

Report of Inter-Modulation
Product Measurements
for
Operation of the Combined FM System

for

KMMS-FM, 94.7 MHz
KISN, 96.7 MHz
KXLB, 100.7 MHz

LOCATED AT
HIGH FLAT ELECTRONICS SITE
BOZEMAN, MONTANA

MEASUREMENTS COLLECTED ON
MAY 30, 2020

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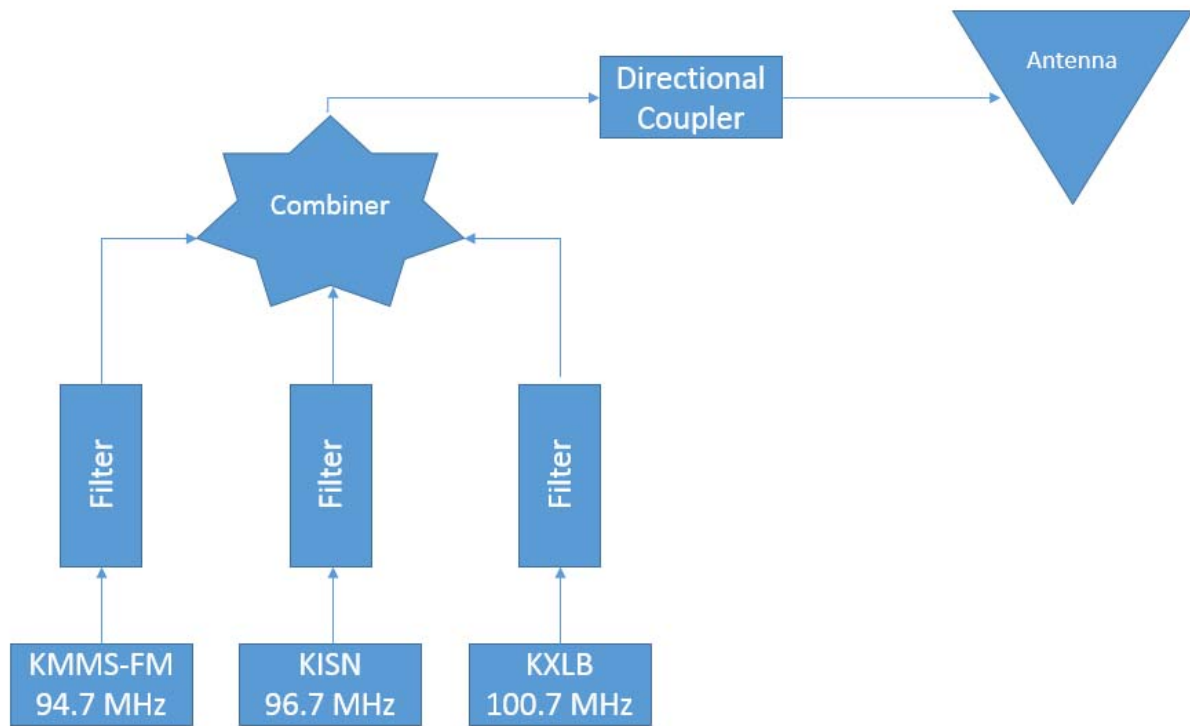
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Figure 1 - Combiner System Layout Diagram



INTRODUCTION

This report of findings provides evidence to show that the operation of a three-station combined facility located at the High Flat Electronics Site southwest of Bozeman, Montana, is in compliance with the FCC Rules and Regulations as required by the Code of Federal Regulations (CFR) Title 47 Section 73.317, 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 are commonly generated from radio stations operating into multiplexed facilities and at congested antenna broadcast sites when inadequate transmitter to transmitter isolation is provided.

In brief, the collection of measurements presented in this report shows that predictable IM products generated by the operation of these stations are less than the maximum allowable level as required by section 73.317(d). Further, the present study investigated possible spurious emissions up to 1 GHz and found no spurious emissions exceeding allowable levels. Martin Stabbert of Townsquare Media performed the measurements summarized herein on May 30, 2020.

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

- Agilent N9340B, Spectrum Analyzer
- Attenuators for adjusting the signal levels to optimize the dynamic range of the instrumentation without exceeding input power limits
- A directional coupler installed at the system output to the antenna

Measurements to verify compliance with section 73.317 (d) were made at the directional coupler installed at the output of the overall combiner system.

TRANSMISSION SYSTEM

The stations included in this combined system are listed in Table 1 where the level of spectral emissions required for 73.317(d) are calculated based on station transmitter power levels at the location of the directional coupler used for measurements.

Table 1 – Combiner System Stations Considered in IM Study

Call Sign	Frequency	ERP (kW)	Required Level per 73.317(d)
KMMS-FM	94.7 MHz	5.3	-80.00 dB
KISN	96.7 MHz	5.3	-80.00 dB
KXLB	100.7 MHz	40	-80.00 dB

The installed filter/combiner system is designed to provide adequate isolation to ensure that interfering signals and any resulting products are sufficiently attenuated to satisfy the section 73.317 paragraph (d) requirement. A functional diagram showing the layout of the combined transmission system is illustrated in Figure 1.

All stations operated at licensed power for the duration of compliance measurements. Martin Stabbert, Engineer, confirmed the operational status of all transmitters during the course of measurements.

The directional coupler used for measurements are factory calibrated with a typical directivity of >40 dB and a coupling level that has generally a flat response across the FM band within approximately +/- 0.5 dB. The coupling level was chosen to ensure signal levels can be adequately measured within the dynamic range of the spectrum analyzer.

