

Intermec Technologies Corporation

**Model: RC12 in
1000CP01**

Tested to the following DFS Specifications:

**FCC 15.407: 2010
RSS-210 Issue 7: 2007
EN 301 893 V1.5.1:2008**

Report No. INMC0648 Rev. 1

Report Prepared By



www.nwemc.com
1-888-EMI-CERT

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DFS Test Report



22975 NW Evergreen Parkway
Suite 400
Hillsboro, Oregon 97124

Certificate of Test
Last Date of Test: December 1, 2010
Intermec Technologies Corporation
Model: RC12 in 1000CP01

Emissions			
Test Description	Specification	Test Method	Pass/Fail
Client Device DFS Conformance Test	FCC 15.407:2010	FCC 06-96:2006	Pass
	RSS-210 Issue 7:2007	RSS-210 Issue 7:2007	Pass
	EN 301 893 V1.5.1:2008	EN 301 893 V1.5.1:2008	Pass

Modifications made to the product
See the Modifications section of this report

Test Facility

The measurement facility used to collect the data is located at:

Northwest EMC, Inc.
22975 NW Evergreen Parkway, Suite 400
Hillsboro, OR 97124

Phone: (503) 844-4066 Fax: 844-3826

This site has been fully described in a report filed with and accepted by the FCC (Federal Communications Commission) and Industry Canada (Site filing #2834D-2).

Approved By:

Greg Kiemel, Director of Engineering

This report must not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the federal government of the United States of America.

Product compliance is the responsibility of the client, therefore the tests and equipment modes of operation represented in this report were agreed upon by the client, prior to testing. This Report may only be duplicated in its entirety. The results of this test pertain only to the sample(s) tested. The specific description is noted in each of the individual sections of the test report supporting this certificate of test.

Revision Number	Description	Date	Page Number
01	Updated with client attestation	1-11-11	8,9

Barometric Pressure

The recorded barometric pressure has been normalized to sea level.



Accreditations and Authorizations

FCC

Accredited by NVLAP for performance of FCC radio, digital, and ISM device testing. Our Open Area Test Sites, certification chambers, and conducted measurement facilities have been fully described in reports filed with the FCC and accepted by the FCC in letters maintained in our files. Northwest EMC has been accredited by ANSI to ISO / IEC Guide 65 as a product certifier. We have been designated by the FCC as a Telecommunications Certification Body (TCB). This allows Northwest EMC to certify transmitters to FCC specifications in accordance with 47 CFR 2.960 and 2.962.



NVLAP

Northwest EMC, Inc. is accredited under the United States Department of Commerce, National Institute of Standards and Technology, and National Voluntary Laboratory Accreditation Program for satisfactory compliance with the requirements of ISO/IEC 17025 for Testing Laboratories. The NVLAP accreditation encompasses Electromagnetic Compatibility Testing in accordance with the European Union EMC Directive 2004/108/EC, and ANSI C63.4. Additionally, Northwest EMC is accredited by NVLAP to perform radio testing in accordance with the European Union R&TTE Directive 1999/5/EEC, the requirements of FCC, and the RSS radio standards for Industry Canada.



NVLAP LAB CODE 200629-0
NVLAP LAB CODE 200630-0
NVLAP LAB CODE 200676-0
NVLAP LAB CODE 200761-0
NVLAP LAB CODE 200881-0

Industry Canada

Accredited by NVLAP for performance of Industry Canada RSS and ICES testing. Our Open Area Test Sites and certification chambers comply with RSS-Gen, Issue 2 and have been filed with Industry Canada and accepted. Northwest EMC has been accredited by ANSI to ISO / IEC Guide 65 as a product certifier. We have been designated by NIST and recognized by Industry Canada as a Certification Body (CB) per the APEC Mutual Recognition Arrangement (MRA). This allows Northwest EMC to certify transmitters to Industry Canada technical requirements. (*Site Filing Numbers - Hillsboro: 2834D-1, 2834D-2, Sultan: 2834C-1, Irvine: 2834B-1, 2834B-2, Brooklyn Park: 2834E-1*)



CAB

Designated by NIST and validated by the European Commission as a Conformity Assessment Body (CAB) to conduct tests and approve products to the EMC directive and transmitters to the R&TTE directive, as described in the U.S. - EU Mutual Recognition Agreement.



NEMKO

Assessed and accredited by NEMKO (Norwegian testing and certification body) for European emissions and immunity testing. As a result of NEMKO's laboratory assessment, they will accept test results from Northwest EMC, Inc. for product certification (Authorization No. ELA 119).



Australia/New Zealand

The National Association of Testing Authorities (NATA), Australia has been appointed by the ACA as an accreditation body to accredit test laboratories and competent bodies for EMC standards. Accredited test reports or assessments by competent bodies must carry the NATA logo. Test reports made by an overseas laboratory that has been accredited for the relevant standards by an overseas accreditation body that has a Mutual Recognition Agreement (MRA) with NATA are also accepted as technical grounds for product conformity. The report should be endorsed with the respective logo of the accreditation body (NVLAP).



VCCI

Accepted as an Associate Member to the VCCI, Acceptance No. 564. Conducted and radiated measurement facilities have been registered in accordance with Regulations for Voluntary Control Measures, Article 8. (Registration Numbers. - Hillsboro: C-1071, R-1025, G-84, C-2687, T-1658, and R-2318, Irvine: R-1943, G-85, C-2766, and T-1659, Sultan: R-871, G-83, C-1784, and T-1511, Brooklyn Park: R-3125, G-86, G-141, C-3464, and T-1634).



BSMI

Northwest EMC has been designated by NIST and validated by C-Taipei (BSMI) as a CAB to conduct tests as described in the APEC Mutual Recognition Agreement (US0017). License No.SL2-IN-E-1017.



