FCC CFR 47 PART 15 SUBPART F §15.519

CERTIFICATION TEST REPORT

FOR

SMART PHONE

MODEL NUMBERS: A2111, A2222, A2223

REPORT NUMBER: 12267350-E2V3

ISSUE DATE: AUGUST 5, 2019

FCC ID: BCG-E3309A

Prepared for

APPLE INC.
ONE APPLE PARK WAY
CUPERTINO, CA 95014, U.S.A.

Prepared by

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NVLAP LAB CODE 200065-0 (FREMONT)

Revision History

Rev.	Issue Date	Revisions	Revised By
V1	07/24/2019	Initial Issue	Thu Chan
V2	07/26/2019	Address TCB Questions	GP Chin
V3	08/05/2019	Clarify Worst Case Test Configuration for Spurious Emission Test in Section 6	Conan Cheung

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1. ATTESTATION OF TEST RESULTS

COMPANY NAME: APPLE INC.
ONE APPLE PARK WAY
CUPERTINO, CA 95014, USA

EUT DESCRIPTION: SMART PHONE

MODELS: A2111, A2222, A2223

SERIAL NUMBER: C7CYP0LDMT5Q

DATE TESTED: May 23 – July 17, 2019

APPLICABLE STANDARDS	
STANDARD	**TEST RESULTS**
FCC §15 Subpart F	Complies

UL Verification Services Inc. tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by UL Verification Services Inc. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Note: The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by UL Verification Services Inc. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Services Inc. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of any government.

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Tested By:

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TEST ENGINEER
UL Verification Services Inc.

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2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with CFR Title 47 Part 15 Subpart F, KDB 393764 D01 UWB FAQ v02 and ANSI C63.10-2013.

3. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 47173 and 47266 Benicia Street, Fremont, California, USA. The following table identifies which facilities were utilized for radiated emission measurements documented in this report. Specific facilities are also identified in the test results sections.

47173 Benicia Street	47266 Benicia Street
☐ Chamber A	☒ Chamber D
☐ Chamber B	☐ Chamber E
☐ Chamber C	☒ Chamber F
	☐ Chamber G
	☐ Chamber H

The above test sites and facilities are covered under FCC Test Firm Registration # 208313. UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0.

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4. CALIBRATION AND UNCERTAINTY

4.1. MEASURING INSTRUMENT CALIBRATION

The measuring equipment utilized to perform the tests documented in this report has been calibrated in accordance with the manufacturer's recommendations and is traceable to recognized national standards.

4.2. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

PARAMETER	UNCERTAINTY
Conducted Disturbance, 9 kHz to 0.15 MHz	3.84 dB
Conducted Disturbance, 0.15 to 30 MHz	3.65 dB
Radiated Disturbance, 9 kHz to 30 MHz	2.52 dB
Radiated Disturbance, 30 to 1000 MHz	4.88 dB
Radiated Disturbance, 1000 to 18000 MHz	4.24 dB
Radiated Disturbance, 18000 to 26000 MHz	4.37 dB
Radiated Disturbance, 26000 to 40000 MHz	5.17 dB
Occupied Channel Bandwidth	±0.39 %
Temperature	±0.9 °C
Supply voltages	±0.45 %
Time	±0.02 %

Uncertainty figures are valid to a confidence level of 95%.

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5. EQUIPMENT UNDER TEST

5.1. DESCRIPTION OF EUT

The EUT is a UWB transceiver with 4 integral antennas (ANT 0,1,2 & 3) installed in a smart phone host and operates on 6.5 GHz (Channel 5) and 8 GHz (Channel 9). The antennas are not user accessible. Six signal configurations (CONFIG 0,1,2,3,4 & 5) are available for each ANT/CH setting.

ANT	CH	CONFIG
0	5	0
0	5	1
0	5	2
0	5	3
0	5	4
0	5	5
0	9	0
0	9	1
0	9	2
0	9	3
0	9	4
0	9	5
1	5	0
1	5	1
1	5	2
1	5	3
1	5	4
1	5	5
1	9	0
1	9	1
1	9	2
1	9	3
1	9	4
1	9	5
2	5	0
2	5	1
2	5	2
2	5	3
2	5	4
2	5	5
2	9	0
2	9	1
2	9	2
2	9	3
2	9	4
2	9	5
3	5	0
3	5	1
3	5	2
3	5	3
3	5	4
3	5	5
3	9	0
3	9	1
3	9	2
3	9	3
3	9	4
3	9	5

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Other RF technologies incorporated on this device are not covered in this report.

5.2. MAXIMUM OUTPUT POWER

Highest Average Powers based on ANT/CH.

ANT	CH	CONFIG	Average Power (dBm/MHz EIRP)
0	5	5	-41.52
0	9	1	-41.53
1	5	1	-41.44
1	9	3	-41.49
2	5	4	-41.41
2	9	1	-41.32
3	5	2	-41.47
3	9	5	-41.34

5.3. DESCRIPTION OF AVAILABLE ANTENNAS

Four integral patch antennas are employed and the antenna gains are listed as follow:

CH	Freq. Band	Gain (dBi)			
	(GHz)	ANT 0	ANT 1	ANT 2	ANT 3
5	6.5	-3.5	-3.1	-6.3	-3.6
9	8.0	0.5	0.6	-4.9	-0.5

5.4. MODULATION

The UWB signal is BPSK pulsed modulated signal.

5.5. SOFTWARE AND FIRMWARE

The Software and Firmware version used at test is 17A525.

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6. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

PERIPHERAL SUPPORT EQUIPMENT LIST			
Description	**Manufacturer**	**Model**	**Serial Number**
Laptop + Adapter	Apple	Mac Book Air	CO2PS2HGG085
Kanzi – USB Adapter	Apple	316FF9	--
Smart Phone	Apple	A2221	C7CYQ06DMTC5

I/O CABLES

EUT is tested with no peripherals attached. Accessories such as AC power adaptor and wired headset do not cause degradation.

TEST SETUP

The EUT was examined at pre-scan test using a fundamental frequency in the portrait (z), landscape (y), and flatbed (x) position and the worst case orientation of individual ANT/CH/CONFIG setting was determined for final spurious emission measurement. Configuration 3 of both CH5 and CH9 on all 4 antennas were selected to test for unwanted emissions as the worst case after pre-scan.

Measurements of spurious average emissions were made with the device operating at a higher power than production power to ensure compliance. Measurements of the in-band signal (peak and average emissions, 10 dBc bandwidth) were all made at the production power settings.

Battery was fully charged in all test cases.

For simultaneous transmission of multiple channels in the UWB, LTE, 2.4 GHz WiFi and 5 GHz WiFi bands, no noticeable new emission was found.

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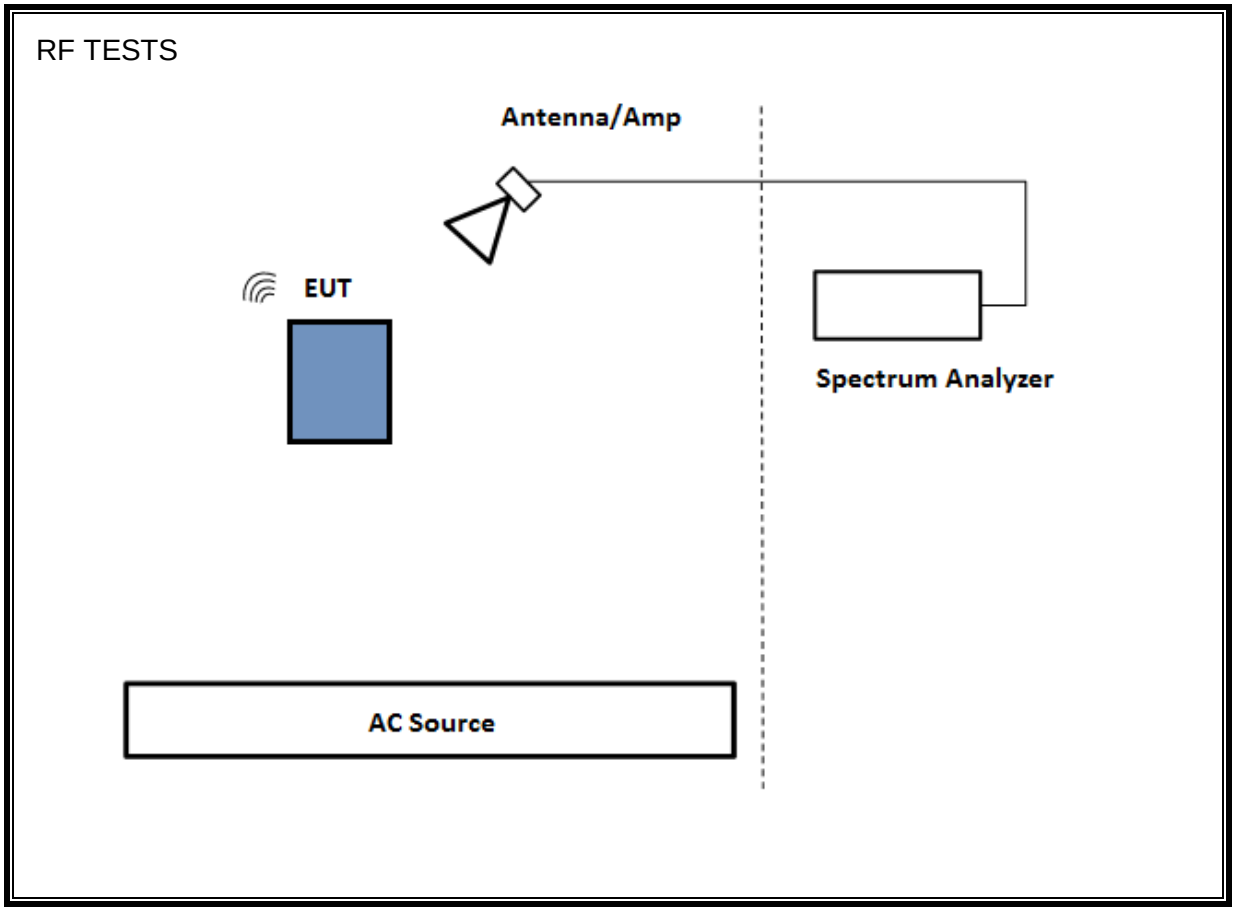
SETUP DIAGRAM FOR TESTS



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7. TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment was utilized for the tests documented in this report:

Test Equipment List						
Description	Manufacturer	Model	S/N	Local ID	Cal Date	Cal Due
EMI Test Receiver	Rohde & Schwarz	ESW44	1328.4100K44-101726-gd	PRE0179377	2/15/2019	2/15/2020
Horn Antenna, 1-18 GHz	ETS Lindgren	3117	154523	T712	2/26/2019	2/26/2020
Preamp, 1-18 GHz	Miteq	AFS42-00101800-25-S-42	--	PRE0183530	5/31/2019	5/31/2020
PXA Signal Analyzer	Agilent	N9030A	MY53310959	T906	1/22/2019	1/22/2020
Hybrid Antenna, 30-1000 MHz	Sunol Sciences	JB3	A051314-1	T900	6/18/2018	6/18/2019*
Preamp, 0.1-1300 MHz	Sonoma Inst.	310	185623	T173	7/6/2018	7/6/2019*
Horn Antenna, 1-18 GHz	ETS Lindgren	3117	143447	T345	5/7/2019	5/7/2020
Preamp, 1-18 GHz	Miteq	AFS42-00101800-25-S-42	--	PRE0183207	12/15/2018	12/15/2019
PXA Signal Analyzer	Agilent	N9030A	MY52350671	T342	1/23/2019	1/23/2020
Amplifier, 10 kHz to 1 GHz	Sonoma Inst.	310	325117	T835	12/15/2018	12/15/2019
Antenna, Active Loop 9KHz to 30MHz	ETS Lindgren	6502	213423	T1616	10/18/2018	10/18/2019
Spectrum Analyzer, 44GHz	Keysight	N9030A	MY53311010	T905	1/24/2019	1/24/2020
Preamplifier, 1-26.5GHz	Agilent	8449B	3008A04710	T404	3/23/2019	3/23/2020
Horn Antenna, 18-26.5GHz	ARA	MWH-1826/B	209336	T447	6/16/2019	6/16/2020
Preamplifier, 26-40 GHz	Miteq	NSTTA2640-35-HG	--	T1864	3/23/2019	3/23/2020
Horn Antenna, 26-40 GHz	ARA	MWH-2640/B	209340	T446	8/9/2019	8/9/2020
Low Pass Filter, CH5	Wainwright Inst. GMBH	WLKX12-5400-5913-1800-60ST	7	--	NCR	--
Low Pass Filter, CH9	Wainwright Inst. GMBH	WLKX10-6400-7424-2100-60ST	5	--	NCR	--
High Pass Filter, CH5	Wainwright Inst. GMBH	WHW2-7100-10000-18000-40DC	11	--	NCR	--
High Pass Filter, CH9	Wainwright Inst. GMBH	WHW2-8165-11500-21000-40CD	5	--	NCR	--
Radiated Software	UL	UL EMC		Ver 9.5.01, Dec. 1 , 2016 Ver 9.5.19 Oct 2016		

*Test data presented in the report was captured with equipment covered within the one year calibration period.

