Electromagnetic Compatibility Test Report

Tested To: FCC Part 15C

On

BLE Device

Model: nIO-BT

900 Northrop Rd.
Wallingford, CT 06492 USA

Prepared by:

TUV Rheinland of North America, Inc.

Manufacturer's statement - attestation

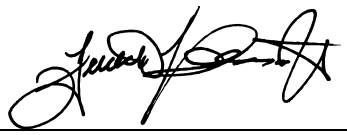
The manufacturer; Sensor Switch, as the responsible party for the equipment tested, hereby affirms:

a) That he has reviewed and concurs that the test shown in this report are reflective of the operational characteristics of the device for which certification is sought;

b) That the device in this test report will be representative of production units;

c) That all changes (in hardware and software/firmware) to the subject device will be reviewed.

d) That any changes impacting the attributes, functionality or operational characteristics documented in this report will be communicated to the body responsible for approving (certifying) the subject equipment.

Frank Pelliccio	
Printed name of official	Signature of official
900 Northrop Road Wallingford, CT 06492 USA	13 August 2015
Address	Date
(203) 303-5447	Frank.Pelliccio@acuitybrands.com
Telephone number	Email address of official

Client:	sensorswitch An AcuityBrands Company 900 Northrop Rd. Wallingford, CT 06492 USA	Frank Pelliccio Ph: (203) 303-5447 Fax: Email: Frank.Pelliccio@acuitybrands.com	
Identification:	BLE Device	***Serial No.:***	PRODUCTION PROTOTYPE
Test item:	Model: nIO-BT	***Date tested:***	05 August 2015
Testing location:	TUV Rheinland of North America 762 Park Avenue Youngsville, NC 27596-9470 U.S.A.	Tel: (919) 554-3668 Fax: (919) 554-3542	
Test specification:	**Emissions: FCC Part 15, Subpart C;** FCC Parts 15.207(a), FCC Parts 15.249(d), 15.209 and 15.215(c) FCC Part 15.249, FCC Parts 15.249(a) and 15.249(c), FCC Part 2.1093,		
Test Result	**The above product was found to be Compliant to the above test standard(s)**		

tested by: Mark Ryan	***reviewed by:*** Michael Moranha
18 September 2015 ***Date*** ***Signature***	*18 September 2015* ***Date*** ***Signature***
Other Aspects:	**None**

Abbreviations: OK, Pass, Compliant, Complies = passed
Fail, Not Compliant, Does Not Comply = failed
N/A = not applicable

FC	ilac-MRA A2LA ACCREDITED	**Industry Canada**
90552 and 100881	**Testing Cert #3331.05**	**2932H-1 and 2932H-2**

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1 General Information

1.1 Scope

This report is intended to document the status of conformance with the requirements of the required standards, based on the results of testing performed on 05 August 2015 on the BLE Device, Model No. nIO-BT, manufactured by Sensor Switch This report only applies to the specific samples tested under the stated test conditions. It is the responsibility of the manufacturer to assure that additional production units of this model are manufactured with identical or EMI equivalent electrical and mechanical components. This report is further intended to document changes and modifications to the EUT throughout its life cycle. All documentation will be included as a supplement.

1.2 Purpose

Testing was performed to evaluate the EMC performance of the EUT (Equipment Under Test) in accordance with the applicable requirements, procedures, and criteria defined in the application of regulations and application of standards listed in this report.

1.3 Revision History

Revision	Date	Description of Revision
- -	24 August 2015	Initial Release
A	18 September 2015	Corrected typos and added Test Setup Block Diagrams.

1.4 Summary of Test Results

Applicant	Sensor Switch 900 Northrop Rd. Wallingford, CT 06492 USA	**Tel**	(203) 303-5447	**Contact**	Frank Pelliccio
		Fax		**e-mail**	Frank.Pelliccio@acuitybrands.com
Description	BLE DEVICE	**Model**	nIO-BT		
Serial Number	Production Prototype	**Test Voltage/Freq.**	5.0 VDC		
Test Date Completed:	05 August 2015	**Test Engineer**	Mark Ryan		

Standards	Description	Severity Level or Limit	Worst-case Values	Test Result
FCC Part 15, Subpart C Standard	Radio Frequency Devices-Subpart C: Intentional Radiators	See called out parts below	See Below	**Complies**
FCC Part 15.249	Operation within the band 2400 to 2483.5 MHz	See called out parts below	See Below	Complies
FCC Parts 15.249(a) and 15.249(c)	Radiated Output Power for Fundamental and Harmonic Frequencies	Fund: Shall not exceed 50 mV/m at 3m Harmonics: Shall not exceed 500µV/m (0.5 mV/m) at 3m, (unresticted bands)	90.89 dBµV/m	Complies
FCC Parts 15.249(d), 15.209 and 15.215(c)	Out-of-Band Spurious Emissions and Band Edges (EUT in Transmit Mode)	Below the applicable limits	50.09 dBµV	Complies
FCC Parts 15.207(a)	Conducted Emissions on AC Mains	150kHz - 30MHz	21.25 dBµV	Complies
FCC Part 2.1093	RF Exposure and Antenna Gain Calulation	SAR or MPE Requirements	0.00007 mW/cm^2	Complies

2 Laboratory Information

2.1 Accreditations

2.1.1 US Federal Communications Commission

TUV Rheinland of North America located at 762 Park Avenue, Youngsville, NC 27596-9470 is accredited by the commission for performing testing services for the general public on a fee basis. This laboratory test facilities have been fully described in reports submitted to and accepted by the FCC (Registration No 90552 and 100881). The laboratory scope of accreditation includes: Title 47 CFR Part 15, and 18. The accreditation is updated every 3 years.

2.1.2 ILAC / A2LA

The laboratory has been assessed and accredited by A2LA in accordance with ISO Standard 17025:2005 (Certificate Number: 3331.05, Master Code: 134288). The scope of laboratory accreditation includes emission and immunity testing. The accreditation is updated annually.

2.1.3 Industry Canada

Registration No.: 2932H-1 The OATS has been accepted by Industry Canada to perform testing to 3 and to 10 meters, based on the test procedures described in ANSI C63.4-2009.

Registration No.: 2932H-2 The 5 meter chamber has been accepted by Industry Canada to perform testing to 3 meters, based on the test procedures described in ANSI C63.4-2009.

2.1.4 Japan – VCCI

The Voluntary Control Council for Interference by Information Technology Equipment (VCCI) is a group that consists of Information Technology Equipment (ITE) manufacturers and EMC test laboratories. The purpose of the Council is to take voluntary control measures against electromagnetic interference from Information Technology Equipment, and thereby contribute to the development of a socially beneficial and responsible state of affairs in the realm of Information Technology Equipment in Japan. TUV Rheinland at the 762 Park Ave. Youngsville, N.C 27596 address has been assessed and approved in accordance with the Regulations for Voluntary Control Measures. (Laboratory Registration No: A-0034).

2.1.5 Sample Calculation – radiated & conducted emissions

The field strength is calculated by subtracting the Amplifier Gain and adding the Cable Loss and Antenna Correction Factor to the measured reading. The basic equation is as follows:

Field Strength (dBµV/m) = RAW - AMP + CBL + ACF

Where: RAW = Measured level before correction (dBµV)

AMP = Amplifier Gain (dB)

CBL = Cable Loss (dB)

ACF = Antenna Correction Factor (dB/m)

$$\mu V/m = 10^{\frac{dB\mu V/m}{20}}$$

Sample radiated emissions calculation @ 30 MHz

Measurement +Antenna Factor–Amplifier Gain+Cable loss=Radiated Emissions (dBuV/m)

25 dBuV/m + 17.5 dB – 20 dB + 1.0 dB = 23.5 dBuV/m

2.2 Measurement Uncertainty Emissions

	U_{lab}	U_{cispr}
Radiated Disturbance @ 10m		
30 MHz – 1,000 MHz	3.3 dB	5.2 dB
Conducted Disturbance @ Mains Terminals		
150 kHz – 30 MHz	1.18 dB	3.6 dB
Disturbance Power		
30 MHz – 300 MHz	3.88 dB	4.5 dB

2.3 Calibration Traceability

All measurement instrumentation is traceable to the National Institute of Standards and Technology (NIST). Measurement method complies with ANSI/NCSL Z540-1-1994 and ISO Standard 17025:2005. Equipment calibration records are kept on file at the test facility.

2.4 Measurement Equipment Used

Equipment	Manufacturer	Model #	Serial/Inst #	Last Cal dd/mm/yy	Next Cal dd/mm/yy
Radiated Emissions (5 Meter Chamber)					
Receiver, EMI	Rohde & Schwarz	ESIB40	100043	19-Aug-14	19-Aug-15
Spectrum Analyzer	Agilent Tec.	E7405A	US39440161	20-Aug-14	20-Aug-15
Amplifier, preamp	Agilent Technologies	8449B	3008A01480	14-Aug-13	14-Aug-15
Ant. BiconiLog	Chase	CBL6140A	1108	16-Sep-13	16-Sep-15
Antenna Horn 1-18 GHz	EMCO	3115	5770	30-Dec14	30-Dec15
Antenna Horn 18-26.5 GHz	ATM	42-442-6/cal	G181104-01	31-Dec-14	31-Dec-15
Cable, Coax	MicroCaox	MKR300C-0-0-1200-500500	002	22-Aug-14	22-Aug-15
Cable, Coax	MicroCaox	MKR300C-0-1968-500310	005	22-Aug-14	22-Aug-15
Cable, Coax	MicroCaox	UFB29C-1-5905-50U-50U	009	22-Aug-14	22-Aug-15
3.0 GHz High Pass Filter	Bonn Electronik	BHF 3000	025155	14-Aug-13	14-Aug-15
Notch Filter	Micro-tronics	BRM50702	049	14-Aug-13	14-Aug-15
Conducted Emissions (AC/DC)					
Receiver, EMI	Rohde & Schwarz	ESCI 7	100917	19-Aug-14	19-Aug-15
Cable, Coax	Pasternack	RG-223	051	22-Aug-14	22-Aug-15
LISN 15-18 (NSLK 8126)	Schwarzbeck Mess-Electronik	NSLK 8126	003885	13-Aug-13	13-Aug-15
Transient Limiter	Schaffner	CFL-9206	1649	13-Aug-13	13-Aug-15
General Laboratory Equipment					
Meter, Multi & Thermocouple	Fluke	179	90580752	19-Aug-14	19-Aug-15
Meter, Temp/Humid/Barom	ExTech	SD700	Q677933	06-May-13	06-May-16
Meter, Temp/Humid/Barom	ExTech	SD700	Q677942	06-May-13	06-May-16

3 Product Information

3.1 Product Description

See Section Appendix A.

