

TEST REPORT

Covering the
DYNAMIC FREQUENCY SELECTION (DFS)
REQUIREMENTS
OF
FCC Part 15 Subpart E (UNII), RSS-210 Annex 9

Motorola Solutions, Inc.
Model(s): KHUSB600 and KHUSB601

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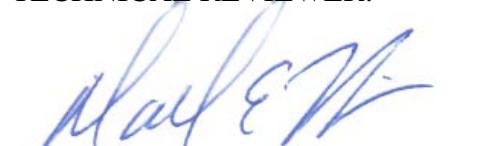
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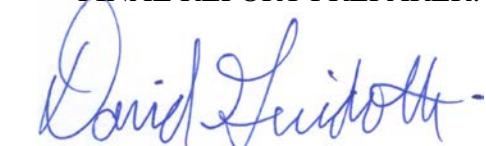
FINAL TEST DATE: November 28, 2012

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REVISION HISTORY

Rev #	Date	Comments	Modified By
1.0	12-14-2012	Initial Release	-
2.0	01-14-2013	Revised antenna gain value	MEH
3.0	08-22-2013	Reissued to add new model number by similarity	DMG

TABLE OF CONTENTS

REVISION HISTORY	2
TABLE OF CONTENTS	3
LIST OF TABLES.....	3
LIST OF FIGURES.....	4
SCOPE.....	5
OBJECTIVE.....	5
STATEMENT OF COMPLIANCE.....	5
DEVIATIONS FROM THE STANDARD.....	5
TEST RESULTS.....	6
TEST RESULTS SUMMARY – FCC PART 15, CLIENT DEVICE	6
MEASUREMENT UNCERTAINTIES.....	6
EQUIPMENT UNDER TEST (EUT) DETAILS.....	7
GENERAL.....	7
ENCLOSURE.....	8
MODIFICATIONS	8
SUPPORT EQUIPMENT	8
EUT INTERFACE PORTS	9
EUT OPERATION	9
RADAR WAVEFORMS.....	10
DFS TEST METHODS	11
RADIATED TEST METHOD	11
DFS MEASUREMENT INSTRUMENTATION.....	13
RADAR GENERATION SYSTEM	13
CHANNEL MONITORING SYSTEM	14
DFS MEASUREMENT METHODS	15
DFS – CHANNEL CLOSING TRANSMISSION TIME AND CHANNEL MOVE TIME	15
DFS – CHANNEL NON-OCCUPANCY AND VERIFICATION OF PASSIVE SCANNING.....	15
DFS CHANNEL AVAILABILITY CHECK TIME	16
TRANSMIT POWER CONTROL (TPC)	16
SAMPLE CALCULATIONS	17
DETECTION PROBABILITY / SUCCESS RATE	17
THRESHOLD LEVEL	17
APPENDIX A TEST EQUIPMENT CALIBRATION DATA	18
APPENDIX B TEST DATA TABLES AND PLOTS FOR CHANNEL CLOSING	19
FCC PART 15 SUBPART E CHANNEL CLOSING MEASUREMENTS	19
APPENDIX C ANTENNA SPECIFICATION	25
APPENDIX D TEST CONFIGURATION PHOTOGRAPH(S).....	26

LIST OF TABLES

Table 1 FCC Part 15 Subpart E Client Device Test Result Summary – n20 mode	6
Table 2 FCC Part 15 Subpart E Client Device Test Result Summary – n40 mode	6
Table 3 FCC Short Pulse Radar Test Waveforms.....	10
Table 4 FCC Long Pulse Radar Test Waveforms.....	10
Table 5 FCC Frequency Hopping Radar Test Waveforms	10
Table 6 FCC Part 15 Subpart E Channel Closing Test Results	19

LIST OF FIGURES

Figure 1 Test Configuration for radiated Measurement Method	11
Figure 2 Channel Closing Time and Channel Move Time – 40 second plot – 5470 to 5725 MHz – a20..	20
Figure 3 Close-Up of Transmissions Occurring More Than 200ms After The End of Radar	21
Figure 4 Channel Closing Time and Channel Move Time – 40 second plot – 5470 to 5725 MHz – n40..	22
Figure 5 Close-Up of Transmissions Occurring More Than 200ms After The End of Radar	23
Figure 6 Radar Channel Non-Occupancy Plot – a20	24
Figure 7 Radar Channel Non-Occupancy Plot – n40.....	24

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 as outlined in NTS Silicon Valley test procedures. The test results recorded herein are based on a single type test of the Motorola Solutions, Inc. model KHUSB600 and therefore apply only to the tested sample. The sample was selected and prepared by Terry Richards of Motorola Solutions, Inc.

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 Solutions, Inc. model KHUSB600 complied with the DFS requirements of FCC Part 15.407(h)(2) and 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.

Testing was performed only on Motorola Solutions, Inc. model KHUSB600. This model was considered representative of the KHUSB600 and KHUSB601. Refer to the product description section starting on page 7 for full details.

DEVIATIONS FROM THE STANDARD

No deviations were made from the test methods and requirements covered by the scope of this report.