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8. APPLICABLE LIMITS AND TEST RESULTS

8.1. OPERATING BANDWIDTH

LIMIT

§15.503 (a)*UWB bandwidth.* For the purpose of this subpart, the UWB bandwidth is the frequency band bounded by the points that are 10 dB below the highest radiated emission, as based on the complete transmission system including the antenna. The upper boundary is designated fH and the lower boundary is designated fL. The frequency at which the highest radiated emission occurs is designated fM.

§15.503 (b)*Center frequency.* The center frequency, FC, equals (FH + FL)/2.

§15.503 (c)*Fractional bandwidth.* The fractional bandwidth equals 2(FH−FL)/ (FH+ FL).

§15.503 (d)*Ultra-wideband (UWB) transmitter.* An intentional radiator that, at any point in time, has a fractional bandwidth equal to or greater than 0.20 or has a UWB bandwidth equal to or greater than 500 MHz, regardless of the fractional bandwidth.

§15.519 (3)(b) The UWB bandwidth of a device operating under the provisions of this section must be contained between 3100 MHz and 10,600 MHz.

TEST PROCEDURE

ANSI C63.10 Clause 10.1.

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RESULTS

ANT	CH	CONFIG	Payload	EUT Orientation	Meas. Ant Polarity	FM (GHz)	FL Delta (GHz)	FH Delta (GHz)	FL (GHz)	FH (GHz)	FC (GHz)	OBW (MHz)	Min. OBW (MHz)	OBW Margin (MHz)	OBW Pass/Fail
0	5	0	125	Portrait	H	6.72875	0.5	0.022	6.22875	6.75075	6.48975	522	500	22	P
0	5	1	125	Portrait	H	6.72875	0.5015	0.024	6.22725	6.75275	6.49	525.5	500	25.5	P
0	5	2	125	Portrait	H	6.72875	0.5005	0.023	6.22825	6.75175	6.49	523.5	500	23.5	P
0	5	3	125	Portrait	H	6.72925	0.501	0.022	6.22825	6.75125	6.48975	523	500	23	P
0	5	4	0	Portrait	H	6.72875	0.5015	0.024	6.22725	6.75275	6.49	525.5	500	25.5	P
0	5	5	0	Portrait	H	6.72825	0.502	0.0255	6.22625	6.75375	6.49	527.5	500	27.5	P
0	9	0	125	Portrait	H	8.22625	0.5015	0.024	7.72475	8.25025	7.9875	525.5	500	25.5	P
0	9	1	125	Portrait	H	8.22625	0.5015	0.024	7.72475	8.25025	7.9875	525.5	500	25.5	P
0	9	2	125	Portrait	H	8.22625	0.5005	0.023	7.72575	8.24925	7.9875	523.5	500	23.5	P
0	9	3	125	Portrait	H	8.22675	0.5005	0.022	7.72625	8.24875	7.9875	522.5	500	22.5	P
0	9	4	0	Portrait	H	8.22575	0.501	0.0245	7.72475	8.25025	7.9875	525.5	500	25.5	P
0	9	5	0	Portrait	H	8.22625	0.5025	0.025	7.72375	8.25125	7.9875	527.5	500	27.5	P
1	5	0	125	Portrait	H	6.72875	0.5005	0.024	6.22825	6.75275	6.4905	524.5	500	24.5	P
1	5	1	125	Portrait	H	6.72875	0.5005	0.024	6.22825	6.75275	6.4905	524.5	500	24.5	P
1	5	2	125	Portrait	H	6.74975	0.5215	0.002	6.22825	6.75175	6.49	523.5	500	23.5	P
1	5	3	125	Portrait	H	6.72825	0.4995	0.023	6.22875	6.75125	6.49	522.5	500	22.5	P
1	5	4	0	Portrait	H	6.72875	0.501	0.024	6.22775	6.75275	6.49025	525	500	25	P
1	5	5	0	Portrait	H	6.72825	0.5005	0.025	6.22775	6.75325	6.4905	525.5	500	25.5	P
1	9	0	125	Portrait	H	8.22625	0.5015	0.024	7.72475	8.25025	7.9875	525.5	500	25.5	P
1	9	1	125	Portrait	H	8.22625	0.5015	0.024	7.72475	8.25025	7.9875	525.5	500	25.5	P
1	9	2	125	Portrait	H	8.22625	0.5005	0.0225	7.72575	8.24875	7.98725	523	500	23	P
1	9	3	125	Portrait	H	8.22675	0.501	0.022	7.72575	8.24875	7.98725	523	500	23	P
1	9	4	0	Portrait	H	8.22625	0.5015	0.024	7.72475	8.25025	7.9875	525.5	500	25.5	P
1	9	5	0	Portrait	H	8.22625	0.5025	0.025	7.72375	8.25125	7.9875	527.5	500	27.5	P
2	5	0	125	Flatbed	H	6.25025	0.024	0.502	6.22625	6.75225	6.48925	526	500	26	P
2	5	1	125	Flatbed	H	6.25025	0.0235	0.502	6.22675	6.75225	6.4895	525.5	500	25.5	P
2	5	2	125	Flatbed	H	6.25125	0.0235	0.4995	6.22775	6.75075	6.48925	523	500	23	P
2	5	3	125	Flatbed	H	6.25025	0.0205	0.4995	6.22975	6.74975	6.48975	520	500	20	P
2	5	4	0	Flatbed	H	6.25025	0.0235	0.502	6.22675	6.75225	6.4895	525.5	500	25.5	P
2	5	5	0	Flatbed	H	6.25075	0.0255	0.5025	6.22525	6.75325	6.48925	528	500	28	P
2	9	0	125	Landscape	H	7.74775	0.0235	0.5025	7.72425	8.25025	7.98725	526	500	26	P
2	9	1	125	Landscape	H	7.74825	0.024	0.502	7.72425	8.25025	7.98725	526	500	26	P
2	9	2	125	Landscape	H	7.74825	0.023	0.5005	7.72525	8.24875	7.987	523.5	500	23.5	P
2	9	3	125	Landscape	H	8.22625	0.4995	0.0225	7.72675	8.24875	7.98775	522	500	22	P
2	9	4	0	Landscape	H	7.74775	0.0235	0.5025	7.72425	8.25025	7.98725	526	500	26	P
2	9	5	0	Landscape	H	7.74825	0.025	0.503	7.72325	8.25125	7.98725	528	500	28	P
3	5	0	125	Portrait	H	6.72825	0.5015	0.024	6.22675	6.75225	6.4895	525.5	500	25.5	P
3	5	1	125	Portrait	H	6.72825	0.5015	0.024	6.22675	6.75225	6.4895	525.5	500	25.5	P
3	5	2	125	Portrait	H	6.72825	0.501	0.023	6.22725	6.75125	6.48925	524	500	24	P
3	5	3	125	Portrait	H	6.48975	0.2615	0.2615	6.22825	6.75125	6.48975	523	500	23	P
3	5	4	0	Portrait	H	6.72825	0.5015	0.024	6.22675	6.75225	6.4895	525.5	500	25.5	P
3	5	5	0	Portrait	H	6.72825	0.502	0.0255	6.22625	6.75375	6.49	527.5	500	27.5	P
3	9	0	125	Portrait	H	8.22625	0.5015	0.024	7.72475	8.25025	7.9875	525.5	500	25.5	P
3	9	1	125	Portrait	H	8.22625	0.5015	0.024	7.72475	8.25025	7.9875	525.5	500	25.5	P
3	9	2	125	Portrait	H	8.22625	0.5005	0.023	7.72575	8.24925	7.9875	523.5	500	23.5	P
3	9	3	125	Portrait	H	8.24725	0.5215	0.001	7.72575	8.24825	7.987	522.5	500	22.5	P
3	9	4	0	Portrait	H	8.22625	0.502	0.024	7.72425	8.25025	7.98725	526	500	26	P
3	9	5	0	Portrait	H	8.22575	0.502	0.0255	7.72375	8.25125	7.9875	527.5	500	27.5	P

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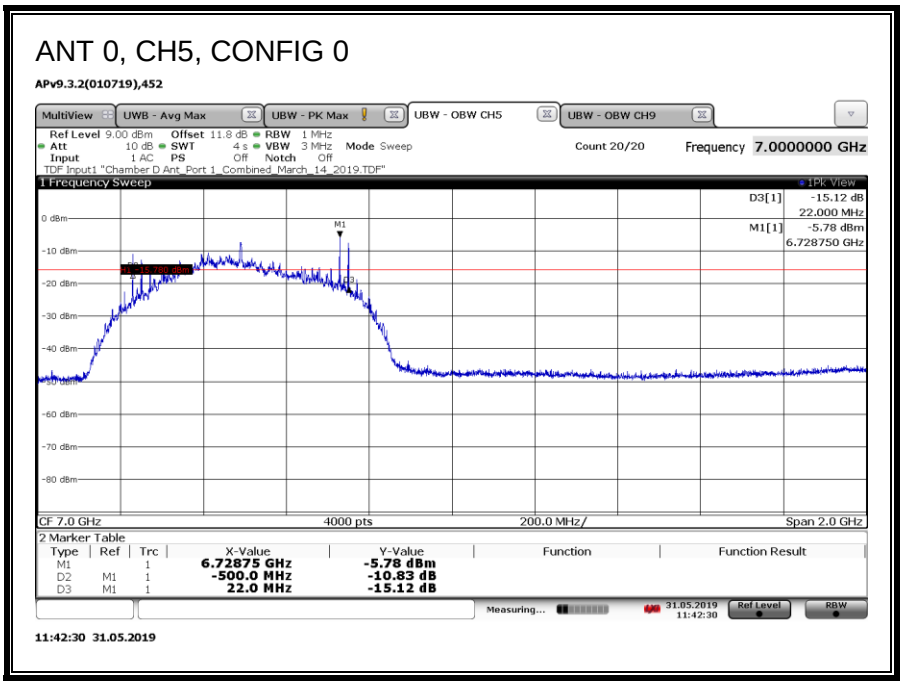
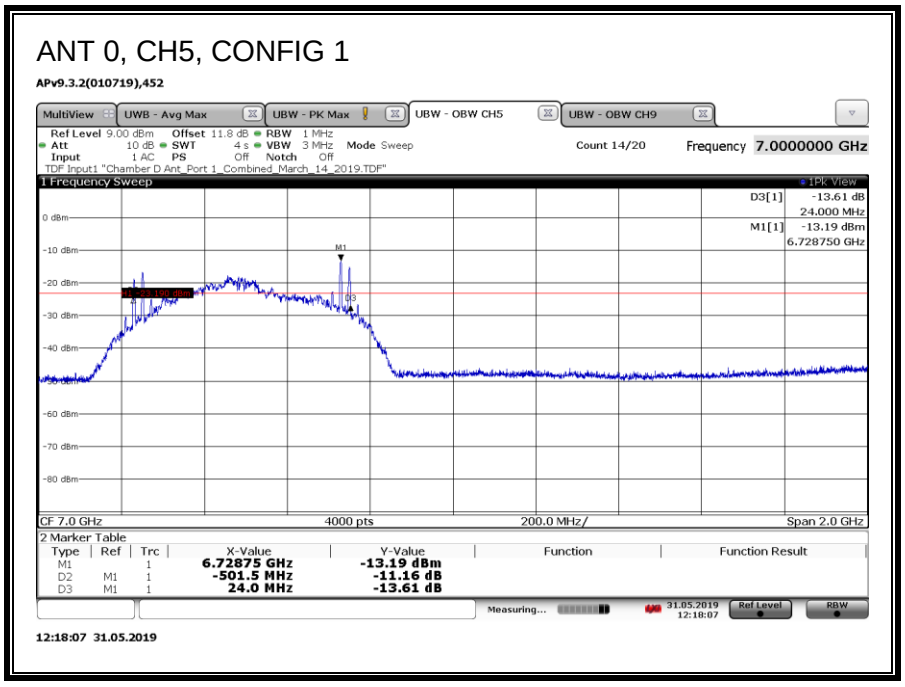
OBW