3.2 Equipment Modifications

No modifications were needed to bring product into compliance.

3.3 Test Plan

The EUT product information, test configuration, mode of operation, test types, test procedures, test levels, pass/failure criteria, in this report were carried out per the product test plan located in appendix A of this report

4 Radiated Emissions in Transmit mode

4.1 Radiated emissions - FCC Parts 15.249

The field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following limits:
Fundamental Frequency: 2400 to 2483.5 MHz – 50 mV/m (94 dB µV/m) at 3m.
Harmonic Frequencies: 500 µV/m (54 dB µV/m) at 3m.
Spurious Emissions: To the limits of FCC Part 15.209.

4.1.1 Over View of Test

Results	**Complies** (as tested per this report)					**Date**	3 – 4 August 2015
Standard	FCC Parts 15.205, 15.209, 15.215(c), 15.249(a), 15.249(c), 15.249(d)						
Product Model	nIO-BT			**Serial#**	Production Prototype		
Test Set-up	Tested in a 5m Semi Anechoic chamber, placed on a 1.0m x 1.5m non-conductive table 80cm above the ground plane on a turn-table.						
EUT Powered By	5.0 VDC	**Temp**	75º F	**Humidity**	43%	**Pressure**	1003 mbar
Perf. Criteria	(Below Limit)		**Perf. Verification**		Readings Under Limit		
Mod. to EUT	None		**Test Performed By**		Mark Ryan		

4.1.2 Test Procedure

Testing was performed in accordance with 47 CFR Part 15 and ANSI C63.10:2009. These test methods are listed under the laboratory's A2LA Scope of Accreditation. This test measures the levels emanating from the EUT, thus evaluating the potential for the EUT to cause radio frequency interference to other electronic devices.

4.1.3 Deviations

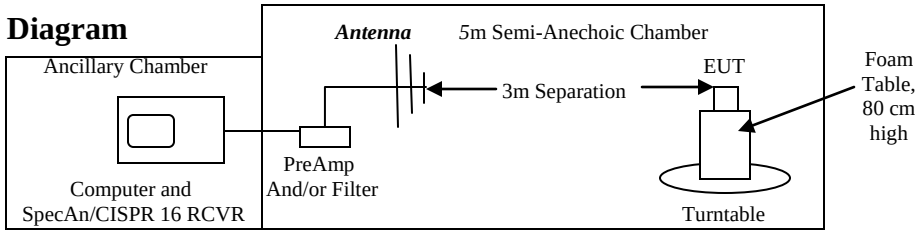
Since all emissions outside the band are within the limits of FCC Part 15.209. The emissions shown below are also compliant with FCC Parts 15.205, 15.209, 15.215(c), 15.249(d).

4.1.4 Final Test

All final radiated spurious emissions measurements were below (in compliance) the limits.

The worst –case emissions are shown below. All other emissions are on file at TUV Rheinland.

4.1.5 Test Setup Block Diagram



4.1.5.1 Final Graphs and Tabulated Data

Orientations:

Emission Freq (MHz)	ANT Polar (H/V)	ANT Pos (m)	Table Pos (deg)	FIM Value (dBµV)	Amp Gain (dB)	Cable Loss (dB)	ANT Factor (dB/m)	E-Field Value (dBµV /m)	Spec Limit (dBµV /m)	Spec Margin (dB)
2440.00:										
Orientation A										
2440.00	H	2	199	63.38	0.00	5.95	28.56	97.89		
2440.00	V	2	74	58.12	0.00	5.95	28.56	92.63		
Orientation B										
2440.00	H	2	181	60.63	0.00	5.95	28.56	95.14		
2440.00	V	1.5	240	64.20	0.00	5.95	28.56	98.71		
Orientation C										
2440.00	H	2	325	61.22	0.00	5.95	28.56	95.73		
2440.00	V	1.6	218	64.80	0.00	5.95	28.56	99.31		
Orientation B										
2402.00	H	1.6	305	59.65	0.00	5.89	28.54	94.08		
2402.00	V	1.6	240	64.40	0.00	5.89	28.54	98.83		
Orientation B										
2480.00	H	1.4	248	65.64	0.00	5.98	28.68	100.30	114.00	-13.70
2480.00	V	1.3	247	66.14	0.00	5.98	28.68	100.80	114.00	-13.20
2480.00	V	1.3	247	56.23	0.00	5.98	28.68	90.89	94.00	-3.11

Spec Margin = E-Field Value - Limit, E-Field Value = FIM Value - Amp Gain + Cable Loss + ANT Factor

Notes: **Red = Peak Detector**, **Blue = Average Detector**

The **Peak** and **Average** measurements were made **WITH MODULATION** using specified RBW.

The Limit is 50 mv/m which is equivalent to 94 dBuV/m (at 3m distance).

The Limit using the Peak Detector is 20dB higher than the Average Detector limit.
EUT in Orientation B is worst case as shown. All other data is on file at TUV Rheinland.

This highlighted frequency and orientation was worst case (2480 MHz, Orientation B).

The maximum average Field Value of 90.89 dBµV/m (35 mV/m) is below the limit value of FCC Part 15.249 which is 94 dBµv/m (50 mV/m).

Therefore, this report is testing to the requirements of FCC Part 15.249

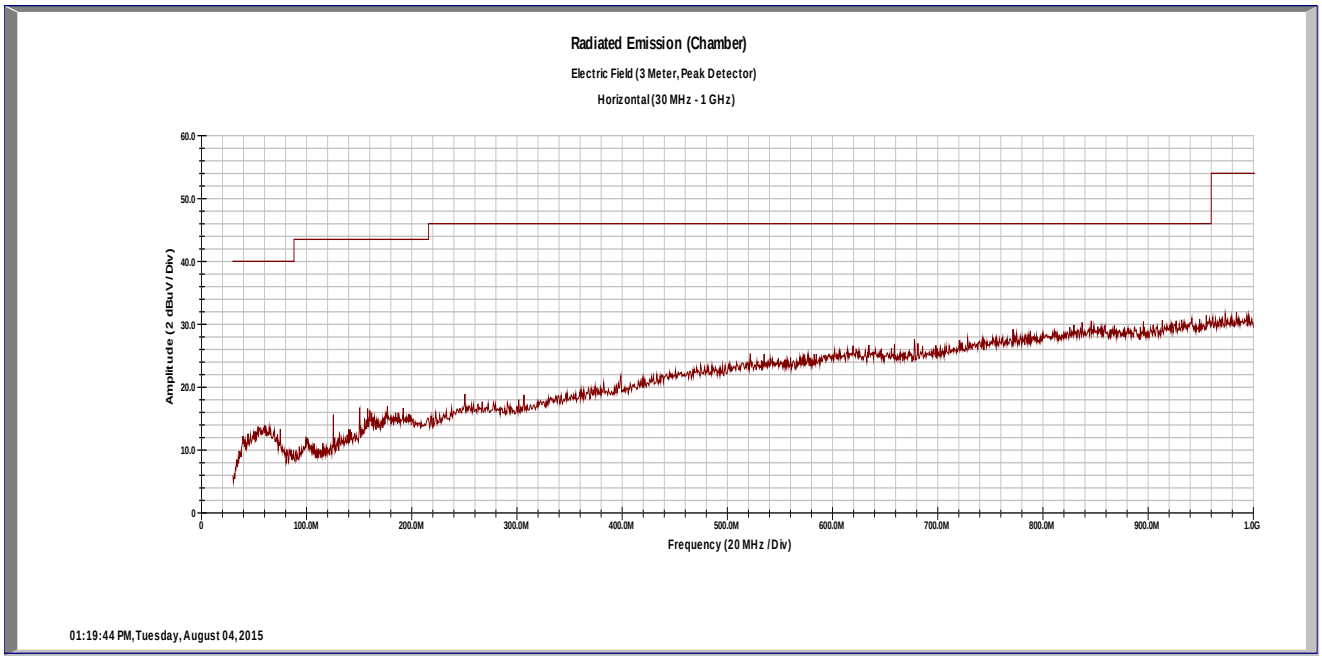
4.1.5.2 Maximum Time-weighted Emission:

The EUT was modified to transmit continuously.

