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ETC Report #: s01e23a207 Release 2 Date: June 5, 2023

EMC testing of SMART QX Series BLE Module, Model: IDQXMOD1 (Tool Sense Controller) within 86" QX Series IFP display, Model: IDQX86-1 in accordance with:

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

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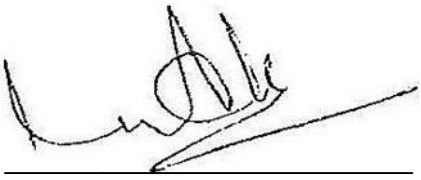

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REVISION RECORD

ISSUE	DATE YYYY/MM/DD	AUTHOR	REVISIONS
DRAFT 1	2023/05/24	I. Akram	Initial draft submitted for review.
Release 1	2023/05/31	I. Akram	Sign Off
Release 2	2023/06/05	I. Akram	Added radio information in section 1.3. Sign Off

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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 86" QX Series 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)
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 0 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

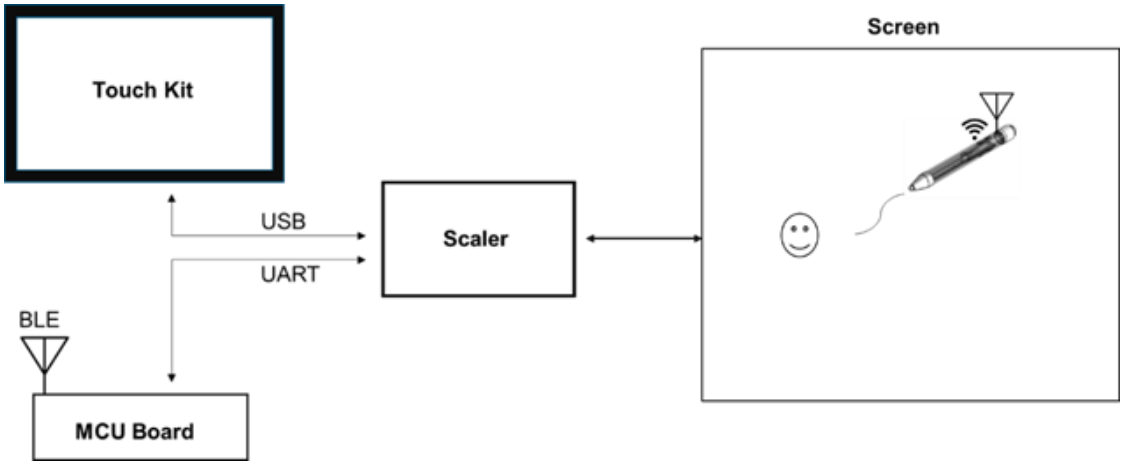
Standards	Description
RSS-GEN, Issue 5	General Requirements for Compliance of Radio Apparatus
FCC, title 47 CFR § 15.207	Intentional radiator, conducted emission limits
FCC, title 47 CFR § 15.209	Intentional radiator, radiated emission limits
ANSI C63.10 (2013)	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

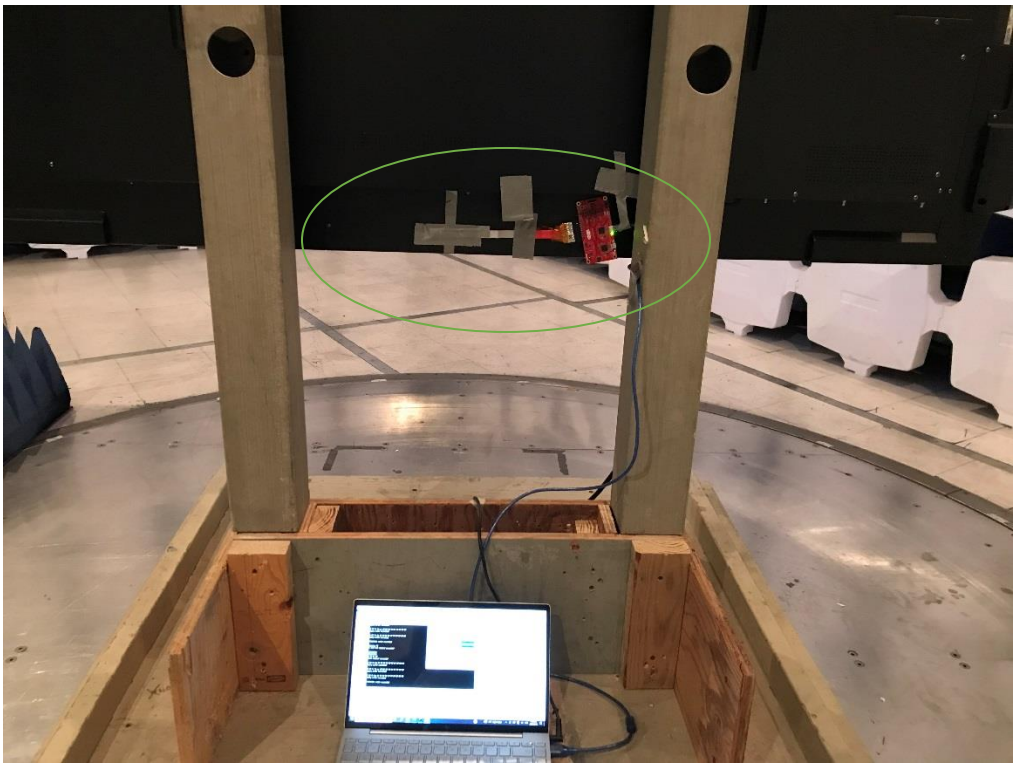
1.6 Acronyms and Abbreviations

Acronyms/Abbreviations	Description
AV	Average
BW	Bandwidth
dB	Decibel, ratio base 10
dBm	Decibel referenced to 1 mW
dBµV	Decibel reference to 1 µV
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
µV	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 Low, Mid or High channel using the provided SMART Tech laptop with the ATM RF Test Tool.

The radio module is located within the SMART QX Series 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 QX Series 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 expended 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
Radiated Emissions Level (26.5 GHz – 40 GHz)	±5.2 dB
Conducted Emissions Level (9 kHz – 150 kHz)	±3.4 dB
Conducted Emissions Level (150 kHz – 30 MHz)	±3.0 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 2, Clause 5.4(d), (a)	Low /MID/ High	QX Series BLE Module, Model: IDQXMOD1 (Tool Sense Controller) within host product, Model: IDQX86-1	**Compliant**
§ 2.2	Radiated Spurious Emissions	FCC Part 15.209 RSS-GEN	30k – 26.5GHz		**Compliant**
§ 2.3	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 86" QX Series IFP display**
Test Personnel: Brendan Van Hee	**Standard: FCC15.247/RSS-247 Issue 2**
Date: 2023/05/11 (22.0°C, 27.5% RH)	**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 2, 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:

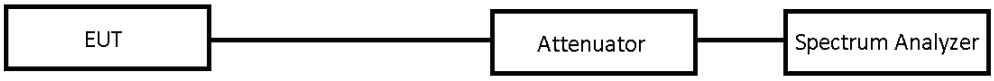
Equipment	Manufacturer	Model #	Asset #	Cal. Date	Cal. Due
EMI receiver	Agilent	N9038A (FW A.25.05)	6130	2022-07-12	2023-07-12
Temp/Humidity	Extech	42270	5871	2022-05-09	2023-05-09
Antenna 1- 18GHz	EMCO	3115	19357	2022-10-05	2024-10-05
RE Cable	A.H. Systems Inc.	SAC-26G-5.23	6187	*2023-03-24	2024-03-24
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.

