Measurement of RF Interference from a Model RCXR-02 Transceiver

For	:	Turning Technologies 241 Federal Plaza West Youngstown, OH 44503
P.O. No.	:	6977
Date Tested	:	January 25 - 29, 2010
Test Personnel	:	Mark Longinotti
Specification	:	FCC "Code of Federal Regulations" Title 47 Part 15, Subpart C, Section 15.249
	:	Industry Canada RSS-210
	:	Industry Canada RSS-GEN

Test Report By : MARK E. LONGINOTTI
Mark E. Longinotti
Senior EMC Engineer

Witnessed by :
Josh Blackann
Steve Nelson
Turning Technologies

Approved By : Raymond J Klouda
Raymond J. Klouda
Registered Professional
Engineer of Illinois - 44894

Elite Electronic Engineering Inc.
1516 Centre Circle
Downers Grove, IL 60515
Tel : (630) 495-9770
Fax: (630) 495-9785
www.elitetest.com

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REVISION HISTORY

Revision	Date	Description
—	February 11, 2010	Initial release

Measurement of RF Emissions from an RCXR-02 Transceiver

1 INTRODUCTION

1.1 Scope of Tests

This document represents the results of the series of radio interference measurements performed on a Transceiver, Part No. RCXR-02, Serial No. 15, (hereinafter referred to as the test item). The test item was designed to transmit and receive in the 2401MHz to 2482MHz band using an internal non-detachable. The test item could transmit large data packets in the frequency range of 2409MHz to 2482MHz. The test item could transmit small data packets in the frequency range of 2401MHz to 2474MHz. The test item was manufactured and submitted for testing by Turning Technologies located in Youngstown, OH.

1.2 Purpose

The test series was performed to determine if the test item meets the conducted and radiated RF emission requirements of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart B, Sections 15.107 and 15.109 for receivers, and Subpart C, Sections 15.207 and 15.249 for intentional radiators operating within the 2400MHz to 2483.5MHz band. Testing was performed in accordance with ANSI C63.4-2003.

The test series was also performed to determine if the test item meets the conducted RF emission requirements of the Industry Canada Radio Standards Specification, RSS-Gen, Section 7.2.2 and the radiated RF emission requirements of the Industry Canada Radio Standards Specification, RSS-210, Annex 2 for transmitters operating within the 2400MHz to 2483.5MHz band. Testing was performed in accordance with ANSI C63.4-2003.

The test series was also performed to determine if the test item meets the conducted and radiated RF emission requirements of the Industry Canada Radio Standards Specification, RSS-Gen, Section 7.2.2 and Section 7.2.3 for receivers. Testing was performed in accordance with ANSI C63.4-2003.

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1.3 Deviations, Additions and Exclusions

There were no deviations, additions to, or exclusions from the test specification during this test series.

1.4 EMC Laboratory Identification

This series of tests was performed by Elite Electronic Engineering Incorporated of Downers Grove, Illinois. The laboratory is accredited by The American Association for Laboratory Accreditation (A2LA). A2LA Certificate Number: 1786.01.

1.5 Laboratory Conditions

The temperature at the time of the test was 22°C and the relative humidity was 22%.

2 APPLICABLE DOCUMENTS

The following documents of the exact issue designated form part of this document to the extent specified herein:

- Federal Communications Commission "Code of Federal Regulations", Title 47, Part 15, Subpart C, dated 1 October 2009
- ANSI C63.4-2003, "American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz"
- Industry Canada RSS-210, Issue 7, June 2007, “Spectrum Management and Telecommunications

Radio Standards Specification, Low-power License-exempt radio communication devices (All Frequency Bands): Category I Equipment"

- Industry Canada RSS-GEN, Issue 2, June 2007, "Spectrum Management and Telecommunications Radio Standards Specification, General Requirements and Information for the Certification of radio communication equipment"

3 TEST ITEM SETUP AND OPERATION

3.1 General Description

The test item is a Transceiver, Part No. RCXR-02. A block diagram of the test item setup is shown as Figure 1.

3.1.1 Power Input

The test item when operating as a transceiver obtained 3VDC power from 2 "AAA" batteries.

3.1.2 Peripheral Equipment

The test item was submitted for testing with no peripheral equipment.

3.1.3 Interconnect Cables

The test item was submitted for testing with no interconnect cables.

3.1.4 Grounding

The test item was not grounded during the tests.

3.2 Operational Mode

The test item was placed on an 80cm high non-conductive stand. The test item was programmed so that it could transmit or receive continuously. Tests were performed separately with the test item transmitting large data packets at 2441MHz, and 2482MHz. Additional tests were performed with the test item transmitting small data packets at 2401MHz.Tests were also performed with the test item receiving at 2441MHz.

3.3 Test Item Modifications

No modifications were required for compliance.

4 TEST FACILITY AND TEST INSTRUMENTATION

4.1 Shielded Enclosure

All tests were performed in a 32ft. x 20ft. x 18ft. hybrid ferrite-tile/anechoic absorber lined test chamber. With the exception of the floor, the reflective surfaces of the shielded chamber are lined with ferrite tiles on the walls and ceiling. Anechoic absorber material is installed over the ferrite tile. The floor of the chamber is used as the ground plane. The chamber complies with ANSI C63.4-2003 for site attenuation.

4.2 Test Instrumentation

The test instrumentation and auxiliary equipment used during the tests are listed in Table 9-1. All equipment was calibrated per the instruction manuals supplied by the manufacturer.

4.3 Calibration Traceability

Test equipment is maintained and calibrated on a regular basis. All calibrations are traceable to the National Institute of Standards and Technology (NIST).

4.4 Measurement Uncertainty

All measurements are an estimate of their true value. The measurement uncertainty characterizes, with a specified confidence level, the spread of values which may be possible for a given measurement system.

The measurement uncertainty for these tests is presented below:

Conducted Emission Measurements		
Combined Standard Uncertainty	1.07	-1.07
Expanded Uncertainty (95% confidence)	2.1	-2.1

Radiated Emission Measurements		
Combined Standard Uncertainty	2.26	-2.18
Expanded Uncertainty (95% confidence)	4.5	-4.4

5 TEST PROCEDURES

5.1 Powerline Conducted Emissions

5.1.1 Receiver

5.1.1.1 Requirements

Since the test item was powered by internal batteries, no conducted emissions tests were performed.

