

**TEST REPORT**

**Covering the  
DYNAMIC FREQUENCY SELECTION (DFS)  
REQUIREMENTS  
OF**

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

**Intel Corporation  
Intel® Centrino® Advanced-N 6235  
Models 6235ANNGW and 6235ANNGU**

COMPANY: Intel Corporation  
2111 N.E. 25th Avenue JF3-3-G14  
Hillsborough, OR, 97124-5961

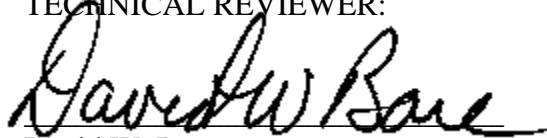
TEST SITE: Elliott Laboratories  
41039 Boyce Road  
Fremont, CA 94538

REPORT DATE: January 14, 2013

FINAL TEST DATE: December 18, 2012

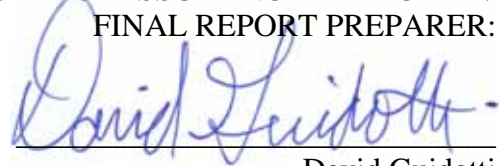
TEST ENGINEER: Mehran Birgani

PROGRAM MGR /  
TECHNICAL REVIEWER:



David W. Bare  
Chief Engineer

QUALITY ASSURANCE DELEGATE /  
FINAL REPORT PREPARER:



David Guidotti  
Senior Technical Writer



Elliott Laboratories is accredited by the A2LA, certificate number 0214.26, to perform the test(s) listed in this report, except where noted otherwise. This report and the information contained herein represent the results of testing test articles identified and selected by the client performed to specifications and/or procedures selected by the client. National Technical Systems (NTS) makes no representations, expressed or implied, that such testing is adequate (or inadequate) to demonstrate efficiency, performance, reliability, or any other characteristic of the articles being tested, or similar products. This report should not be relied upon as an endorsement or certification by NTS of the equipment tested, nor does it represent any statement whatsoever as to its merchantability or fitness of the test article, or similar products, for a particular purpose. This report shall not be reproduced except in full

**REVISION HISTORY**

Rev #	Date	Comments	Modified By
1.0	1-14-2013	First Release	-

**TABLE OF CONTENTS**

**COVER PAGE.....1**  
**REVISION HISTORY .....2**  
**TABLE OF CONTENTS .....3**  
**LIST OF TABLES.....4**  
**LIST OF FIGURES.....4**  
**SCOPE.....5**  
**OBJECTIVE.....5**  
**STATEMENT OF COMPLIANCE.....5**  
**DEVIATIONS FROM THE STANDARD.....5**  
**EQUIPMENT UNDER TEST (EUT) DETAILS.....6**  
    GENERAL.....6  
    ENCLOSURE.....7  
    MODIFICATIONS .....7  
    SUPPORT EQUIPMENT .....7  
    EUT INTERFACE PORTS .....7  
    EUT OPERATION .....7  
**RADAR WAVEFORMS.....8**  
**DFS TEST METHODS .....9**  
    RADIATED TEST METHOD .....9  
**DFS MEASUREMENT INSTRUMENTATION.....11**  
    RADAR GENERATION SYSTEM .....11  
    CHANNEL MONITORING SYSTEM .....12  
**DFS MEASUREMENT METHODS .....13**  
    DFS – CHANNEL CLOSING TRANSMISSION TIME AND CHANNEL MOVE TIME .....13  
    DFS – CHANNEL NON-OCCUPANCY AND VERIFICATION OF PASSIVE SCANNING.....13  
    DFS CHANNEL AVAILABILITY CHECK TIME.....14  
    TRANSMIT POWER CONTROL (TPC) .....14  
**SAMPLE CALCULATIONS .....15**  
    DETECTION PROBABILITY / SUCCESS RATE .....15  
    THRESHOLD LEVEL .....15  
**APPENDIX A TEST EQUIPMENT CALIBRATION DATA .....16**  
**APPENDIX B TEST DATA TABLES AND PLOTS FOR CHANNEL CLOSING .....17**  
    FCC PART 15 SUBPART E CHANNEL CLOSING MEASUREMENTS .....17  
**APPENDIX C TEST CONFIGURATION PHOTOGRAPHS.....23**