GOST

Northwest EMC, Inc. has been assessed and accredited by the Russian Certification bodies Certinform VNIINMASH, CERTINFO, SAMTES, and Federal CHEC, to perform EMC and Hygienic testing for Information Technology Products. As a result of their laboratory assessment, they will accept test results from Northwest EMC, Inc. for product certification



KCC

Northwest EMC, Inc is a CAB designated by MRA partners and recognized by Korea. (Assigned Lab Numbers: Hillsboro: US0017, Irvine: US0158, Sultan: US0157)



VIETNAM

Vietnam MIC has approved Northwest EMC as an accredited test lab. Per Decision No. 194/QD-QLCL (dated December 15, 2009), Northwest EMC test reports can be used for Vietnam approval submissions.



SCOPE

For details on the Scopes of our Accreditations, please visit:

<http://www.nwemc.com/accreditations/>



Northwest EMC Locations



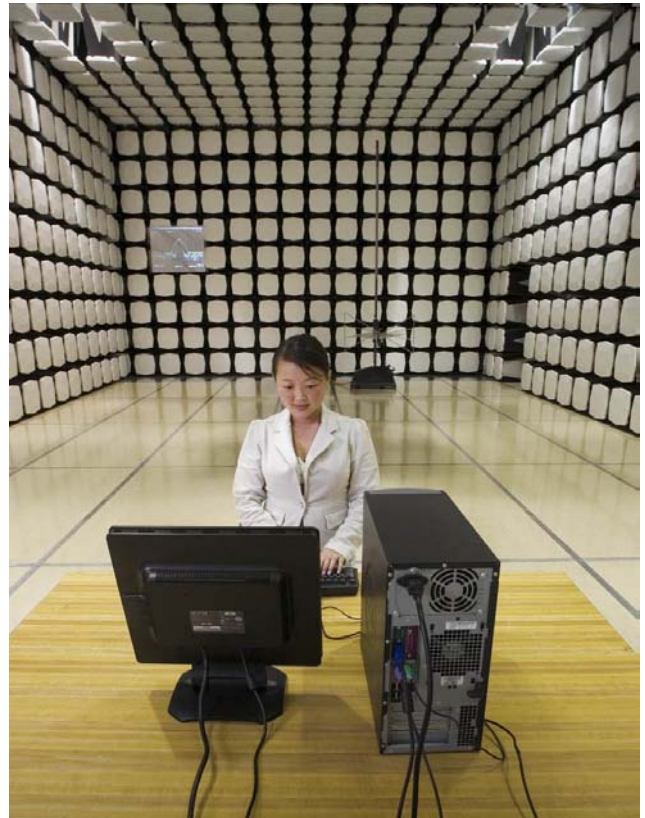
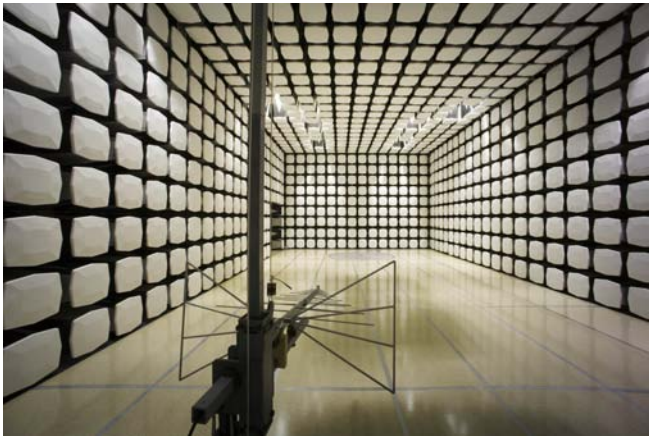
Oregon
Labs EV01-EV12
22975 NW Evergreen Pkwy
Suite 400
Hillsboro, OR 97124
(503) 844-4066

California
Labs OC01-OC13
41 Tesla
Irvine, CA 92618
(949) 861-8918

Minnesota
Labs MN01-MN08
9349 W Broadway Ave.
Brooklyn Park,
MN 55445
(763) 425-2281

Washington
Labs SU01-SU07
14128 339th Ave. SE
Sultan, WA 98294
(360) 793-8675

New York
Labs WA01-WA04
4939 Jordan Rd.
Elbridge, NY 13060
(315) 685-0796



Party Requesting the Test

Company Name:	Intermec Technologies Corporation
Address:	6001 36 th Avenue West
City, State, Zip:	Everett, WA 98203-1264
Test Requested By:	Wayne Rieger
Model:	RC12 in 1000CP01
First Date of Test:	December 1, 2010
Last Date of Test:	December 1, 2010
Receipt Date of Samples:	November 30, 2010
Equipment Design Stage:	Production
Equipment Condition:	No Damage

U-NII Device Description**Functional Description**

The Model RC12 is an 802.11a/b/g/n - Bluetooth radio module. It is a client device and has no radar detection and no ad-hoc capability. For this DFS test, it was installed in Intermec's handheld computer, Model 1000CP01.

Hardware, Firmware, and OS Versions:

Hardware version: P4
 Firmware version: 6.1.0.0.337
 OS versions: 1.20.0.0512

The operating frequency range(s) of the equipment.

2412 – 2462 MHz

5180 – 5240 MHz

5260 - 5320 MHz (DFS Band)

5500 – 5700 MHz (DFS Band)

5745 – 5825 MHz

The operating modes (Master and/or Client) of the U-NII device.

Client device with no radar detection and no ad-hoc capability

For Client devices, indicate whether or not it has DFS capabilities and indicate the FCC (and IC) identifier for the Master U-NII Device that is used with it for DFS testing.

