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ETC Report #: s01e23a334_65" Release 2

Date: April 9, 2024

EMC testing of SMART QX Series BLE Module, Model: IDQXMOD1 (Tool Sense Controller) within 65" IFP display, Model: IDQR65-A in accordance with:

- **RSS-GEN, Issue 5**
- **FCC, title 47 CFR § 15.207 and 15.209**

Test Personnel: Brendan Van Hee, Janet Mijares

Test Dates: December 12-14, 2023

Prepared for: SMART Technologies ULC
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REVISION RECORD

ISSUE	DATE YYYY/MM/DD	AUTHOR	REVISIONS
DRAFT 1	2023/12/21	B. Van Hee	Initial draft submitted for review.
DRAFT 2	2024/01/02	B. Van Hee	Added panel serial number Added EUT description
Release 1	2024/01/10	I. Akram	Sign Off
Release 2	2024/04/09	I. Akram	See changes below. Sign off

Release 2 Updates

- Updated customer address on page 1 and in appendix A form.
- Added RSS-247 and FCC part 15.247 reference standards in section 1.5.
- Added conducted output power test uncertainty in section 1.8.
- Added Standard horn antenna/LNA (18-26GHz) in section 2.3.3 test equipment table.
- Added RSS-247 and FCC Part 15.247 out of band emission requirement in section 2.3.1.
- Added conversion note from dBµv/m to dBµA/m below section 2.3.5 table.
- Corrected RSS-247 Issue from 2 to 3.
- Added duty cycle correction factors (DCCF) for Radiated Band edge measurement in section 2.2.
- Explanation note is added in section 1.7 why the unit is tested in floor standing test setup only.
- Emission results which are unrelated to BLE transmitter extrapolated to the specified distance using an extrapolation factor of 20 dB/decade (inverse linear-distance for field strength measurements) in table-1 of section 2.3.5.

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1 INTRODUCTION

1.1 Scope

The purpose of this report is to present the results of compliance testing performed in accordance with RSS-GEN Issue 5, and FCC 47 CFR 15.207, 15.209 as specified by SMART Technologies. All test procedures, limits, criteria, and results described in this report apply only to the SMART QX Series BLE Module, Model: IDQXMOD1 (Tool Sense Controller) within 65" IFP display test sample, referred to herein as the EUT (Equipment Under Test).

The sample has been provided by the customer.

This report does not imply product endorsement by the Electronics Test Centre, A2LA, nor any Canadian Government agency.

1.2 Applicant

This test report has been prepared for SMART Technologies, located in Calgary, Alberta, Canada.

1.3 Test Sample Description

As provided to ETC (Airdrie) by SMART Technologies:

Product Description	SMART QX Series BLE Module (Tool Sense Controller)
Panel Serial #	C080PW39A0021
Model number	IDQXMOD1
Frequency Range	2402 – 2480 MHz
Antenna Type/Gain	Flexible Printed Circuit / 4 dBi
Type Modulation	BLE / GFSK
Rated output power	0 dBm
Rated power (EIRP)	4 dBm
Data rate	1 Mbps
Software/Firmware	Atmosic RF Tool, Version 1.6.4 / Atmosic SDK, Version 5.1.0
Power	5 VDC

More detailed information is provided by SMART Technologies in Appendix A.

1.4 General Test Conditions

The EUT was set up and exercised using the configurations, modes of operation and arrangements defined in this report only. All inputs and outputs to and from other equipment associated with the EUT were simulated as per the customer setup (refer to section 1.7 for details).

Where relevant, the EUT was only tested using the monitoring methods and test criteria defined in this report.

The environmental conditions are recorded during each test, and are reported in the relevant sections of this document.

1.5 Reference standards

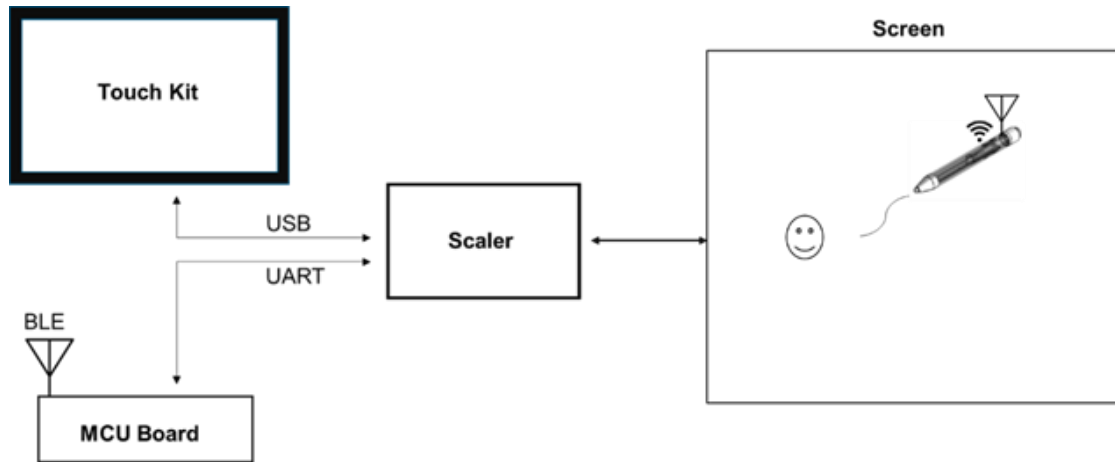
Standards	Description
RSS-GEN, Issue 5	General Requirements for Compliance of Radio Apparatus
FCC, title 47 CFR § 15.207	Intentional radiator, conducted emission limits
FCC, title 47 CFR § 15.209	Intentional radiator, radiated emission limits
FCC, title 47 CFR § 15.247	Operation within the bands 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz.
RSS-247 Issue 3 (08-2023)	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
ANSI C63.10 (2013)	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

1.6 Acronyms and Abbreviations

Acronyms/Abbreviations	Description
AV	Average
BW	Bandwidth
dB	Decibel, ratio base 10
dBm	Decibel referenced to 1 mW
dB μ V	Decibel reference to 1 μ V
EUT	Equipment Under Test
ETC	Electronics Test Centre
GHz	Giga-Hertz
kHz	Kilo-Hertz
m	meter
mW	Milli-Watt
MHz	Mega-Hertz
PK	Peak
QP	Quasi-Peak
QC	Quality Check
SE/AE	Support/Auxiliary Equipment
μ V	Micro-Volt

1.7 Test Sample Verification, Configuration & Modifications

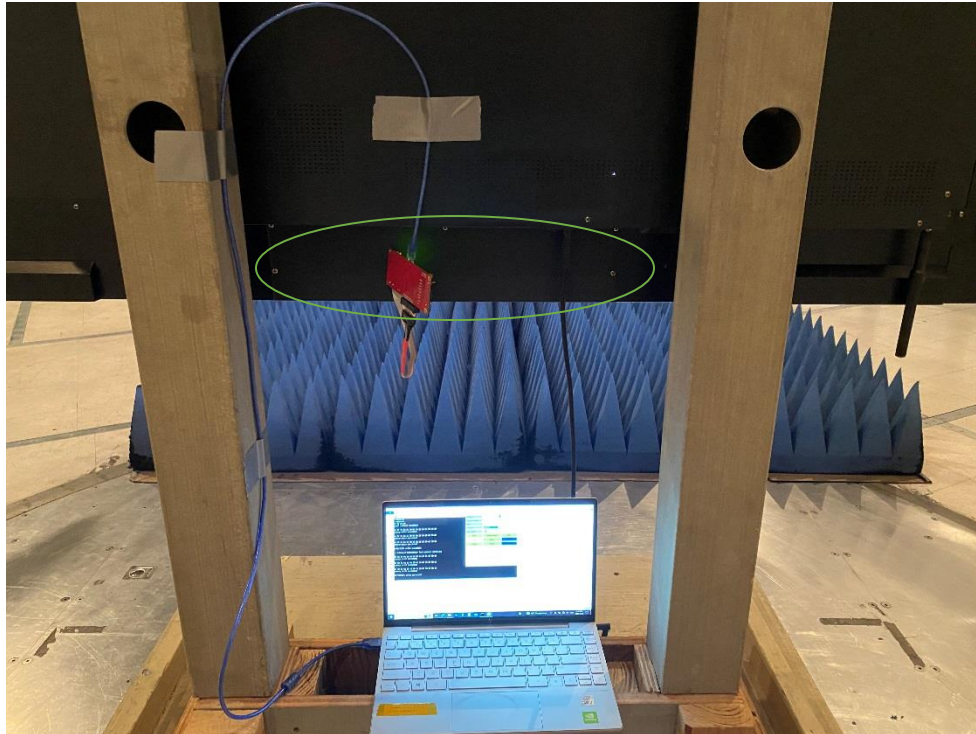
EUT setup, configuration, protocols for operation and monitoring functions are detailed here. Any modifications performed in order to meet the requirements, are detailed in each Test Case of Section 2 of this report.



During Radiated Emissions testing, the BLE module is configured to constantly transmit on the worse selected channel (High channel) using the provided SMART Tech laptop with the ATM RF Test Tool.

Note: The device is designed to be either wall mounted or floor standing (using mobile stand accessory) during operation. For the purposes of testing this large equipment it was impractical to test wall-mounted therefore the system was tested according to ANSI C63.10 as floor-standing equipment with the device mounted to a floor-standing mount. For radiated emissions testing as per ANSI C63.10: Where possible, the antenna(s) of the EUT shall be located at a height of 1.5 m above the floor, and the intentional radiator circuitry shall be located within the system at a height of at least 0.8 m above the floor. For this device the radiator circuitry and antennas are located at the bottom of the device which was 1m above the floor of the chamber for 65" panel. It was not practical to safely raise the system to have the antennas at the 1.5m height.

The radio module is located within the SMART IFP display (area contained within the green circle) with connection to the laptop through the ATM Interface Board mounted externally on the display. Any references to the 'EUT' in this report refer to the BLE module only. The SMART IFP display is considered support equipment and has already gone through the required testing.



1.8 Uncertainty of Measurement

The factors contributing to measurement uncertainty are identified and calculated in accordance with CISPR 16-4-2: 2011.

This uncertainty estimate represents an expanded uncertainty expressed at approximately 95% confidence using a coverage factor of k = 2.

Test Method	Uncertainty
Radiated Emissions Level (30 MHz – 1 GHz)	±5.8 dB
Radiated Emissions Level (1 GHz – 18 GHz)	±4.9 dB
Radiated Emissions Level (18 GHz – 26.5 GHz)	±5.0 dB
Conducted Emissions Level (150 kHz – 30 MHz)	±3.0 dB
Uncertainty Conducted Power level	±0.5 dB

2 TEST CONCLUSION

STATEMENT OF COMPLIANCE

The customer equipment referred to in this report was found to **COMPLY** with the requirements, as summarized below.

The measurement uncertainty is not accounted for determination of the statement of compliance. The statement of compliance is based only on the measurement value recorded.

The EUT was subjected to the following tests. Compliance status is reported as **Compliant** or **Non-compliant**. If testing was not performed at this time, the appropriate field is marked **n/t**. **N/A** indicates the test was Not Applicable to the EUT.

***Note:** 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 EUT with respect to the standards detailed in this test report.*

The following table summarizes the tests performed in terms of the specification, class or performance criterion applied, and the EUT modification state.

Test Case	Test Type	Specification	Range	Test Sample	Result
§ 2.1	Conducted/Radiated Output power	FCC Part 15.247(b, 3), RSS-247 Issue 3, Clause 5.4(d), (a)	Low /MID/ High	QX Series BLE Module, Model: IDQXMOD1 (Tool Sense Controller) within host product, Model: IDQR65-A	Compliant
§ 2.2	Radiated Band edge (Restricted Band)	FCC Part 15.209 RSS-GEN	Low / High		Compliant
§ 2.3	Radiated Spurious Emissions (Restricted Band)	FCC Part 15.209 RSS-GEN	9.0kHz – 26.5GHz		Compliant
§ 2.4	AC Main Conducted Emissions	FCC Part 15.207 RSS-GEN	150k – 30MHz		Compliant

Refer to the test data for applicable test conditions.

2.1 EIRP Output Power

Test Lab: Electronics Test Centre, Airdrie	EUT: SMART QX Series BLE Module, Model: IDQXMOD1 (Tool Sense Controller) within 65" IFP display
Test Personnel: Janet Mijares	
Date: 2023/12/12 (21.4°C, 13.7% RH)	Standard: FCC15.247/RSS-247 Issue 3
	Basic Standard: ANSI C63.10-2013
EUT status: Compliant	

Specification:

FCC Part 15.247(b, 3): For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt.

RSS-247 Issue 3, Clause 5.4(d), (a): For DTSs employing digital modulation techniques operating in the bands 902 – 928 MHz and 2400 – 2483.5 MHz, the maximum peak conducted output power shall not exceed 1 W. The e.i.r.p. shall not exceed 4W, except as provided in Section 5.4(e).

2.1.1 Test Guidance: ANSI C63.10-2013, Clause 9.5

Calculate the EIRP from the antenna port conducted emission by adding the transmit antenna dBi gain.

2.1.2 Deviations From The Standard:

There were no deviations from the EUT setup or methodology specified in the standard.

2.1.3 Test Equipment

Testing was performed with the following equipment:

Equipment	Manufacturer	Model #	Asset #	Cal. Date	Cal. Due
EMI receiver	Agilent	N9038A (FW A.25.05)	6130	2023-08-11	2024-08-11
Temp/Humidity	Extech	42270	5871	2023-04-14	2024-04-14
Antenna 1- 18GHz	EMCO	3115	19357	2022-10-05	2024-10-05
RE Cable	A.H. Systems Inc.	SAC-26G-5.23	6187	*2023-03-24	2024-03-24
Attenuator	Fairview Microwave	SA18N5WA-10	6886	Cal. before each use	
Coaxial Cables (RF)	W.L. Gore	Pgr10R01036.0	-	Cal. before each use	

* In house cable loss verification performed.

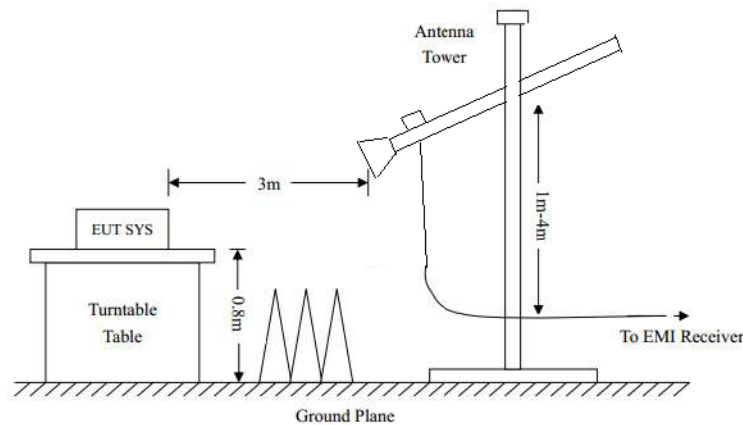
2.1.4 Test Sample Verification, Configuration & Modifications

The EUT was set to a selected channel with test-specific software. The output was modulated as in normal operation

Test setup diagrams for Conducted EIRP testing:



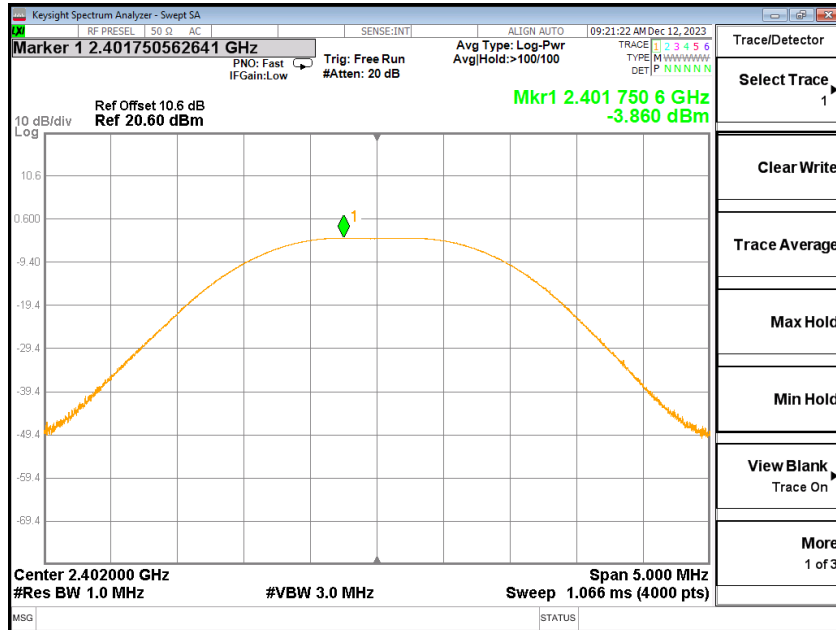
Test setup diagrams for Radiated EIRP testing:



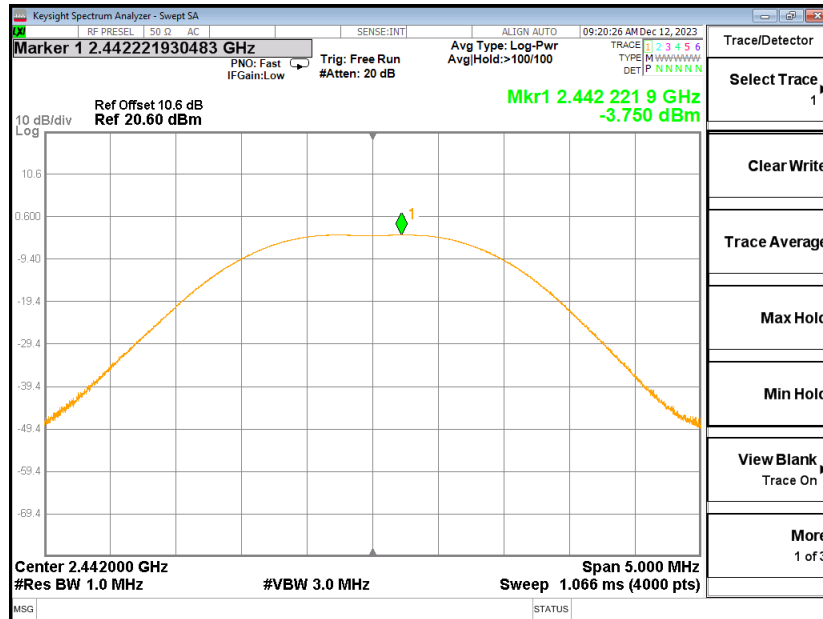
2.1.5 EIRP Data (Conducted)

Frequency (MHz)	Conducted Reading (dBm)	Max Antenna Gain dBi	EIRP dBm	EIRP (Watts)	EIRP Limit (Watts)
Conducted Output Power Measurement					
2402	-3.860	4	0.14	0.0010328	≤ 4 (36dBm)
2442	-3.750	4	0.25	0.0010592	
2480	-3.625	4	0.375	0.0010908	

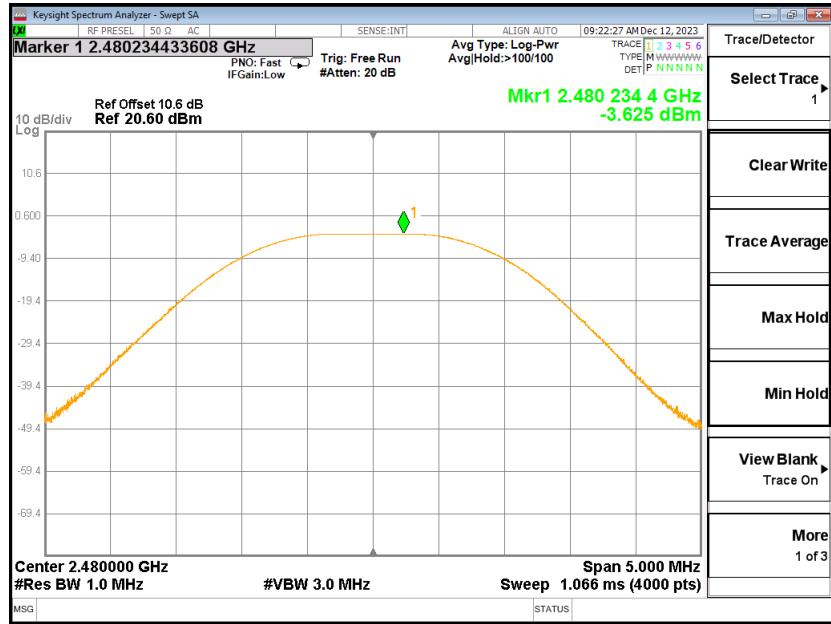
Low Channel:



