



TEST REPORT

Report Number. : 13320213-E1V2

Applicant : SONOS INC.
614 CHAPALA STREET
SANTA BARBARA, CA 93101, U.S.A

Model : S18

FCC ID : SBVRM016

IC : 5373A-RM016

EUT Description : 802.11a/b/g/n HT20 CLIENT DEVICE

Test Standard(s) : FCC 47 CFR PART 15 SUBPART E (Exclude DFS)
ISED RSS-247 ISSUE 2
ISED RSS-GEN ISSUE 5

Date Of Issue:

May 28, 2020

Prepared by:

UL Verification Services Inc.
47173 Benicia Street
Fremont, CA 94538 U.S.A.
TEL: (510) 319-4000
FAX: (510) 661-0888



NVLAP Lab code: 200065-0

REPORT REVISION HISTORY

Rev.	Issue Date	Revisions	Revised By
V1	5/22/2020	Initial Issue	
V2	5/28/2020	Updatde Section 5.3, 8.5.3 - 8.5.6 and 9.2	K.Kedida

TABLE OF CONTENTS

REPORT REVISION HISTORY	2
TABLE OF CONTENTS	3
1. ATTESTATION OF TEST RESULTS	5
2. TEST METHODOLOGY	7
3. FACILITIES AND ACCREDITATION	7
4. DECISION RULES AND MEASUREMENT UNCERTAINTY	8
4.1. METROLOGICAL TRACEABILITY	8
4.2. DECISION RULES.....	8
4.3. MEASUREMENT UNCERTAINTY.....	8
4.4. SAMPLE CALCULATION	9
5. EQUIPMENT UNDER TEST	10
5.1. EUT DESCRIPTION	10
5.2. DESCRIPTION OF CLASS II PERMISSIVE CHANGE	10
5.3. MAXIMUM OUTPUT POWER.....	10
5.4. DESCRIPTION OF AVAILABLE ANTENNAS	10
5.5. SOFTWARE AND FIRMWARE.....	10
5.6. WORST-CASE CONFIGURATION AND MODE.....	11
5.7. DESCRIPTION OF TEST SETUP.....	12
6. MEASUREMENT METHOD.....	14
7. TEST AND MEASUREMENT EQUIPMENT	15
8. ANTENNA PORT TEST RESULTS	16
8.1. ON TIME AND DUTY CYCLE.....	16
8.2. 26 dB BANDWIDTH.....	18
8.2.1. 802.11a MODE IN THE 5.2 GHz BAND.....	18
8.2.2. 802.11n HT20 MODE IN THE 5.2 GHz BAND	21
8.2.3. 802.11a MODE IN THE 5.3 GHz BAND.....	24
8.2.4. 802.11n HT20 MODE IN THE 5.3 GHz BAND	27
8.2.5. 802.11a MODE IN THE 5.6 GHz BAND.....	30
8.2.6. 802.11n HT20 MODE IN THE 5.6 GHz BAND	33
8.2.7. 802.11a MODE IN THE 5.8 GHz BAND.....	36
8.2.8. 802.11n HT20 MODE IN THE 5.8 GHz BAND	39
8.3. 99% BANDWIDTH.....	42
8.3.1. 802.11a MODE IN THE 5.2 GHz BAND.....	42

8.3.2.	802.11n HT20 MODE IN THE 5.2 GHz BAND	45
8.3.3.	802.11a MODE IN THE 5.3 GHz BAND.....	48
8.3.4.	802.11n HT20 MODE IN THE 5.3 GHz BAND	51
8.3.5.	802.11a MODE IN THE 5.6 GHz BAND.....	54
8.3.6.	802.11n HT20 MODE IN THE 5.6 GHz BAND	57
8.3.7.	802.11a MODE IN THE 5.8 GHz BAND.....	60
8.3.8.	802.11n HT20 MODE IN THE 5.8 GHz BAND	63
8.4.	6 dB BANDWIDTH.....	67
8.4.1.	802.11a MODE IN THE 5.8 GHz BAND.....	67
8.4.2.	802.11n HT20 MODE IN THE 5.8 GHz BAND	71
8.5.	OUTPUT POWER AND PSD.....	75
8.5.1.	802.11a MODE IN THE 5.2 GHz BAND.....	79
8.5.2.	802.11n HT20 MODE IN THE 5.2 GHz BAND	83
8.5.3.	802.11a MODE IN THE 5.3 GHz BAND.....	87
8.5.4.	802.11n HT20 MODE IN THE 5.3 GHz BAND	91
8.5.5.	802.11a MODE IN THE 5.6 GHz BAND.....	95
8.5.6.	802.11n HT20 MODE IN THE 5.6 GHz BAND	99
8.5.7.	802.11a MODE IN THE 5.8 GHz BAND.....	103
8.5.8.	802.11n HT20 MODE IN THE 5.8 GHz BAND	107
9.	RADIATED TEST RESULTS.....	111
9.1.	TRANSMITTER ABOVE 1 GHz	113
9.1.1.	TX ABOVE 1 GHz 802.11a MODE IN THE 5.2 GHz BAND	113
9.1.2.	TX ABOVE 1 GHz 802.11n HT20 MODE IN THE 5.2 GHz BAND.....	121
9.1.3.	TX ABOVE 1 GHz 802.11a MODE IN THE 5.3 GHz BAND	129
9.1.4.	TX ABOVE 1 GHz 802.11n HT20 MODE IN THE 5.3 GHz BAND.....	137
9.1.5.	TX ABOVE 1 GHz 802.11a MODE IN THE 5.6 GHz BAND	145
9.1.6.	TX ABOVE 1 GHz 802.11n HT20 MODE IN THE 5.6 GHz BAND.....	155
9.1.7.	TX ABOVE 1 GHz 802.11a MODE IN THE 5.8 GHz BAND	165
9.1.8.	TX ABOVE 1 GHz 802.11n HT20 MODE IN THE 5.8 GHz BAND.....	175
9.2.	WORST CASE BELOW 30MHZ	185
9.3.	WORST CASE BELOW 1 GHZ.....	187
9.4.	WORST CASE 18-26 GHZ.....	189
9.5.	WORST CASE 26-40 GHZ.....	191
10.	AC POWER LINE CONDUCTED EMISSIONS.....	193
10.1.1.	AC Power Line Norm	194
11.	SETUP PHOTOS.....	196

1. ATTESTATION OF TEST RESULTS

COMPANY NAME: SONOS INC.
614 CHAPALA STREET
SANTA BARBARA, CA 93101, U.S.A.

EUT DESCRIPTION: 802.11a/b/g/n HT20 CLIENT DEVICE

MODEL: S18

SERIAL NUMBER: 78-28-CA-FB-79-F6-4 (Radiated)
78-28-CA-FE-01-D6-8 (Radiated)
78-28-CA-FE-01-EA-8 (Conducted)

DATE TESTED: May 3, 2020 – May 14, 2020

APPLICABLE STANDARDS	
STANDARD	TEST RESULTS
CFR 47 Part 15 Subpart E	Complies
ISED RSS-247 Issue 2	Complies
ISED RSS-GEN Issue 5	Complies

UL Verification Services Inc. tested the above equipment in accordance with the requirements set forth in the above standards. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. It is the manufacturer's responsibility to assure that additional production units of this model are manufactured with identical electrical and mechanical components. All samples tested were in good operating condition throughout the entire test program. Measurement Uncertainties are published for informational purposes only and were not taken into account unless noted otherwise.

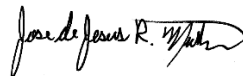
This document may not be altered or revised in any way unless done so by UL Verification Services Inc. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Services Inc. will constitute fraud and shall nullify the document. This 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 the U.S. government.

Approved & Released For
UL Verification Services Inc. By:



DAN CORONIA
Operations Leader
Consumer Technology Division
UL Verification Services Inc.

Prepared By:



JOSE MARTINEZ
Test Engineer
Consumer Technology Division
UL Verification Services Inc.

Reviewed By:



KIYA KEDIDA
Senior Project Engineer
Consumer Technology Division
UL Verification Services Inc.

2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with FCC CFR 47 Part 2, FCC CFR 47 Part 15, FCC 14-30, FCC KDB 662911 D01 v02r01, FCC KDB 662911 D02 v01, FCC KDB 789033 D02 v02r01, KDB 414788 D01 Radiated Test Site v01r01, ANSI C63.10-2013, FCC 06-96, RSS-GEN Issue 5, and RSS-247 Issue 2.

3. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 47173 and 47266 Benicia Street, and 47658 Kato Road, Fremont, California, USA. Line conducted emissions are measured only at the 47173 address. 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	47658 Kato Rd
<input type="checkbox"/> Chamber A	<input type="checkbox"/> Chamber D	<input type="checkbox"/> Chamber I
<input type="checkbox"/> Chamber B	<input type="checkbox"/> Chamber E	<input type="checkbox"/> Chamber J
<input type="checkbox"/> Chamber C	<input type="checkbox"/> Chamber F	<input checked="" type="checkbox"/> Chamber K
	<input type="checkbox"/> Chamber G	<input type="checkbox"/> Chamber L
	<input type="checkbox"/> Chamber H	<input type="checkbox"/> Chamber M

The above test sites and facilities are covered under FCC Test Firm Registration # 208313. Chambers above are covered under Industry Canada company address and respective code: 2324A.

UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0

4. DECISION RULES AND MEASUREMENT UNCERTAINTY

4.1. METROLOGICAL TRACEABILITY

All test and measuring equipment utilized to perform the tests documented in this report are calibrated on a regular basis, with a maximum time between calibrations of one year or the manufacturers' recommendation, whichever is less, and where applicable is traceable to recognized national standards.

4.2. DECISION RULES

The Decision Rule is based on Simple Acceptance in accordance with ISO Guide 98-4:2012 Clause 8.2. (Measurement uncertainty is not taken into account when stating conformity with a specified requirement.)

4.3. MEASUREMENT UNCERTAINTY

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

PARAMETER	U_{Lab}
Worst Case Conducted Disturbance, 9KHz to 0.15 MHz	3.39 dB
Worst Case Conducted Disturbance, 0.15 to 30 MHz	3.07 dB
Worst Case Radiated Disturbance, 9KHz to 30 MHz	2.52 dB
Worst Case Radiated Disturbance, 30 to 1000 MHz	4.88 dB
Worst Case Radiated Disturbance, 1000 to 18000 MHz	4.24 dB
Worst Case Radiated Disturbance, 18000 to 26000 MHz	4.37 dB
Worst Case Radiated Disturbance, 26000 to 40000 MHz	5.17 dB

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

4.4. SAMPLE CALCULATION

RADIATED EMISSIONS

Where relevant, the following sample calculation is provided:

Field Strength (dBuV/m) = Measured Voltage (dBuV) + Antenna Factor (dB/m) + Cable Loss (dB) – Preamp Gain (dB)

$36.5 \text{ dBuV} + 18.7 \text{ dB/m} + 0.6 \text{ dB} - 26.9 \text{ dB} = 28.9 \text{ dBuV/m}$

MAINS CONDUCTED EMISSIONS

Where relevant, the following sample calculation is provided:

Final Voltage (dBuV) = Measured Voltage (dBuV) + Cable Loss (dB) + Limiter Factor (dB) + LISN Insertion Loss.

$36.5 \text{ dBuV} + 0 \text{ dB} + 10.1 \text{ dB} + 0 \text{ dB} = 46.6 \text{ dBuV}$

5. EQUIPMENT UNDER TEST

5.1. EUT DESCRIPTION

The EUT is 802.11 a/b/g/n HT20 CLIENT DEVICE.

5.2. DESCRIPTION OF CLASS II PERMISSIVE CHANGE

This is to request a Class II permissive change for FCC ID: SBVRM016 and IC Certification No: 5373A-RM016. The major change filed under this application is:

- Enable the 3rd chain on U-NII bands

5.3. MAXIMUM OUTPUT POWER

The transmitter has a maximum conducted output power as follows:

Frequency Range (MHz)	Mode	Output Power (dBm)	Output Power (mW)
5.2 GHz band, 3TX			
5180-5240	802.11a	13.75	23.71
5180-5240	802.11n HT20	14.66	29.24
5.3 GHz band, 3TX			
5260-5320	802.11a	19.16	82.41
5260-5320	802.11n HT20	20.09	102.09
5.6 GHz band, 3TX			
5500-5700	802.11a	19.52	89.54
5500-5700	802.11n HT20	20.24	105.68
5.8 GHz band, 3TX			
5745-5825	802.11a	19.32	85.51
5745-5825	802.11n HT20	20.30	107.15

5.4. DESCRIPTION OF AVAILABLE ANTENNAS

Frequency (MHz)	5GHz Max Antenna Gain dBi		
	Chain 0 (Vertical Polarization)	Chain 1 (Vertical Polarization)	Chain 2 (Horizontal Polarization)
5180 - 5850	0.6	2.6	2.2

Note: Antenna 0= Chain 0, Antenna 1= Chain 1, Antenna 2= Chain 2

5.5. SOFTWARE AND FIRMWARE

The EUT firmware installed during testing was V59.0-75030

The test utility software used during testing was Sonos Compliance GUI V4.0.