The client device has no radar detection and no ad-hoc capability. A DFS-compliant Master device was used for testing. It's the CISCO Model AIR-AP1252AG-A-K9, FCC ID:LDK102061, IC: 2461B-102061

List the highest and the lowest possible power level (equivalent isotropic radiated power (EIRP) of the equipment.

The maximum EIRP of the 5 GHz equipment is 17.8 dBm, and the minimum possible EIRP is 12.1 dBm.

Test sequences or messages that should be used for communication between Master and Client Devices, which are used for loading the Channel.

1. Stream the test file from the Master Device to the Client Device for IP based systems or frame based systems which dynamically allocate the talk/listen ratio.
2. For frame based systems with fixed talk/listen ratio, set the ratio to 45%/55% and stream the test file from the Master to the Client.
3. For other system architectures, supply appropriate Channel loading methodology.

System testing was performed with the MPEG test file that streams full motion video at 30 frames per second from the Master to the Client IP based system. Intermec provided the following attestation of how the channel loading requirements were met:

“Per Section 7.7 of the FCC Procedure, the Intermec DFS test system uses the test file designated by the NTIA. The video format and codec are equivalent to those specified by the NTIA.”

Transmit Power Control description.

This device does not exceed 27dBm EIRP, so no transmit power control is implemented.

System architectures, data rates, U-NII Channel bandwidths.

1. Indicate the type(s) of system architecture (e.g. IP based or Frame based) that the U-NII device employs. Each type of unique architecture must be tested.

The client device (EUT) employs IP based system architecture.

The time required for the Master Device and/or Client Device to complete its power-on cycle.

The Master device used in the test system requires 1.44 minutes to complete its power-on cycle. The client device (EUT) does not have radar detection, so its power-on time is not applicable, but was measured to be 1.8 minutes.

Manufacturer statement confirming that information regarding the parameters of the detected Radar Waveforms is not available to the end user.

The client device (EUT) does not have radar detection, so the parameters of the Radar Waveforms are not available to the end user.

Uniform Channel Spreading requirement for Master Devices. For Master Devices, indicate how the master provides, on aggregate, uniform Channel loading of the spectrum across all Channels.

The client device (EUT) does not have radar detection, so this requirement is not applicable.

List all antenna assemblies and their corresponding gains.

1. If radiated tests are to be performed, the U-NII Device should be tested with the lowest gain antenna assembly (regardless of antenna type). The report should indicate which antenna assembly was used for the tests. For devices with adjustable output power, list the output power range and the maximum EIRP for each antenna assembly.
2. If conducted tests are to be performed, indicate which antenna port/connection was used for the tests and the antenna assembly gain that was used to set the DFS Detection Threshold level during calibration of the test setup.
 - a. Indicate the calibrated conducted DFS Detection Threshold level.
 - b. For devices with adjustable output power, list the output power range and the maximum EIRP for each antenna assembly.
 - c. Indicate the antenna connector impedance. Ensure that the measurement instruments match (usually 50 Ohms) or use a minimum loss pad and take into account the conversion loss.
3. Antenna gain measurement verification for tested antenna.
 - a. Describe procedure
 - b. Describe the antenna configuration and how it is mounted
 - c. If an antenna cable is supplied with the device, cable loss needs to be taken into account. Indicate the maximum cable length and either measure the gain with this cable or adjust the measured gain accordingly. State the cable loss.

The client device (EUT) has only one antenna port. A conducted DFS test was performed using the client device's only antenna port. It has 50 ohm impedance.

The antenna gain of the client device was measured by Intermec in their ETS Lindgren antenna chamber. It was a free space measurement of the antenna gain while installed in its final configuration in the Model 1000CP01 handheld computer. The measured gain included cable loss from the antenna cable connecting the antenna to the radio module's RF output. The maximum gain in the 5 GHz bands is 4.0 dBi. The minimum gain is 1.4 dBi.

The calibrated conducted DFS detection threshold was set to -63 dBm at the antenna port of the Master. This is equal to the DFS Detection Threshold of the Master + 1 dB.

Applicability of DFS Requirements Prior to Use of a Channel

Requirement	Operational Mode		
	Master	Client (without DFS)	Client (with DFS)
Non-Occupancy Period	Yes	Not required	Yes
DFS Detection Threshold	Yes	Not required	Yes
Channel Availability Check Time	Yes	Not required	Not required
Uniform Spreading	Yes	Not required	Not required
U-NII Detection Bandwidth	Yes	Not required	Yes

Applicability of DFS requirements during normal operation

Requirement	Operational Mode		
	Master	Client (without DFS)	Client (with DFS)
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

DFS Response Requirement Values

Parameter	Value
Non-occupancy	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 80% of the UNII 99% transmission power bandwidth. (See Note 3).
<p>Note 1: The instant that the Channel Move Time and the Channel Closing Transmission Time begins is as follows:</p> <ul style="list-style-type: none"> • 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 Waveform. <p>Note 2: The Channel Closing Transmission Time is comprised of 200 milliseconds starting at the beginning of the Channel Move Time plus any additional intermittent control signals required to facilitate a Channel move (an aggregate of 60 milliseconds) during the remainder of the 10 second period. The aggregate duration of control signals will not count quiet periods in between transmissions.</p> <p>Note 3: During the U-NII Detection Bandwidth detection test, radar type 1 is used and for each frequency step the minimum percentage of detection is 90 percent. Measurements are performed with no data traffic.</p>	

DFS Detection Thresholds for Master or Client Devices Incorporating DFS

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.