MID Channel:



High Channel:



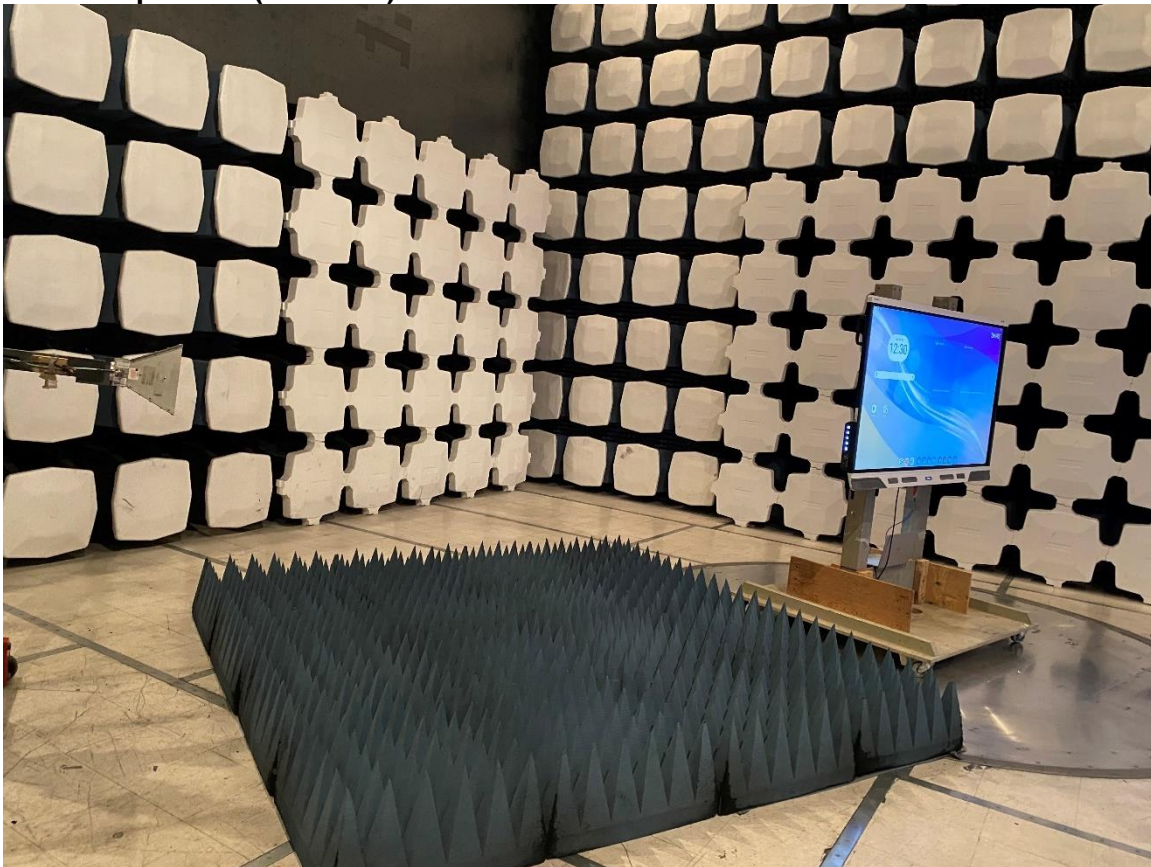
Setup Photo Conducted:



2.1.6 EIRP Data (Radiated)

Maximized Radiated Output power Measurement					
Polarity	Frequency (MHz)	Corrected Field Strength Reading (Peak) (dBμ/m)	Converting Field Strength to dBm (dBμ/m -95.3)	EIRP (Watts)	EIRP Limit (Watts)
			(EIRP dBm)		
Horizontal	2402	95.44	0.14	0.0010327	≤ 4 (36dBm)
	2442	92.48	-2.82	0.0005224	
	2480	91.1	-4.2	0.0003802	
Vertical	2402	92.72	-2.58	0.0005521	
	2442	92.47	-2.83	0.0005212	
	2480	97.56	2.26	0.0016827	

Test Setup Photo (Radiated)



2.2 Radiated Band Edge (Restricted-band band-edge)

Test Lab: Electronics Test Centre, Airdrie Test Personnel: Janet Mijares Date: 2023/12/12 (21.4°C, 13.7% RH)	EUT: SMART QX Series BLE Module, Model: IDQXMOD1 (Tool Sense Controller) within 65" IFP display Standard: FCC Part 15.209, RSS-GEN Basic Standard: ANSI C63.10
EUT status: Compliant	

2.2.1 Test Guidance

Above 1000 MHz, measurements are performed with a DRG Horn antenna and a resolution bandwidth of 1 MHz.

Low and high channels are optimized. The EUT is rotated in azimuth over 360 degrees and the azimuth of maximum value is noted and antenna height is varied from 1 – 4 meters at this azimuth to obtain the maximum value. Then the maximum level is measured with the appropriate peak and average detector and recorded.

2.2.2 Deviations From The Standard

There were no deviations from the EUT setup or methodology specified in the standard.

2.2.3 Test Equipment

Testing was performed with the following equipment:

Equipment	Manufacturer	Model #	Asset #	Cal. Date YYYY/MM/DD	Cal. Due YYYY/MM/DD
EMC Software	UL	Ver. 9.5	SWE021	N/A	
EMI receiver	Agilent	N9038A (FW v. A.25.05)	6130	2023-08-11	2024-08-11
DRG Horn	EMCO	3115	19357	2022-10-05	2024-10-05
T/H Logger	Extech	42270	5892	2023-04-14	2024-04-14
RE Cable	A.H. Systems Inc.	SAC-26G-5.23	6187	*2023-03-24	2024-03-24

* In house cable loss verification performed.

2.2.4 Band Edge Data

Test Channel	Frequency (MHz)	Detector	Correction Factor (Antenna + Cable Loss) (dB)	DCCF (dB)	Corrected Level (dBμV/m)	Limit@3m (dBμV/m)	Margin (dB)
Low	2390	Peak	32.2	-	52.9	74	-21.10
	2390	Average		-8.53	33.899	54	-20.10
High	2483.60	Peak	32.5	-	53.535	74	-20.465
	2483.60	Average		-8.53	34.491	54	-19.509

Receiver Reading in dBμV + Correction factor offset (dB/m + dB) + DCCF (dB) = Corrected Field Strength in dBμV/m.

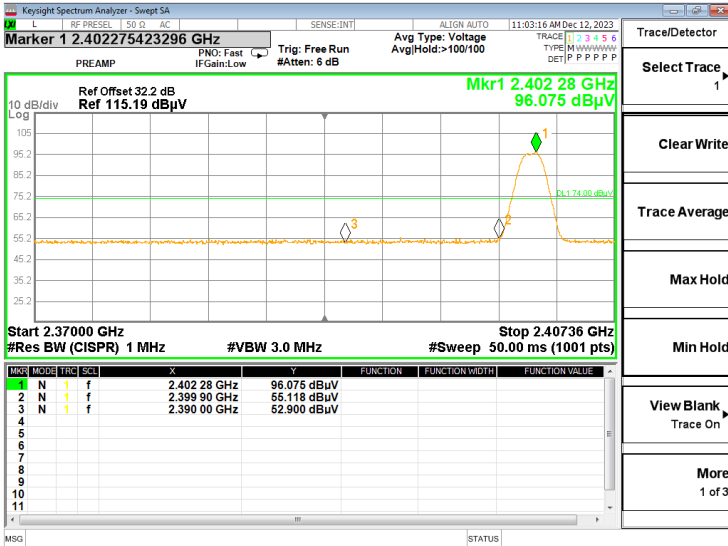
Notes:

- Measurement done at both polarizations only the worst vales reported in the table.
- Measurements reported are the result of adjusting the turntable azimuth and antenna height to obtain the maximum emission value. The reported measurement is obtained with the appropriate peak and Average detector after the height and azimuth have been adjusted for maximum emission.
- Antenna factor (dB/m) and cable loss (dB) together used as offset in the receiver setting.
- Test mode Duty Cycle (D) = 53.4% (.534)
 $DCCF = 10\log(1/D) = 10\log(1/.534) = 2.72 \text{ dB}$
 Maximum operating duty cycle (D) = 7.5% (0.075)
 $DCCF = 10\log(1/D) = 10\log(1/0.075) = 11.25 \text{ dB}$
 DCCF applied to Band edge Avg measurements = (Test mode duty cycle) – (Max operating duty cycle)
 $DCCF = 2.72 - 11.25$
 $DCCF = -8.53 \text{ dB}$

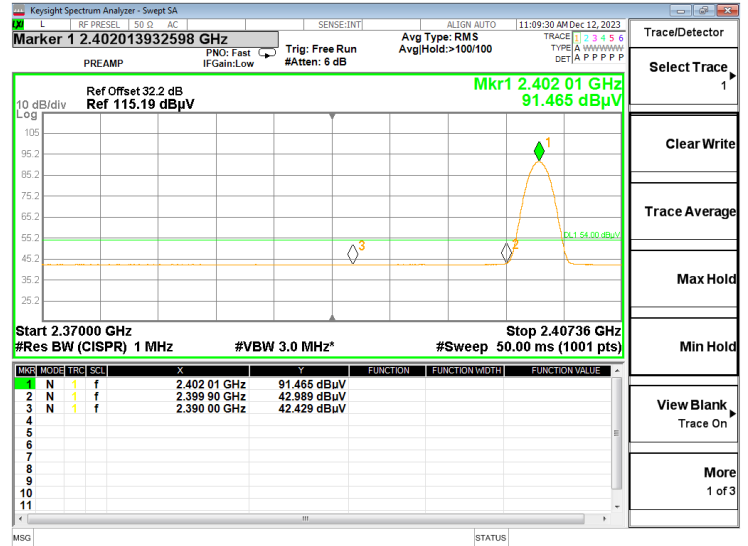
Negative values for Delta indicate compliance.

Test Plots:

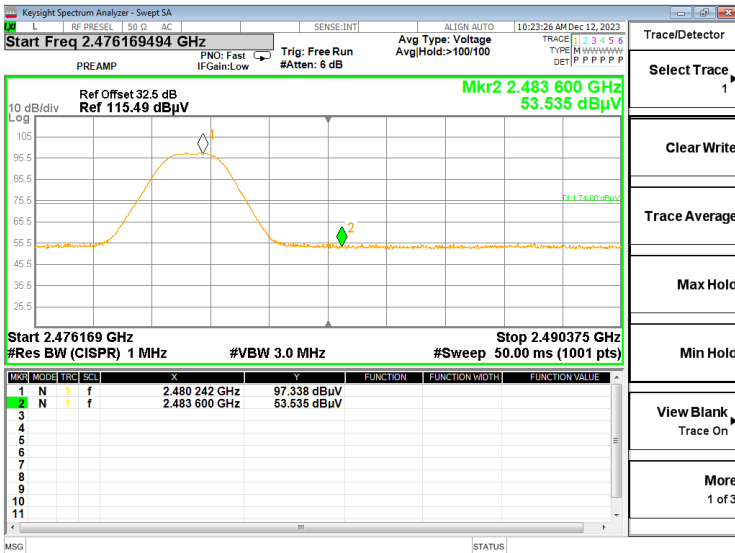
Low Channel Peak



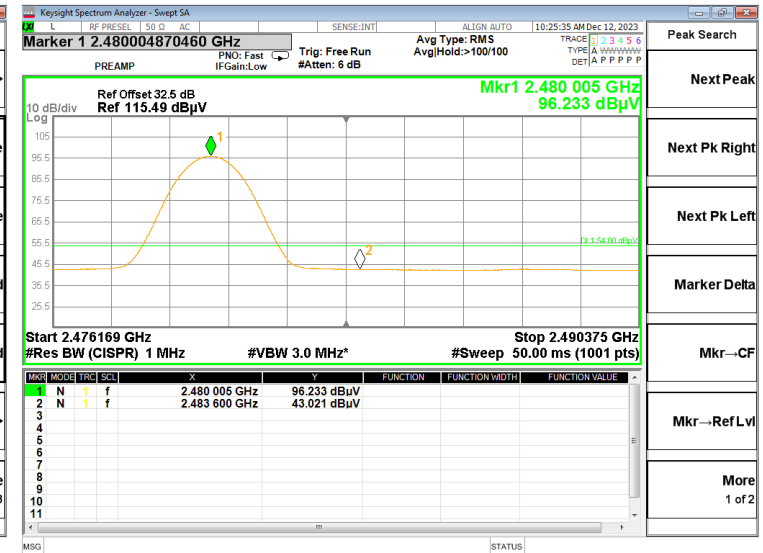
Low Channel Average



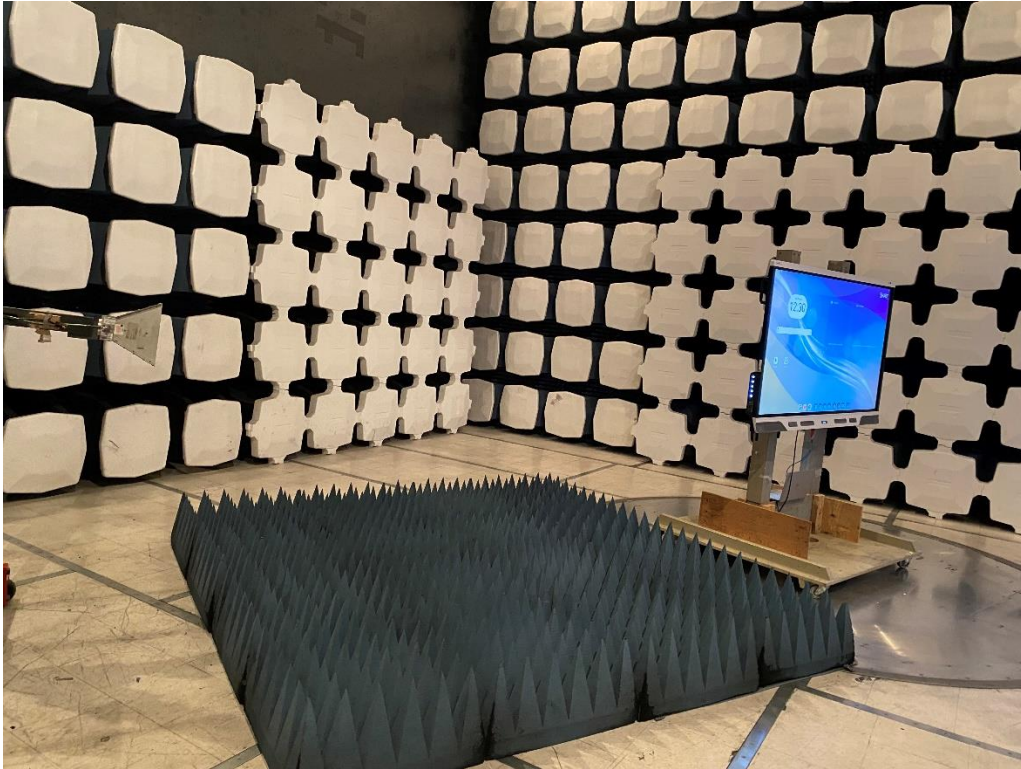
High Channel Peak



High Channel Average



Setup Photo:
Horizontal:



Vertical:



2.3 Radiated Spurious Emissions (Restricted Band)

Test Lab: Electronics Test Centre, Airdrie Test Personnel: Janet Mijares B. Van Hee Date: 2023/12/12 (21.4°C, 13.7% RH) 2023/12/13 (21.1°C, 12.8% RH) 2023/12/14 (21.4°C, 13.4% RH)	EUT: SMART QX Series BLE Module, Model: IDQXMOD1 (Tool Sense Controller) within 65" IFP display Standard: FCC Part 15.209, RSS-GEN Basic Standard: ANSI C63.10
EUT status: Compliant	

Specification: FCC Part 15.209 / RSS-GEN

Frequency (MHz)	Limit 3m (dBµV/m)
0.009 – 0.490	128.5 – 93.8
0.490 – 1.705	73.8 – 62.97
1.705 – 30	69.54 – 69.54
30 – 88	40
88 – 216	43.52
216 – 960	46.02
Above 960	53.98

Criteria: The radiated emissions produced by a radio device falling in restricted band, measured at a distance of 3 meters, shall not exceed the 15.209/RSS-GEN limits.

Frequency (MHz)	FCC Part 15 Class A 10 m Limit (dBµV/m)	FCC Part 15 Class A 3 m Limit (dBµV/m)
30 – 88	39.08	49.54
88 – 216	43.52	53.98
216 – 960	46.44	56.90
Above 960	49.54	60.00

Criteria: The radiated emissions produced by a digital device, measured at a distance of 3 meters, shall not exceed the Class A limit

FCC Part 15.205 Restricted Band List			
MHz	MHz	MHz	GHz
0.090–0.110	16.42–16.423	399.9–410	4.5–5.15
¹ 0.495–0.505	16.69475–16.69525	608–614	5.35–5.46
2.1735–2.1905	16.80425–16.80475	960–1240	7.25–7.75
4.125–4.128	25.5–25.67	1300–1427	8.025–8.5
4.17725–4.17775	37.5–38.25	1435–1626.5	9.0–9.2
4.20725–4.20775	73–74.6	1645.5–1646.5	9.3–9.5
6.215–6.218	74.8–75.2	1660–1710	10.6–12.7
6.26775–6.26825	108–121.94	1718.8–1722.2	13.25–13.4
6.31175–6.31225	123–138	2200–2300	14.47–14.5
8.291–8.294	149.9–150.05	2310–2390	15.35–16.2
8.362–8.366	156.52475–156.52525	2483.5–2500	17.7–21.4
8.37625–8.38675	156.7–156.9	2690–2900	22.01–23.12
8.41425–8.41475	162.0125–167.17	3260–3267	23.6–24.0
12.29–12.293	167.72–173.2	3332–3339	31.2–31.8
12.51975–12.52025	240–285	3345.8–3358	36.43–36.5
12.57675–12.57725	322–335.4	3600–4400	

2.3.1 Test Guidance

From 30 MHz to 1000 MHz, measurements are performed with a broadband biconilog antenna and a resolution bandwidth of 120 kHz.

Above 1000 MHz, measurements are performed with a DRG Horn antenna or a Standard Gain horn, and a resolution bandwidth of 1 MHz.

The scan is performed at discreet increments of turntable azimuth and stepped antenna height, with peak detector and Max Hold function which are selected in accordance with the applicable standard in order to assure capture of frequencies of interest. Optimization is performed based on the scan data.

After the scan is completed, the frequencies of interest are optimized. The EUT is rotated in azimuth over 360 degrees and the direction of maximum emission is noted.

Antenna height is varied from 1 – 4 meters at this azimuth to obtain the maximum emission. Then the maximum level is measured with the appropriate detector and recorded. This may produce a different reading than the pre-scan trace. Up to 1 GHz, measurements are performed with a Quasi-Peak detector. Above 1 GHz, measurements are recorded with Peak and/or Average detectors, as applicable.

RSS-247 Issue 3 Clause 5.5 (unwanted Emission)

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. **Attenuation below the general field strength limits specified in RSS-Gen is not required.**

FCC Part 15.247 (d)

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. **Attenuation below the general limits specified in § 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in § 15.209(a) (see § 15.205(c)).**

2.3.2 Deviations From The Standard

There were no deviations from the EUT setup or methodology specified in the standard.