TEST RESULTS**TEST RESULTS SUMMARY – FCC Part 15, CLIENT DEVICE****Table 1 FCC Part 15 Subpart E Client Device Test Result Summary – n20 mode**

Description	Radar Type	EUT Frequency	Measured Value	Requirement	Test Data	Status
Channel closing transmission time	Type 1	5500MHz	6.74ms	< 60ms	Appendix B	Pass
Channel move time	Type 1	5500MHz	1.942s	< 10s	Appendix B	Pass
Non-occupancy period - associated	Type 1	5500MHz	1800sec	> 30 minutes	Appendix B	Pass
Passive Scanning	N/A	N/A	Refer to manufacturer attestation			

1) Tests were performed using the radiated test method.
 2) Channel availability check, detection threshold and non-occupancy period are not applicable to client devices.

Table 2 FCC Part 15 Subpart E Client Device Test Result Summary – n40 mode

Description	Radar Type	EUT Frequency	Measured Value	Requirement	Test Data	Status
Channel closing transmission time	Type 1	5510MHz	7.18ms	< 60ms	Appendix B	Pass
Channel move time	Type 1	5510MHz	1.958s	< 10s	Appendix B	Pass
Non-occupancy period - associated	Type 1	5510MHz	1800sec	> 30 minutes	Appendix B	Pass
Passive Scanning	N/A	N/A	Refer to manufacturer attestation			

1) Tests were performed using the radiated test method.
 2) Channel availability check, detection threshold and non-occupancy period are not applicable to client devices.

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 Solutions, Inc. model KHUSB600 is a 2x2 802.11abgn USB WIPS Sensor with its radio configured as a wireless intrusion sensor designed to associate with access points (i.e a client). If that access point is determined by the WIPS server to be unauthorized for operation on the network; the sensor will send shutdown commands to that access point once another client has associated.

Testing performed on the KHUSB600 is considered by Motorola Solutions, Inc. to be representative of KHUSB600 and KHUSB601. The only differences between the existing model KHUSB600 and the new model KHUSB601 is that instead of using internal antennas, the KHUSB601 has RF connectors and can use the following external antennas:

ML-2452-APA2-02:

2.4G antenna gain: 3.2dBi
5G antenna gain: 4.6dBi

ML-2452-HPAG5A8-01

2.4G antenna gain: 5dBi
5G antenna gain: 8dBi

ML-2452-HPA6M6-072

2.4G antenna gain: 2.8dBi
5G antenna gain: 6.5dBi

The sample was received on November 28, 2012 and tested on November 28, 2012. The EUT consisted of the following component(s):

Manufacturer	Model	Description	Serial Number
Motorola	KHUSB600	2x2 802.11abgn USB WIPS Sensor	1221452200119

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

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

Client Device (no In Service Monitoring, no Ad-Hoc mode)

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

	5250 – 5350 MHz	5470 – 5725 MHz
Lowest Antenna Gain (dBi)	5.49	5.49
Highest Antenna Gain (dBi)	5.9	5.9
EIRP Output Power (dBm)	16	16

Power can exceed 200mW eirp

Channel Protocol

IP Based
 Frame Based
 OTHER _____

ENCLOSURE

The EUT enclosure measures approximately 15 by 7.5 by 4.5 centimeters. It is primarily constructed of uncoated coated plastic.

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:

Local Support Equipment				
Manufacturer	Model	Description	Serial Number	FCC ID
Air Defense Inc.	3650 Rev.1	WIPS Server	36510901094	Class A
Net Gear	FS108v2	Hub	FS2314CCB05940	DoC
Phihong	POE60U-560(G)-VC-R	POE Injector (AP)	-	-
Phihong	POE60U-560(G)-VC-R	POE Injector (AP)	-	-
Motorola	AP-8132	Access Point	1205652201367	UZ7AP8132
<i>Motorola</i>	<i>AP-7131N</i> <i>firmware 5.2.0.0-126461X</i>	<i>Access Point</i>	<i>9151520900220</i>	<i>UZ7AP7131N</i>

Remote Support Equipment

Manufacturer	Model	Description	Serial Number	FCC ID
IBM	T42p	Laptop Computer	237410RW	DoC
Dell	PP32LB	Laptop Computer (client device)	29832449617	DoC
HP	KJ039UC#ABA	Client Laptop (streaming movie)	CDN84219SN	DoC
HP	Elitebook 8460B	Monitoring laptop (serial)	CNU2202967	DoC

The italicized device was the master device.

EUT INTERFACE PORTS

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

Port	Connected To	Cable(s)		
		Description	Shielded or Unshielded	Length (m)
Ethernet (PoE Injector)	Server Laptop	CAT5	Unshielded	5.0
Console	Monitoring Laptop	CAT5 to 9pin dsub	unshielded to shielded	5.0
AC Power	AC Mains	3 wire	Unshielded	2.0
Ethernet (PoE Injector)	EUT	CAT5	Unshielded	2.0

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.