5.6. WORST-CASE CONFIGURATION AND MODE

Radiated emissions below 1GHz, above 18GHz, and power line conducted emission were performed with the EUT set to transmit at the channel with highest output power as worst-case scenario.

Band edge and radiated emissions between 1GHz and 18GHz were performed with the EUT set to transmit at the highest power on low, middle and high channels.

The EUT can only be setup in desktop orientation; therefore, all radiated testing was performed with the EUT in desktop orientation.

Worst-case data rates as provided by the client were:

802.11a mode: 6 Mbps

802.11n HT20mode: MCS0

5.7. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List				
Description	Manufacturer	Model	Serial Number	FCC ID
Laptop	Lenovo	X230	R9-Y89ZW 13/04	N/A
AC Adapter	Lenovo	42T4430	11S42T4430Z1ZGWE15VFTD	N/A

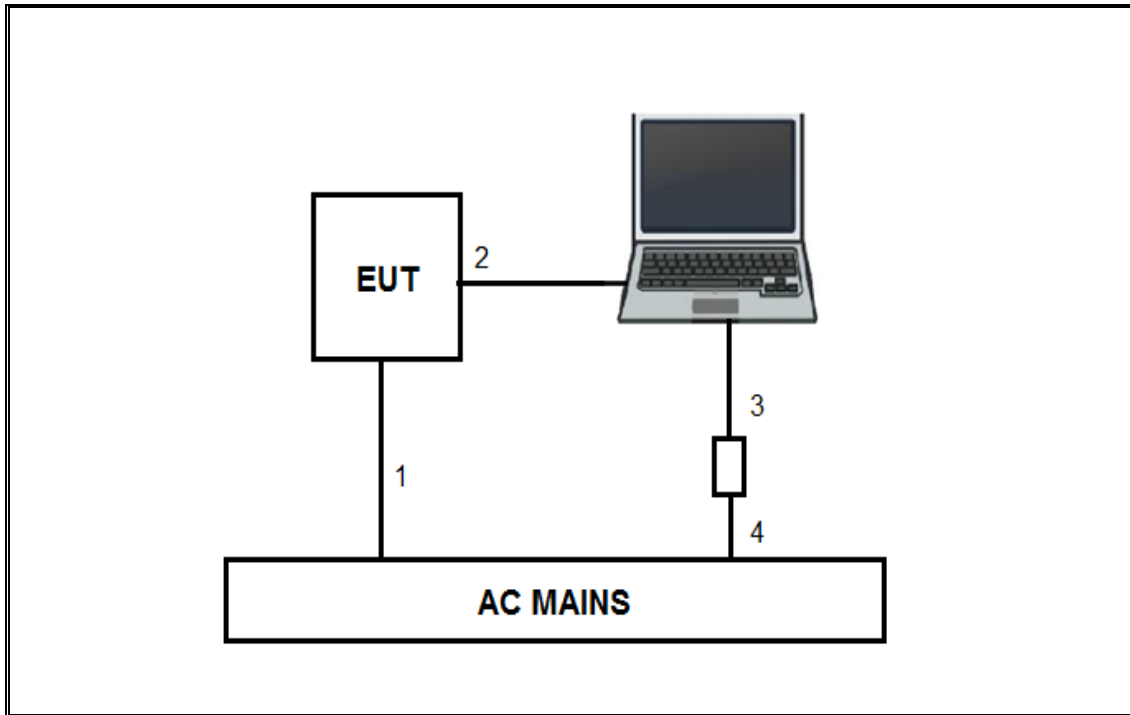
I/O CABLES

I/O Cable List						
Cable No	Port	# of identical ports	Connector Type	Cable Type	Cable Length (m)	Remarks
1	AC Power	1	AC	Unshielded	2	AC Mains to EUT
2	Ethernet	1	RJ45	Unshielded	10	EUT to Laptop
3	DC Power	1	DC	Shielded	1.2	AC/DC Adapter to Laptop
4	AC Power	1	AC	Unshielded	1	AC Mains to AC/DC Adapter

TEST SETUP

The EUT is a stand-alone unit, and the radio is exercised by Sonos Compliance GUI V4.0 test utility software via Ethernet.

SETUP DIAGRAMS



6. MEASUREMENT METHOD

On Time and Duty Cycle: KDB 789033 D02 v02r01, Section II B.

6 dB Emission BW: KDB 789033 D02 v02r01, Section C.2

26 dB Emission BW: KDB 789033 D02 v02r01, Section C.1

99% Occupied BW: KDB 789033 D02 v02r01, Section D.

Conducted Output Power: KDB 789033 D02 v02r01, Section E.3.b (Method PM-G) and KDB 789033 D02 v02r01, Section E.2.b (Method SA-1)

Power Spectral Density: KDB 789033 D02 v02r01, Section F

Unwanted emissions in restricted bands: KDB 789033 D02 v02r01, Sections G.3, G.4, G.5, and G.6.

Unwanted emissions in non-restricted bands: KDB 789033 D02 v02r01, Sections G.3, G.4, and G.5.

AC Power Line Conducted Emissions: ANSI C63.10-2013, Section 6.2.

Radiated Spurious Emissions Below 30MHz: ANSI C63.10-2013 Section 6.4

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	ID Num	Cal Due	Last Cal
Amplifier, 100MHz-18GHz	AMPLICAL	AMP0.1G18-47-20	PRE0197319	05/04/2021	05/04/2020
Antenna	ETS-Lindgren	3117	EMC4294	06/14/2020	06/14/2019
Amplifier, 9KHz to 1GHz, 32dB	SONOMA INSTRUMENT	310	175953	01/23/2021	01/23/2020
Antenna, BroadBand Hybrid, 30MHz to 3GHz	Sunol Sciences Corp.	JB3	PRE0181574	10/14/2020	10/14/2019
Antenna, Passive Loop 30Hz - 1MHz	ELECTRO METRICS	EM-6871	PRE0179466	05/31/2020	05/31/2019
Antenna, Passive Loop 100KHz - 30MHz	ELECTRO METRICS	EM-6872	PRE0179468	05/31/2020	05/31/2019
EMI TEST RECEIVER	Rohde & Schwarz	ESW44	PRE0179377	02/23/2021	02/23/2020
Spectrum Analyzer, PXA, 3Hz to 44GHz	Keysight Technologies Inc	N9030A	T905	01/24/2021	01/24/2020
Spectrum Analyzer, PSA, 3Hz to 44GHz	Keysight Technologies Inc	E4446A	T146	01/29/2021	01/29/2020
Power Meter, P-series single channel	Keysight Technologies Inc	N1911A	T1269	01/21/2021	01/21/2020
Power Sensor, P - series, 50MHz to 18GHz, Wideband	Keysight Technologies Inc	N1921A	T1225	02/13/2021	02/13/2020

Test Software List			
Description	Manufacturer	Model	Version
Radiated Software	UL	UL EMC	Ver 9.5, Apr 30, 2020
Radiated Software	UL	UL EMC	Ver 9.5, Oct 21, 2019
Antenna Port Software	UL	UL RF	2020.3.11
AC Line Conducted Software	UL	UL EMC	Ver 9.5, Feb 21, 2020

8. ANTENNA PORT TEST RESULTS

8.1. ON TIME AND DUTY CYCLE

LIMITS

None; for reporting purposes only.

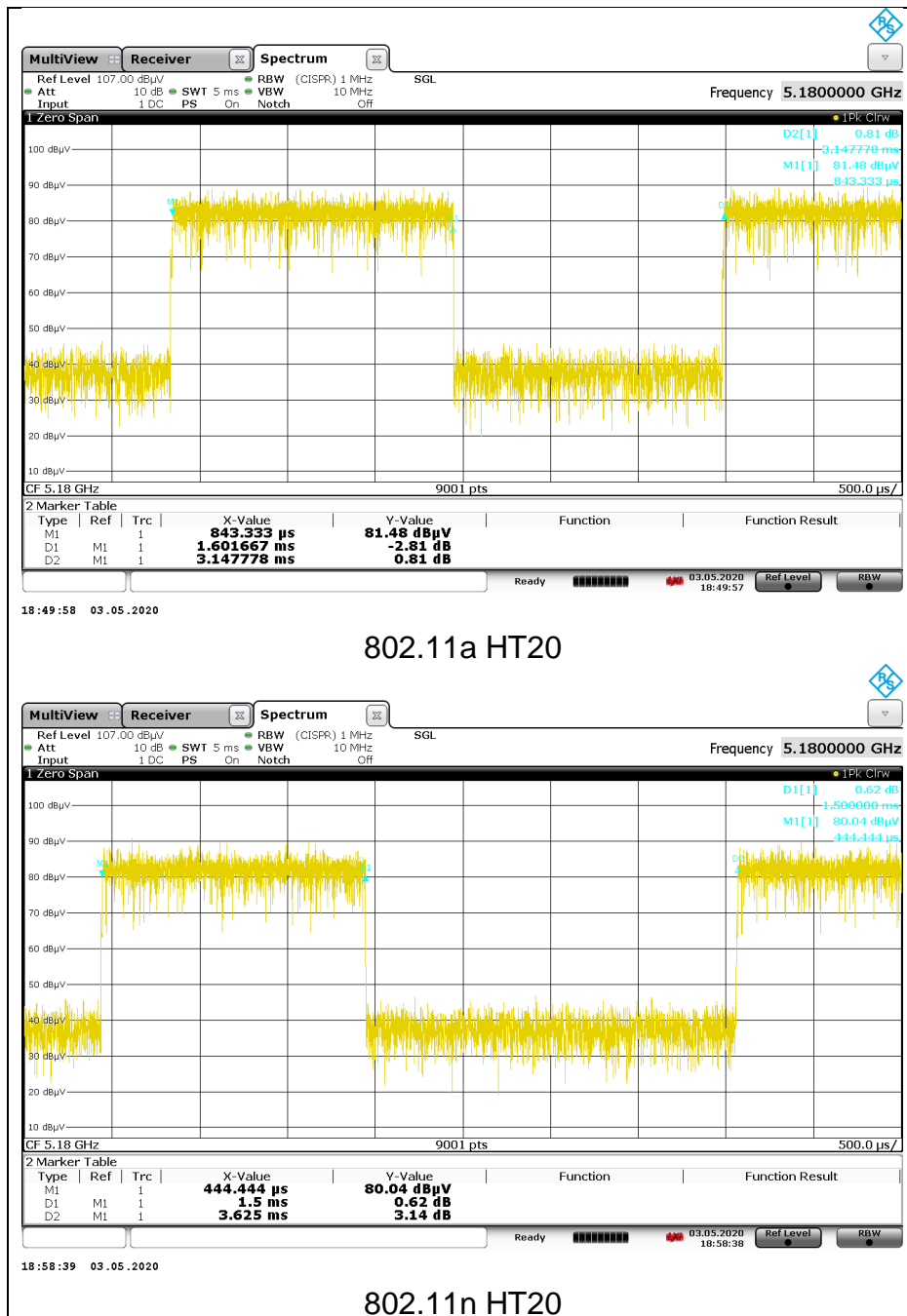
PROCEDURE

KDB 558074 Zero-Span Spectrum Analyzer Method.