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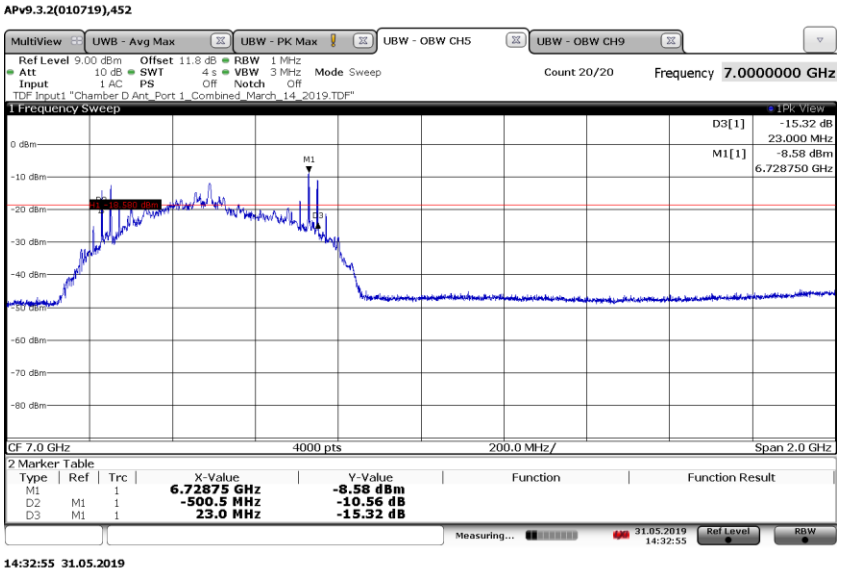
ANT 0, CH5, CONFIG 2



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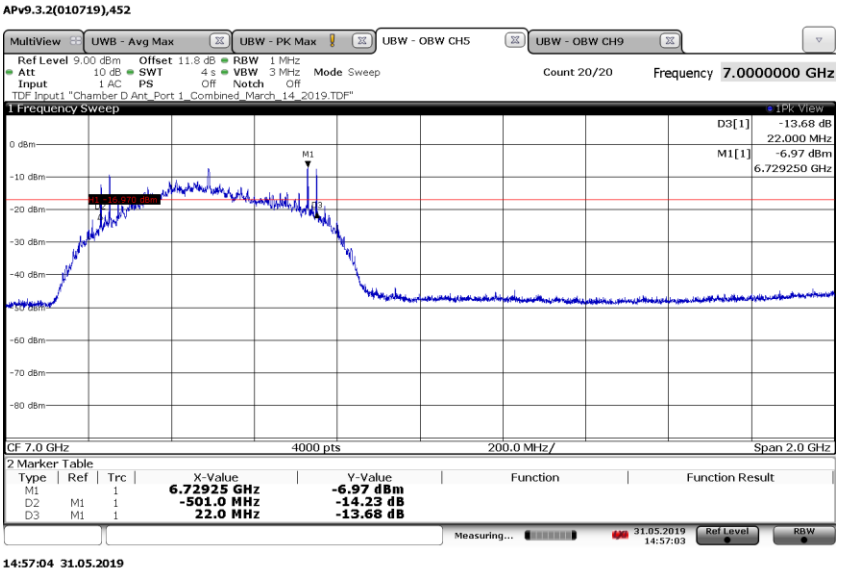

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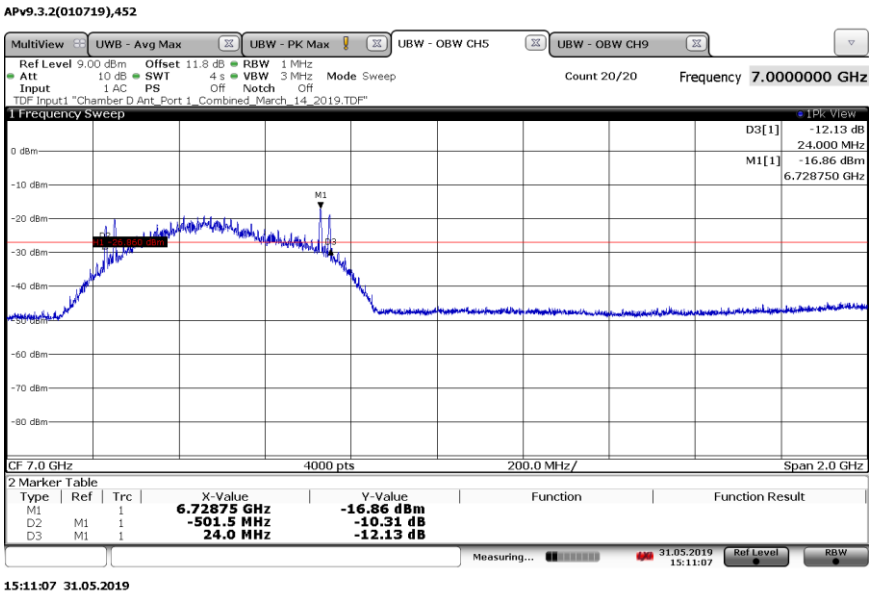
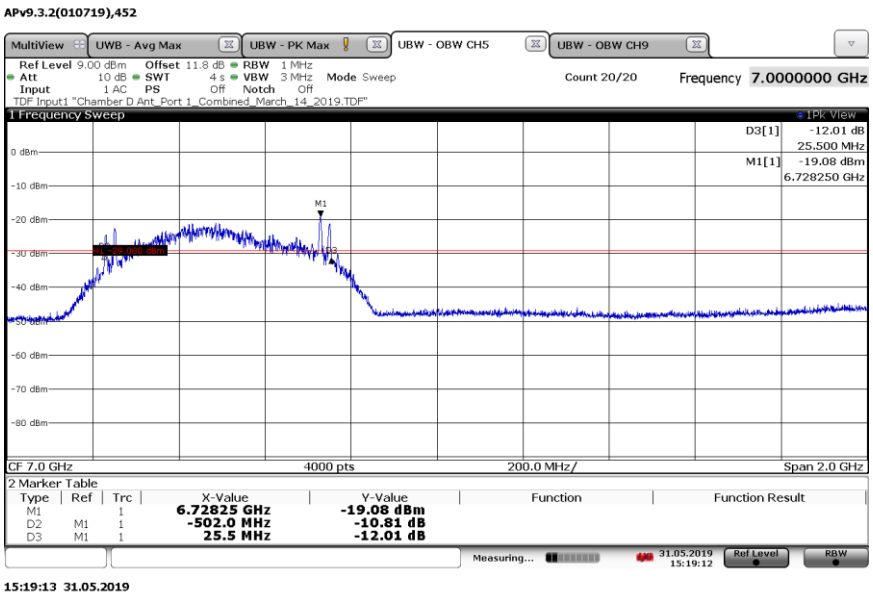
ANT 0, CH5, CONFIG 4



ANT 0, CH5, CONFIG 5



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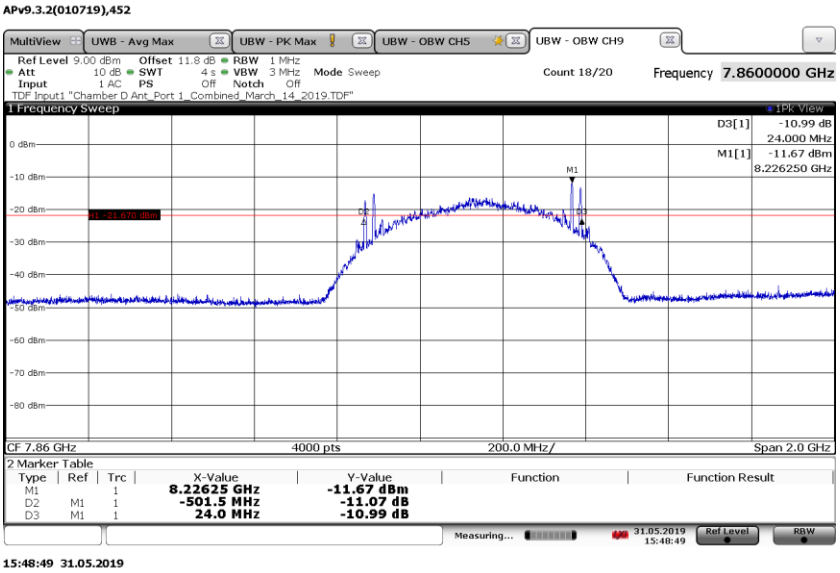
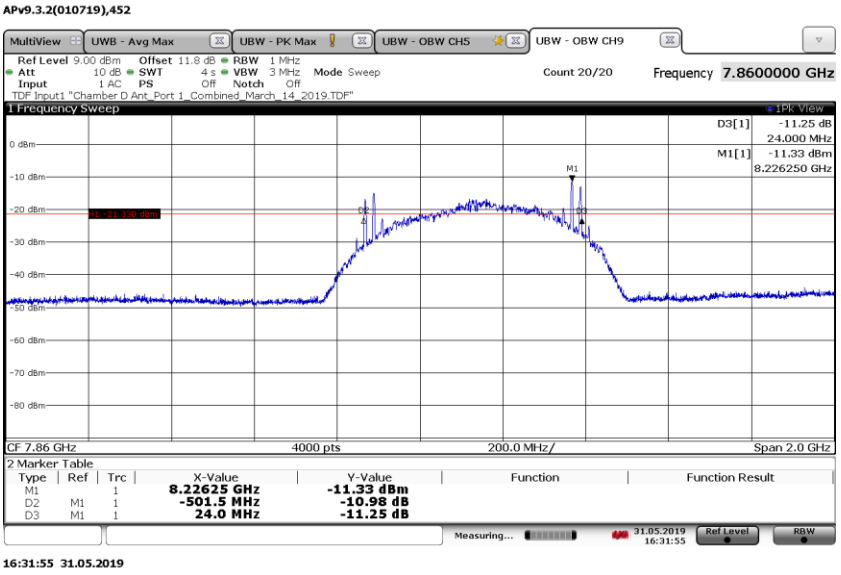
ANT 0, CH9, CONFIG 0