Client Device: 5.5.0.0-163261Y

As the EUT sensor is not designed to function as a WLAN and stream data over the network, the master device was configured to stream the “FCC” test file to the support client device laptop. The EUT was associated with the master device on the operating channel. Prior to applying radar to the master device, the EUT was instructed (by the WIPS server) to terminate the master device. This is the only operating condition where the EUT would transmit. Radar was applied to the master device on the channel being monitored by the sensor. The master device detected the radar signals and sent the requisite command packets for all clients to vacate the channel. The master device jumped to a new channel and the previous channel was monitored to ensure no further transmissions from the EUT were present on that channel.

During the channel moving tests the system was configured with a streaming video file from the master device (sourced by the PC connected to the master device via an Ethernet interface) to the support client device.

The streamed file was the “FCC” test file and the client device was using Windows Media Player Classic as required by FCC Part 15 Subpart E

The support Master Access Point was operating with the following software. The software is secured by encryption to prevent the user from disabling the DFS function.

Master Device: 5.2.0.0-126461X

RADAR WAVEFORMS**Table 3 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 4 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 5 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.

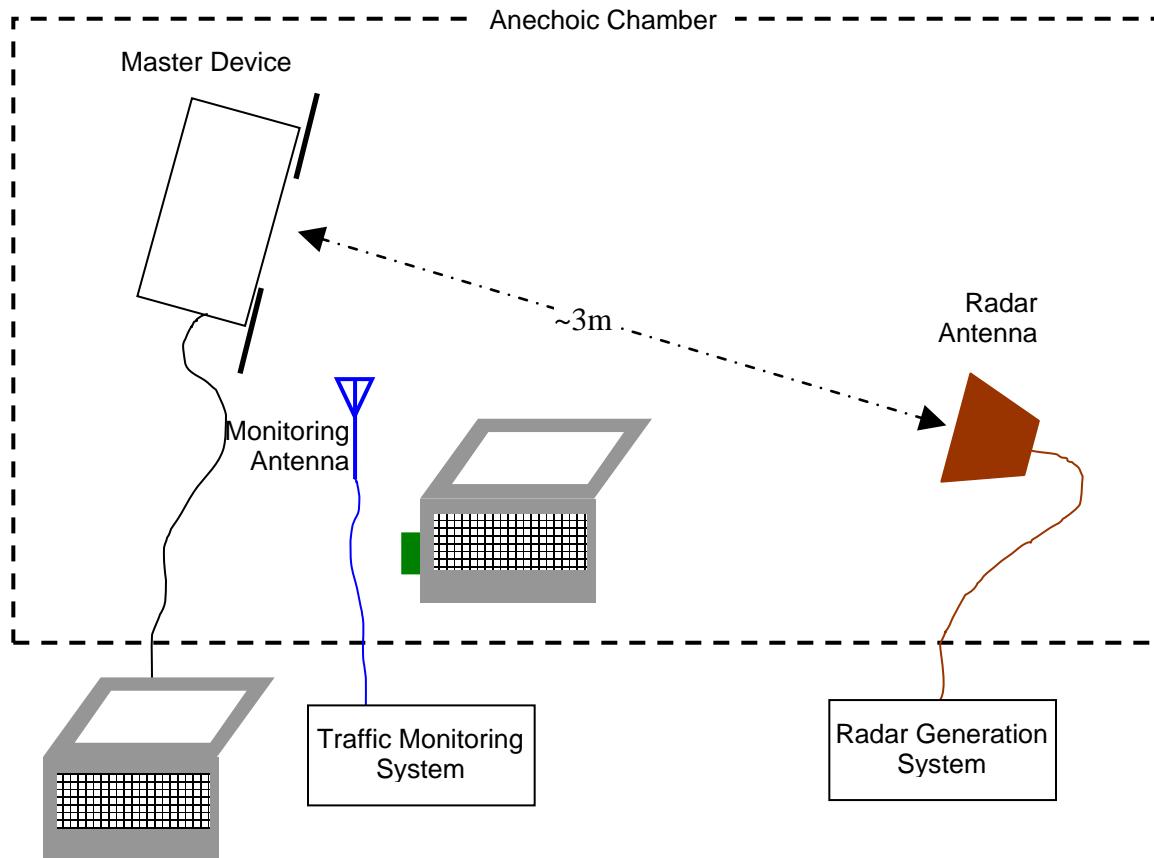


Figure 1 Test Configuration for radiated Measurement Method

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 CLOSING TRANSMISSION TIME AND CHANNEL MOVE TIME

Channel clearing and closing times are measured by applying a burst of radar with the device configured to change channel and by observing the channel for transmissions. The time between the end of the applied radar waveform and the final transmission on the channel is the channel move time.

The aggregate transmission closing time is measured in the following way:

FCC/KCC Notice No. 2010-48 – the total time of all individual transmissions from the EUT that are observed starting 200ms at the end of the last radar pulse in the waveform. This value is required to be less than 60ms.

DFS – CHANNEL NON-OCCUPANCY AND VERIFICATION OF PASSIVE SCANNING

The channel that was in use prior to radar detection by the master is additionally monitored for 30 minutes to ensure no transmissions on the vacated channel over the required non-occupancy period. This is achieved by tuning the spectrum analyzer to the vacated channel in zero-span mode and connecting the IF output to an oscilloscope. The oscilloscope is triggered by the radar pulse and set to provide a single sweep (in peak detect mode) that lasts for at least 30 minutes after the end of the channel move time.

