DYNAMIC FREQUENCY SELECTION

DFS Test Report

APPLICANT	:	**Motorola Solutions Inc.**
EQUIPMENT 1	:	**1)EVOLVE SMART HANDHELD W STD BATTERY**
		2)EVOLVE SMART HANDHELD W HICAP BATT
EQUIPMENT 2	:	**EVOLVE-i IS SMART HANDHELD W IS HICAP BATT**
BRAND NAME	:	**Motorola Solutions**
MODEL NAME 1	:	**EVOLVE**
MODEL NAME 2	:	**EVOLVE-i**
MODEL NUMBER 1	:	**1)HK2136A**
		2)HK2156A
MODEL NUMBER 2	:	**HK2137A**
FCC ID	:	**AZ489FT7134**
STANDARD	:	**FCC Part 15 Subpart E**
CLASSIFICATION	:	**(NII) Unlicensed National Information Infrastructure**
TEST DATE(S)	:	**Oct. 05, 2021**

We, Sporton International (Kunshan) Inc., would like to declare that the tested sample has been evaluated in accordance with the procedures and shown to be compliant with the applicable technical standards.

The test results in this report apply exclusively to the tested model / sample. Without written approval of Sporton International (Kunshan) Inc., the test report shall not be reproduced except in full.

Jason Jia

Reviewed by: Jason Jia / Supervisor

Alex wang

Approved by: Alex Wang / Manager

ACCREDITED
Cert #5145.02

Sporton International (Kunshan) Inc.
No. 1098, Pengxi North Road, Kunshan Economic Development Zone Jiangsu Province 215300
People's Republic of China

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REVISION HISTORY

REPORT NO.	VERSION	DESCRIPTION	ISSUED DATE
FZ052616-24	Rev. 01	Initial issue of report	Dec. 21, 2021
FZ052616-24	Rev. 02	Update the Equipment 1's name	Jun. 07, 2022

SUMMARY OF DYNAMIC FREQUENCY SELECTION TEST

UNII	Bandwidth and Channel	Description	Measured	Limit	Result
U-NII-2C 5500-5720MHz	80MHz (CH106) 5530MHz	Channel Move Time	504.017ms	10 sec	Pass
		Channel Closing Transmission time	<200ms + 32.8ms (aggregate)	200 ms + aggregate of 60 ms over remaining 10 s period	Pass
		Non-Occupancy Period and Client Beacon Test	No transmission or Beacons occurred	30 minutes	Pass

Note: Since the product is client without radar detection function, only Channel Move Time, Channel Closing Transmission Time and Non-Occupancy Period Test are required to be performed.

1 General Description

1.1. Applicant

Motorola Solutions Inc.
8000 West Sunrise Boulevard, Fort Lauderdale, Florida

1.2. Manufacturer

Motorola Solutions Malaysia Sdn. Bhd.
Plot 2A, Medan Bayan Lepas, Mukim 12, S.W.D. 11900 Bayan Lepas, Penang, Malaysia.

1.3. Feature of Equipment Under Test

Product Feature	
Equipment 1	1)EVOLVE SMART HANDHELD W STD BATTERY 2)EVOLVE SMART HANDHELD W HICAP BATT
Equipment 2	EVOLVE-i IS SMART HANDHELD W IS HICAP BATT
Brand Name	Motorola Solutions
Model Name 1	EVOLVE
Model Name 2	EVOLVE-i
Model Number 1	1)HK2136A 2)HK2156A
Model Number 2	HK2137A
FCC ID	AZ489FT7134
IMEI Code	354850210041802/354850215041807
HW Version	PVT
SW Version	EVOLVE-userdebug 10 QKQ1.200623.002 D01.01.43 release-keys
EUT Stage	Identical Prototype

Remark:

1. The above EUT's information was declared by manufacturer. Please refer to the specifications or user's manual for more detailed description.

2. This is a variant report. The purpose is to add 802.11ac VHT20/VHT40/VHT80 by software, for sample change note from HW P2.0 to HW PVT Stage, please refer the Product Equality Declaration as Appendix B. Based on the similarity between current and previous project, only the related test cases of 802.11 ac mode were verified from Original test report which can be found on FCC website under original application.

3. According to the Product Equality Declaration as Appendix B about the difference between EVOLVE and EVOLVE-i, the test result is not affected by two samples, we only performed testing about adding 802.11ac mode with EVOLVE sample.

