ELECTROMAGNETIC EMISSIONS

CLASS II PERMISSIVE CHANGE TEST REPORT

Testing Laboratory 3702

Applicant:	Cisco Systems Inc. 125 West Tasman Dr, Bldg. P, San Jose, California, 95134 USA
Manufacturer:	Cisco Systems Inc. 125 West Tasman Dr, Bldg. P, San Jose, California, 95134 USA
Product Name:	FM4500EMB-HW
Brand Name:	Cisco Fluidmesh FM4500 EMBEDDED
Model No.:	FM4500EMB
Model Difference:	N/A
Report Number:	ER/2021/A0114
FCC ID	R5SX500E
Date of EUT Received:	October 28, 2021
Date of Test:	January 21, 2022 ~ March 8, 2022
Issue Date:	May 19, 2022

Approved By _____
Blue Yang

We hereby certify that:

The above equipment was tested by SGS Taiwan Ltd. Central RF Lab The test data, data evaluation, test procedures, and equipment configurations shown in this report were made in accordance with the procedures given in ANSI C63.10:2013 and the energy emitted by the sample EUT comply with FCC rule part §15.407.

The results of this report relate only to the sample identified in this report.

Revision History

Report Number	Revision	Description	Issue Date	Revised By	Remark
ER/2021/A0114	00	Original	May 5, 2022	Violetta Tang	*
ER/2021/A0114	01	Revise typo of the product description on page 4	May 19, 2022	Violetta Tang	

Note:

1、 The remark "*" indicates modification of the report upon requests from certification body.

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1 GENERAL INFORMATION

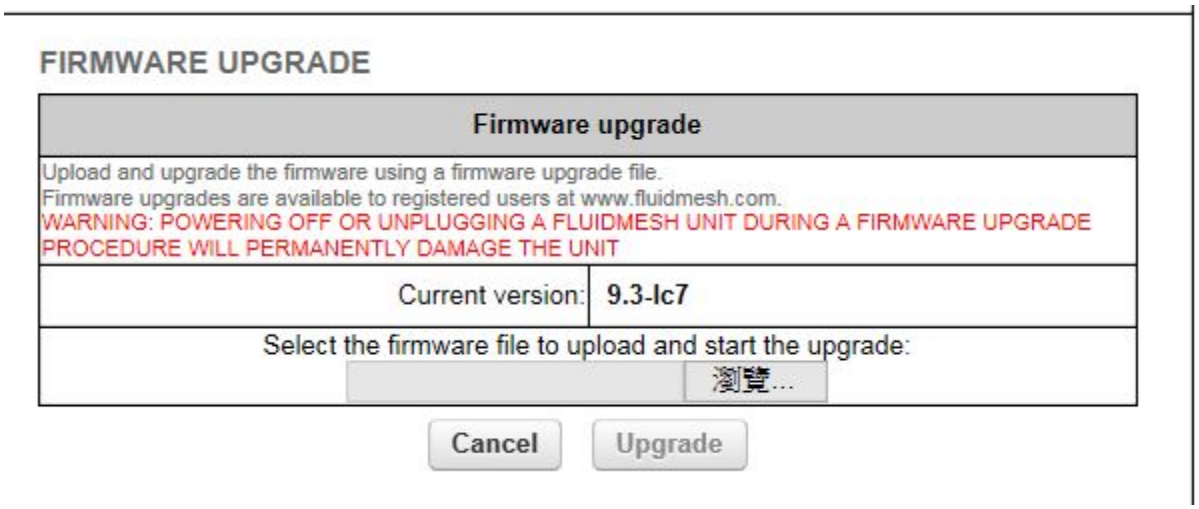
1.1 Product Description

Product Name:	FM4500EMB-HW
Brand Name:	Cisco Fluidmesh FM4500 EMBEDDED
Model No.:	FM4500EMB
Model Difference:	N/A
Hardware Version:	N/A
Firmware Version:	N/A
EUT Series No.:	3500150659
Class II Permissive Change:	FM4500EMB module INSTALLED IN FM3500, FM4500
Host Information:	Product Name: FM3500ENDO-HW Brand Name: Cisco Fluidmesh FM3500 ENDO Model Name: FM3500, FM4500 Model Differences as below. 1. Some passive components of the DCIN circuit are mounted on PCB in FM4500 model. 2. Antenna connectors are different: RPSMA on FM3500, QMA on FM4500. 3. Bottom part of FM4500 enclosure has M12 connectors instead of RJ45 ports: M12 DCIN port is added on FM4500.
Power Supply:	56Vdc

1.2 Modulation & Data Rate

Modulation type:	64QAM, 16QAM, QPSK, BPSK for OFDM
	256QAM for OFDM in 802.11ac only
Transition Rate:	802.11 n_20MHz: 6.5 - 144.4 Mbps
	802.11 n_40MHz: 13.5 - 300 Mbps
	802.11 ac_20MHz: 6.5 - 173.4 Mbps
	802.11 ac_40MHz: 13.5 - 400 Mbps
	802.11 ac_80MHz: 29.3 - 866.6 Mbps

1.3 DFS Firmware version:



1.4 FCC WLAN 5GHz:

Wi-Fi	Frequency Range	Channels	Rated Power(Avg) (dBm) (Worst Case)	Modulation Technology
n_HT/ ac_VHT 20M	5180~5240	4	9.46 dBm	OFDM
	5260~5320	4	9.26 dBm	OFDM
	5500~5700	11	9.64 dBm	OFDM
	5745-5825	5	17.55 dBm	OFDM
n_HT/ ac_VHT 40M	5190~5230	2	9.44 dBm	OFDM
	5270~5310	2	12.18 dBm	OFDM
	5510~5670	5	12.29 dBm	OFDM
	5755-5795	2	17.42 dBm	OFDM
ac_VHT 80M	5210	1	7.46 dBm	OFDM
	5290	1	7.17 dBm	OFDM
	5530~5610	2	12.27 dBm	OFDM
	5775	1	16.42 dBm	OFDM