The maximum measured Duty Cycle of the signal is 40.76%

4.1.5.3 Emissions Outside the Frequency Band:

Radiated Emissions – 30 MHz to 1 GHz
Horizontal



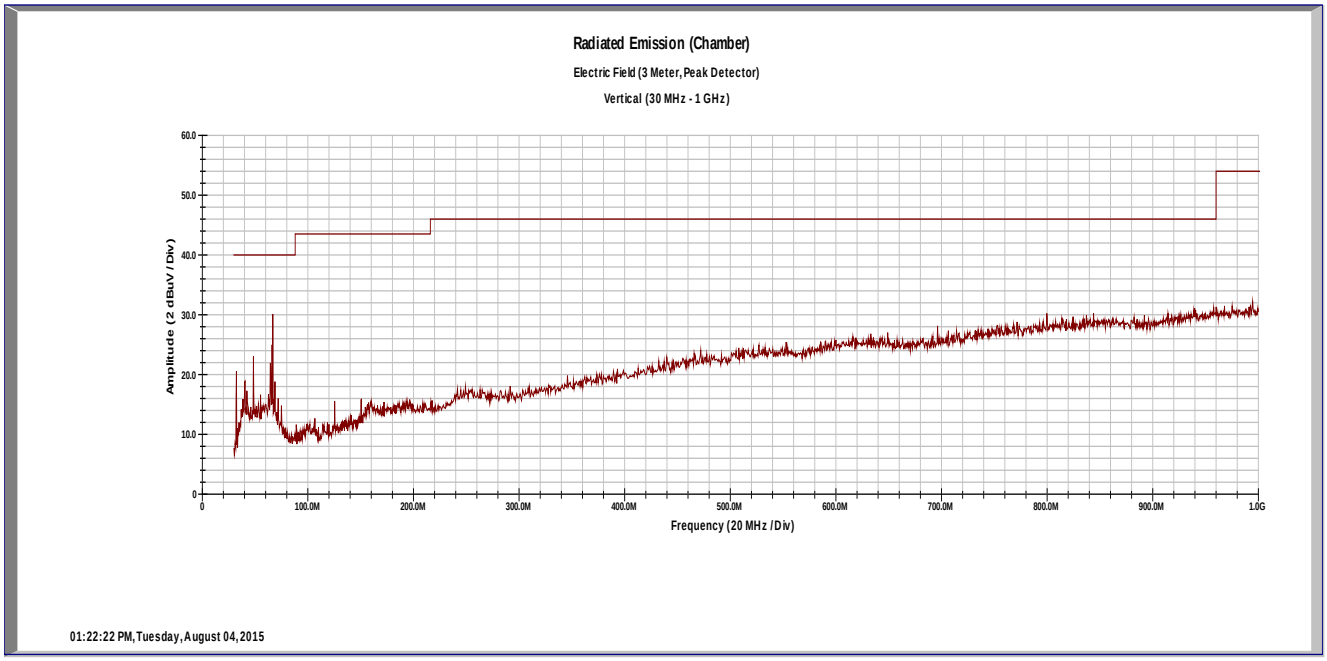
Emission Freq (MHz)	ANT Polar (H/V)	ANT Pos (m)	Table Pos (deg)	FIM Value (dBuV)	Amp Gain (dB)	Cable Loss (dB)	ANT Factor (dB/m)	E-Field Value (dBuV/m)	Spec Limit (dBuV/m)	Spec Margin (dB)

Spec Margin = E-Field Value - Limit, E-Field Value = FIM Value - Amp Gain + Cable Loss + ANT Factor

Notes: Transmitting Mode-Low, mid and high Channels

Radiated Emissions – 30 MHz to 1 GHz

Vertical



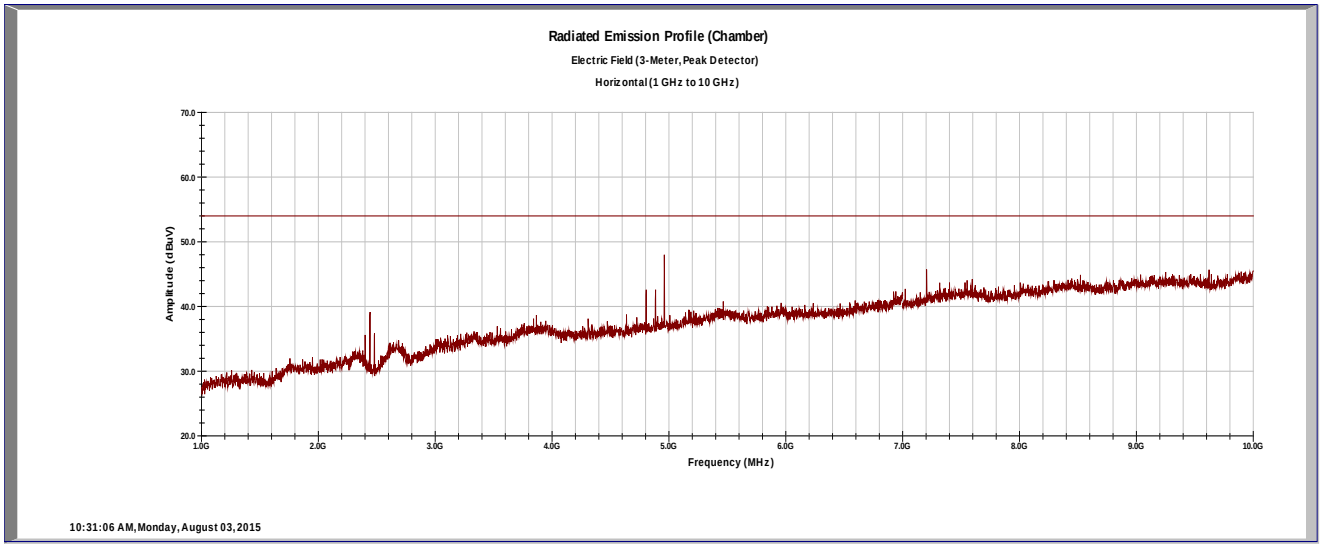
Emission Freq (MHz)	ANT Polar (H/V)	ANT Pos (m)	Table Pos (deg)	FIM Value (dBuV)	Amp Gain (dB)	Cable Loss (dB)	ANT Factor (dB/m)	E-Field Value (dBuV/m)	Spec Limit (dBuV/m)	Spec Margin (dB)
66.80	V	1.2	0	8.36	0.00	0.94	9.72	19.02	40.00	-20.98

Spec Margin = E-Field Value - Limit, E-Field Value = FIM Value - Amp Gain + Cable Loss + ANT Factor

Notes: Transmitting Mode-Low, mid and high Channels

Radiated Emissions – 1 to 10 GHz

Horizontal



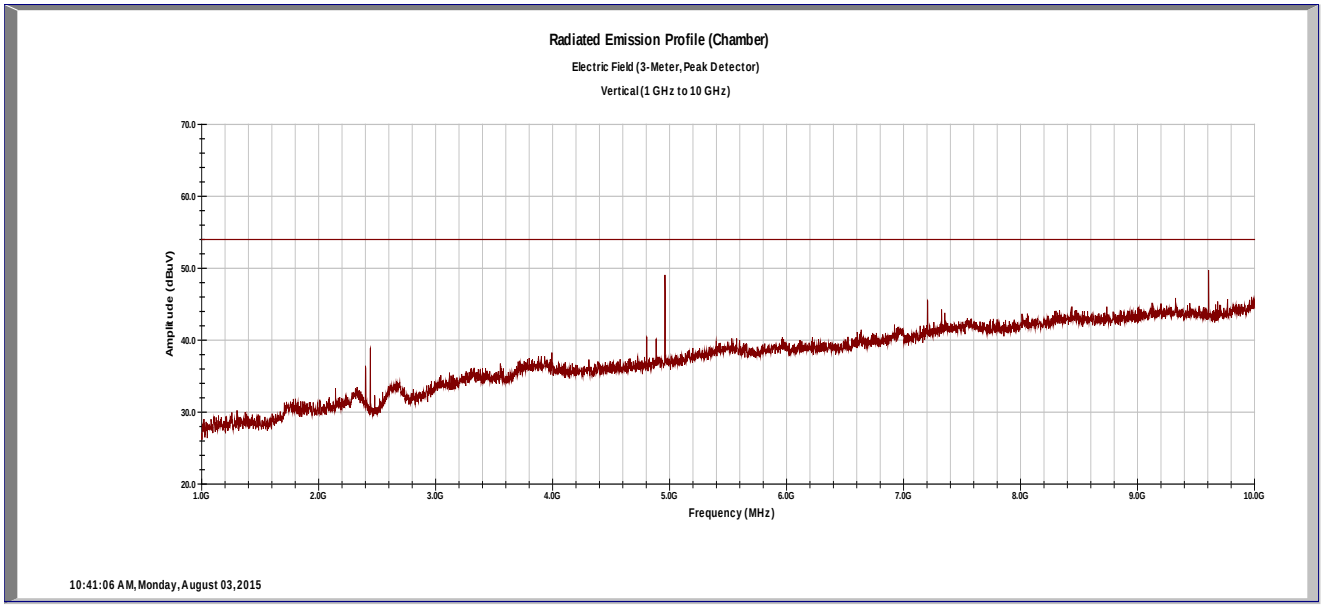
Emission Freq (MHz)	ANT Polar (H/V)	ANT Pos (m)	Table Pos (deg)	FIM Value (dBuV)	Amp Gain (dB)	Cable Loss (dB)	ANT Factor (dB/m)	E-Field Value (dBuV/m)	Spec Limit (dBuV/m)	Spec Margin (dB)
4959.92	H	1.0	61	29.33	33.66	11.81	33.19	40.68	54.00	-13.32
4959.92	H	1.0	61	42.25	33.66	11.81	33.19	53.60	74.00	-20.40
7206.80	H	1.0	226	24.15	33.61	14.51	36.07	41.12	54.00	-12.88
7206.80	H	1.0	226	39.97	33.61	14.51	36.07	56.94	74.00	-17.06

Spec Margin = E-Field Value - Limit, E-Field Value = FIM Value - Amp Gain + Cable Loss + ANT Factor

Notes: Transmitting Mode-Low, Mid and High Channels
A 2.4GHz band-notch filter was used at the input of the preamp for the 1 GHz to 10 GHz range.
The emissions shown in **GREEN** are using the average detector and average limits
The emissions shown in **BLUE** are using the peak detector and peak limits.
The **HIGHLIGHTED** cells indicate frequencies that do NOT fall within a Restricted band (-20dBc Limit).