Short Pulse Radar Test Waveforms

Radar Type	Pulse Width (μsec)	PRI (μsec)	Number of Pulses	Minimum Percentage of Successful Detection	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

Long Pulse Radar Test Waveforms

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

Frequency Hopping Radar Test Waveform

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

CONFIGURATION 1 INMC0648

EUT			
Description	Manufacturer	Model/Part Number	Serial Number
EUT - WLAN Client	Intermec	CN70	24311047002

Peripherals in test setup boundary			
Description	Manufacturer	Model/Part Number	Serial Number
USB Snapon adapter	Intermec	225-773-001	None
AC Adapter	Intermec	AE39	02061000875

Remote Equipment Outside of Test Setup Boundary			
Description	Manufacturer	Model/Part Number	Serial Number
WLAN Master Access Point	Cisco	AIR-LAP1252G-A-K9	FTX123590JT

Cables					
Cable Type	Shield	Length (m)	Ferrite	Connection 1	Connection 2
AC Mains	No	1.8m	No	AC Adapter	AC Mains
DC Power	PA	1.8m	PA	AC Adapter	Snap-on adapter
PA = Cable is permanently attached to the device. Shielding and/or presence of ferrite may be unknown.					

Equipment modifications

Item	Date	Test	Modification	Note	Disposition of EUT
1	12/1/2010	Client Device DFS Conformance Test	Tested as delivered to Test Station.	No EMI suppression devices were added or modified during this test.	Scheduled testing was completed.

For a Client Device without DFS, the Channel Move Time and Channel Closing Transmission Time requirements are verified with one Short Pulse Radar. For testing a Client Device with In-Service Monitoring, two configurations must be tested. The Client Device must demonstrate it can detect the Radar Waveform. The Channel Move Time and Channel Closing Transmission Time requirements specified will be verified utilizing Short Pulse Radar.

Channel Closing Transmission Time: The total duration of transmissions, consisting of data signals and the aggregate of control signals, by a U-NII device during the Channel Move Time.

Channel Move Time: The time to cease all transmissions on the current Channel upon detection of a Radar Waveform above the DFS Detection Threshold.

A Client Device will not transmit before having received appropriate control signals from a Master Device.

Time and Channel Closing Transmission Time requirements. The Client Device will not resume any transmissions until it has again received control signals from a Master Device.

If a Client Device is performing In-Service Monitoring and detects a Radar Waveform above the DFS Detection Threshold, it will inform the Master Device.

Irrespective of Client Device or Master Device detection, the Channel Move Time and Channel Closing Transmission Time requirements remain the same.

DFS Detection Thresholds for Master or Client Devices Incorporating DFS

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.	

DFS Response Requirement Values

Parameter	Value
<i>Non-occupancy period</i>	Minimum 30 minutes
<i>Channel Availability Check Time</i>	60 seconds
<i>Channel Move Time</i>	10 seconds See Note 1.
<i>Channel Closing Transmission Time</i>	200 milliseconds + an aggregate of 60 milliseconds over remaining 10 second period. See Notes 1 and 2.

Setting the Test Signal Level

The radar test signal level is set at the Master Device, or the Client Device with In-Service Monitoring, as appropriate for the particular test. This device is known as the Radar Detection Device (RDD).

- When a Client Device without In-Service Monitoring is the UUT, the Master Device is the RDD.
- When a Client Device with In-Service Monitoring is the UUT, and is tested for response to the Master Device detections, the Master Device is the RDD.
- When a Client Device with In-Service Monitoring is the UUT, and is tested for independent response to detections by the Client Device, the Client Device is the RDD.

A spectrum analyzer is used to establish the test signal level for each radar type. During this process, there are no transmissions by either the Master Device or Client Device. The spectrum analyzer is switched to the zero span (time domain) mode at the frequency of the Radar Waveform generator. The peak detector function of the spectrum analyzer is utilized. The spectrum analyzer resolution bandwidth (RBW) and video bandwidth (VBW) are set to at least 3 MHz.

The signal generator amplitude and/or step attenuators are set so that the power level measured at the spectrum analyzer is equal to the DFS Detection Threshold that is required for the tests. The signal generator and attenuator settings are recorded for use during the test.

DFS MONITORING

System testing will be performed with the designated MPEG test file that streams full motion video at 30 frames per second for Channel loading. If the designated MPEG test file is not utilized then an equivalent test file will be used, subject to FCC approval.

CHANNEL LOADING

System testing will be performed with the designated MPEG test file that streams full motion video at 30 frames per second for Channel loading. If the designated MPEG test file is not utilized then an equivalent test file will be used, subject to FCC approval.

TEST EQUIPMENT

Description	Manufacturer	Model	ID	Last Cal.	Interval
Spectrum Analyzer	Agilent	E4440A	AFD	6/1/2009	24 mo
RF Vector Signal Generator	Agilent	V2920A	TIC	10/27/2010	12 mo
Oscilloscope	Tektronix	TDS 3052	TOF	12/10/2008	24 mo
Signal Generator	Agilent	E8257D	TGX	12/10/2008	25 mo
Power Meter	Gigatronics	8651A	SPM	1/7/2010	13 mo

TEST DESCRIPTION

The tests in this section are run sequentially and the UUT must pass all tests successfully. If the UUT fails any one of the tests it will count as a failure of compliance. To show compliance, all tests must be performed with waveforms randomly generated as specified with test results meeting the required percentage of successful detection criteria. All test results must be reported to the FCC. One frequency will be chosen from the operating Channels of the UUT within the 5.25-5.35 GHz or 5.47-5.725 GHz bands.