1.4. Product Specification of Equipment Under Test

Product Specification subjective to this standard	
DFS Function	Client without radar detection function
Tx/Rx Channel Frequency Range	5260 MHz ~ 5320 MHz 5500 MHz ~ 5720 MHz
EUT support WLAN function	802.11a 802.11n HT20 802.11n HT40 802.11ac VHT20 802.11ac VHT40 802.11ac VHT80
Type of Modulation	802.11a/n : OFDM (BPSK / QPSK / 16QAM / 64QAM) 802.11ac : OFDM (BPSK / QPSK / 16QAM / 64QAM / 256QAM)

1.5. Modification of EUT

No modifications are made to the EUT during all test items.

1.6. Specification of Accessory

Accessories Information				
MUC Charger base	**Brand Name**	Motorola	**Model Name**	PMPN4563A
	Description	CHGR DESKTOP MULTI UNIT EXT PS BASE		
AC Adapter MUC (US)	**Brand Name**	Motorola	**Model Name**	PMPN4564A
	Power Rating	I/P: 100 - 240Vac, 1.3A, O/P: 15Vdc, 6A		
AC Adapter 1 (US) Micro-USB rapid-rate plug-in charger	**Brand Name**	Motorola	**P/N**	PS000150A11
	Power Rating	I/P: 100 - 240Vac, 0.25A, O/P: 5Vdc, 1.5A		
DC Adapter 2 Vehicular Power Adapter (VPA)	**Brand Name**	Motorola	**P/N**	PMPN4169A
	Power Rating	I/P: 10.8 – 33.0Vac, 1.1A, O/P: 5Vdc, 1.5A		
Battery 1	**Brand Name**	Motorola Solutions	**P/N**	BT000593A01
	Rated	5800mAh		
Battery 2	**Brand Name**	Motorola Solutions	**P/N**	BT000592A01
	Rated	2900mAh		
Battery 3	**Brand Name**	Motorola Solutions	**P/N**	BT000594A01
	Rated	5800mAh		
Earpiece	**Brand Name**	Motorola Solutions	**P/N**	PMLN8191A
	Signal Line	1.128meter, non-shielded cable, without ferrite core		
Remote Speaker Microphone 1	**Brand Name**	Motorola Solutions	**P/N**	PMMN4125B
	Signal Line	0.54 meter(normal), 2.5 meter (stretch) shielded cable, without ferrite core		
BT Wired Speaker Mic (WM500)	**Brand Name**	Motorola Solutions	**P/N**	PMMN4127A

Bluetooth Earpiece	**Brand Name**	Motorola Solutions	**P/N**	PMLN7851A(EP900)
Belt Clip Holster	**Brand Name**	Motorola Solutions	**Model Name**	PMLN6970A
Belt Clip Holster (Short)	**Brand Name**	Motorola Solutions	**Model Name**	NTN8266B
Belt Clip Holster (Long)	**Brand Name**	Motorola Solutions	**Model Name**	PMLN7965A

Remark: Battery 1 and Battery 2 are for EVOLVE sample, Battery 3 is for EVOLVE-i Sample.

1.7. Testing Site

Sporton International (Kunshan) Inc. is accredited to ISO/IEC 17025:2017 by American Association for Laboratory Accreditation with Certificate Number 5145.02.

Test Firm	Sporton International (Kunshan) Inc.		
Test Site Location	No. 1098, Pengxi North Road, Kunshan Economic Development Zone Jiangsu Province 215300 People's Republic of China TEL : +86-512-57900158 FAX : +86-512-57900958		
Test Site No.	**Sporton Site No.**	**FCC Designation No.**	**FCC Test Firm Registration No.**
	DFS01-KS	CN1257	314309

1.8. Applied Standards

According to the specifications of the manufacturer, the EUT must comply with the requirements of the following standards:

- FCC Part 15 Subpart E
- FCC KDB 905462 D02 UNII DFS Compliance Procedures New Rules v02
- FCC KDB 905462 D03 UNII Clients Without Radar Detection New Rules v01r02

Remark: All test items were verified and recorded according to the standards and without any deviation during the test.

1.9. Support Unit used in test configuration and system

Item	Equipment	Trade Name	Model Name	FCC ID	HW / FW Version	Power Cord
1.	WLAN AP	ASUS	RT-AX88U	MSQ-RTAXHP00	FW: 3.0.0.4.384_4730-g8g74d3c	Unshielded, 1.8 m
2.	Notebook	Lenovo	Edge E335	PPD-AR5B95	N/A	AC I/P: Unshielded, 1.2 m DC O/P: Shielded, 1.8 m

2 Requirements and Parameters for DFS Test

2.1. Summary of Dynamic Frequency Selection Test

Bandwidth and Channel	Test Items	Limit
80MHz 5530MHz (CH106)		
80MHz (CH106) 5530MHz	Channel Move Time	10 sec
	Channel Closing Transmission time	200 ms + aggregate of 60 ms over remaining 10 s period
	Non-Occupancy Period and Client Beacon Test	30 minutes

2.2. Applicability of DFS Requirements

EUT is client and operates as client without radar detection function.