2.3.3 Test Equipment

Testing was performed with the following equipment:

Equipment	Manufacturer	Model #	Asset #	Cal. Date YYYY/MM/DD	Cal. Due YYYY/MM/DD
EMC Software	UL	Ver. 9.5	SWE021	N/A	
EMI receiver	Agilent	N9038A (FW v. A.25.05)	6130	2023/08/11	2024/08/11
Active Loop Antenna	EMCO	6502	10868	2023/06/21	2025/06/21
Biconilog Antenna	SunAR	JB1	6905	2023/11/29	2025/11/29
DRG Horn (1 – 18 GHz)	EMCO	3115	19357	2022/10/05	2024/10/05
STD Horn (18-26 GHz)	Quinstar	QWH-KRPS00	6163	2022-10-10	2025-10-10
T/H Logger	Extech	42270	5892	2023/04/14	2024/04/14
Notch filter (2.4-2.5 GHz)	Micro-Tronics	BRM50702	6953	*Monitored	
Low Noise Amplifier (1-18 GHz)	MITEQ	JS43-01001800- 21-5P	4354	*Monitored	
Low Noise Amplifier (18-26 GHz)	MITEQ	JS44-01002650- 33-3P	6163	*Monitored	
Pre-Amplifier (0.1-1.3 MHz)	HP	8447D	9291	*Monitored	

* In house loss / gain verification performed.

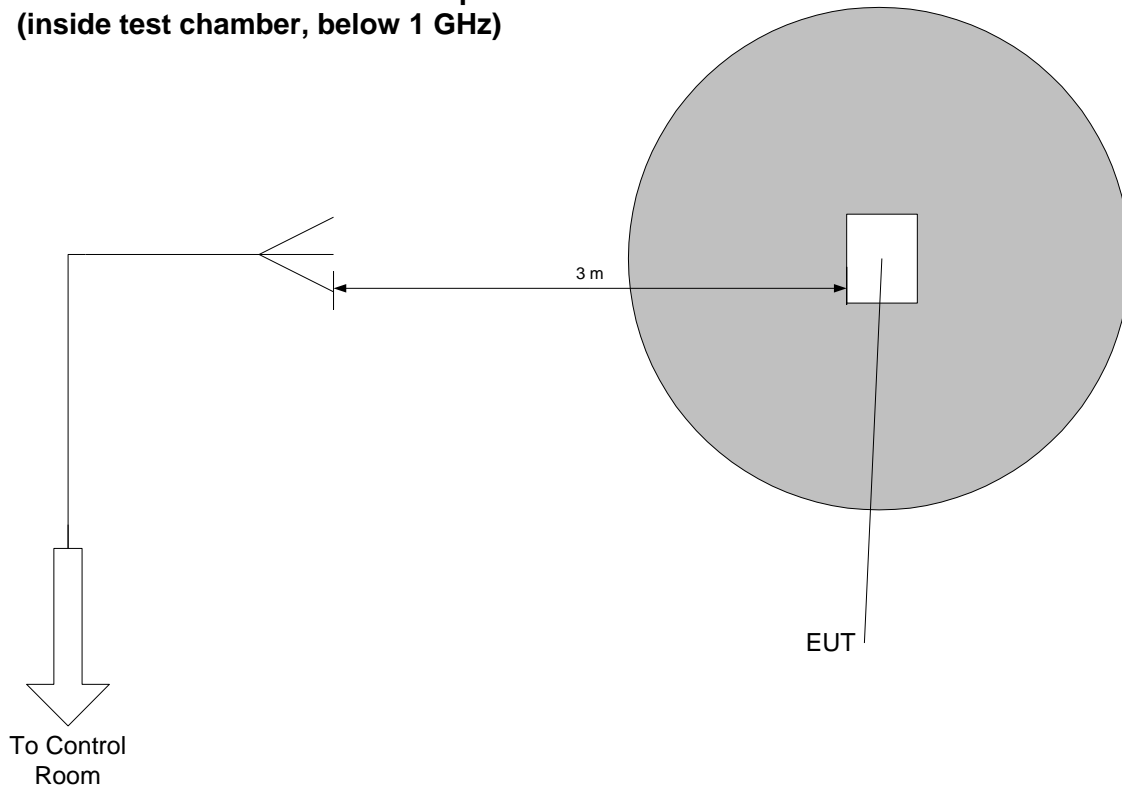
2.3.4 Test Sample Verification, Configuration & Modifications

See diagram in section 1.7

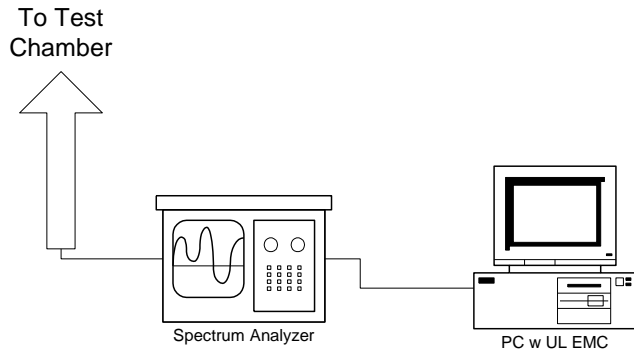
The EUT met the requirements without modification.

Prior to the test, each channel’s radiated power was measured to determine the worse channel which would be used for the detailed compliance measurement. High channel 2480 MHz was found in both conducted and radiated output measurement as worse channel and used for full radiated spurious emission analysis.

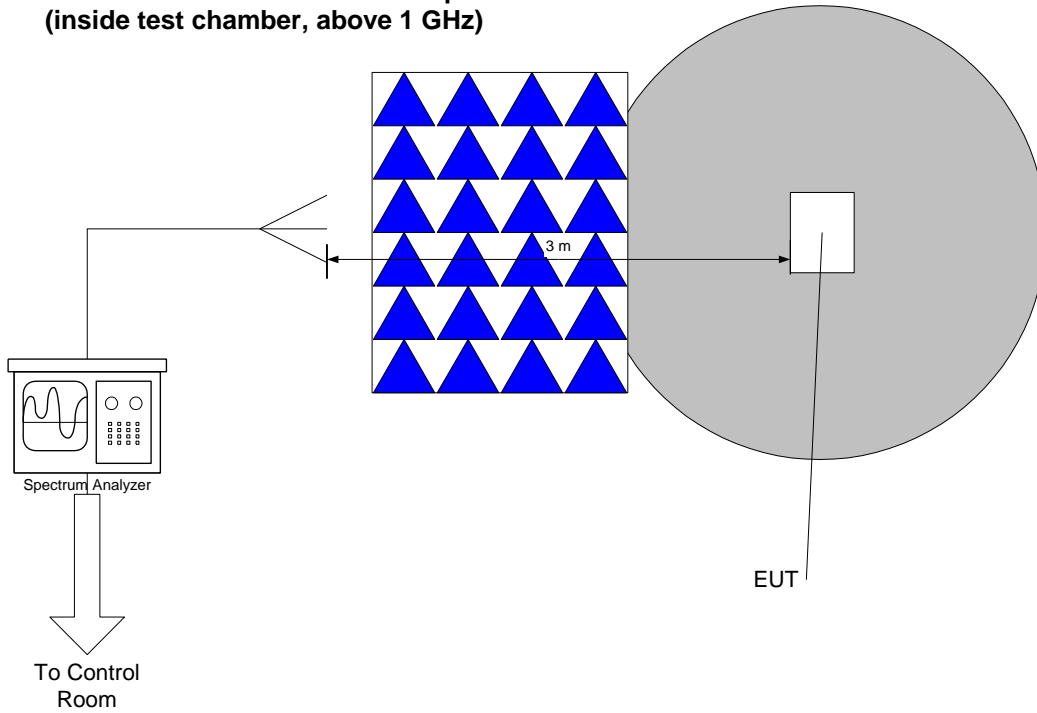
Radiated Emissions Test Setup (inside test chamber, below 1 GHz)



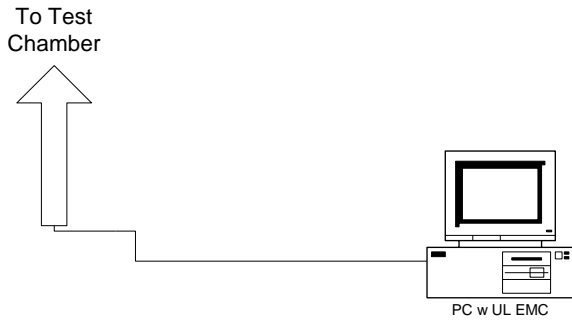
Radiated Emissions Test Setup (inside control room, below 1 GHz)



**Radiated Emissions Test Setup
(inside test chamber, above 1 GHz)**



**Radiated Emissions Test Setup
(inside control room, above 1 GHz)**



2.3.5 Radiated Emissions Maximized Data (High Channel)

The emissions data are presented in tabular form, showing turntable azimuth, antenna height and polarization, the uncorrected spectrum analyzer reading, the correction factors applied, the net result, the value of the limit at the frequency investigated, and the Delta between the result and the limit.

Table-1 below 1 GHz

Freq. Marker	Freq. [MHz]	Raw reading [dBμV]	Det	Antenna Factor [dB/m]	Cable Loss [dB]	Corrected Reading [dBμV/m]	10 m Class A Limit [dBμV/m]	Delta [dB]	Azimuth [Deg]	Height [cm]	Polarization
1	*72.41	47.21	QP	12.3	-24.0	25.05	39.08	-14.03	165	295	Horizontal
2	*174.02	46.03	QP	15.7	-22.7	28.57	43.50	-14.93	323	132	Horizontal
5	*38.41	39.50	QP	18.9	-24.7	23.24	39.08	-15.84	104	107	Vertical
6	*72.47	45.82	QP	12.3	-24.0	23.66	39.08	-15.42	285	102	Vertical
Note FCC15.31: When performing measurements at a distance other than that specified, the results shall be extrapolated to the specified distance using an extrapolation factor of 20 dB/decade (inverse linear-distance for field strength measurements). Test results are extrapolated from measured at 3m to 10m.											
Marker	Freq. [MHz]	Raw reading [dBμV]	Det	Antenna Factor [dB/m]	Cable Loss [dB]	Corrected Reading [dBμV/m]	RSS-GEN FCC 15.209 Limit [dBμV/m]	Delta [dB]	Azimuth [Deg]	Height [cm]	Polarization
3	281.99	39.28	QP	17.5	-21.9	34.88	46.02	-11.14	140	105	Horizontal
4	325.06	41.08	QP	18.0	-21.6	37.48	46.02	-8.54	56	105	Horizontal
7	114.78	35.35	QP	17.4	-23.4	29.35	43.52	-14.17	48	109	Vertical
8	324.32	37.60	QP	17.9	-21.6	33.90	46.02	-12.12	322	119	Vertical

* Emission not falling in restricted band and unrelated to transmitter meet Class A limit

Corrected E Field Strength in dBμV/m = Meter Reading in dBμV + Antenna Factor in dB/m + Gain/Loss Factor in dB

Magnetic Field Strength dBμA/m = dBμV/m – 51.5

Notes:

- When a preamp is used, the resulting gain is compensated, producing a negative value for the Cable Loss.
- Measurements reported are the result of adjusting the turntable azimuth and antenna height to obtain the maximum emission. This may produce a different reading than the plot trace. The plot is a Peak Hold function obtained at discreet increments of height and azimuth, while the reported measurement is obtained with the appropriate Quasi Peak or Average detector after the height and azimuth have been adjusted for maximum emission.
- The limits in CFR 47, Part 15, Subpart C, paragraph 15.209(a), are identical to those in RSS-GEN Section 8.9, Table 6, since the measurements are performed in terms of magnetic field strength and converted to electric field strength levels using the free space impedance of 377Ω factor 51.5. see note below 0.15-30MHz plots
- QP = Quasi-Peak detector

Negative values for Delta indicate compliance.

Table-2 above 1 GHz

Freq. Marker	Freq. [GHz]	Raw reading [dBμV]	Det	Antenna Factor [dB/m]	Cable Loss [dB]	Corrected Reading [dBμV/m]	RSS-GEN FCC 15.209 Limit [dBμV/m]	Delta [dB]	Azimuth [Deg]	Height [cm]	Polarization
1	*1.45	42.23	AV	25.7	-34.7	33.23	54	-20.77	99	369	Horizontal
		61.56	PK			52.56	74	-21.44			
2	2.97	41.96	AV	29.9	-32.4	39.46	54	-14.54	250	227	Horizontal
		57.69	PK			55.19	74	-18.81			
7	*1.30	35.07	AV	25.2	-34.5	25.77	54	-28.53	330	131	Vertical
		59.93	PK			50.63	74	-23.37			
8	*1.45	45.18	AV	25.7	-34.7	36.18	54	-17.82	191	108	Vertical
		65.76	PK			56.76	74	-17.24			
9	*1.63	36.18	AV	26.4	-34.1	28.48	54	-25.52	31	158	Vertical
		51.34	PK			43.64	74	-30.36			
10	2.97	42.86	AV	29.9	-32.4	40.36	54	-13.64	14	171	Vertical
		61.04	PK			58.54	74	-15.46			
3	5.94	31.09	AV	33.9	-29.4	35.59	54	-18.41	212	174	Horizontal
		49.11	PK			53.61	74	-20.39			
4	*7.44	35.24	AV	36.6	-26.3	45.54	54	-8.46	153	177	Horizontal
		43.58	PK			53.88	74	-20.12			
5	8.90	21.44	AV	37.3	-24.0	34.74	54	-19.26	220	128	Horizontal
		38.61	PK			51.91	74	-22.09			
6	*17.88	14.97	AV	46.7	-16.2	45.47	54	-8.53	30	395	Horizontal
		27.84	PK			58.34	74	-15.66			
11	5.94	30.43	AV	34.0	-29.4	35.03	54	-18.97	206	212	Vertical
		48.20	PK			52.80	74	-21.20			
12	*7.44	40.06	AV	36.6	-26.3	50.36	54	-3.64	219	136	Vertical
		47.23	PK			57.53	74	-16.47			
13	8.92	20.60	AV	37.3	-24.3	33.60	54	-20.40	246	137	Vertical
		39.66	PK			52.66	74	-21.34			
14	*17.80	14.56	AV	46.2	-16.5	44.26	54	-9.74	0	387	Vertical
		27.19	PK			56.89	74	-17.11			
1	*19.84	24.69	AV	34.9	-21.5	38.09	54	-15.91	175	392	Horizontal
		39.74	PK			53.14	74	-20.86			
2	*19.84	29.00	AV	34.9	-21.5	42.40	54	-11.60	206	387	Vertical
		41.81	PK			55.21	74	-18.79			

* Emissions fell into the restricted band and met 15.209 limits. Rest emissions are out of the restricted band, and 15.209 limits are not applicable, but they still meet the 209 limit, considering it the worst case senior.

Meter Reading in dBμV + Antenna Factor in dB/m + Gain/Loss Factor in dB = Corrected Field Strength in dBμV/m.

Notes:

- When a preamp is used, the resulting gain is compensated, producing a negative value for the Cable Loss.
- Measurements reported are the result of adjusting the turntable azimuth and antenna height to obtain the maximum emission. This may produce a different reading than the plot trace. The plot is a Peak Hold function obtained at discreet increments of height and azimuth, while the reported measurement is obtained with the appropriate Quasi Peak or Average detector after the height and azimuth have been adjusted for maximum emission.
- AV = Average detector; PK = Peak detector

Negative values for Delta indicate compliance.

Test mode Duty Cycle (D) = 53.4% (.534)

DCCF = $10\log(1/D) = 10\log(1/.534) = 2.72 \text{ dB}$

Maximum operating duty cycle (D) = 7.5% (0.075)

DCCF = $10\log(1/D) = 10\log(1/0.075) = 11.25 \text{ dB}$

DCCF applied to harmonic Avg measurements = (Test mode duty cycle) – (Max operating duty cycle)

DCCF = 2.72 - 11.25

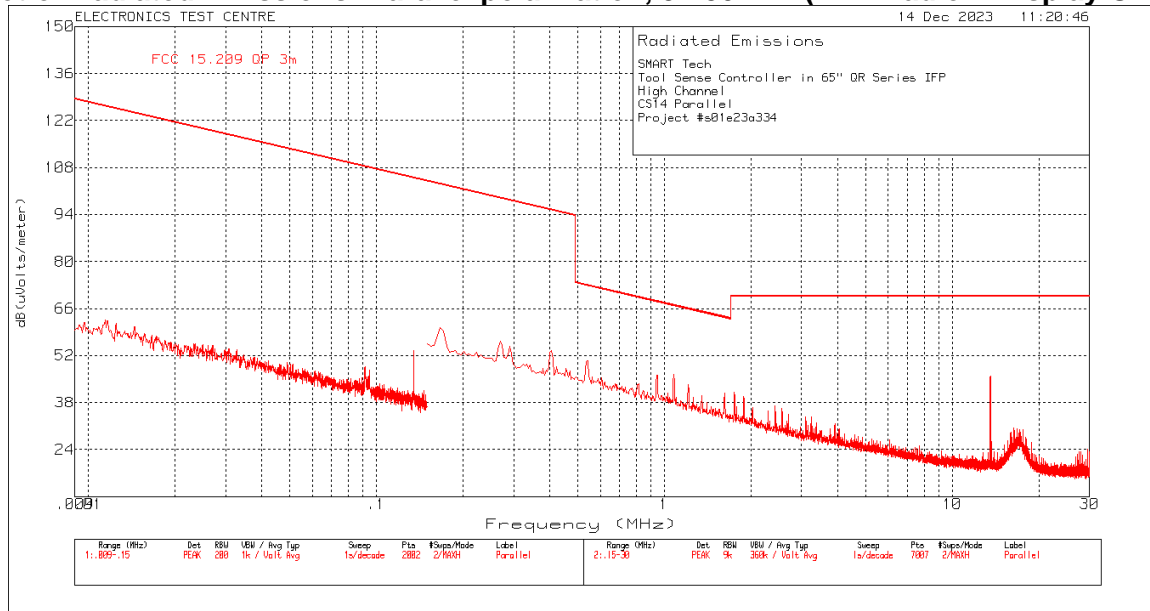
DCCF = -8.53 dB

Freq. Marker	Freq. [GHz]	Measured AV Reading [dBμV/m]	D.C Correction Factor (dB)	Corrected Average Value [dBμV/m]	RSS-GEN FCC 15.209 Limit [dBμV/m]	Delta [dB]	Polarization
1	1.45	33.23	-8.53	24.70	54	-29.30	Horizontal
7	1.30	35.07	-8.53	26.54	54	-27.46	Vertical
8	1.45	36.18	-8.53	27.65	54	-26.35	Vertical
9	1.63	28.48	-8.53	19.95	54	-34.05	Vertical
4	7.44	45.54	-8.53	37.01	54	-16.99	Horizontal
6	17.88	45.47	-8.53	36.94	54	-17.06	Horizontal
12	7.44	50.36	-8.53	41.83	54	-12.17	Vertical
14	17.80	44.26	-8.53	35.73	54	-18.27	Vertical
1	19.84	38.09	-8.53	29.56	54	-24.44	Horizontal
2	19.84	42.40	-8.53	33.87	54	-20.13	Vertical

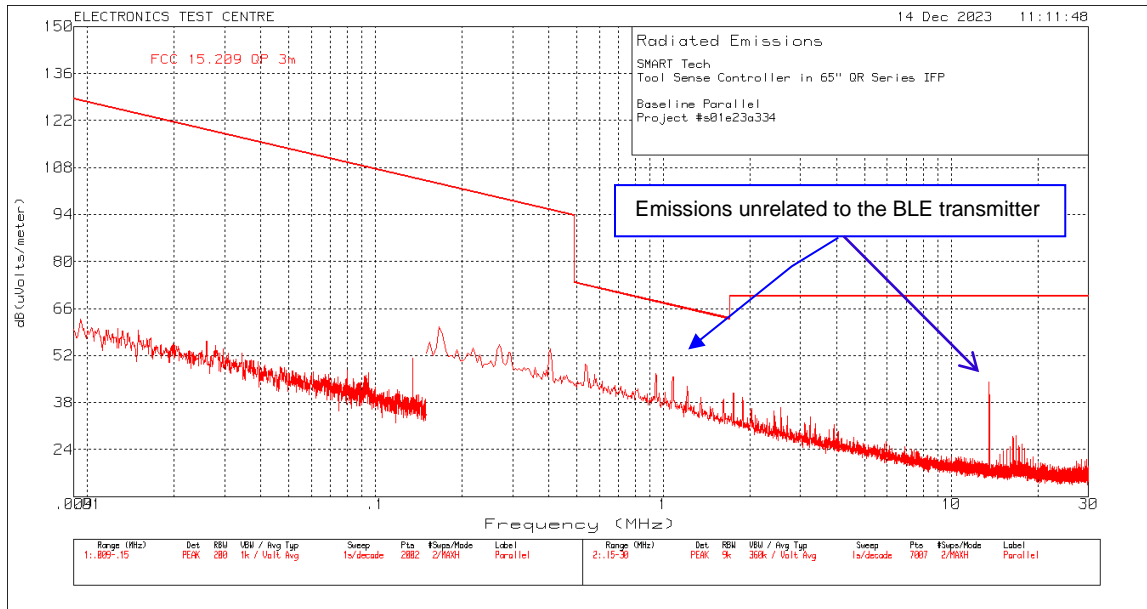
- Measured average reading using linear average detector during radiated emission is corrected with operating duty cycle correction factors.