ANT 0, CH9, CONFIG 1



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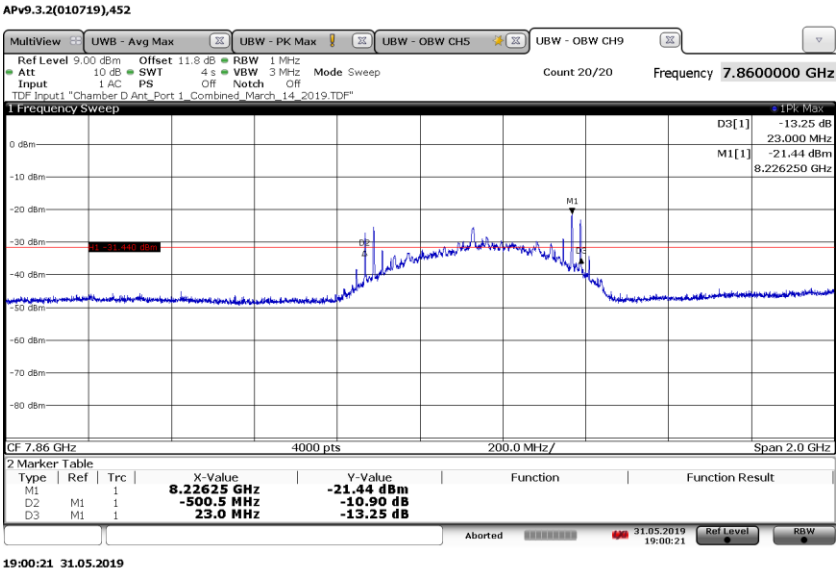
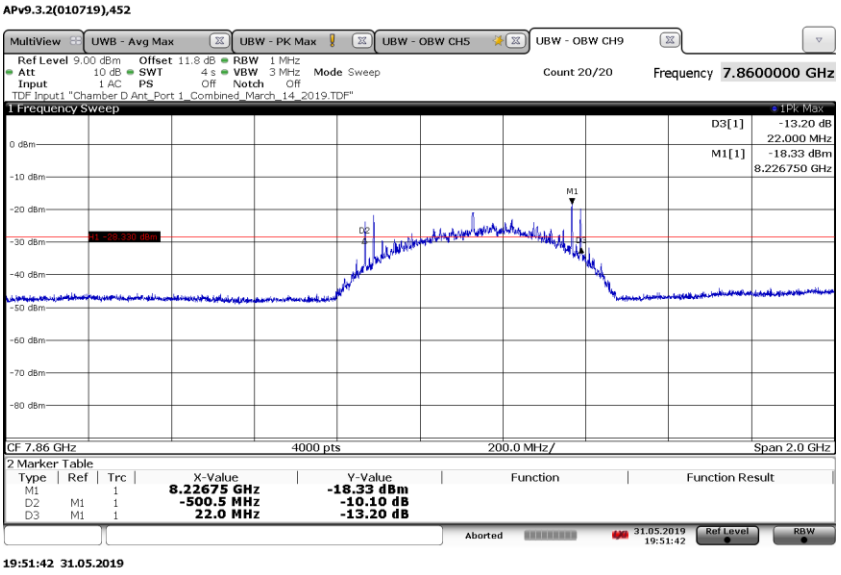
ANT 0, CH9, CONFIG 2



ANT 0, CH9, CONFIG 3



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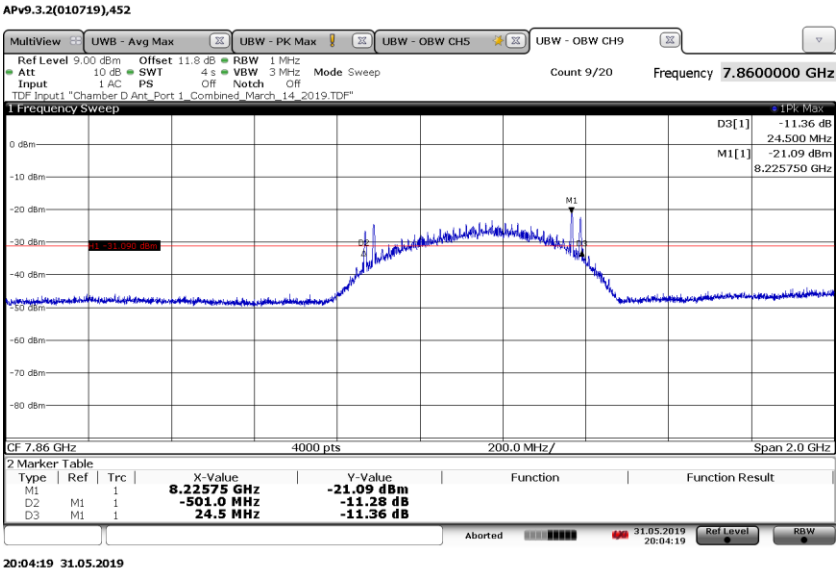
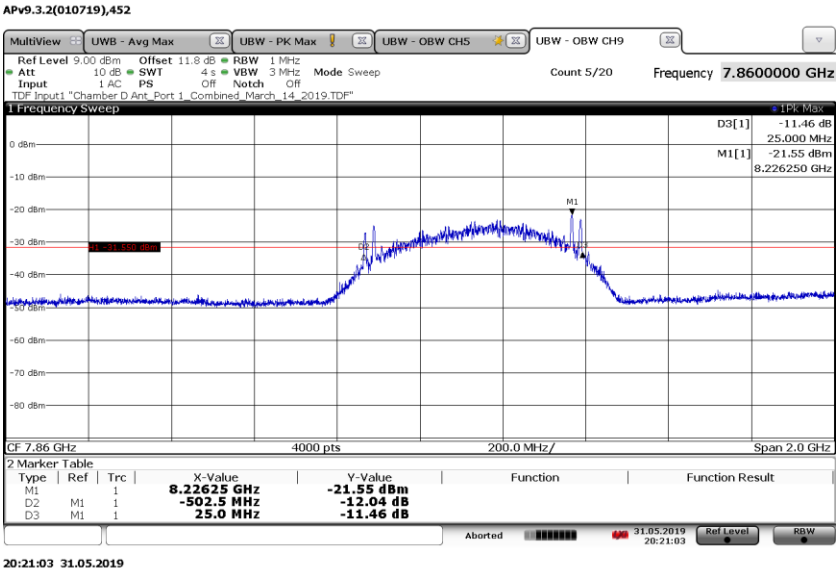
ANT 0, CH9, CONFIG 4



ANT 0, CH9, CONFIG 5



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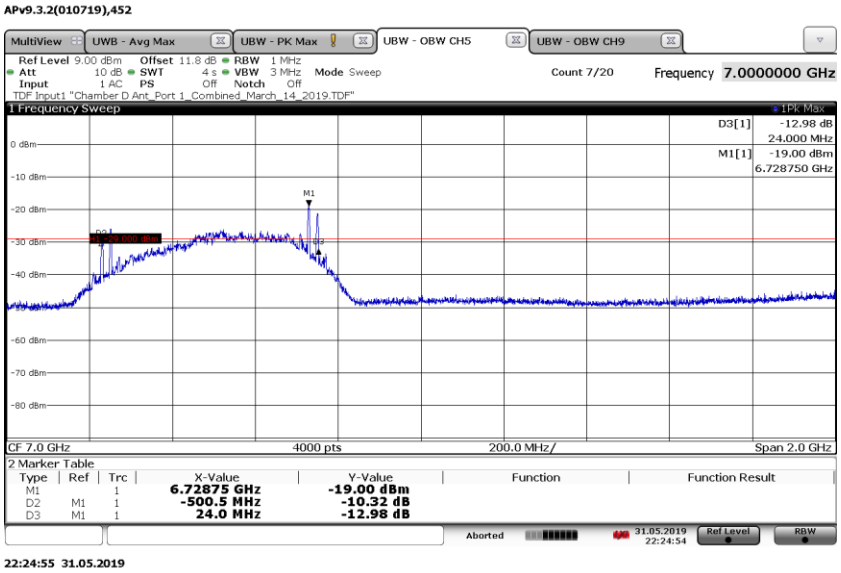
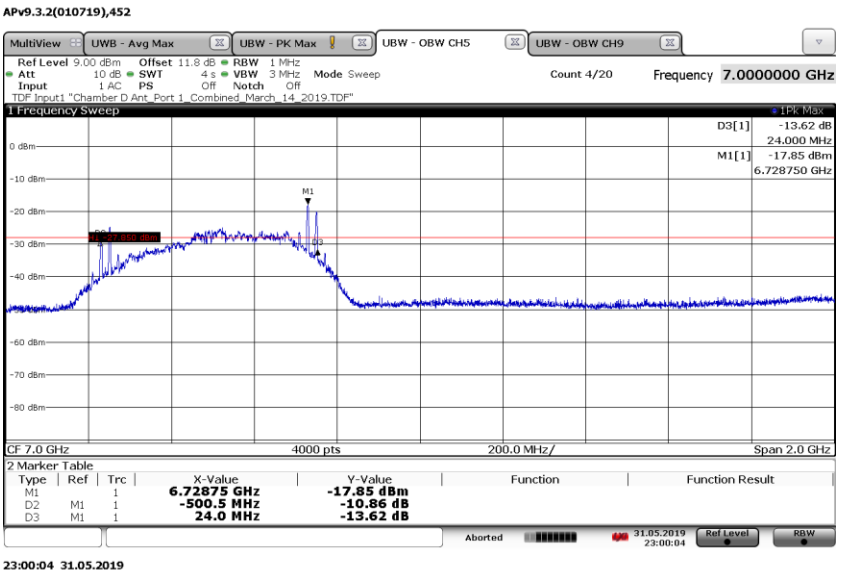
ANT 1, CH5, CONFIG 0



ANT 1, CH5, CONFIG 1



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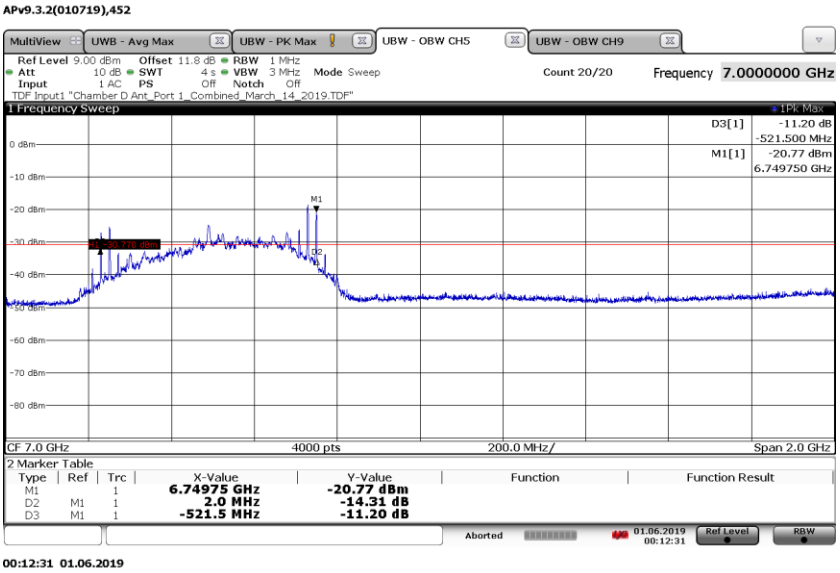
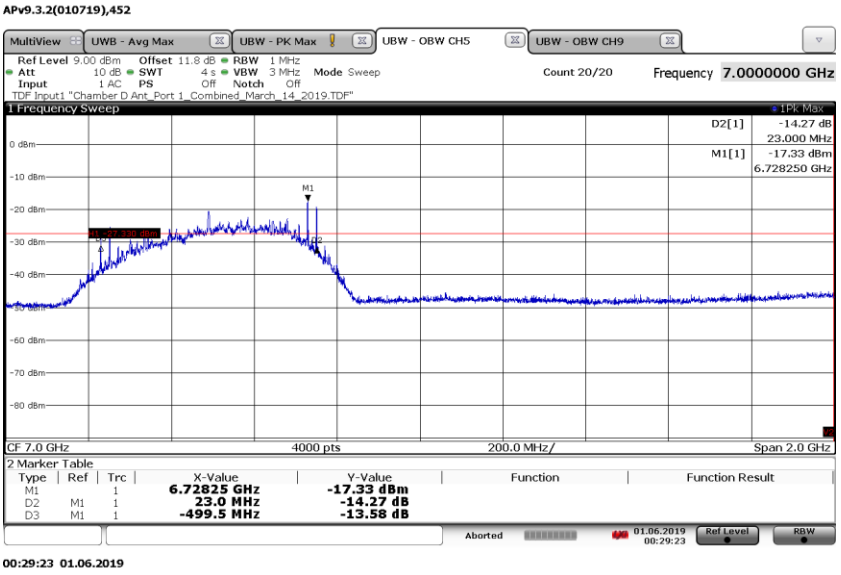
ANT 1, CH5, CONFIG 2