Radiated Emissions – 1 to 10 GHz

Vertical



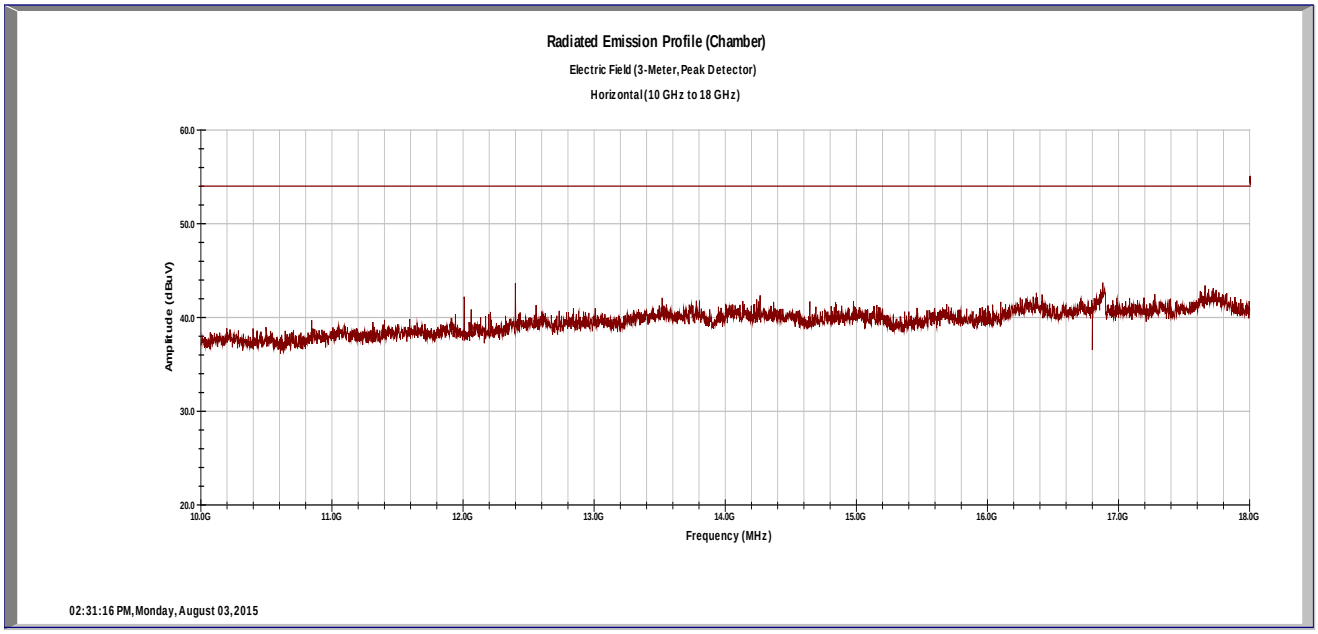
Emission Freq (MHz)	ANT Polar (H/V)	ANT Pos (m)	Table Pos (deg)	FIM Value (dBuV)	Amp Gain (dB)	Cable Loss (dB)	ANT Factor (dB/m)	E-Field Value (dBuV/m)	Spec Limit (dBuV/m)	Spec Margin (dB)
4960.40	V	1.3	346	29.04	33.66	11.81	33.19	40.39	54.00	-13.61
4960.40	V	1.3	346	43.27	33.66	11.81	33.19	54.62	74.00	-19.38
7206.80	V	1.0	216	24.56	33.61	14.51	36.07	41.53	54.00	-12.47
7206.80	V	1.0	215	40.01	33.61	14.51	36.07	56.98	74.00	-17.02
9607.21	V	1.4	7	25.13	34.18	16.88	37.93	45.76	54.00	-8.24
9607.21	V	1.4	7	39.12	34.18	16.88	37.93	59.75	74.00	-14.25

Spec Margin = E-Field Value - Limit, E-Field Value = FIM Value - Amp Gain + Cable Loss + ANT Factor

Notes: Transmitting Mode-Low, Mid and High Channels
A 2.4GHz band-notch filter was used at the input of the preamp for the 1 GHz to 10 GHz range.
The emissions shown in **GREEN** are using the average detector and average limits
The emissions shown in **BLUE** are using the peak detector and peak limits.
The **HIGHLIGHTED** cells indicate frequencies that do NOT fall within a Restricted band (-20dBc Limit).

Radiated Emissions – 10 to 18 GHz

Horizontal



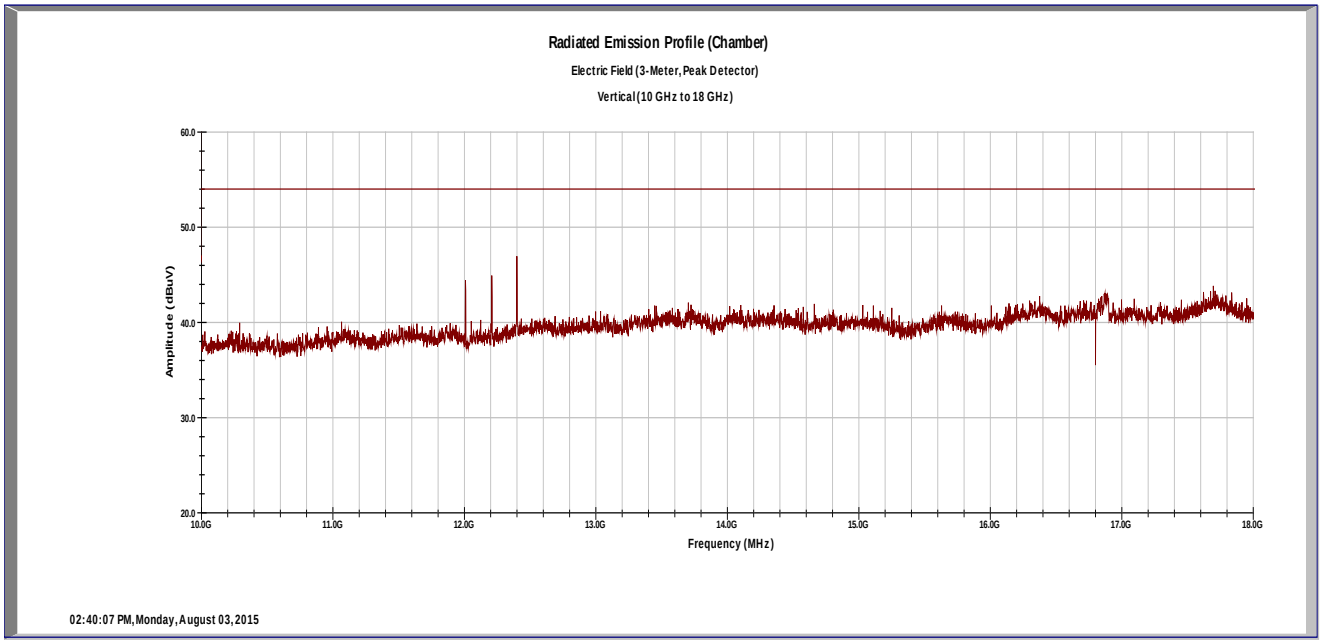
Emission Freq (MHz)	ANT Polar (H/V)	ANT Pos (m)	Table Pos (deg)	FIM Value (dBuV)	Amp Gain (dB)	Cable Loss (dB)	ANT Factor (dB/m)	E-Field Value (dBuV/m)	Spec Limit (dBuV/m)	Spec Margin (dB)

Spec Margin = E-Field Value - Limit, E-Field Value = FIM Value - Amp Gain + Cable Loss + ANT Factor

Notes: Transmitting Mode-Low, Mid and High Channels
A 3 GHz high-pass filter was used at the input of the preamp for the 10 GHz to 18 GHz range.

Radiated Emissions – 10 to 18 GHz

Vertical



Emission Freq (MHz)	ANT Polar (H/V)	ANT Pos (m)	Table Pos (deg)	FIM Value (dBuV)	Amp Gain (dB)	Cable Loss (dB)	ANT Factor (dB/m)	E-Field Value (dBuV/m)	Spec Limit (dBuV/m)	Spec Margin (dB)
12398.80	V	1.6	0	24.01	32.95	20.00	39.02	50.09	54.00	-3.91
12398.80	V	1.6	0	40.59	32.95	20.00	39.02	66.67	74.00	-7.33

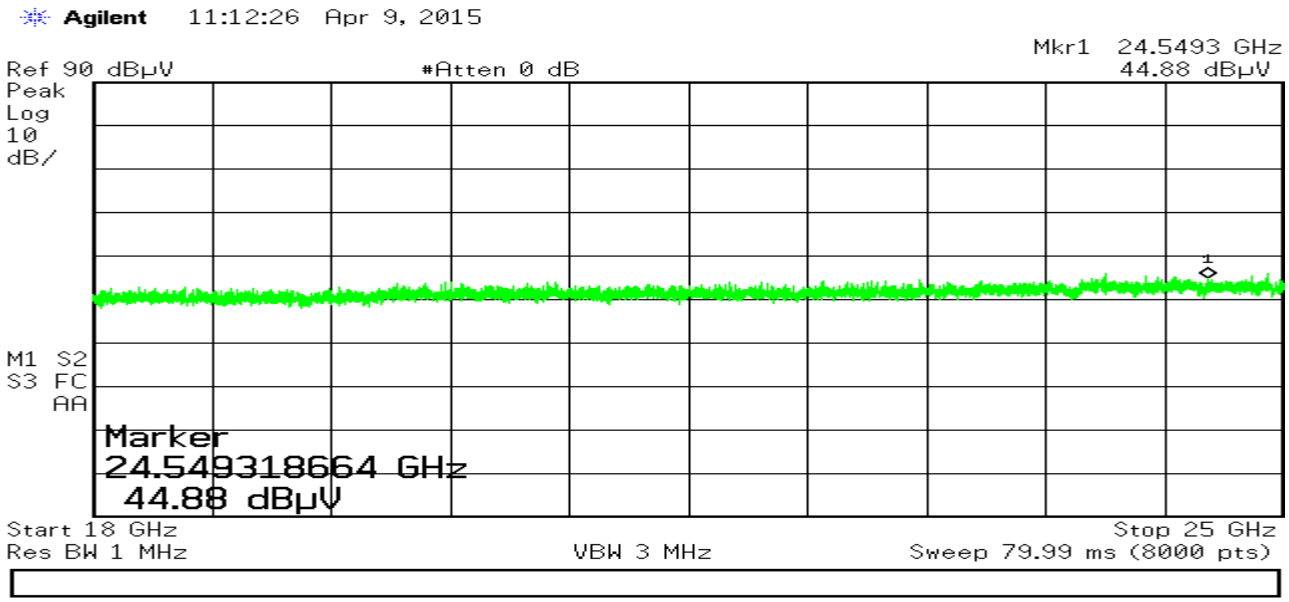
Spec Margin = E-Field Value - Limit, E-Field Value = FIM Value - Amp Gain + Cable Loss + ANT Factor

Notes: Transmitting Mode-Low, Mid and High Channels
A 3 GHz high-pass filter was used at the input of the preamp for the 10 GHz to 18 GHz range.
The **HIGHLIGHTED** cells show the worst-case harmonic emission.