ON TIME AND DUTY CYCLE RESULTS

Mode	ON Time B (msec)	Period (msec)	Duty Cycle x (linear)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)	1/B Minimum VBW (kHz)
802.11a	1.602	3.148	0.509	50.88%	2.93	0.624
802.11n HT20	1.500	3.625	0.414	41.38%	3.83	0.667

DUTY CYCLE PLOTS



8.2. 26 dB BANDWIDTH LIMITS

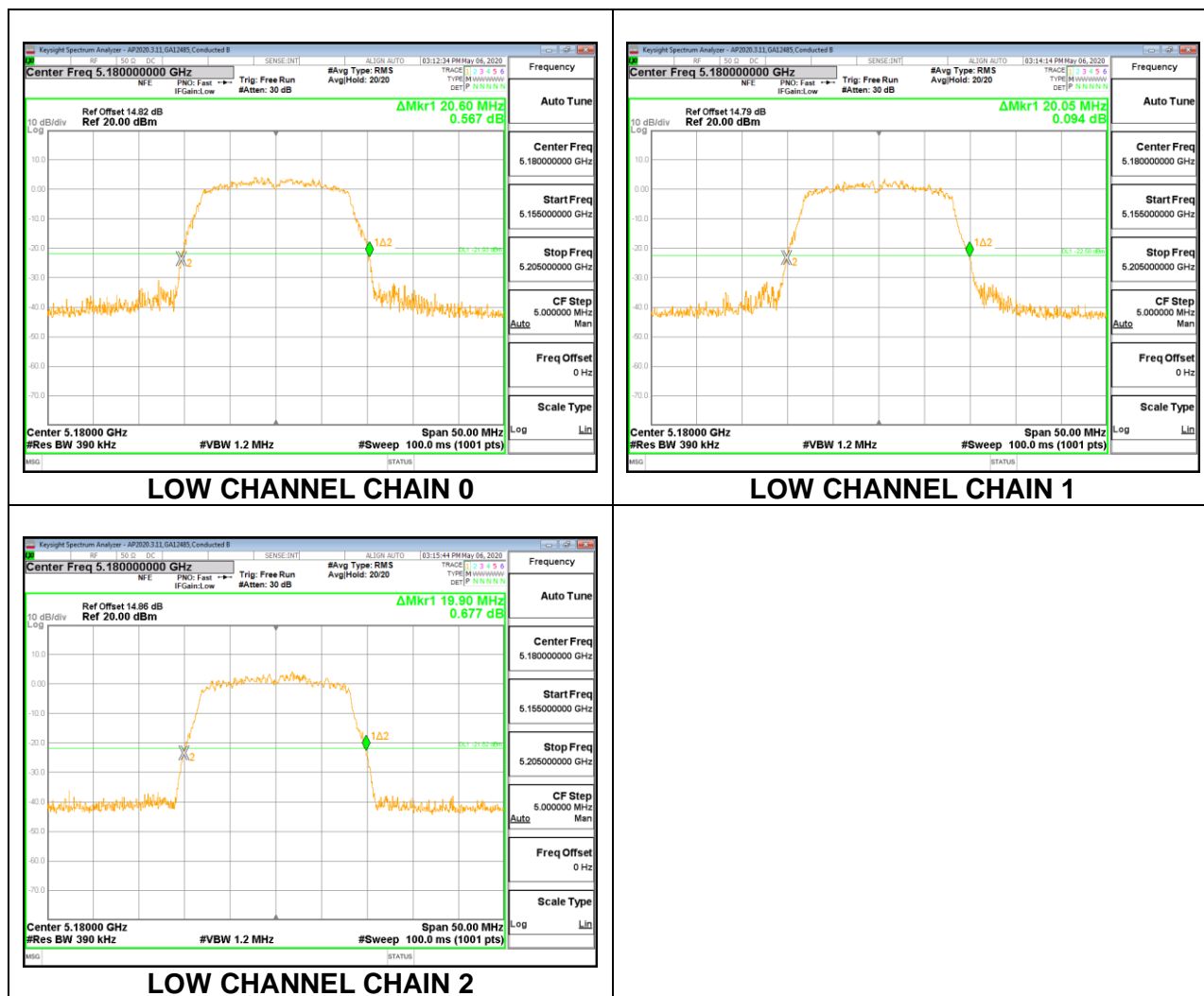
None; for reporting purposes only.

RESULTS

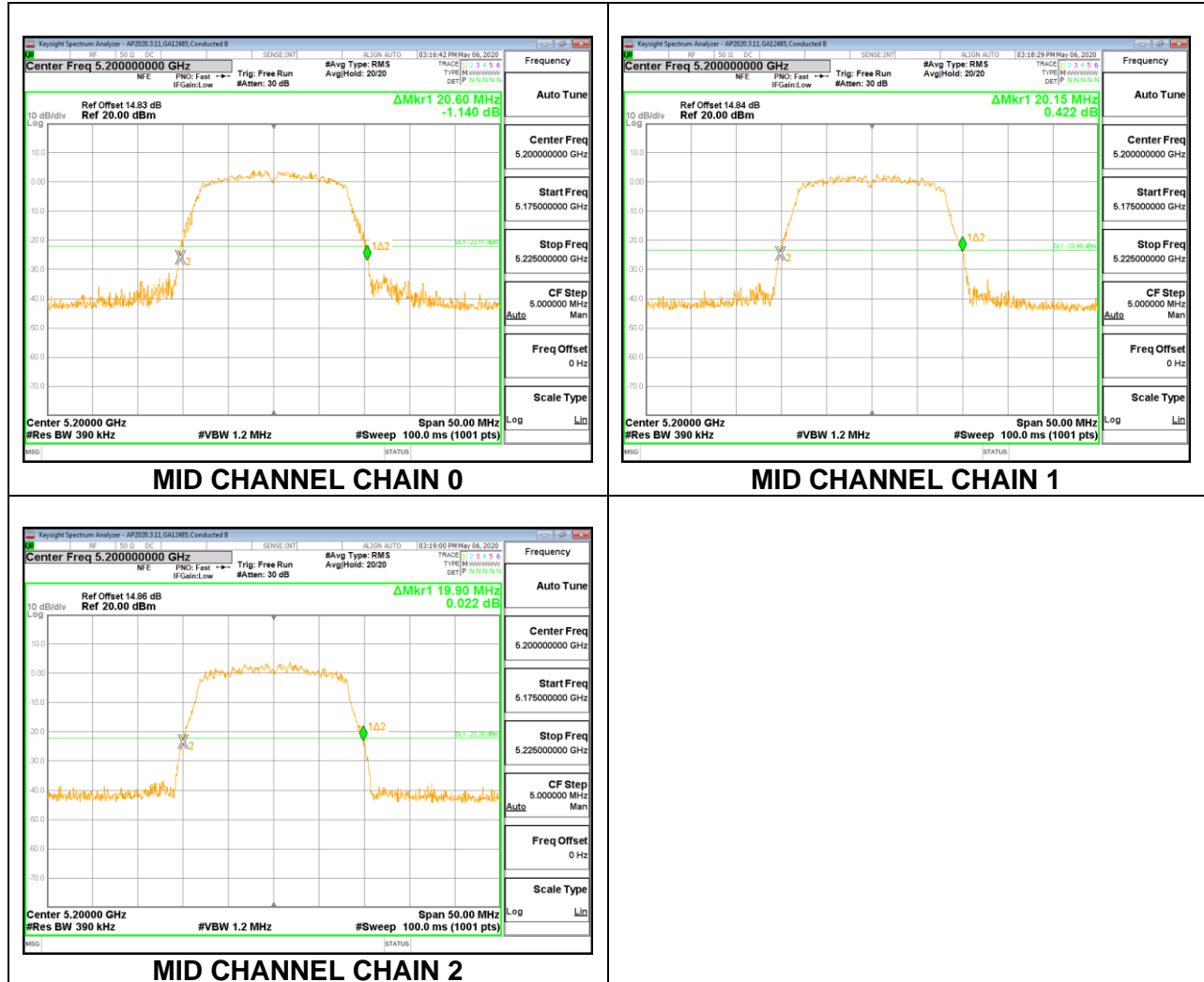
8.2.1. 802.11a MODE IN THE 5.2 GHz BAND

Channel	Frequency (MHz)	26 dB Bandwidth Chain 0 (MHz)	26 dB Bandwidth Chain 1 (MHz)	26 dB Bandwidth Chain 2 (MHz)
Low	5180	20.60	20.05	19.90
Mid	5200	20.60	20.15	19.90
High	5240	20.50	20.10	20.00