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 Bandwidth	Yes	Not required	Yes

Table 2: Applicability of DFS requirements during normal operation

Requirement	Operational Mode		
	Master	Client Without Radar Detection	Client With Radar Detection
DFS Detection Threshold	Yes	Not required	Yes
Channel Closing Transmission Time	Yes	Yes	Yes
Channel Move Time	Yes	Yes	Yes
U-NII Detection Bandwidth	Yes	Not required	Yes
Client Beacon Test	N/A	Yes	Yes

Additional requirements for devices with multiple bandwidth modes	Operational Mode	
	Master 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.

2.3. Interference Threshold values, Master or Client incorporating In-Service Monitoring

Maximum Transmit Power	Value (see notes 1 and 2)
≥ 200 milliwatt	-64 dBm
< 200 milliwatt	-62 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.	

The radar *Detection Threshold*, lowest antenna gain is the parameter of Interference *radar DFS detection threshold*, The Interference *Detection Threshold* is the *(-62dBm)* + *(0)* [dBi]+ 1 dB= -61 dBm.

2.4. 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 99% power bandwidth See Note 3.

Note 1: The instant that the *Channel Move Time* and the *Channel Closing Transmission Time* begins is as follows:

- For the Short pulse radar Test Signals this instant is the end of the *Burst*.
- For the Frequency Hopping radar Test Signal, this instant is the end of the last radar *Burst* generated.
- For the Long Pulse radar Test Signal this instant is the end of the 12 second period defining the radar transmission.

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 *Channel* changes (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 is used and for each frequency step the minimum percentage of detection is 90%. Measurements are performed with no data traffic.

2.5. Short Pulse Radar Test Waveforms

As the EUT is a Client Device with no Radar Detection, only one type radar pulse is required for the testing. Radar Pulse type 0 was used in the evaluation of the Client device for the purpose of measuring the Channel Move Time and the Channel Closing Transmission Time.

Radar Type	Pulse Width (μsec)	PRI (μsec)	Number of Pulses	Minimum Percentage of Successful Detection	Minimum Trials
0	1	1428	18	60%	30
1	1	Test A Test B	$\text{Roundup}\left\{\left(\frac{1}{360}\right)\cdot\left(\frac{19\cdot 10^6}{\text{PRI}_{\mu\text{sec}}}\right)\right\}$	60%	30
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

Test A: 15 unique PRI values randomly selected from the list of 23 PRI values in Table 5a
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

A minimum of 30 unique waveforms are required for each of the short pulse radar types 2 through 4. For short pulse radar type 1, the same waveform is used a minimum of 30 times. If more than 30 waveforms are used for short pulse radar types 2 through 4, then each additional waveform must also be unique and not repeated from the previous waveforms.

If more than 30 waveforms are used for Short Pulse Radar Type 1, then each additional waveform is generated with Test B and must also be unique and not repeated from the previous waveforms in Tests A or B.

The aggregate is the average of the percentage of successful detections of short pulse radar types 1-4.

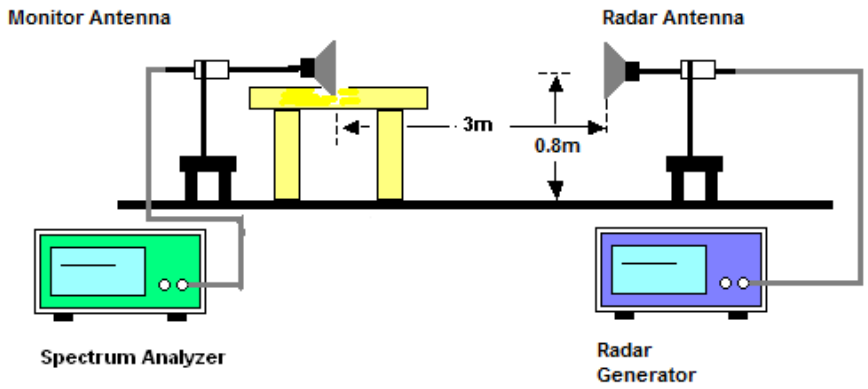
3 Calibration Setup and DFS Test Results