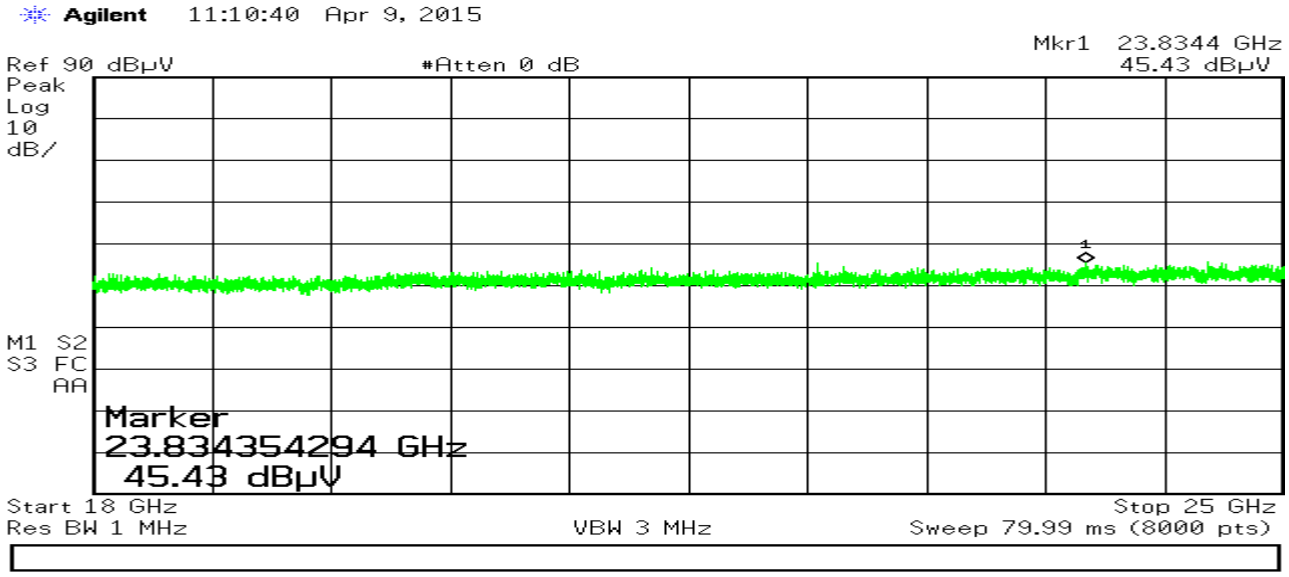
Radiated Emissions – 18 GHz to 25 GHz

Notes:
No measureable emissions found outside the band.
Plots utilizing a Peak detector shown below.
Remaining plots for the other frequencies are on file at TUV Rheinland.

Radiated Emissions – 18 GHz to 24 GHz – Horizontal:



Radiated Emissions – 18 GHz to 24 GHz – Vertical:



Note: Base-line scan, no correction factors were applied.

4.2 Conducted Emissions on AC Mains – FCC 207(a)

This test measures the electromagnet levels of spurious signals generated by the EUT on the AC power line that may affect the performance of other nearby electronic equipment.

4.2.1 Over View of Test

Results	**Complies** (as tested per this report)					**Date**	5 August 2015
Standard	FCC Parts 15.207(a)						
Product Model	nIO-BT			**Serial#**	Production Prototype		
Test Set-up	Tested in shielded room. EUT placed on table, see test plans for details						
EUT Powered By	5.0 VDC	**Temp**	72º F	**Humidity**	56%	**Pressure**	1001 mbar
Frequency Range	150 kHz – 30 MHz						
Perf. Criteria	(Below Limit)	**Perf. Verification**	Readings Under Limit for L1 & Neutral				
Mod. to EUT	None	**Test Performed By**					

4.2.2 Test Procedure

Conducted and FCC emissions tests were performed using the procedures of ANSI C63.10:2009 including methods for signal maximizations and EUT configuration. The photos included with the report show the EUT in its maximized configuration.

The frequency range from 150kHz – 30MHz was investigated for conducted emissions.

Conducted Emissions measurements were performed in either the shielded room or ground plane location (with attached vertical ground plane) using procedures specified in the test plan and standard.

The EUT was powered by a 5 VDC Power Module. The emissions were made on the AC Mains side of the Module.

There were no deviations from the test methodology listed in the test plan for the conducted emission test.

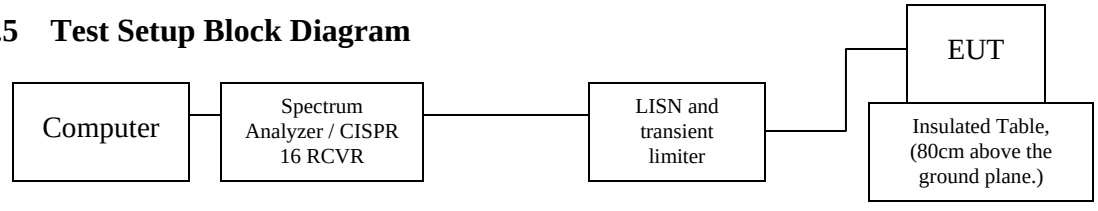
4.2.3 Deviations

There were no deviations from the test methodology listed in the test plan for the conducted emission test.

4.2.4 Final Test

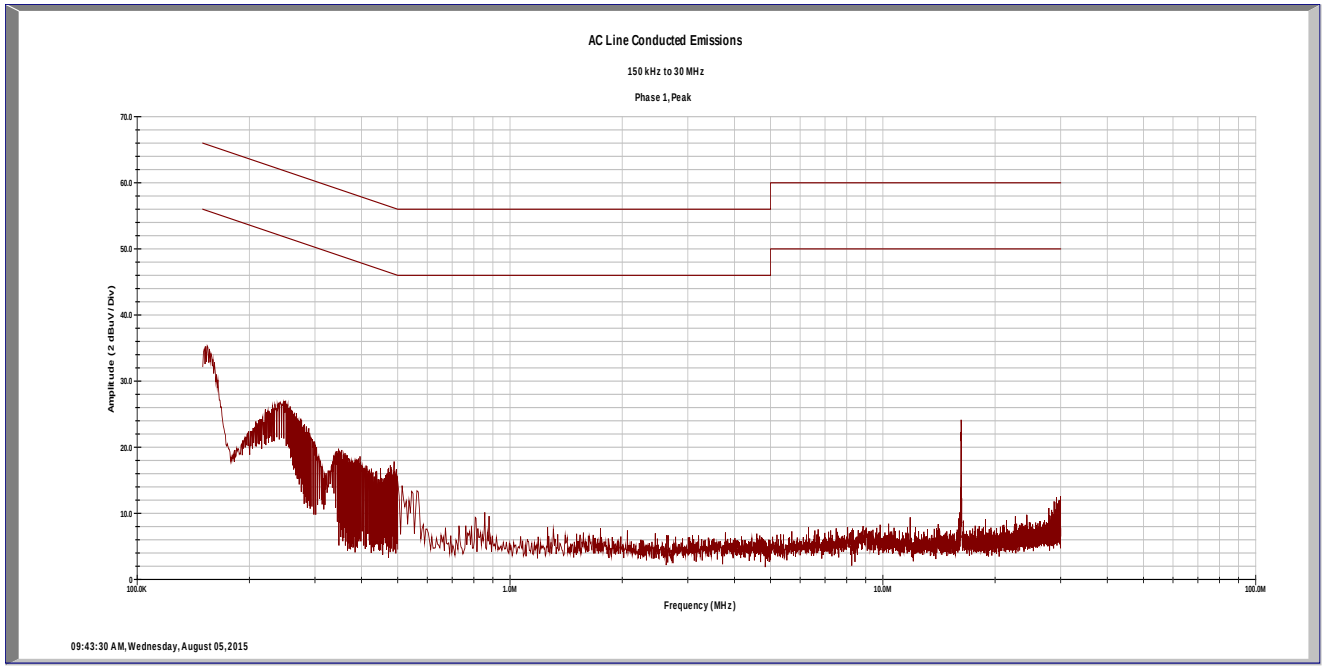
All final conducted emissions measurements were below (in compliance) the limits.

4.2.5 Test Setup Block Diagram



4.2.6 Final data and Graphs

Conducted Emissions @ 120V/60Hz
Line 1



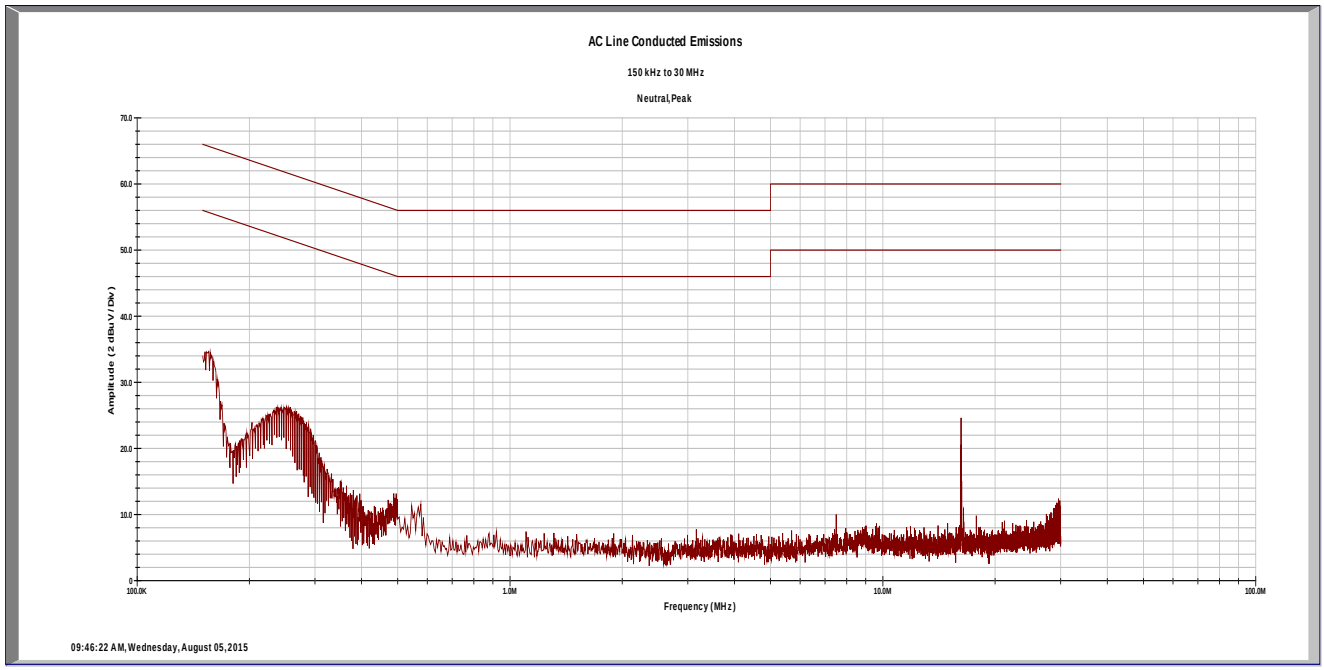
Freq (MHz)	ID (1,2,3,N)	Quasi FIM (dBµV)	Ave FIM (dBµV)	Cable Loss (dB)	TL/LISN (dB)	Limit QP (dBµV)	Limit AVE (dBµV)	Margin QP (dB)	Margin AVE (dB)
0.15	1	18.31	2.91	0.03	9.97	65.78	55.78	-37.48	-42.88
0.24	1	8.71	0.02	0.03	9.97	62.03	52.03	-43.32	-42.01
16.22	1	3.38	0.01	0.27	10.74	60.00	50.00	-45.62	-38.99