The forward ports of the output directional couplers are used for sampling all outgoing carrier levels and IM products. The sampled signal was fed by shielded cable into an Agilent N9340B spectrum analyzer.

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 $2F_1 - F_2$). Figure 2 and 3 show the FM band noise floor, with nearby channels and potential IM products marked. The collection of measurements presented in this report shows that all possible third order inter-modulation (IM) products generated by the operation of these stations are less than the maximum allowable level as required by section 73.317(d), and further, that no products or harmonics exist in excess of required levels. The present study investigated possible spurious emissions up to 1 GHz and found no spurious emissions exceeding allowable levels.

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

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

The potential third-order product frequencies for the combined system are calculated and listed in Table 2.

Table 2 - Potential Third Order IM Products

		F2 MHz (Interfering Frequency)		
F1 MHz (Transmitter Frequency)		94.7	96.7	100.7
	94.7		92.7	88.7
	96.7	98.7		92.7
	100.7	106.7	104.7	

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 are listed in Table 3 and are used as the reference level for possible IM products.

Table 3 - Transmitter Forward Power Reference Levels

Call Sign	Frequency	Transmitter Forward Reference 300 kHz RBW
KMMS - FM	94.7 MHz	-16.8
KISN	96.7 MHz	-17.2
KXLB	100.7 MHz	-8.4

The IM product measurements recorded are listed in Table 4. The harmonic product measurements are recorded in Table 5.

Figure 2 shows the baseband measurement with the three combined stations off; note the presence of an in-market signal on 88.7 MHz.

Figures 4 through 9 show the FM band with carrier and IM products indicated. Individual sweeps are shown for each intermod product studied.

All product levels for the combined system meet requirements.

Table 4 – Intermod Product Measurements - Combined System

Carrier Frequency (MHz)	Interfering Frequency (MHz)	2A-B Product Frequency (MHz)	Carrier Reference Level (dBm)	Measured Level (dBc)	Target Level (dB)	Level relative to Requirement (dB)
94.7	96.7	92.7	-16.8	-112.8	-96.8	-16
94.7	100.7	88.7	-16.8	-91.4	-96.8	+5.4
96.7	94.7	98.7	-17.2	-113.2	-97.2	-16
96.7	100.7	92.7	-17.2	-112.8	-97.2	-15.6
100.7	94.7	106.7	-8.4	-113.0	-88.4	-24.6
100.7	96.7	104.7	-8.4	-113.1	-88.4	-24.7

Note: 88.7 MHz is present at the same level, even when all three of the subject transmitters are turned off. The 88.7 MHz signal originates from FM translator K204GR, which is licensed at a site 39 kilometers distant, but holds a construction permit to operate from the High Flat transmitter site.

Table 5 – Harmonic Product Measurements - Combined System

Carrier Frequency (MHz)	Carrier Reference Level (dBm)	2 nd Harmonic Frequency (MHz)	2 nd Harmonic Measured Level (dBc)	2 nd Harmonic Level relative to requirement (dB)	3 rd Harmonic Frequency (MHz)	3 rd Harmonic Measured Level (dBc)	3 rd Harmonic Level relative to requirement (dB)
94.7	-96.8	189.4	-113.2	-16.4	284.1	-113.3	-16.5
96.7	-97.2	193.4	-113.3	-16.1	290.1	-113.4	-16.2
100.7	-88.4	201.4	-112.9	-24.5	302.1	-113.4	-25.0

Figure 2 – All 3 Stations Off – Baseline Spectrum (Markers indicate IM products to be tested)