1.5 Antenna Designation

Antenna Type	Supplier	Antenna Part No.	Freq. (MHz)	Peak Antenna Gain (dBi)	Directional Gain (dBi)
Direction	Fluidmesh	FM-TUBE	5150~5250	14.60	17.61
			5250~5350		
			5470~5725		
			5725~5850		
Omnidirection	Fluidmesh	FM-SHARK-DUAL	5150~5250	13.00	16.01
			5250~5350		
			5470~5725		
			5725~5850		
Direction	Fluidmesh	FM-HORN-90	5150~5250	10.00	13.01
			5250~5350		
			5470~5725		
			5725~5850		
Omnidirection	Fluidmesh	FM-OMNI-5-V	5150~5250	4.00	7.52
			5250~5350		
			5470~5725		
			5725~5850		
Omnidirection	Fluidmesh	FM-OMNI-5-H	5150~5250	5.00	
			5250~5350		
			5470~5725		
			5725~5850		
Omnidirection	MP Antenna LTD.	08-ANT-0985	5150~5250	3.00	6.01
			5250~5350		
			5470~5725		
			5725~5850		

Note:

1. Pre-scanned was done on the above antennas, measurements were demonstrated by using the antenna with the lowest gain as worst case scenarios.
2. Antenna information is provided by the applicant.

1.6 Test Methodology of Applied Standards

FCC Part 15, Subpart E §15.407
FCC KDB 905462 D02 UNII DFS Compliance Procedures New Rules v02

1.7 Test Facility

Laboratory	Test Site Address	Test Site Name	FCC Designation number	IC CAB identifier
SGS Taiwan Ltd. Central RF Lab. (TAF code 3702)	No.134, Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan.	SAC 1	TW0027	TW3702
		SAC 3		
		Conduction 1		
		Conducted 1		
		Conducted 2		
		Conducted 3		
		Conducted 4		
		Conducted 5		
		Conducted 6		
	No.2, Keji 1st Rd., Guishan District, Taoyuan City, Taiwan 333	Conduction C	TW0028	
		SAC C		
		SAC D		
		SAC G		
		Conducted A		
		Conducted B		
		Conducted C		
		Conducted D		
		Conducted E		
		Conducted F		
		Conducted G		
Note: Test site name is remarked on the equipment list in each section of this report as an indication where measurements occurred in specific test site and address.				

1.8 Special Accessories

There are no special accessories used while test was conducted.

1.9 Equipment Modifications

There was no modification incorporated into the EUT.

2 SUMMARY OF TEST RESULT

FCC and ISED Rules	Description Of Test	Result
§15.407(h) FCC KDB 905462 D02	TPC and DFS Measurement	Compliant

3 MEASUREMENT UNCERTAINTY

Test Items	Uncertainty		
TPC and DFS Measurement	+/-	0.88	Hz
Temperature	+/-	0.4	°C
Humidity	+/-	3.5	%
DC / AC Power Source	+/-	1	%

This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.

The conformity assessment statement in this report is based solely on the test results, measurement uncertainty is excluded.

4 TPC AND DFS MEASUREMENT

4.1 TPC Requirements

According to Part 15.407 (h)(1) Transmit power control (TPC). U-NII devices operating in the 5.25-5.35 GHz band and the 5.47-5.725 GHz band shall employ a TPC mechanism. The U-NII device is required to have the capability to operate at least 6 dB below the mean EIRP value of 30 dBm. A TPC mechanism is not required for systems with an e.i.r.p. of less than 500 mW.

Result: Yes, The EUT equipped with TPC function.

4.2 DFS: Standard Applicable

According to §15.407(h)(2) and FCC KDB 905462 D02 , Radar Detection Function of Dynamic Frequency Selection (DFS).

Radar Detection Function of Dynamic Frequency Selection (DFS). U-NII devices operating with any part of its 26 dB emission bandwidth in the 5.25-5.35 GHz and 5.47-5.725 GHz bands shall employ a DFS radar detection mechanism to detect the presence of radar systems and to avoid co-channel operation with radar systems. Operators shall only use equipment with a DFS mechanism that is turned on when operating in these bands. The device must sense for radar signals at 100 percent of its emission bandwidth. The minimum DFS detection threshold for devices with a maximum e.i.r.p. of 200 mW to 1 W is −64 dBm. For devices that operate with less than 200 mW e.i.r.p. and a power spectral density of less than 10 dBm in a 1 MHz band, the minimum detection threshold is −62 dBm. The detection threshold is the received power averaged over 1 microsecond referenced to a 0 dBi antenna. For the initial channel setting, the manufacturers shall be permitted to provide for either random channel selection or manual channel selection.

(i) Operational Modes. The DFS requirement applies to the following operational modes:

(a) The requirement for channel availability check time applies in the master operational mode.

(b) The requirement for channel move time applies in both the master and slave operational modes.

(ii) Channel Availability Check Time. A U-NII device shall check if there is a radar system already operating on the channel before it can initiate a transmission on a channel and when it has to move to a new channel. The U-NII device may start using the channel if no radar signal with a power level greater than the interference threshold values listed in paragraph (h)(2) of this section, is detected within 60 seconds.

(iii) Channel Move Time. After a radar's presence is detected, all transmissions shall cease on the operating channel within 10 seconds. Transmissions during this period shall consist of normal traffic for a maximum of 200 ms after detection of the radar signal. In addition, intermittent management and control signals can be sent during the remaining time to facilitate vacating the operating channel.

Non-occupancy Period. A channel that has been flagged as containing a radar system, either by a channel availability check or in-service monitoring, is subject to a non-occupancy period of at least 30 minutes. The non-occupancy period starts at the time when the radar system is detected.