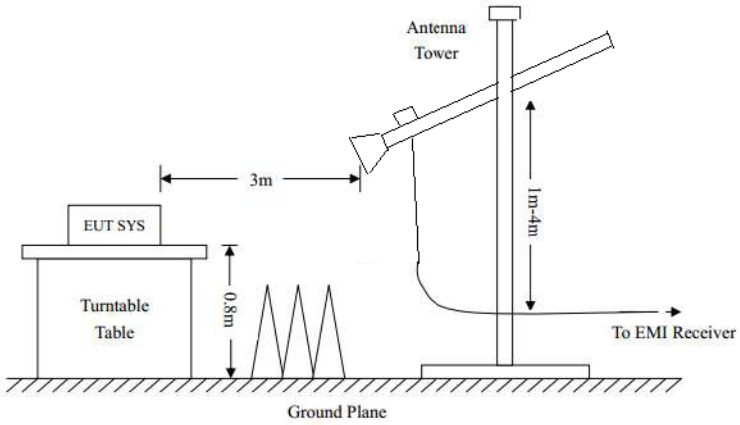
2.1.4 Test Sample Verification, Configuration & Modifications

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

Frequency (MHz)	Conducted Reading (dBm)	Max Antenna Gain dBi	EIRP dBm	EIRP (Watts)	EIRP Limit (Watts)	Margin (Output - limit)
Conducted Output Power Measurement						
2402	-2.356	4	1.644	0.0014602	≤ 4 (36dBm)	-3.99854
2440	-2.002	4	1.998	0.0015842		-3.99842
2480	-2.094	4	1.906	0.001551		-3.99845

Polarity	Frequency (MHz)	Corrected Field Strength Reading (dBµ/m)	Converting Field Strength to dBm (dBµ/m -95.2) (EIRP dBm)	EIRP (Watts)	EIRP Limit (Watts)	Margin (Output - limit)
Maximized Radiated Output power Measurement						
Horizontal	2402	95.9	0.7	0.001175	≤ 4 (36dBm)	-3.99883
	2440	94.1	-1.1	0.0007763		-3.99922
	2480	97.97	2.77	0.001892		-3.99811
Vertical	2402	97.32	2.12	0.001629		-3.99837
	2440	98.67	3.47	0.002223		-3.99778
	2480	99.33	4.13	0.002588		-3.99741

Test Setup Photo (Conducted)

Test Setup Photo (Radiated)

2.2 Radiated Spurious Emissions

Test Lab: Electronics Test Centre, Airdrie	**EUT: SMART QX Series BLE Module, Model: IDQXMOD1 (Tool Sense Controller) within 86" QX Series IFP display**
Test Personnel: B. Van Hee	**Standard: FCC Part 15.209, RSS-GEN**
Date: 2023/05/11 (22.0°C, 27.5% RH)	**Basic Standard: ANSI C63.10**
2023/05/12 (25.0°C,25.0% RH)	

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 device, measured at a distance of 3 meters, shall not exceed the limits as specified.

2.2.1 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.

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	2022/07/12	2023/07/12
Loop Antenna	Electro-Metrics	ALP-70	3703	2022/01/05	2025/01/05
Biconilog Antenna	SunAR	JB1	6905	2021/10/29	2023/10/29
DRG Horn	EMCO	3115	19357	2022/10/05	2024/10/05
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	
Pre-Amplifier (0.1-1.3 MHz)	HP	8447D	9291	*Monitored	

* In house loss / gain verification performed.

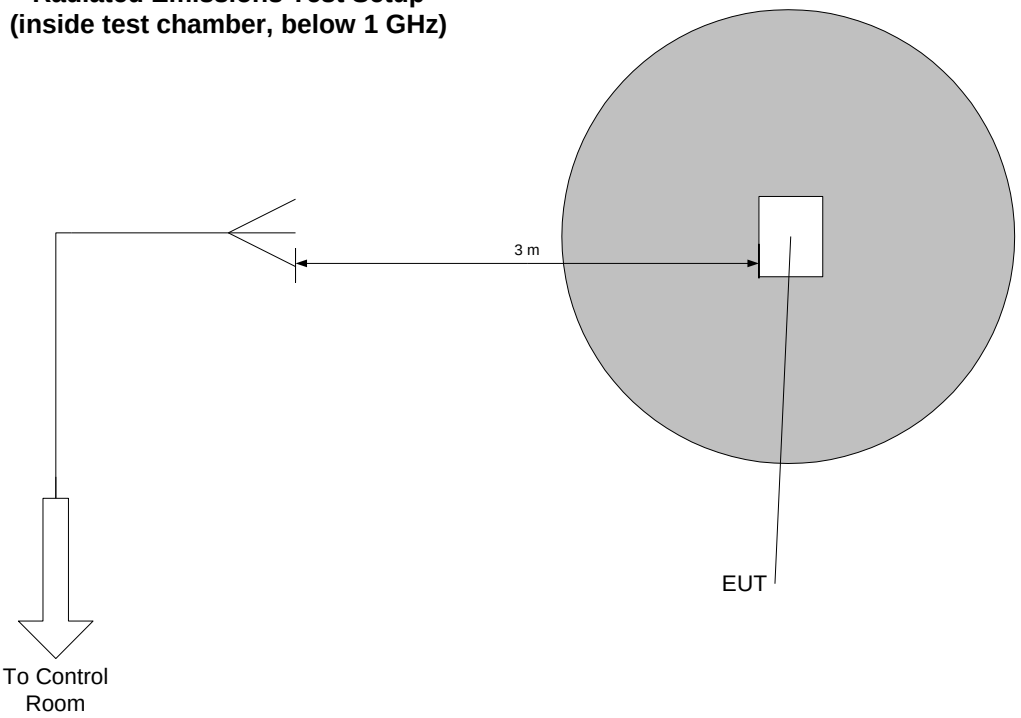
2.2.4 Test Sample Verification, Configuration & Modifications

See diagram in section 1.7

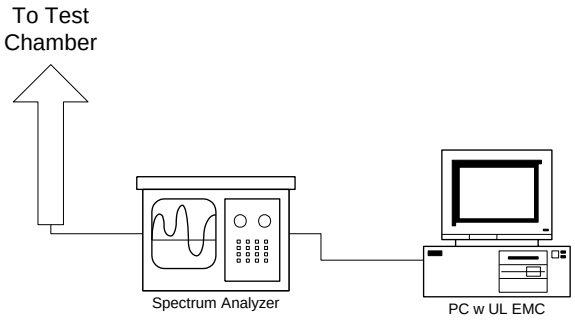
The EUT met the requirements without modification.

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. For LOW and MID channels above 1 GHz radiated spurious emission spot check was performed. Data is provided in section 2.2.6 and 2.2.7.