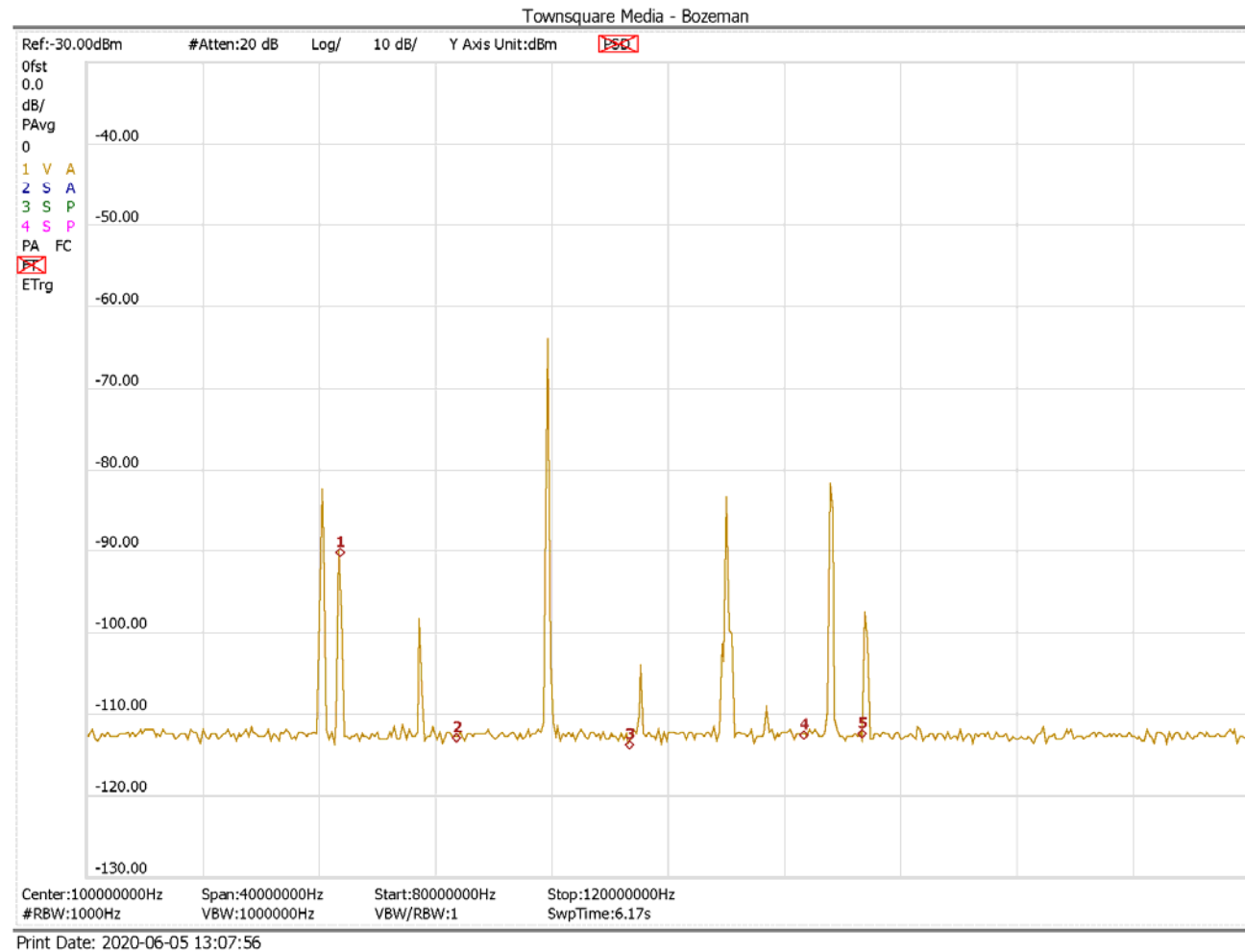
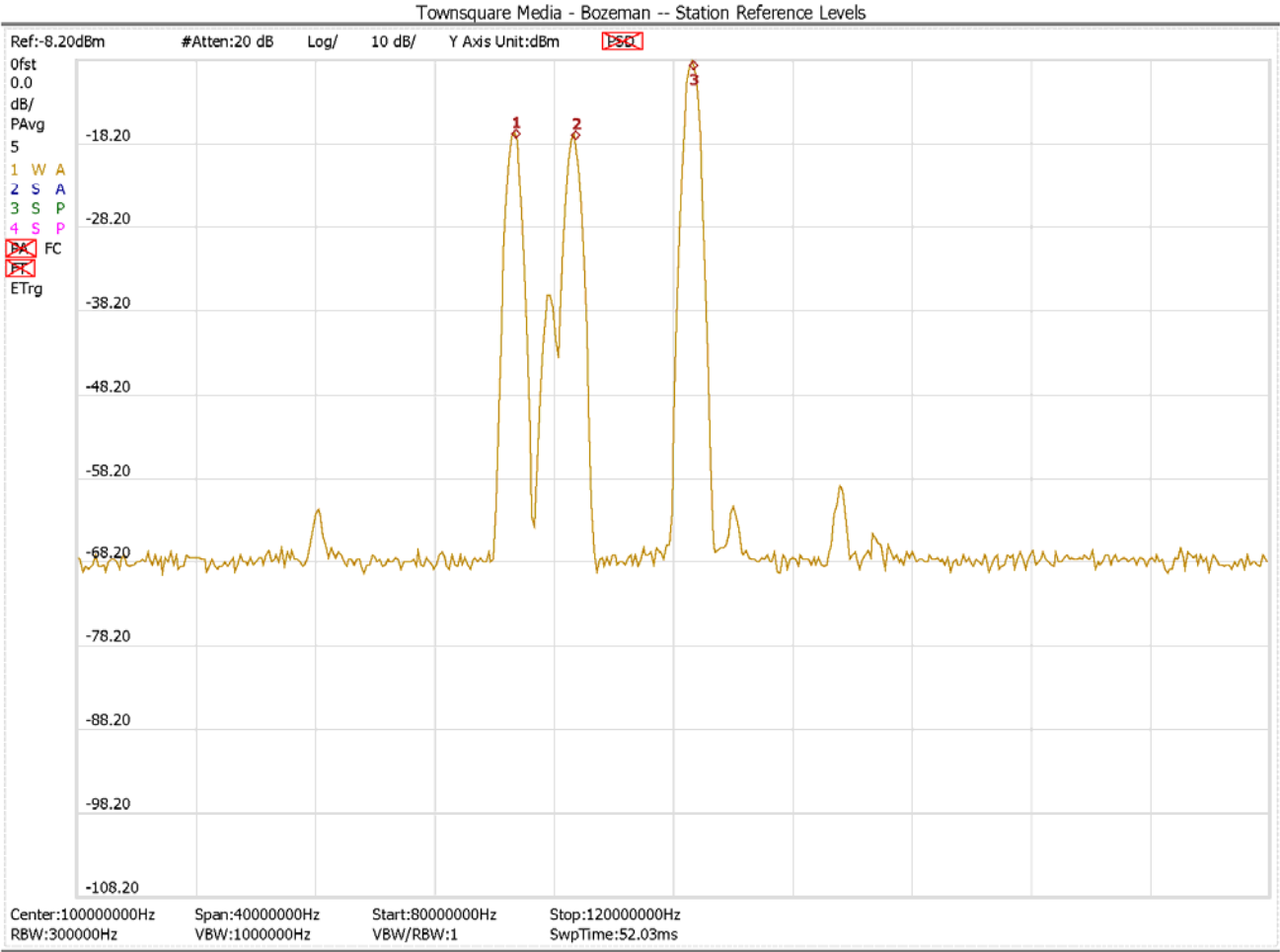