5 APPLICABLE STANDARDS

Table 1: Applicability of DFS requirements prior to use of a channel

Requirement	Operational Mode		
	Master	Client(without radar detection)	Client(with radar detection)
Non-occupancy Period	Yes	Not required	Yes
DFS Detection Threshold	Yes	Not required	Yes
Channel Availability Check Time	Yes	Not required	Not required
U-NII Detection Band-width	Yes	Not required	Yes

Table 2: Applicability of DFS requirements during normal operation

Requirement	Operational Mode	
	Master Device or Client with Radar Detection	Client Without Radar Detection
DFS Detection Threshold	Yes	Not required
Cannel Closing Transmis-sion time	Yes	Yes
Channel Move time	Yes	Yes
U-NII Detection Bandwidth	Yes	Not required

Additional requirements for devices with multiple bandwidth mode	Master Device or Client with Radar Detection	Client Without Radar Detection
U-NII Detection Bandwidth and Statistical Performance Check	All BW modes must be tested	Not required
Channel Move Time and Channel Closing Transmission Time	Test using widest BW mode available	Test using the widest BW mode available for the link
All other tests	Any single BW mode	Not required
Note: Frequencies selected for statistical performance check (Section 7.8.4) should include several frequencies within the radar detection bandwidth and frequencies near the edge of the radar detection bandwidth. For 802.11 devices it is suggested to select frequencies in each of the bonded 20 MHz channels and the channel center frequency.		

Table 3: Interference Threshold values, Master or Client incorporating In-Service Monitoring

Maximum Transmit Power	Value (See Notes 1, 2, and 3)
EIRP ≥ 200 milliwatt	-64 dBm
EIRP < 200 milliwatt and power spectral density < 10 dBm/MHz	-62 dBm
EIRP < 200 milliwatt that do not meet the power spectral density requirement	-64 dBm
Note 1: This is the level at the input of the receiver assuming a 0 dBi receive antenna. **Note 2:** Throughout these test procedures an additional 1 dB has been added to the amplitude of the test transmission waveforms to account for variations in measurement equipment. This will ensure that the test signal is at or above the detection threshold level to trigger a DFS response. **Note3:** EIRP is based on the highest antenna gain. For MIMO devices refer to KDB Publication 662911 D01.		

Table 4: DFS Response requirement values

Parameter	Value
Non-occupancy period	Minimum 30 minutes
Channel Availability Check Time	60 seconds
Channel Move Time	10 seconds See Note 1.
Channel Closing Transmission Time	200 milliseconds + an aggregate of 60 milliseconds over remaining 10 second period. See Notes 1 and 2.
U-NII Detection Bandwidth	Minimum 100% of the U-NII 99% transmission power bandwidth. See Note 3.

Note 1: Channel Move Time and the Channel Closing Transmission Time should be performed with Radar Type 0. The measurement timing begins at the end of the Radar Type 0 burst.
Note 2: The Channel Closing Transmission Time is comprised of 200 milliseconds starting at the beginning of the Channel Move Time plus any additional intermittent control signals required to facilitate a Channel move (an aggregate of 60 milliseconds) during the remainder of the 10 second period. The aggregate duration of control signals will not count quiet periods in between transmissions.
Note 3: During the U-NII Detection Bandwidth detection test, radar type 0 should be used. For each frequency step the minimum percentage of detection is 90 percent. Measurements are performed with no data traffic.

Table 5: Radar Test Waveforms

Short Pulse Radar

Radar Type	Pulse Width (µsec)	PRI (µsec)	Number of Pulses	Minimum Percentage of Successful Detection	Minimum Number of Trials
0	1	1428	18	See Note 1	See Note 1
1	1	Test A: 15 unique PRI values randomly selected from the list of 23 PRI values in Table 5a	Roundup $\left\{\left(\frac{1}{360}\right)\cdot\left(\frac{19\cdot10^6}{PRI_{\mu sec}}\right)\right\}$	60%	30
		Test B: 15 unique PRI values randomly selected within the range of 518-3066 µsec, with a minimum increment of 1 µsec, excluding PRI values selected in Test A			
2	1-5	150-230	23-29	60%	30
3	6-10	200-500	16-18	60%	30
4	11-20	200-500	12-16	60%	30
Aggregate (Radar Types 1-4)				80%	120
Note 1: Short Pulse Radar Type 0 should be used for the detection bandwidth test, channel move time, and channel closing time tests.					

Long Pulse Radar

Radar Type	Pulse Width (µsec)	Chirp Width (MHz)	PRI (µsec)	Number of Pulses per *Burst*	Number of *Bursts*	Minimum Percentage of Successful Detection	Minimum Number of Trials
5	50-100	5-20	1000-2000	1-3	8-20	80%	30