For devices with a client-mode that are being evaluated against FCC rules the manufacturer must supply an attestation letter stating that the client device does not employ any active scanning techniques (i.e. does not transmit in the DFS bands without authorization from a Master device).

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.

To evaluate the channel availability check, a single burst of each radar type is applied at random periods during the 60-second 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 performed a total of four times for each radar type.

Compliance with the channel loading requirement, where appropriate (i.e. when channel selection is not determined under control of the network), is demonstrated by power cycling the product multiple times and recording the channel selected for use. The distribution of channels is compared against a probabilistic channel selection to verify that the distribution falls within the expected random distribution (i.e. $1/n$ probability for each channel, given n channels) for the number of trials performed.

TRANSMIT POWER CONTROL (TPC)

Compliance with the transmit power control requirements for devices is demonstrated through measurements showing multiple power levels and manufacturer statements explaining how the power control is implemented.

SAMPLE CALCULATIONS

DETECTION PROBABILITY / SUCCESS RATE

The detection probability, or success rate, for any one radar waveform equals the number of successful trials divided by the total number of trials for that waveform.

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

<u>Manufacturer</u>	<u>Description</u>	<u>Model #</u>	<u>Asset #</u>	<u>Cal Due</u>
Hewlett Packard	EMC Spectrum Analyzer, 9 kHz - 6.5 GHz	8595EM	780	25-Jan-13
EMCO	Antenna, Horn, 1-18 GHz (SA40-Blu)	3115	1386	26-Sep-14
EMCO	Antenna, Horn, 1-18 GHz	3117	1662	25-May-14
Agilent	PSG Vector Signal Generator (250kHz - 20GHz)	E8267C	1877	11-May-13
Tektronix	500MHz, 2CH, 5GS/s Scope	TDS5052B	2118	22-Oct-13

Appendix B Test Data Tables and Plots for Channel Closing**FCC PART 15 SUBPART E Channel Closing Measurements****Table 6 FCC Part 15 Subpart E Channel Closing Test Results**

Waveform Type	Bandwidth	Channel Closing Transmission Time ¹		Channel Move Time		Result
		Measured	Limit	Measured	Limit	
Radar Type 1	a20	6.74ms	60 ms	1.942s	10 s	Pass
Radar Type 1	n40	7.18ms	60 ms	1.958s	10 s	Pass

After the final channel closing test the channel was monitored for a further 30 minutes. No transmissions occurred on the channel.

¹ Channel closing time for FCC measurements is the aggregate transmission time starting from 200ms after the end of the radar signal to the completion of the channel move.