Figure 3 – Townsquare Station Reference Levels



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Figure 4 – High Pass to 500 MHz (Markers indicate 2nd and 3rd harmonics)

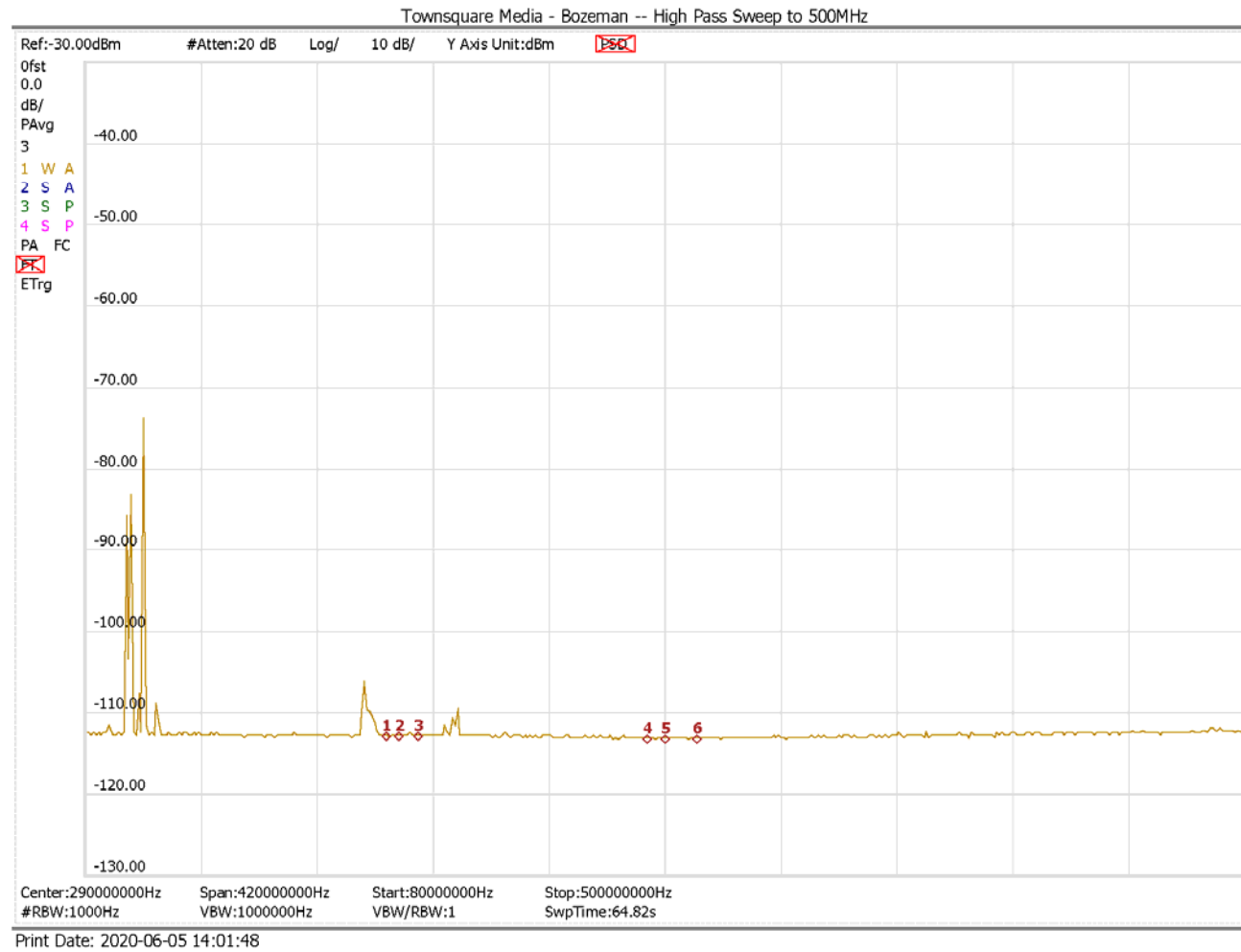


Figure 5 – High Pass to 1 GHz (Markers indicate 2nd and 3rd harmonics)

