TEST REPORT

Covering the DYNAMIC FREQUENCY SELECTION (DFS) REQUIREMENTS OF

FCC Part 15 Subpart E (UNII), RSS-210 Annex 9

Motorola Solution, Inc.
Model(s): AP-7161

COMPANY:	Motorola Solution, Inc. One Motorola Plaza Holtsville, NY, 11742
TEST SITE:	National Technical Systems - Silicon Valley 41039 Boyce Road Fremont, CA 94538
REPORT DATE:	January 3, 2014
FINAL TEST DATE:	November 19, 2013
TEST ENGINEER:	Mehran Birgani
TOTAL NUMBER OF PAGES:	25

VALIDATING SIGNATORIES

PROGRAM MGR /
TECHNICAL REVIEWER:

Mark Hill
Staff Engineer

REPORT PREPARER:

Mehran Birgani
EMC Engineer

QUALITY ASSURANCE DELEGATE

David Guidotti
Senior Technical Writer

REVISION HISTORY

Rev #	Date	Comments	Modified By
-	01-03-2014	Initial Release	-

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SCOPE

Test data has been taken pursuant to the relevant DFS requirements of the following standard(s):

- FCC Part 15 Subpart E Unlicensed National Information Infrastructure (U-NII) Devices.
- RSS-210 Annex 9 Local Area Network Devices.

Tests were performed in accordance with these standards together with the current published versions of the basic standards referenced therein including FCC KDB 848637 and the appendix to FCC 06-96 MO&O as outlined in NTS Silicon Valley test procedures. The test results recorded herein are based on a single type test of the Motorola Solution, Inc. model AP-7161 and therefore apply only to the tested sample. The sample was selected and prepared by Daniel Scheve of Motorola Solution, Inc.

Note – the testing was limited to the Scan-Ahead feature described in the Motorola "Scan-ahead_operation_description_rev6.pdf".

OBJECTIVE

The objective of the manufacturer is to comply with the standards identified in the previous section. In order to demonstrate compliance, the manufacturer or a contracted laboratory makes measurements and takes the necessary steps to ensure that the equipment complies with the appropriate technical standards. Compliance with some DFS features is covered through a manufacturer statement or through observation of the device.

STATEMENT OF COMPLIANCE

The tested sample of the Motorola Solution, Inc. model AP-7161 complied with the DFS requirements of FCC Part 15.407(h)(2), RSS-210 Annex 9.3.

Maintenance of compliance is the responsibility of the manufacturer. Any modifications to the product should be assessed to determine their potential impact on the compliance status of the device with respect to the standards detailed in this test report.

DEVIATIONS FROM THE STANDARD

The following deviations were made from the test methods and requirements covered by the scope of this report:

1. Only the Scan-Ahead feature was assessed. All other DFS functionality has been previously tested and found to comply with the requirements of FCC Part 15.

TEST RESULTS

TEST RESULTS SUMMARY – FCC Part 15, MASTER DEVICE

Table 1 - FCC Part 15 Subpart E Master Device Test Result Summary

Description	Radar Type	EUT Frequency	Measured Value	Requirement	Test Data	Status
Channel Availability Check (CAC) Time	Type 1	5520MHz	70s	≥ 60s	Appendix B	PASS
1) Tests were performed using the radiated test method.						

MEASUREMENT UNCERTAINTIES

ISO/IEC 17025 requires that an estimate of the measurement uncertainties associated with the emissions test results be included in the report. The measurement uncertainties given below are based on a 95% confidence level, with a coverage factor (k=2) and were calculated in accordance with UKAS document LAB 34.

Measurement	Measurement Unit	Expanded Uncertainty
Timing (Channel move time, aggregate transmission time)	ms	Timing resolution ±0.24%
Timing (non occupancy period)	seconds	5 seconds
DFS Threshold (radiated)	dBm	1.6
DFS Threshold (conducted)	dBm	1.2

EQUIPMENT UNDER TEST (EUT) DETAILS

GENERAL

The Motorola Solution, Inc. model AP-7161 is a mesh wireless access point.

