurate to the best of the undersigned's knowledge and belief.

Ross Steve Campbell (NV PE Electrical 16245)
Entronics
June 15, 2023

Table 1 Billings Coburn Road Defacto Antenna Farm

ASRN	Tower Owner					°	
	Station	FCC FacID	ERP	Height (RCAGL)	Polarization	Vector (Meters/Degrees	Comment
1002037	Townsquare License, LLC					0<0	Tower Subject of this Report
	KCTR-FM	16773	100.0 kW	98.0 M	CP	0<0	
	KKBR	16774	50.0 kW	98.0 M	CP	0<0	
	KCHH	1315	100.0 kW	98.0 M	CP	0<0	
	K277DS	202296	0.099 kW	51.0 M	CP	0<0	
1239653	SBA GC Towers, LLC					93<190	
	KLRV	91499	7.5 kW	124.0 M	V		
1225265	SBA GC Towers, LLC					137<209	
	KYSX	76918	6.0 kW	29.0 M	CP		
	KPLN	164108	100.0 kW	100.0 M	CP		
	KBXI	10336	100.0 kW	133.0 M	CP		
1027300	Rapid Broadcasting Company					180<230	
1020873	SBA GC Towers, LLC					204<210	
	KEWF	50356	100.0 kW	50.0 M	CP		
	K45KS-D	131138	5.0 kW	17.0 M	H		
	K51KR(LD)	131137	5.0 kW	14.0 M	Eliptical		
1214911	SBA GC Towers, LLC					263<188.5	
	KLMT	89849	1.5 kW	83.0 M	CP		Shively Type 1 Antenna
	KRSQ	4992	100.0 kW	40.0 M	CP		Shively Type 1 Antenna
	KRPM	78211	100.0 kW	64.0 M	CP		
1270180	Scripps Broadcast Holdings, LLC					178.8<258.6	
	KINV-LD	74352	10.5 kW	48.0 M	H		
1001064	Scripps Broadcast Holdings LLC					241<89	
	KMHK	35370	100.0 kW	76.0 M	CP		
	K20HB-D	125475	51.2 kW	45.0 M	H		
1250854	Scripps Broadcast Holdings LLC					244.0<294.5	
	KBGS-TV (CP)	169030	38.6 kW	98.0 M	Eliptical		
	KTVQ(DT)	35694	26.1 kW	112.4 M	H		
	KTVQ(DT) CP	35694	1000.0 kW	114.8 M	Eliptical		
1006702	Gallatin Wireless Internet, LLC					283.1<318.4	
	K25BP-D	5244	14.0 kW	61.0 M	H		
	K27IM-D	125462	0.810 kW	61.0 M	H		
1059250	Fox, Richard J dba+Comanche Enterprises					432<310	
1221062	Lockwood Fire District 8					507.6<318.7	
1280711	Montana Department of Transportation					577.8<316.8	
1280721	State of Montana-Transportation					589.9<317.9	
1234373	Montana Department of Transportation					589.7<318.6	
Non Registered						338<198.8	
1007673	CTI Towers Assets II, LLC					658<165.7	
	K251CI	200745	0.250 kW	51.8 M	CP		
	K288HA	200746	0.250 kW	51.8 M	CP		
	KRKX	63870	100.000 kW	106.0 M	CP		
	KRZN	78476	100.000 kW	139.0 M	CP		
	KULR	63880	60.000 kW	139.0 M	CP		
	KBLW	89078	1.600 kW	62.0 M	CP		Shively Type 1
1005272	Cowles Montana Media Company					685<177.8	
	KULR (TV)	35724	16.0 kW	110.0 M	H		
1056361	CTI Towers Assets II, LLC					774<169.5	
1002174	CCATT LLC					793<152.8	
1238339	CCATT LLC					781.5<152.9	
1016817	Pinnacle Towers LLC					763.5<162.4	
	KBIL	91510	4.1 kW	132.0 M	CP		Shively Type 1
Non Registered							
	K248BL	152964	0.250 kW	58.0 M	CP	800<167.4	
	K217EM	93793	0.075 kW	30.5 M	V	816.3<167	
	K255CW	93794	0.050 kW	30.5 M	V	816.3<167	
	K234CP	146157	0.250 kW	50.0 M	CP	821.6<166.2	


Townsquare License, LLC
Figure 1 Site Map Showing Coburn Road defacto Antenna Farm
Cavell, Mertz & Associates
Legend
1280721
1280711
1221062
1059250
1006702
Coburn Road, Billings, Montana
Locked and Posted Gate
Townsquare Controlled Property, Gate and Fence Line
1250854
1001064
Townsquare Coburn Road Billings Tower Site
1002037
1270180
1239653
Locked and Posted Gate
1027300
1225265
1020873
1214911
N
Google Earth
200 m