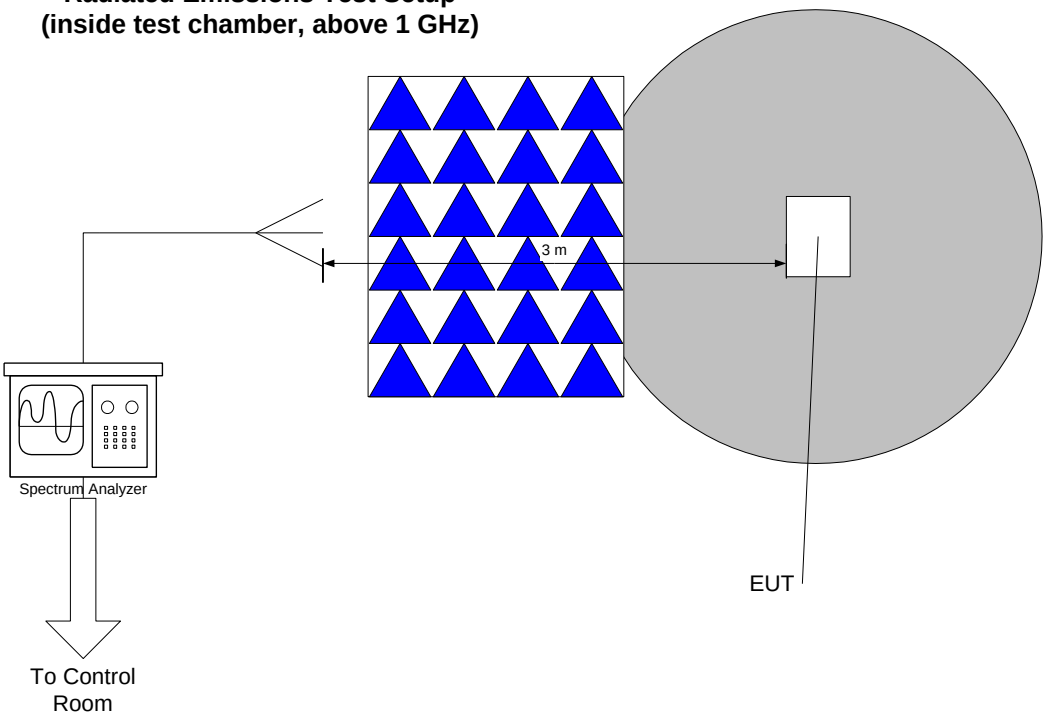
Radiated Emissions Test Setup
(inside test chamber, below 1 GHz)



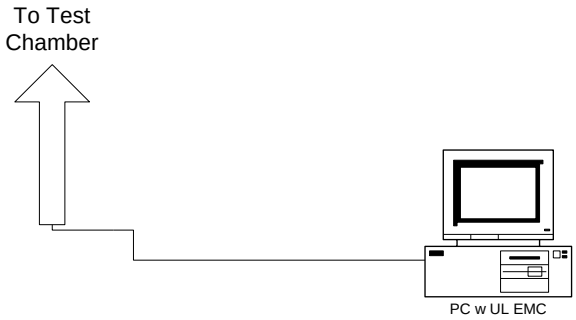
Radiated Emissions Test Setup
(inside control room, below 1 GHz)



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



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



2.2.5 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.

Freq. 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
1	0.1350	54.61	QP	10.4	.1	65.11	104.99	-39.88	151	200	Parallel
2	08095	43.35	QP	10.5	.2	54.05	69.43	-15.38	156	200	Parallel
3	1.48	35.46	QP	10.8	.3	46.56	64.16	-17.6	157	200	Parallel
1	0.135	51.17	QP	10.4	.1	61.67	104.99	-43.32	92	200	Perpendicular
2	0.8104	40.41	QP	10.5	.2	51.11	69.52	-18.31	90	200	Perpendicular
3	1.48	32.52	QP	10.8	.3	43.62	64.16	-20.54	89	200	Perpendicular
4	13.56	32.75	QP	10.9	.9	44.55	69.56	-25.01	37	200	Perpendicular
1	60.37	39.0	QP	11.6	-24.2	26.4	40.01	-13.61	77	273	Horizontal
2	71.98	42.23	QP	12.2	-24.0	30.43	40.01	-9.58	94	245	Horizontal
3	122.9	33.53	QP	17.9	-23.3	28.13	43.53	-15.4	55	150	Horizontal
4	414.75	32.63	QP	20.1	-21.1	31.63	46.03	-14.4	53	228	Horizontal
5	959.98	28.11	QP	26.6	-18.4	36.31	46.03	-9.72	276	106	Horizontal
6	60.05	46.14	QP	11.6	-24.2	33.54	40.01	-6.47	82	105	Vertical
7	339.91	37.1	QP	18.2	-21.5	33.8	46.03	-12.23	237	118	Vertical
8	466.94	28.46	QP	21.1	-20.8	28.76	46.03	-17.27	80	223	Vertical

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.
- QP = Quasi-Peak detector; AV = Average detector; PK = Peak detector

Negative values for Delta indicate compliance.

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	1.2204	30.16	AV	25.1	-38	20.26	54	-33.74	330	367	Horizontal
		42.76	PK			32.86	74	-41.14			
2	1.6127	32.16	AV	26.3	-34.2	24.26	54	-29.74	10	346	Horizontal
		51.78	PK			43.88	74	-30.12			
3	3.064	27.32	AV	30.4	-32.7	25.02	54	-28.98	1	338	Horizontal
		45.54	PK			43.24	74	-30.76			
4	1.1169	34.63	AV	24.8	-35.2	24.23	54	-29.77	71	188	Vertical
		48.52	PK			38.12	74	-35.88			
5	1.633	33.85	AV	26.5	-34.2	26.15	54	-27.85	74	186	Vertical
		52.72	PK			45.02	74	-28.98			
6	2.0785	33.42	AV	27.9	-34.1	27.22	54	-26.78	297	192	Vertical
		45.29	PK			39.09	74	-34.91			
7	3.0648	28.37	AV	30.4	-32.7	26.07	54	-27.93	229	188	Vertical
		50.53	PK			48.23	74	-25.77			
8	5.3172	22.94	AV	33.7	-29.6	27.04	54	-26.96	329	137	Horizontal
		37.09	PK			41.19	74	-32.81			
9	7.4408	36.1	AV	36.6	-26.8	45.9	54	-8.10	306	139	Horizontal
		45.42	PK			55.22	74	-18.78			
10	9.921	28.3	AV	38	-25.1	41.2	54	-12.80	212	263	Horizontal
		38.93	PK			51.83	74	-22.17			
11	4.3074	37.9	AV	32.1	-31.5	38.5	54	-15.50	102	273	Vertical
		43.93	PK			44.53	74	-29.47			
12	5.3128	23.36	AV	33.7	-29.5	27.56	54	-26.44	97	218	Vertical
		50.0	PK			54.2	74	-19.80			
13	6.6461	22.32	AV	34.9	-27.4	29.82	54	-24.18	137	188	Vertical
		36.01	PK			43.51	74	-30.49			
14	7.441	36.1	AV	36.6	-26.8	45.9	54	-8.10	282	207	Vertical
		45.9	PK			55.7	74	-18.30			
15	9.9191	30.58	AV	38	-25.1	43.48	54	-10.52	252	210	Vertical
		40.62	PK			53.52	74	-20.48			
1	19.84	28.18	AV	34.9	-21.4	41.68	54	-12.32	255	189	Horizontal
		41.19	PK			54.69	74	-19.31			
2	19.84	30.3	AV	34.9	-21.5	43.7	54	-10.30	315	172	Vertical
		41.79	PK			55.19	74	-18.81			

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 = 10log (1/D) = 10log (1/.534) = 2.72 dB