The sample was received on November 18, 2013 and tested on November 19, 2013. The EUT consisted of the following component(s):

Manufacturer	Model	Description	Serial Number
Motorola Solutions	AP-7161	Mesh wireless Access Point	683BME0023

The manufacturer declared values for the EUT operational characteristics that affect DFS are as follows:

Operating Modes (5250 – 5350 MHz, 5470 – 5725 MHz)

☒ Master Device 5250-5350MHz and 5470-5725 MHz

Antenna Gains / EIRP (5250 – 5350 MHz, 5470 – 5725 MHz)

	5250 – 5350 MHz	5470 – 5725 MHz
Lowest Antenna Gain (dBi)	5.4	5.4
Highest Antenna Gain (dBi)	5.4	5.4
EIRP Output Power (dBm)	25.13dBm	25.13dBm

☒ Power can exceed 200mW eirp

Channel Protocol

☒ IP Based

ENCLOSURE

The EUT enclosure measures approximately 22 by 29 by 10 centimeters. It is primarily constructed of aluminum.

MODIFICATIONS

The EUT did not require modifications during testing in order to comply with the requirements of the standard(s) referenced in this test report.

SUPPORT EQUIPMENT

The following equipment was used as local support equipment for testing:

Manufacturer	Model	Description	Asset Number	FCC ID
HP(Client)	*EliteBook*	*Laptop*	*AH050036*	*PD962205ANH*
HP (Server)	EliteBook	Laptop	AH050040	DoC
HP (Monitoring)	EliteBook	Laptop	AH050144	DoC
Netgear	GS108 v2	Switch		

The italicized device was the client device.

EUT INTERFACE PORTS

The I/O cabling configuration during testing was as follows:

		Cable(s)		
Port	Connected To	Description	Shielded /Unshielded	Length (m)
Ethernet	Switch	UTP cat 5	Unshielded	1.0
Serial	Laptop (Monitoring)	UTP to USB	Unshielded	5.0
Ethernet (server)	Switch	UTP cat 5	Unshielded	1.0

EUT OPERATION

The EUT was operating with the following software. The software is secured by encryption to prevent the user from disabling the DFS function.

Master Device: AP71XX version 5.5.1.0-190666X built on 11/15/13 11:03:33

During testing, the EUT was configured with a limited number of available channels. This resulted in the Primary and Secondary radios initiating CAC on a known channel. A log file was recording all the system messages from the EUT.

RADAR WAVEFORMS

Table 2 - FCC Short Pulse Radar Test Waveforms

Radar Type	Pulse Width (μsec)	PRI (μsec)	Pulses / burst	Minimum Detection Percentage	Minimum Number of Trials
1	1	1428	18	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

Table 3 - FCC Long Pulse Radar Test Waveforms

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

Table 4 - FCC Frequency Hopping Radar Test Waveforms

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

DFS TEST METHODS

RADIATED TEST METHOD

The combination of master and slave devices is located in an anechoic chamber. The simulated radar waveform is transmitted from a directional horn antenna (typically an EMCO 3115) toward the unit performing the radar detection (radar detection device, RDD). Every effort is made to ensure that the main beam of the EUT's antenna is aligned with the radar-generating antenna.