Elliott Timing Plots - Channel Closing

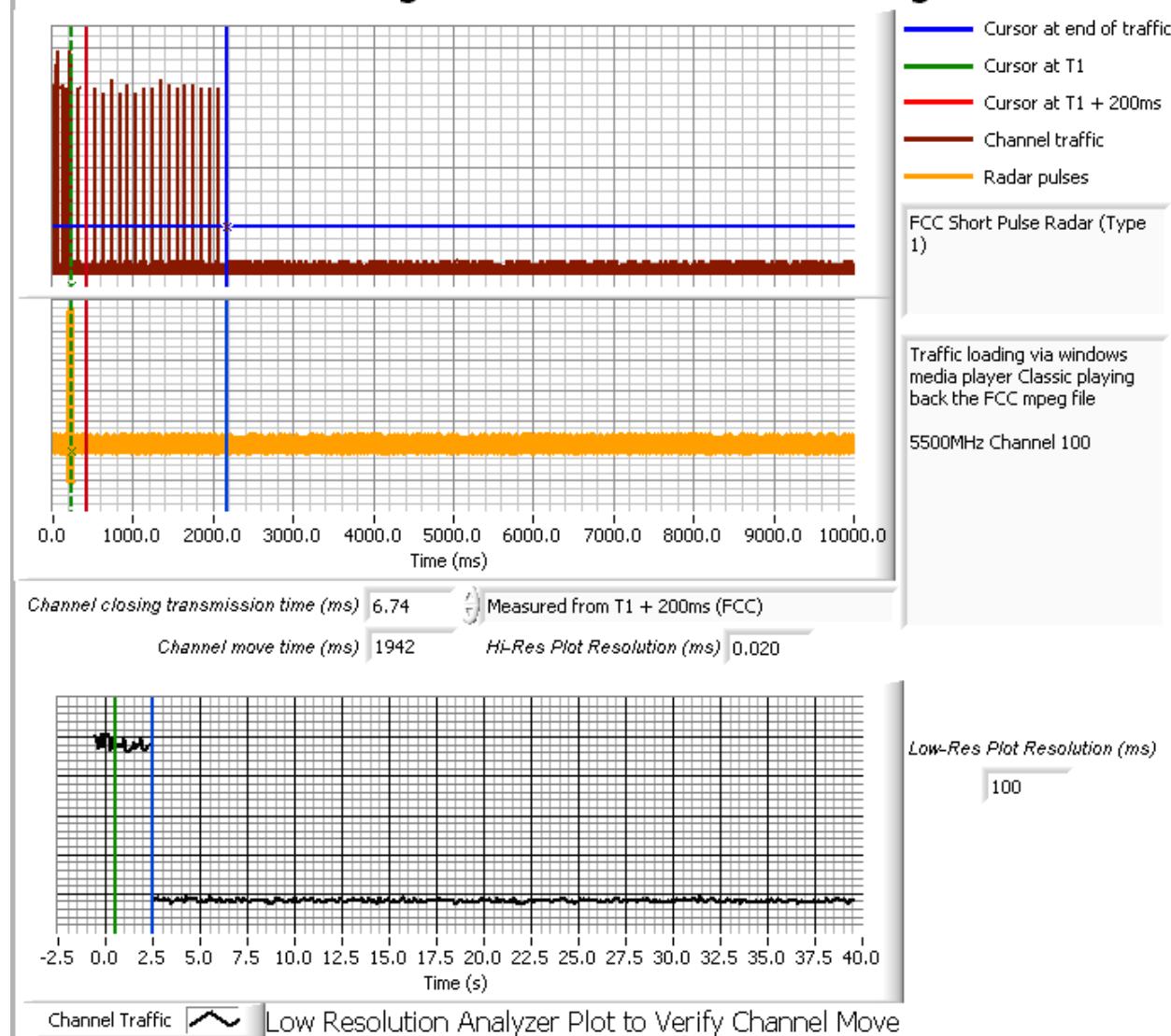


Figure 2 Channel Closing Time and Channel Move Time – 40 second plot – 5470 to 5725 MHz – a20

Elliott Timing Plots - Channel Closing

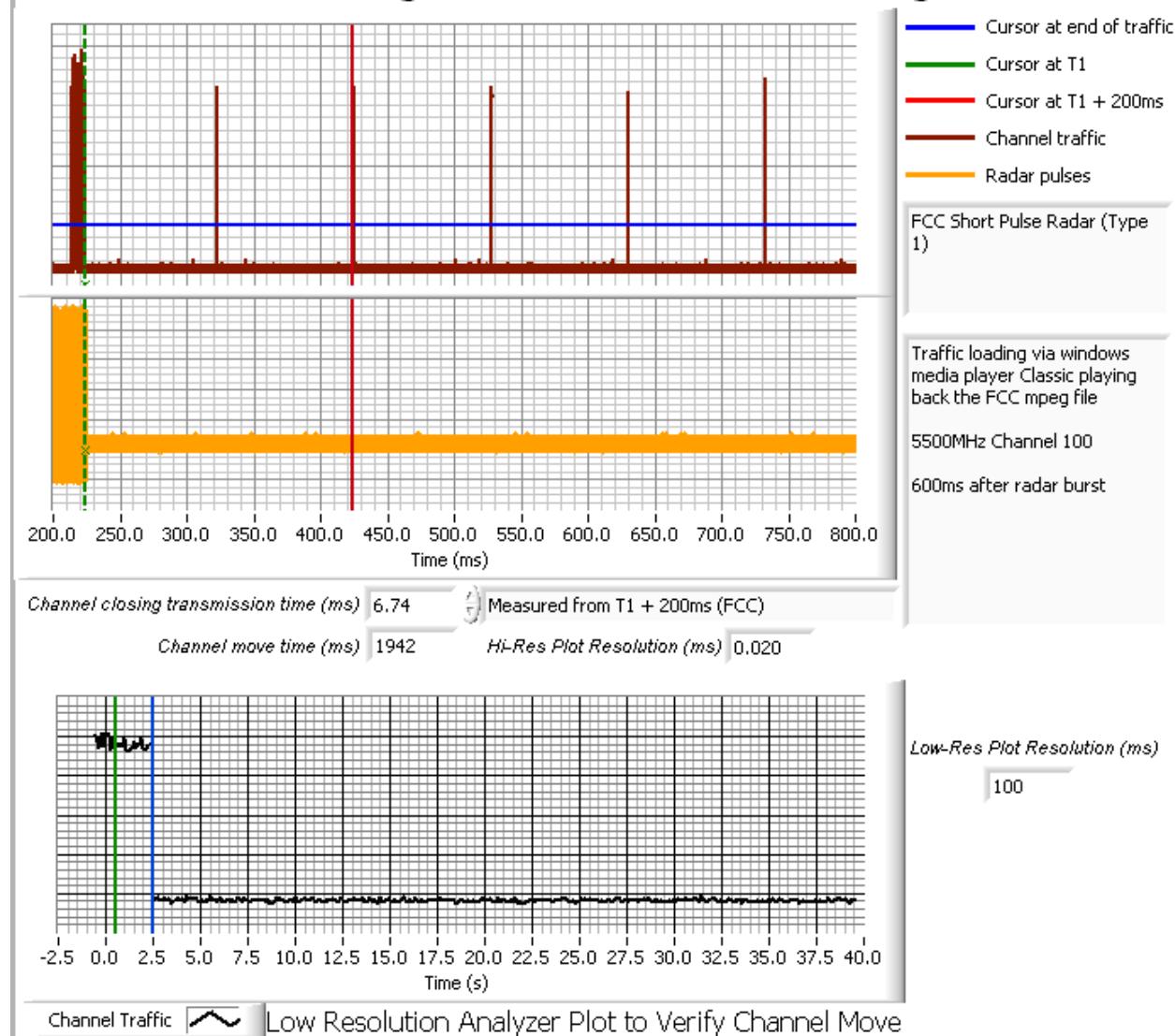


Figure 3 Close-Up of Transmissions Occurring More Than 200ms After The End of Radar