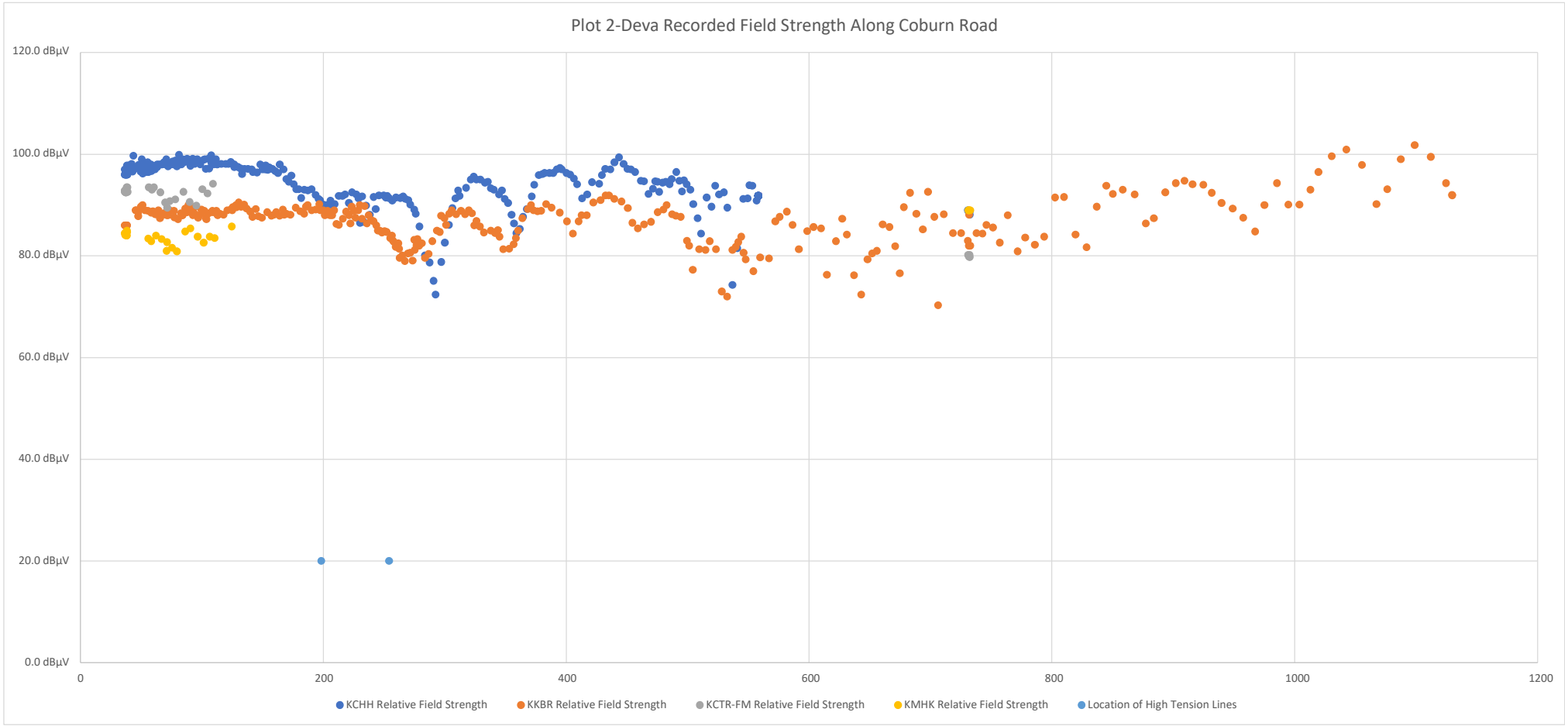

Plot 1-FCC FM Model Predictions, Townsquare License, LLC Coburn Road Transmitter Site, Billings, MT
200.0 µW/cm2
180.0 µW/cm2
160.0 µW/cm2
140.0 µW/cm2
120.0 µW/cm2
100.0 µW/cm2
80.0 µW/cm2
60.0 µW/cm2
40.0 µW/cm2
20.0 µW/cm2
0.0 µW/cm2
0.0 M
50.0 M
100.0 M
150.0 M
200.0 M
250.0 M
300.0 M
350.0 M
400.0 M
450.0 M
KCHH
KCTR-FM
KKBR
Sum of Three


Townsquare License, LLC
Figure 2 Site Map Showing Measurements Below 50% General Public/Uncontrolled RF Power Density Limit
Cavell, Mertz & Associates
Legend
N
Google Earth
200 m


Townsquare License, LLC
Figure 3 Site Map Showing Measurements between 50% and 100% General Public/Uncontrolled RF Power Density
Legend
N