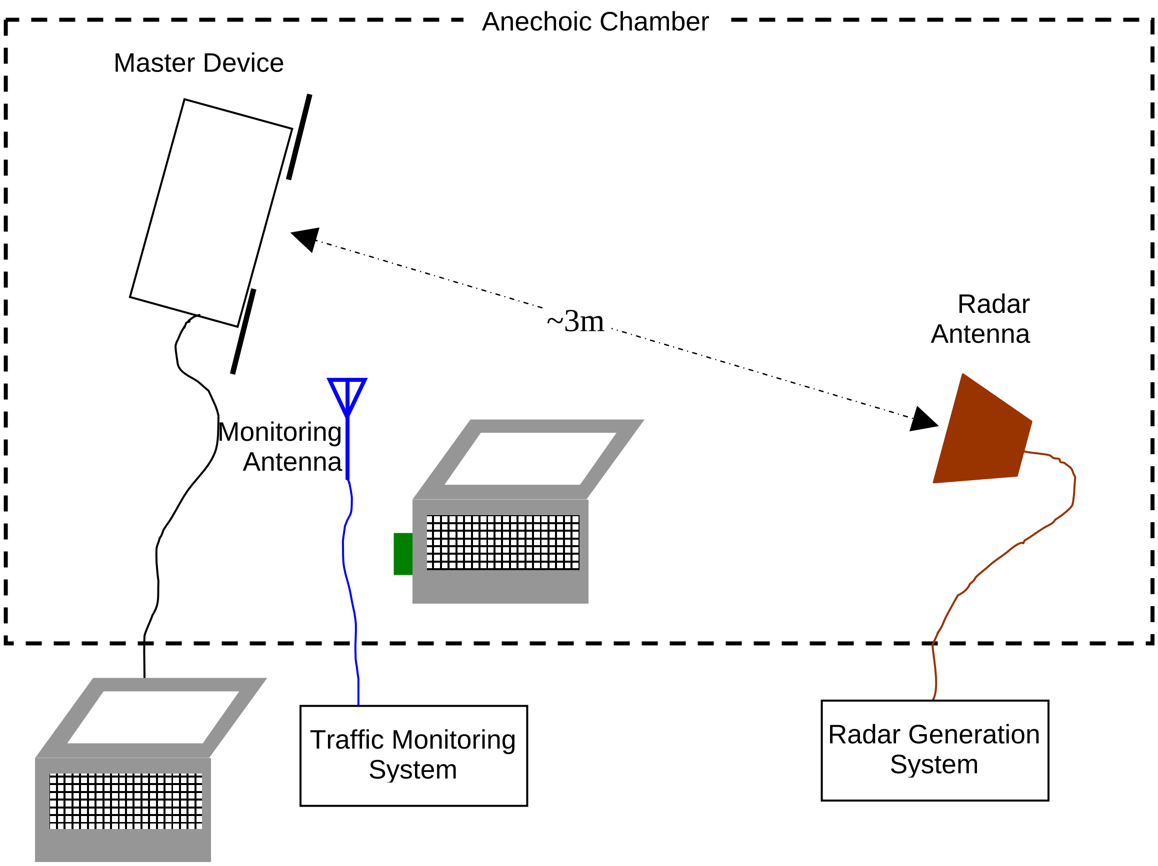


Figure 1 Test Configuration for radiated Measurement Method

The signal level of the simulated waveform is set to a reference level equal to the threshold level (plus 1dB if testing against FCC requirements). Lower levels may also be applied on request of the manufacturer. The level reported is the level at the RDD antenna and so it is not corrected for the RDD's antenna gain. The RDD is configured with the lowest gain antenna assembly intended for use with the device.

The signal level is verified by measuring the CW signal level from the radar generation system using a reference antenna of gain G_{REF} (dBi). The radar signal level is calculated from the measured level, R (dBm), and any cable loss, L (dB), between the reference antenna and the measuring instrument:

$$\text{Applied level (dBm)} = R - G_{REF} + L$$

If both master and client devices have radar detection capability then the device not under test is positioned with absorbing material between its antenna and the radar generating antenna, and the radar level at the non RDD is verified to be at least 20dB below the threshold level to ensure that any responses are due to the RDD detecting radar.

The antenna connected to the channel monitoring subsystem is positioned to allow both master and client transmissions to be observed, with the level of the EUT's transmissions between 6 and 10dB higher than those from the other device.

DFS MEASUREMENT INSTRUMENTATION

RADAR GENERATION SYSTEM

An Agilent PSG is used as the radar-generating source. The integral arbitrary waveform generators are programmed using Agilent's "Pulse Building" software and NTS Silicon Valley custom software to produce the required waveforms, with the capability to produce both un-modulated and modulated (FM Chirp) pulses. Where there are multiple values for a specific radar parameter then the software selects a value at random and, for FCC tests, the software verifies that the resulting waveform is truly unique.