5.1.2 Transmitter

5.1.2.1 Requirements

Since the test item was powered by internal batteries, no conducted emissions tests were performed.

5.2 Duty Cycle Factor Measurements

5.2.1 Procedures

The duty cycle factor is used to convert peak detected readings to average readings. This factor is computed from the time domain trace of the pulse modulation signal.
With the transmitter set up to transmit for maximum pulse density, the time domain trace is displayed on the spectrum analyzer. This trace is obtained by tuning center frequency to the transmitter frequency and then setting a zero span width with 100usec/div. The amplitude settings are adjusted so that the on/off transitions clear the 4th division from the bottom of the display. The markers are set at the beginning and end of a word period. The sweep time was then increased to 10msec to show the worst case time between each pulse. The duty cycle is then computed as the On-time/(On-time + Off-time).

5.2.2 Results

The plots of the small packet duty cycle are shown on data pages 17 and 18. The duty cycle factor was computed to be -34.8dB.

The plots of the large packet duty cycle are shown on data pages 19 and 20. The duty cycle factor was computed to be -29.6dB.

5.3 Radiated Measurements

5.3.1 Receiver

5.3.1.1 Requirements

Per the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart B, Section 15.101(b), receivers operating above 960MHz are exempt from complying with the technical provisions of part 15.
Per Industry Canada RSS-Gen, Section 7.2.3, all radio frequency emissions from a receiver shall be below the limits shown on the following table:

Frequency MHz	Distance between Test Item And Antenna in Meters	Field Strength uV/m	Field Strength dBuV/m
30-88	3	100	40
88-216	3	150	43.5
216-960	3	200	46
Above 960	3	500	54

Note: The tighter limit shall apply at the edge between the two frequency bands.
Per Industry Canada RSS-Gen, section 4.10, spurious emissions shall be measured from 30MHz to 3 times the highest tuneable or local oscillator frequency.

5.3.1.2 Procedures

All tests were performed in a 32ft. x 20ft. x 18ft. hybrid ferrite-tile/anechoic absorber lined test chamber. The walls and ceiling of the shielded chamber are lined with ferrite tiles. Anechoic absorber material is installed over the ferrite tile. The floor of the chamber is used as the ground plane. The chamber complies with ANSI C63.4 2003 for site attenuation.

The shielded enclosure prevents emissions from other sources, such as radio and TV stations from interfering with the measurements. All powerlines and signal lines entering the enclosure pass through filters on the enclosure wall. The powerline filters prevent extraneous signals from entering the enclosure on these leads. Since quasi-peak and average measurements require long integration times, it is not practical to automatically sweep through the quasi-peak or average levels. Therefore, radiated emissions from the test item were first scanned using a peak detector and automatically plotted. The frequencies where significant emission levels were noted were then remeasured using the quasi-peak or average detector.

For preliminary radiated emissions sweeps from 30MHz to 9GHz, the broadband measuring antenna was positioned at a 3 meter distance from the test item. The frequency range from 30MHz to 9GHz was investigated using a peak detector function with the bilog antenna below 1GHz and the double-ridged waveguide antenna above 1GHz. The maximum levels were plotted.

Final radiated emissions were performed on all significant broadband and narrowband emissions found in the preliminary sweeps using the following methods:

1) Measurements below 1GHz were made using a quasi-peak detector and a bilog antenna. Measurements above 1GHz were made using an average detector and a double ridged waveguide antenna.
2) To ensure that maximum or worst case, emission levels were measured, the following steps were taken:

   a. The test item was rotated so that all of its sides were exposed to the receiving antenna.

b. Since the measuring antenna is linearly polarized, both horizontal and vertical field components were measured.
c. The measuring antenna was raised and lowered from 1 to 4 meters for each antenna polarization to maximize the readings.

5.3.1.3 Results

The preliminary plots, with the test item receiving at 2441MHz, are presented on data pages 21 through 24. The plots are presented for a reference only, and are not used to determine compliance.

The final radiated levels, with the test item receving at 2441MHz, are presented on data page 25. As can be seen from the data, all emissions measured from the test item were within the specification limits for receivers. The emissions level closet to the limit (worst case) occurred at 7335MHz. The emissions level at this frequency was 11.5dB within the limit. Photographs of the test configuration are shown on Figure 3.

5.3.2 Transmitter

5.3.2.1 Requirements

The test item must comply with the requirements of FCC "Code of Federal Regulations Title 47", Part 15, Subpart C, Section 15.249(a) and Industry Canada RSS-210 Annex 2, Section A2.9. Both standards have the following radiated emission limits:

Fundamental Frequency MHz	Field Intensity mV/m @ 3 meter	Field Strength of Harmonics and Spurious uV/m @ 3 meter
2400 – 2483.5	50	500

The field strength limits are based on average limits. However, the peak field strength of any emission shall not exceed the maximum permitted average limits by more than 20 dB under any condition of modulation.

5.3.2.2 Procedures

All measurements were performed in a 32ft. x 20ft. x 14ft. high shielded enclosure. The shielded enclosure prevents emissions from other sources, such as radio and TV stations from interfering with the measurements. All powerlines and signal lines entering the enclosure pass through filters on the enclosure wall. The powerline filters prevent extraneous signals from entering the enclosure on these leads. The floor of the chamber is used as the ground plane. The chamber complies with ANSI C63.4-2003 for site attenuation.

A preliminary radiated emissions test was performed to determine the emission characteristics of the test item. For the preliminary test, a broadband measuring antenna was positioned at a 3 meter distance from the test item. The entire frequency range from 30MHz to 25GHz was investigated using a peak detector function. The data was then processed by the computer to calculate equivalent field intensity.

The final emission tests were then manually performed over the frequency range of 30MHz to 25GHz. Between 30MHz and 1000MHz, a bilog antenna was used as the pick-up device. A broadband double ridged waveguide antenna was used as the pick-up device for all frequencies above 1GHz. All significant broadband and narrowband signals were measured and recorded.

To ensure that maximum or worst case, emission levels were measured, the following steps were taken:

1) The test item was rotated so that all of its sides were exposed to the receiving antenna.
2) Since the measuring antenna is linearly polarized, both horizontal and vertical field components were measured.
3) The measuring antenna was raised and lowered from 1 to 4 meters for each antenna polarization to maximize the readings.