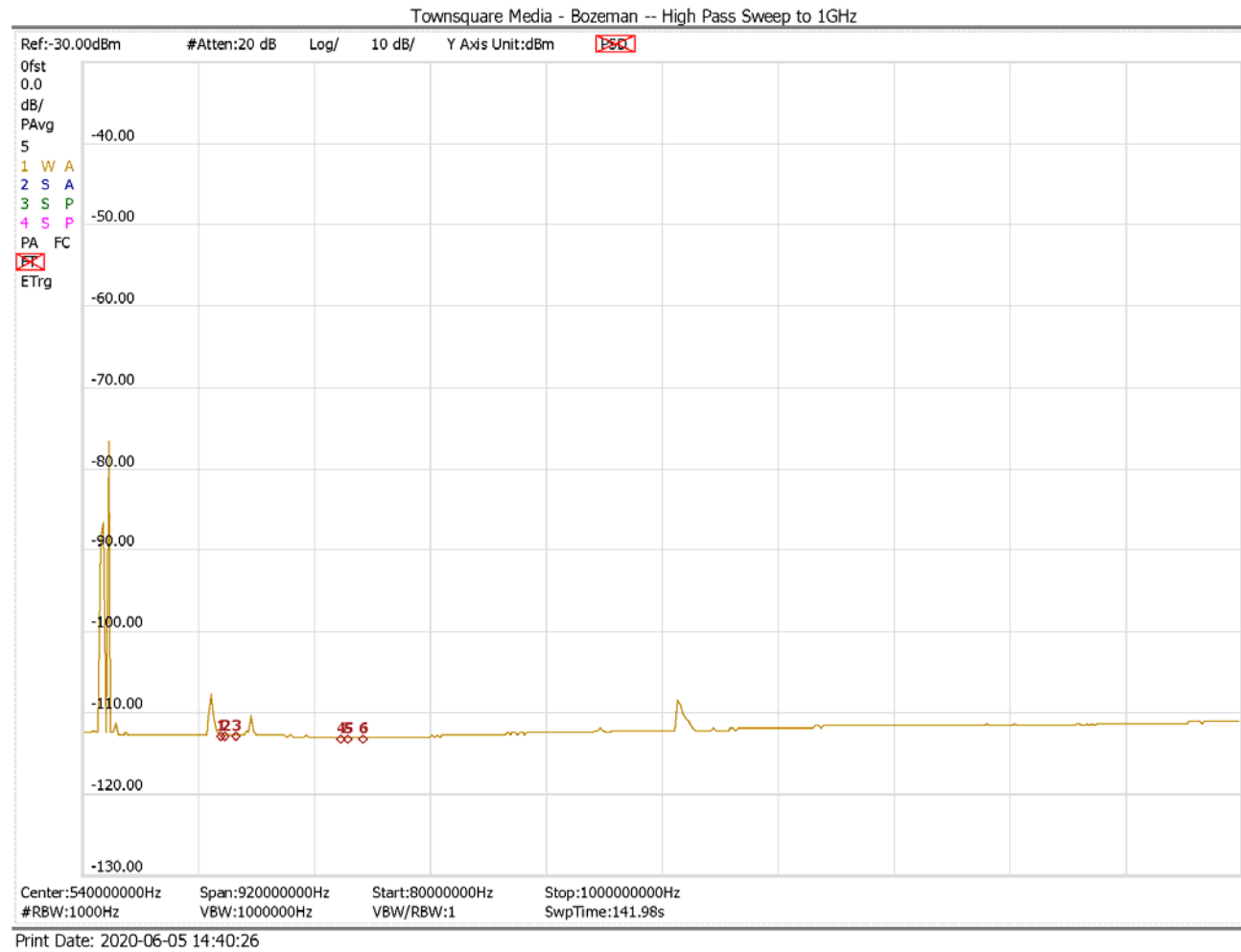


Figure 6 – 88.7 MHz (Marker 4) Product Measurement (note 88.7 MHz station in market)