ANT 1, CH5, CONFIG 3



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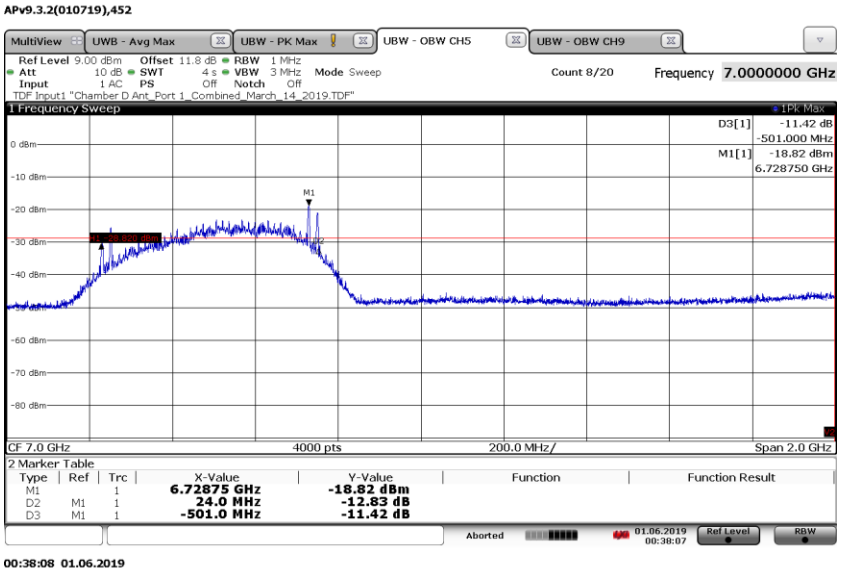
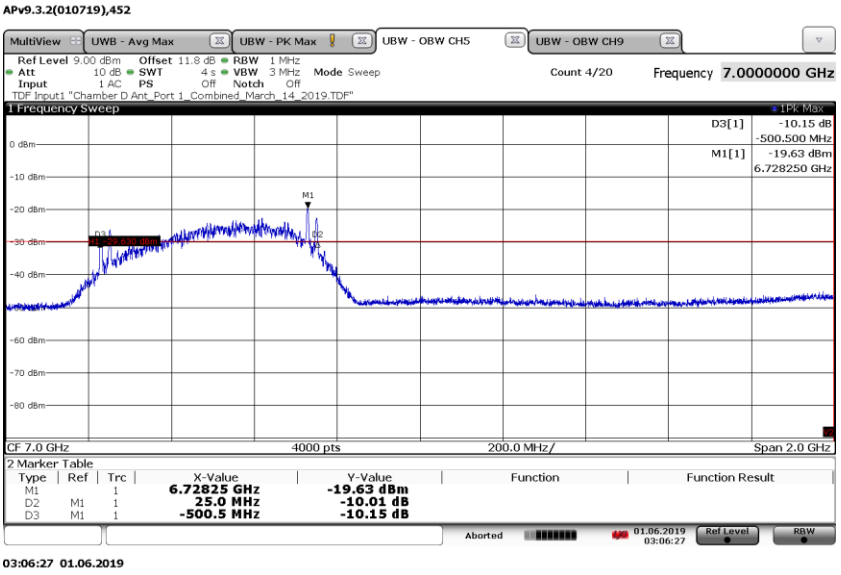
ANT 1, CH5, CONFIG 4



ANT 1, CH5, CONFIG 5



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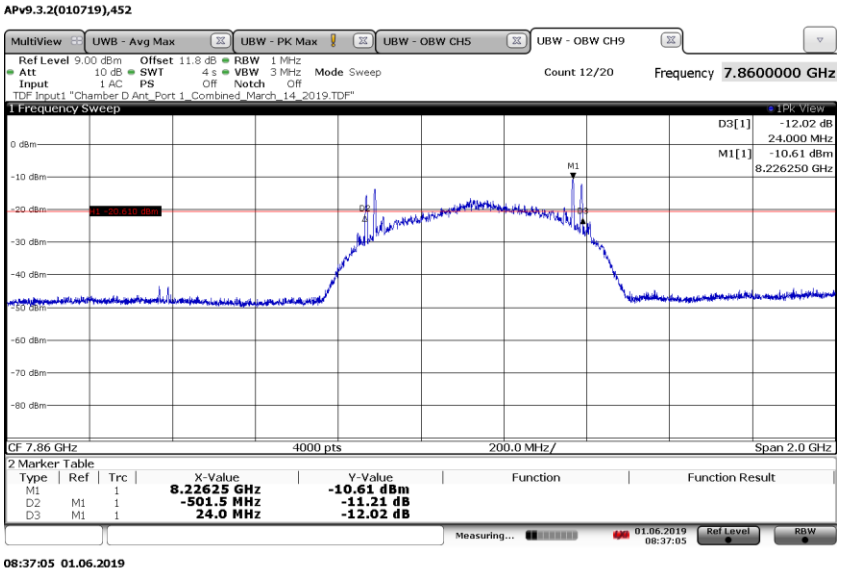
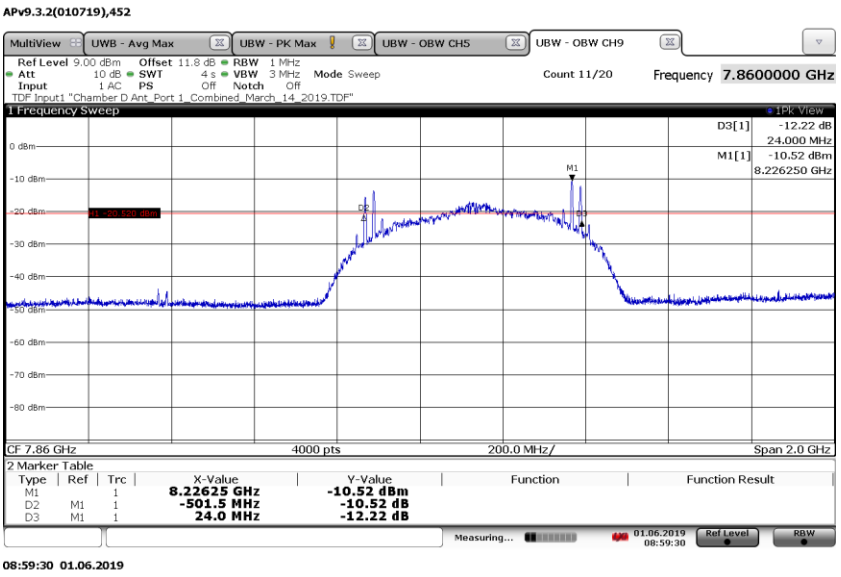
ANT 1, CH9, CONFIG 0



ANT 1, CH9, CONFIG 1



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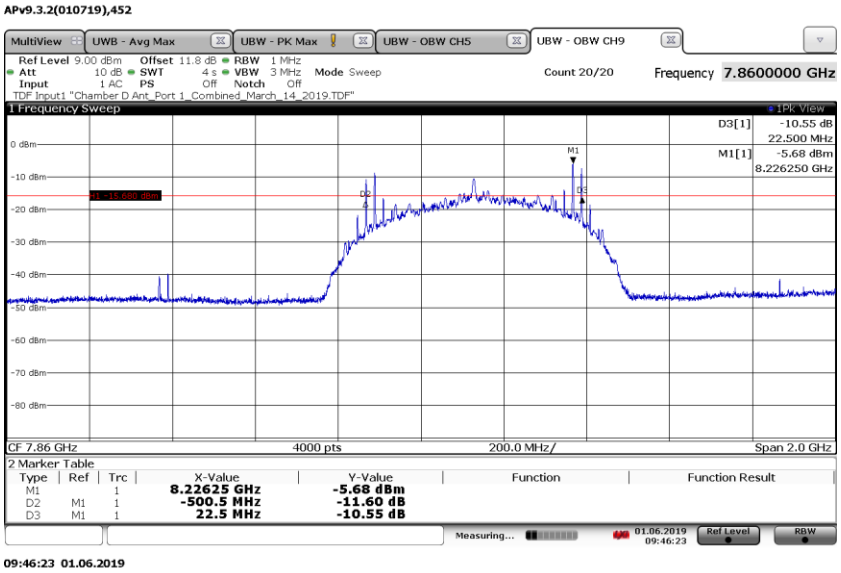
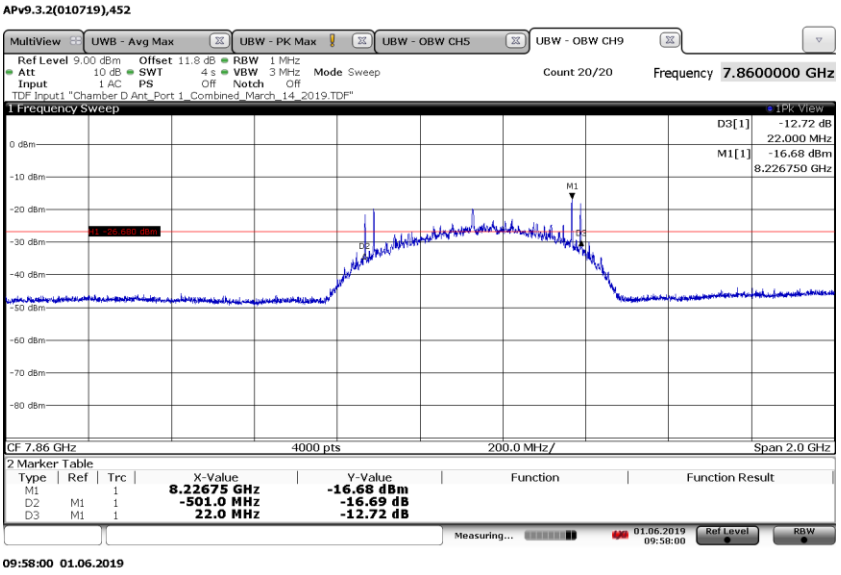
ANT 1, CH9, CONFIG 2