Negative values for Delta indicate compliance.

Plot of Radiated Emissions: Parallel polarization, 9k-30MHz (BLE Radio + Display ON)

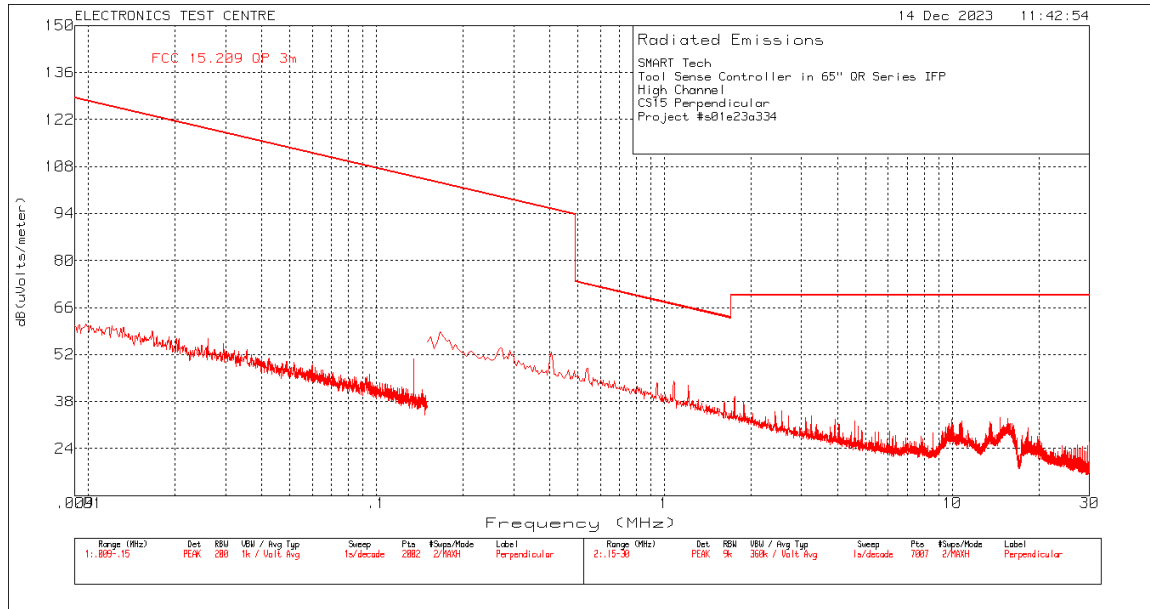


Plot of Radiated Emissions: BLE Radio OFF, Display ON, Parallel polarization, 9k-30MHz

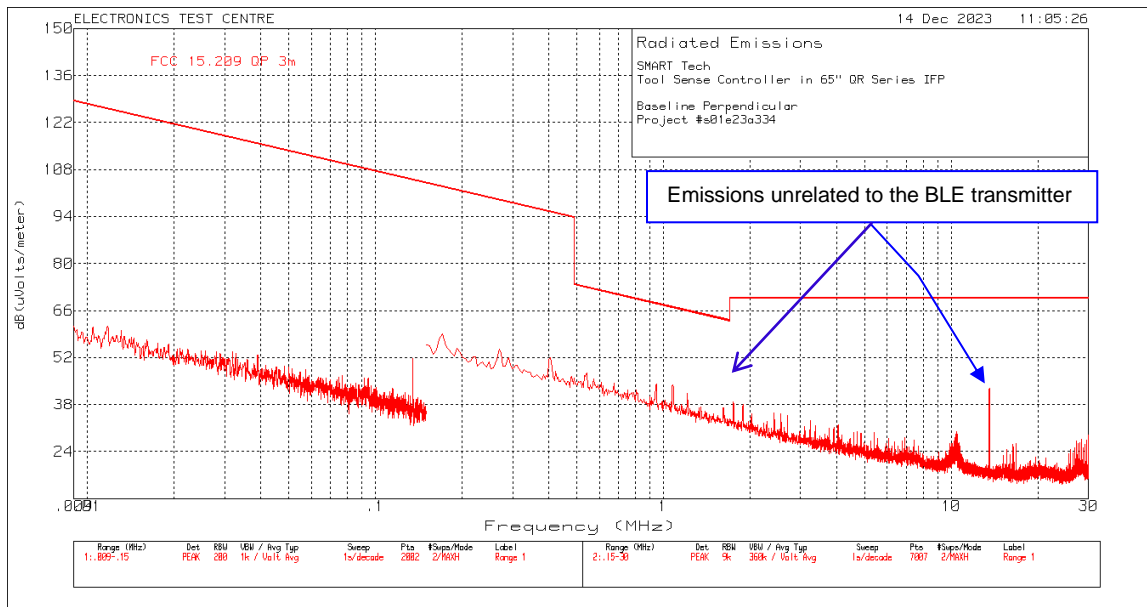


Note: **Magnetic Field Strength $\text{dB}\mu\text{A}/\text{m} = \text{dB}\mu\text{V}/\text{m} - 51.5$**
 Electric Field Strength $(\text{dB}\mu\text{V}/\text{m}) = \text{dB}\mu\text{A}/\text{m} + 51.5$

Plot of Radiated Emissions: Perpendicular polarization, 9k-30MHz (BLE Radio + Display ON)

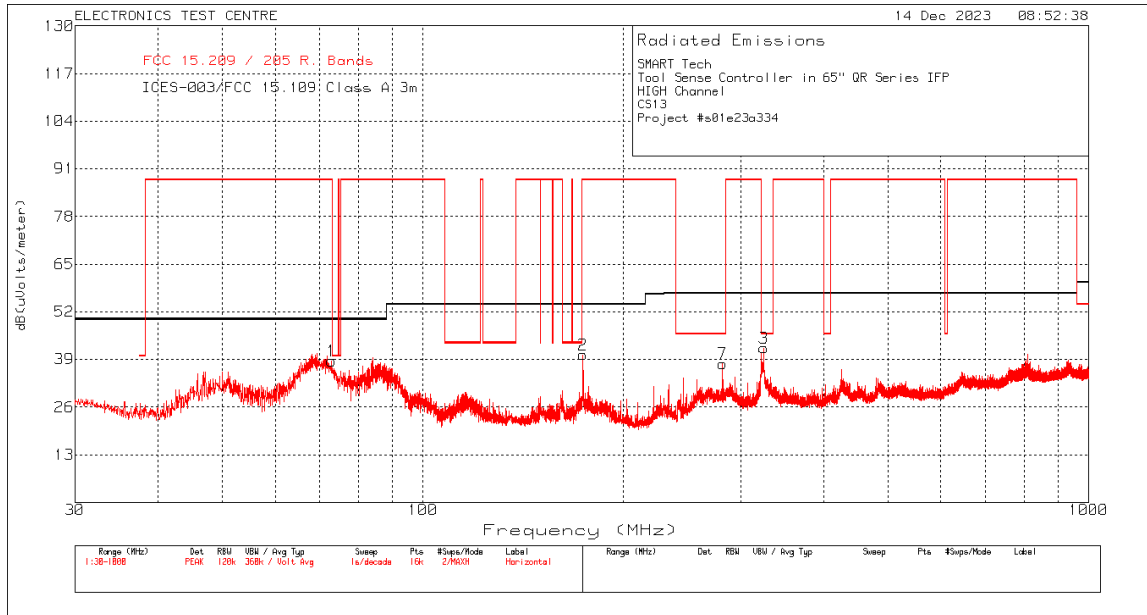


Plot of Radiated Emissions: BLE Radio OFF, Display ON, Perpendicular polarization, 9k-30MHz

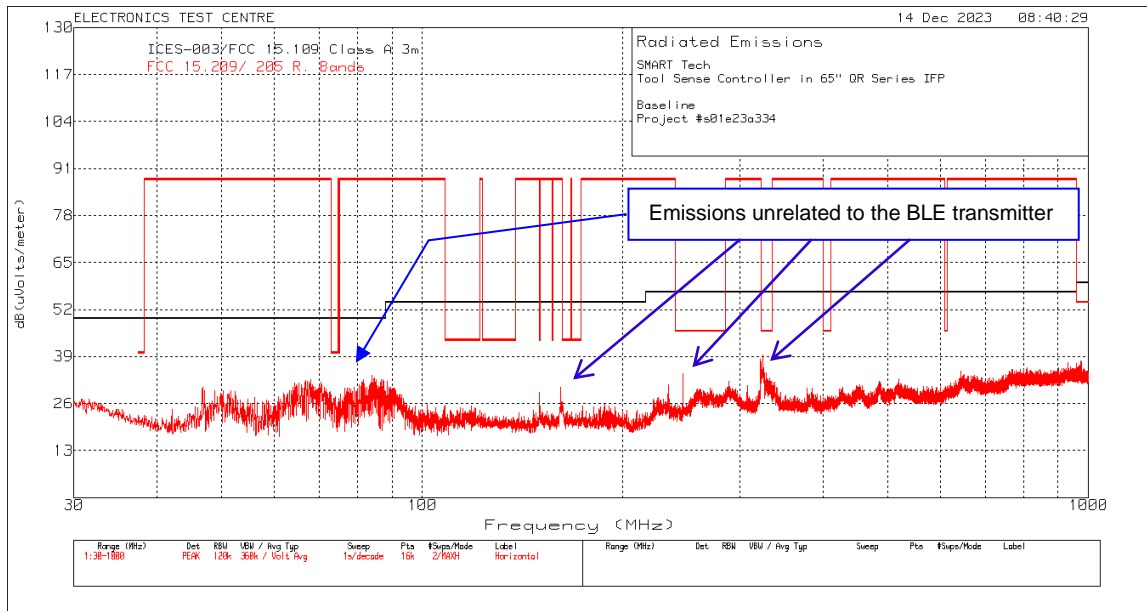


Note: **Magnetic Field Strength $dB\mu A/m = dB\mu V/m - 51.5$**
Electric Field Strength $(dB\mu V/m) = dB\mu A/m + 51.5$

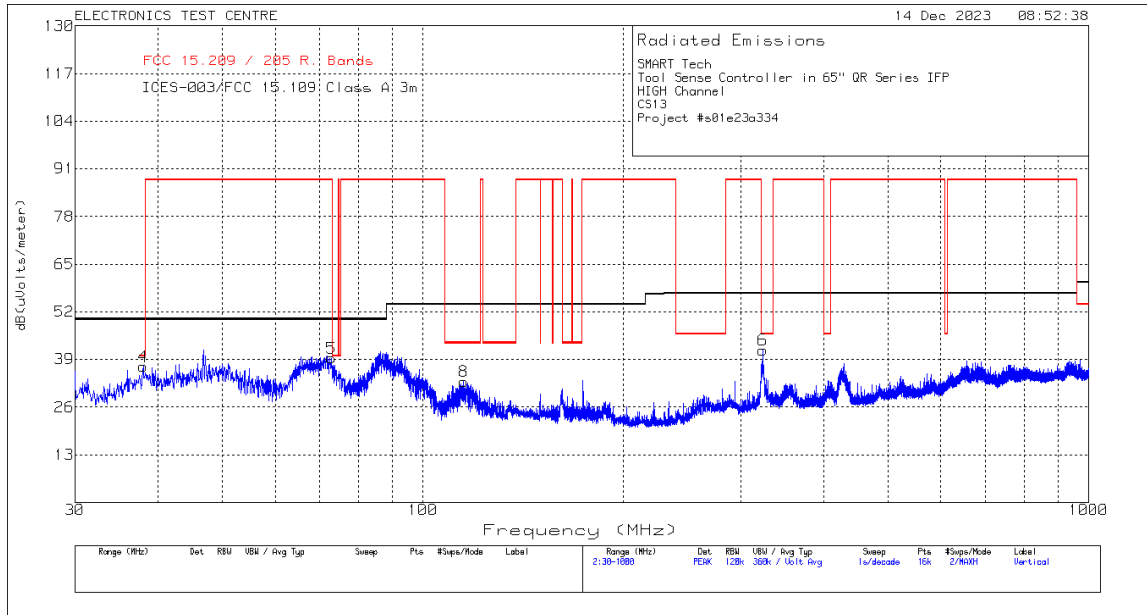
Plot of Radiated Emissions: Horizontal polarization, 30M-1GHz (BLE radio + Display ON)



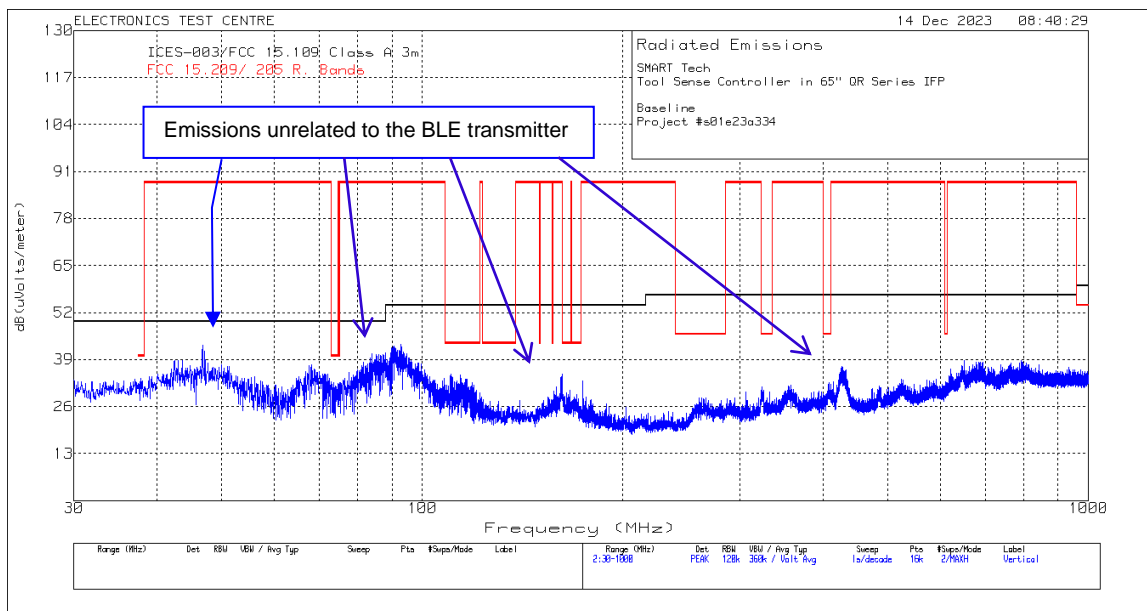
Plot of Radiated Emissions: BLE Radio OFF, Display ON, Horizontal polarization, 30M-1GHz



Plot of Radiated Emissions: Vertical polarization, 30M-1GHz

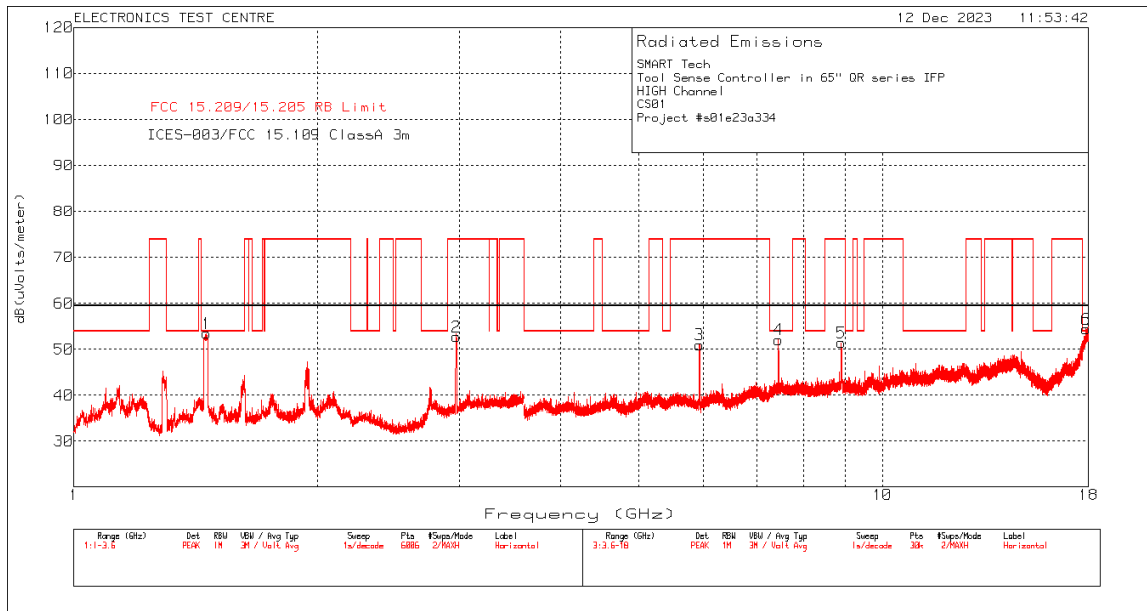


Plot of Radiated Emissions: BLE Radio OFF, Display ON, Vertical polarization, 30M-1GHz