Elliott Timing Plots - Channel Closing

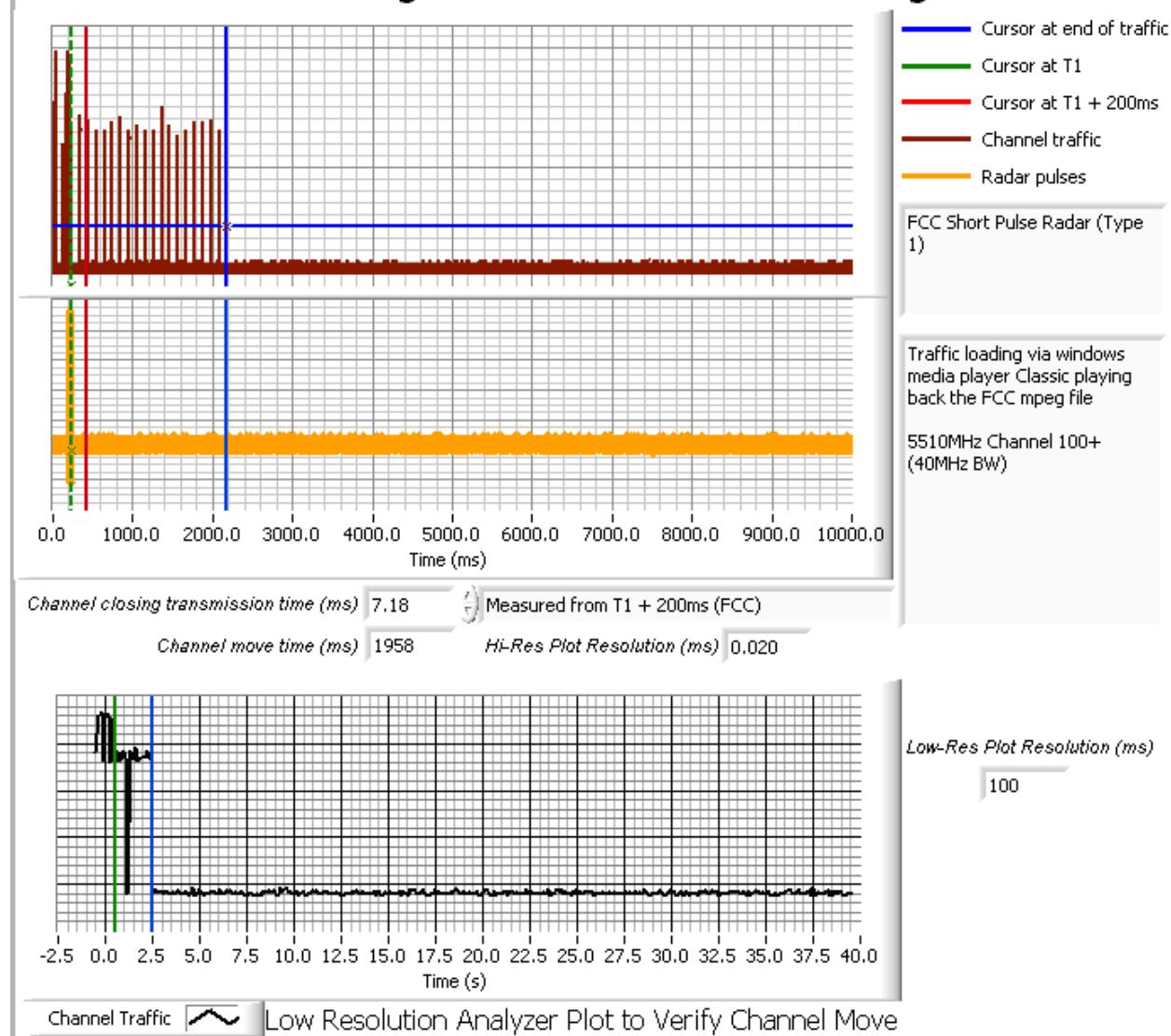


Figure 4 Channel Closing Time and Channel Move – 40 second plot – 5470 to 5725 MHz – n40