**LIST OF TABLES**

Table 1 FCC Short Pulse Radar Test Waveforms..... 8  
Table 2 FCC Long Pulse Radar Test Waveforms ..... 8  
Table 3 FCC Frequency Hopping Radar Test Waveforms ..... 8  
Table 4 FCC Part 15 Subpart E Channel Closing Test Results ..... 17

**LIST OF FIGURES**

Figure 1 Test Configuration for radiated Measurement Method ..... 9  
Figure 2 Channel Closing Time and Channel Move Time, n20 mode – 40 second plot ..... 18  
Figure 3 Close-Up of Transmissions Occurring More Than 200ms After The End of Radar ..... 19  
Figure 4 Channel Closing Time and Channel Move Time, n40 mode – 40 second plot ..... 20  
Figure 5 Close-Up of Transmissions Occurring More Than 200ms After The End of Radar ..... 21  
Figure 6 Radar Channel Non-Occupancy Plot..... 22

## **SCOPE**

The Federal Communications Commission publish standards regarding ElectroMagnetic Compatibility and Radio spectrum Matters for radio-communications devices. Tests have been performed on the Intel Corporation model Intel® Centrino® Advanced-N 6235 in accordance with these standards.

Test data has been taken pursuant to the relevant DFS requirements of the following standard(s). In the cases of ETSI (EN) standards, testing was limited to those aspects covering essential requirements under article 3.2 of the R&TTE Directive pertaining to DFS:

- FCC Part 15 Subpart E Unlicensed National Information Infrastructure (U-NII) Devices

Tests were performed in accordance with these standards together with the current published versions of the basic standards referenced therein as outlined in Elliott Laboratories test procedures.

The test results recorded herein are based on a single type test of the Intel Corporation model Intel® Centrino® Advanced-N 6235 and therefore apply only to the tested sample. The sample was selected and prepared by Steve Hackett of Intel Corporation.

## **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 Intel Corporation model Intel® Centrino® Advanced-N 6235 complied with the DFS requirements of:

FCC Part 15.407(h)(2)

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**

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

**EQUIPMENT UNDER TEST (EUT) DETAILS**

**GENERAL**

The Intel Corporation model Intel® Centrino® Advanced-N 6235 is a PCIe Half Mini Card form factor Bluetooth/IEEE 802.11a/b/g/n wireless network adapters. The card supports MIMO (2x2) for 802.11n modes and MISO (1x2) for 802.11a/b/g modes. Bluetooth operates on a single chain and supports Basic rate, Enhanced data rate and Low Energy modes. The Basic and Enhanced data rates fully support frequency hopping while the Low Energy (LE) mode can operate in both hopping and non-hopping modes. The LE mode was evaluated under the rules for digital modulation systems while the other modes were evaluated as FHSS. When Bluetooth is operational then 802.11b/g/n modes operate as SISO (1x1). 802.11a/n modes still operate as MIMO (2x2) with Bluetooth operational.

The sample was received on December 10, 2012 and tested on December 18, 2012. The EUT consisted of the following component(s):

Manufacturer	Model	Description	MAC Address
Intel	Intel® Centrino® Advanced-N 6235	WiFi Module	001500B50432

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)	3.7	4.8
Highest Antenna Gain (dBi)	3.7	4.8
Output Power (dBm)	16	16.1

**Channel Protocol**

- IP Based

**ENCLOSURE**

The EUT has no enclosure. It is designed to be installed within the enclosure of a host computer.