With the exception of the hopping waveforms required by the FCC's rules (see below), the radar generator is set to a single frequency within the radar detection bandwidth of the EUT. The frequency is varied from trial to trial by stepping in 5MHz steps.

Frequency hopping radar waveforms are simulated using a time domain model. A randomly hopping sequence algorithm (which uses each channel in the hopping radar's range once in a hopping sequence) generates a hop sequence. A segment of the first 100 elements of the hop sequence are then examined to determine if it contains one or more frequencies within the radar detection bandwidth of the EUT. If it does not then the first element of the segment is discarded and the next frequency in the sequence is added. The process repeats until a valid segment is produced. The radar system is then programmed to produce bursts at time slots coincident with the frequencies within the segment that fall in the detection bandwidth. The frequency of the generator is stepped in 1 MHz increments across the EUT's detection range.

The radar signal level is verified during testing using a CW signal with the AGC function switched on. Correction factors to account for the fact that pulses are generated with the AGC functions switched off are measured annually and an offset is used to account for this in the software.

The generator output is connected to the coupling port of the conducted set-up or to the radar-generating antenna.

CHANNEL MONITORING SYSTEM

Channel monitoring is achieved using a spectrum analyzer and digital storage oscilloscope. The analyzer is configured in a zero-span mode, center frequency set to the radar waveform's frequency or the center frequency of the EUT's operating channel. The IF output of the analyzer is connected to one input of the oscilloscope.

A signal generator output is set to send either the modulating signal directly or a pulse gate with an output pulse co-incident with each radar pulse. This output is connected to a second input on the oscilloscope and the oscilloscope displays both the channel traffic (via the if input) and the radar pulses on its display.

For in service monitoring tests the analyzer sweep time is set to > 20 seconds and the oscilloscope is configured with a data record length of 10 seconds for the short duration and frequency hopping waveforms, 20 seconds for the long duration waveforms. Both instruments are set for a single acquisition sequence. The analyzer is triggered 500ms before the start of the waveform and the oscilloscope is triggered directly by the modulating pulse train. Timing measurements for aggregate channel transmission time and channel move time are made from the oscilloscope data, with the end of the waveform clearly identified by the pulse train on one trace. The analyzer trace data is used to confirm that the last transmission occurred within the 10-second record of the oscilloscope. If necessary the record length of the oscilloscope is expanded to capture the last transmission on the channel prior to the channel move.

Channel availability check time timing plots are made using the analyzer. The analyzer is triggered at start of the EUT's channel availability check and used to verify that the EUT does not transmit when radar is applied during the check time.

The analyzer detector and oscilloscope sampling mode is set to peak detect for all plots.

DFS MEASUREMENT METHODS

DFS CHANNEL AVAILABILITY CHECK TIME

It is preferred that the EUT report when it starts the radar channel availability check. If the EUT does not report the start of the check time, then the time to start transmitting on a channel after switching the device on is measured to approximate the time from power-on to the end of the channel availability check. The start of the channel availability check is assumed to be 60 seconds prior to the first transmission on the channel.

To evaluate the channel availability check, a single burst of one radar type is applied within the first 2 seconds of the start of the channel availability check and it is verified that the device does not use the channel by continuing to monitor the channel for a period of at least 60 seconds. The test is repeated by applying a burst of radar in the last 2 seconds (i.e. between 58 and 60 seconds after the start of CAC when evaluating a 60-second CAC) of the channel availability check.

SAMPLE CALCULATIONS

THRESHOLD LEVEL

The threshold level is the level of the simulated radar waveform at the EUT's antenna. If the test is performed in a conducted fashion then the level at the rf input equals the level at the antenna plus the gain of the antenna assembly, in dBi. The gain of the antenna assembly equals the gain of the antenna minus the loss of the cabling between the rf input and the antenna. The lowest gain value for all antenna assemblies intended for use with the device is used when making this calculation.

If the test is performed using the radiated method then the threshold level is the level at the antenna.