EMC

DFS CHANNEL SHUTDOWN, MOVE, NON-OCCUPANCY

EUT:	RC12 in 1000CP01	Work Order:	INMC0648
Serial Number:	24311047002	Date:	12/01/10
Customer:	Intermec Technologies Corporation	Temperature:	22°C
Attendees:	None	Humidity:	38%
Project:	None	Barometric Pres.:	30.11 inches
Tested by:	Rod Peloquin & Don Facticeau	Power:	120VAC/60Hz
		Job Site:	EV06

TEST SPECIFICATIONS		Test Method
FCC 15.407:2010		FCC 06-96:2006

COMMENTS
The calibrated conducted DFS detection threshold was set to -63 dBm at the antenna port of the Master. This is equal to the DFS Detection Threshold of the Master + 1 dB

DEVIATIONS FROM TEST STANDARD

No Deviations

Configuration #	1	<i>Rod P. P. P.</i> Signature
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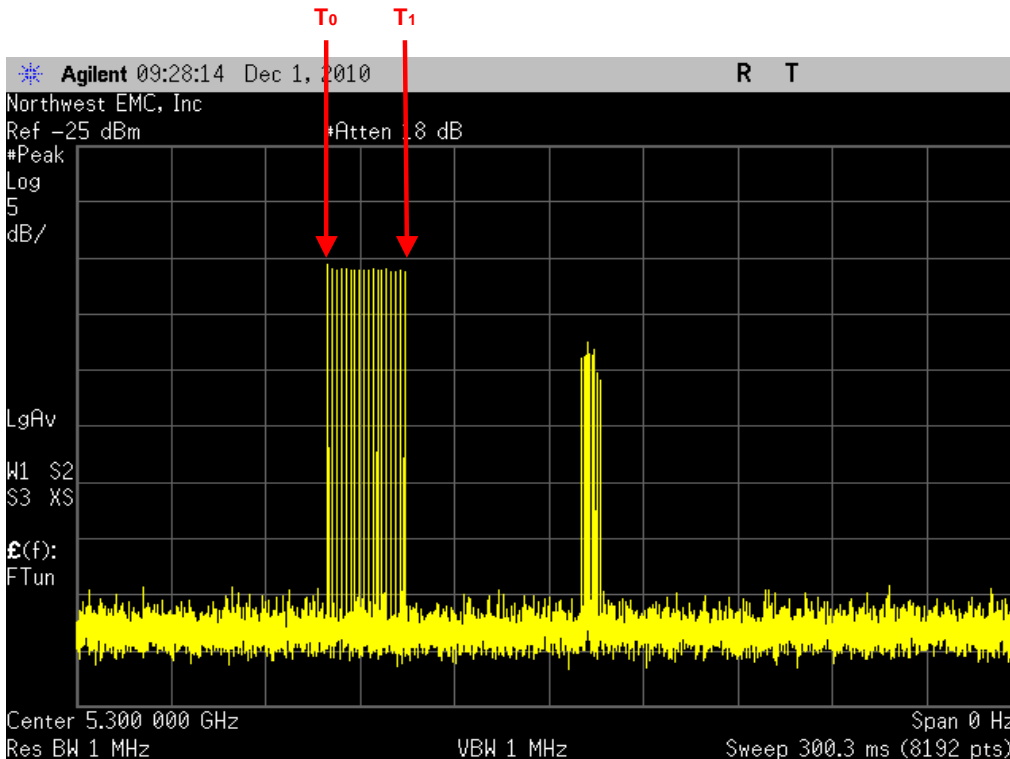
	Value	Limit	Results
Lower Sub-Band 5250 MHz - 5350 MHz			
300 ms period	25.7 ms	N/A	N/A
1.2s period	< 260 ms	≤ 260 ms aggregate	Pass
12.5s period	< 1 second	≤ 10 seconds	Pass
30 minute period	> 30 Minutes	≥ 30 Minutes	Pass
Upper Sub-Band 5470 MHz - 5725 MHz			
300 ms period	25.7 ms	N/A	N/A
1.2s period	< 260 ms	≤ 260 ms aggregate	Pass
12.5s period	< 1 second	≤ 10 seconds	Pass
30 minute period	> 30 Minutes	≥ 30 Minutes	Pass