ANT 1, CH9, CONFIG 3



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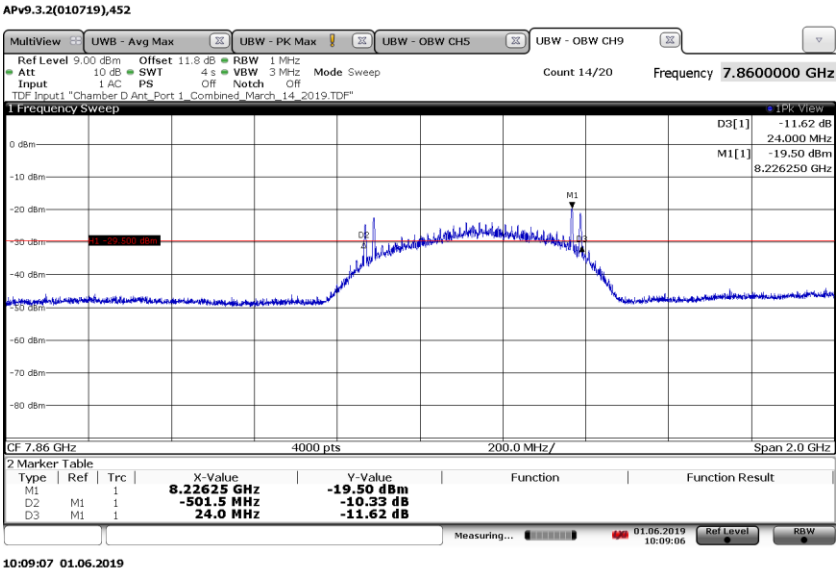
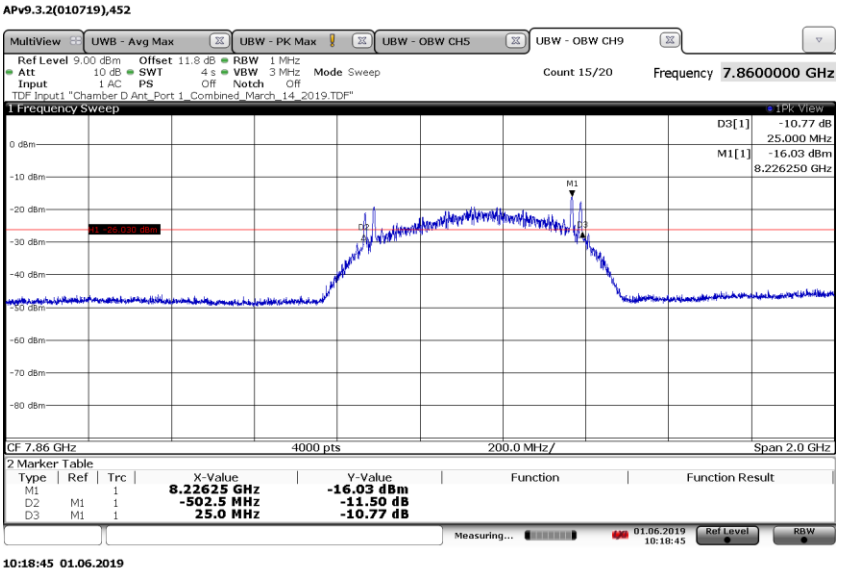
ANT 1, CH9, CONFIG 4



ANT 1, CH9, CONFIG 5



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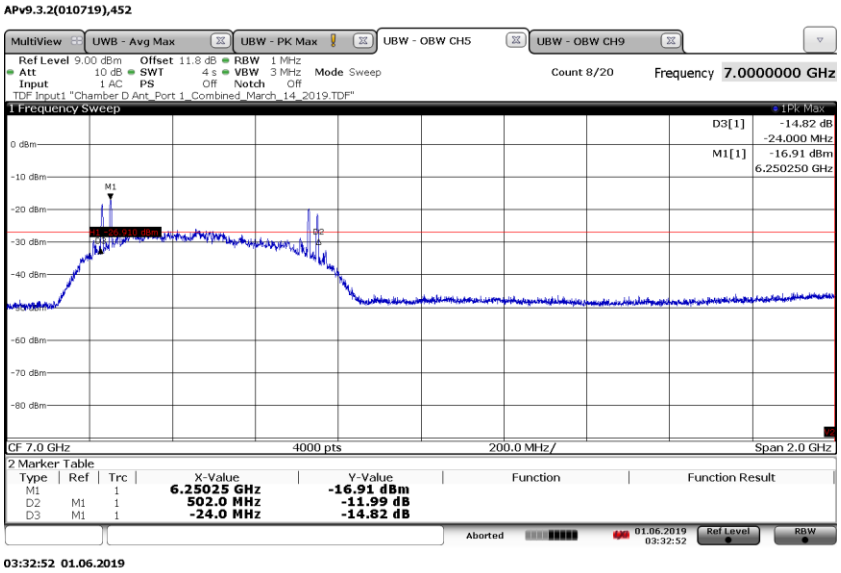
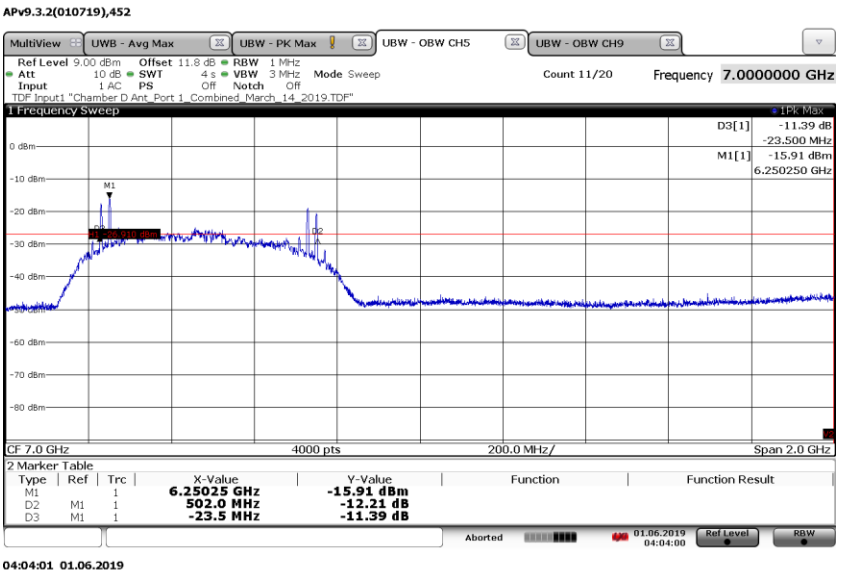
ANT 2, CH5, CONFIG 0



ANT 2, CH5, CONFIG 1



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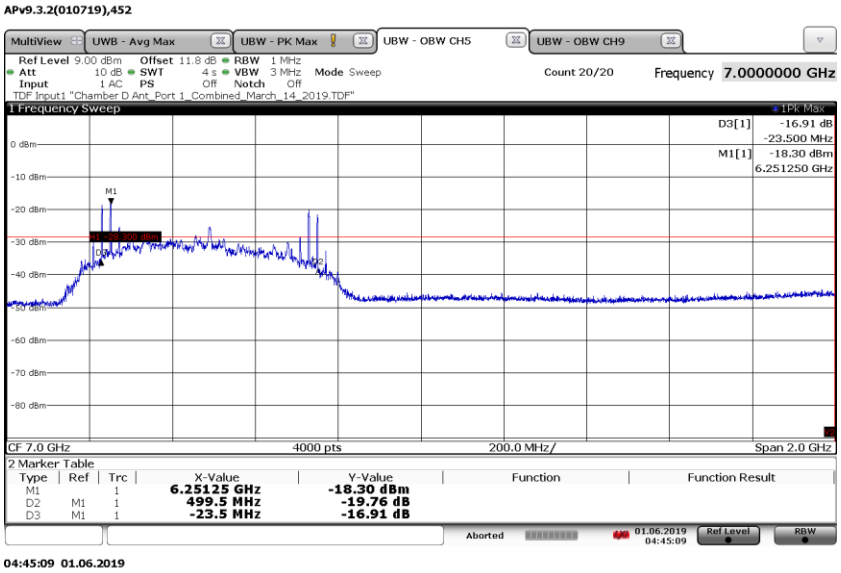
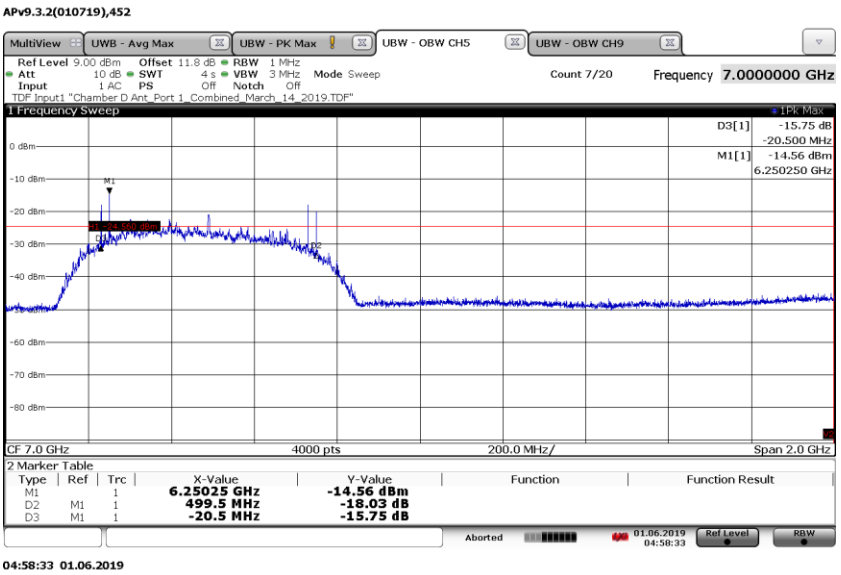
ANT 2, CH5, CONFIG 2



ANT 2, CH5, CONFIG 3



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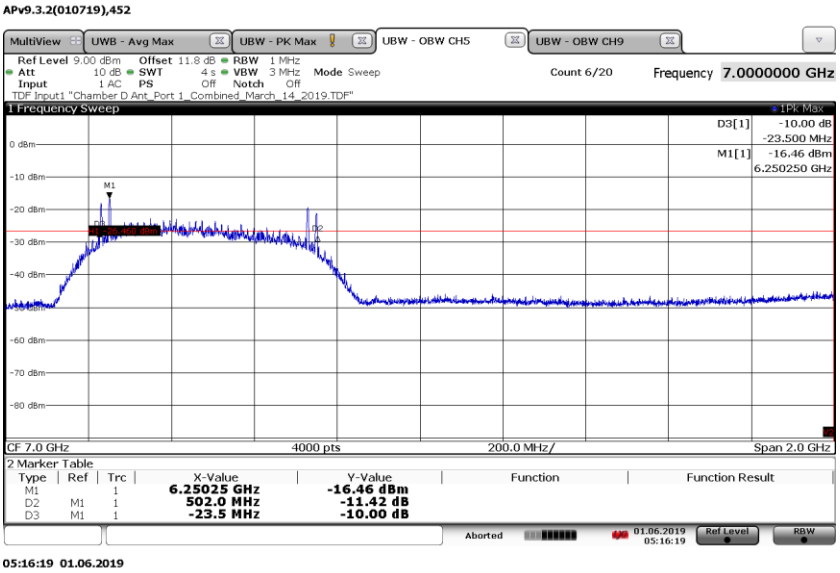
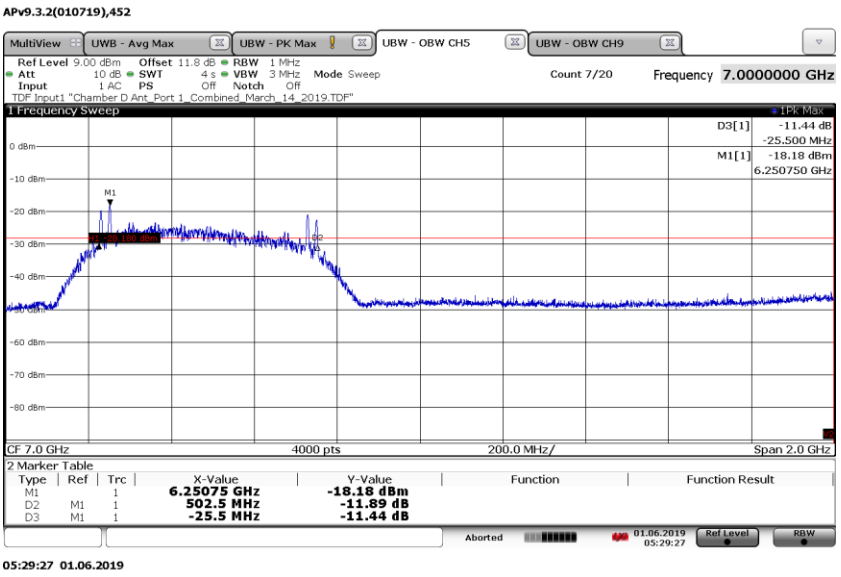
ANT 2, CH5, CONFIG 4