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

DCCF = 10log (1/D) = 10log (1/.075) = 11.25 dB

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

DCCF = 2.72 - 11.25

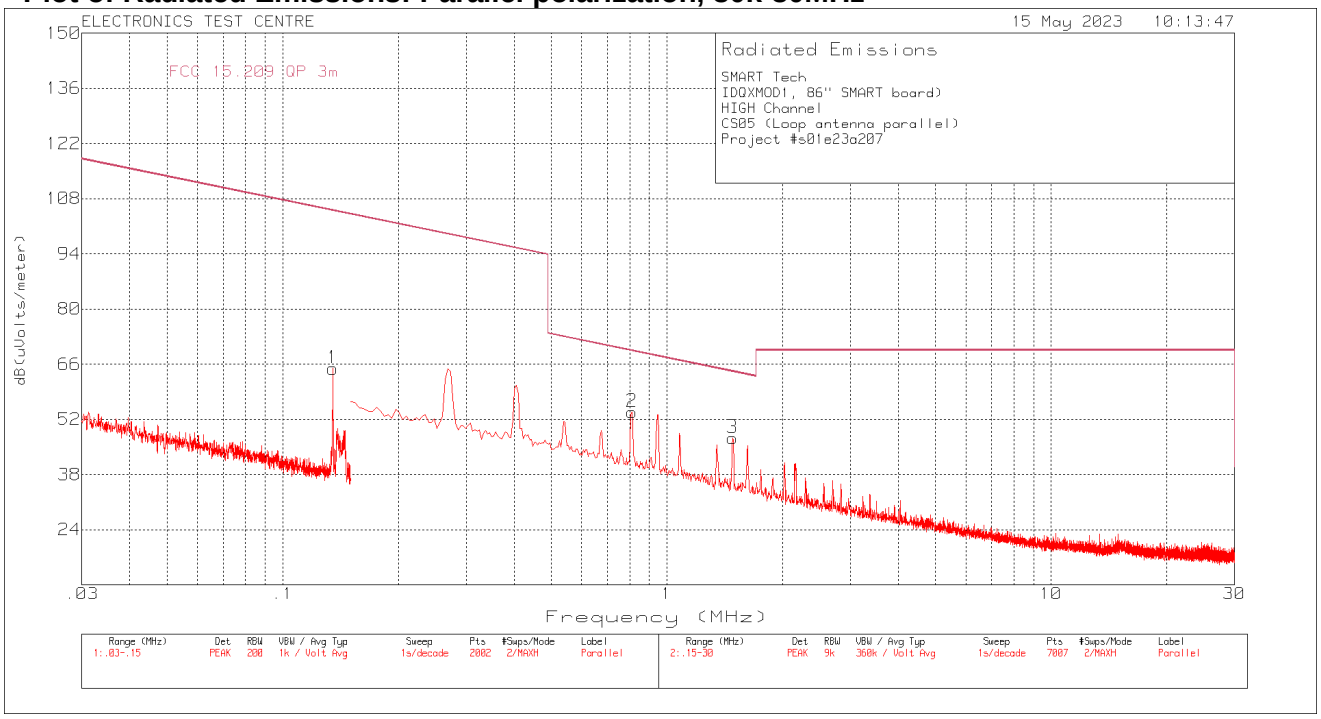
DCCF = -8.53 dB

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
9	7.4408	45.9	-8.53	37.37	54	-16.63	Horizontal
10	9.921	41.2	-8.53	32.67	54	-21.33	Horizontal
14	7.441	45.9	-8.53	37.37	54	-16.63	Vertical
15	9.9191	43.48	-8.53	34.95	54	-19.05	Vertical
1	19.84	41.68	-8.53	33.15	54	-20.85	Horizontal
2	19.84	43.7	-8.53	35.17	54	-18.83	Vertical

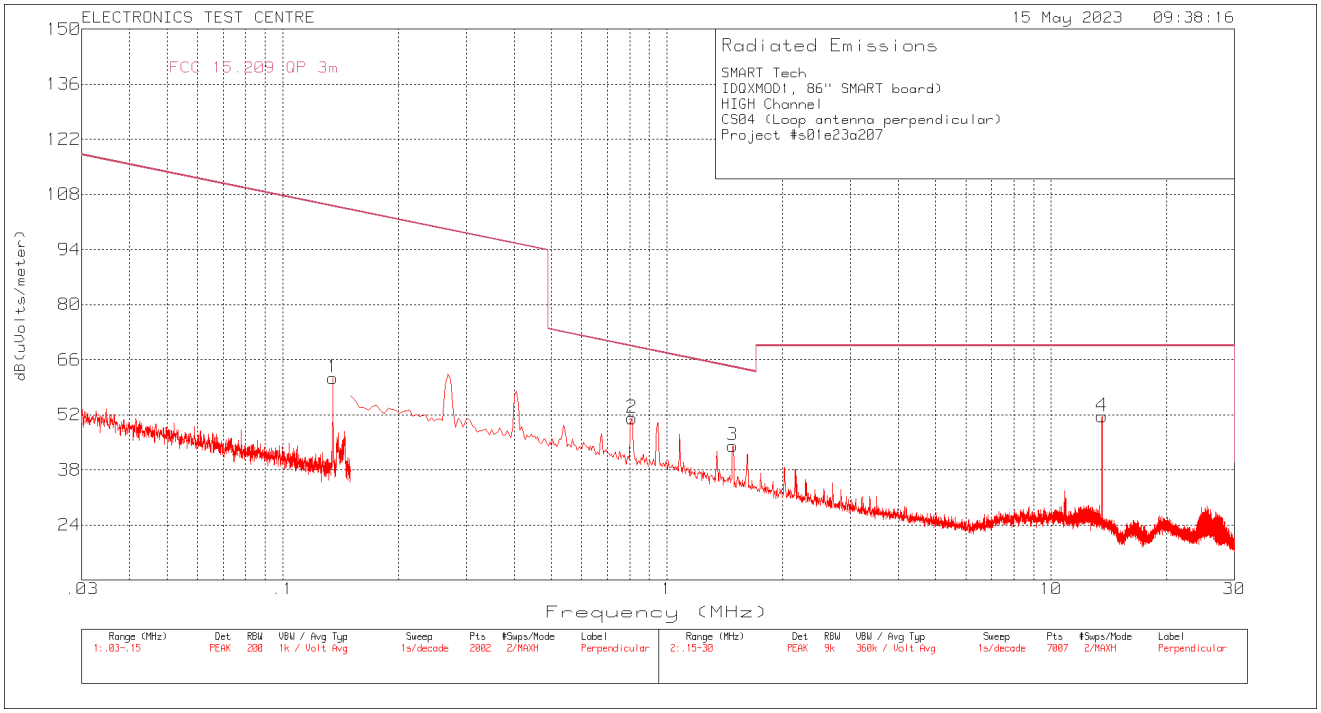
- Measured average reading using linear average detector during radiated emission is corrected with operating duty cycle correction factors.

Negative values for Delta indicate compliance.