Elliott Timing Plots - Channel Closing

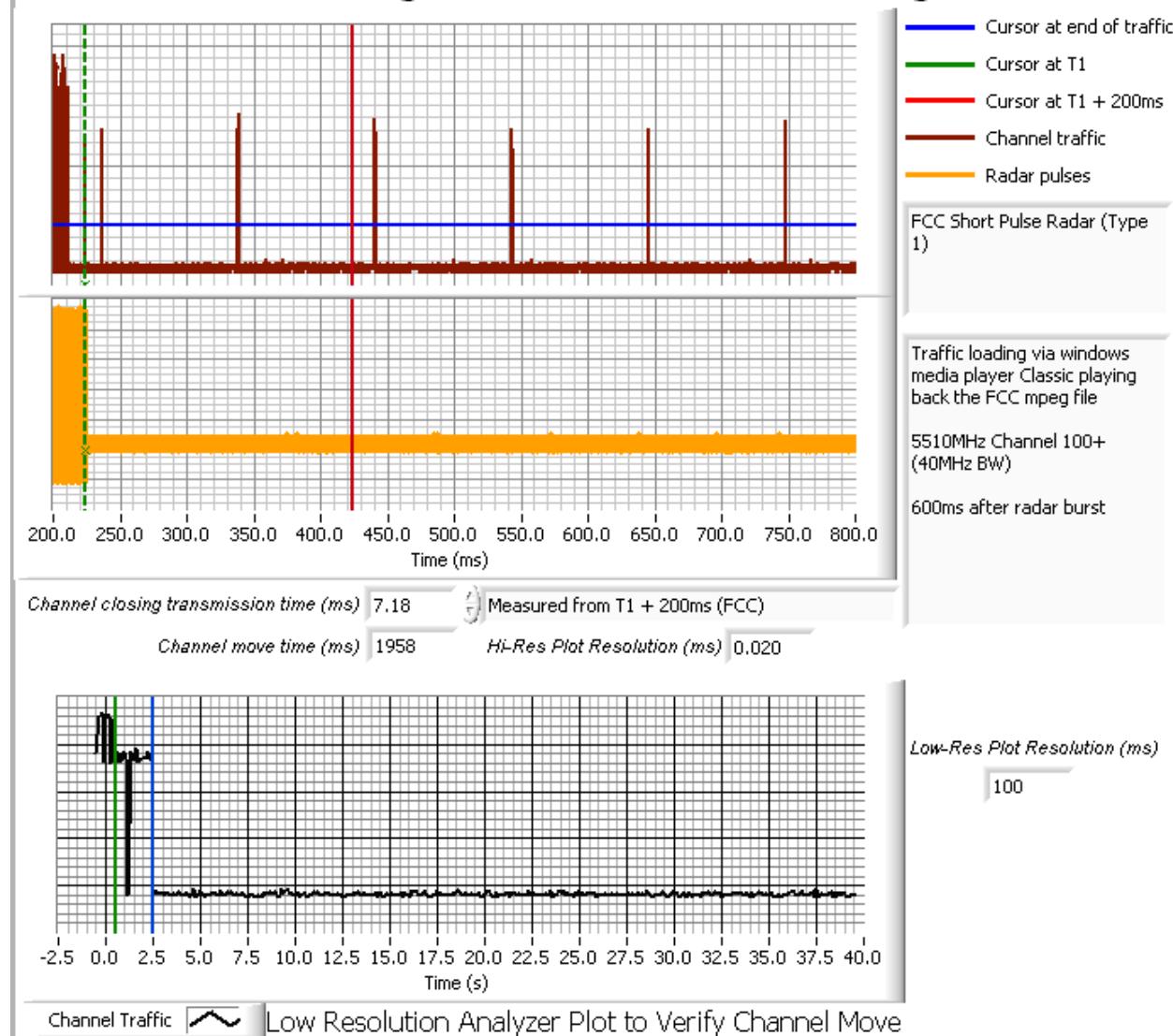


Figure 5 Close-Up of Transmissions Occurring More Than 200ms After The End of Radar