Lower Sub-Band 5250 MHz - 5350 MHz, 300 ms period

Result: N/A

Value: 25.7 ms

Limit: N/A

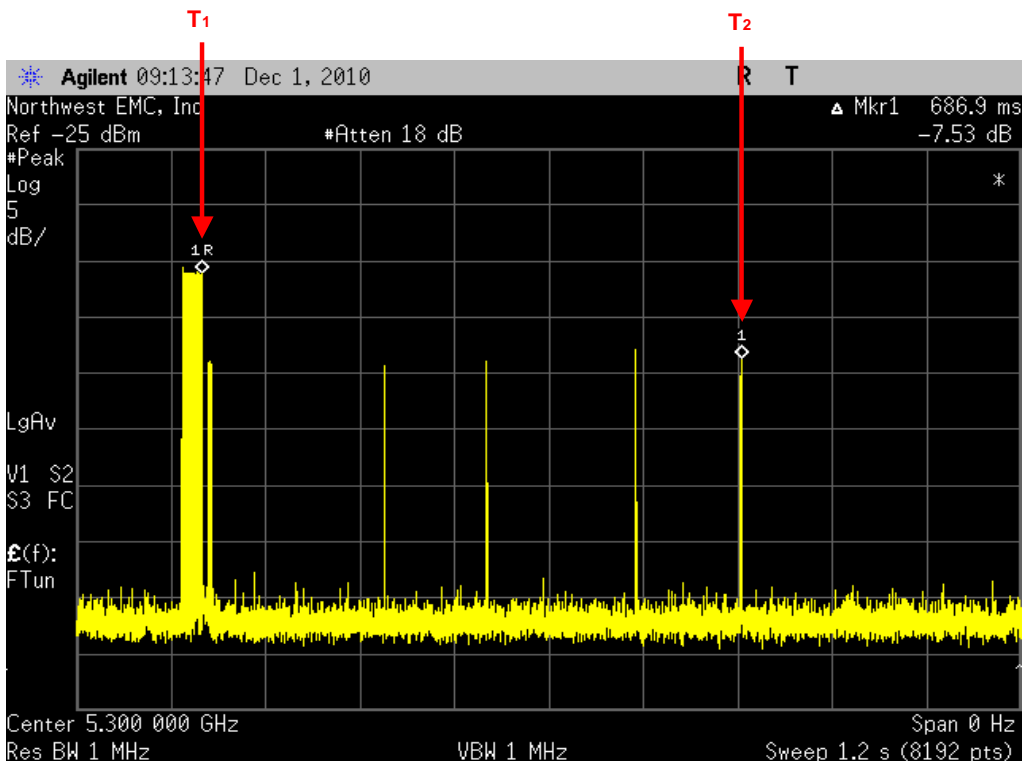


Lower Sub-Band 5250 MHz - 5350 MHz, 1.2s period

Result: Pass

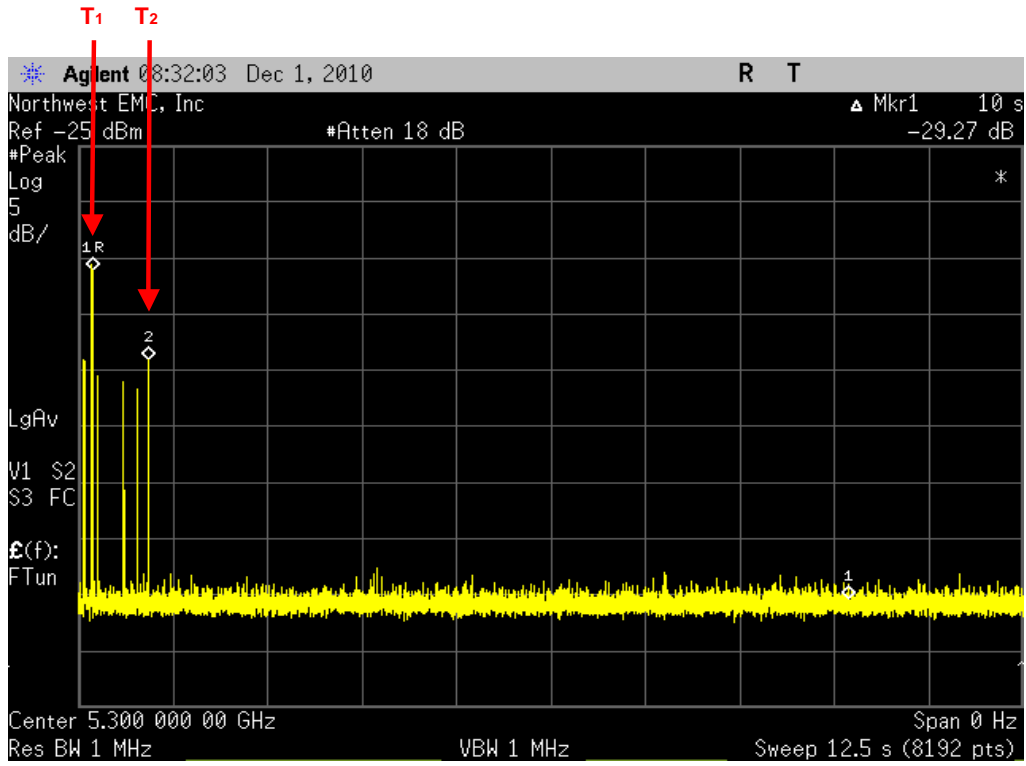
Value: < 260 ms

Limit: ≤ 260 ms aggregate



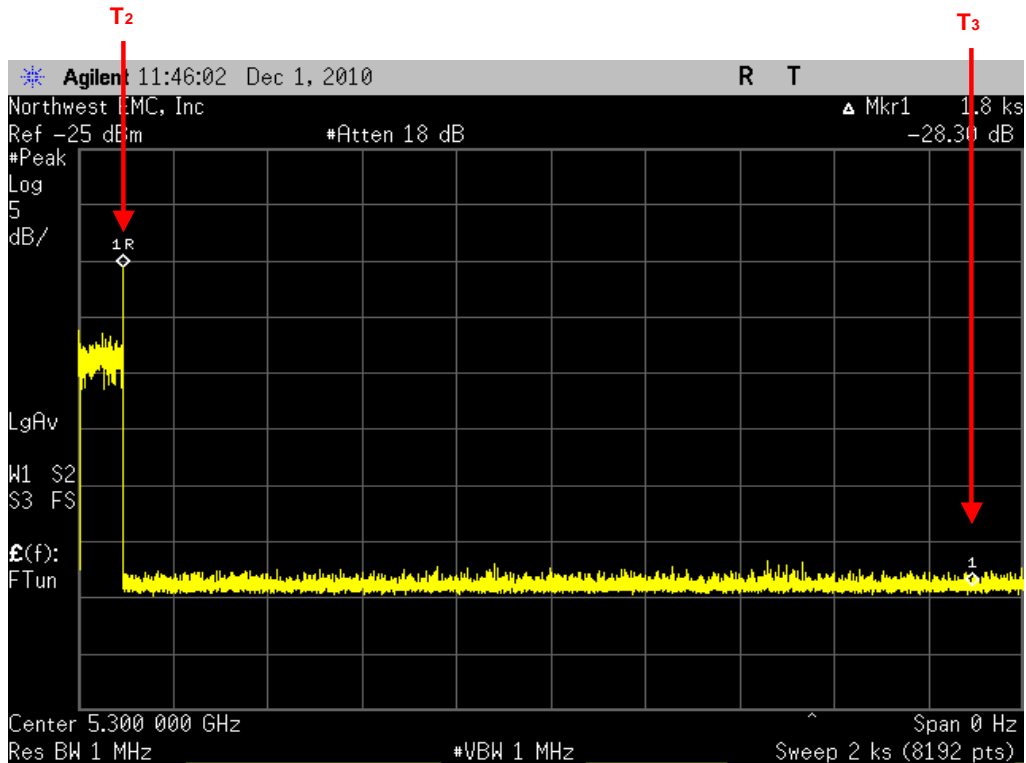
Lower Sub-Band 5250 MHz - 5350 MHz, 12.5s period