**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	Serial Number	FCC ID
Toshiba	PSAG8U-04001W	Host Laptop	49290792Q	DoC
<i>Cisco</i>	<i>AIR-RM1252G-A-K9</i>	<i>Access Point</i>	<i>FTX1209906V</i>	<i>FCC:LDK102062 IC:2461B-24610262</i>
Delta Electronics	ADP-755B AB	Power Adaptor	-	-

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)
Remote Laptop	DHCP Server Ethernet	CAT5 UTP	Unshielded	2.0
DHCP Server Ethernet	PoE Injector Ethernet	CAT5 UTP	Unshielded	1.0
PoE Injector Ethernet	Access Point Ethernet	CAT5 UTP	Shielded	10.0

**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:**

During the in-service monitoring detection probability and 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 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

**RADAR WAVEFORMS**

<b>Table 1 FCC Short Pulse Radar Test Waveforms</b>					
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

<b>Table 2 FCC Long Pulse Radar Test Waveforms</b>							
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

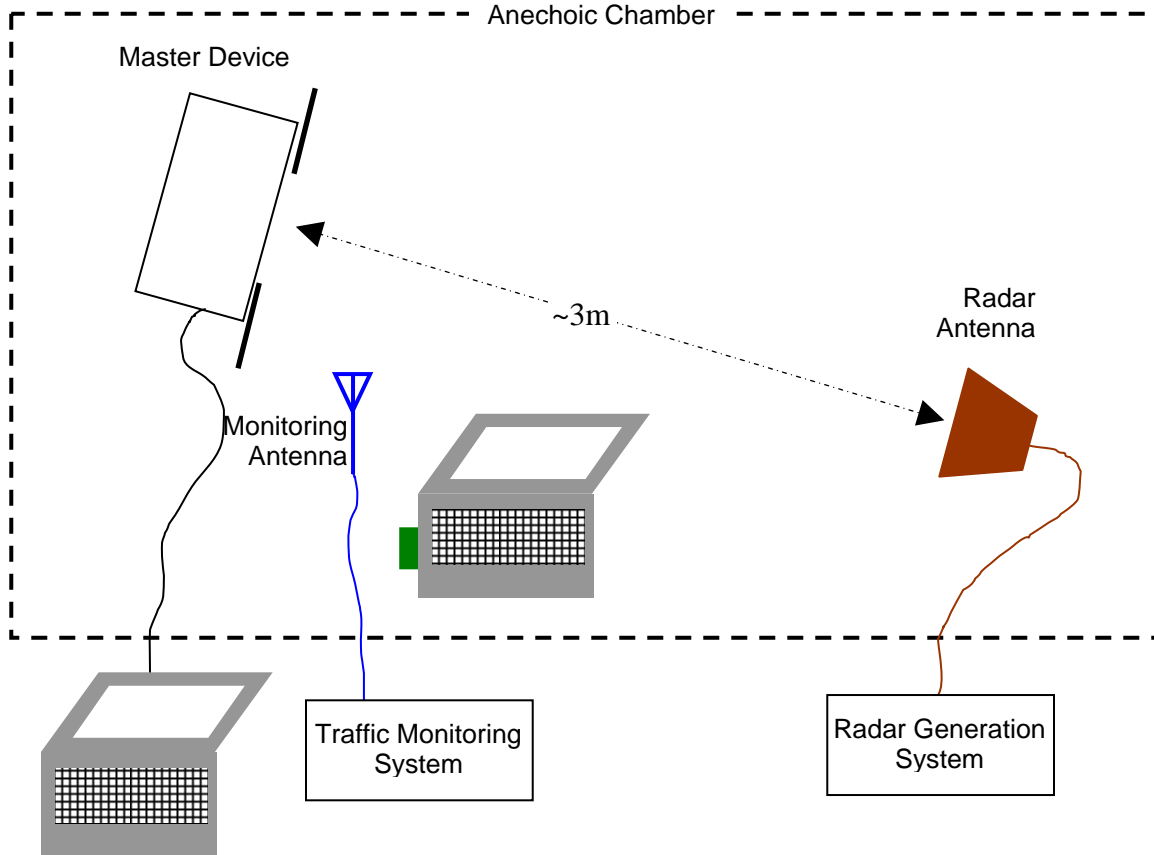
<b>Table 3 FCC Frequency Hopping Radar Test Waveforms</b>							
Radar Type	Pulse Width (μsec)	PRI (μsec)	Pulses / hop	Hopping Rate (kHz)	Hopping Sequence Length (msec)	Minimum Detection Percentage	Minimum Number of Trials
6	1	333	9	0.333	300	70%	30



**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  $G$  (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 Elliott custom software to produce the required waveforms, with the capability to produce both unmodulated 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 one of two ways:

FCC – 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.