4) For hand-held or body-worn devices, the test item was rotated through three orthogonal axes to determine which orientation produces the highest emission relative to the limit.

5) In some instances, it was necessary to use a shortened cable between the measuring antenna and the spectrum analyzer and the antenna could not be raised to 4 meters. The measuring antenna was raised and lowered as much as the cable would allow and the test item is rotated through all axis to ensure the maximum readings are recorded. See attached Figure 2.

5.3.2.3 Results

The preliminary plots, with the test item transmitting at 2401MHz are presented on pages 26 through 33. The plots are presented for a reference only, and are not used to determine compliance. The final radiated levels are presented on pages 34 through 35. As can be seen from the data, all emissions measured from the test item were within the specification limits. The emissions level closet to the limit (worst case) occurred at 7203MHz. The emissions level at this frequency was 4.7dB within the limit.

The preliminary plots, with the test item transmitting at 2441MHz are presented on pages 36 through 43. The plots are presented for a reference only, and are not used to determine compliance. The final radiated levels are presented on pages 44 through 45. As can be seen from the data, all emissions measured from the test item were within the specification limits. The emissions level closet to the limit (worst case) occurred at 7323MHz. The emissions level at this frequency was 4.3dB within the limit.

The preliminary plots, with the test item transmitting at 2482MHz are presented on pages 46 through 53. The plots are presented for a reference only, and are not used to determine compliance. The final radiated levels are presented on pages 54 through 55. As can be seen from the data, all emissions measured from the test item were within the specification limits. The emissions level closet to the limit (worst case) occurred at 7446MHz. The emissions level at this frequency was 6.1dB within the limit.
Photographs of the test configuration which yielded the highest, or worst case, radiated emission levels are shown on Figure 3 and Figure 4.

5.4 Band Edge Compliance

5.4.1 Requirement

In accordance with FCC "Code of Federal Regulations Title 47", Part 15, Subpart C, Section 15.249, emissions outside of the specified frequency bands shall be below the general radiated emissions limits of 15.209. Therefore the radiated emissions at the band edges (2400MHz and 2483.5MHz) must meet the general limits of 15.209.

In accordance with Industry Canada RSS-210 Annex 2, Section A2.9(b), emissions outside of the specified frequency bands shall be below the general radiated emissions limits of RSS-210 Annex 2, Section A2.9(a). Therefore the radiated emissions at the band edges (2400MHz and 2483.5MHz) must meet the general limits of Annex 2 Section A2.9.

5.4.2 Procedures

Low Band Edge

1) The test item was setup inside the test chamber on a non-conductive stand.
2) A broadband measuring antenna was placed at a test distance of 3 meters from the test item.
3) The test item was maximized for worst case emissions at the measuring antenna. A peak reading was taken with a resolution bandwidth of 1MHz and a video bandwidth of 1MHz or greater The maximum peak meter readings were recorded.
4) To determine the band edge compliance, the following spectrum analyzer settings were used:

a. Center frequency = low band-edge frequency.
b. Span = Wide enough to capture both the peak level of the fundamental emission and the band-edge emission under investigation.
c. Resolution bandwidth (RBW) = 1% of the span (but never less than 30kHz).
d. The 'Max-Hold' function was engaged. The analyzer was allowed to scan until the envelope of the transmitter bandwidth was defined.
e. The marker was set on the peak of the in-band emissions. This level corresponds to the maximized peak reading previously taken. The "marker-delta" method described in Public Notice DA 00-705 was then used to determine band edge compliance. The delta between the marker and the general limit (74dBuV/m for peak readings) was calculated by subtracting the general limit (74dBuV/m) from the maximum reading taken with a 1MHz bandwidth. This delta represents how far below the marker the emissions outside of the authorized band of operation must be. A display line was placed at this level. All emissions which fall outside of the authorized band of operation must be below the display line. (All emissions to the left of the center frequency (band-edge) must be below the display line.)
f. The analyzer's display was plotted using a 'screen dump' utility.

High Band Edge

1) The test item was setup inside the test chamber on a non-conductive stand.
2) A broadband measuring antenna was placed at a test distance of 3 meters from the test item.
3) The test item was maximized for worst case emissions at the measuring antenna. A peak reading was taken with a resolution bandwidth of 1MHz and a video bandwidth of 1MHz or greater The maximum peak meter readings were recorded.
4) To determine the band edge compliance, the following spectrum analyzer settings were used:

a. Center frequency = high band-edge frequency.
b. Span = Wide enough to capture both the peak level of the fundamental emission and the band-edge emission under investigation.
c. Resolution bandwidth (RBW) = 1% of the span (but never less than 30kHz).
d. The 'Max-Hold' function was engaged. The analyzer was allowed to scan until the envelope of the transmitter bandwidth was defined.
e. The marker was set on the peak of the in-band emissions. This level corresponds to the maximized peak reading previously taken. The "marker-delta" method described in Public Notice DA 00-705 was then used to determine bandedge compliance. The delta between the marker and the general limit (74dBuV/m for peak readings) was calculated by subtracting the general limit (74dBuV/m) from the maximum reading taken with a 1MHz bandwidth. This delta represents how far below the marker the emissions outside of the authorized band of operation must be. A display line was placed at this level. All emissions which fall outside of the authorized band of operation must be below the display line. (All emissions to the right of the center frequency (band-edge) must be below the display line.)
f. The analyzer's display was plotted using a 'screen dump' utility.

5.4.3 Results

Pages 56 through 57 show the radiated band-edge compliance results. As can be seen from these plots, the radiated emissions at the low end band edge and the high end band edge are within the general limits.

The 99% bandwidth was measured to be 877.8kHz for the small data packets and 1.03MHz for the large data packets.

6 OTHER TEST CONDITIONS

6.1 Test Personnel and Witnesses

All tests were performed by qualified personnel from Elite Electronic Engineering Incorporated. The test series was witnessed by Turning Technologies personnel.

6.2 Disposition of the Test Item

The test item and all associated equipment were returned to Turning Technologies upon completion of the tests.

7 CONCLUSIONS

It was determined that the Turning Technologies Transceiver, Part No. RCXR-02, Serial No. 15, did fully meet the conducted and radiated emission requirements of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart B, Sections 15.107 and 15.109 for receivers, and Subpart C, Sections 15.207 and 15.249 for Intentional Radiators Operating within the 2400 – 2483.5MHz band, when tested per ANSI C63.4-2003.