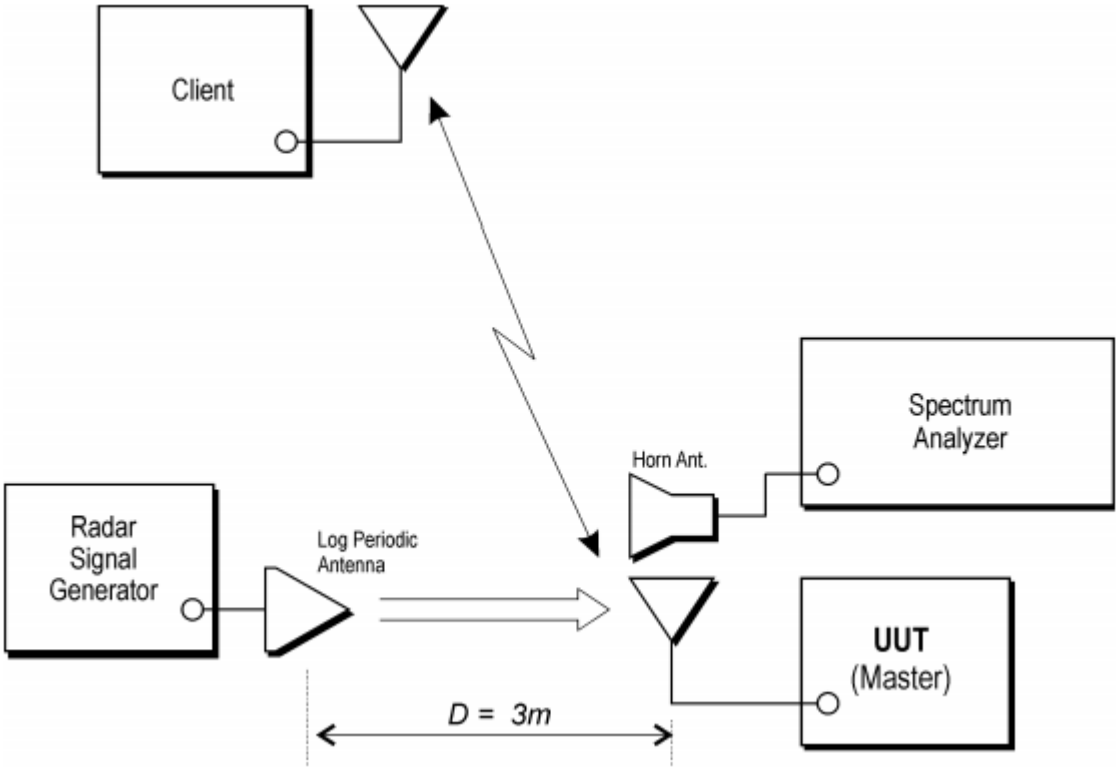
Frequency Hopping Radar

Radar Type	Pulse Width (µsec)	PRI (µsec)	Pulses per Hop	Hopping Rate (kHz)	Hopping Sequence Length (msec)	Minimum Percentage of Successful Detection	Minimum Number of Trials
6	1	333	9	0.333	300	70%	30

The applicant of this given application confirms that information regarding the parameters of the detected Radar Waveforms is not available to the end user.

6 TEST SETUP

Setup for Master with injection at the Master (Radiated)



7 TEST EQUIPMENT USED:

Radiated Emission Test Site: FAC 3					
EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL.	CAL DUE.
Horn antenna	ETS.LINDGREN	3117	139056	11/25/2021	11/24/2022
Horn antenna	ETS.LINDGREN	3117	135200	12/27/2021	12/26/2022
EXA Spectrum Analyzer	KEYSIGHT	N9010B	MY60242081	09/30/2021	09/29/2022
Signal Generator	KEYSIGHT	N5182B	MY61252553	09/22/2021	09/21/2022

8 DESCRIPTION OF EUT:

EUT operates over below frequency ranges.

UNII-Band	
☒	UNII-2A (5250-5350 MHz)
☒	UNII-2C (5470-5725 MHz)

And is a Master device with radar detection and DFS capability

The EUT utilizes below architecture and nominal channel bandwidths.

802.11	20M	40M	80M	160M
a	☐	N/A	N/A	N/A
n	☒	☒	N/A	N/A
ac	☒	☒	☒	☐
ax	☐	☐	☐	☐

Timing plots are required with calculations demonstrating a minimum channel loading of approximately 17% or greater.

The rated output power of the master unit is ≧23dBm(EIRP).therefore the required interference threshold level is -64dBm.after correction for antenna gain and procedural adjustments, the required conducted threshold at the antenna port is -64dBm.

The rated output power of the master unit is <23 dBm(EIRP).therefore the required interference threshold level is -62dBm.after correction for antenna gain and procedural adjustments, the required threshold at the antenna port is -62dBm.

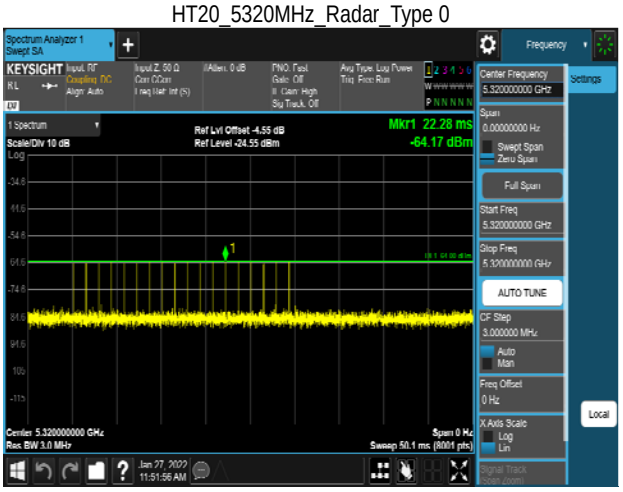
While calibrate the path on antenna port of DFS test equipment (master), measurements equipments (spectrum) is ensured to be 50 Ohms, and therefore verification on antenna gain measurement can be ignored.

The EUT uses one transmitter/receiver chains and one receive only chain, each connected to an antenna to perform radiated tests.

The Slave device associated with the EUT during these tests does not have radar detection capability.