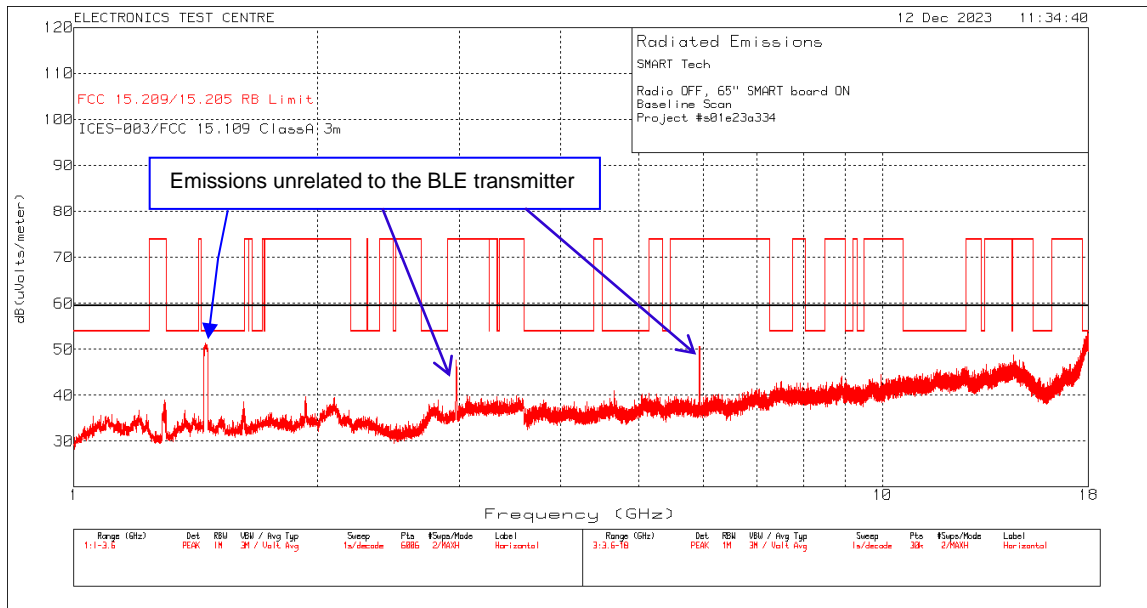


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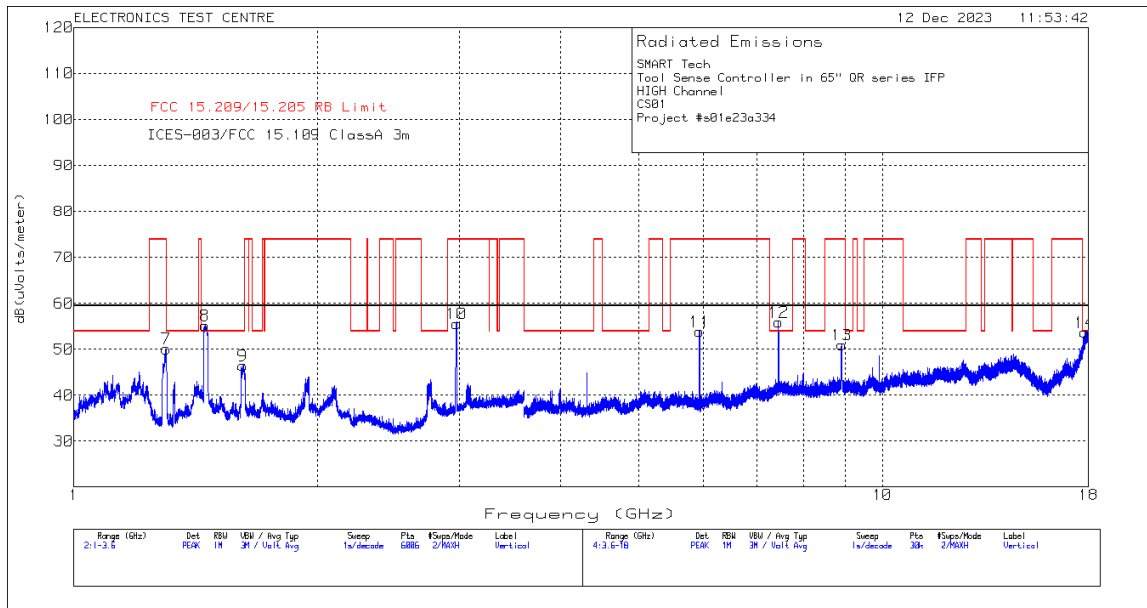
Plot of Radiated Emissions: Horizontal polarization, 1-18GHz



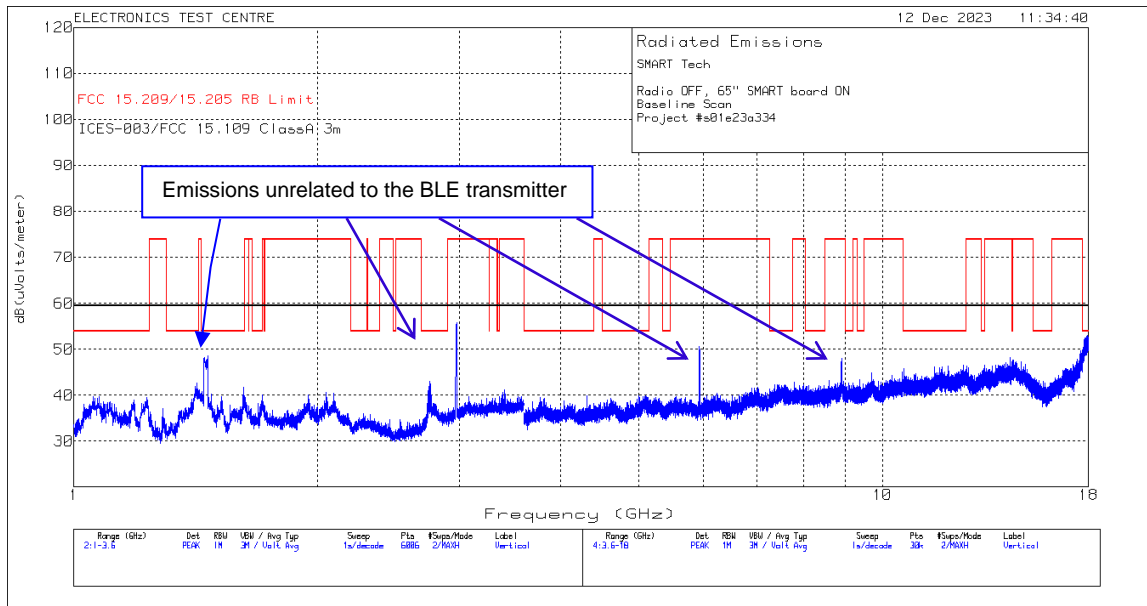
Plot of Radiated Emissions: BLE Radio OFF, Display ON, Horizontal polarization, 1-18GHz



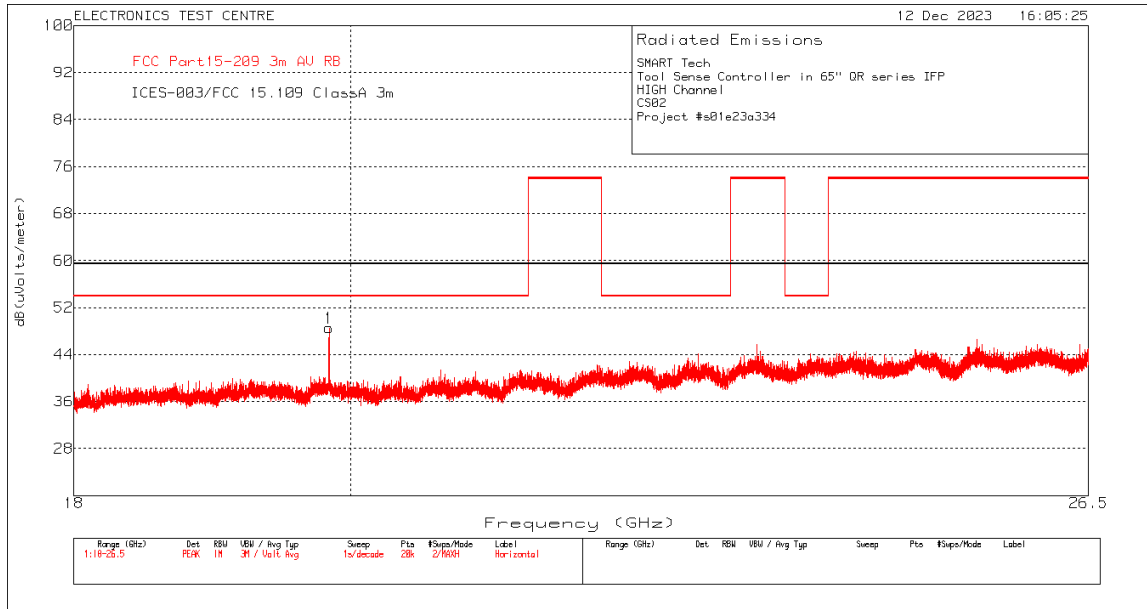
Plot of Radiated Emissions: Vertical polarization, 1-18GHz



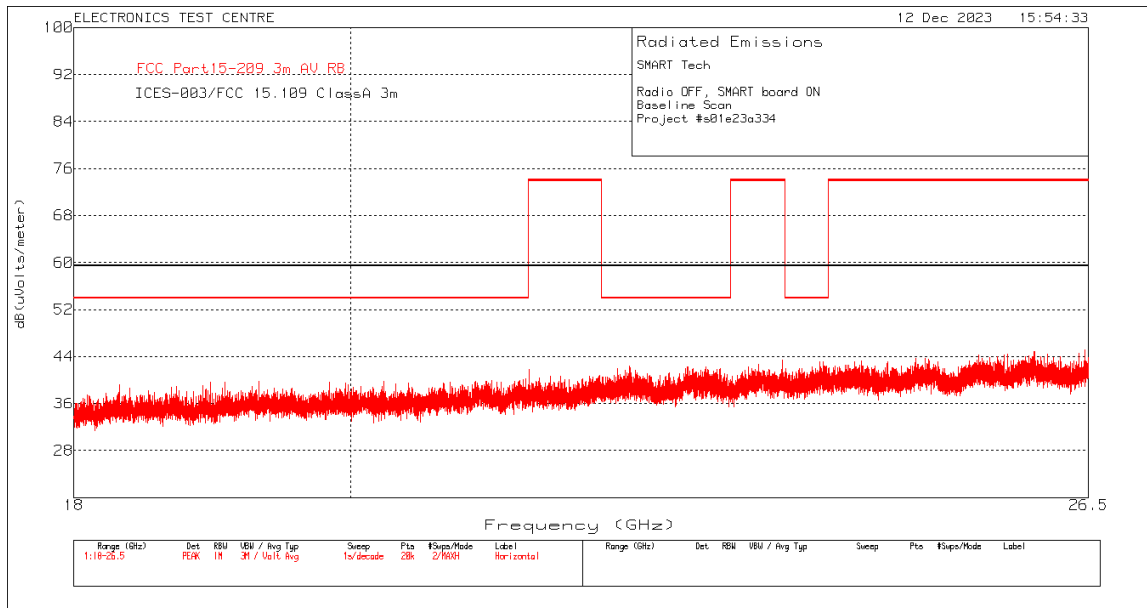
Plot of Radiated Emissions: BLE Radio OFF, Display ON, Vertical polarization, 1-18GHz



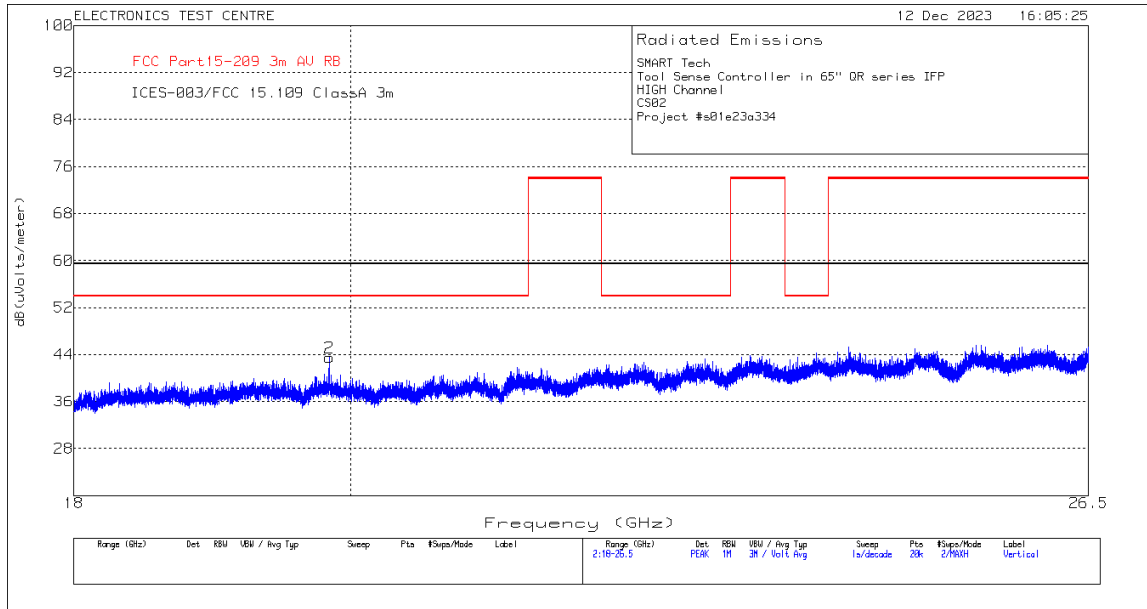
Plot of Radiated Emissions: Horizontal polarization, 18-26.5GHz



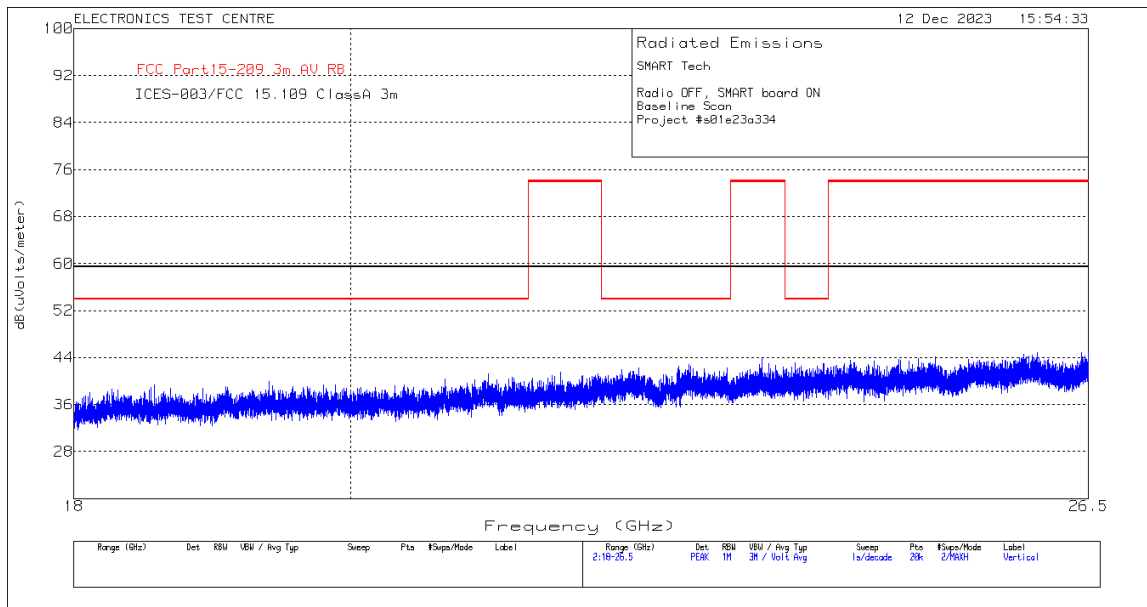
Plot of Radiated Emissions: BLE Radio OFF, Display ON, Horizontal polarization, 18-26.5GHz



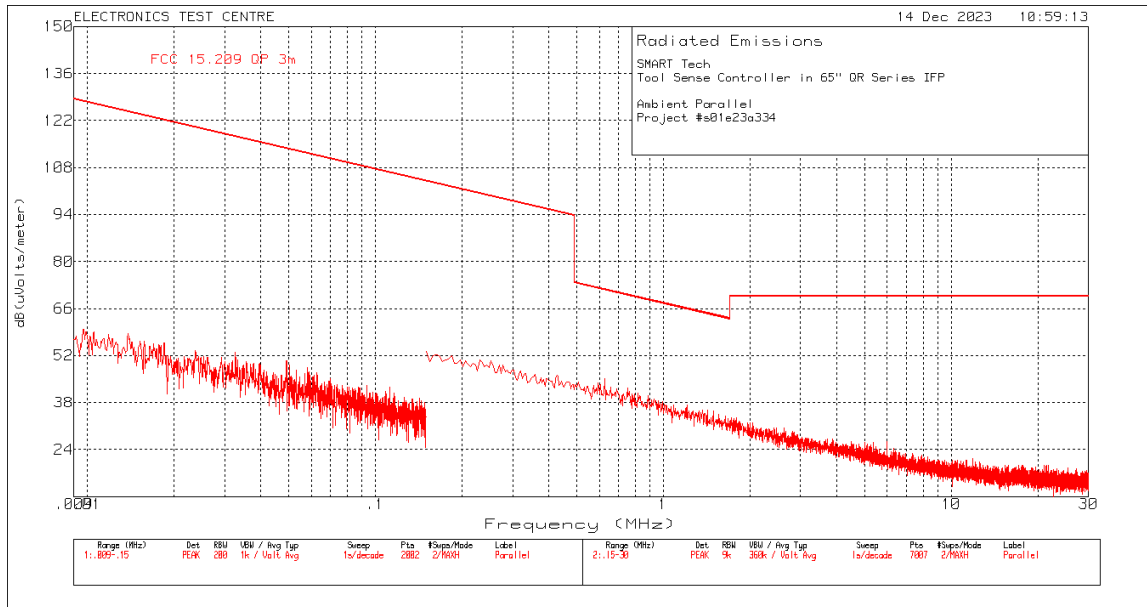
Plot of Radiated Emissions: Vertical polarization, 18-26.5GHz



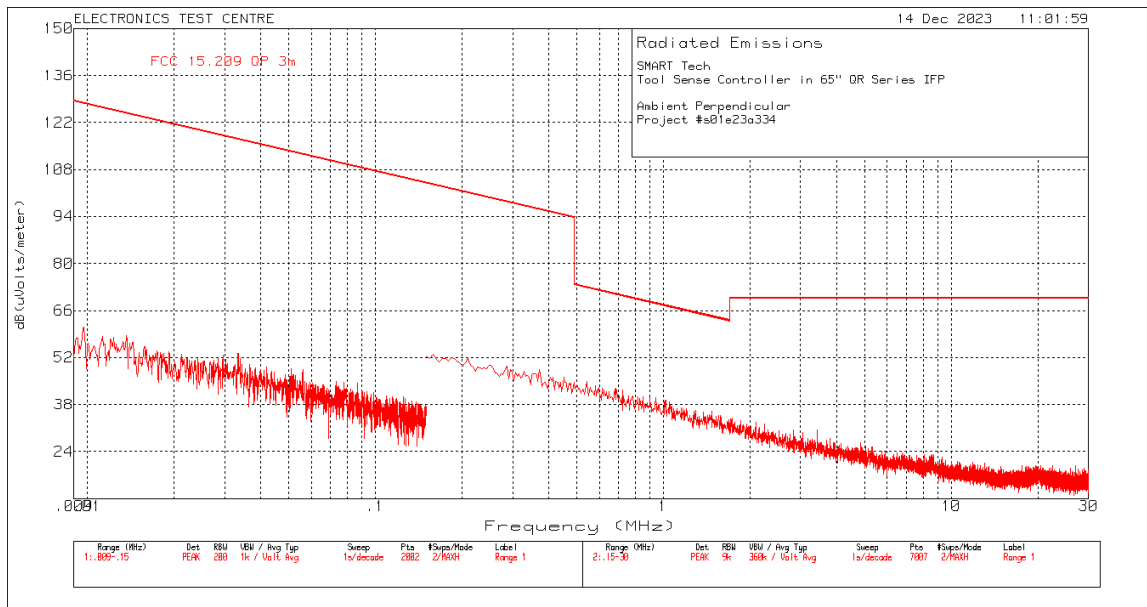
Plot of Radiated Emissions: BLE Radio OFF, Display ON, Vertical polarization, 18-26.5GHz



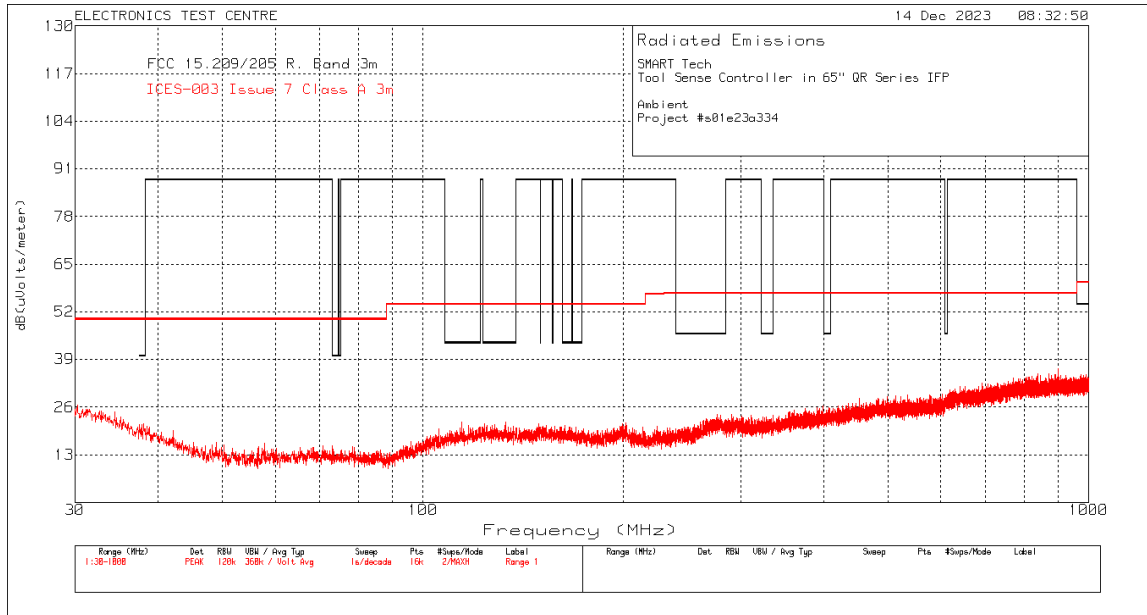
Plot of Test Chamber Ambient: Parallel (9 KHz – 30 MHz)