Result: Pass **Value:** < 1 second **Limit:** ≤10 seconds



Lower Sub-Band 5250 MHz - 5350 MHz, 30 minute period

Result: Pass **Value:** > 30 Minutes **Limit:** ≥ 30 Minutes

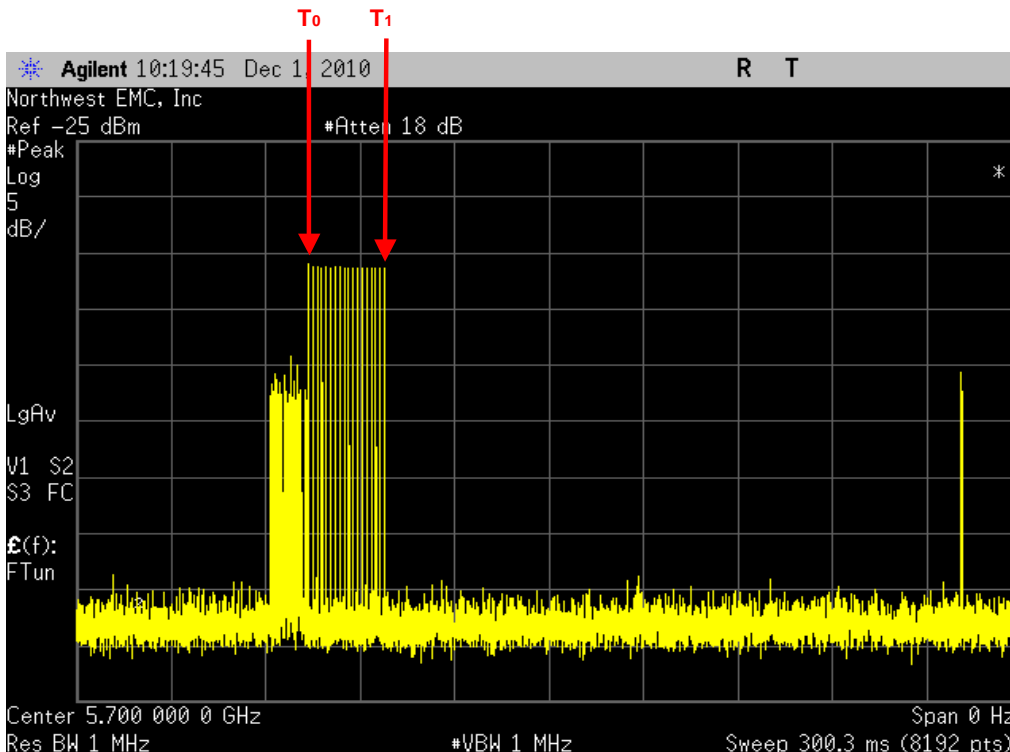


Upper Sub-Band 5470 MHz - 5725 MHz, 300 ms period

Result: N/A

Value: 25.7 ms

Limit: N/A

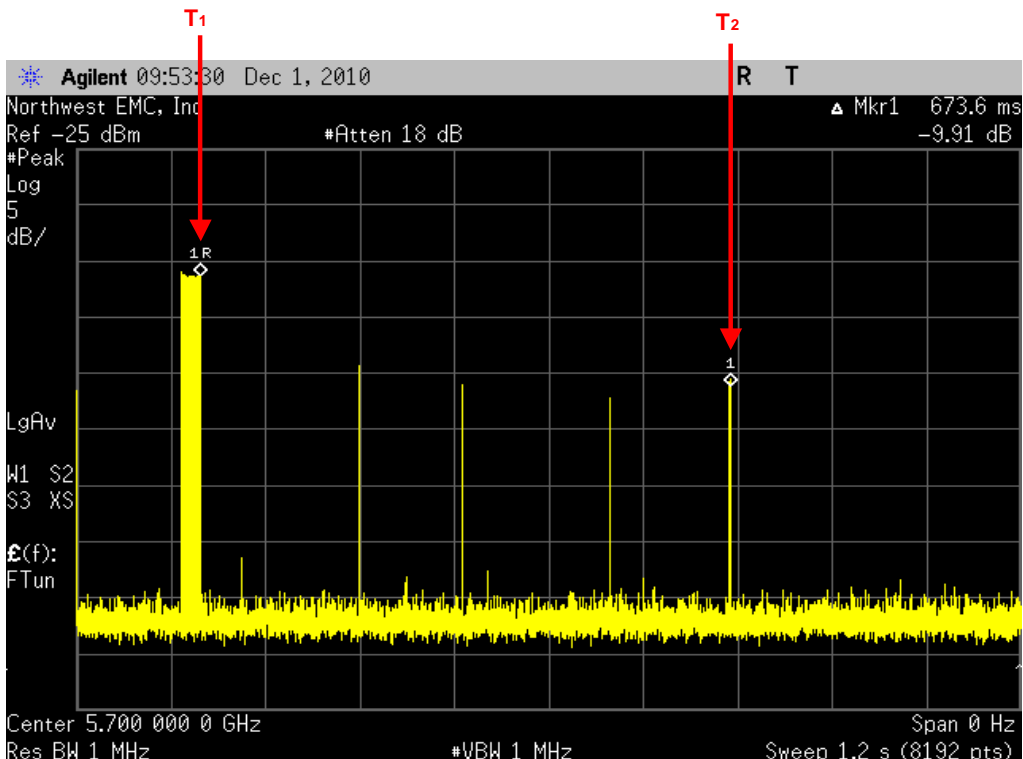


Upper Sub-Band 5470 MHz - 5725 MHz, 1.2s period