ANT 2, CH5, CONFIG 5



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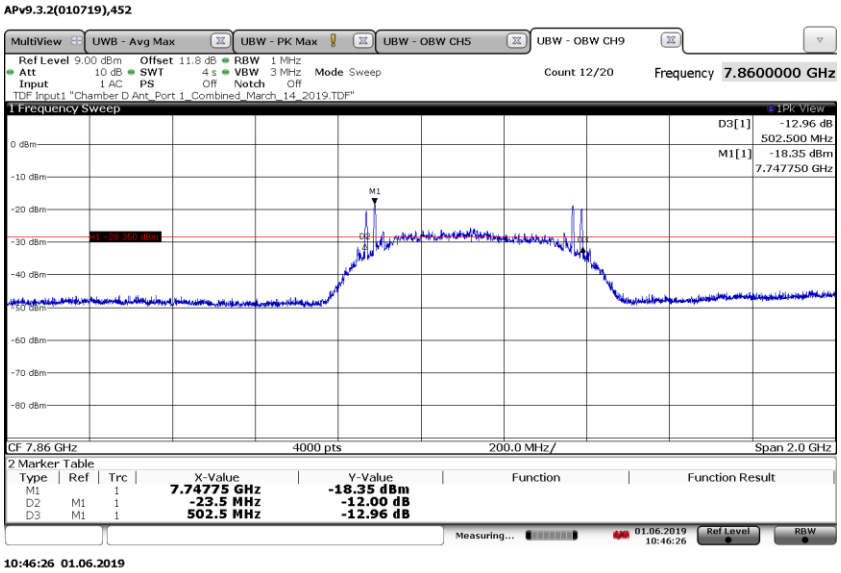
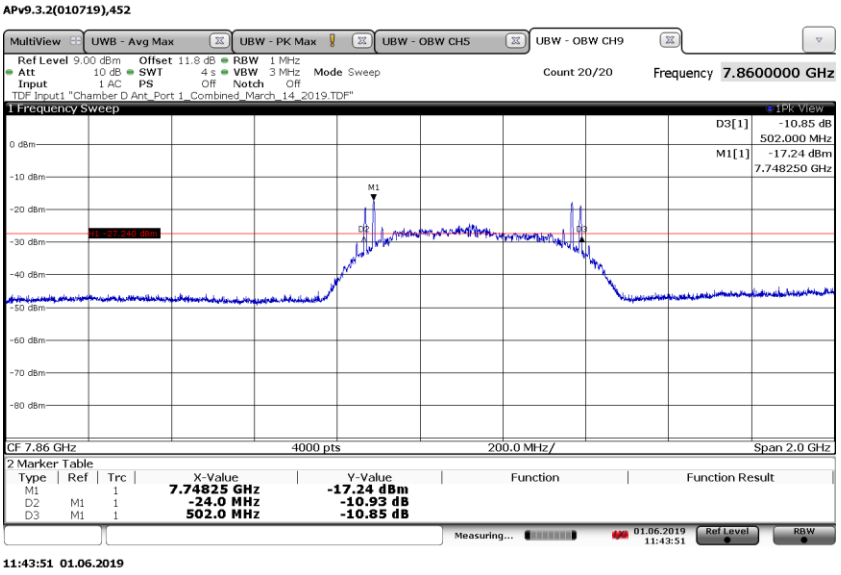
ANT 2, CH9, CONFIG 0



ANT 2, CH9, CONFIG 1



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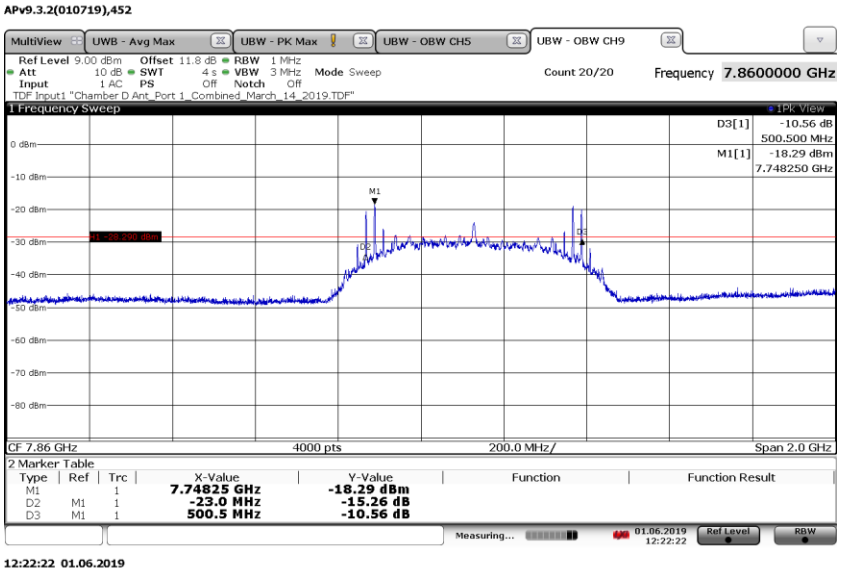
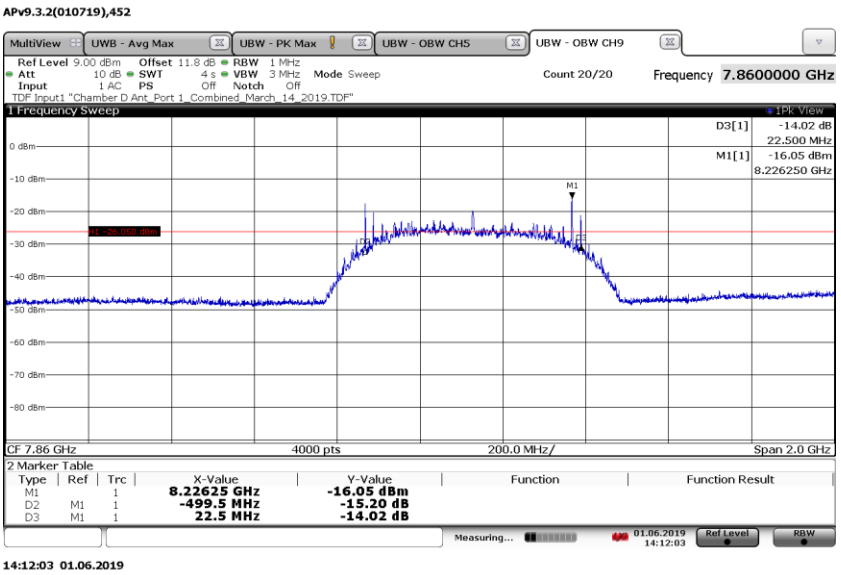
ANT 2, CH9, CONFIG 2



ANT 2, CH9, CONFIG 3



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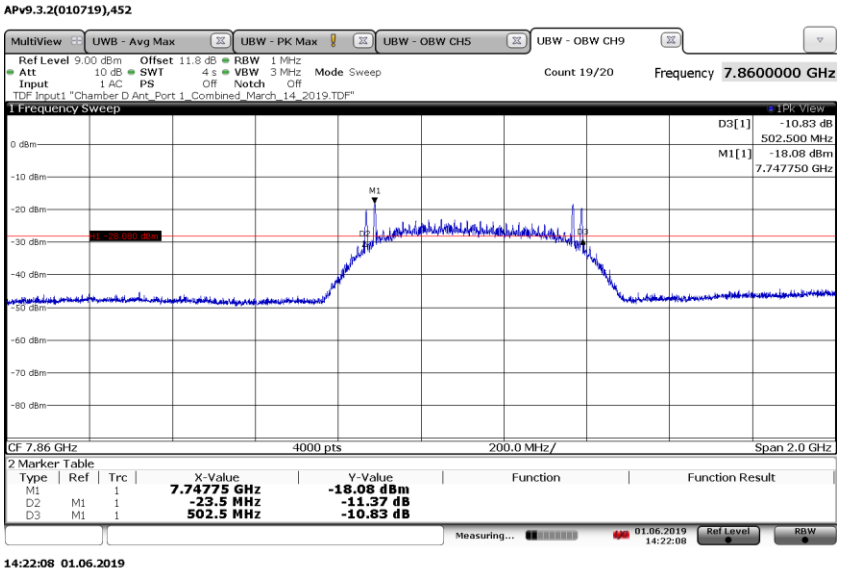
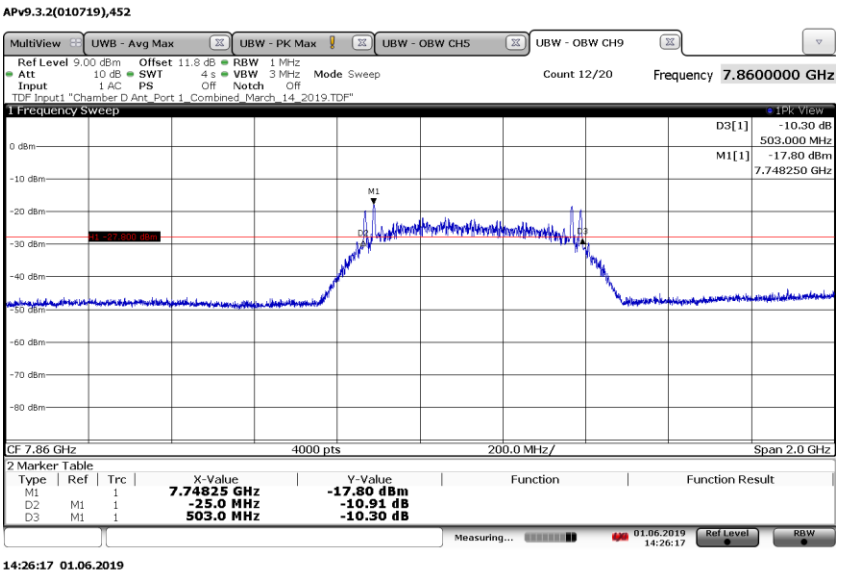
ANT 2, CH9, CONFIG 4