3.1 Calibration of Radar Waveform

3.1.1 Radar Waveform Calibration Procedure

The Interference **Radar Detection Threshold Level** is *(-62dBm) + (0)* [dBi]+ 1 dB= -61dBm that had been taken into account the output power range and antenna gain. The following equipment setup was used to calibrate the radiated Radar Waveform. A vector signal generator was utilized to establish the test signal level for radar type 0. During this process there were no transmissions by either the Master or Client Device. The spectrum analyzer was switched to the zero span (Time Domain) at the frequency of the Radar Waveform generator. Peak detection was used. The spectrum analyzer resolution bandwidth (RBW) and video bandwidth (VBW) were set to 3 MHz to measure the type 0 radar waveform. The spectrum analyzer had offset -4.5dB to compensate receiving horn antenna gain 10.5dBi and RF cable loss 6dB. The vector signal generator amplitude was set so that the power level measured at the spectrum analyzer was *(-62dBm) + (0)* [dBi]+ 1 dB= -61 dBm. Capture the spectrum analyzer plots on short pulse radar waveform.

3.1.2 Radiated Calibration Setup

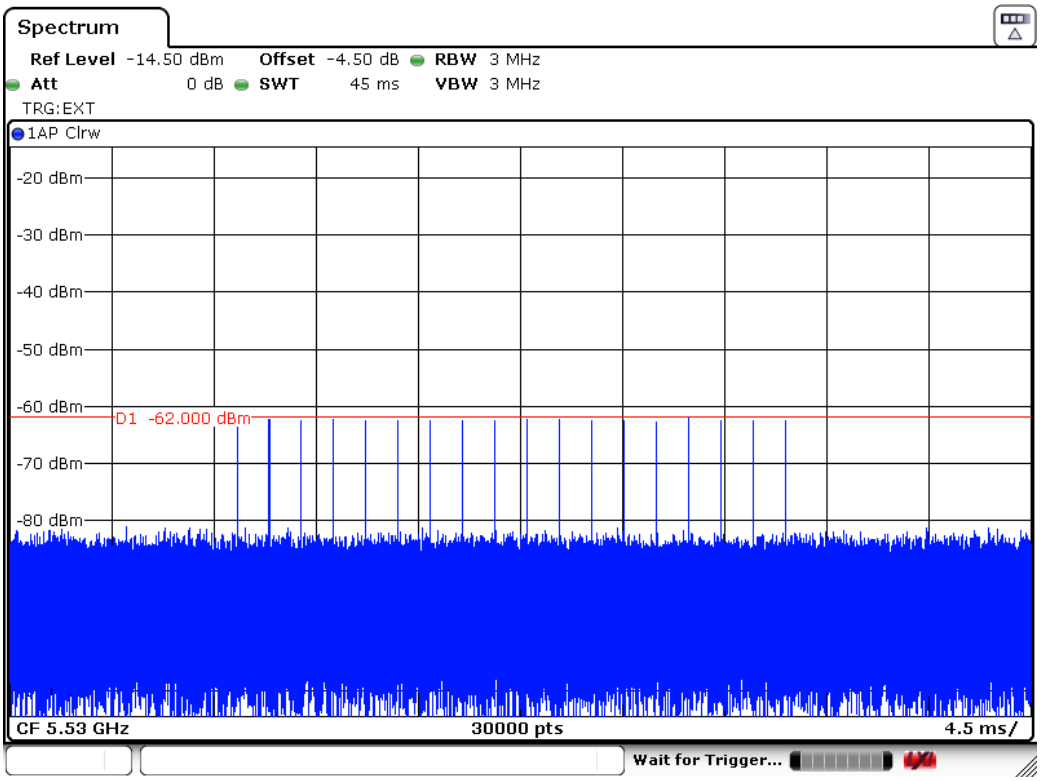


3.1.3 Calibration Deviation

There is no deviation with the original standard.

3.1.4 Radar Waveform Calibration Result

<80MHz / 5530MHz> Radar Type 0
Radar / DFS detection threshold level and the burst of pulses on the Channel frequency



3.2 In-Service Monitoring: Channel Move Time, Channel Closing Transmission Time and Non-Occupancy Period

3.2.1 Limit of In-Service Monitoring

The EUT has In-Service Monitoring function to continuously monitor the radar signals, If radar is detected, it must leave the channel (Shutdown). The Channel Move Time to cease all transmissions on the current Channel upon detection of a Radar Waveform above the DFS Detection Threshold within 10 sec. The total duration of *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 *Channel* changes (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.