9 RADAR TYPE WAVEFORM CALIBRATION AT DFS DETECTION THESHOLD

HT20_5320MHz_Radar_Type 0



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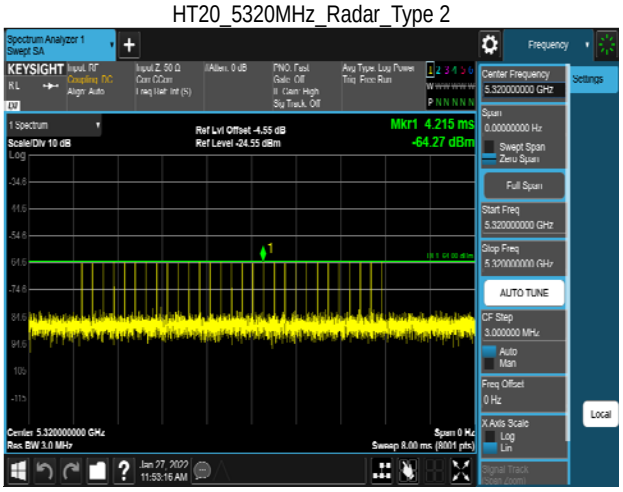
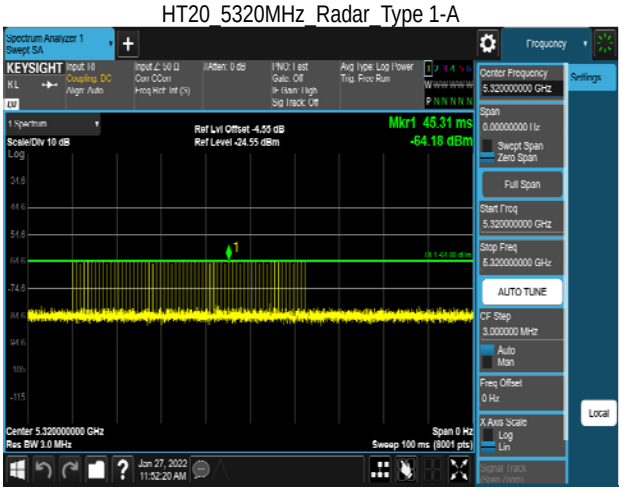
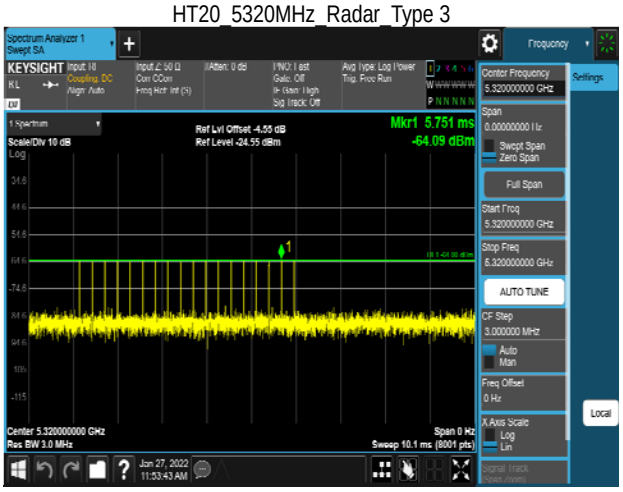