Quasi Spec Margin = Quasi FIM + Cable Loss + TL/LISN - QP Limit
Ave Spec Margin = Ave FIM + Cable Loss + TL/LISN CF - Ave Limit

Notes: The highlighted average cells show the worst-case emission (21.25 dBµV)

Conducted Emissions @ 120V/60Hz

Neutral



Freq (MHz)	ID (1,2,3,N)	Quasi FIM (dBµV)	Ave FIM (dBµV)	Cable Loss (dB)	TL/LISN (dB)	Limit QP (dBµV)	Limit AVE (dBµV)	Margin QP (dB)	Margin AVE (dB)
0.15	N	17.91	1.98	0.03	9.97	65.78	55.78	-37.88	-43.81
0.25	N	8.13	0.01	0.03	9.96	61.89	51.89	-43.77	-41.89
16.23	N	4.61	0.02	0.27	10.37	60.00	50.00	-44.76	-39.35

Quasi Spec Margin = Quasi FIM + Cable Loss + TL/LISN - QP Limit
Ave Spec Margin = Ave FIM + Cable Loss + TL/LISN CF - Ave Limit

Notes:

4.3 Band Edge requirements - FCC Part 15.249(d)

4.3.1 Test Over View

Results	**Complies** (as tested per this report)					**Date**	6 July 2015
Standard	FCC Part 15.249(d)						
Product Model	nIO-BT			**Serial#**		Production Prototype	
Test Set-up	Radiated Measurement						
EUT Powered By	5.0 VDC	**Temp**	78º F	**Humidity**	43%	**Pressure**	1003 mbar
Perf. Criteria	(Below Limit)			**Perf. Verification**		Readings Under Limit	
Mod. to EUT	None			**Test Performed By**		Mark Ryan	

4.3.2 Test Procedure

Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in Sec. 15.209, whichever is the lesser attenuation.

4.3.3 Deviations

The Marker-delta method for band-edge measurements (section 6.9.3 of ANSI C63.10:2009) was used, as emissions up to 2 MHz removed from the band edge will also be measured.

The total span of band-edge measurements were approximately 4.8 MHz.

RBW of 100 kHz was chosen as it is within 1% to 5% of the total span. (4.8%)

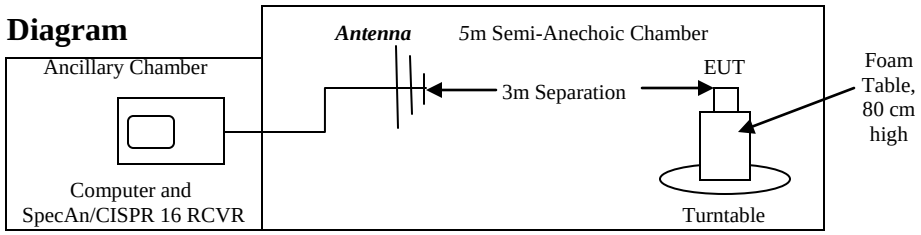
The VBW of 300 kHz was chosen as it is 3 times the 100 kHz RBW.

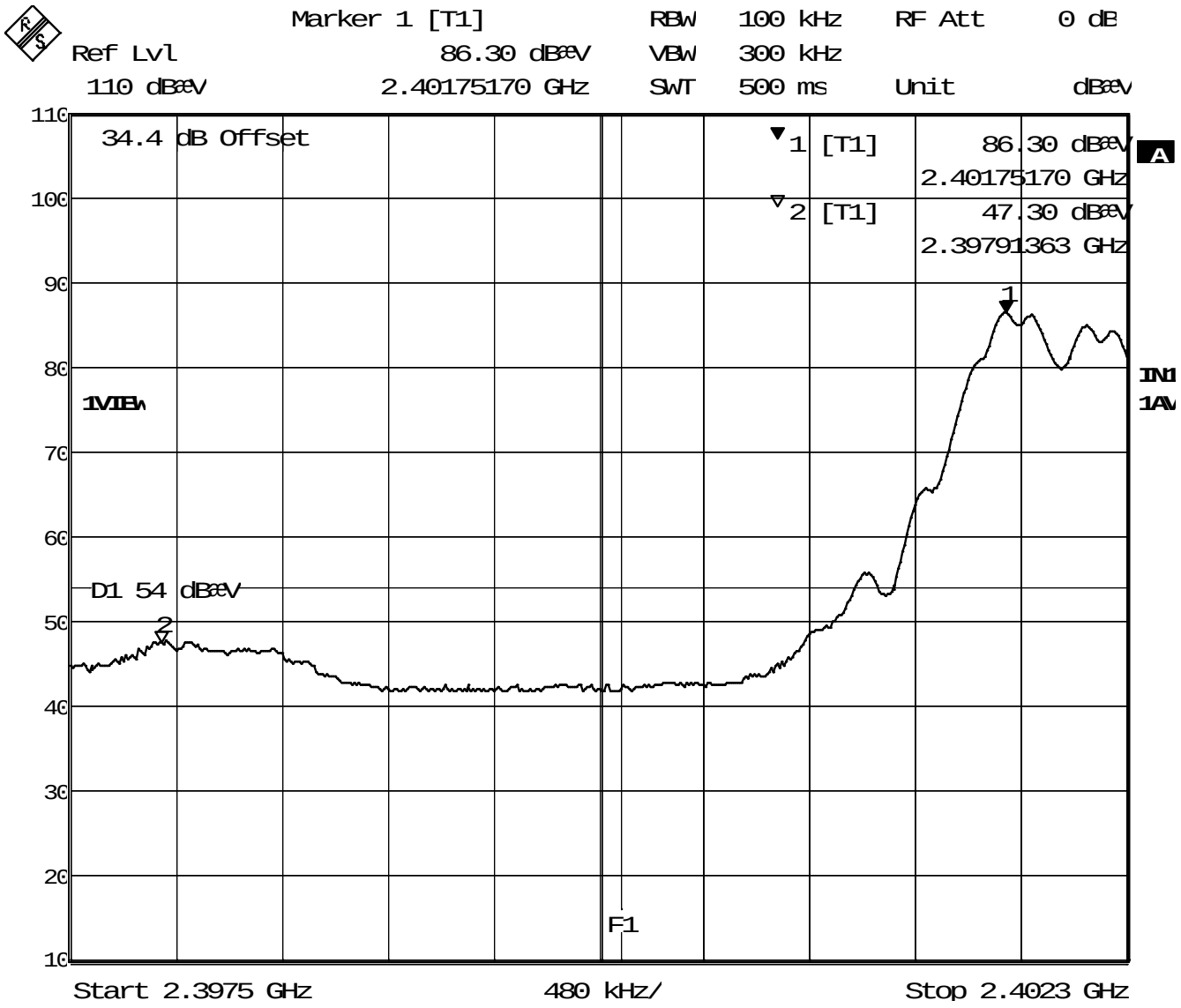
The Sweep time was set to Auto.

4.3.4 Final Test

The EUT met the performance criteria requirement as specified in the standards.