Appendix A Test Equipment Calibration Data

Manufacturer	Description	Model #	Asset #	Cal Due
Hewlett Packard	EMC Spectrum Analyzer, 9 kHz - 6.5 GHz	8595EM	780	07-Mar-14
EMCO	Antenna, Horn, 1-18 GHz	3117	1662	25-May-14
Agilent Technologies	PSG Vector Signal Generator (250kHz - 20GHz)	E8267C	1877	05-Jun-14
Tektronix	500MHz, 2CH, 5GS/s Scope	TDS5052B	2118	23-Oct-14

Appendix B Test Data – Channel Availability Check

5470 – 5725 MHz

The Secondary radio will never transmit; therefore in order to determine the CAC timing of the Secondary radio the time-stamps of the system log were used. The system had a configuration commit to it, which would initiate the systems startup procedure.

Band of operation: 5470-5725 MHz except 5600-5650MHz
Bandwidth Mode: 20MHz Operation
Frequency of primary radio: 5540 MHz
Frequency of secondary radio: 5520 MHz

Excerpts from the logs are provided below.

CAC Timing – System messages – Extracted from "20MHz_CAC_No_Radar"

Start of CAC on Primary Radio (R2):

Nov 16 15:35:48 2013: ap7161-4AE22C : %RADIO-6-RADAR_SCAN_STARTED: Radar scan on primary channel 108 freq 5540 MHz for a duration 70 secs on radio 'ap7161-4AE22C:R2'

End of CAC on Primary Radio (R2):

Nov 16 15:36:59 2013: ap7161-4AE22C : %RADIO-6-RADAR_SCAN_COMPLETED: Radar scan done on primary channel 108 freq 5540 MHz on radio 'ap7161-4AE22C:R2'

CAC Time: 71s (15:35:48 to 15:36:59)

Start of CAC on Secondary Radio (R1):

Nov 16 15:37:01 2013: ap7161-4AE22C : %RADIO-5-RADIO_STATE_CHANGE: Radio 'ap7161-4AE22C:R1' changing state from 'Scanning' to 'CAC Radar Scan'

End of CAC on Secondary Radio (R1):

Nov 16 15:38:11 2013: ap7161-4AE22C : %RADIO-5-RADIO_STATE_CHANGE: Radio 'ap7161-4AE22C:R1' changing state from 'CAC Radar Scan' to 'Future channel'

CAC Time: 70s (15:37:01 to 15:38:11)

Radar at the beginning of CAC – the reference test signal was applied within 2seconds from the start of CAC on the Secondary radio. System messages were used to confirm that the EUT detected the radar, and initiated CAC on a different channel.

Band of operation: 5470-5725 MHz except 5600-5650MHz
Bandwidth Mode: 20MHz Operation
Frequency of primary radio: 5540 MHz
Frequency of secondary radio: 5520 MHz

Extracted from "20MHz_CAC_Beginning_of_Radar"

Start of CAC on Secondary Radio (R1):

Nov 16 17:00:16 2013: ap7161-4AE22C : %RADIO-5-RADIO_STATE_CHANGE: Radio 'ap7161-4AE22C:R1' changing state from 'Scanning' to 'CAC Radar Scan'

Detection of Radar on Secondary Radio (R1):

Nov 16 17:00:20 2013: ap7161-4AE22C : %RADIO-4-RADAR_DETECTED: Radar found on channel 104 freq 5520 MHz

Radar at the end of CAC – the reference test signal was applied within 2seconds from the end of CAC on the Secondary radio. System messages were used to confirm that the EUT detected the radar, and initiated CAC on a different channel.

Band of operation: 5470-5725 MHz except 5600-5650MHz
Bandwidth Mode: 20MHz Operation
Frequency of primary radio: 5540 MHz
Frequency of secondary radio: 5520 MHz

Extracted from "20MHz_CAC_End_of_Radar"

Start of CAC on Secondary Radio (R1):

Nov 16 15:59:34 2013: ap7161-4AE22C : %RADIO-5-RADIO_STATE_CHANGE: Radio 'ap7161-4AE22C:R1' changing state from 'Scanning' to 'CAC Radar Scan'

Detection of Radar on Secondary Radio (R1):

Nov 16 16:00:44 2013: ap7161-4AE22C : %RADIO-4-RADAR_DETECTED: Radar found on channel 104 freq 5520 MHz

Radar at the beginning of CAC – the reference test signal was applied within 2seconds from the start of CAC on the Secondary radio. System messages were used to confirm that the EUT detected the radar, and initiated CAC on a different channel.