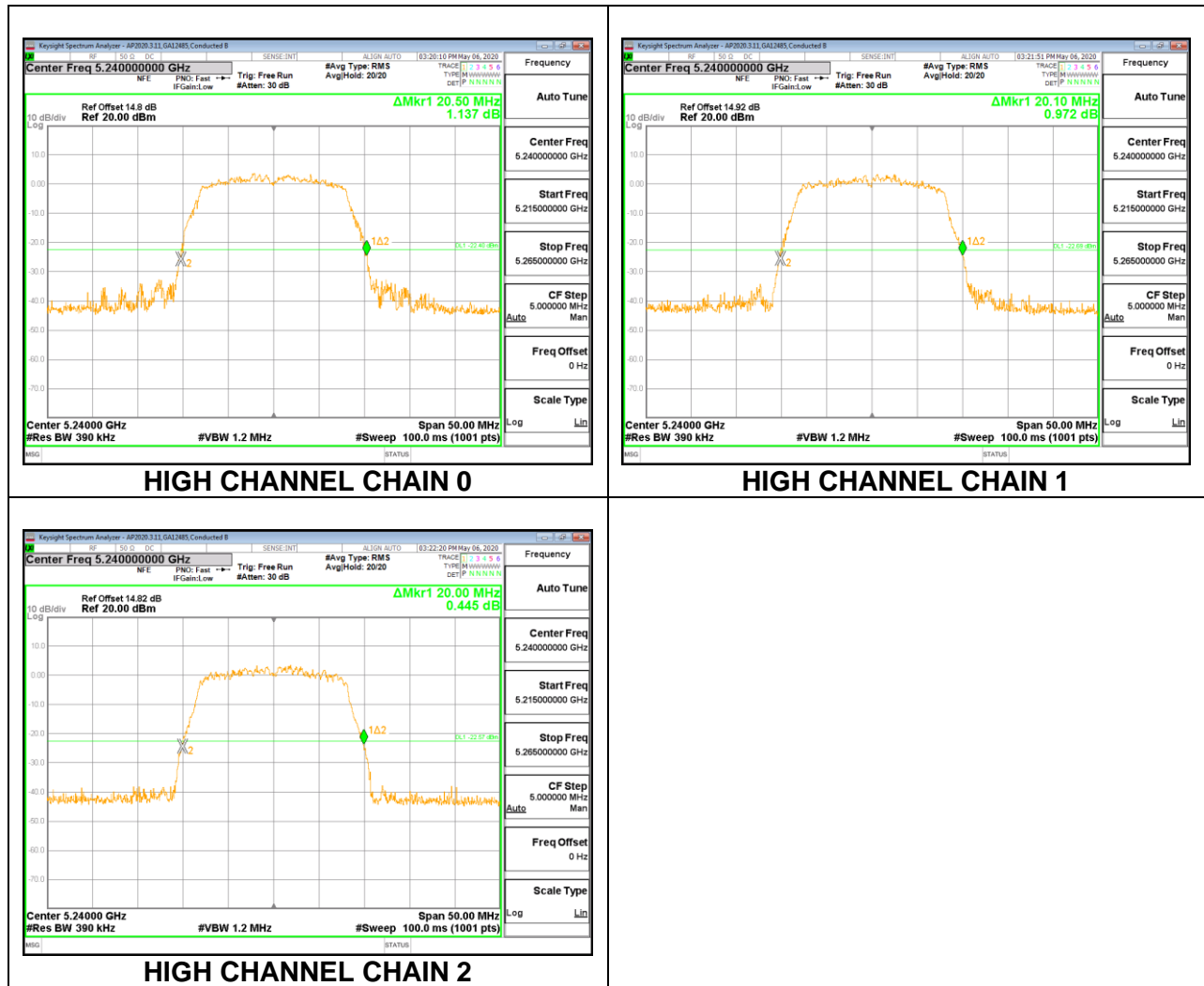
LOW CHANNEL



MID CHANNEL



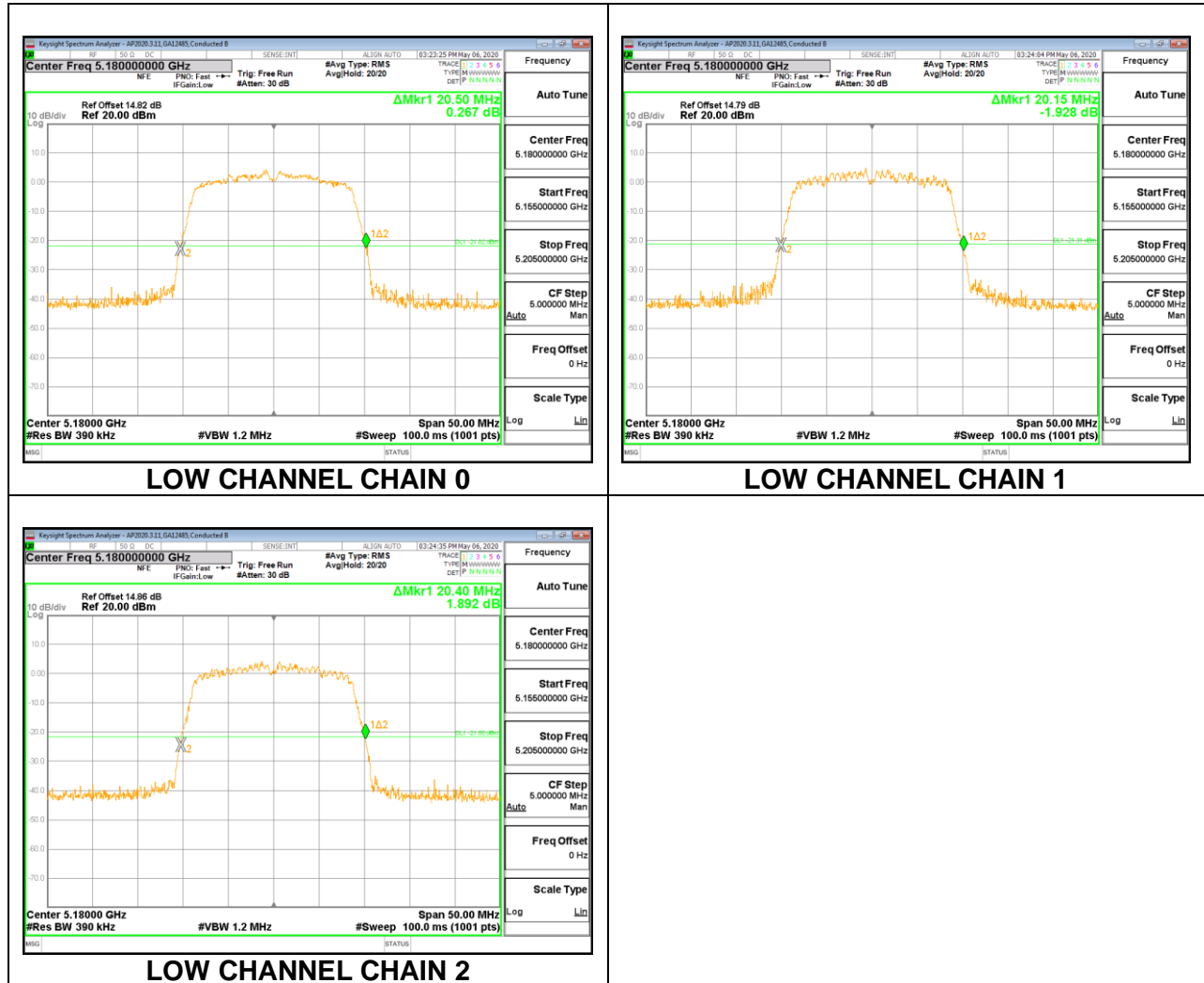
HIGH CHANNEL



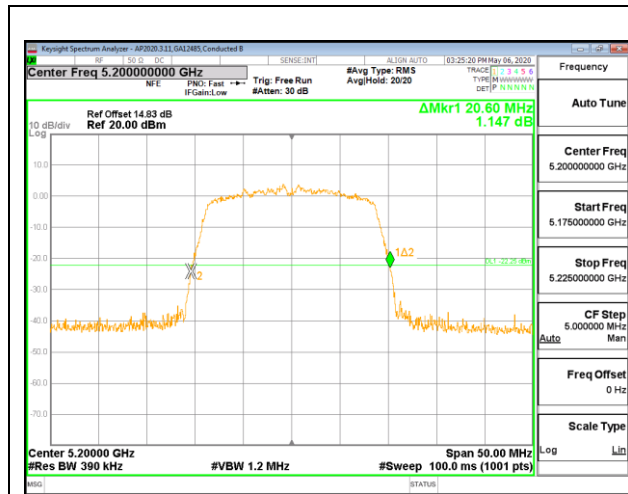
8.2.2. 802.11n HT20 MODE IN THE 5.2 GHz BAND

Channel	Frequency (MHz)	26 dB Bandwidth Chain 0 (MHz)	26 dB Bandwidth Chain 1 (MHz)	26 dB Bandwidth Chain 2 (MHz)
Low	5180	20.50	20.15	20.40
Mid	5200	20.60	20.15	20.40
High	5240	20.60	20.25	20.45

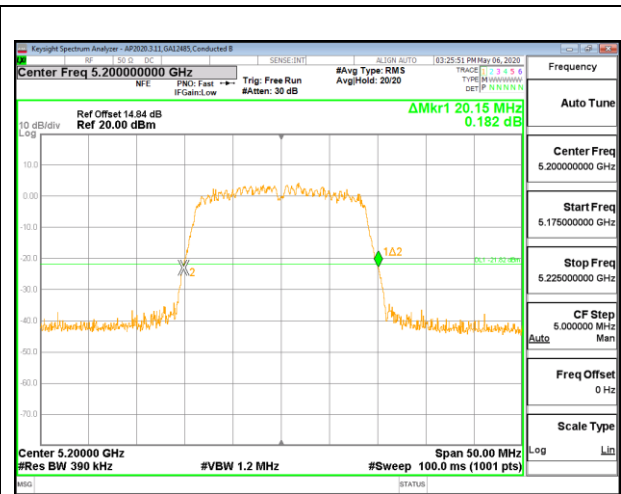
LOW CHANNEL



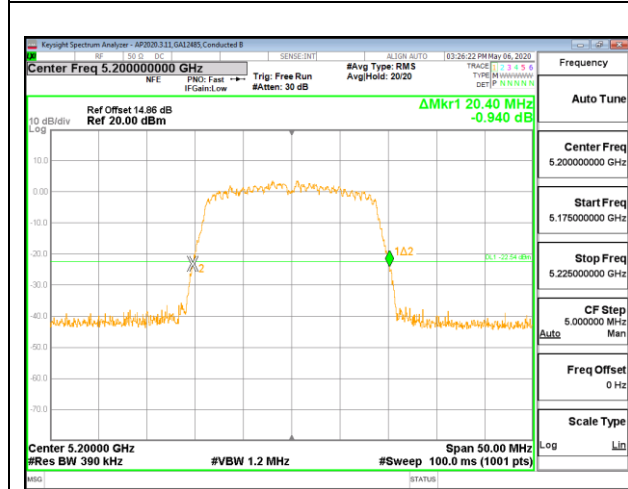
MID CHANNEL



MID CHANNEL CHAIN 0

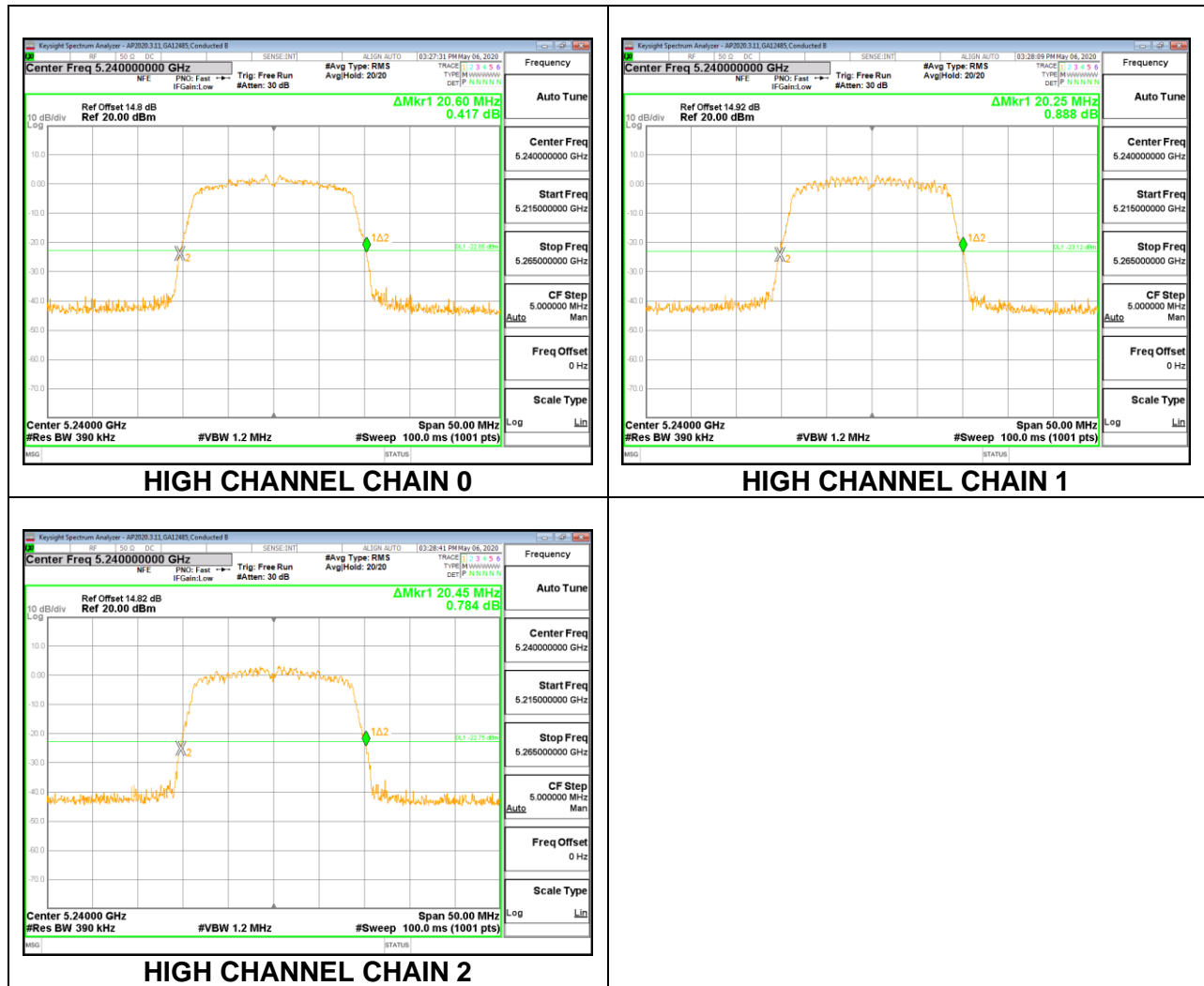


MID CHANNEL CHAIN 1



MID CHANNEL CHAIN 2

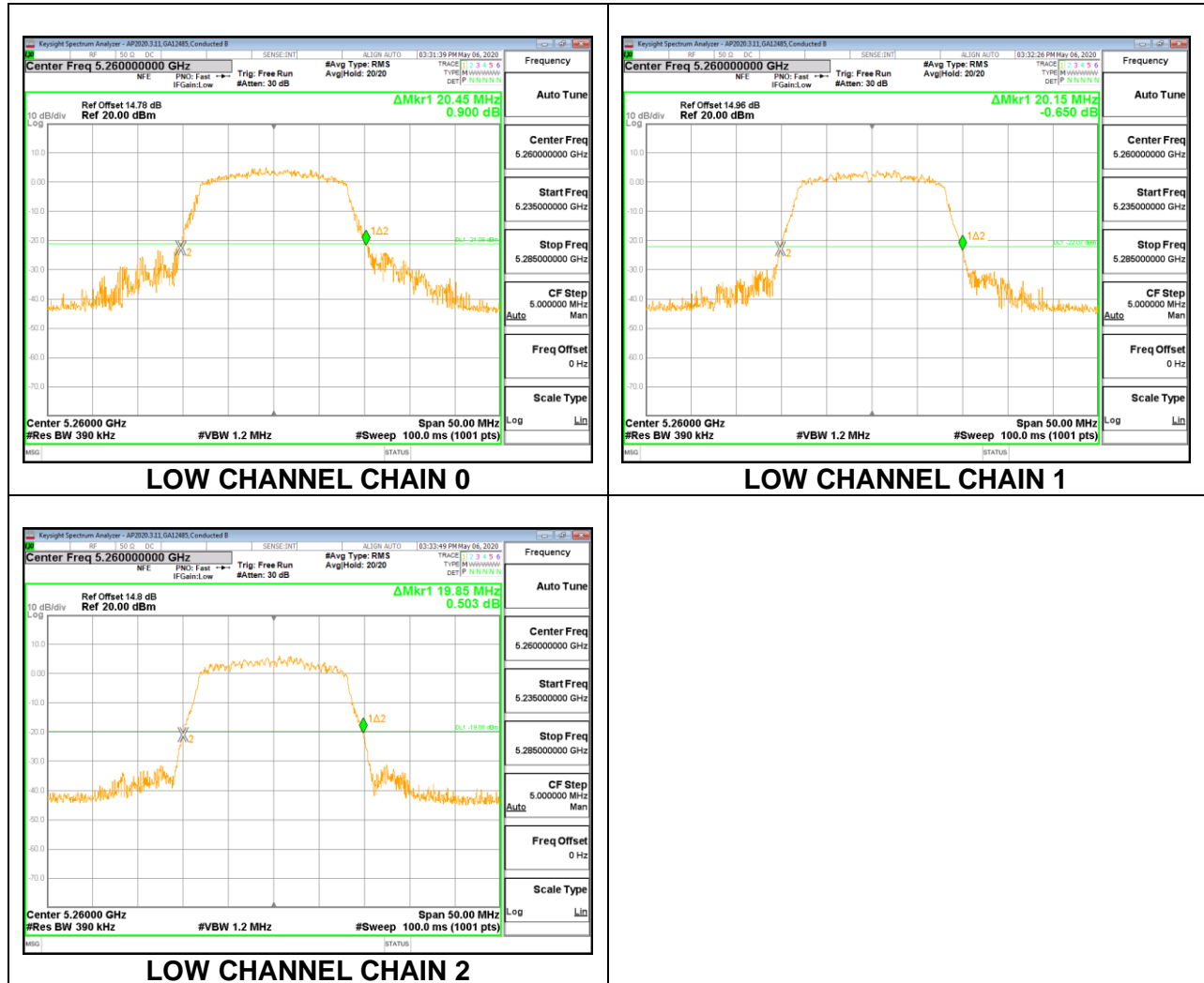
HIGH CHANNEL



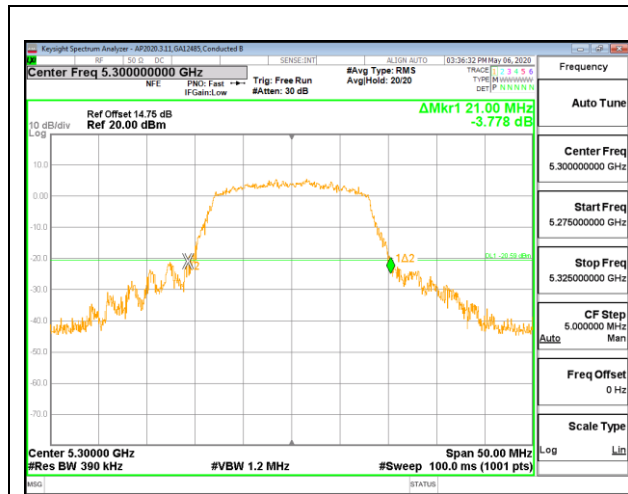
8.2.3. 802.11a MODE IN THE 5.3 GHz BAND

Channel	Frequency (MHz)	26 dB Bandwidth Chain 0 (MHz)	26 dB Bandwidth Chain 1 (MHz)	26 dB Bandwidth Chain 2 (MHz)
Low	5260	20.45	20.15	19.85
Mid	5300	21.00	20.00	19.90
High	5320	21.35	20.75	20.00