It was also determined that the Turning Technologies Transceiver, Part No. RCXR-02, Serial No. 15, did fully meet the conducted and radiated emission requirements of the Industry Canada Radio Standards Specification, RSS-Gen, Section 7.2.2 and Section 7.2.3 for receivers and the Industry Canada Radio Standards Specification RSS-Gen Section 7.2.2 and RSS-210 Annex 2, section A2.9 for Transmitters, when tested per ANSI C63.4-2003.

8 CERTIFICATION

Elite Electronic Engineering Incorporated certifies that the information contained in this report was obtained under conditions which meet or exceed those specified in the test specifications.

The data presented in this test report pertains to the test item at the test date *as operated by Turning Technologies personnel. Any electrical or mechanical modification made to the test item subsequent to the specified test date will serve to invalidate the data and void this certification.

This report must not be used to claim product endorsement by NVLAP or any agency of the US Government.

9 EQUIPMENT LIST

Table 9-1 Equipment List

Eq ID	Equipment Description	Manufacturer	Model No.	Serial No.	Frequency Range	Cal Date	Due Date
APW0	PREAMPLIFIER	PLANAR ELECTRONICS	PE2-30-20G20R6G	PL2926/0646	20GHZ-26.5GHZ	7/28/2009	7/28/2010
APW2	PREAMPLIFIER	PLANAR ELECTRONICS	PE2-35-120-5R0-10	PL2925	1GHZ-20GHZ	7/28/2009	7/28/2010
NHG0	STANDARD GAIN HORN ANTENNA	NARDA	638	---	18-26.5GHZ	NOTE 1	
NWI0	RIDGED WAVE GUIDE	AEL	H1498	153	2-18GHZ	12/5/2009	12/5/2010
RBB0	EMI TEST RECEIVER 20HZ TO 40 GHZ.	ROHDE & SCHWARZ	ESIB40	100250	20 HZ TO 40GHZ	3/11/2009	3/11/2010
SES1	24VDC POWER SUPPLY	P TRANS	FS-32024-1M	002	18-27VDC	NOTE 1	
XOB1	ADAPTER	HEWLETT PACKARD	K281C	10422	18-26.5GHZ	NOTE 1	
XPR0	HIGH PASS FILTER	K&L MICROWAVE	11SH10-4800/X20000	001	4.8-20GHZ	7/27/2009	7/27/2010

N/A: Not Applicable

Note 1: For the purpose of this test, the equipment was calibrated over the specified frequency range, pulse rate, or modulation prior to the test or monitored by a calibrated instrument.