***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**

<b><u>Manufacturer</u></b>	<b><u>Description</u></b>	<b><u>Model #</u></b>	<b><u>Asset #</u></b>	<b><u>Cal Due</u></b>
Hewlett Packard	EMC Spectrum Analyzer, 9 KHz-26.5 GHz	8593EM	780	25-Jan-13
EMCO	Antenna, Horn, 1-18 GHz	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	TDS5052 B	2118	N/A



**Appendix B Test Data Tables and Plots for Channel Closing**

**FCC PART 15 SUBPART E Channel Closing Measurements**

<b>Table 4 FCC Part 15 Subpart E Channel Closing Test Results</b>					
Waveform Type	Channel Closing Transmission Time <sup>1</sup>		Channel Move Time		Result
	Measured	Limit	Measured	Limit	
Radar Type 1, 802.11n 20MHz	1.6 ms	60 ms	0.6 s	10 s	PASS
Radar Type 1, 802.11n 40MHz	1.6 ms	60 ms	0.6 s	10 s	PASS

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

---

<sup>1</sup> 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.

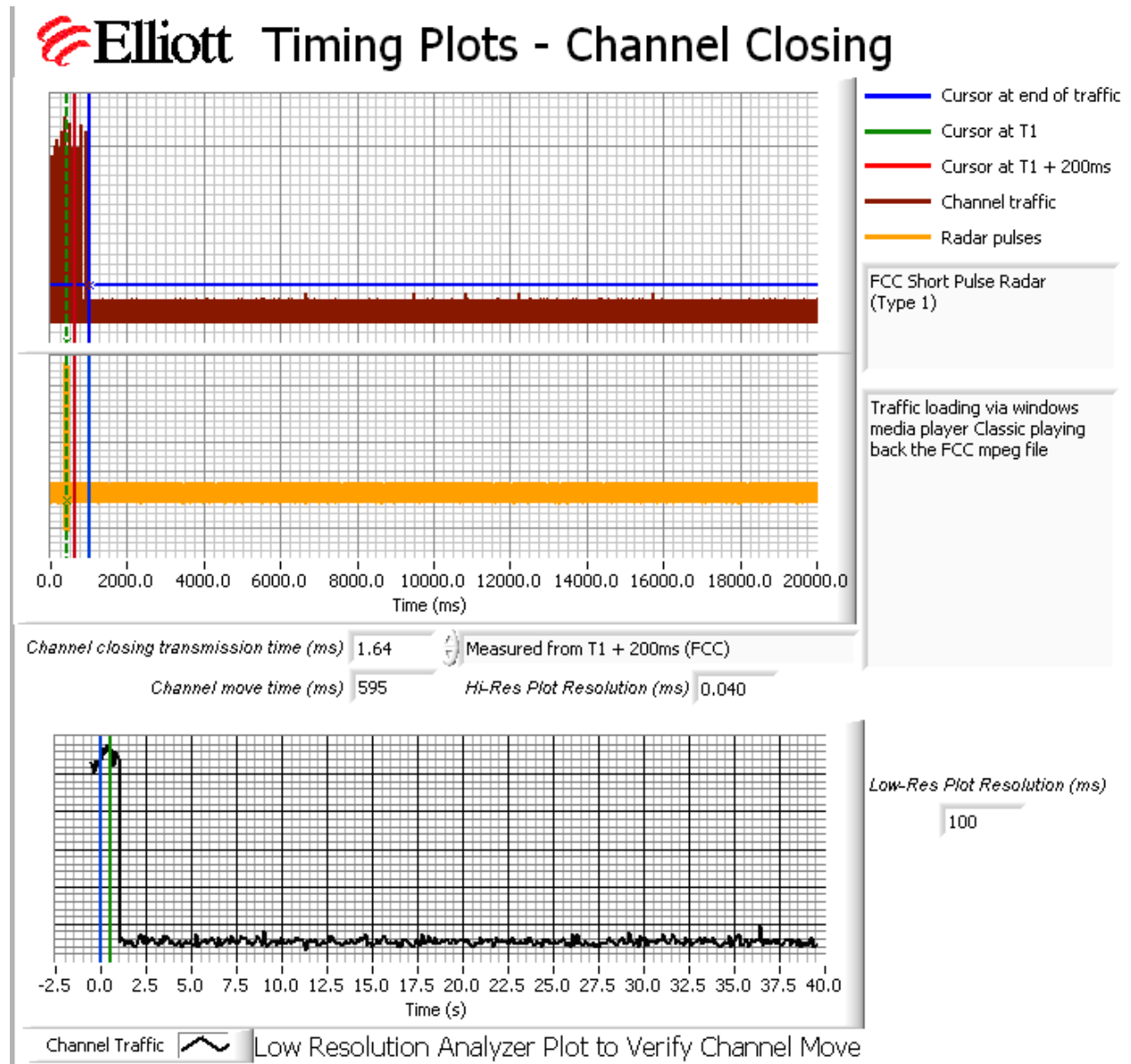


Figure 2 Channel Closing Time and Channel Move Time, n20 mode – 40 second plot

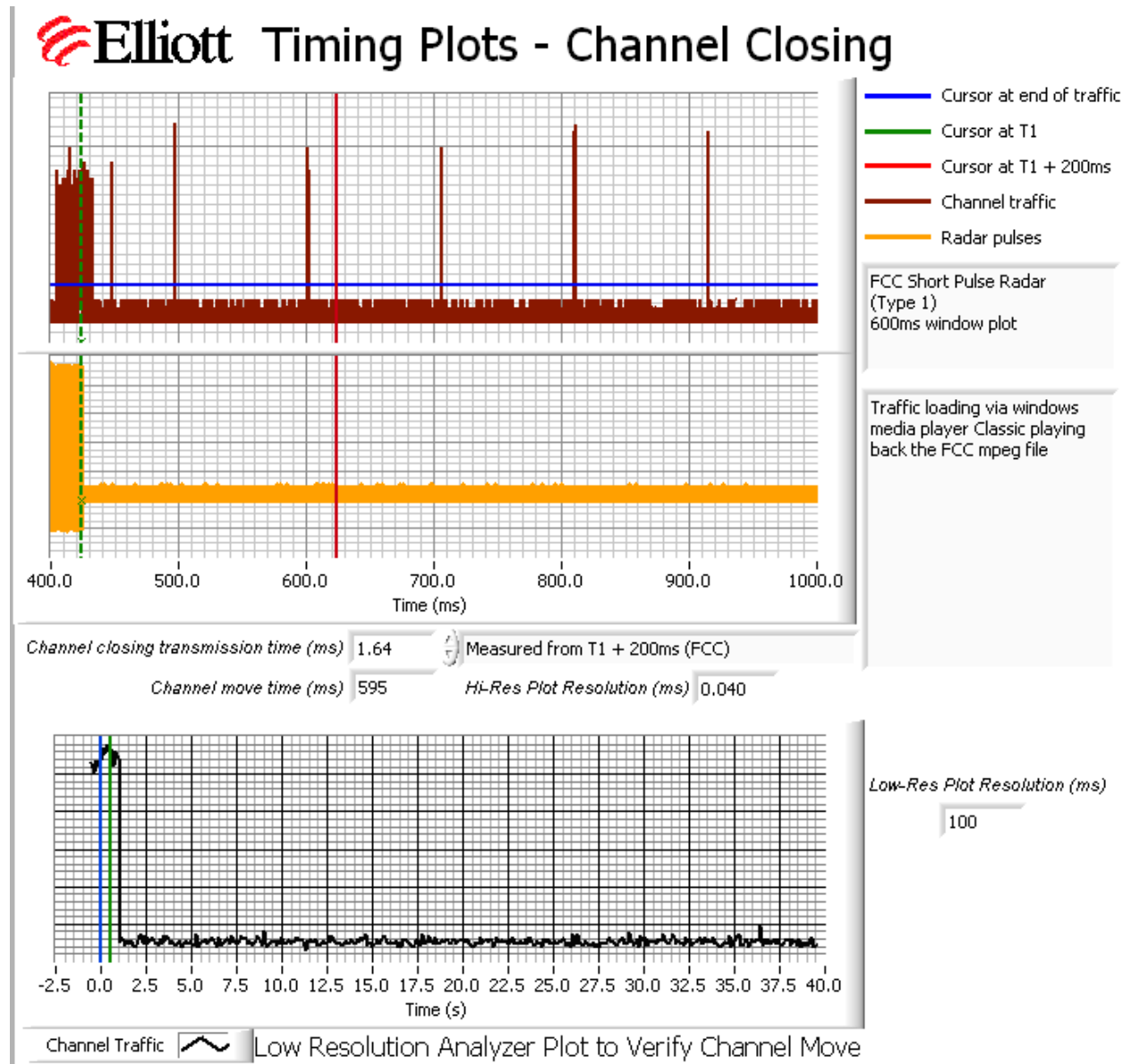


Figure 3 Close-Up of Transmissions Occurring More Than 200ms After The End of Radar