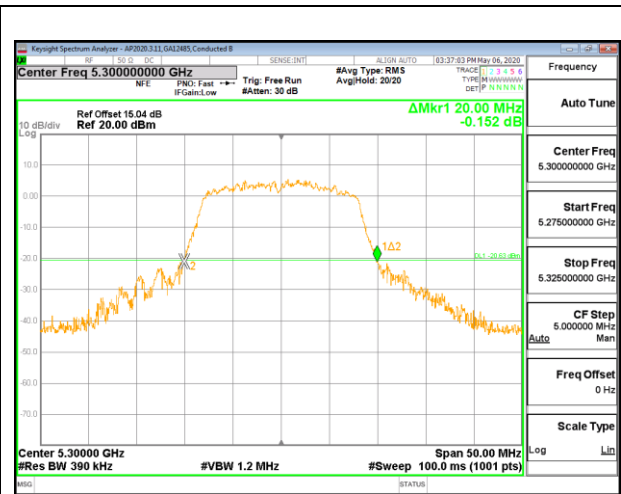
LOW CHANNEL



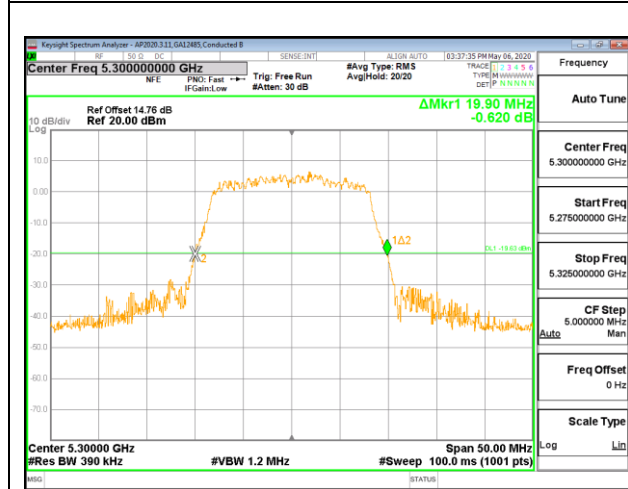
MID CHANNEL



MID CHANNEL CHAIN 0

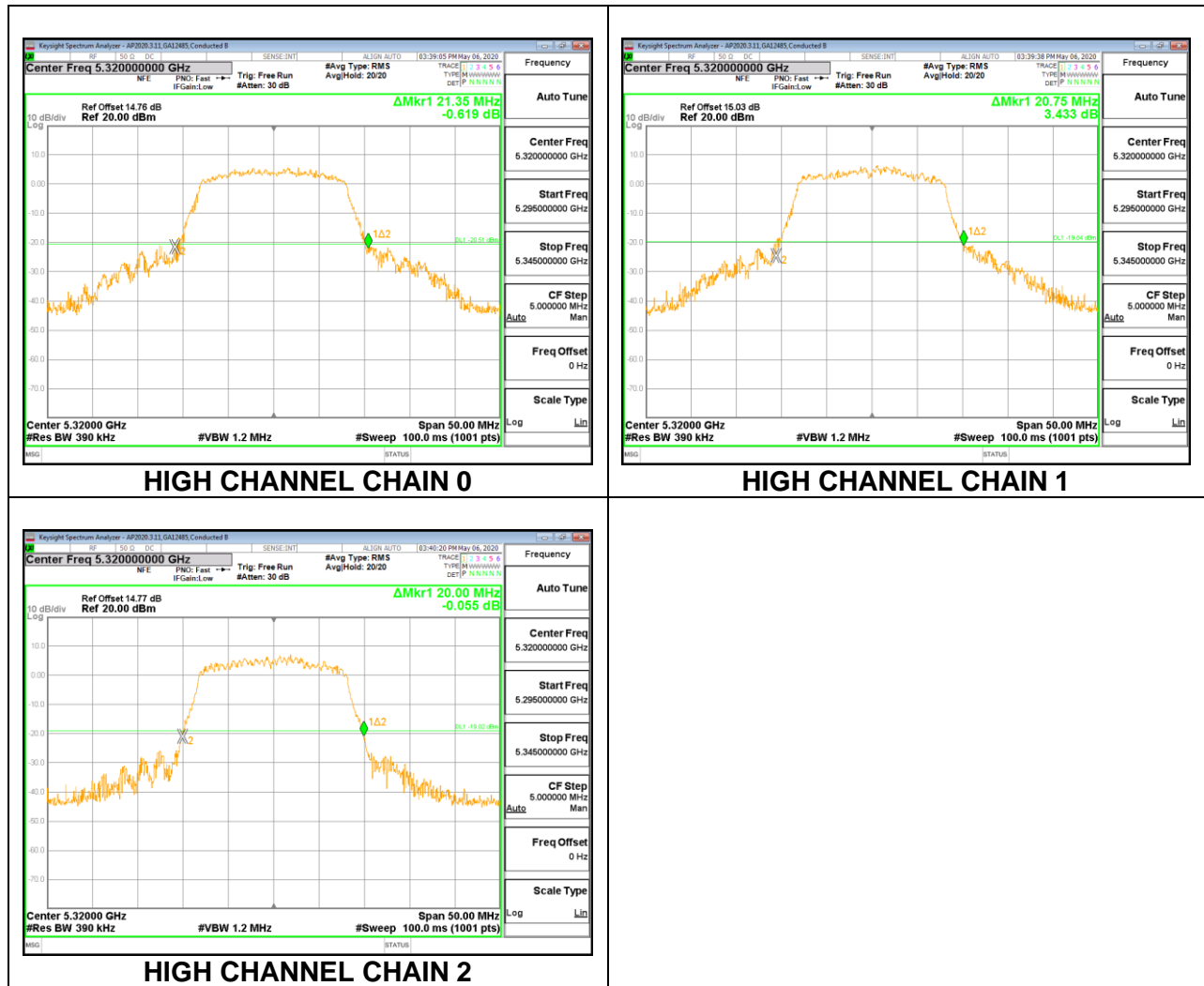


MID CHANNEL CHAIN 1



MID CHANNEL CHAIN 2

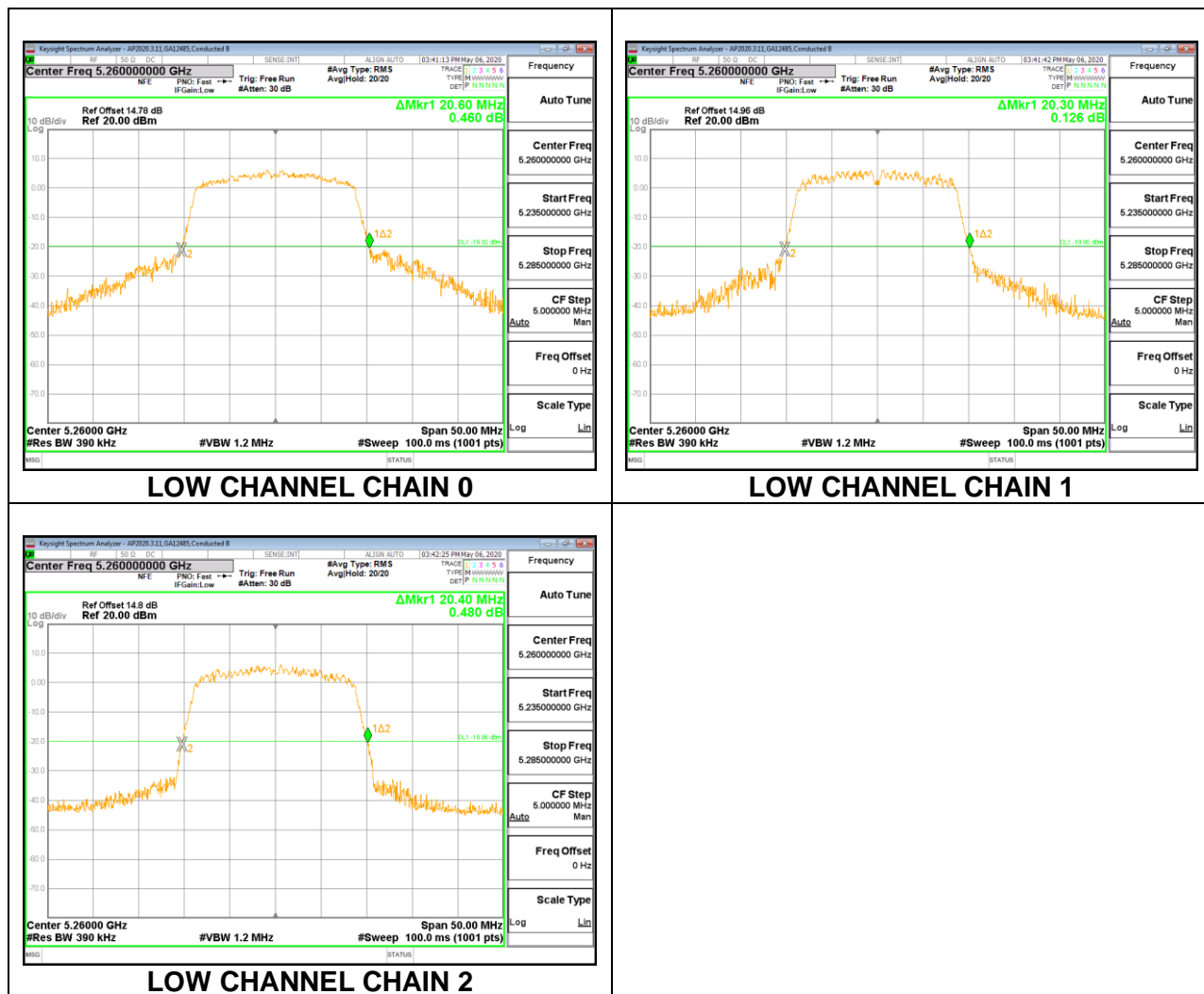
HIGH CHANNEL



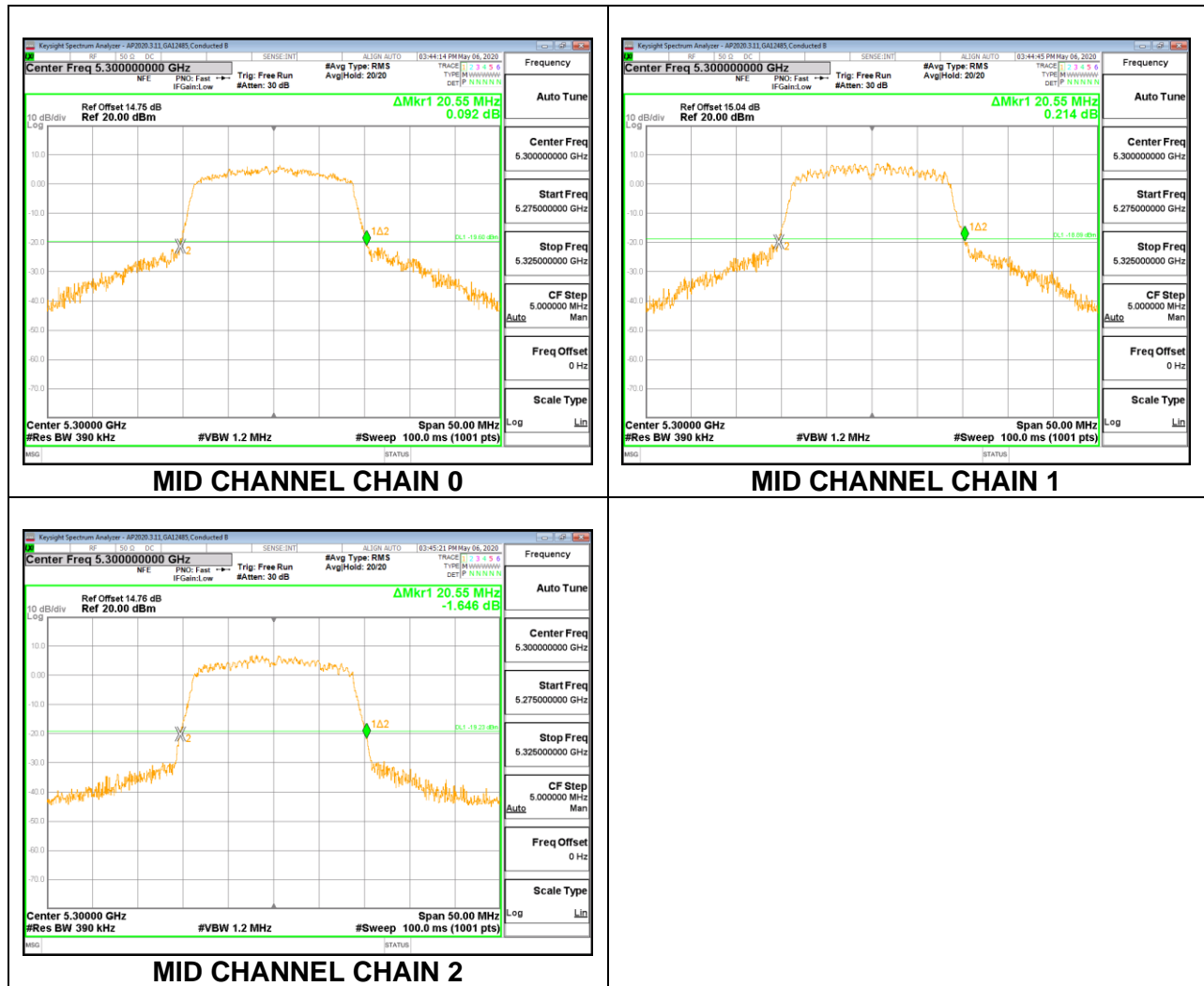
8.2.4. 802.11n HT20 MODE IN THE 5.3 GHz BAND

Channel	Frequency (MHz)	26 dB Bandwidth Chain 0 (MHz)	26 dB Bandwidth Chain 1 (MHz)	26 dB Bandwidth Chain 2 (MHz)