4.3.1 Test Setup Block Diagram





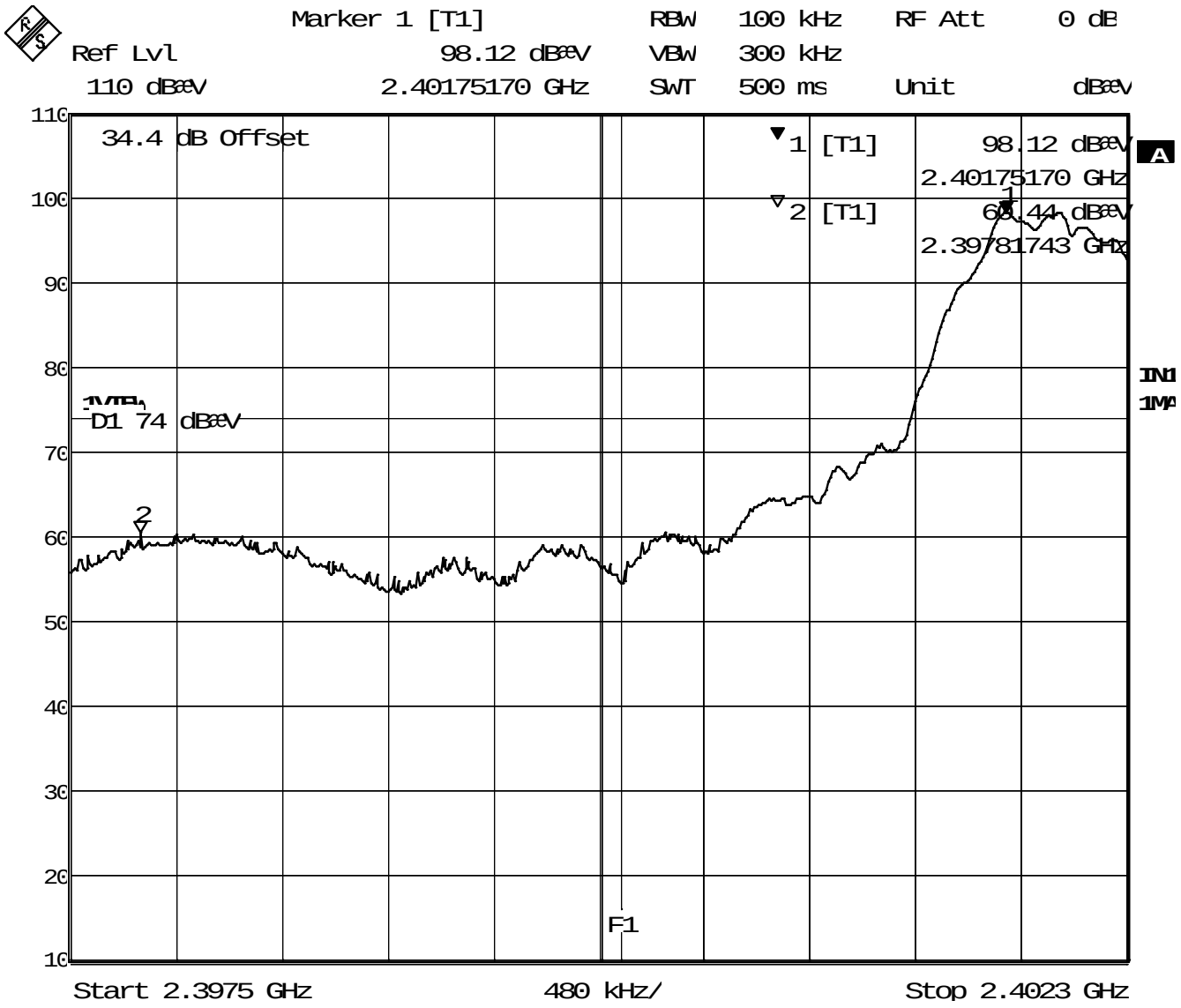
Date: 3.AUG.2015 16:25:27

Notes: Plot includes Correction Factors. Measured using the Average Detector, Line F1 is the Band Edge is at 2.4 GHz. Line D1 is the Restricted Band Peak limit.

The nearest restricted band (2390MHz) is 10 MHz below the band edge

The Highest frequency outside the band is at 47.30 dBµV (using the Average Detector) which is 6.7 dB below the average Limit for a restricted band.

Figure 1: Lower Band Edge Measurement (Radiated Emission-Average)



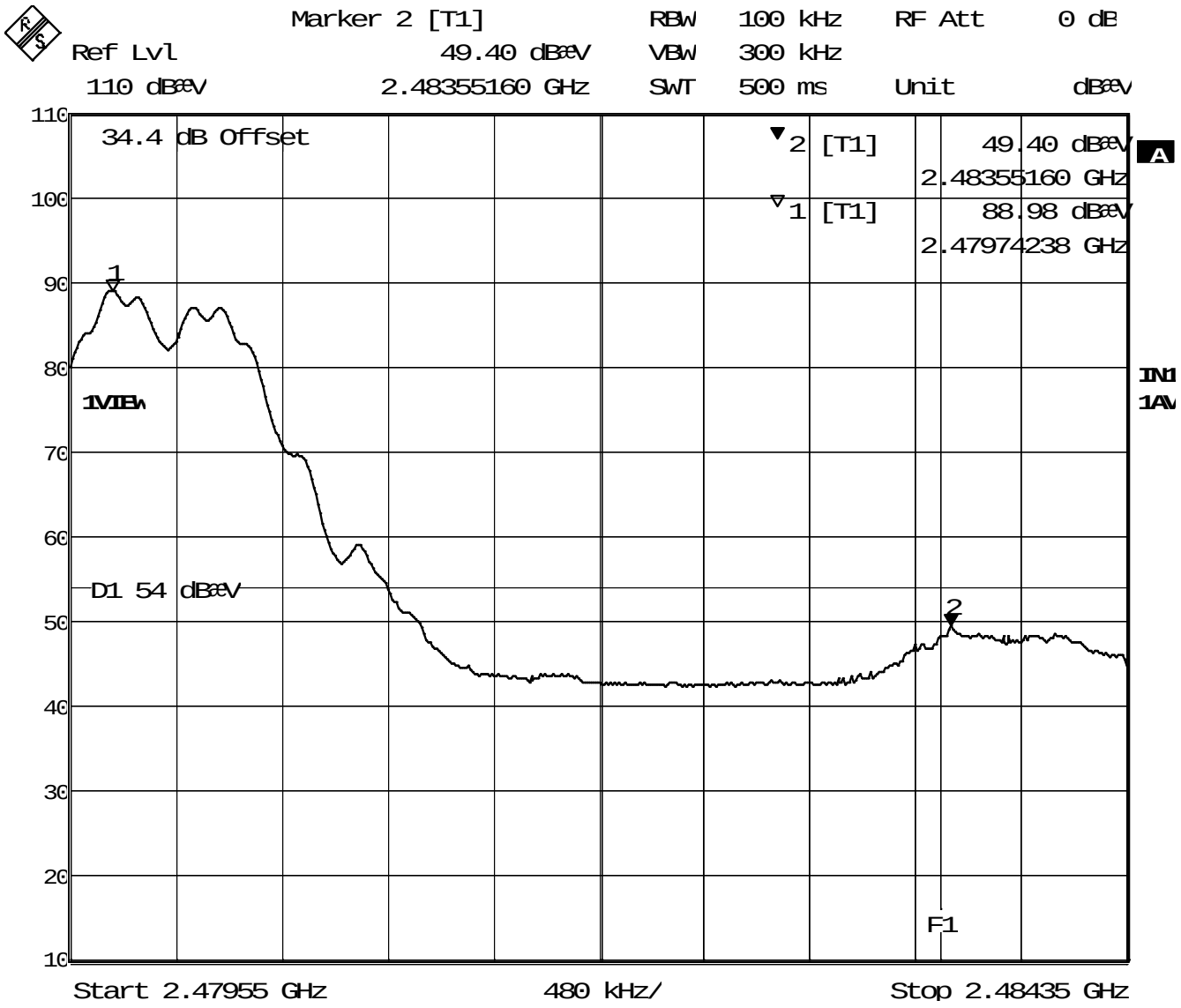
Notes: Plot includes Correction Factors. Measured using the Peak Detector, Line F1 is the Band Edge is at 2.4 GHz. Line D1 is the Restricted Band Peak limit.

The nearest restricted band (2390MHz) is 10 MHz below the band edge

The Highest frequency outside the band is at 60.44 dBµV (using the Peak Detector) which is 13.56 dB below the peak Limit for a restricted band.

The -20dBc value was not shown, as it can be clearly seen that that point is well within the band and would be very close the 15.209 limit line.

Figure 2: Lower Band Edge Measurement (Radiated Emission-Peak)

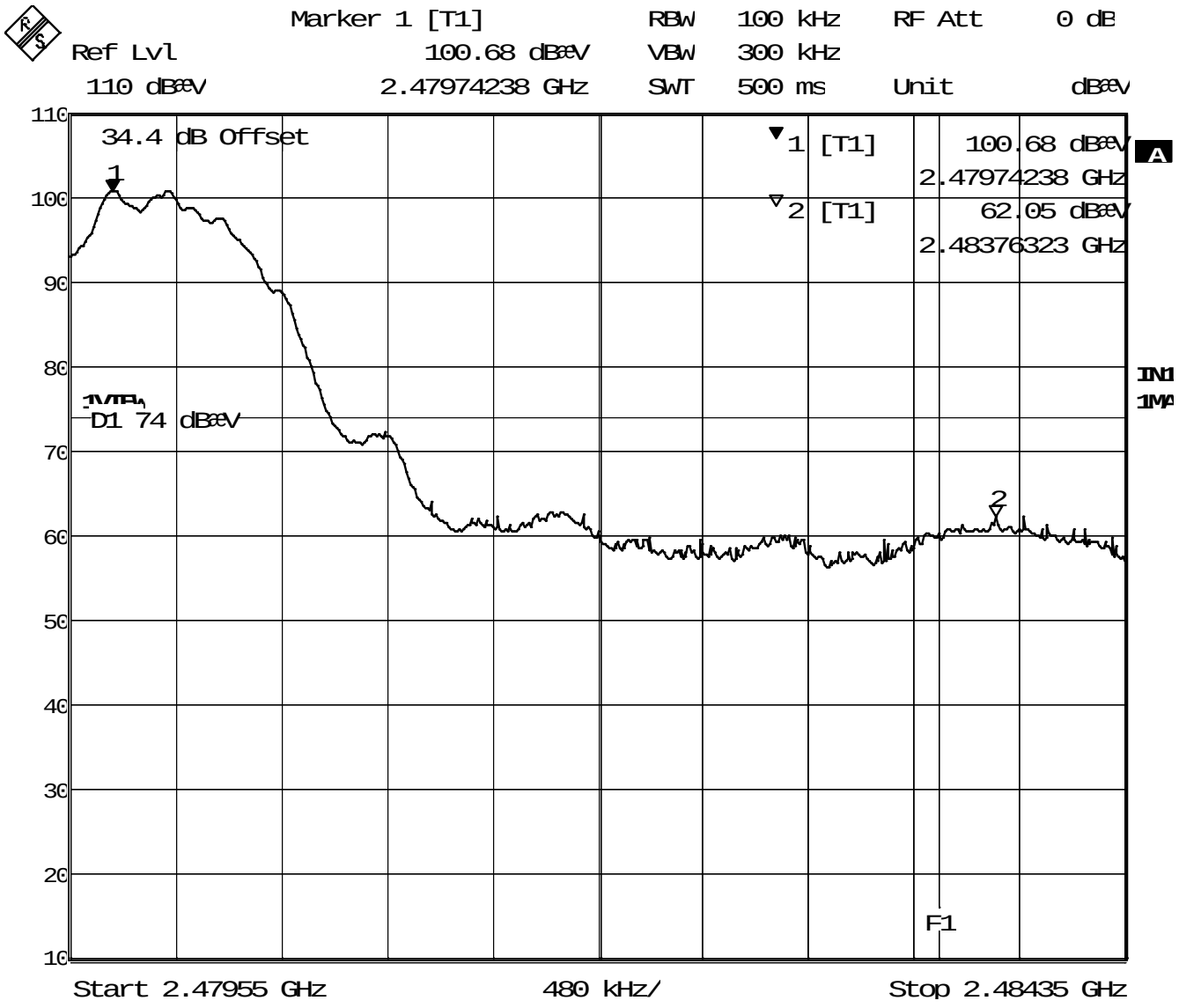


Note: Measured using the Average detector. Band Edge is at 2.483.5 MHz (Line F1), line D1 is the average restricted band limit.