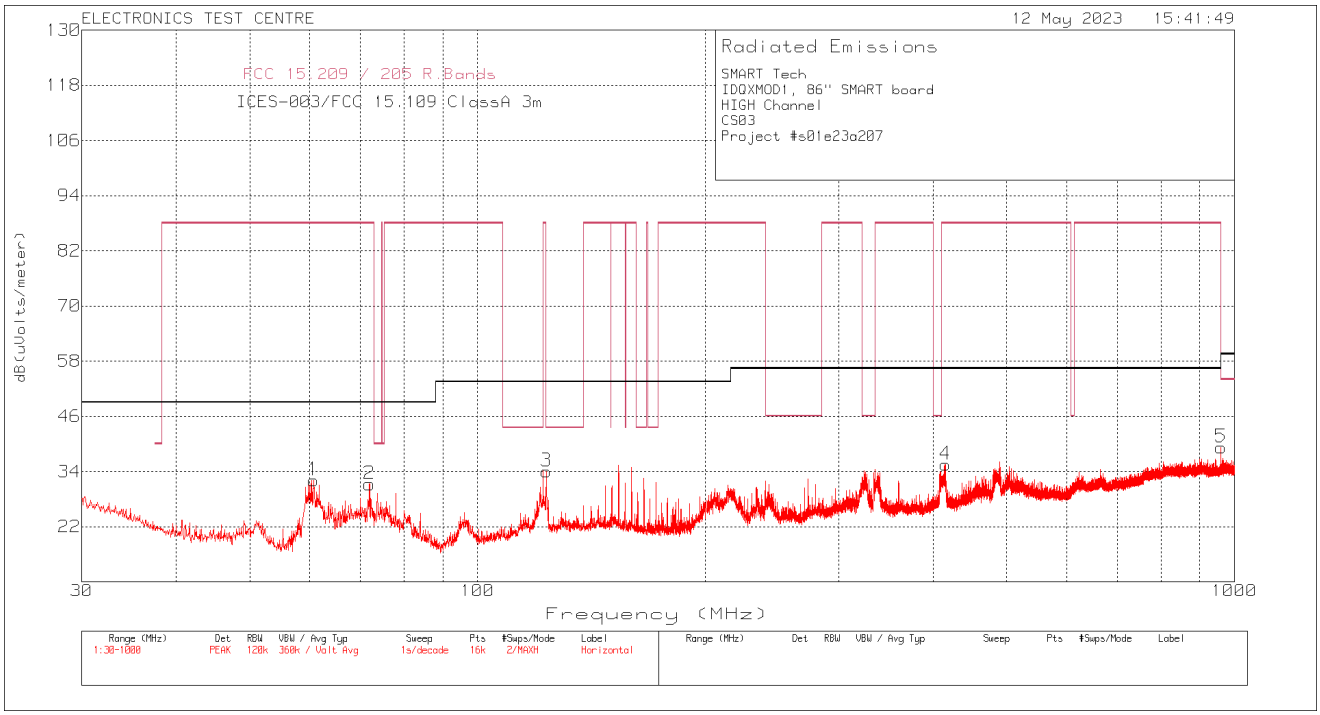
Plot of Radiated Emissions: Parallel polarization, 30k-30MHz



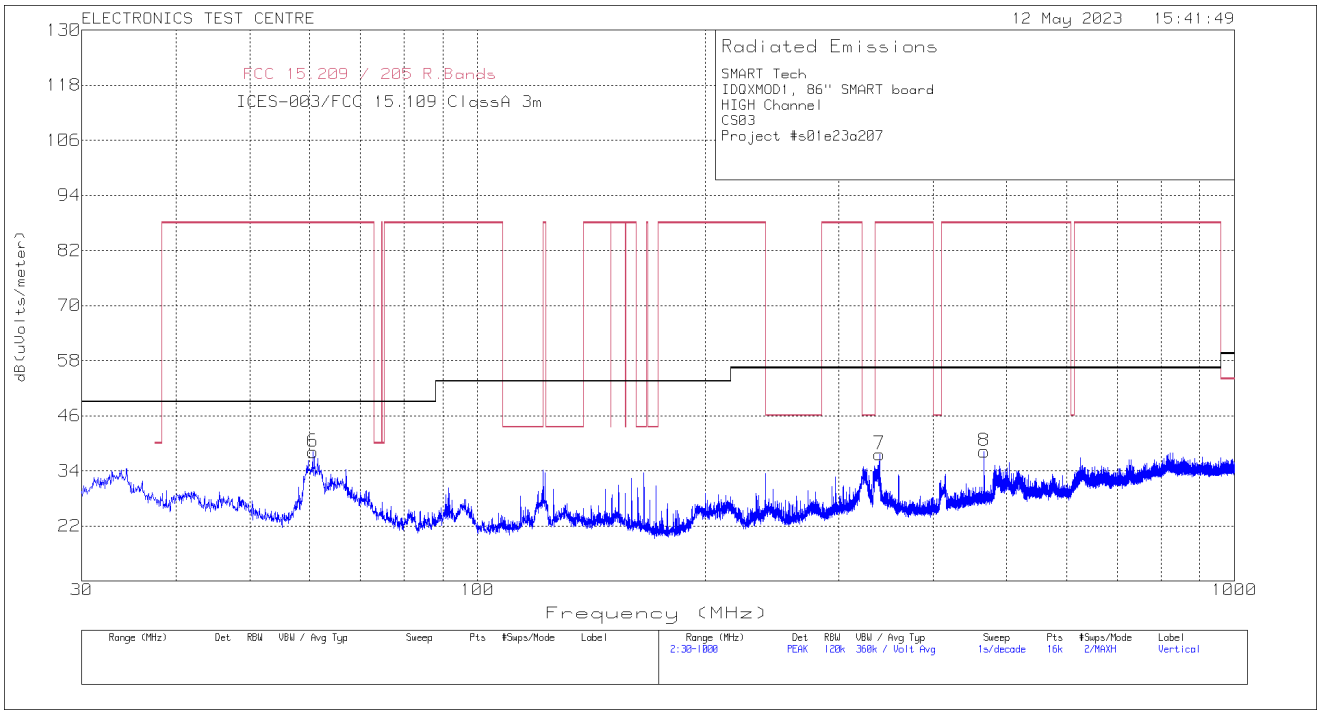
Plot of Radiated Emissions: Perpendicular polarization, 30k-30MHz



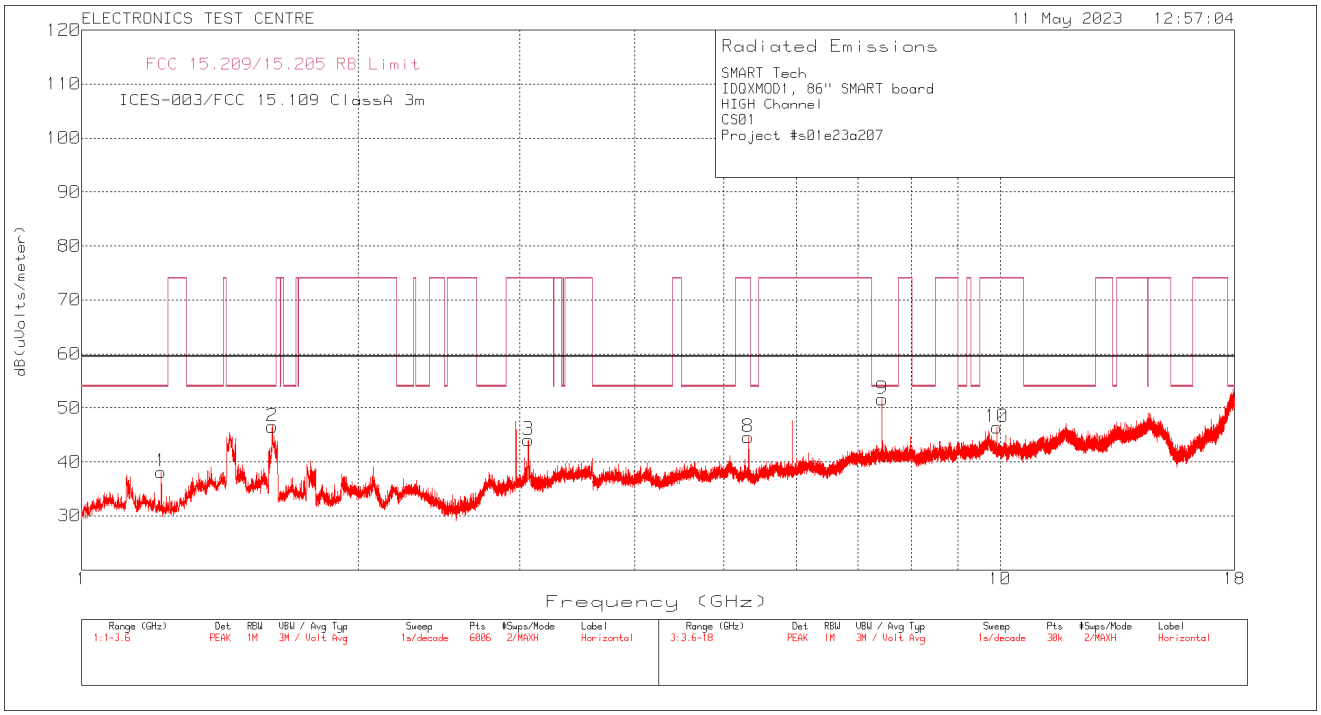
Plot of Radiated Emissions: Horizontal polarization, 30M-1GHz