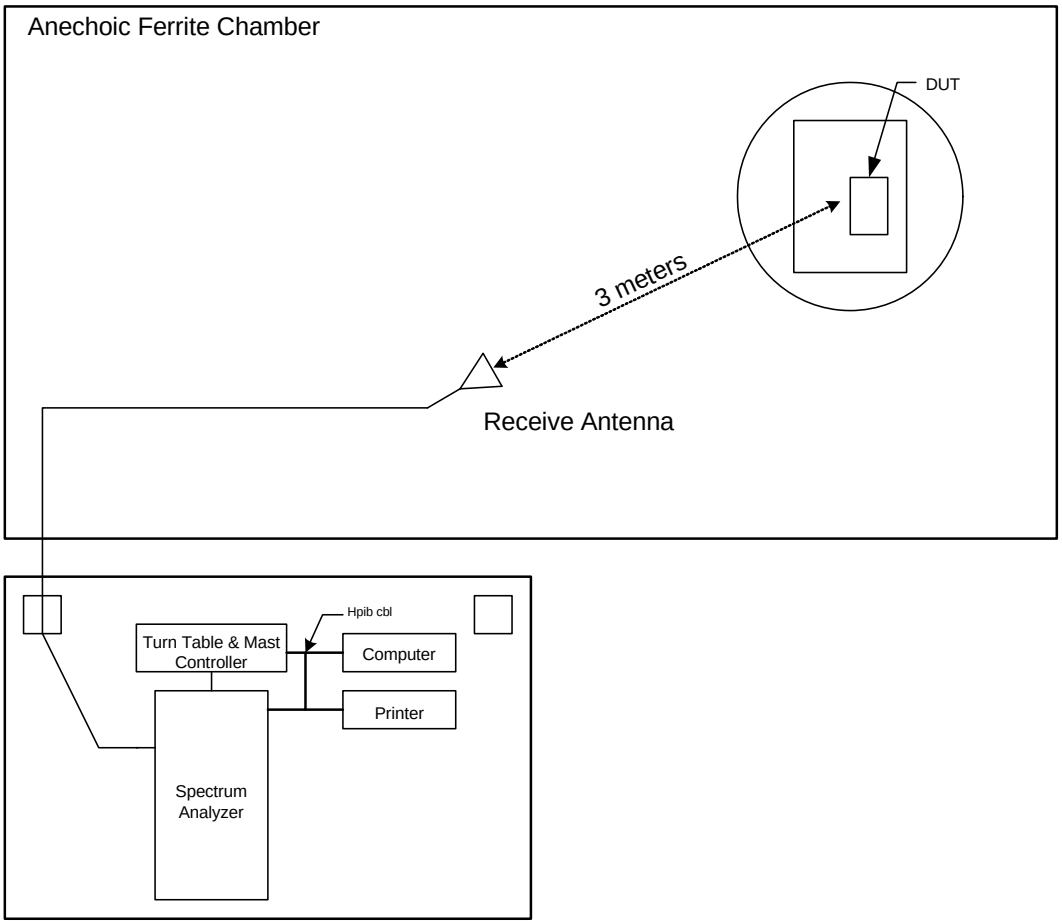


FIGURE 1 BLOCKDIAGRAM OF TEST SETUP

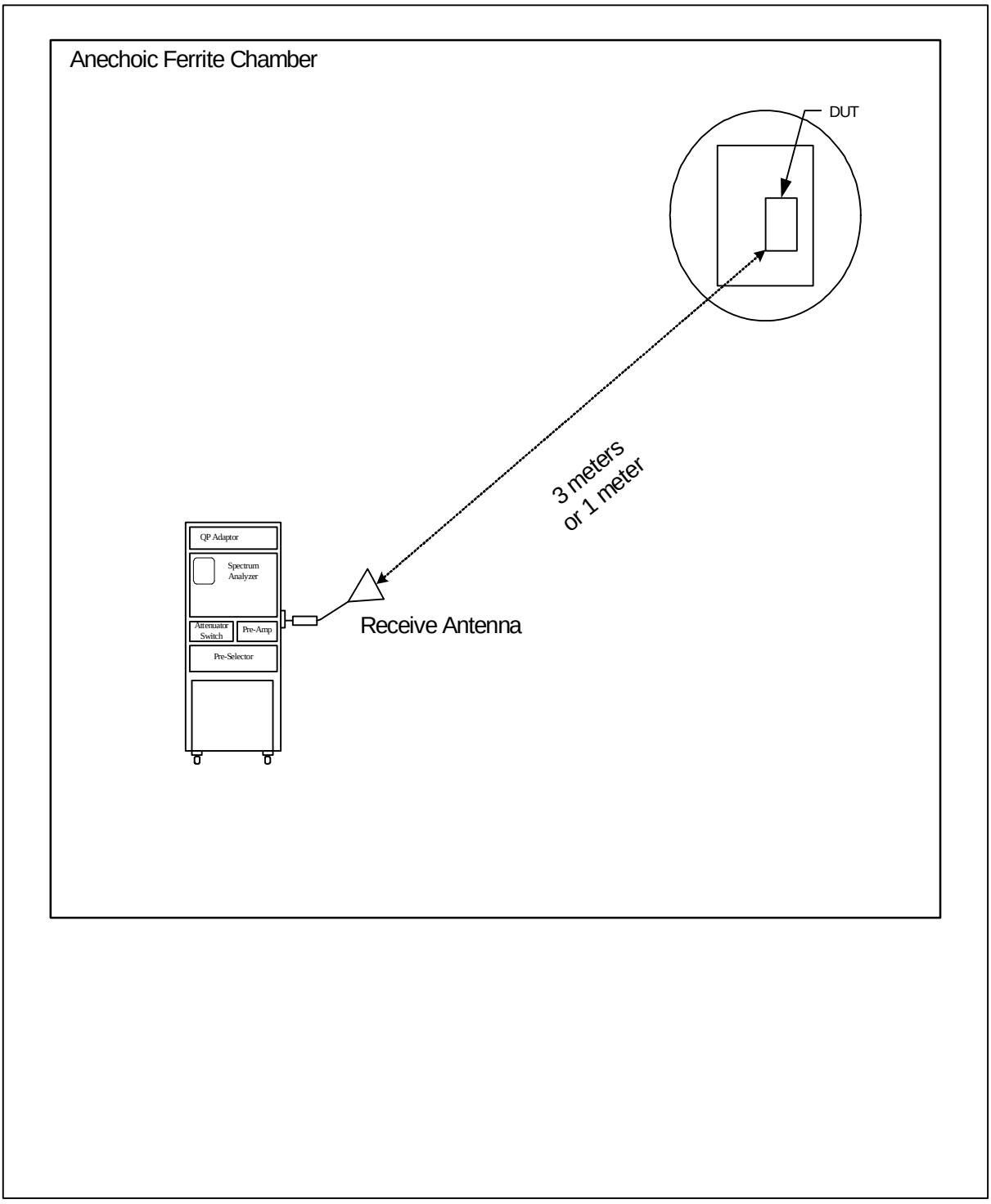