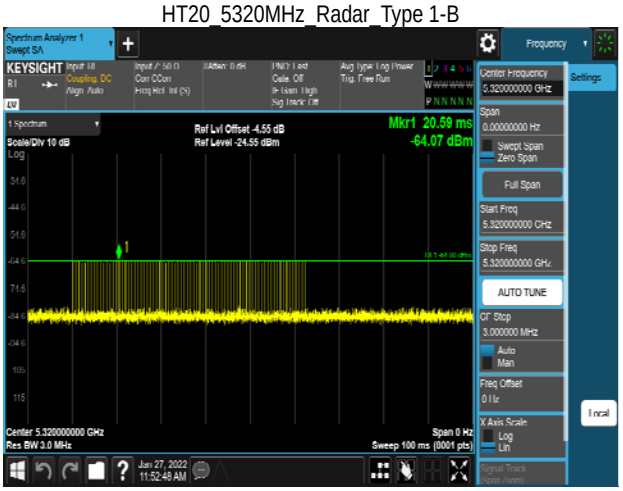
HT20_5320MHz_Radar_Type 1-A



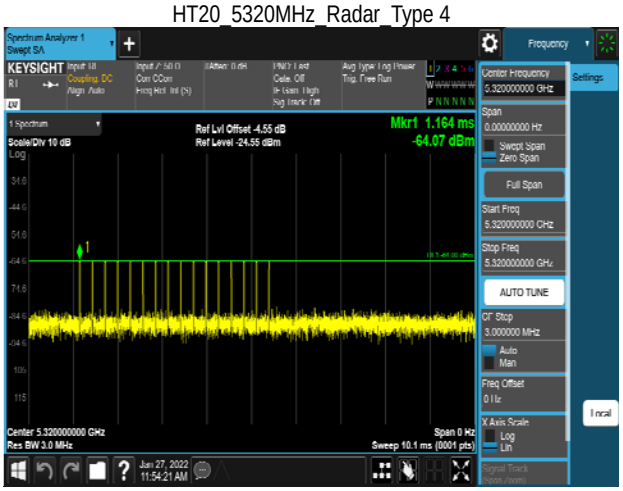
HT20_5320MHz_Radar_Type 3



HT20_5320MHz_Radar_Type 1-B



HT20_5320MHz_Radar_Type 4



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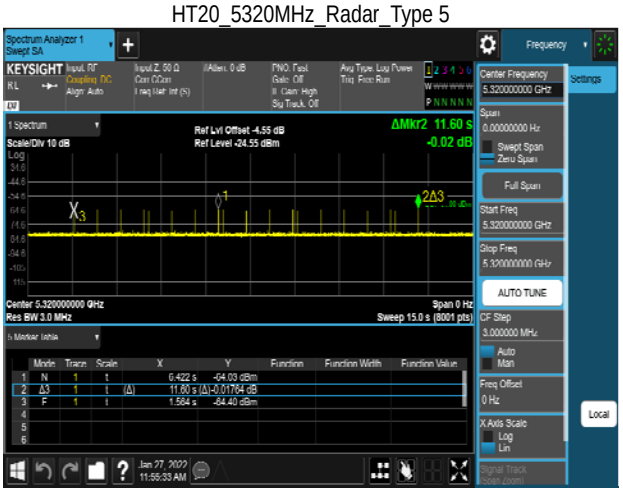
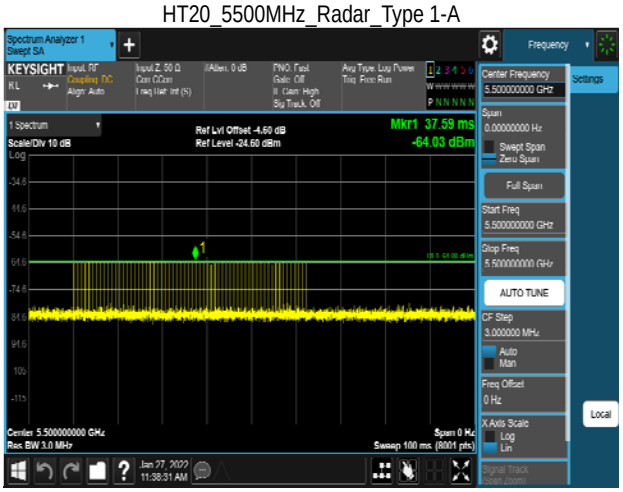


HT20_5500MHz_Radar_Type 1-A



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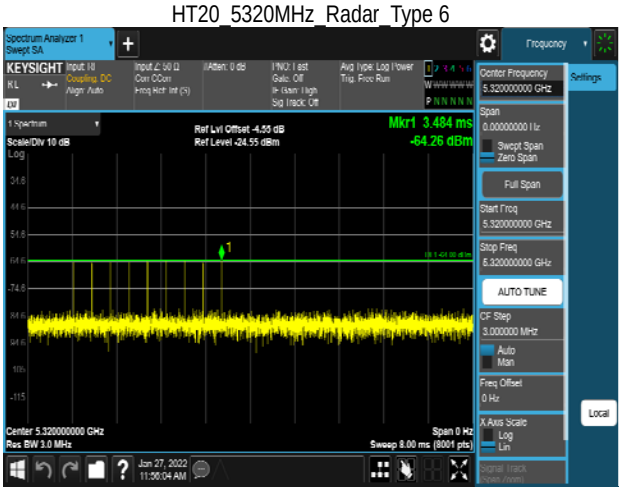
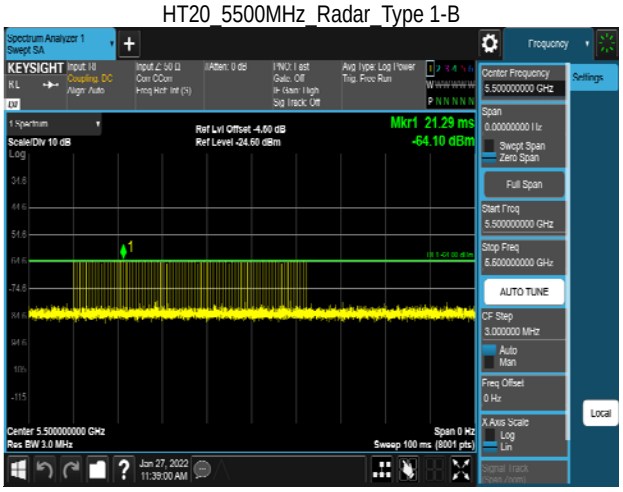
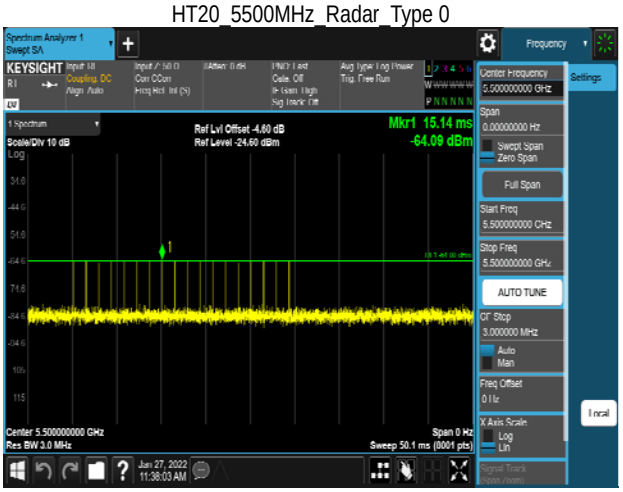