Low	5260	20.60	20.30	20.40
Mid	5300	20.55	20.55	20.55
High	5320	20.55	20.60	20.25

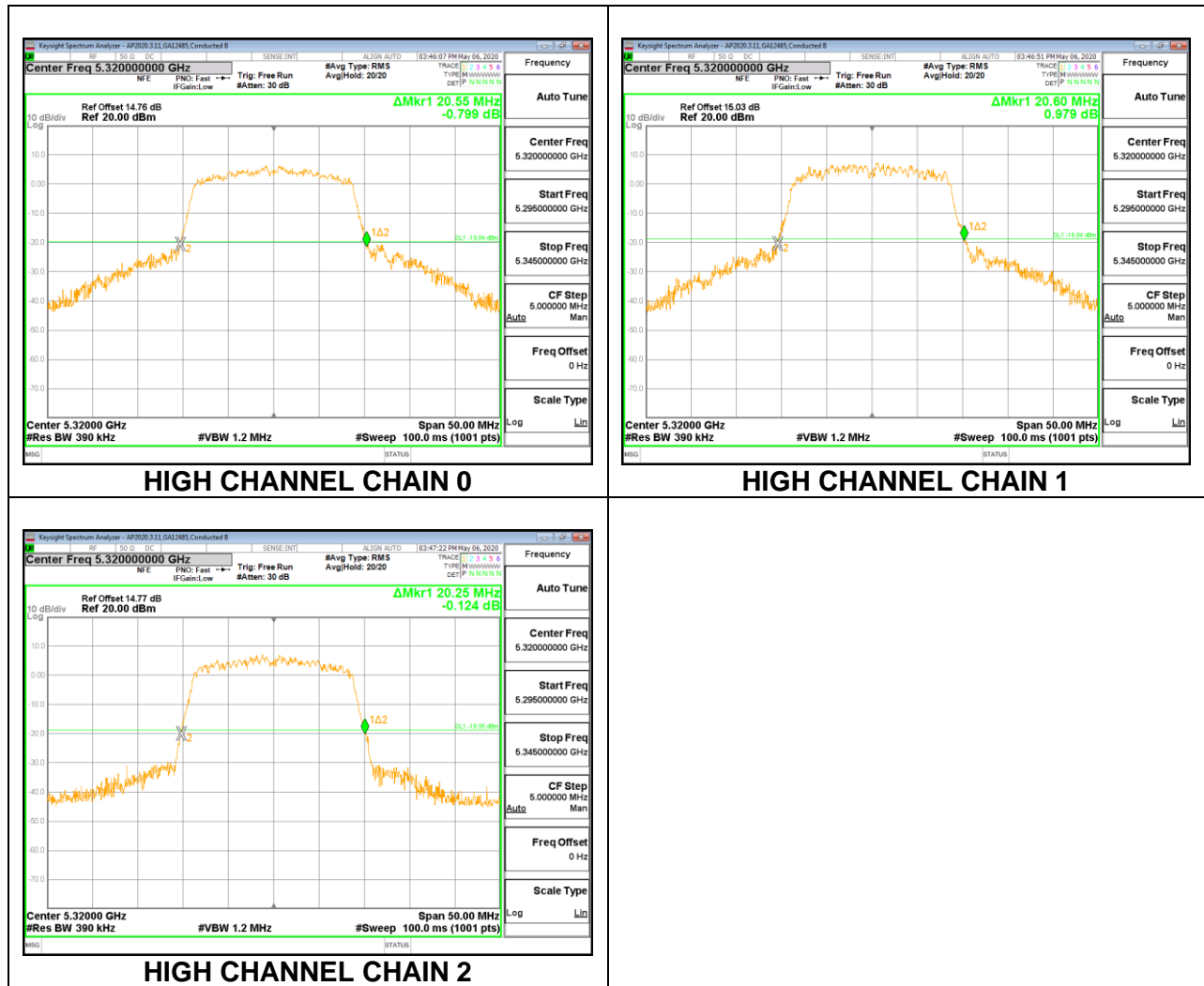
LOW CHANNEL



MID CHANNEL



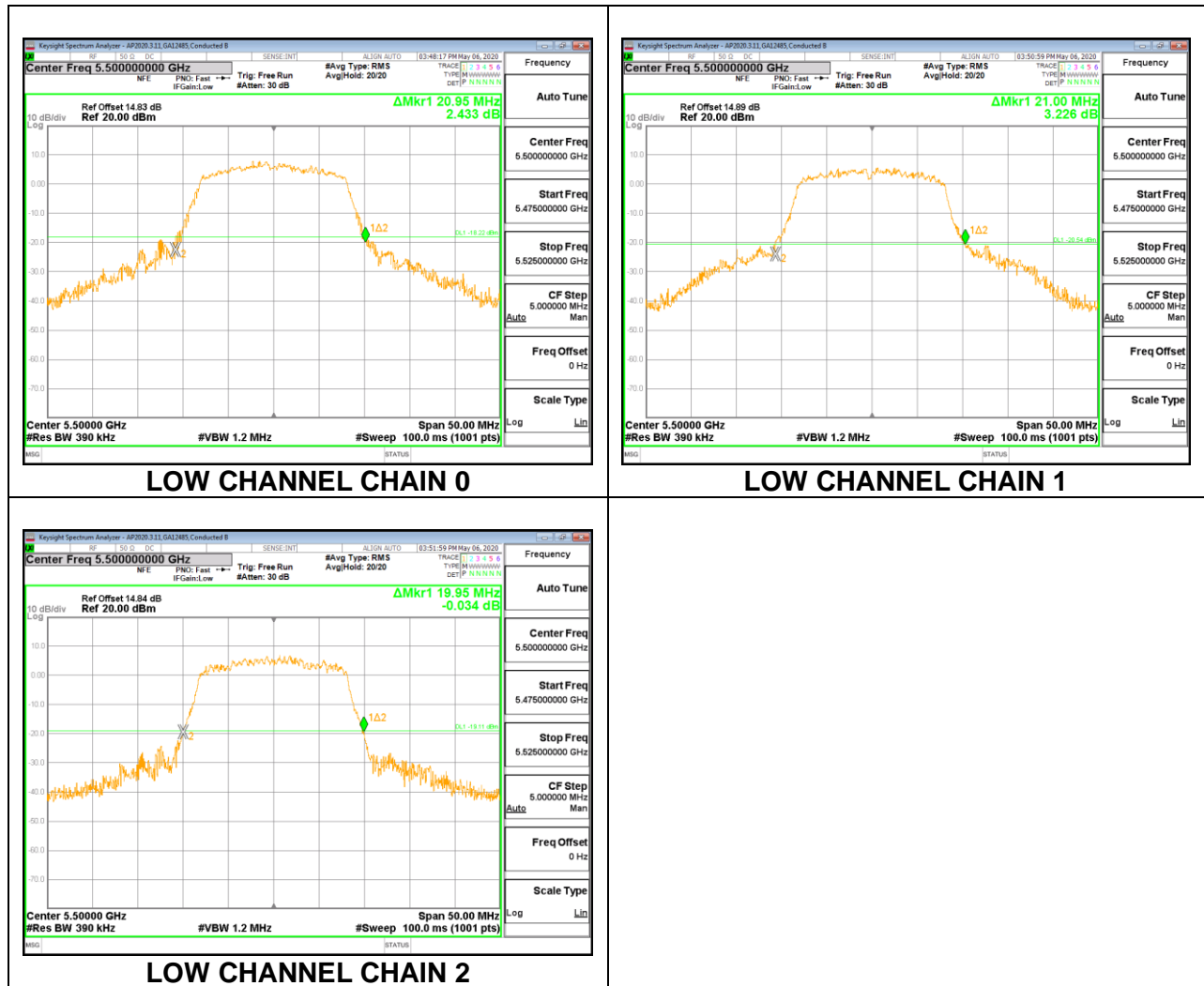
HIGH CHANNEL



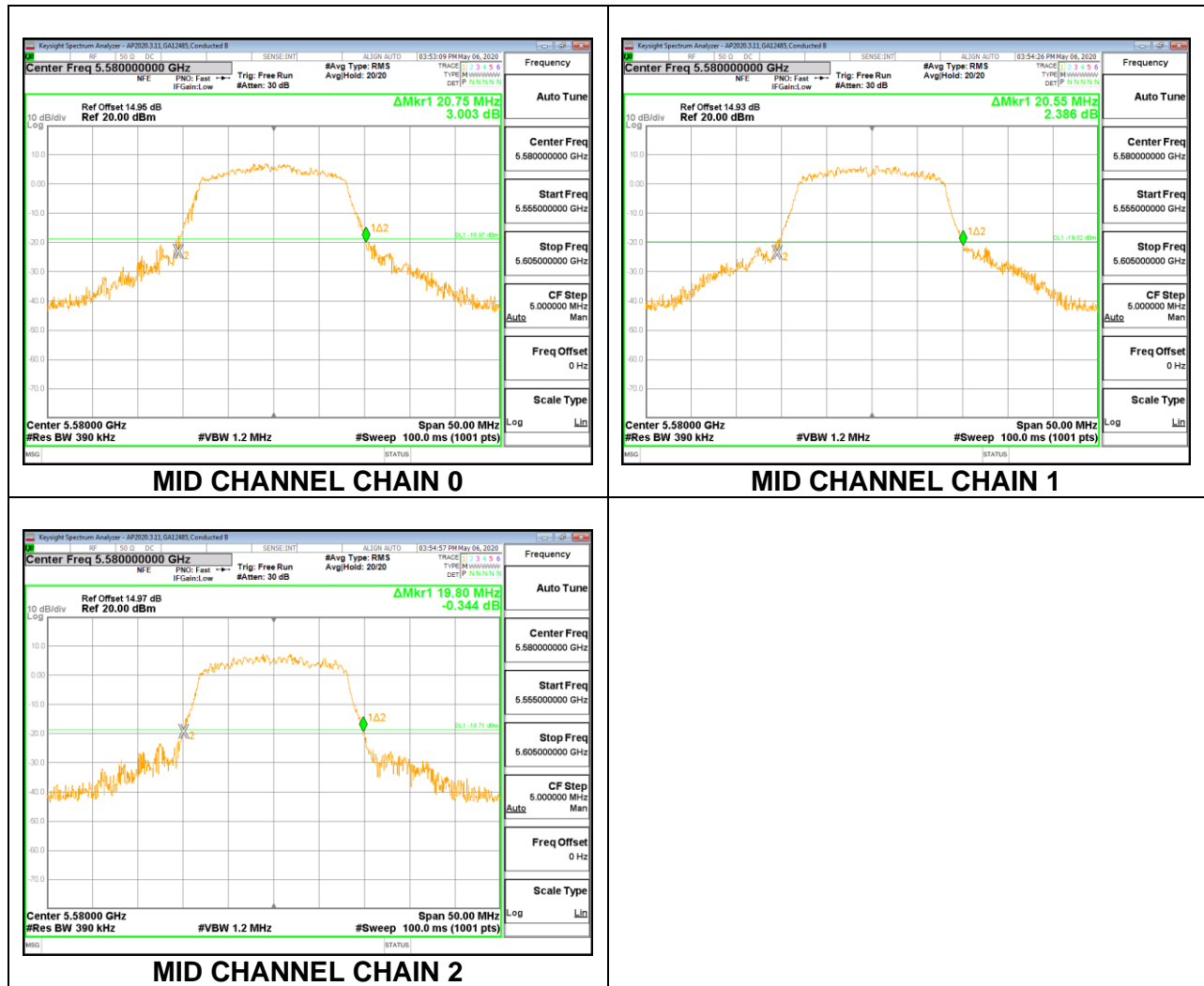
8.2.5. 802.11a MODE IN THE 5.6 GHz BAND

Channel	Frequency (MHz)	26 dB Bandwidth Chain 0 (MHz)	26 dB Bandwidth Chain 1 (MHz)	26 dB Bandwidth Chain 2 (MHz)
Low	5500	20.95	21.00	19.95
Mid	5580	20.75	20.55	19.80
High	5700	20.90	20.80	19.85