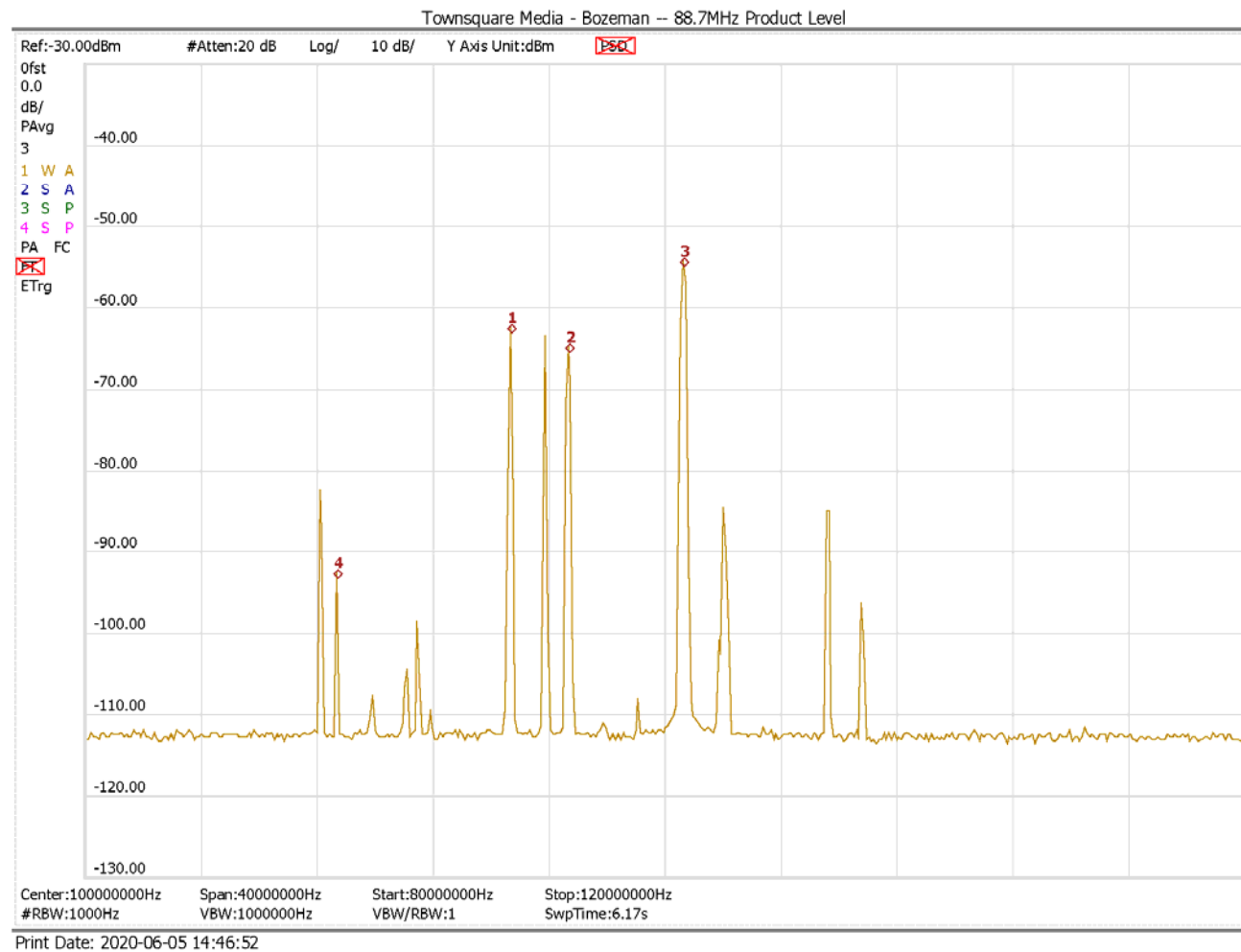


Figure 7 – 92.7 MHz (Marker 4) Product Measurement

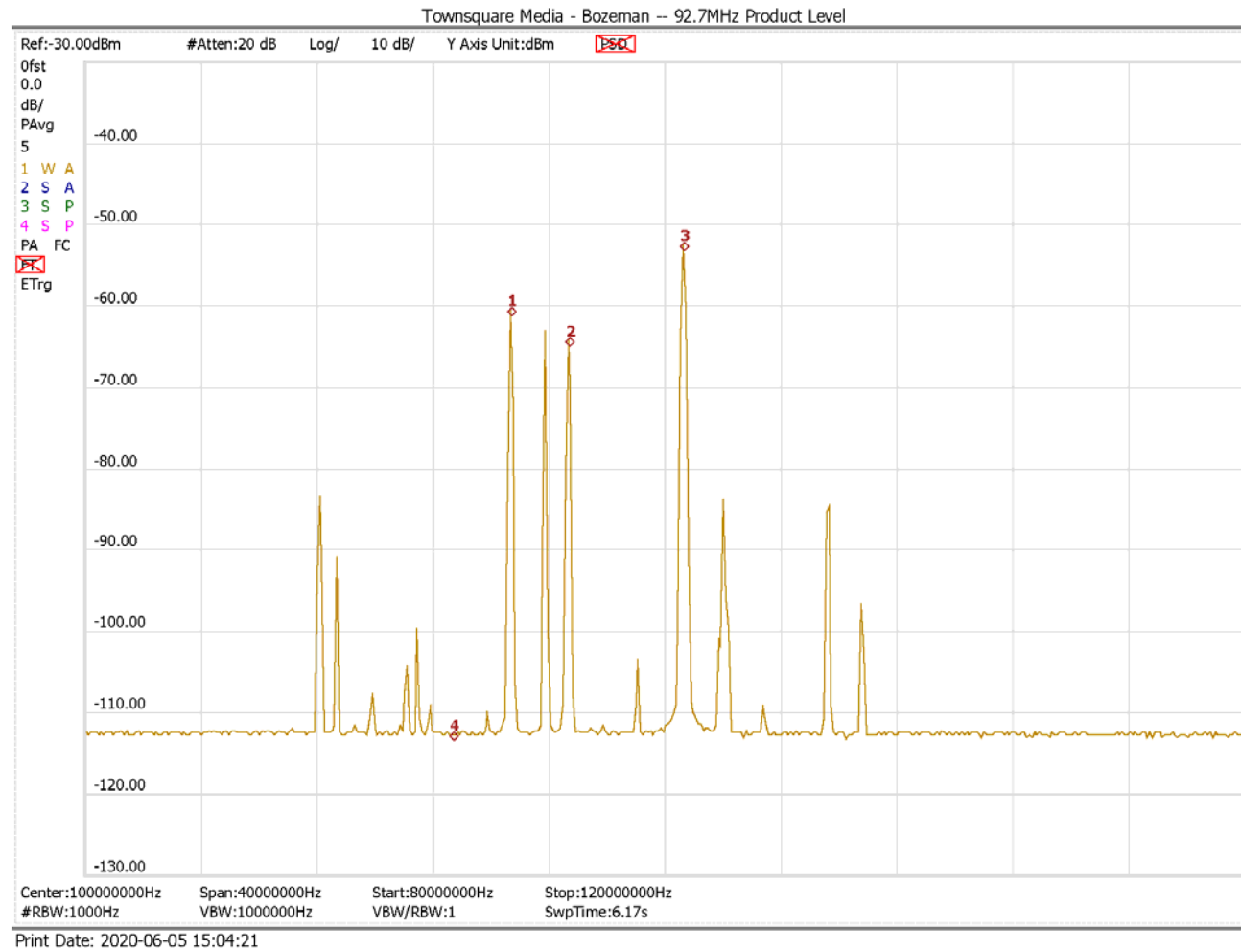


Figure 8 – 98.7 MHz (Marker 4) Product Measurement

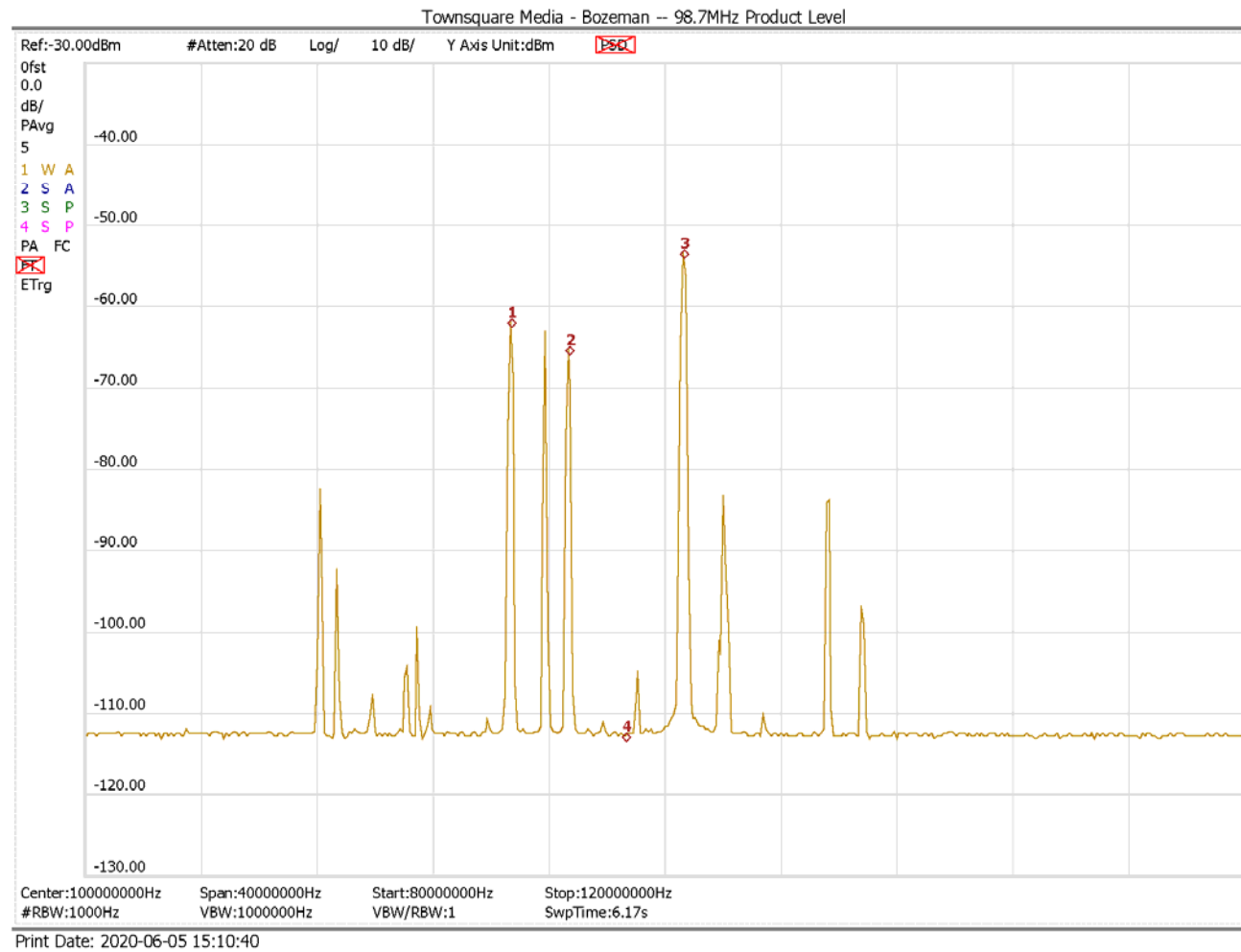


Figure 9 – 104.7 MHz (Marker 4) Product Measurement

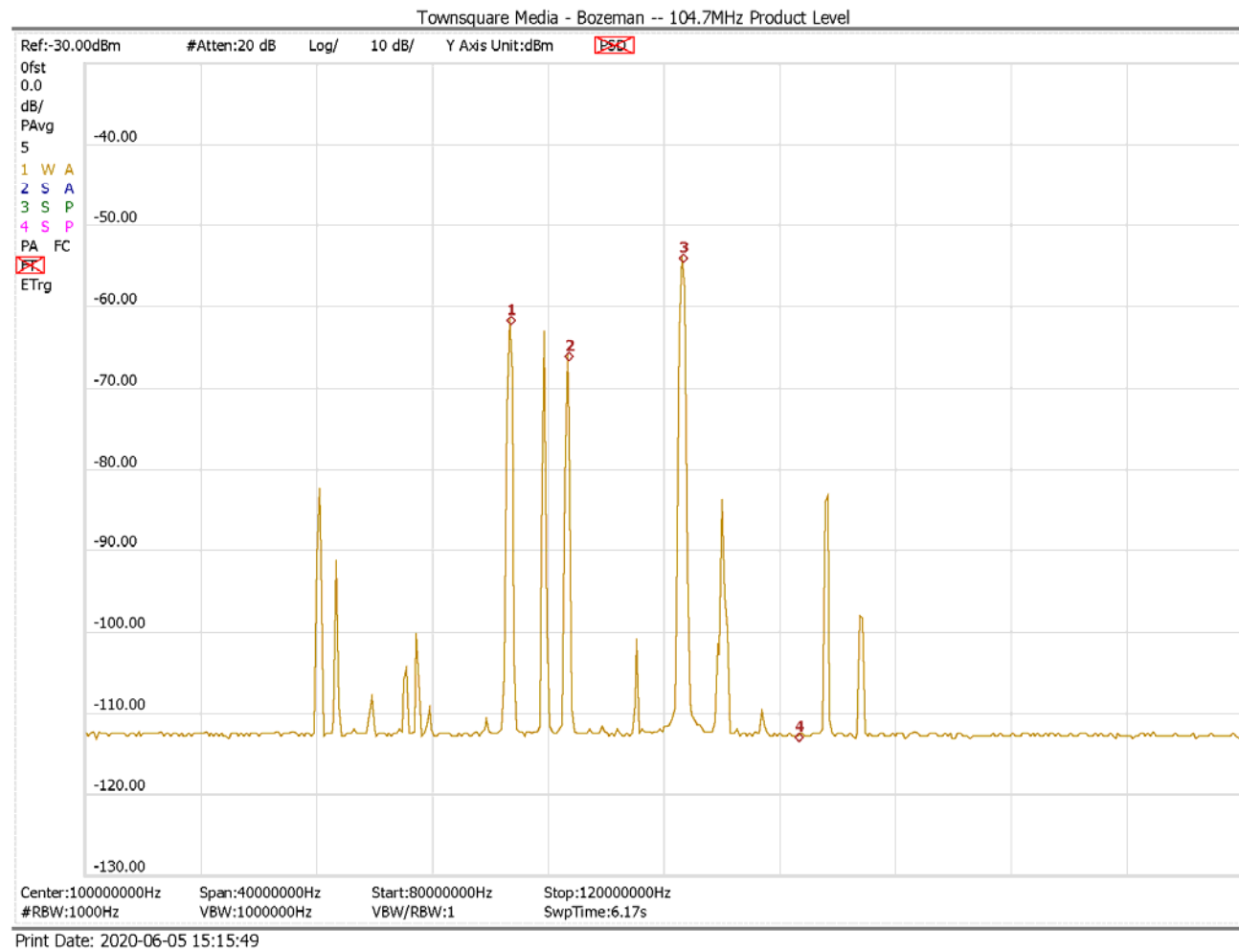