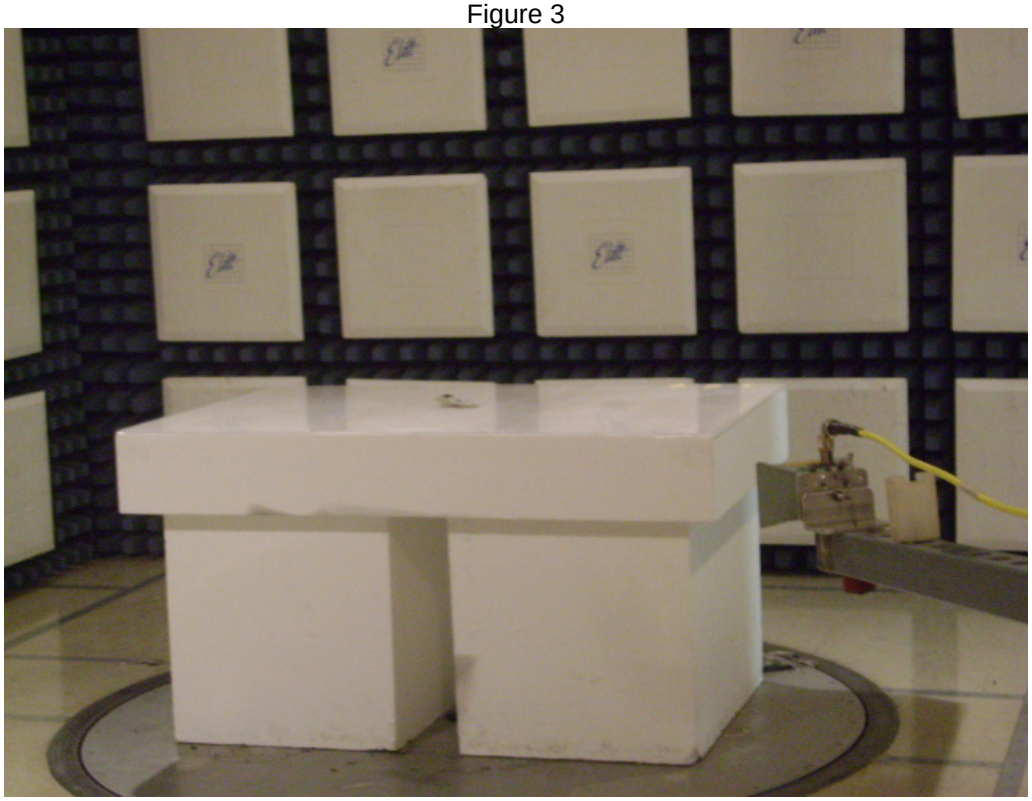
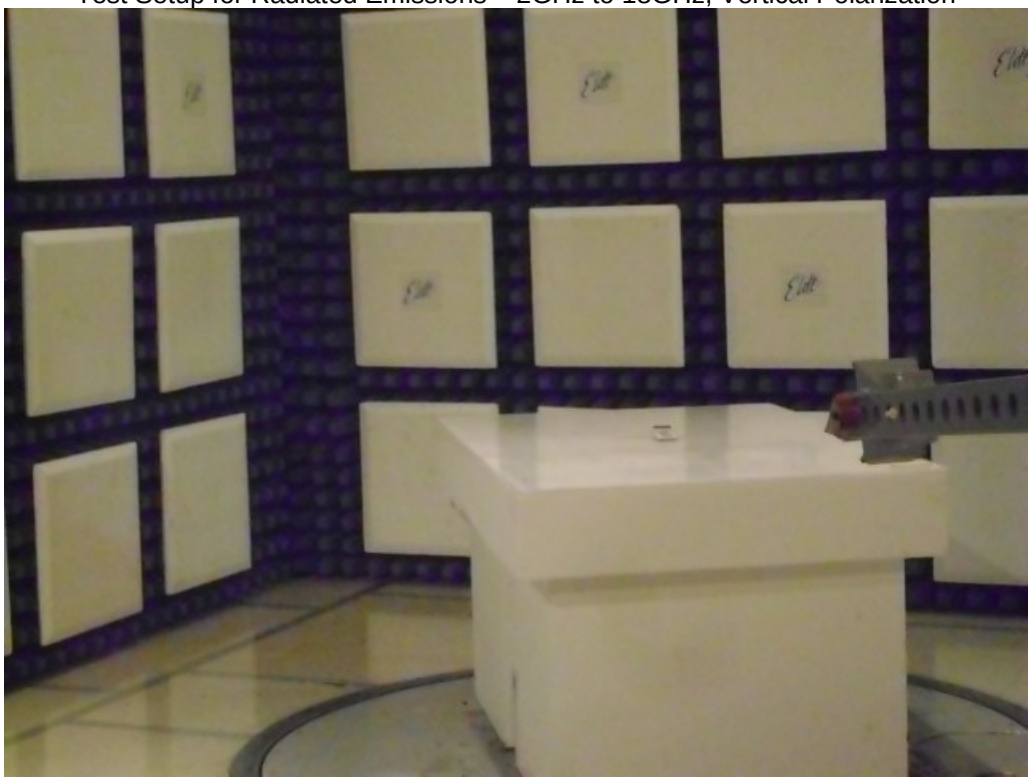