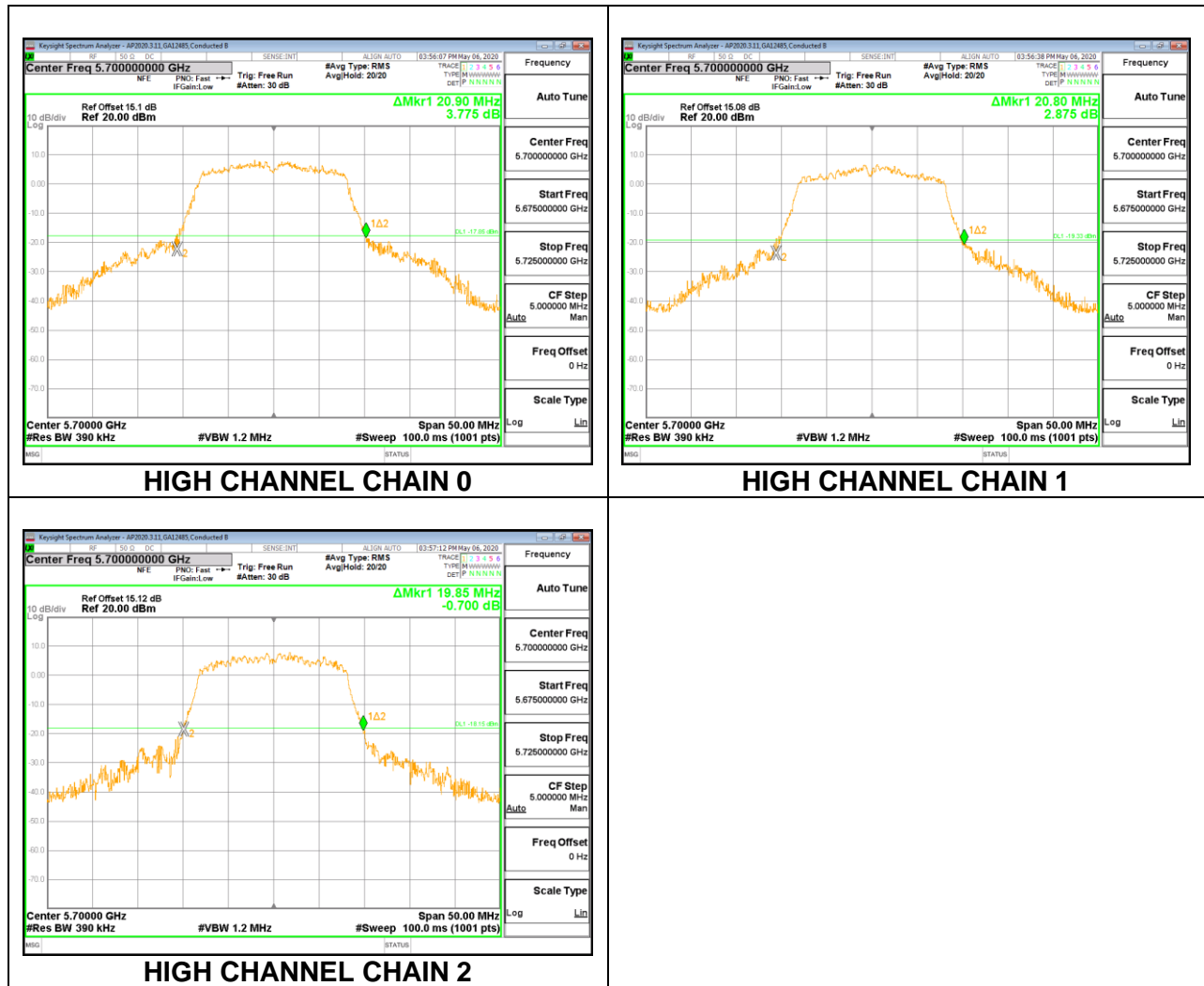
LOW CHANNEL



MID CHANNEL



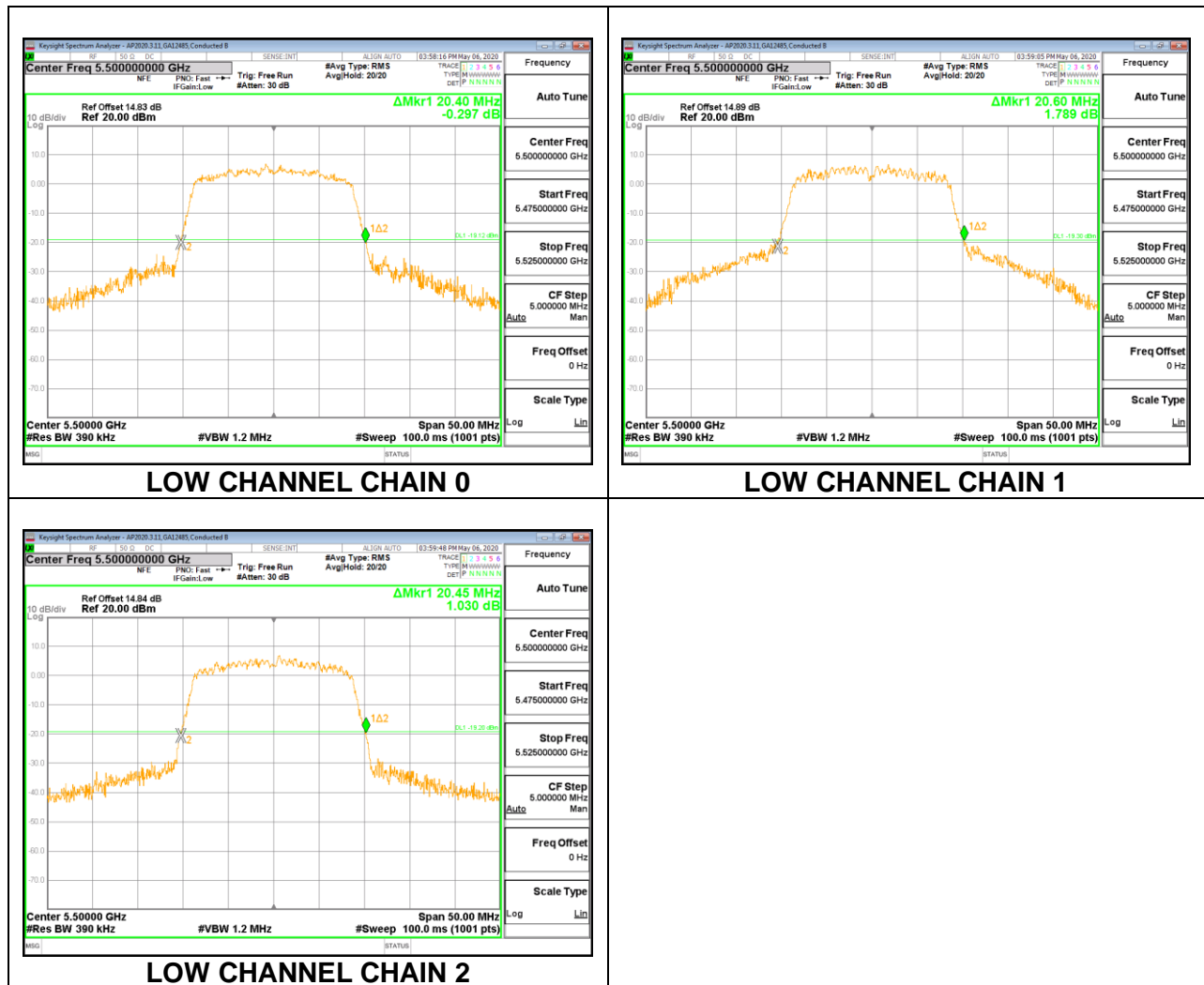
HIGH CHANNEL



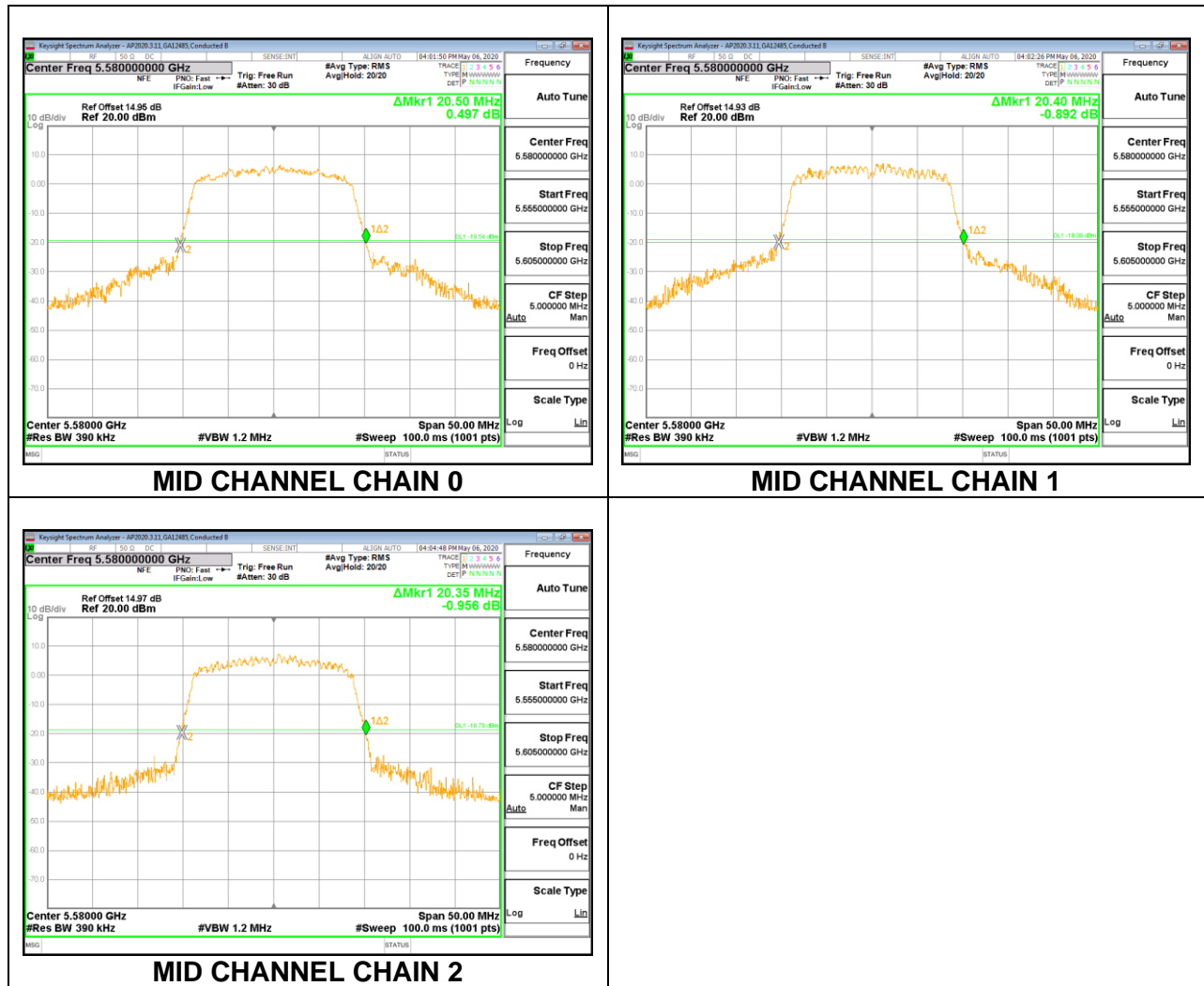
8.2.6. 802.11n HT20 MODE IN THE 5.6 GHz BAND