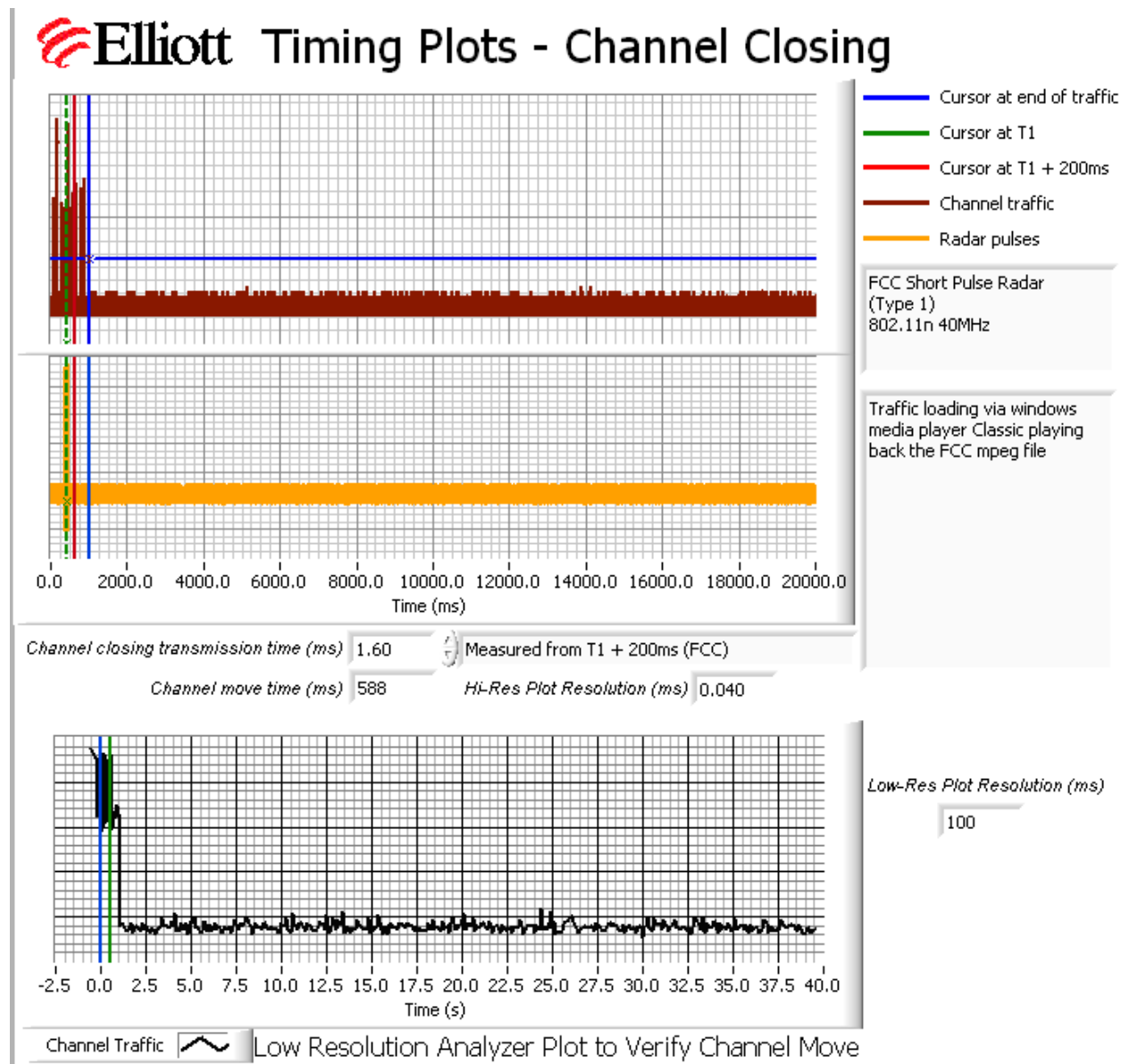


Figure 4 Channel Closing Time and Channel Move Time, n40 mode – 40 second plot

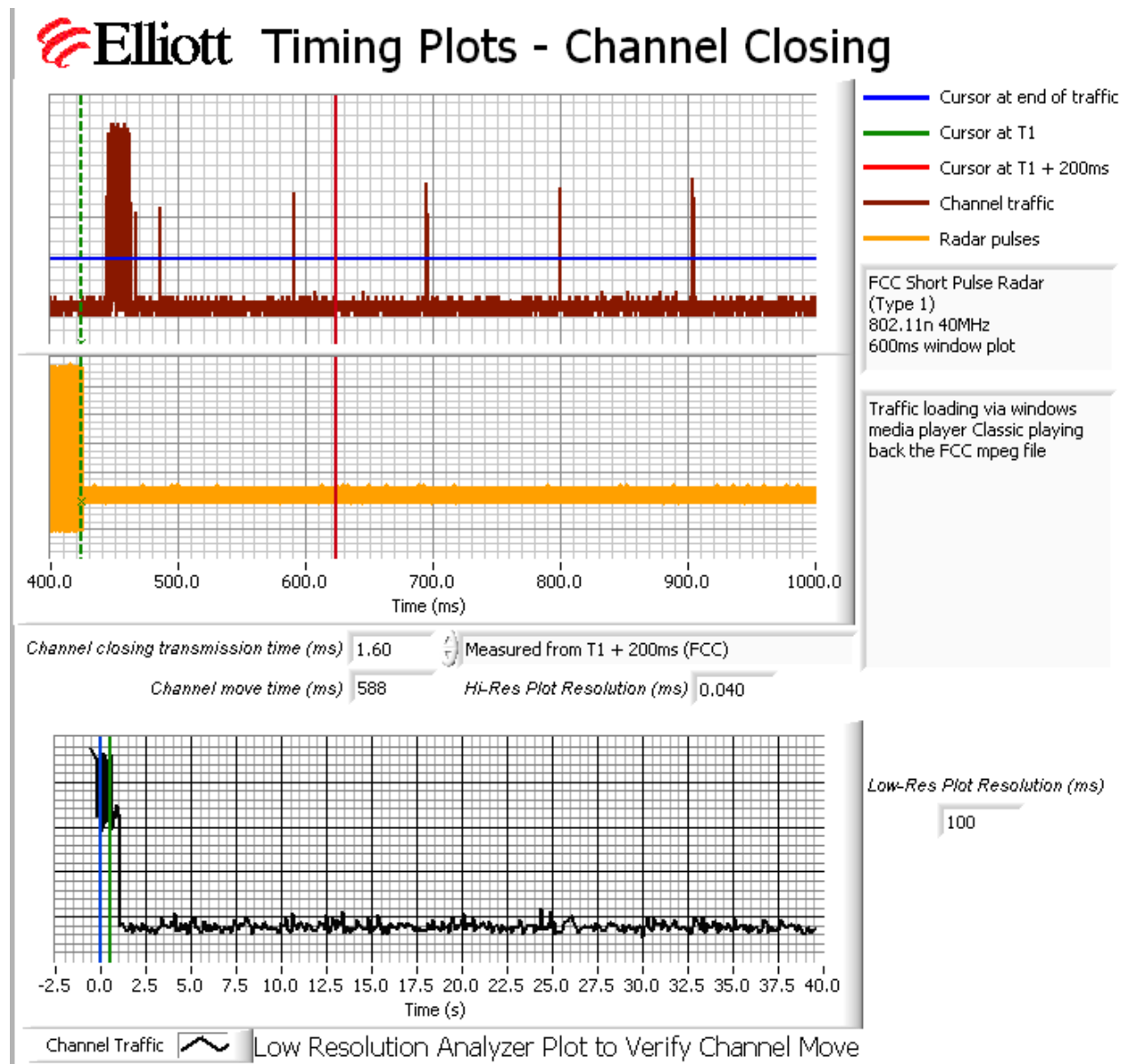
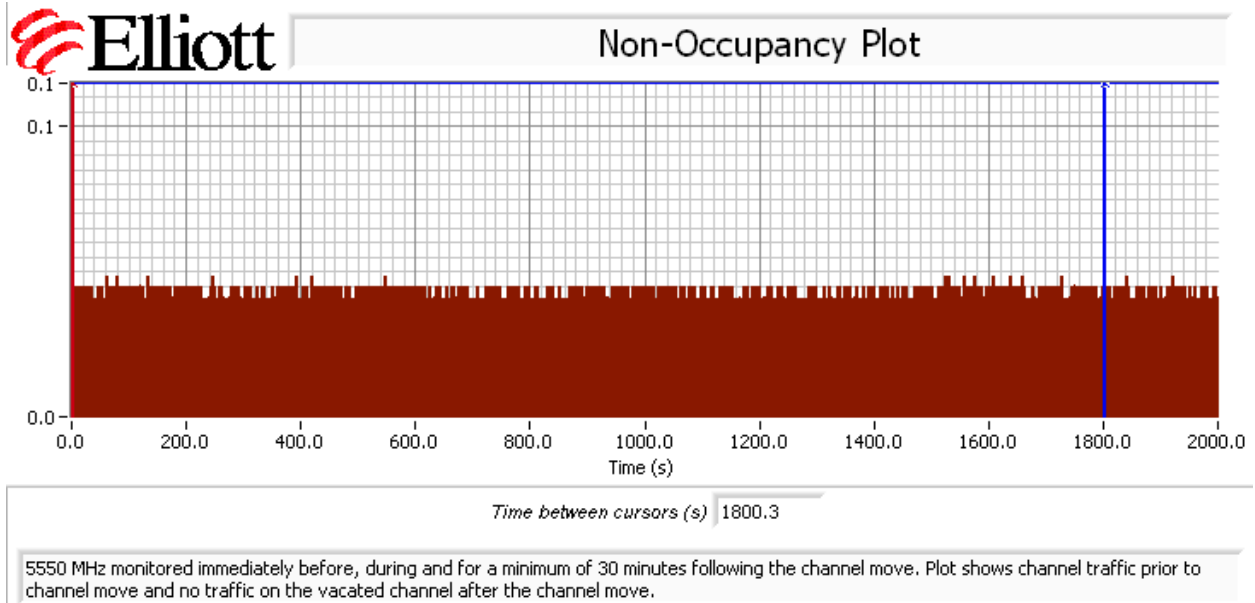


Figure 5 Close-Up of Transmissions Occurring More Than 200ms After The End of Radar



**Figure 6 Radar Channel Non-Occupancy Plot**

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.

After the channel move the client re-associated with the master device on the new channel. After the channel move the client device stopped transmitting.

*Appendix C Test Configuration Photographs*