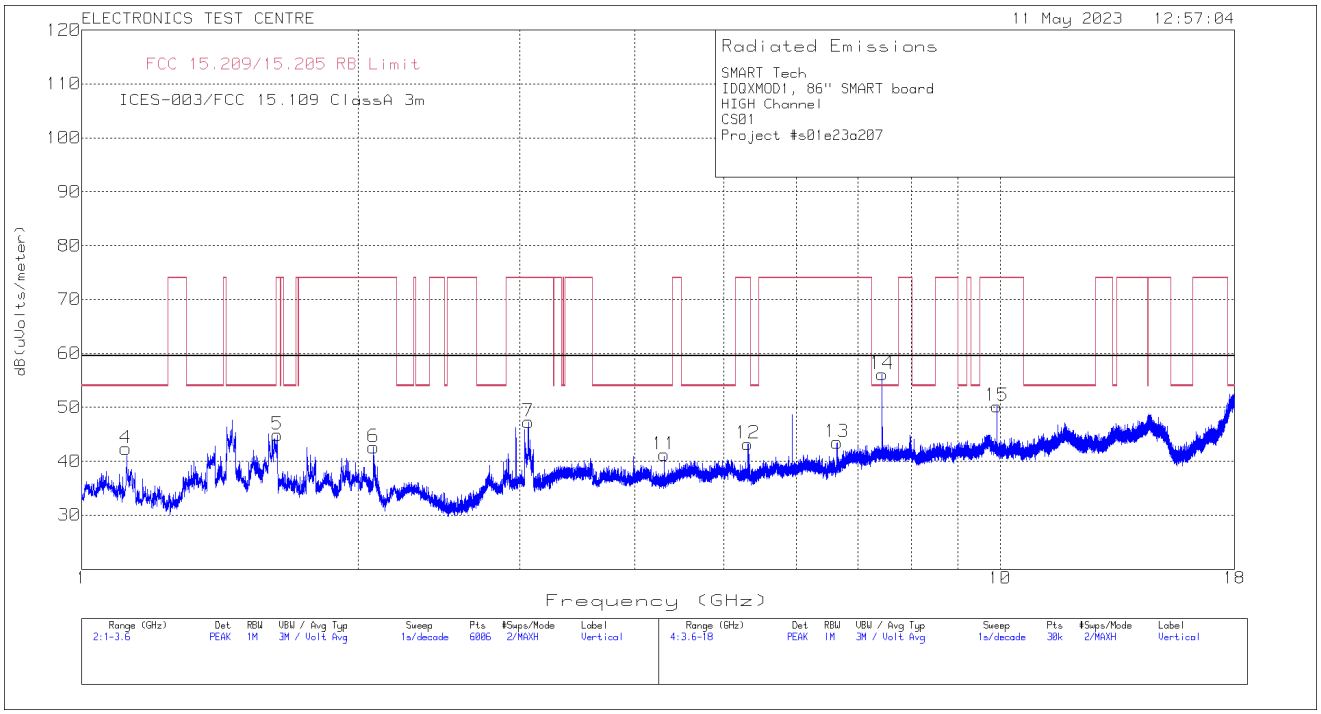
Plot of Radiated Emissions: Vertical polarization, 30M-1GHz



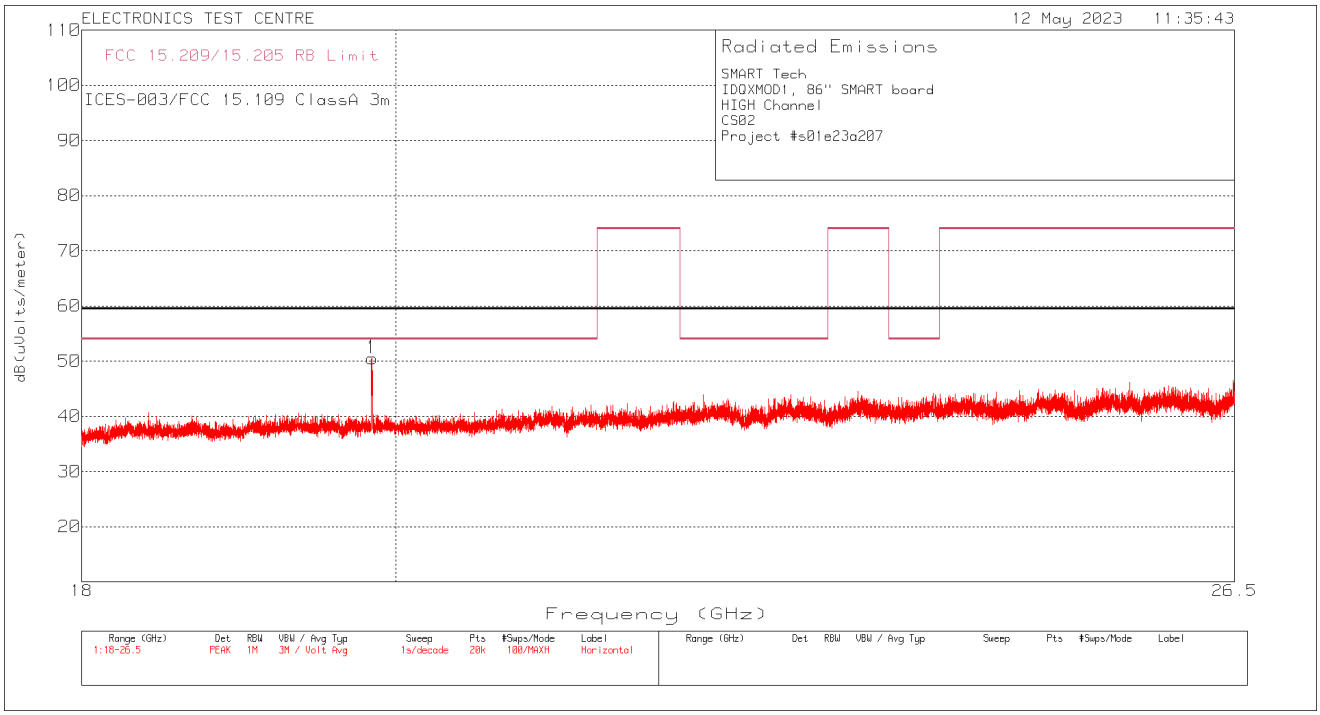
Plot of Radiated Emissions: Horizontal polarization, 1-18GHz