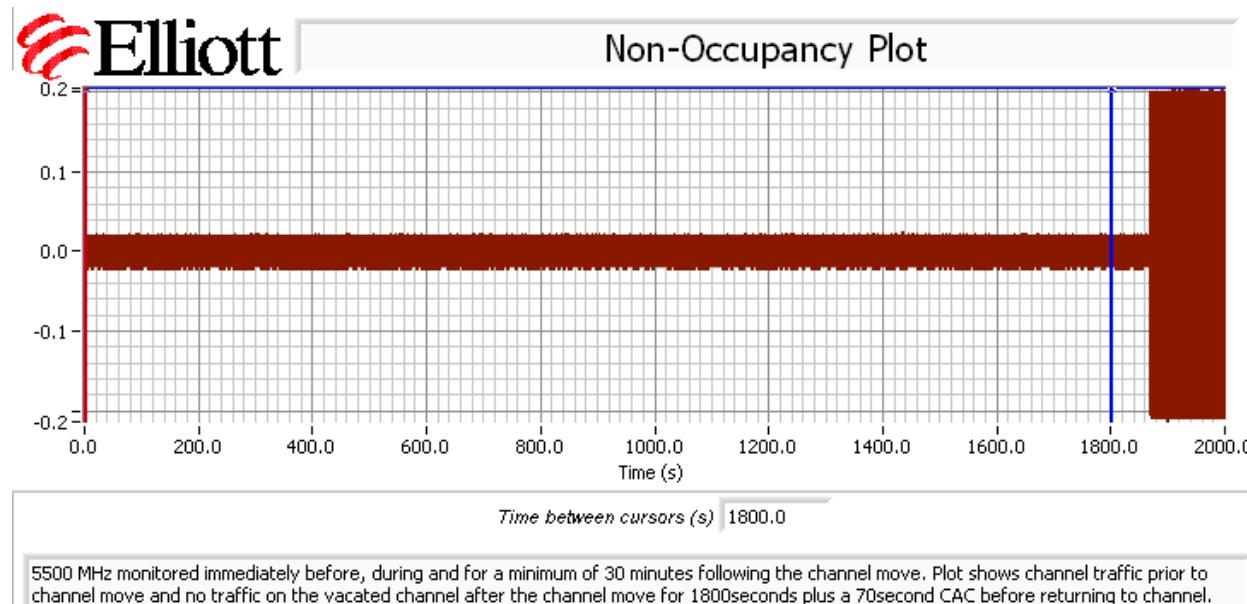


Figure 6 Radar Channel Non-Occupancy Plot – a20

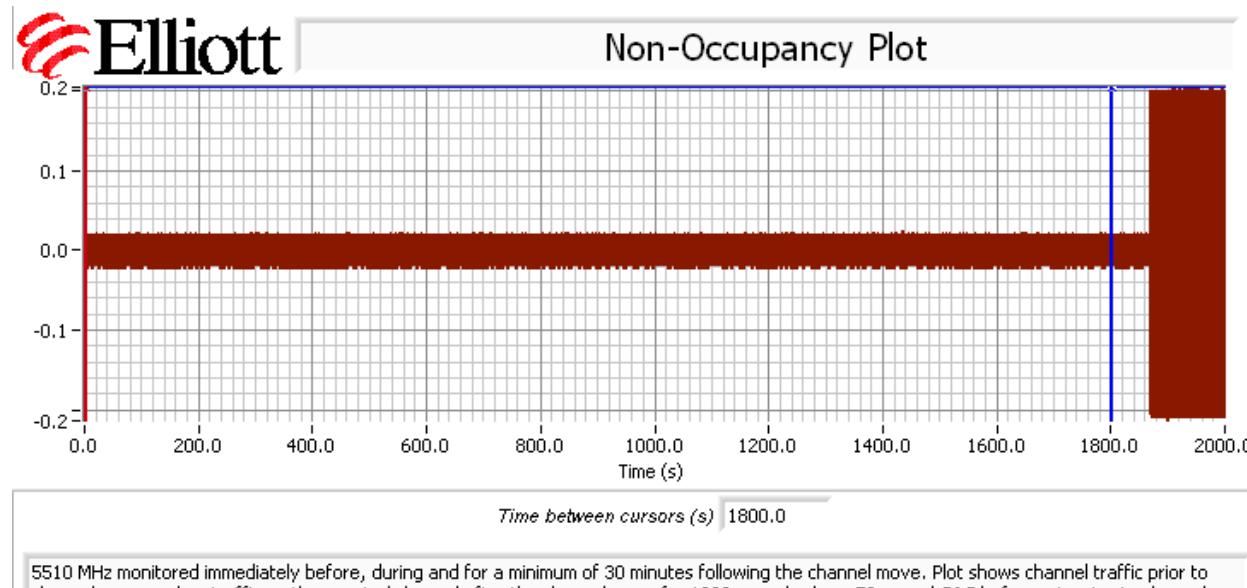


Figure 7 Radar Channel Non-Occupancy Plot – n40

The non-occupancy plot was made over a 30-minute time period following the channel move time with the analyzer IF output connected to the scope and tuned to the vacated channel. No transmissions were observed after the channel move had been completed; followed by a 70 second CAC after which the master AP returned to the channel.

Appendix C Antenna Specification

Revisions			
Rev	Description	Date	Approved
A	New Release	05/01/2012	
Antenna Characteristics			
Parameter	Performance		
Model Number	N/A		
Motorola P/N	ANKH-INT-ANT		
Frequency (MHz)	2400-2500, 5150-5950		
Average Gain (dBi) including cable loss	N/A		
Peak Gain (dBi) including cable loss	2G:5.8 / 5G:5.9		
Cable Loss (dB)	N/A		
Polarization	Linear, vertical		
Antenna type	Inverted F		
VSWR	<2.0		
Isolation (dB), typical	2G: -15 / 5G: -23		
Azimuth Plane 3dB Beam width, typical	2G: 90° / 5G: 120°		
Elevation Plane 3dB Beam width	2G: 150° / 5G: 150°		
Built-in Cable Length (inches)	N/A		
Connector Type	N/A		
Operational temperature	-20 to +70 degree C		
Storage temperature	-40 to +70 degree C		
Plenum rated			
Antenna metal material type			

 **MOTOROLA**

ANT: USB 2x2 RADIO		
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	1 of 8	A

Appendix D Test Configuration Photograph(s)