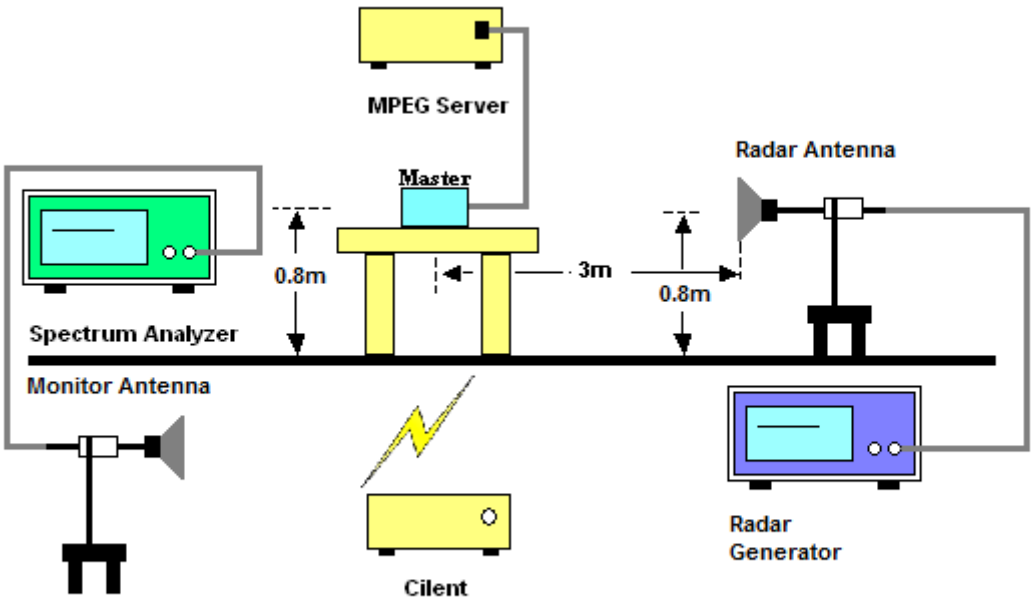
Non-Occupancy Period time is 30 minute during which a Channel will not be utilized after a Radar Waveform is detected on that Channel. The non-associated Client Beacon Test is during the 30 minutes observation time. The EUT should not make any transmissions in the DFS band after EUT power up.

3.2.2 Test Procedures

1. The radar pulse generator is setup to provide a pulse at frequency that the Master and Client are operating. A type 0 radar pulse with a 1us pulse width and a 1428 us PRI is used for the testing.
2. The vector signal generator is adjusted to provide the radar burst (18 pulses) at a level of approximately -62dBm at the antenna of the Master device.
3. A trigger is provided from the pulse generator to the DFS monitoring system in order to capture the traffic and the occurrence of the radar pulse.
4. A U-NII device operating as a Client Device will associate with the Master at Channel. The MPEG file “TestFile.mpg” specified by the FCC is streamed from the “file computer” through the Master to the Client Device, Software to ping the client is permitted to simulate data transfer and have random ping intervals.
5. When a radar Burst with a level equal to the DFS Detection Threshold + 1dB is generated on the Operating Channel of the U-NII device. At time T0 the Radar Waveform generator sends a Burst of pulse of the radar waveform at Detection Threshold + 1dB.
6. Observe the transmissions of the EUT at the end of the radar Burst on the Operating Channel. Measure and record the transmissions from the EUT during the observation time (Channel Move Time). One 12 seconds plot is reported for the Short Pulse Radar Types 1. The plot for the Short Pulse Radar Types start at the end of the radar burst. The Channel Move Time will be calculated based on the zoom in 600ms plot of the Short Pulse Radar Type.
7. Measurement of the aggregate duration of the Channel Closing Transmission Time method. With the spectrum analyzer set to zero span tuned to the center frequency of the EUT operating channel at the radar simulated frequency, peak detection, and max hold, the dwell time per bin is given by: **Dwell (0.4ms)= S (12000ms) / B (30000)**; where Dwell is the dwell time per spectrum analyzer sampling bin, S is the sweep time and B is the number of spectrum analyzer sampling bins. An upper bound of the aggregate duration of the intermittent control signals of Channel Closing Transmission Time is calculated by: **C (ms)= N X Dwell (0.4 ms)**; where C is the Closing Time, N is the number of spectrum analyzer sampling bins (intermittent control signals) showing a U-NII transmission and Dwell is the dwell time per bin.
8. Measure the EUT for more than 30 minutes following the channel move time to verify that no transmissions or beacons occur on this Channel.

3.2.3 Test Setup

Radiated Test Setup Photo



3.2.4 Test Deviation

There is no deviation with the original standard.