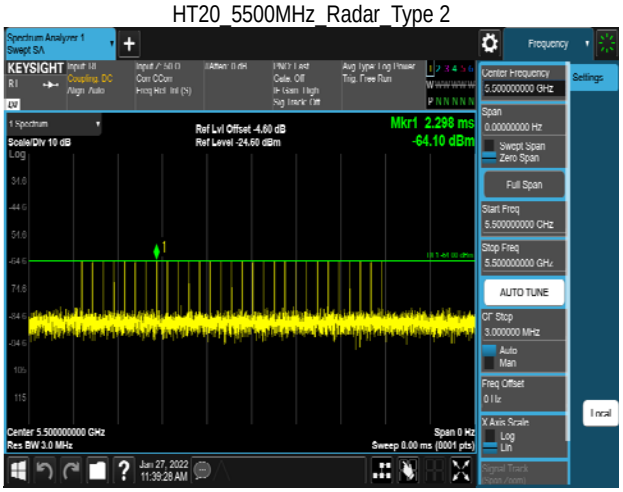
HT20_5500MHz_Radar_Type 1-B



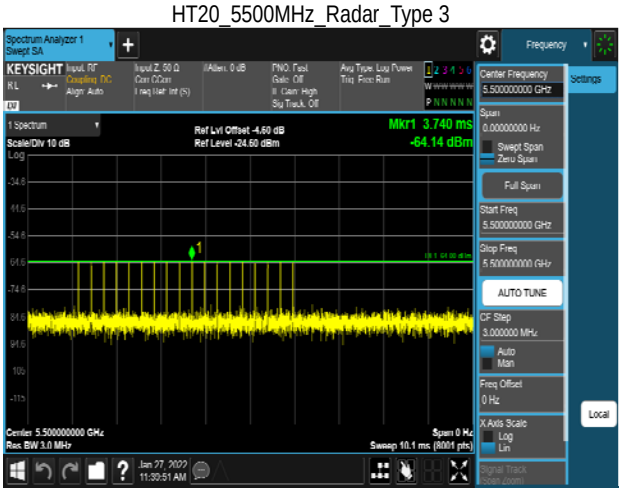
HT20_5500MHz_Radar_Type 0



HT20_5500MHz_Radar_Type 2



HT20_5500MHz_Radar_Type 3



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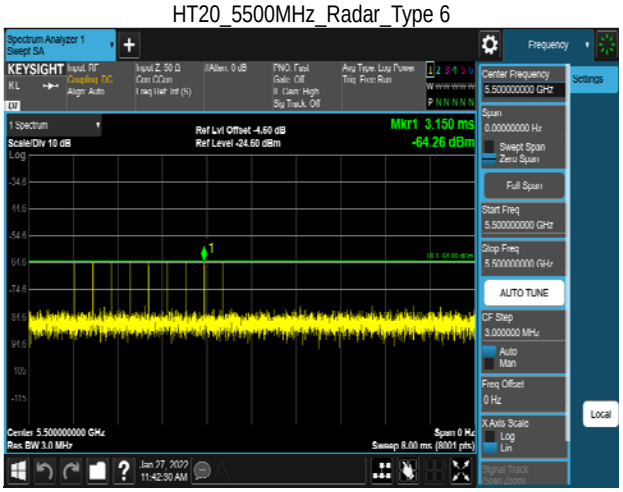

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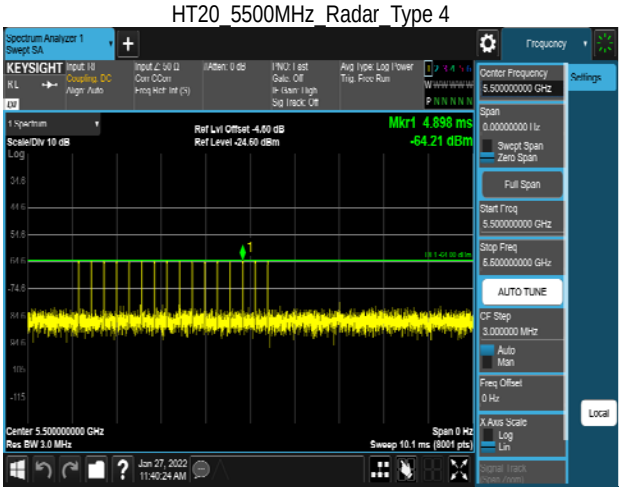

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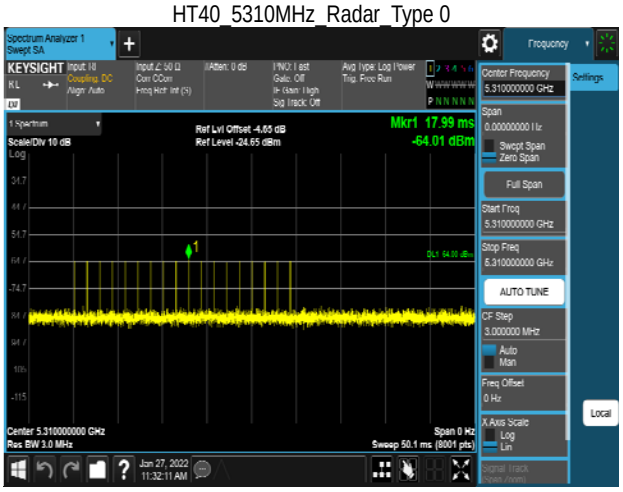
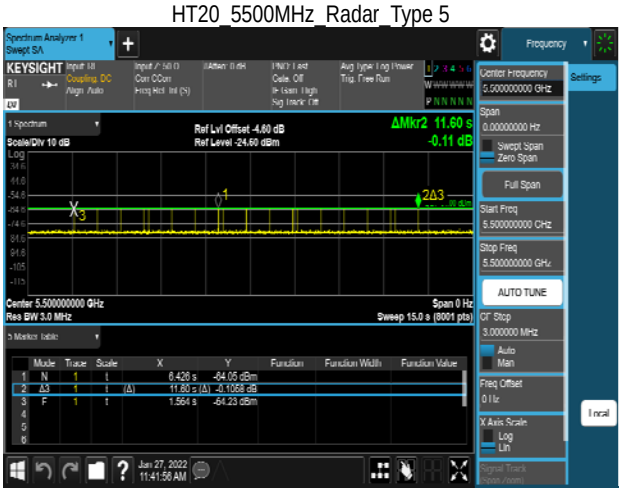
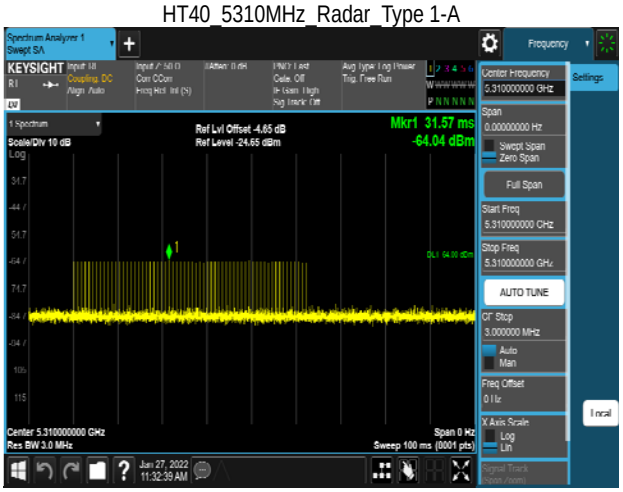