Anechoic Ferrite Chamber
DUT
3 meters
or 1 meter
QP Adaptor
Spectrum
Analyzer
Attenuator
Switch
Pre-Amp
Pre-Selector
Receive Antenna

Figure 3

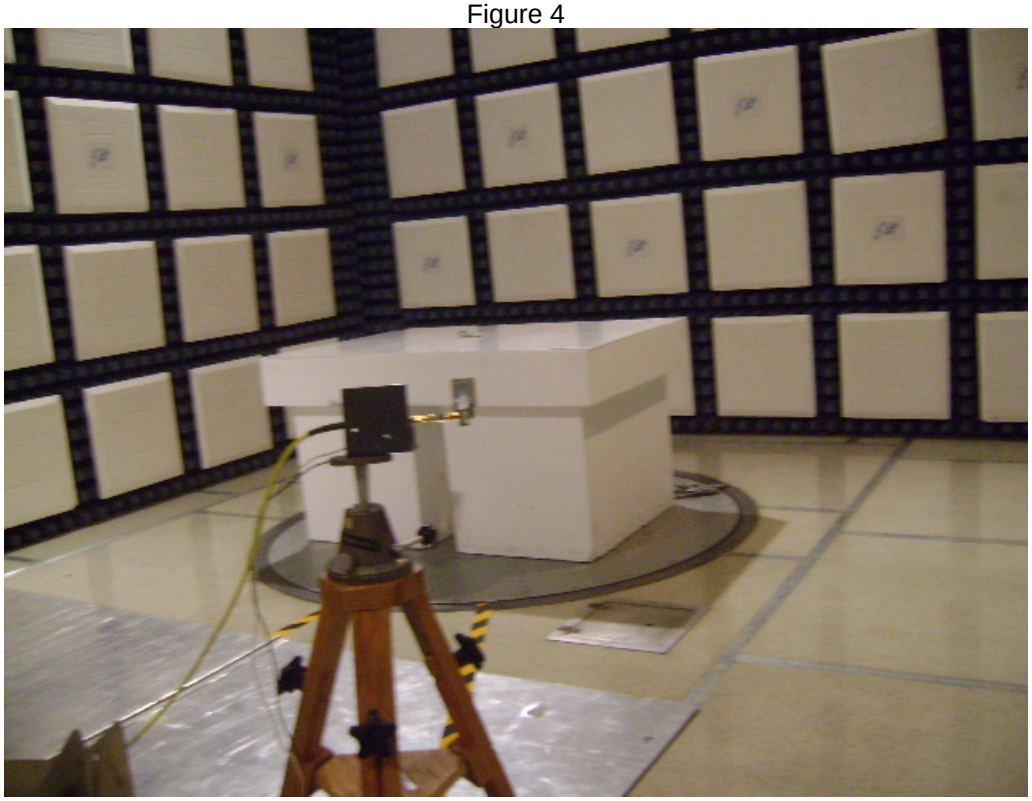


Test Setup for Radiated Emissions – 2GHz to 18GHz, Vertical Polarization



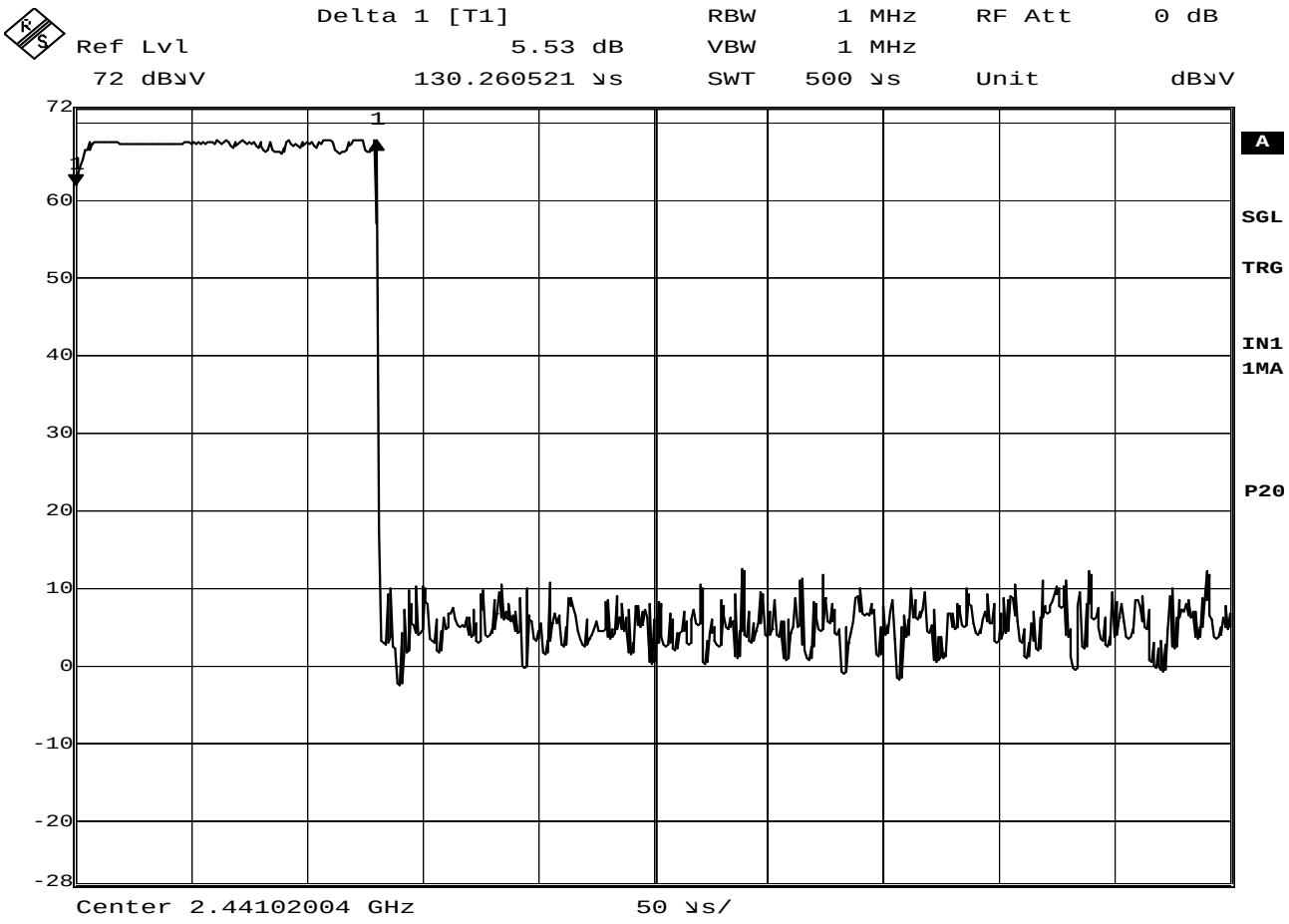
Test Setup for Radiated Emissions – 2GHz to 18GHz, Horizontal Polarization

Figure 4



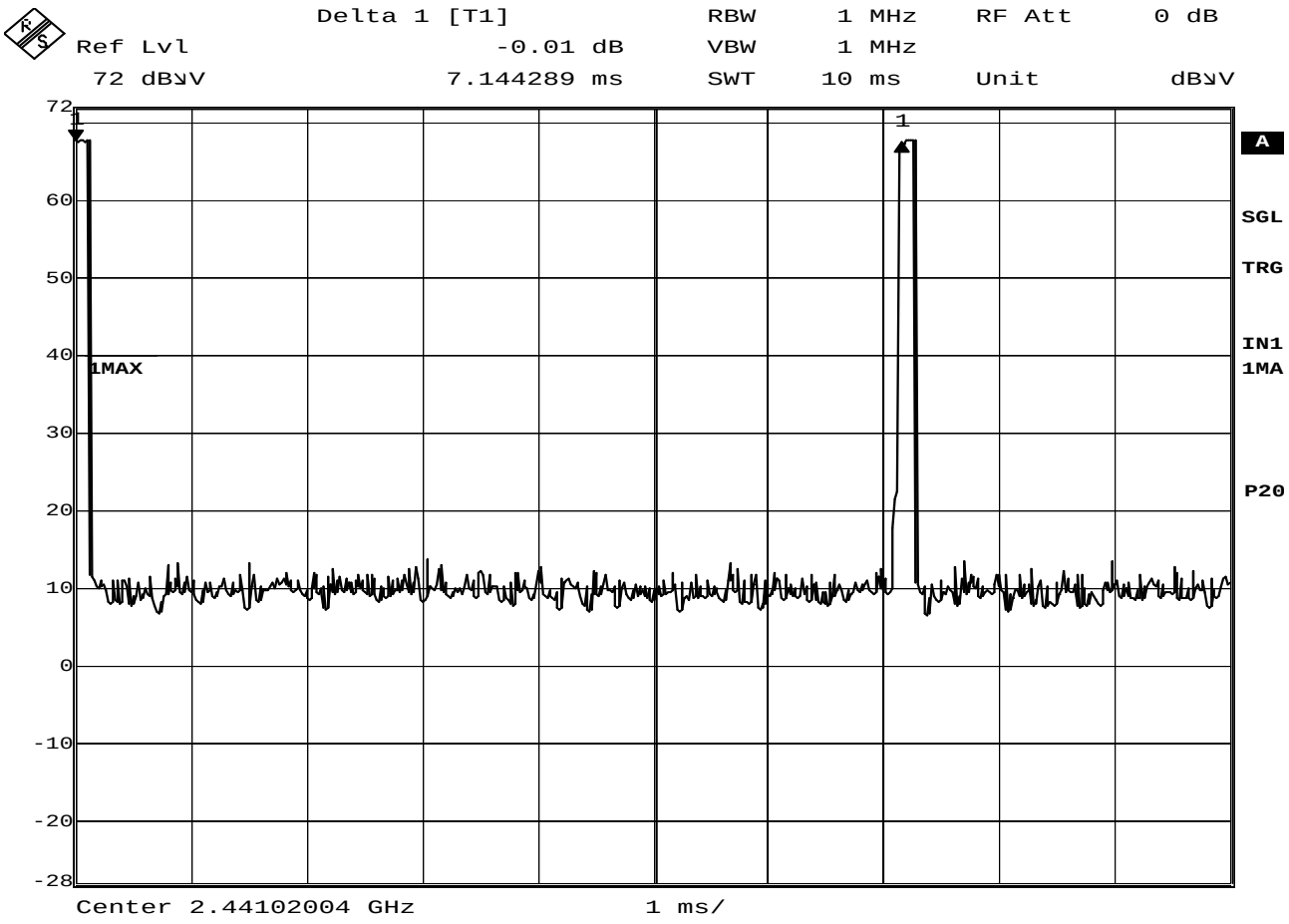
Test Setup for Radiated Emissions – 18GHz to 25GHz, Horizontal Polararization