3.2.5 Result of Channel Move Time, Channel Closing Transmission Time and Non-Occupancy Period for Client Beacon Test

Test Mode :	Client without radar detection	**Temperature :**	23.7℃
Test Engineer :	Eloise Wang	**Relative Humidity :**	48%

BW / Channel	Test Item	Test Result	Limit	Pass/Fail
80MHz / 5530MHz	Channel Move Time	504.017ms	< 10s	Pass
	Channel Closing Transmission Time	200ms + 32.8ms	< 260ms	Pass
	Non-Occupancy Period	≥ 30	≥ 30 min	Pass

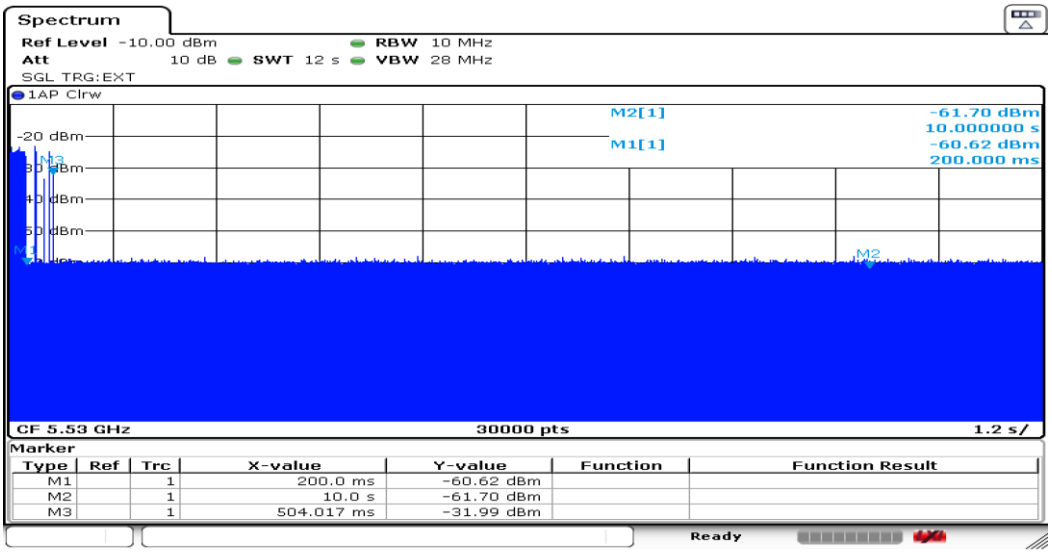
Note: The Channel Closing Transmission Time is comprised of 200 milliseconds starting at the beginning of the Channel Move Time plus any additional intermittent control signals required to facilitate a Channel move (an aggregate of 60 milliseconds) during the remainder of the 10 seconds period. The aggregate duration of control signals will not count quiet periods in between transmissions.

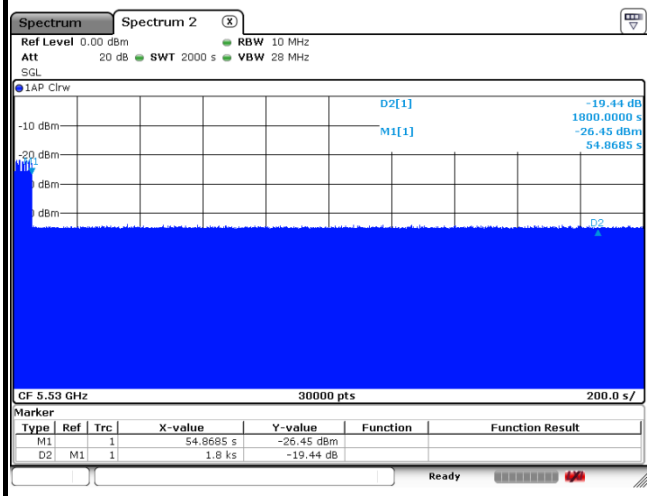
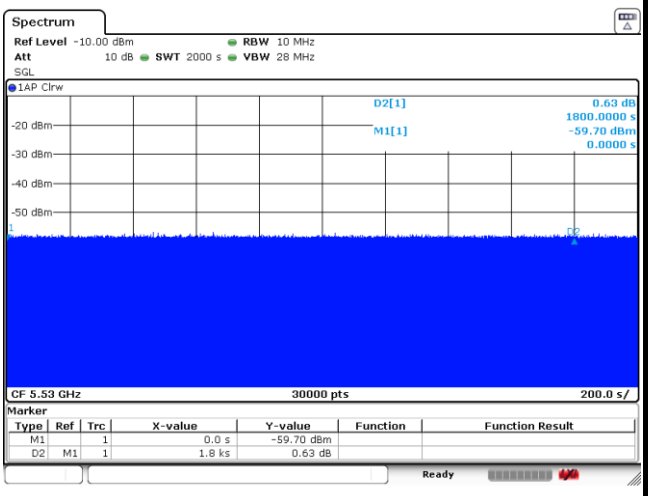
3.2.6 Channel Move Time, Channel Closing Transmission Time and Non-Occupancy Period for Client Beacon Test Plots