Townsquare License, LLC
Figure 4 Site Map Showing Measurements above General Public/Uncontrolled and below Occupational/Controlled RF Power Density
Legend
N


Townsquare License, LLC
Figure 5 Site Map Showing Measurements above Occupational/Controlled RF Power Density
Legend
N


Plot 2-Deva Recorded Field Strength Along Coburn Road
120.0 dBµV
100.0 dBµV
80.0 dBµV
60.0 dBµV
40.0 dBµV
20.0 dBµV
0.0 dBµV
0
200
400
600
800
1000
1200
KCHH Relative Field Strength
KKBR Relative Field Strength
KCTR-FM Relative Field Strength
KMHK Relative Field Strength
Location of High Tension Lines

Townsquare Media Billings – Combined FM System

KCHH / KKBR / KCTR

System Gains and Losses

TPO CALCULATION SHEET
ERI SHPX-10C6-SP

Station Call Sign	KCHH	KKBR	KCTR
Frequency (MHz)	95.5	97.1	102.9
	Analog	Analog	Analog
ERP (W)	**100000**	**50000**	**100000**
Antenna Model	ERI SHPX-10C6-SP	ERI SHPX-10C6-SP	ERI SHPX-10C6-SP
Antenna gain elevation **From ERI Tech Quote # 20220303-534**	5.420	5.609	5.350
Antenna azimuth gain	1	1	1
Antenna Gain, peak of beam (multiplier)	5.4200	5.6090	5.3500
Antenna input power (W)	**18450**	**8914**	**18692**
Upper Transmission Line [Rigid Line for Slug Tuning]	4-1/16" Rigid	4-1/16" Rigid	4-1/16" Rigid
Line Length (feet) [17 x 17.5-ft]	297.5	297.5	297.5
Line loss per hundred feet (dB/100')	0.073	0.073	0.075
Vertical Line loss total (dB)	0.2172	0.2172	0.2231
Power Into Rigid Transmission Line (W)	**19396**	**9371**	**19677**
Lower Transmission Line	HJ11-50 4" Heliax	HJ11-50 4" Heliax	HJ11-50 4" Heliax
Line Length (feet) [350-ft less rigid line for tuning]	31	31	31
Line loss per hundred feet (dB/100')	0.111	0.113	0.116
Vertical Line loss total (dB)	0.0344	0.0350	0.0360
Power Into Heliax Transmission Line (W)	**19551**	**9447**	**19841**
Filter Insertion Loss (dB) (measured)	0.197	0.208	0.220
Power Input to Filter (W)	**20458**	**9911**	**20872**
TX to Combiner Line (rigid in KCTR TX Building)			3-1/8" Rigid
Line Length (feet)			10.7
Line loss per hundred feet (dB/100') [from Myat catalog]			-0.0943
Line loss total (dB)			-0.0101
TX to Combiner Line (flex jumper from KCTR TX Building to Combiner Building)			HJ8-50B 3" Heliax
Line Length (feet)			31
Line loss per hundred feet (dB/100')			-0.144
Line loss total (dB)			-0.0446
TX to Combiner Line (Rigid Line in Combiner Building)	3-1/8" Rigid	3-1/8" Rigid	3-1/8" Rigid
Line Length (feet)	25.3	18.2	8.5
Line loss per hundred feet (dB/100') [from Myat catalog]	-0.0908	-0.0916	-0.0943
Line loss total (dB)	-0.0230	-0.0167	-0.0080
TPO (W)	*20566*	*9949*	*20910*
TPO (kW) Rounded per 47CFR73.212	**20.5**	**9.9**	**21.0**

Recommendation: Try to avoid heating caused by direct sunlight during measurements with thermocouple probes. Consider an adequate settling time for stabilization of the probe in case of temperature changes. A settling time of about 15 minutes will ensure stabilized conditions. Extremely high steps of the environmental temperature changes may require longer settling times.

Strong low frequency fields

The result display when measuring high frequency electromagnetic fields can be falsified by low frequency fields. Wideband probes will detect signals even if the frequency is well outside the specified measurement range (out-of-band attenuation is 20 dB/decade). A probe specified to measure from 100 kHz to 3 GHz would therefore attenuate signals down to 100 Hz by at least 60 dB (= field strength / 1000). However, very high field strengths of several thousand V/m can occur in the vicinity of high tension lines. An RF wideband probe would therefore register several V/m.

Recommendation: Thoroughly inspect every measurement location before any measurement and make a note of any possible sources of interference, such as high tension lines in the vicinity. Keep a critical eye on any possible increase in the minimum display value (noise floor) which may indicate interfering factors. Increase the distance from the source of low frequency interference or use a probe that has a higher frequency cutoff point at the lower end of its range.

Further useful information can be found under FAQ at **www.narda-sts.com**