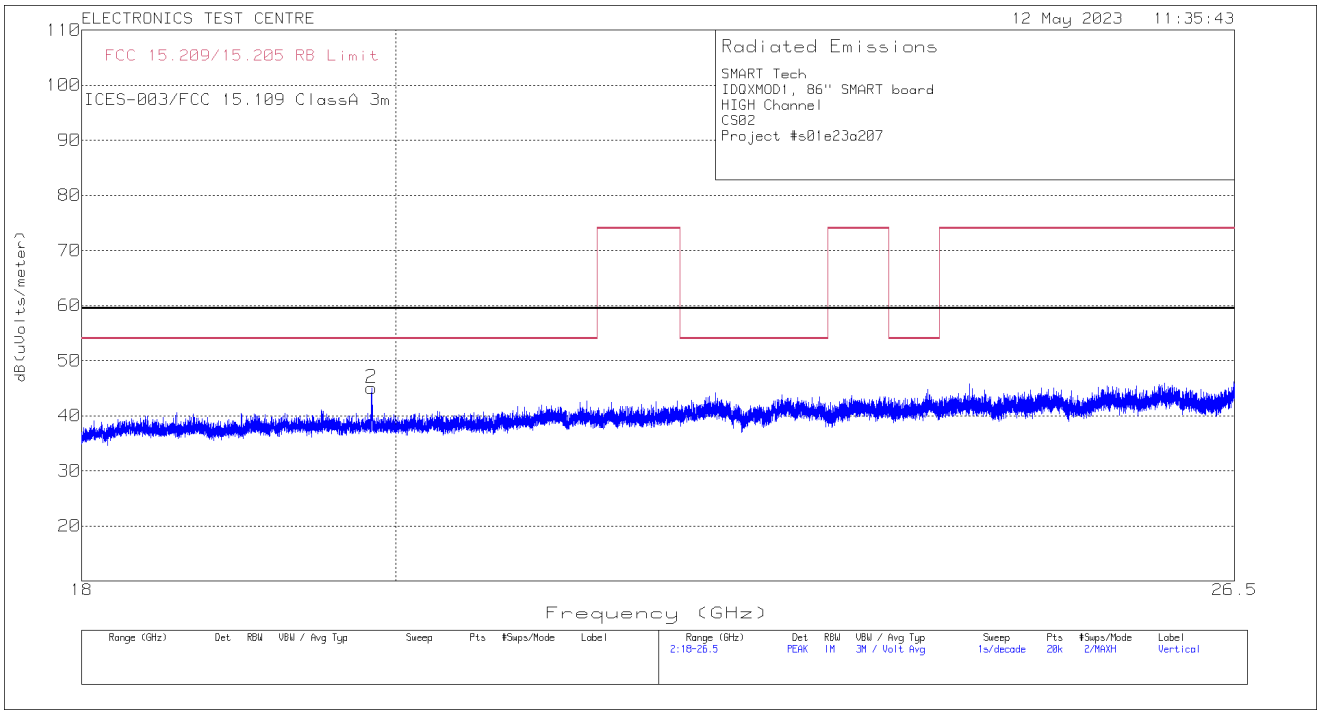
Plot of Radiated Emissions: Vertical polarization, 1-18GHz



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



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



2.2.6 Radiated Emissions Maximized Data (LOW 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.

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	7.2052	28.7	AV	36	-26.6	38.1	54	-15.90	159	269	Horizontal
		40.16	PK			49.56	74	-24.44			
2	9.6091	24.34	AV	37.6	-24.7	37.24	54	-16.76	239	264	Horizontal
		35.54	PK			48.44	74	-25.56			
3	5.3152	23.31	AV	33.7	-29.6	27.41	54	-26.59	112	213	Vertical
		48.6	PK			52.7	74	-21.30			
4	7.2052	35.44	AV	36	-26.6	44.84	54	-9.16	305	180	Vertical
		45.99	PK			55.39	74	-18.61			
5	9.6091	29.68	AV	37.6	-24.7	42.58	54	-11.42	280	237	Vertical
		40.14	PK			53.04	74	-20.96			
1	19.216	34.33	AV	34.6	-22.1	46.83	54	-7.17	299	147	Horizontal
		44.91	PK			57.41	74	-16.59			
2	19.216	30.35	AV	34.6	-22.1	42.75	54	-11.25	238	155	Vertical
		42.42	PK			54.82	74	-19.18			

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

- 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

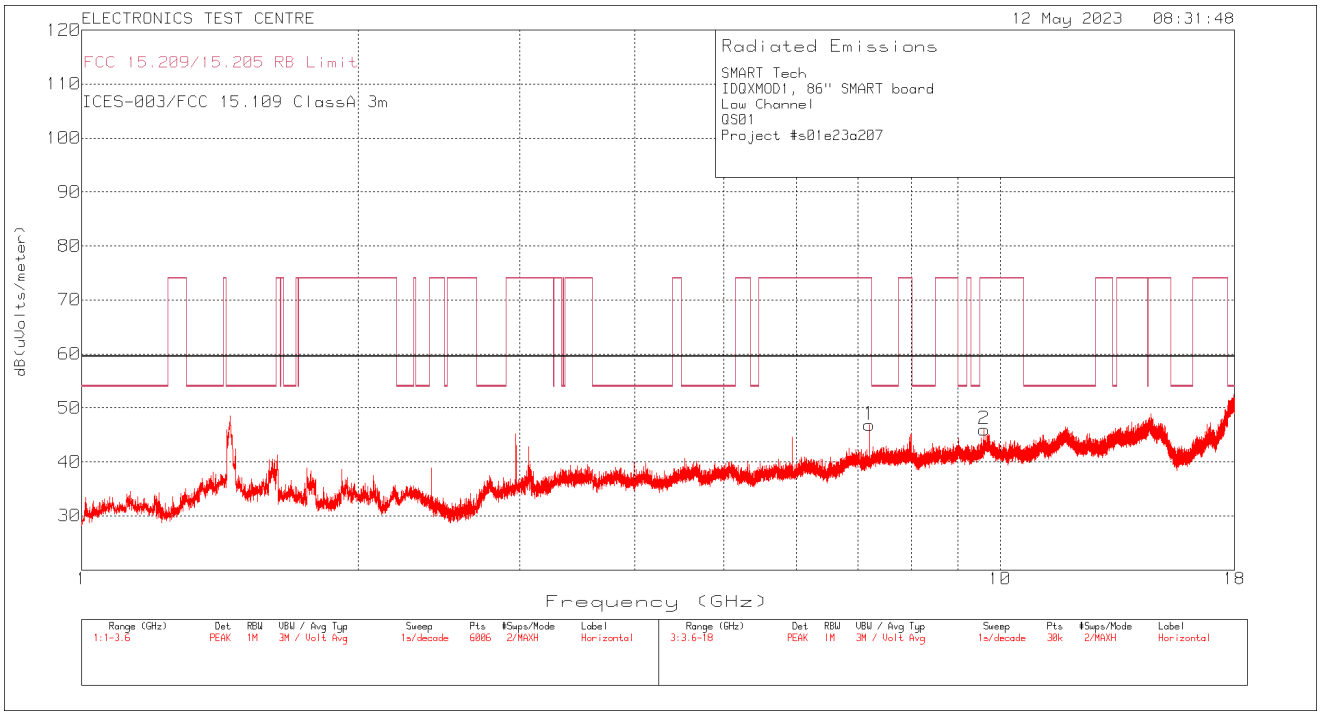
Test mode Duty Cycle (D) = 53.4% (.534)
DCCF = 10log (1/D) = 10log (1/.534) = 2.72 dB
Maximum operating duty cycle (D) = 7.5% (0.075)
DCCF = 10log (1/D) = 10log (1/.075) = 11.25 dB