Frequency (MHz)	26 dB Bandwidth Chain 0 (MHz)	26 dB Bandwidth Chain 1 (MHz)	26 dB Bandwidth Chain 2 (MHz)
5500	20.40	20.60	20.45
5580	20.50	20.40	20.35
5700	20.70	20.55	20.30

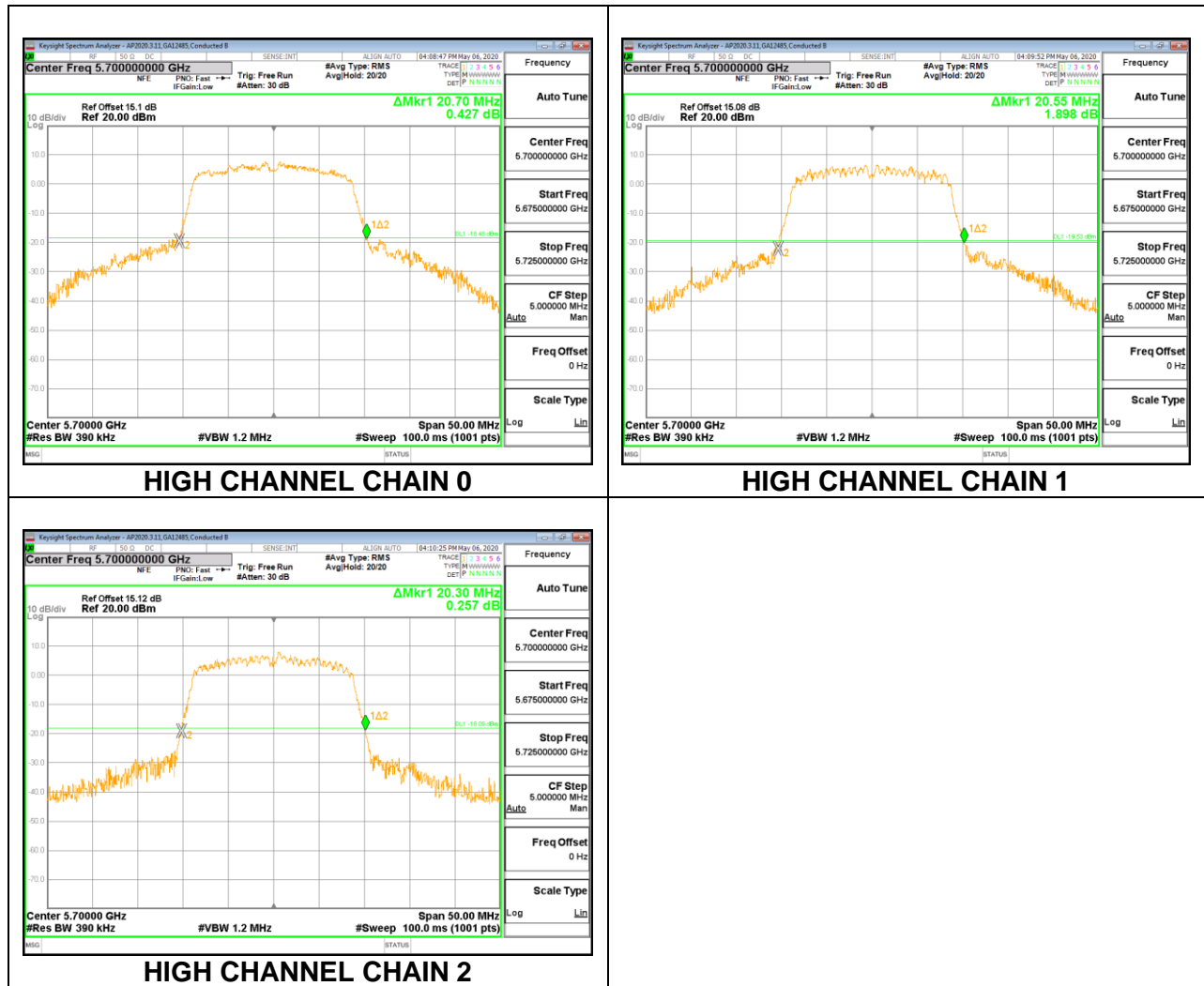
LOW CHANNEL



MID CHANNEL



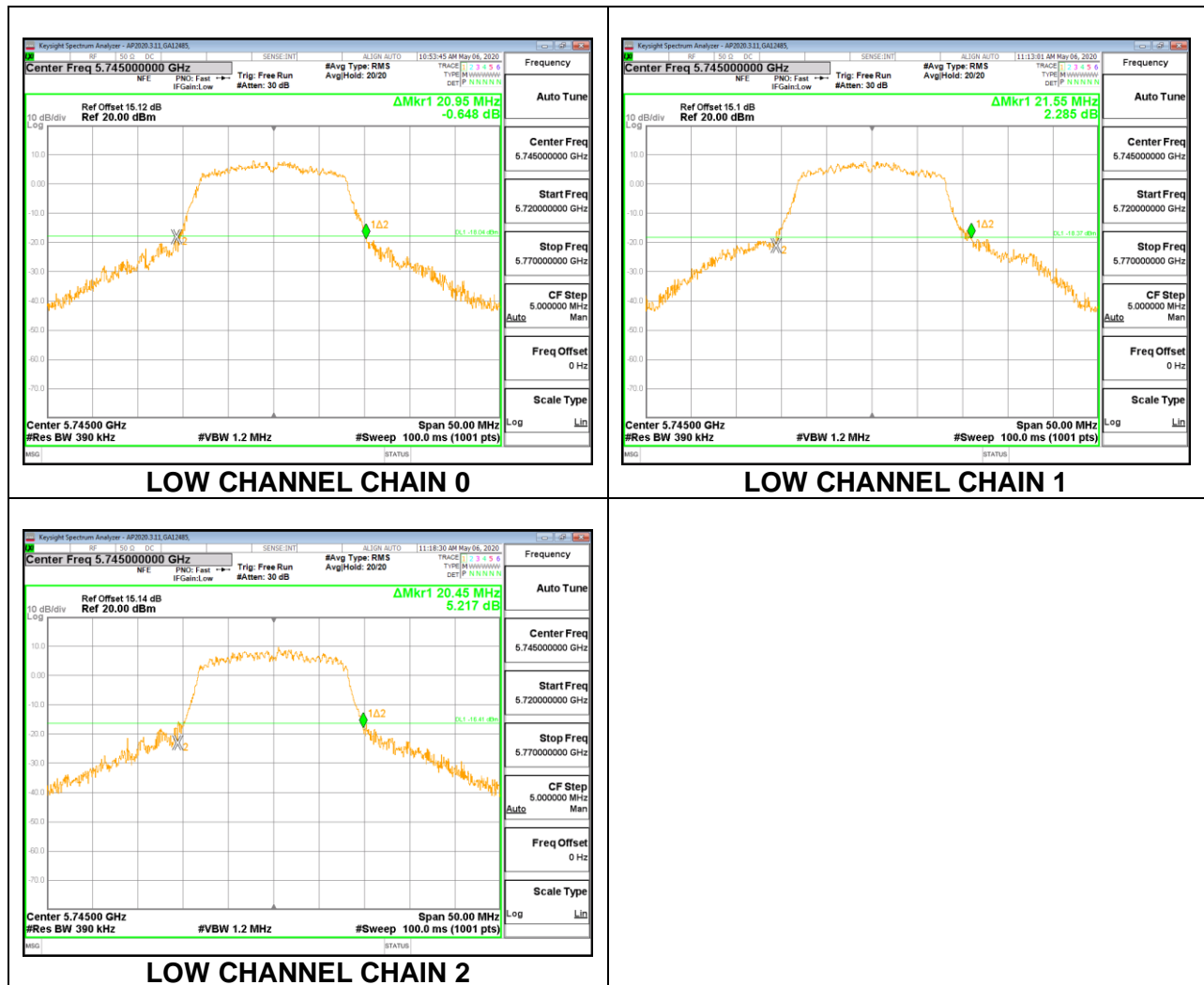
HIGH CHANNEL



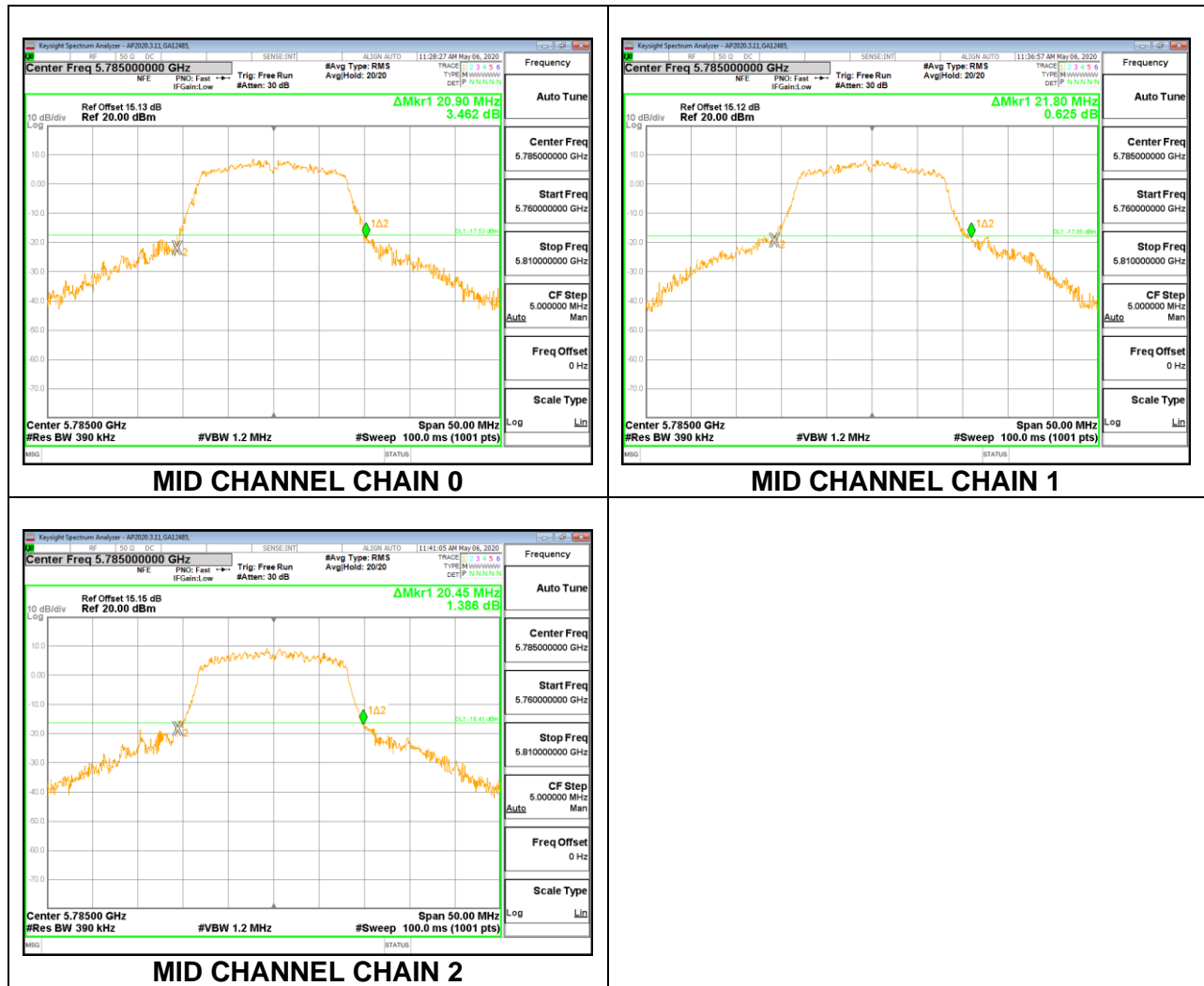
8.2.7. 802.11a MODE IN THE 5.8 GHz BAND

Channel	Frequency (MHz)	26 dB Bandwidth Chain 0 (MHz)	26 dB Bandwidth Chain 1 (MHz)	26 dB Bandwidth Chain 2 (MHz)
Low	5745	20.95	21.55	20.45
Mid	5785	20.90	21.80	20.45
High	5825	21.05	21.95	20.65

LOW CHANNEL



MID CHANNEL



HIGH CHANNEL