The Band edge (Line F1) at 2483.5 MHz is also the start of a restricted band, so the restricted band rules apply.

The Highest frequency outside the band is at 49.40 dBµV (using the Average Detector) which is 4.6 dB below the Average restricted-band limits)

Figure 3: Upper Band Edge Measurement (Radiated Emission-Average)



Note: Measured using the Peak detector. Band Edge is at 2.483.5 MHz (Line F1), line D1 is the peak restricted band limit.

The Band edge (Line F1) at 2483.5 MHz is also the start of a restricted band, so the restricted band rules apply.

The Highest frequency outside the band is at 62.05 dBµV (using the Peak Detector) which is 11.95 dB below the Peak restricted-band limits)

Figure 4: Upper Band Edge Measurement (Radiated Emission-Peak)

The EUT is compliant with the rules.

5 RF Exposure

5.1 Classification

The antenna of the product, under normal use condition, is at least 20cm away from the body of the user. Warning statement to the user for keeping at least 20cm or more separation distance with the antenna should be included in user's manual. Therefore, this device is classified as a **Mobile Device**.

5.2 Test Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

5.2.1 Antenna Gain

The maximum published Gain of the antenna is +3 dBi peak or 2.0 (numeric).

5.2.2 Output Power into Antenna & RF Exposure value at distance 20cm:

Calculations for this report are based on highest power calculation and the highest gain of the antenna.
Limit for MPE (from FCC part 1.1310 table 1) which is 1.0 mW/cm^2 for the 2400MHz band.
Assuming a duty cycle of 100% will give a worst case value. Actual value, including the Duty Cycle, will be much lower than that shown below.

Highest Pout is 0.185 mW or 0.000184W*

The maximum published gain of the antenna is +3 dBi. Linear gain = $10^{(\text{dBi Gain} / 10)}$ = 2.0

and R is 20cm or 0.2m.

FCC:					
Controlled Exposures - Limit (mW/cm^2) =	5				
Uncontrolled Exposures - Limit (mW/cm^2) =	1				
Pd =	0.0007175	mW/cm^2		Pd = (Pout*G) / (4*π*R^2)	
Controlled Margin to Limit =	4.9993	mW/cm^2			
Uncontrolled Margin to Limit =	**0.9993**	**mW/cm^2**			

*Note: The Pout value was taken from the 100.8 dBµV/m value from section 4.1.4.1 of this report.
This value was applied to the P = (E*D)^2 / (30*G) equation, factoring in the published gain of the antenna.
Where:

"E" is the field strength in V/m (($10^{(\text{dBµV/m value} / 20)}$) / 10^6 = V/m) = 0.035 V/m)
"G" is the numeric gain of the transmitting antenna over an isotropic radiator. (2)
"d" is the distance at which the measurement is being executed. (3m)
"P" is the transmitter power in Watts. (0.0001845 W or 0.184 mW)

All calculations are on file at TUV Rheinland.

5.2.3 Sample Calculation

The Friis transmission formula: $Pd = (Pout*G) / (4*\pi*R^2)$

Where;

Pd = power density in mW/cm_2
Pout = output power to antenna in mW (0.018 mW).
G = gain of antenna in linear scale (we are assuming a numeric gain of 2 as a worst-case scenario).
$\pi \approx 3.1416$

R = distance between observation point and center of the radiator in cm (20cm)

Ref. : David K. Cheng, *Field and Wave Electromagnetics*, Second Edition, Page 640, Eq. (11-133).

$Pd = (0.184* 2)/(4*\pi*20^2) = .368 / 5026.55 = 0.000073\ mW/cm^2$

5.2.4 Results

Calculated PD (mW/cm^2)	Uncontrolled Exposure Limit (mW/cm^2)	Uncontrolled Margin to Limit (mW/cm^2)
0.000073	1	-0.9993

Appendix A

6 Test Plan

This test report is intended to follow this test plan outlined here in unless otherwise stated in this here report. The following test plan will give details on product information, standards to be used, test set ups and refer to TUV test procedures. The test procedures will give the steps to be taken when performing the stated test. The product information below came via client, product manual, product itself and or the internet.

6.1 General Information

Client	SENSOR SWITCH
Address 1	900 Northrop Rd.
Address 2	Wallingford, CT 06492 USA
Contact Person	Frank Pelliccio
Telephone	(203) 303-5447
e-mail	Frank.Pelliccio@acuitybrands.com

6.1.1 Product Name

nIO-BT - Tel Job # 129566 (21532486)

6.1.2 Type of Product

BLE Device (Bluetooth-Low Energy)

6.2 Equipment Under Test (EUT) Description

The Sensor Switch nIO-BT device is a Bluetooth Low Energy (now known as Bluetooth Smart) device that facilitates wireless communications with Sensor Switch's proprietary wired nLight RS-485 network. The nIO-BT unit derives its power from 16-28VDC provided by the nLight bus via CAT5e cable. The nIO-BT has a dedicated microcontroller and a specialized *BlueNRG-QTR* monolithic BLE coprocessor from ST Microelectronics. The nIO-BT EUT is expected to communicate within the specifications for the BLE protocol, which are intentional radiated emissions from 2402MHz to 2480MHz.

6.2.1 Testing Preparation

Connect the provided 10' CAT5e cable between the nIO-BT EUT and the nPS-80 power supply to provide the EUT power. If necessary, the 10' cable may be replaced by any CAT5e-compliant cable that is terminated with RJ-45 connectors. The nPS-80 can be powered directly from 60Hz 100VAC-120VAC U.S. mains power.

6.3 General Product Information

Size	**H**	2.54cm	**W**	5.03cm	**L**	6.45cm	
Weight	0.04Kg		**Fork-Lift Needed**		No		
Notes							

Product environmental operating conditions:

-10º to 71º C Operating temperature range.

20 to 90% non-condensing Operating humidity range.

N/A Operating pressure range.

6.3.1 EUT Electrical Powered Information

6.3.1.1 Electrical Power Type

☐	**AC**	☐	**DC**	☐	**Batteries**	☒	**Host** – 120VAC mains-powered nLight nPS-80 Power Supply

6.3.1.2 Electrical Power Information

Name	**Type**	**Voltage**		**Frequency**	**Current**	**Notes**
		min	**max**			
nLight nPS-80	AC-DC converter	100VAC	120VAC	60Hz	0.015A	
Notes	nPS-80 device powers nIO-BT EUT via CAT5e cable					

6.3.2 EUT Modes of Operation

nIO-BT EUT must be connected to nLight nPS-80 via CAT5e cable via either port on the EUT and either port on the nPS-80 power supply. Once powered, the nIO-BT LED will rapidly flash briefly. At this point, the BLE radio is broadcasting advertising packets. By pressing then releasing the button on the device a certain number of times, different test modes can be entered. The EUT must be power-cycled before entering a new test mode, by either removing then re-inserting the CAT5e cable from the EUT, or by power cycling the nPS-80 power supply.

- One button press – Carrier Wave Tone Mode : The nIO-BT EUT will enter tone mode by pressing the button once. The unit will round-robin cycle the tone frequency in 2MHz increments between 2.401750GHz and 2479.75MHz for BLE channels 0-39 (f = 2402 + channel * 2 - 0.250 MHz, with channel = 0 to 39). Each frequency will emit the tone for a duration of 2 seconds before switching to the next frequency.

- Two button presses – Data Transmit Mode : The nIO-BT EUT will enter a constant data transmit mode by pressing the button twice. The unit will round-robin between BLE channels @ 2402MHz, 2442MHz, 2480MHz, transmitting a continuous stream of BLE-modulated data on each channel for a duration of 2 seconds per channel before switching to the next channel.
- Three button presses – The radio will be placed into Receive Mode.
- Four button presses – 2442 MHz Carrier Wave Tone Mode: The nIO-BT EUT will transmit a constant 2442MHz carrier tone.

6.3.3 EUT Clock/Oscillator Frequencies

☐	**Less than 108MHz**	**FCC – scan up to 1GHz**
☐	**Less than 500MHz**	**FCC – scan up to 2GHz**
☐	**Less than 1000MHz**	**FCC – scan up to 5GHz**
☒	**Greater than 1000MHz**	**FCC – scan up to 5th Harmonic or 40GHz**

6.3.4 Electrical Support Equipment

Type	Manufacture	Model	Connected To
Power Supply	nLight	nPS-80	120VAC mains power, then to nIO-BT EUT via CAT5e cable.

6.3.5 EUT Equipment/Cabling Information

EUT Port	Connected To	Location	Cable Type		
			Length	Shielded	Bead
RJ-45	nPS-80		10’ Cat5e		

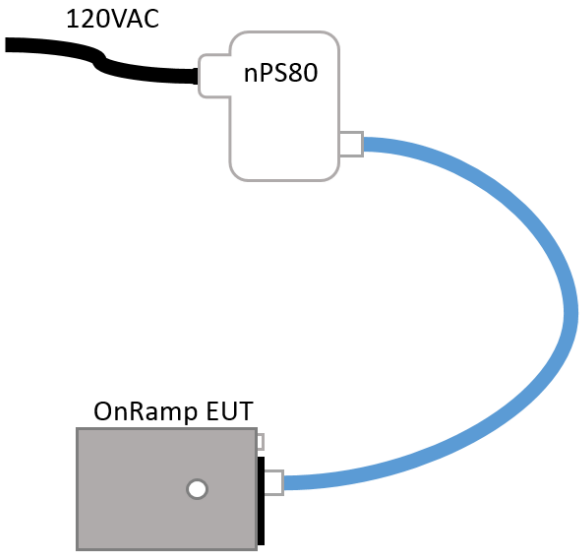
6.4 EUT Test Program

See: “**6.3.2 EUT Modes of Operation**”

6.5 Monitoring of EUT during Testing

No external monitoring required during testing. nIO-BT EUT will output a constant RF signal during any of the test modes outlined in section *1.7*.

6.5.1 Block Diagram



Note: the nPS80 is a power module used to simulate a typical host device providing power to the EUT.