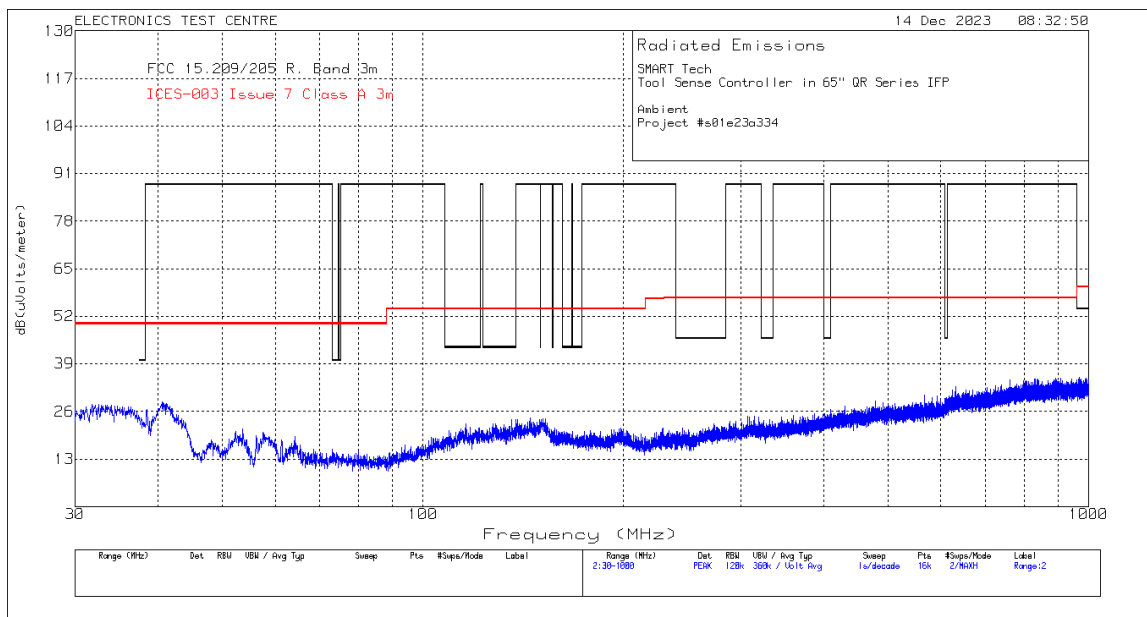
Plot of Test Chamber Ambient: Perpendicular (9 KHz – 30 MHz)



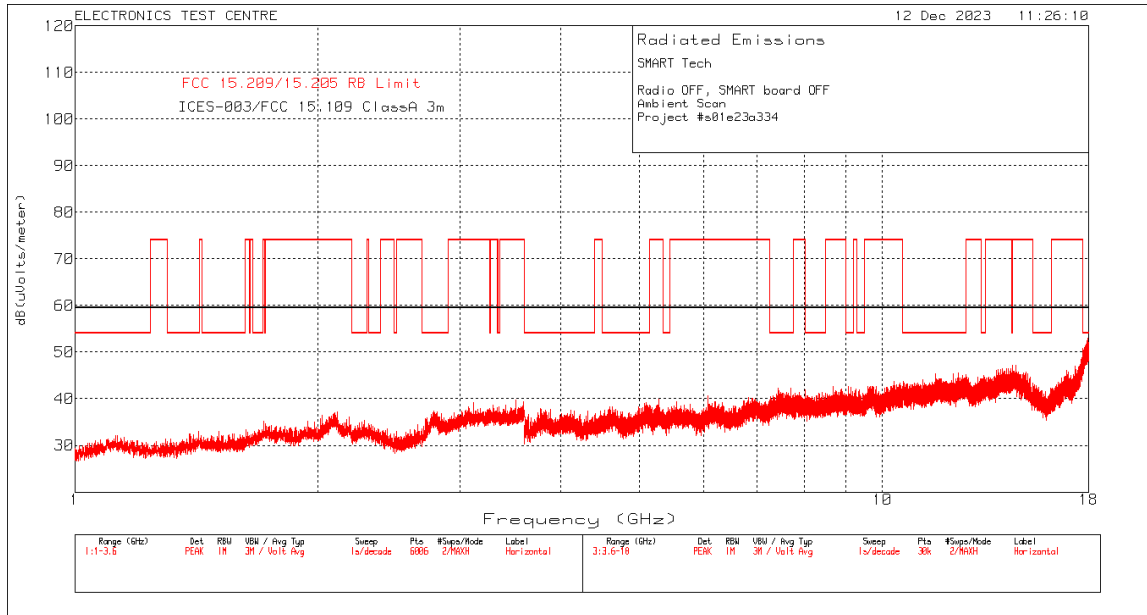
Plot of Test Chamber Ambient: Horizontal polarization (30 – 1000 MHz)



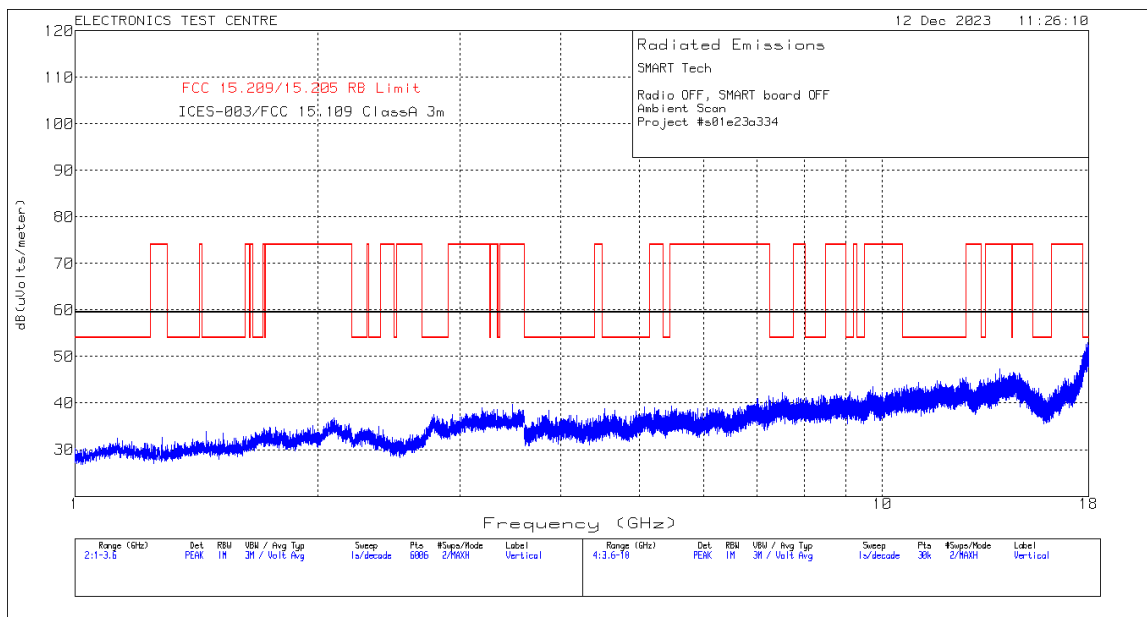
Plot of Test Chamber Ambient: Vertical polarization (30 – 1000 MHz)



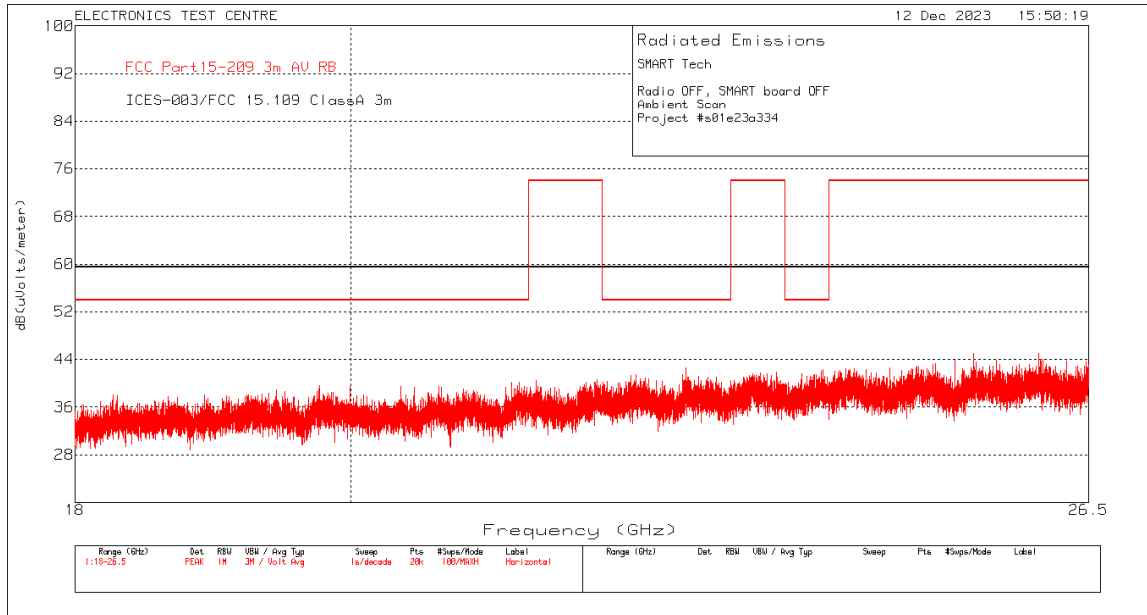
Plot of Test Chamber Ambient: Horizontal polarization (1 – 18 GHz)



Plot of Test Chamber Ambient: Vertical polarization (1 – 18 GHz)



Plot of Test Chamber Ambient: Horizontal polarization (18 – 26.5 GHz)



Plot of Test Chamber Ambient: Vertical polarization (18 – 26.5 GHz)

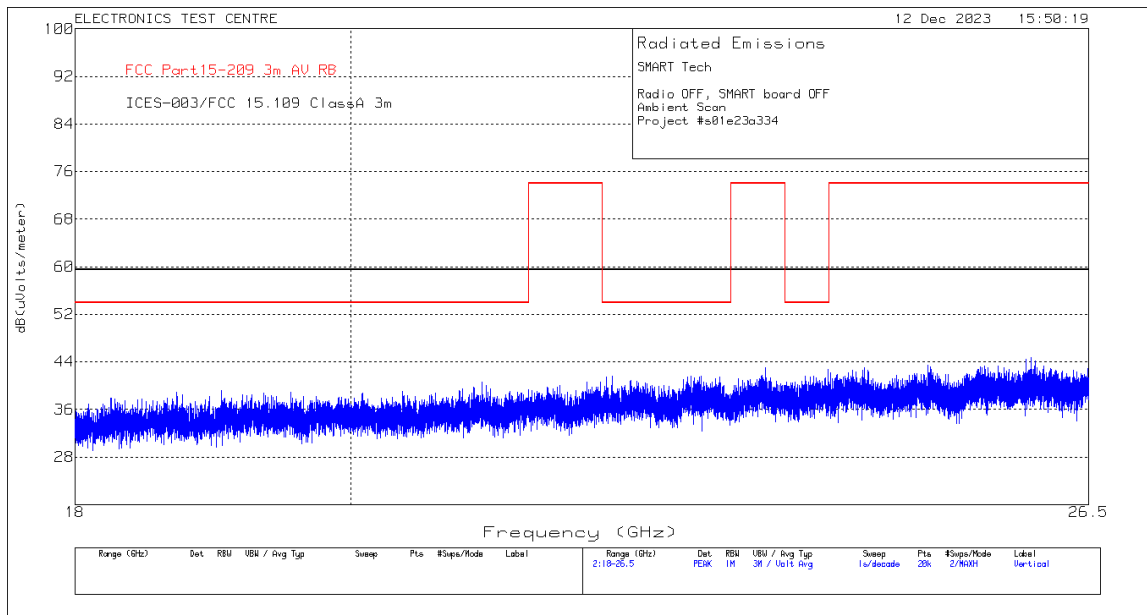


Photo of Radiated Emissions test setup: 9k-30MHz



Photo of Radiated Emissions test setup: 30M-1GHz

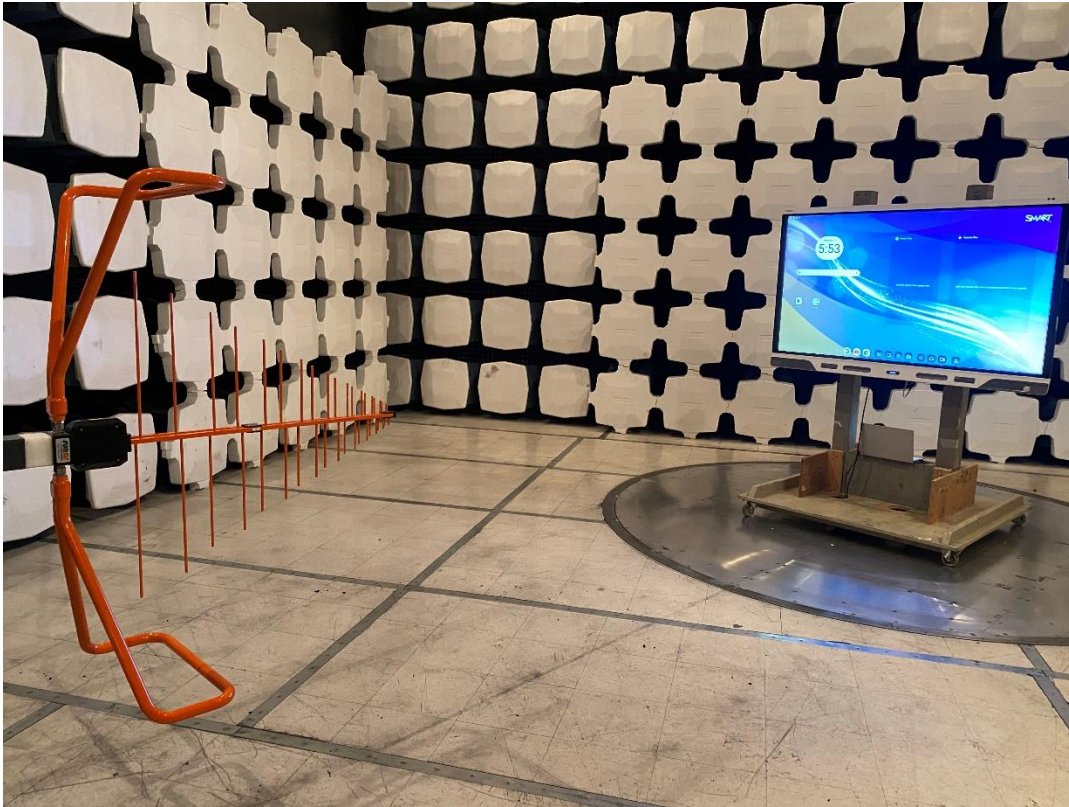


Photo of Radiated Emissions test setup: 1-18GHz

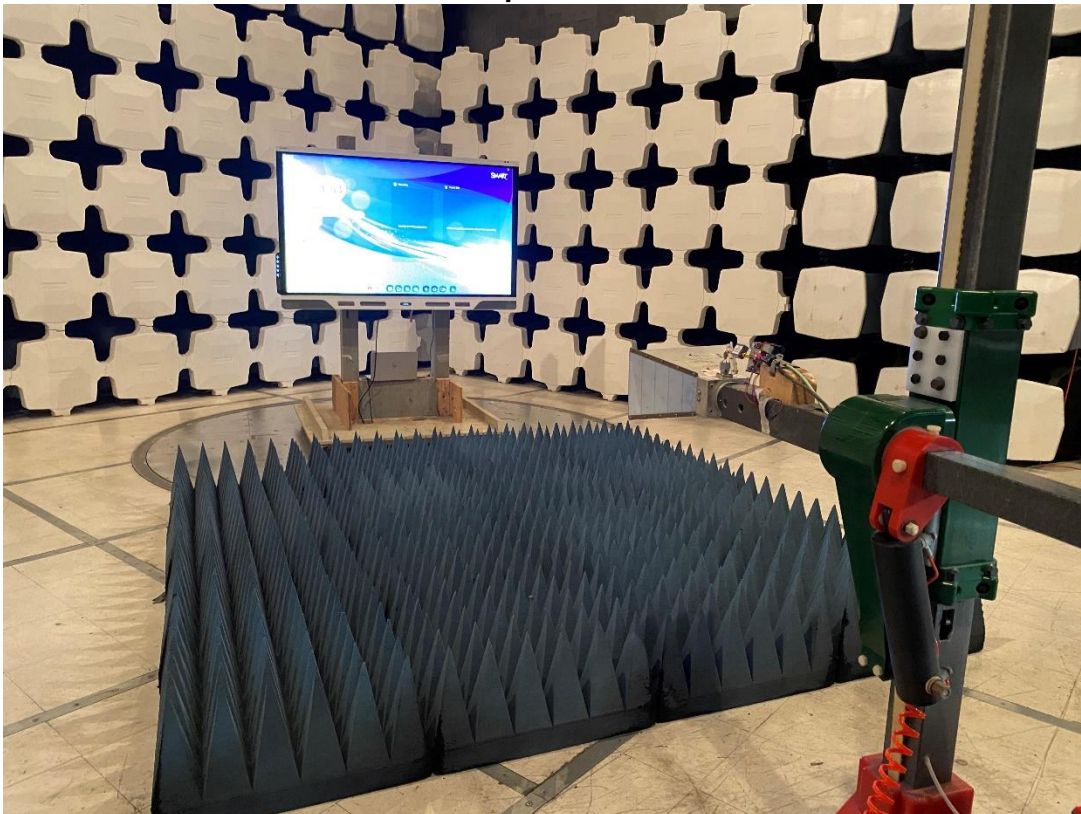
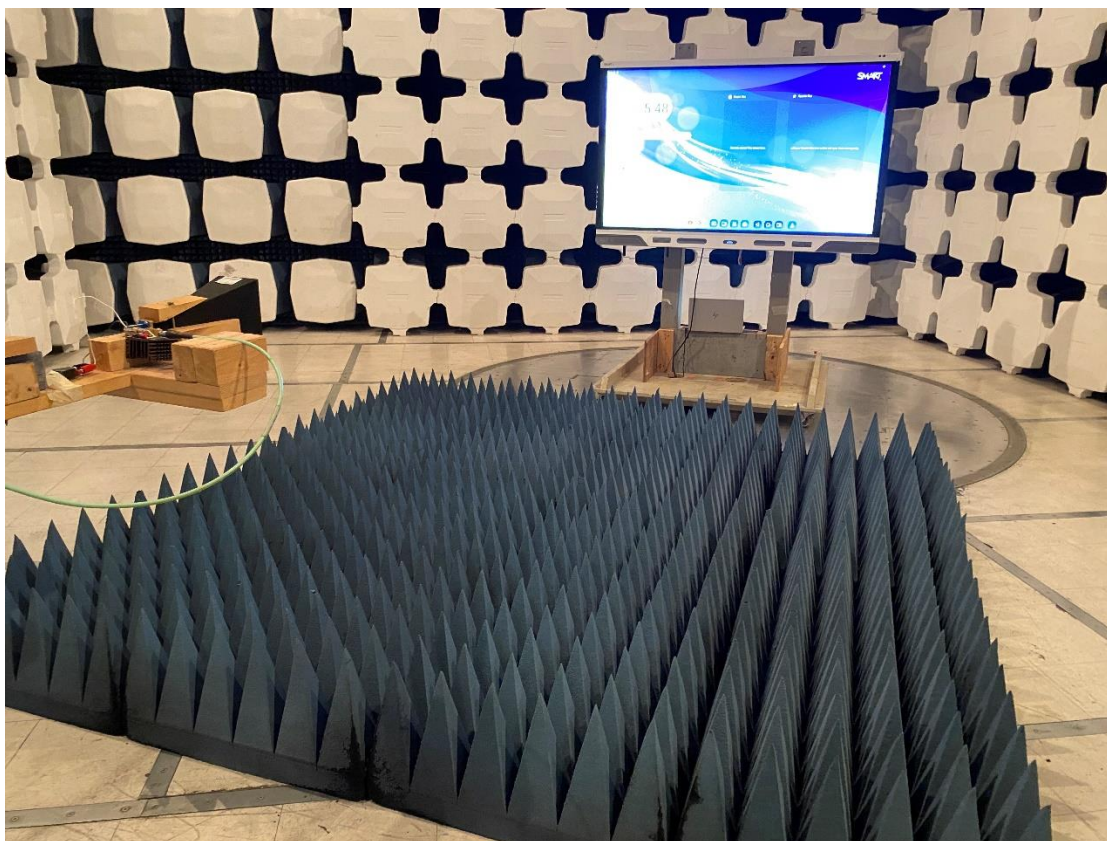


Photo of Radiated Emissions test setup: 18-26.5GHz



2.4 AC Main Conducted Emissions

Test Lab: Electronics Test Centre, Airdrie Test Personnel: J. Mijares Date: 2023/12/14 (21.4°C, 13.4% RH)	EUT: SMART QX Series BLE Module, Model: IDQXMOD1 (Tool Sense Controller) within 65" IFP display Standard: FCC Part 15.207, RSS-GEN Basic Standard: ANSI C63.10-2013
EUT status: Compliant	

Specification: FCC Part 15.207 / RSS-GEN

Frequency (MHz)	Limit (dBµV)	
	QP	AV
0.15 – 0.5	66 to 56 *	56 to 46 *
0.5 – 5	56	46
5 – 30	60	50

Criteria: The conducted emissions produced by a device shall not exceed the limits as specified.