Result: Pass

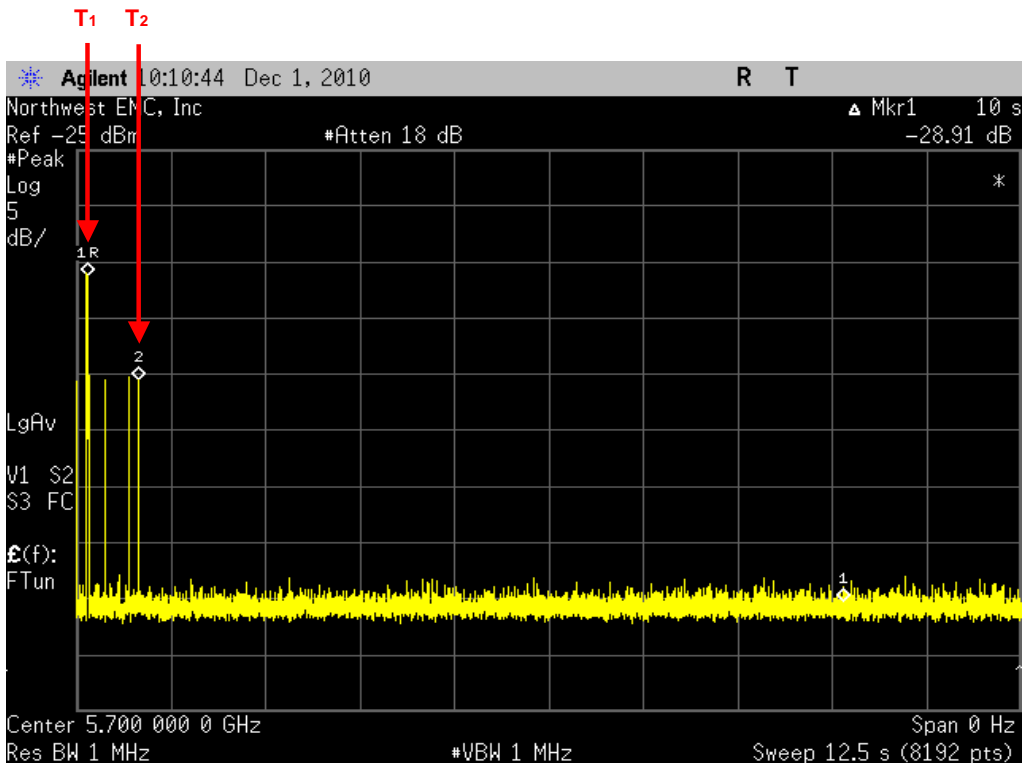
Value: < 260 ms

Limit: ≤ 260 ms aggregate



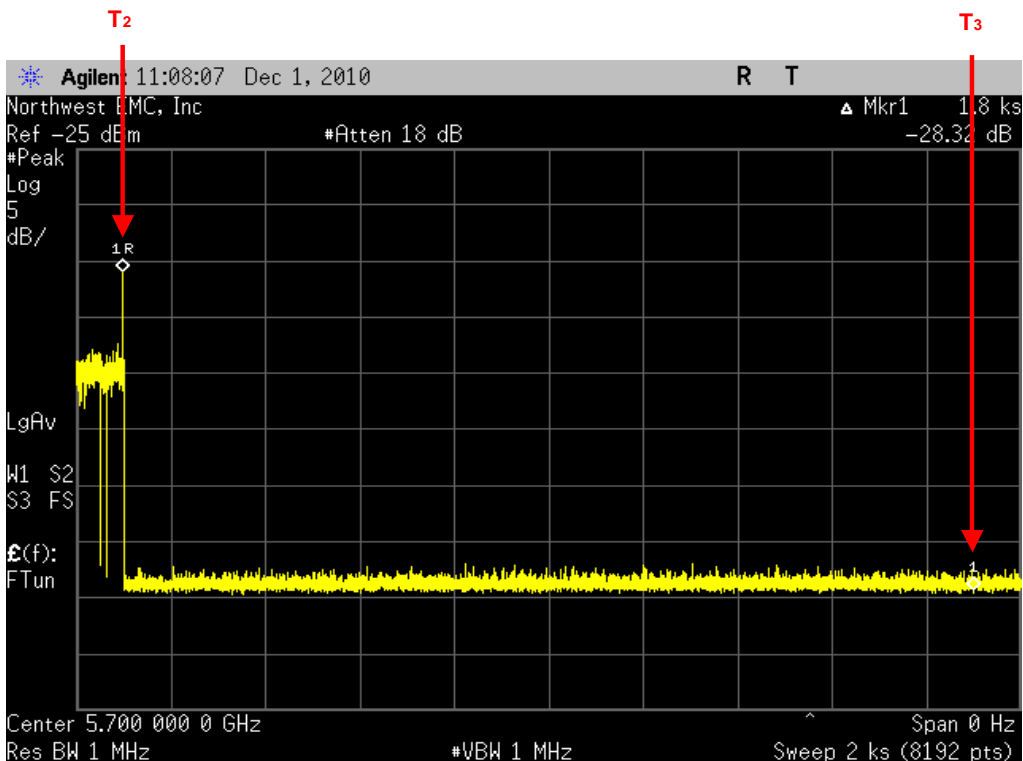
Upper Sub-Band 5470 MHz - 5725 MHz, 12.5s period

Result: Pass Value: < 1 second Limit: ≤ 10 seconds



Upper Sub-Band 5470 MHz - 5725 MHz, 30 minute period

Result: Pass Value: > 30 Minutes Limit: ≥ 30 Minutes



System Block Diagram