Band of operation: 5470-5725 MHz except 5600-5650MHz
Bandwidth Mode: 40MHz Operation
Frequency of primary radio: 5540 MHz
Frequency of secondary radio: 5510 MHz

Extracted from "40MHz_CAC_Beginning_of_Radar"

Start of CAC on Secondary Radio (R1):

Nov 16 17:09:18 2013: ap7161-4AE22C : %RADIO-5-RADIO_STATE_CHANGE: Radio 'ap7161-4AE22C:R1' changing state from 'Scanning' to 'CAC Radar Scan'

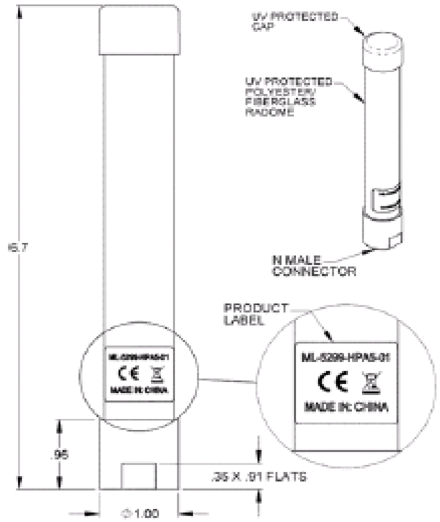
Detection of Radar on Secondary Radio (R1):

Nov 16 17:09:20 2013: ap7161-4AE22C : %RADIO-4-RADAR_DETECTED: Radar found on channel 104 freq 5520 MHz

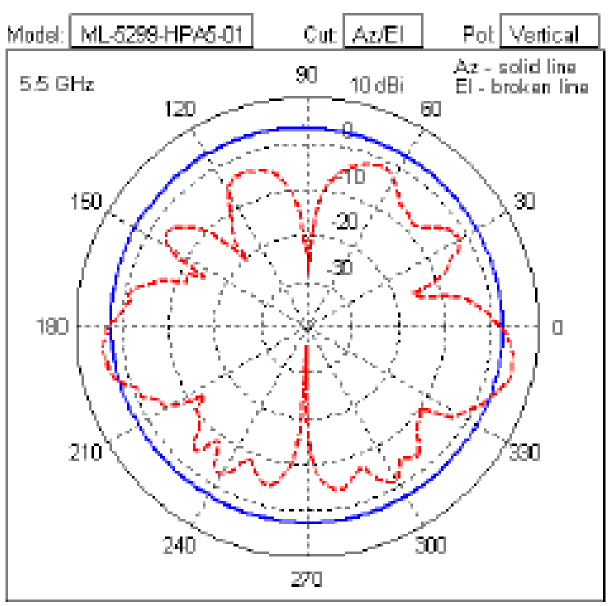
As compliance with the CAC requirements the 40MHz mode was demonstrated in the original testing, no further testing was performed on the Scan-Ahead feature.

Appendix C Antenna Specification

4.1.8 ML-5299-HPA5-01 Outdoor Dipole Omni N-Male



Type	Dipole Omni
Frequency	4900-5800
Gain (dBi)	5.6
Polarization	Linear, Vertical
Azimuth	3dB Beamwidth: 360°
Elevation	3dB Beamwidth: 22°
Cable Length (in.)	n/a
Cable Type	n/a
Connector Type	N-Type Male
Weight	73.8 grams
Plenum Antenna	No
Plenum Cable	n/a
Outdoor Rated	Yes



Appendix D Test Configuration Photograph(s)

Appendix E Scan-Ahead Operational Description

Document uploaded separately for confidentiality

Appendix F DFS Test Plan

Document uploaded separately for confidentiality

End of Report

This page is intentionally blank and
marks the last page of this test report.