Test Setup for Radiated Emissions – 18GHz to 25GHz, Vertical Polarization



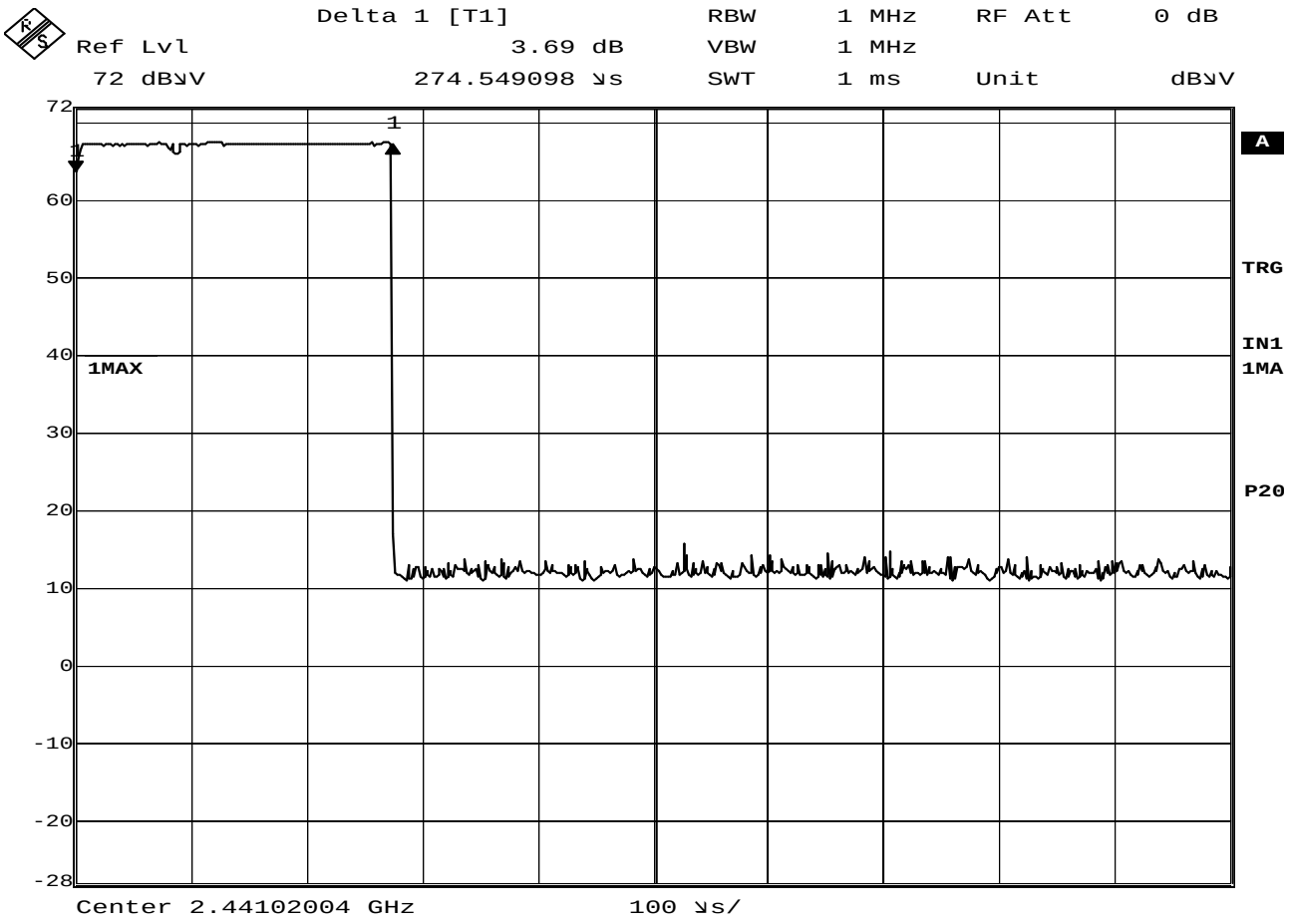
FCC DUTY CYCLE CORRECTION FACTOR

MANUFACTURER	:	Turning Technologies
MODEL NUMBER	:	RCRX-02
SERIAL NUMBER	:	15
TEST MODE	:	Tx @ 2441MHz Small Packets
TEST DATE	:	January 25, 2010
TEST PARAMETERS	:	Pulse width is 130.26usec.
NOTES	:	
EQUIPMENT USED	:	RBB0, NWI0



FCC DUTY CYCLE CORRECTION FACTOR

MANUFACTURER	:	Turning Technologies
MODEL NUMBER	:	RCRX-02
SERIAL NUMBER	:	15
TEST MODE	:	Tx @ 2441MHz Small Packets
TEST DATE	:	January 25, 2010
TEST PARAMETERS	:	Pulse width is 130.26usec. The fastest repetition rate is 1 pulse every
	:	7.14 msec.
	:	Duty cycle correction factor = 20 log (word on time/total word length)
	:	Duty cycle correction factor = 20 log (0.13026msec/7.14msec)
	:	Duty cycle correction factor = -34.8dB
NOTES	:	
EQUIPMENT USED	:	RBB0, NWI0



FCC DUTY CYCLE CORRECTION FACTOR

MANUFACTURER	:	Turning Technologies
MODEL NUMBER	:	RCRX-02
SERIAL NUMBER	:	15
TEST MODE	:	Tx @ 2441MHz Large Packets
TEST DATE	:	January 25, 2010
TEST PARAMETERS	:	Pulse width is 274.55usec
NOTES	:	
EQUIPMENT USED	:	RBB0, NWI0