<80MHz / 5530> In-Service Monitoring

Channel Move Time &

Channel Closing Transmission Time



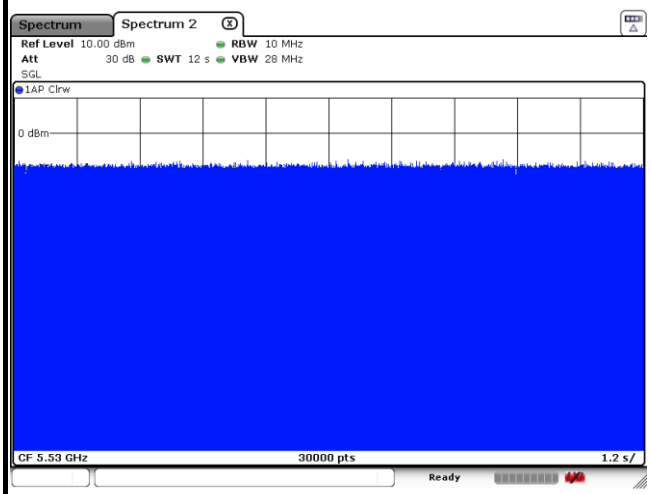
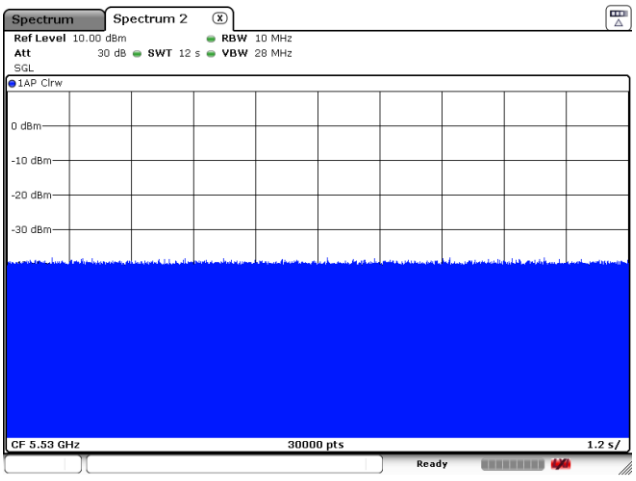
Non-Occupancy Period	**Non-associated test** **Master was off. (beacon test)**
	

Note:

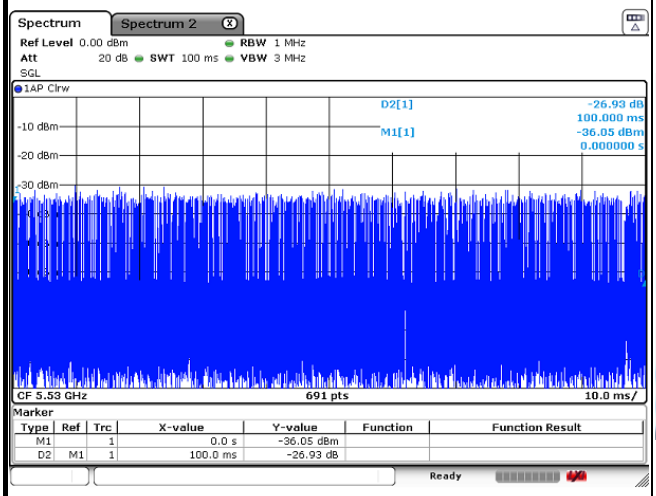
Dwell (0.4 ms)= Sweep Time (12000 ms) / Sweep Point Bins (30000)

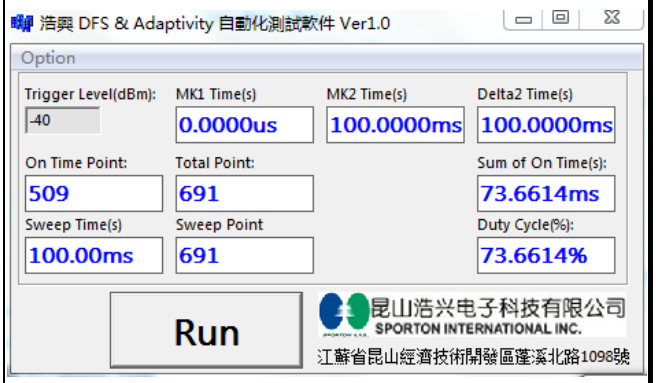
Channel Closing Transmission Time (200 +32.8ms) = 200 + Number (82X Dwell (0.4 ms) < 260ms