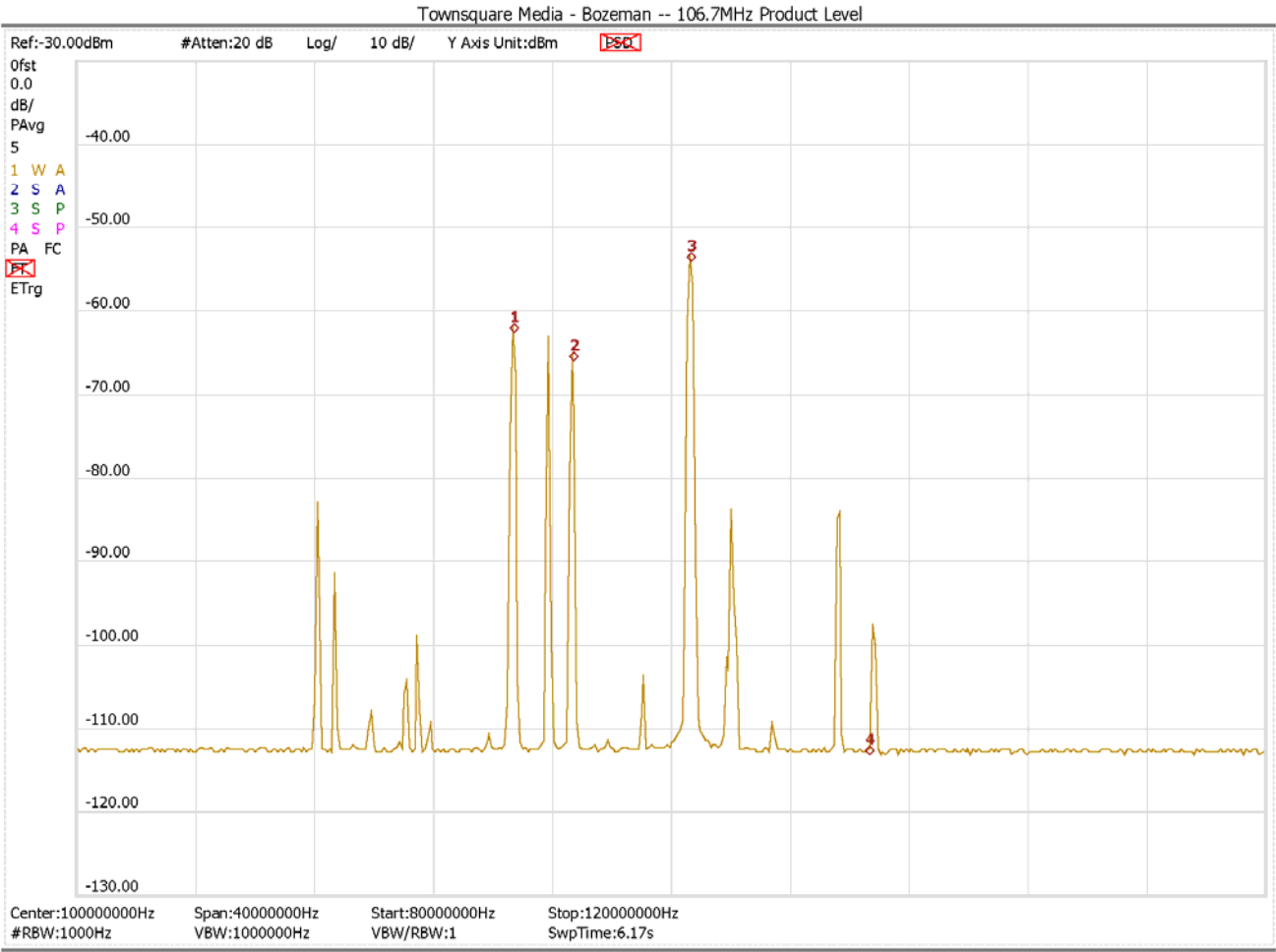


Figure 10 – 106.7 MHz (Marker 4) Product Measurement



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CONCLUSIONS

Based upon the observations and measurements recorded in this document, I, Martin Stabbert, find the operation of the combined FM system for stations:

- KMMS-FM, 94.7 MHz
- KISN, 96.7 MHz
- KXLB, 100.7 MHz

as described herein and located at the High Flat electronics site near Bozeman, Montana, to be in compliance with the requirements of CFR Title 47, Section 73.317 as related to generation of intermodulation products.

Respectfully submitted by Martin Stabbert, VP Engineering, Townsquare Media.

June 5, 2020