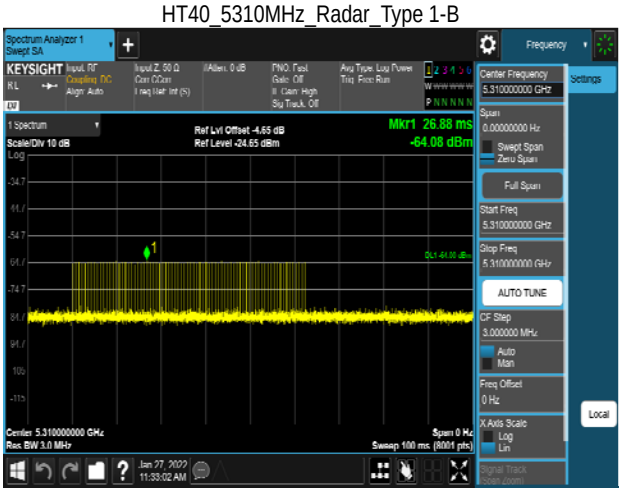
HT20_5500MHz_Radar_Type 5



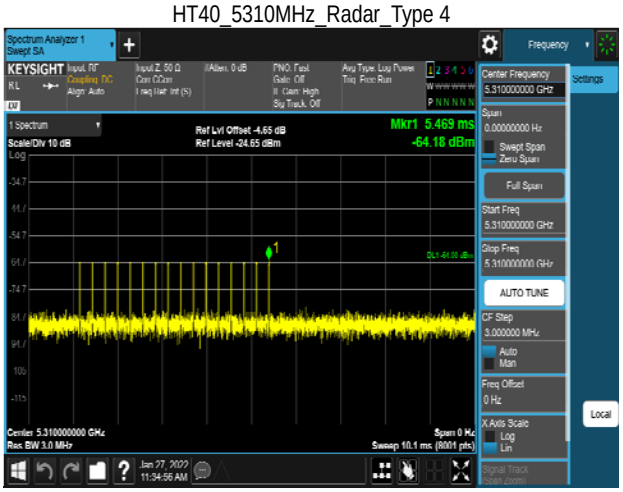
HT40_5310MHz_Radar_Type 1-A



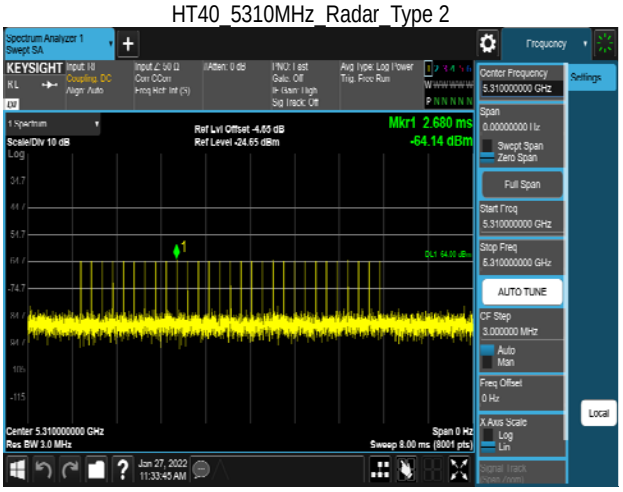
HT40_5310MHz_Radar_Type 1-B



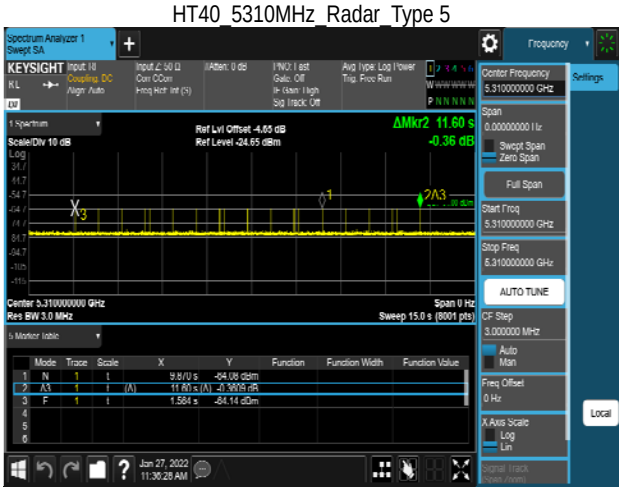
HT40_5310MHz_Radar_Type 4



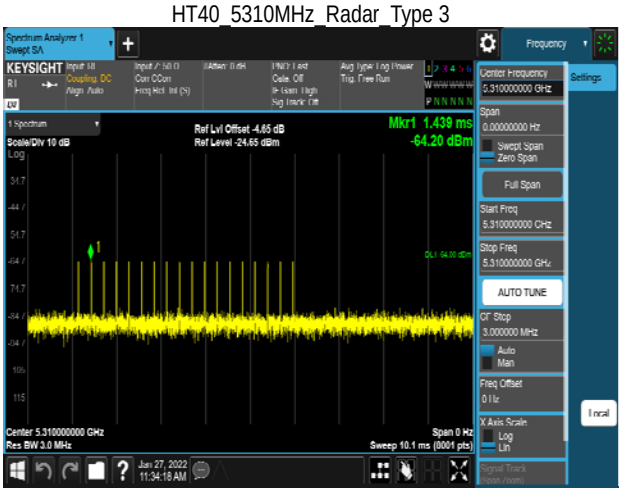
HT40_5310MHz_Radar_Type 2



HT40_5310MHz_Radar_Type 5



HT40_5310MHz_Radar_Type 3



HT40_5310MHz_Radar_Type 6