3.2.7 Data Traffic and Noise Floor Plots

EUT data traffic (Client)	Noise Floor (No transmission)
	

Channel Loading (Duty Cycle 73.6614% > 17%)





4 List of Measuring Equipment

Instrument	Manufacturer	Model No.	Serial No.	Characteristics	Calibration Date	Test Date	Due Date	Remark
Spectrum Analyzer	R&S	FSV7	101632	10Hz~7GHz	Jan. 07, 2021	Oct. 05, 2021	Jan. 06, 2022	DFS (DFS01-KS)
Signal Generator	KEYSIGHT	N5172B	MY53050604	9KHz~6GHz	Oct. 27, 2020	Oct. 05, 2021	Oct. 26, 2021	DFS (DFS01-KS)
Horn Antenna	BEIJING XIBAO	XB-WDB-A-18	040505	1GHz ~ 18GHz	Jan. 06, 2021	Oct. 05, 2021	Jan. 05, 2022	DFS (DFS01-KS)
Horn Antenna	Com-Power	AHA-118	701030	1GHz ~ 18GHz	Nov. 09, 2020	Oct. 05, 2021	Nov. 08, 2021	DFS (DFS01-KS)

NCR: No Calibration Required

---------- THE END ----------

Appendix B. Product Equality Declaration

MOTOROLA SOLUTIONS

Date: March 25, 2021

Product Equality Declaration

We, Motorola Solutions Malaysia Sdn Bhd, declare on our sole responsibility for the product of EVOLVE as below:
From hardware vintage P2 EVOLVE SKU to hardware vintage P2.2 EVOLVE SKU,

	Main Changes
1	increase bypassing capacitors to Charger Contactor Pin, Qet Circuitry, VPH_PWR, Battery Connector, Speaker Springs，Vibrator Springs and Side Key/Receiver/Main Key/Toggle Key/Universal Serial Bus/Headset/Volume Knob flexible printed circuit , to lower de-sense to antenna.
2	increase Single Retriggerable Monostable Multivibrator to power on circuitry to improve user experiences of power on
3	increase springs to enhance grounding between printed circuit board assembly and front housing.
4	diversity antenna, change feed point position, to improve diversity reception performance
5	move part of VPH_PWR line from surface layer to inner layer
6	Optimize clearance of antenna tuner and antenna spring of both main antenna and diversity antenna
7	Remove the screw and nut under WiFi/Bluetooth/global navigation satellite system antenna
8	Optimize WIFI 5G layout to solve Radiated Spurious Emission issue
9	Increase capacitors on headset microphone signals and around audio codec to get 3dB margin in Radio Frequency, Common mode(CS) test wall charger and accessory mode

Except listings above, the others are all the same.

Should you have any questions or comments regarding this matter, please have my best attention.

Sincerely yours,

Contact Person: Mahen Kirubakaran
COMPANY: Motorola Solutions Malaysia Sdn Bhd
Tel: +60 (4) 2241218
Fax: N/A
E-Mail: mahen@motorolasolutions.com

MOTOROLA SOLUTIONS

Date: March 25, 2021

Product Equality Declaration

We, Motorola Solutions Malaysia Sdn Bhd, declare on our sole responsibility for the product of EVOLVE-i as below:
From hardware vintage P2.2 EVOLVE-i SKU to hardware vintage P3 EVOLVE-i SKU,

	Main Changes
1	Increase LDO as MIC_BIAS power supplier, to solve EU RED Cert-Radio Frequency, Common mode(CS) test issue.
2	Optimize GPS routing, from inner layer to bottom layer.
3	Due to above changes, the PCB will update the part number.
4	Add a new Battery

Except listings above, the others are all the same.

Should you have any questions or comments regarding this matter, please have my best attention.

Sincerely yours,

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Date: October 22, 2021

Product Equality Declaration

We, Motorola Solutions Inc. CORPORATION, declare on our sole responsibility for the product of EVOLVE and EVOLVE-i as below:

There is no difference between P3 and PVT HW version, and, the difference of EVOLVE-i and EVOLVE is RF section is same only with extra protection components in EVOLVE-i.

i) Both SKUs share the same PCB with all traces.

ii) EVOLVE-i SKU will have protection circuits with fuse and Zener diode (BOM different).

iii) EVOLVE SKU the fuse will become 0 ohm and Zener diodes will be not populated.

iv) The RF sections are the same for both EVOLVE-i and EVOLVE SKUs.

Except listings above, the others are all the same.

Should you have any questions or comments regarding this matter, please have my best attention.

Sincerely yours,

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