Decreases linearly with the logarithm of the frequency

2.4.1 Test Guidance

Before any testing is performed, the Ambient (measurement noise floor) is recorded, and a QC check is performed to show that the system is functioning correctly.

The EUT is powered through a 50µH Line Impedance Stabilizing Network (LISN) which is placed 80cm away from the EUT. For tabletop equipment, a vertical ground plane is placed 40cm from the edge of the table. Lastly, the spectrum analyzer is connected to the LISN via armored cable run from the control room to the test chamber. Both the LISN and vertical ground plane are grounded to the reference ground plane on the chamber floor.

Testing starts with a scan, performed under software control. After this is complete, the list of frequencies of interest is generated. These frequencies are then investigated for quasi-peak and average amplitude, as applicable. Emissions measured with a QP detector that fall below the Average limit are deemed to meet both requirements.

2.4.2 Deviations From The Standard

There were no deviations from the EUT setup or methodology specified in the standard.

2.4.3 Test Equipment

Testing was performed with the following equipment:

Equipment	Manufacturer	Model #	Asset #	Cal. Date YYYY/MM/DD	Cal. Due YYYY/MM/DD
EMC Software	UL	Ver. 9.5	ETC-SW-EMC 2.1	N/A	
EMI receiver	Agilent	N9038A (FW v. A.25.05)	6130	2023/08/11	2024/08/11
LISN	Com-Power	LI-215A	6180	2022/08/04	2024/08/04
Milli-Ohm meter	HP	4328A	9060	2022/01/28	2024/01/28
T/H Logger	Extech	42270	5892	2023/04/14	2024/04/14
Cable (9 kHz-30 MHz)	Insulated Wire	KPS-1501A-3600	4436	*2023/03/24	2024/03/24
Transient Limiter	Electro-metrics	EM-7600	4454	*2023/03/24	2024/03/24

* In house loss verification performed.

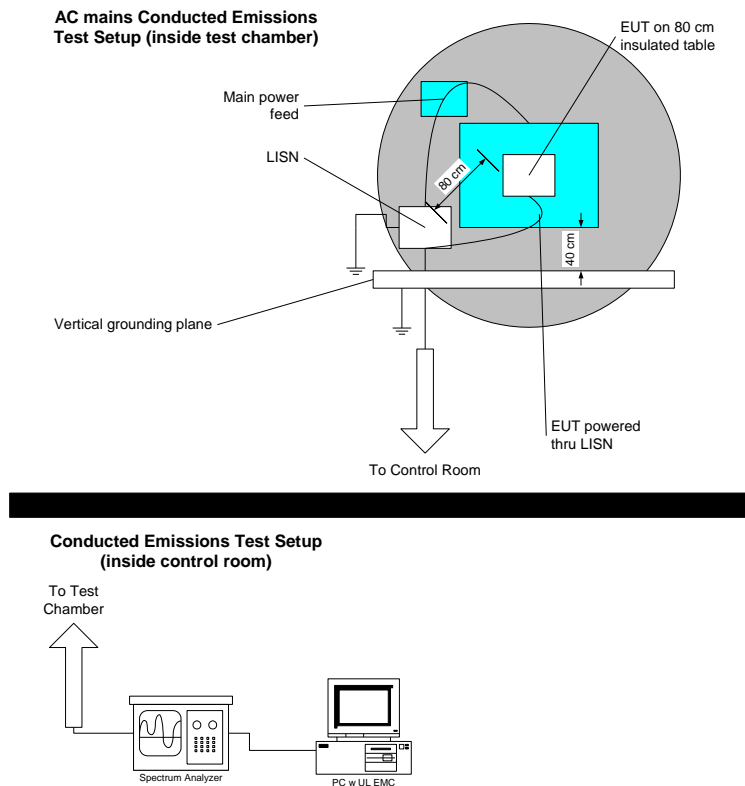
2.4.4 Test Sample Verification, Configuration & Modifications

See diagram in section 1.7

Prior to the test, each channel's radiated power was measured to determine which would be used for the compliance measurement.

The EUT met the requirements without modification.

Diagram of setup for Conducted Emissions testing:



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2.4.5 Conducted Emissions Data

The emissions data is presented in tabular form, showing the uncorrected spectrum analyzer reading, the correction factors applied, the net result, the value(s) of limit at the frequency measured, and the Delta between the result and the limit.

Freq. Marker	Freq. (MHz)	Raw reading (dBµV)	Det.	LISN Factor (dB/m)	Cable Loss (dB)	Corrected Reading (dBµV)	RSS-GEN FCC 15.207 Limit (dBµV)	Delta (dB)	L / N
4	7.859	21.22	AV	0	10.2	31.42	50.00	-18.58	Line
5	10.491	17.42	AV	0	10.3	27.72	50.00	-22.28	Line
6	18.581	14.98	AV	0.1	10.6	25.68	50.00	-24.32	Line
4	7.240	17.77	AV	0	10.1	27.87	50.00	-22.13	Neutral
5	8.572	22.05	AV	0	10.2	32.25	50.00	-17.75	Neutral
6	13.561	11.40	AV	0	10.5	21.90	50.00	-28.10	Neutral

Meter Reading in dBµV + LISN Factor in dB + Gain/Loss Factor in dB = Corrected Emission Strength in dBµV.

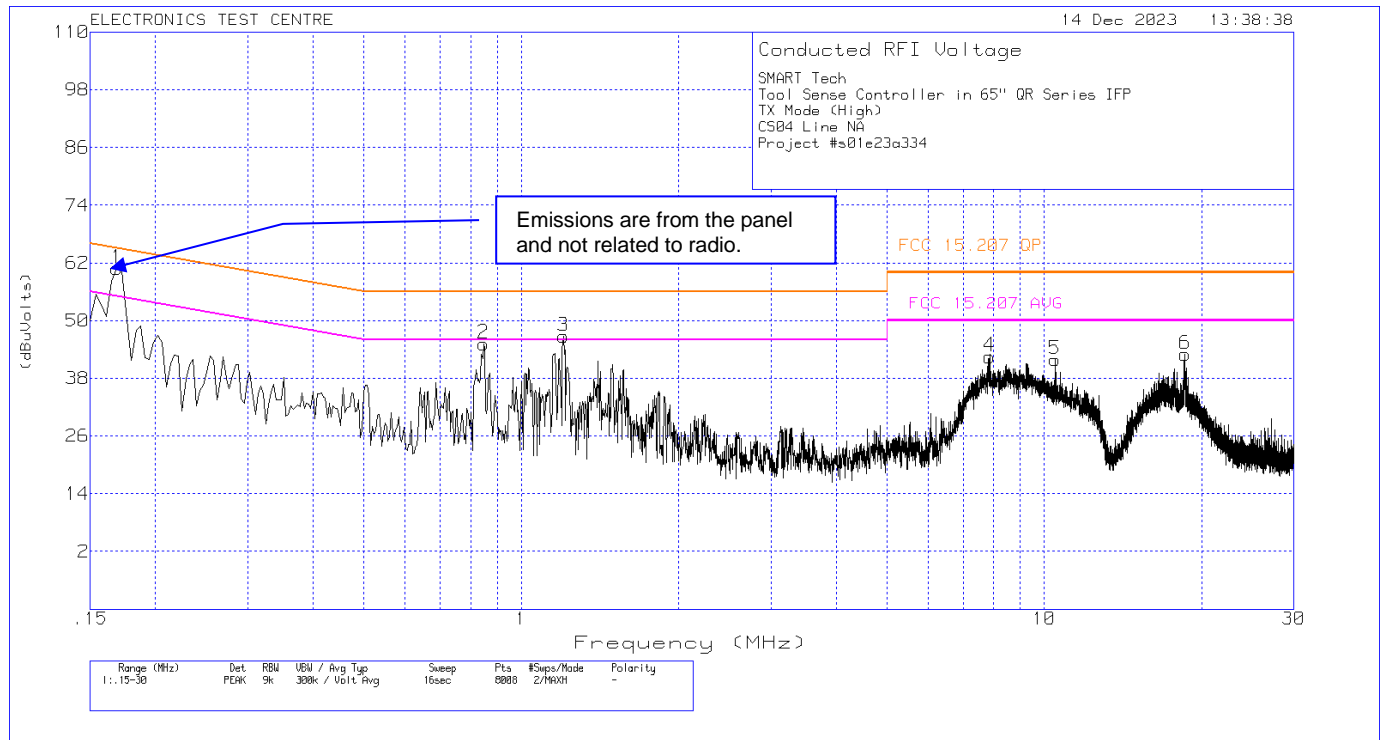
Notes:

- When a preamp is used, the resulting gain is compensated, producing a negative value for the Cable Loss.
- AV = Average detector
- Peaks marked 1-3 were present in the Baseline scans (BLE radio OFF, IFP ON). Class A limits are applicable to those peaks

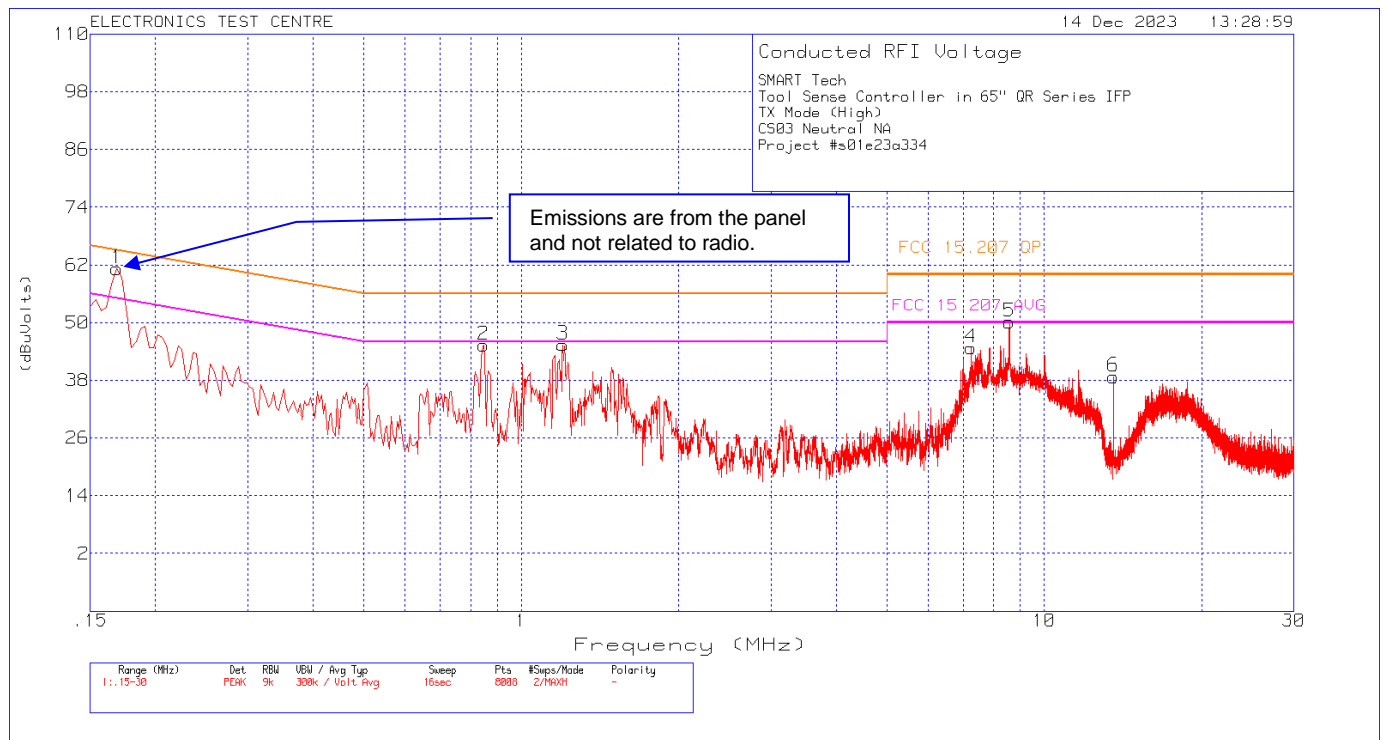
Negative values for Delta indicate compliance.

The Ground Bond was measured and found to be 1.2 mΩ.