ANT 2, CH9, CONFIG 5



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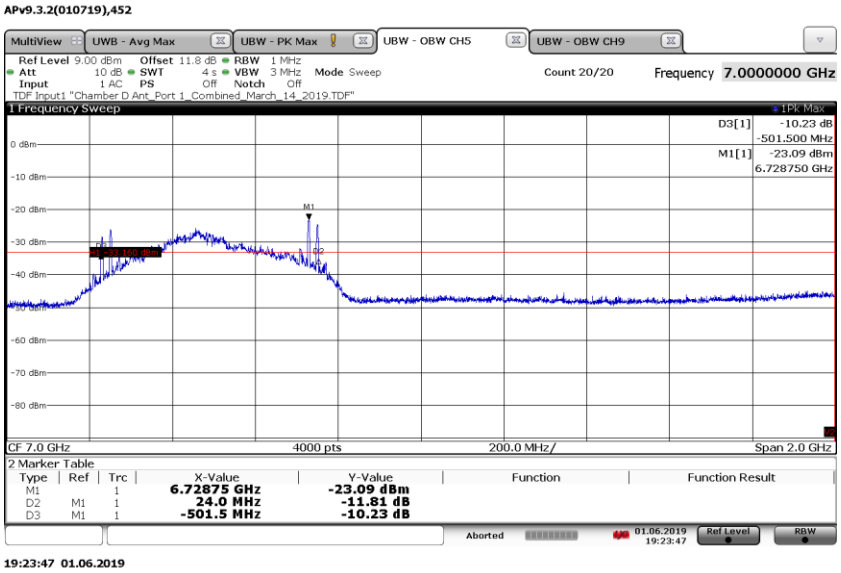
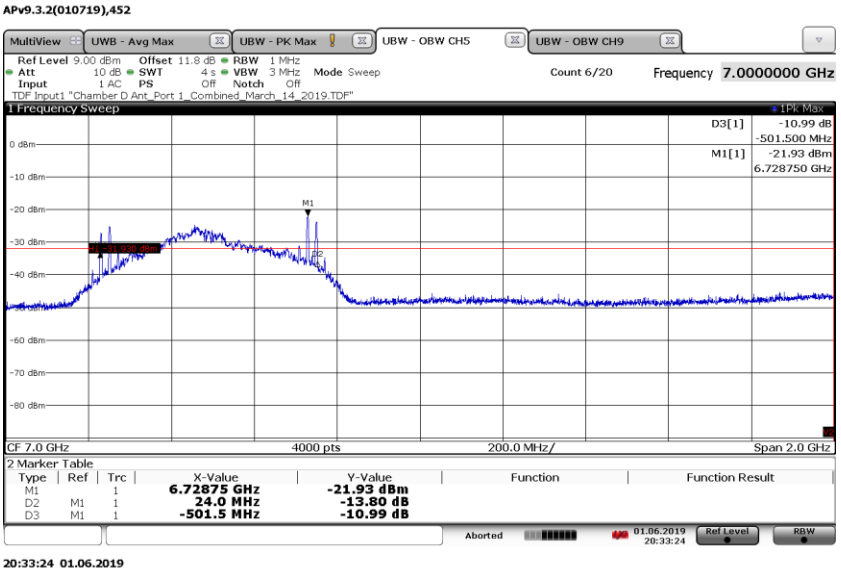
ANT 3, CH5, CONFIG 0



ANT 3, CH5, CONFIG 1



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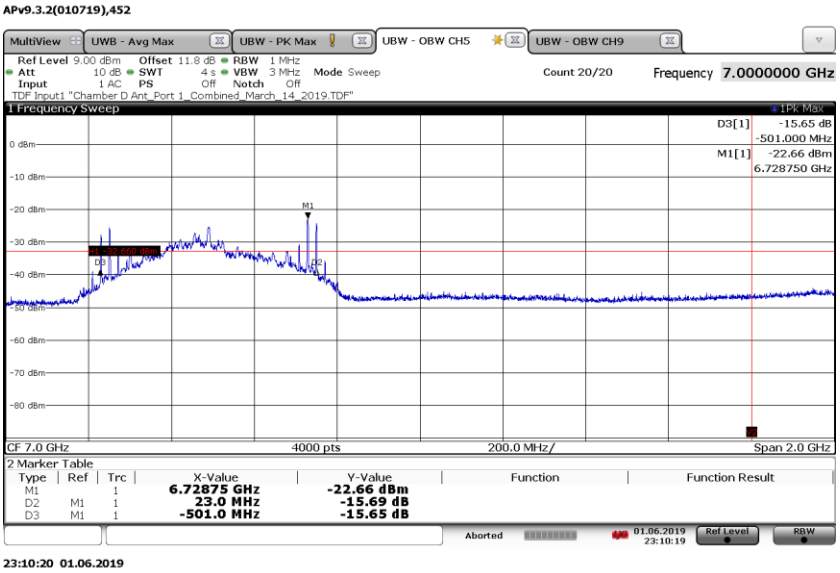
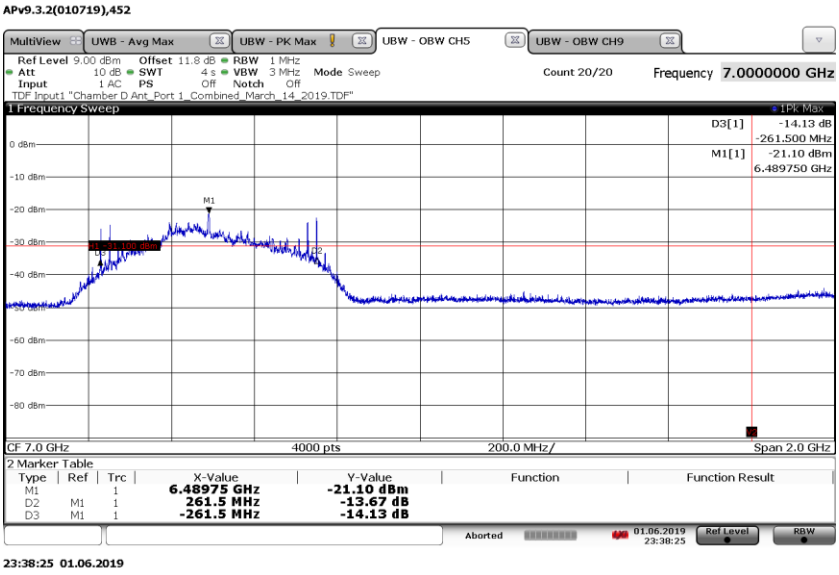
ANT 3, CH5, CONFIG 2



ANT 3, CH5, CONFIG 3



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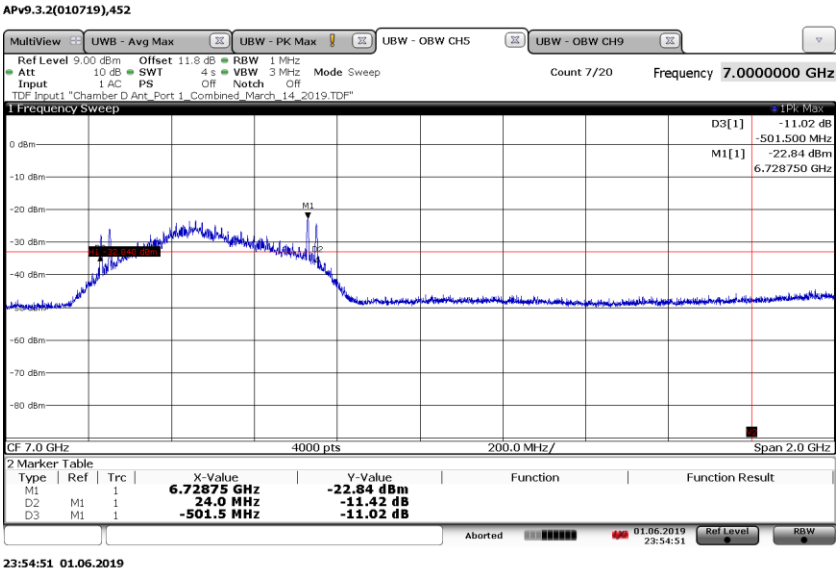
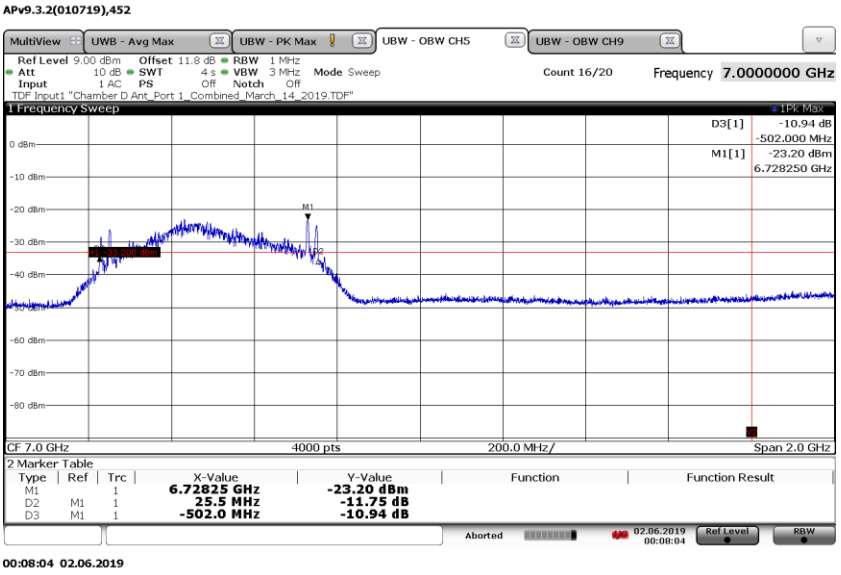
ANT 3, CH5, CONFIG 4



ANT 3, CH5, CONFIG 5



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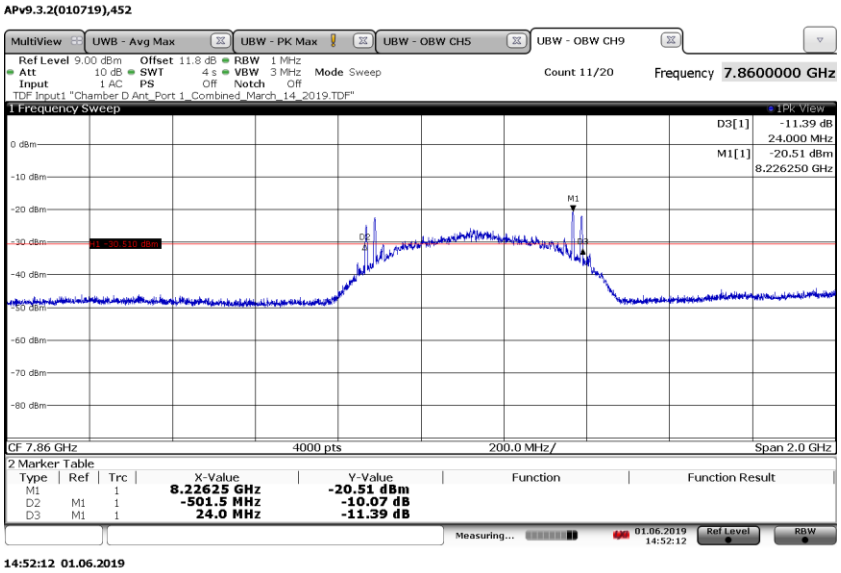
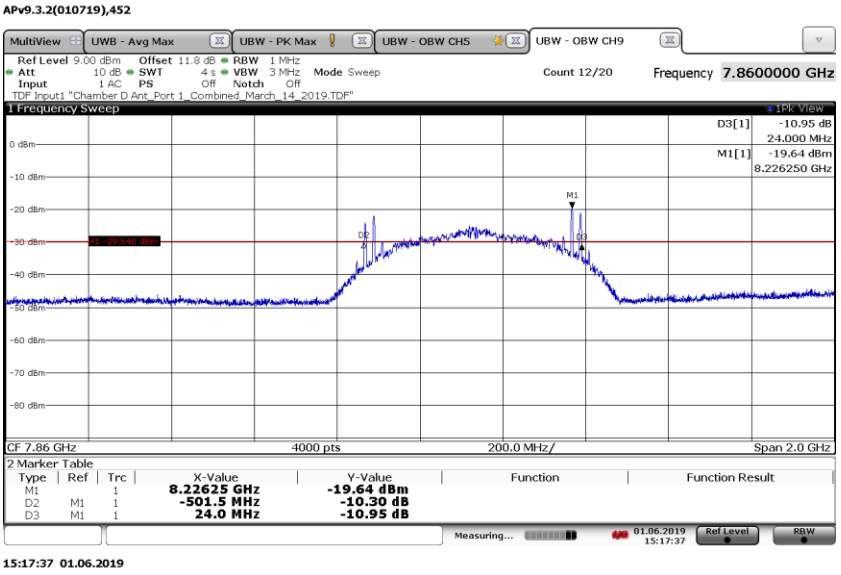
ANT 3, CH9, CONFIG 0



ANT 3, CH9, CONFIG 1



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