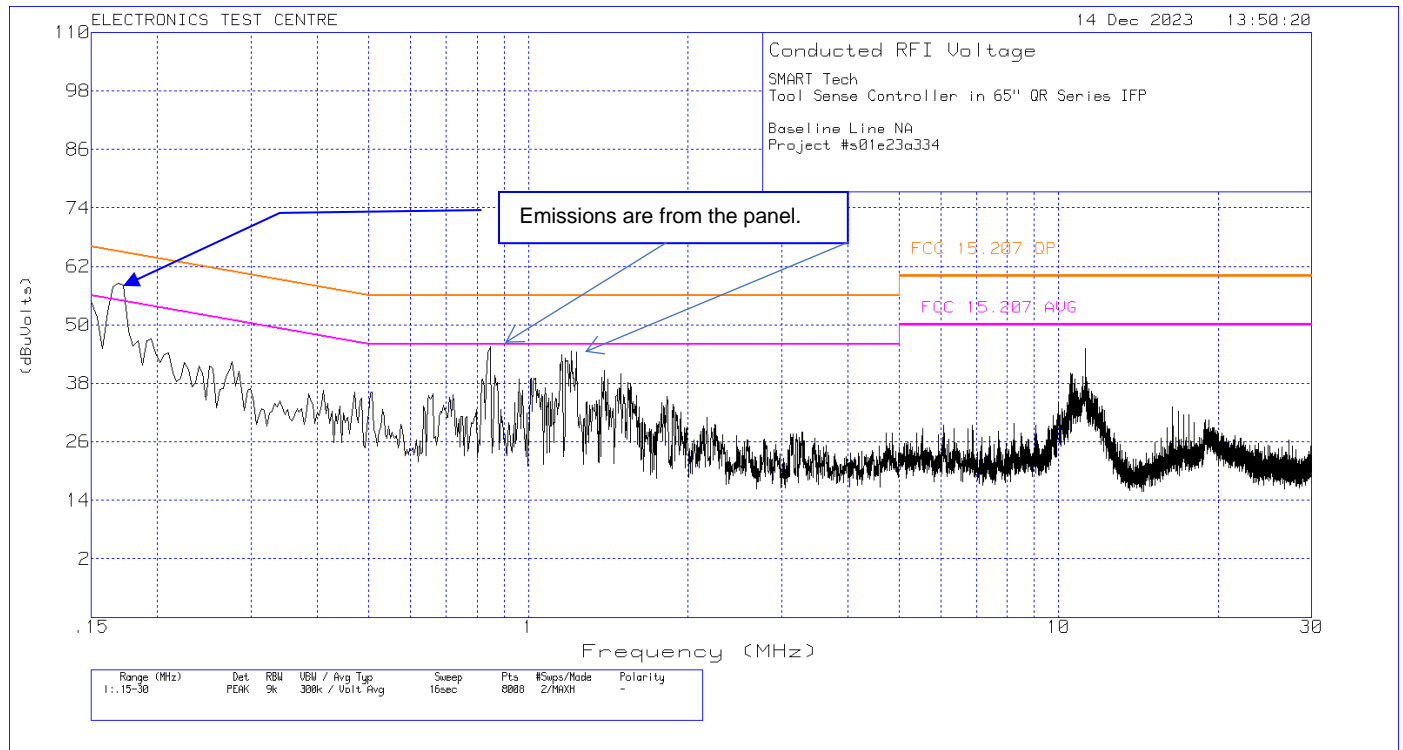
Plot of Conducted Emissions: Line



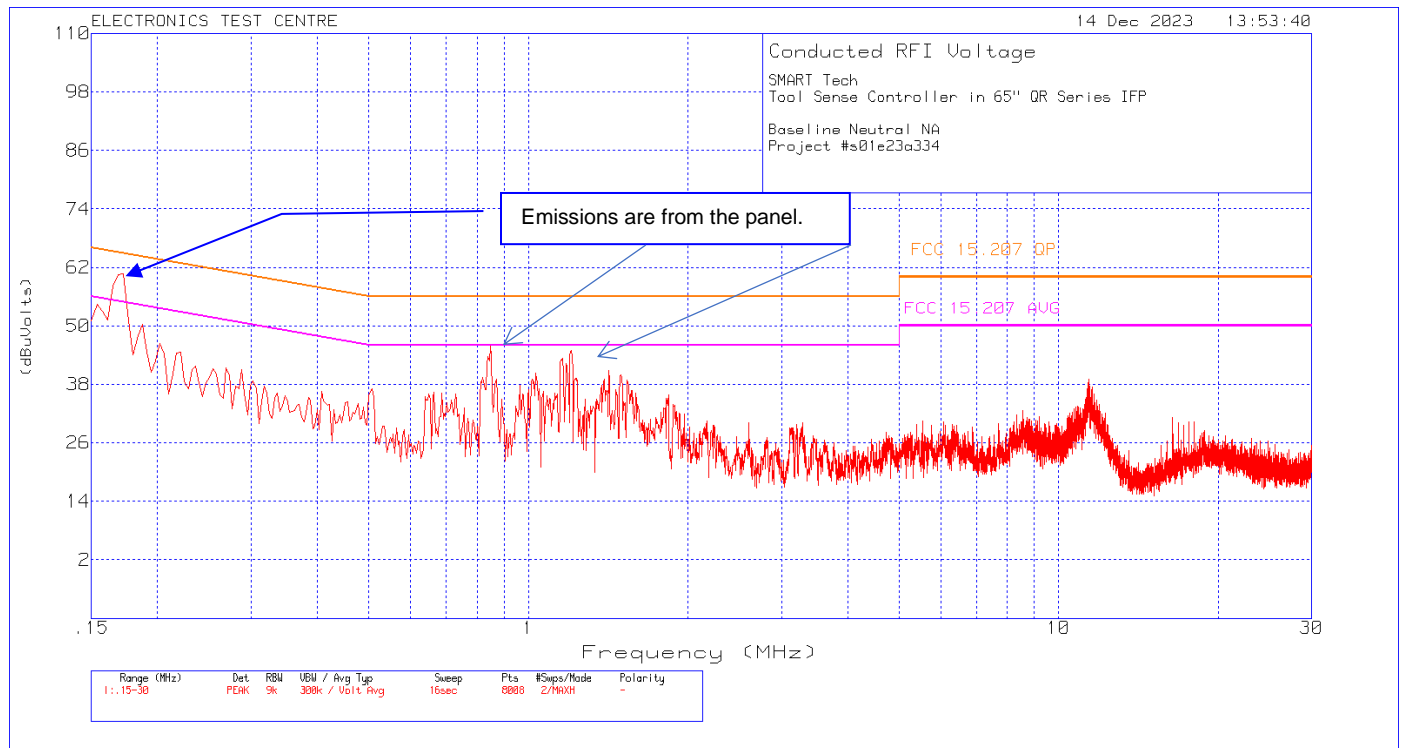
Plot of Conducted Emissions: Neutral



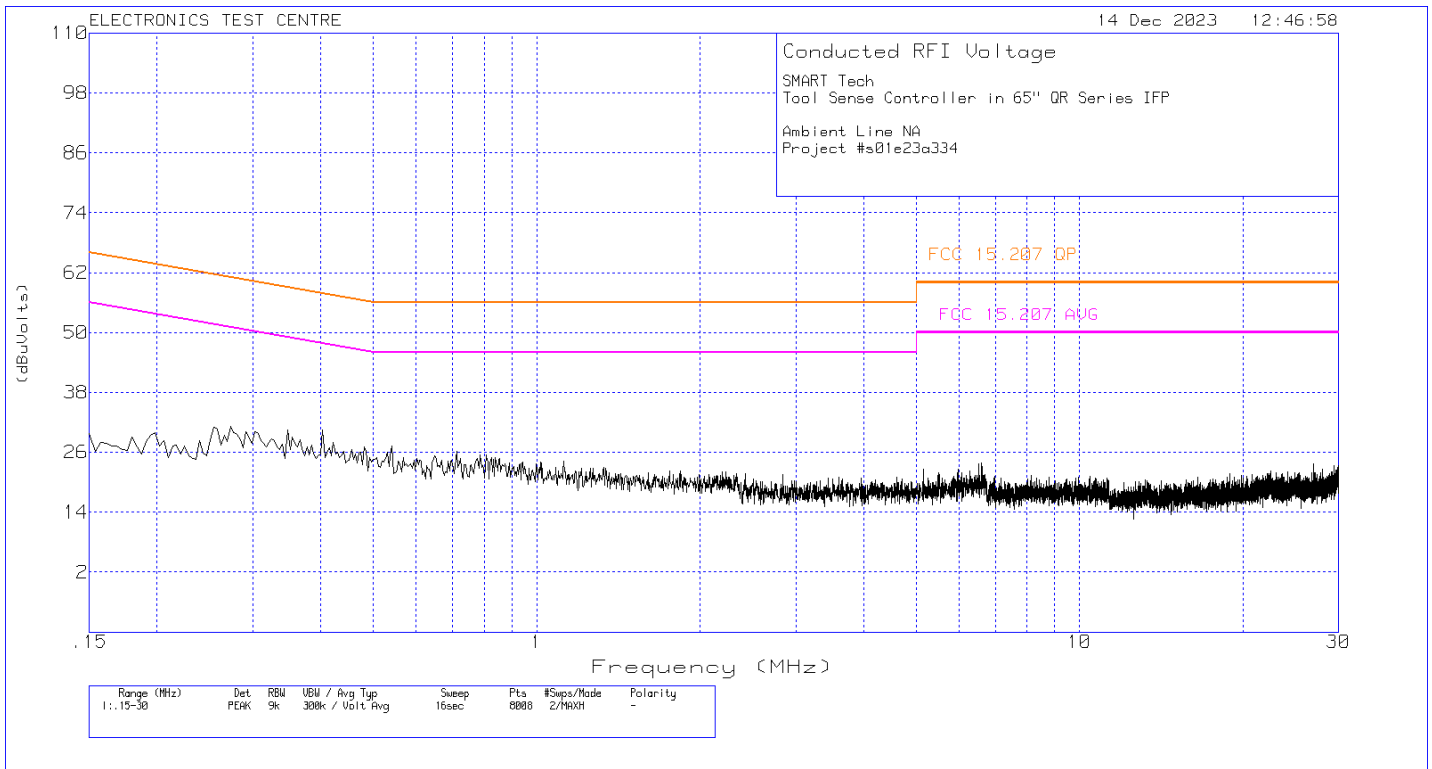
Plot of Test Ambient: BLE OFF (A.E Display ON) Line



Plot of Test Ambient: BLE OFF (A.E Display ON) Neutral



Plot of Test Ambient: BLE OFF (A.E Display OFF) Line



Plot of Test Ambient: BLE OFF (A.E Display OFF) Neutral

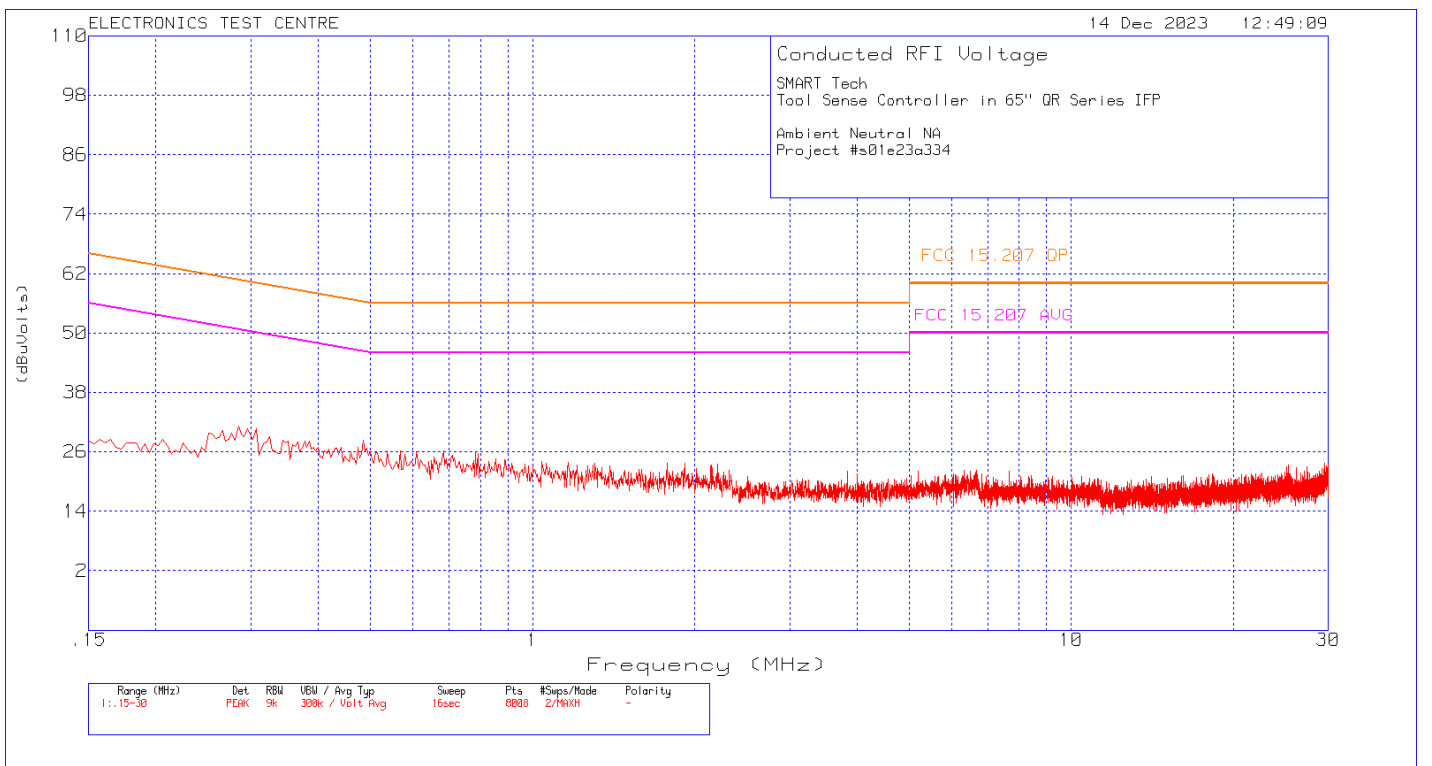
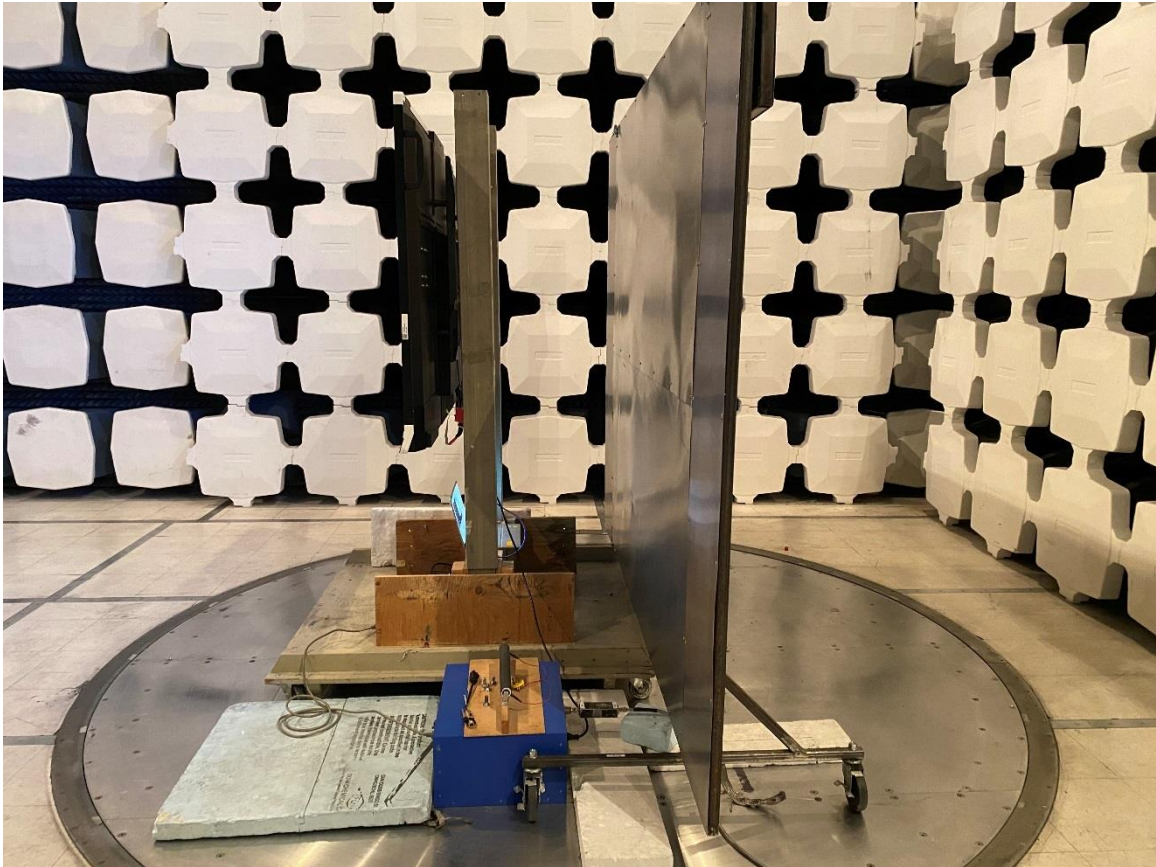


Photo of Conducted Emissions test setup:



3 TEST FACILITY

3.1 Location

The SMART QX Series BLE Module, Model: IDQXMOD1 (Tool Sense Controller) within 65" IFP display (Model: IDQR65-A) was tested at the Electronics Test Centre laboratory located in Airdrie, Alberta, Canada. The Radio Frequency Anechoic Chamber (RFAC), identified as Chamber 1, has a usable working space measuring 10.6 m long x 7.3 m wide x 6.5 m high.

Measurements taken at this site are accepted by Industry Canada as evidence of conformity per registration file # 2046A. This site is also listed with the FCC under Registration Number CA2046.

The floor, walls and ceiling consist of annealed steel panels. The walls and ceiling are covered with ferrite tile, augmented by RF absorbant foam material on the end wall nearest the turntable, and on the adjacent walls and the ceiling. The chamber floor supports a 15 cm high internal floor, constructed of annealed steel panels, that forms the ground plane, and is bonded to the chamber walls.

The 3-m diameter turntable is flush-mounted with the floor. A sub-floor cable-way is provided to route cables between the turntable pit and EUT support equipment located in the Control Room. Cables reach the EUT through an opening in the centre of the turntable.

Test instrumentation and EUT support equipment is located in the Control Room, consisting of two shielded vestibules joined together at the side of the main room. Cables are routed through bulkhead panels between the rooms and the test chamber as required. Power feeds are routed into the main room and vestibules through line filters providing at least 100 dB of attenuation between 10 kHz and 10 GHz.

Either floor mounted or table-top equipment can be tested at this facility.

3.2 Grounding Plan

The EUT was placed at the center of the test chamber turntable. The EUT was grounded according to SMART Technologies ULC specifications.

3.3 Power Supply

All EUT power was supplied by filtered AC Main.

3.4 Emissions Profile

Ambient emission profiles were generated throughout the tests and are included in the test data.

Appendix A: Test Sample Description

Quotation Number: s01q23a401		Project Number: s01e23a334	
Company Name: SMART Technologies		Contact Name: Sean MacKellar	
Address: Suite 600, 214 11 Ave SW		Phone: +1 (360) 201-8932	
Calgary, Alberta T2R 0K1		Fax: 403-228-2500	
Canada		E-mail: SeanMacKellar@smarttech.com	
Product Name: SMART QX Series BLE Module (Tool Sense Controller)			# of units to be tested: 1 each
Part/Model #: IDQXMOD1			Serial # (Critical): Host Sample #1
Product Application		Designated Marketplaces	
Residential <input type="checkbox"/> Industrial <input checked="" type="checkbox"/> Military <input type="checkbox"/>		Canada <input checked="" type="checkbox"/> Other _____ United States of America <input checked="" type="checkbox"/> European Union <input type="checkbox"/>	
GENERAL INFORMATION REQUIRED FOR ALL PRODUCTS			
Dimensions (L x W x H) 4.5cm x 10cm x 0.5cm		Weight: <u>10</u> (lbs. kgs.)	Engineering Evaluation? YES <input type="checkbox"/> NO (compliance test only) <input checked="" type="checkbox"/>
If compliance testing, to what standards?			
Regulatory Compliance testing: Yes: <input checked="" type="checkbox"/> No: <input type="checkbox"/>		For: FCC <input checked="" type="checkbox"/> Industry Canada <input checked="" type="checkbox"/> Other <input type="checkbox"/> Specify: _____	ETC to do the submission? YES <input type="checkbox"/> NO <input checked="" type="checkbox"/>
Power Requirements: (A DC powered device that is sold with an AC/DC adaptor is considered to be AC powered for emissions testing purposes.)		AC (incl wall wart) <input type="checkbox"/> Voltage: _____ VAC # of AC phases: _____ Current: _____ Amps Frequency: _____ Hz	
Duration of self-test: _____		Fault Recovery Time: _____	Reaction Time (delay between fault & alarm): _____
External <input checked="" type="checkbox"/> Internal Battery <input type="checkbox"/> Voltage: <u>5</u> VDC Current: _____ Amps			
Product Intended Application		BLE radio – Tool Sense Controller installed in RX/QX-V2 Series IFPs	
Product Deployment Environments		School classrooms, Business	
Operating Modes in the Field		Communication with IFP accessories (i.e.: Model: PQX-1 pen)	
Peripheral and/or Support Equipment to Monitor and Operate the Product (to be supplied by client):			
Description of interconnecting leads & cables (Attach separate sheet, if required)	Type: Connectors: Terminations: Shielding: Length:	Cable 1 Interface Flex Tool Sense Controller > Interface Board No 10 cm	Cable 2 USB USB Interface Board > Laptop Yes 0.5 m
List of internally generated frequencies: Crystal / Oscillator / Switcher / LO		2.402 – 2.480 GHz	
Typical installation and operating instructions/configuration to expedite EUT set-up (Attach a Separate sheet, if required)		BLE radio installed in RX Series IFPs, Models: RX/QX-V2 Series IFPs, Models: IDQR65-A, IDQR75-A, IDQR86-A. Test application provided to support TX/RX mode spurious emissions testing. Test application provided to monitor communication with pen (IFP accessory).	
Brief Functional description of Product including System Block Diagram (Attach a Separate sheet, if required)		BLE radio – data communication with IFP accessories (i.e.: Model: PQX-1 pen)	
Any additional information?		- Test mode duty cycle: 53.4%, correlates to an upward duty cycle correction factor (DCCF) of +2.72 dB, which is applied to the Average measurement to account for the radio transmitted <98%. - Maximum operating duty cycle: 7.5%, which correlates to a downward DCCF of -11.25, which is applied to account for the maximum operating duty cycle during typical operation. The overall DCCF: (+2.72 – 11.25) = -8.53 dB should be applied to the Average measurements of all transmitter harmonics.	

WIRELESS PRODUCT INFORMATION

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Electronics Test Centre - MPB Technologies Inc.

Type of Radio Device (check all applicable Equipment Configurations)			
Intentional transmitter	<input checked="" type="checkbox"/>	Receiver	<input checked="" type="checkbox"/>
		Transceiver	<input type="checkbox"/>
Type of Radio Operating License			
Unlicensed Personal Communication	<input checked="" type="checkbox"/>	Unlicensed National Information Infrastructure	<input type="checkbox"/>
		Ultra-Wideband Operation	<input type="checkbox"/>
		Licensed	<input type="checkbox"/>
Type of Modulation of Radio Device			
CDMA	<input type="checkbox"/>	TDMA	<input type="checkbox"/>
		Other	<input type="checkbox"/>
Spread Spectrum Technology	<input type="checkbox"/>	Direct sequencer	<input type="checkbox"/>
		Frequency hopper	<input checked="" type="checkbox"/>
Transmitter Power Output : 4 dBm EIRP		Emission Designator :	
Information on Radio Frequencies			
Transmitter Operating Frequency(s) & Bandwidth	2 MHz		
Transmitter Channel Frequencies & separations (If required, attach a separate sheet)	2402 – 2480 MHz		
Receiver Operating Frequency(s) & Bandwidth	2 MHz		
Receiver Channel Frequencies & separations (If required, attach a separate sheet)	2402 – 2480 MHz		
Information on Antenna(s)			
Is the antenna removable?	YES NO	<input type="checkbox"/> <input checked="" type="checkbox"/>	Antenna Connector Type : u.fl
		Number of Antennas : 1	
Gain of Each Antenna (and tolerance)	4 dBi		
Activity and State of Digital Circuitry during ON Time	TX mode: BLE_1M		
Radio Transmission Type			
Continuous	<input checked="" type="checkbox"/>	Intermittent	<input type="checkbox"/>
		ON Time/ OFF Time : 7.5% (Typical)	
Activity and State of Digital Circuitry during OFF Time	Receive mode. Transmission only occurs during pen firmware updates (OTA).		
Pre-Approved Radio Systems & Sub-Assemblies			
FCC ID:	Grantee Code:	Approval Agency /TCB:	
Software changes to the Pre-Approved Equipment?			
Software additions to the Pre-Approved Equipment			
Hardware changes to the Pre-Approved Equipment?			
Hardware additions to the Pre-Approved Equipment?			
Prepared By: Sean MacKellar	Title: Sr. Regulatory Specialist	Date: 5/22/2023	

End of Document