DCCF applied to the Average measurements = (Test mode duty cycle) – (Max operating duty cycle)
DCCF = 2.72 - 11.25
DCCF = -8.53 dB

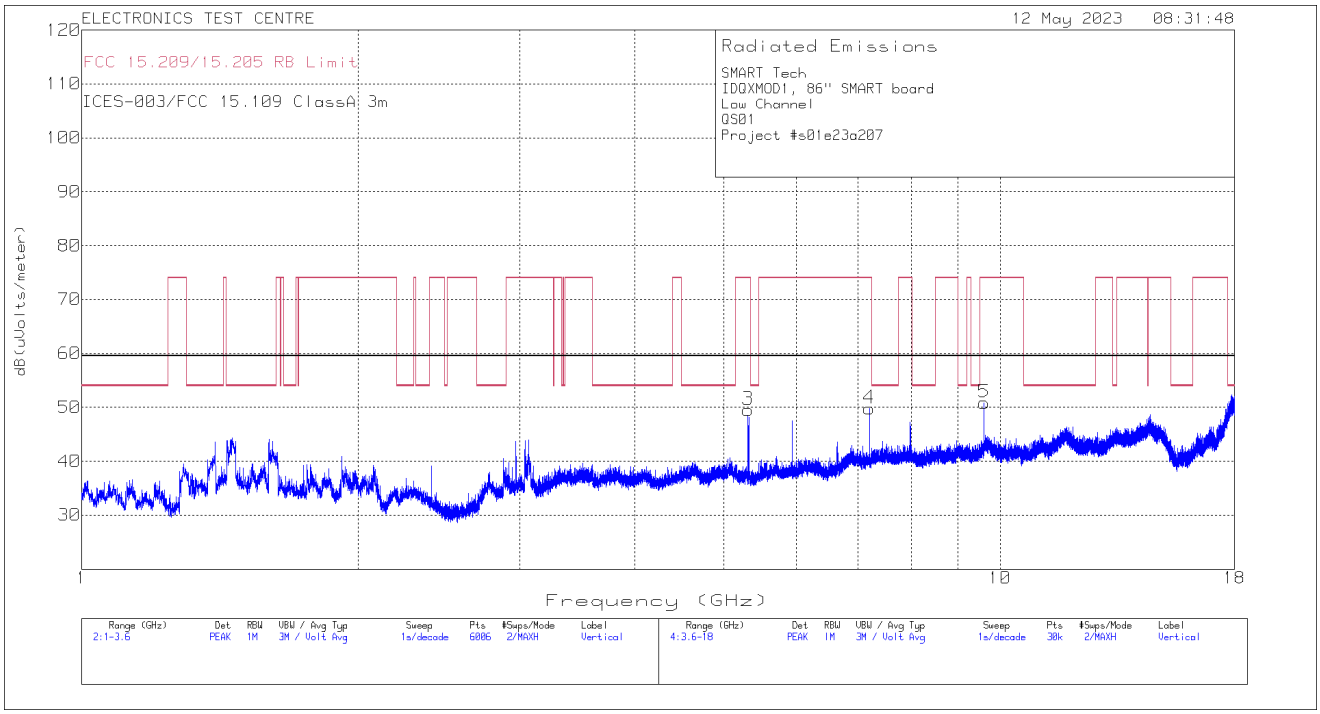
Freq. Marker	Freq. [GHz]	Measured AVG Value [dBµV/m]	D.C Correction Factor (dB)	Corrected Average Value [dBµV/m]	RSS-GEN FCC 15.209 Limit [dBµV/m]	Delta [dB]	Polarization
1	7.2052	38.1	-8.53	29.57	54	-24.43	Horizontal
2	9.6091	37.24	-8.53	28.71	54	-25.29	Horizontal
3	7.2052	44.84	-8.53	36.31	54	-17.69	Vertical
4	9.6091	42.58	-8.53	34.05	54	-19.95	Vertical
1	19.216	46.83	-8.53	38.3	54	-15.7	Horizontal
2	19.216	42.75	-8.53	34.22	54	-19.78	Vertical

Negative values for Delta indicate compliance.

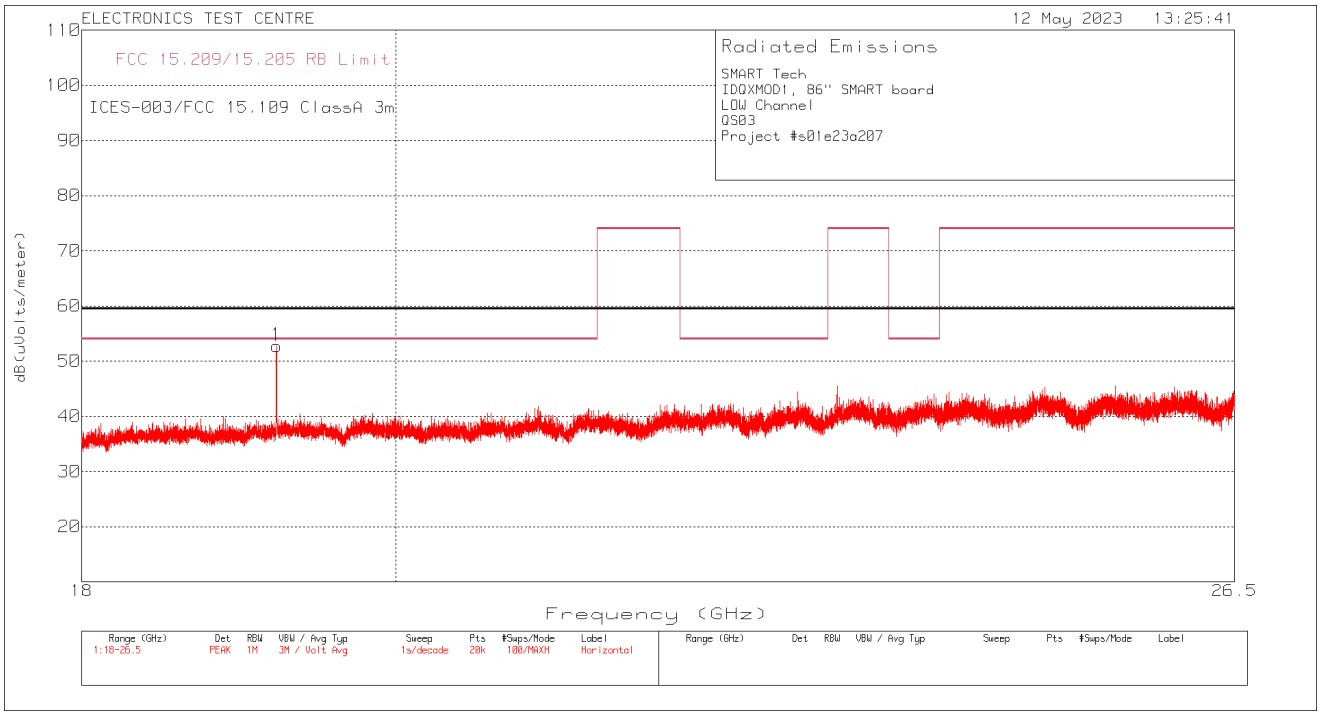
Plot of Radiated Emissions: Horizontal polarization, 1-18GHz



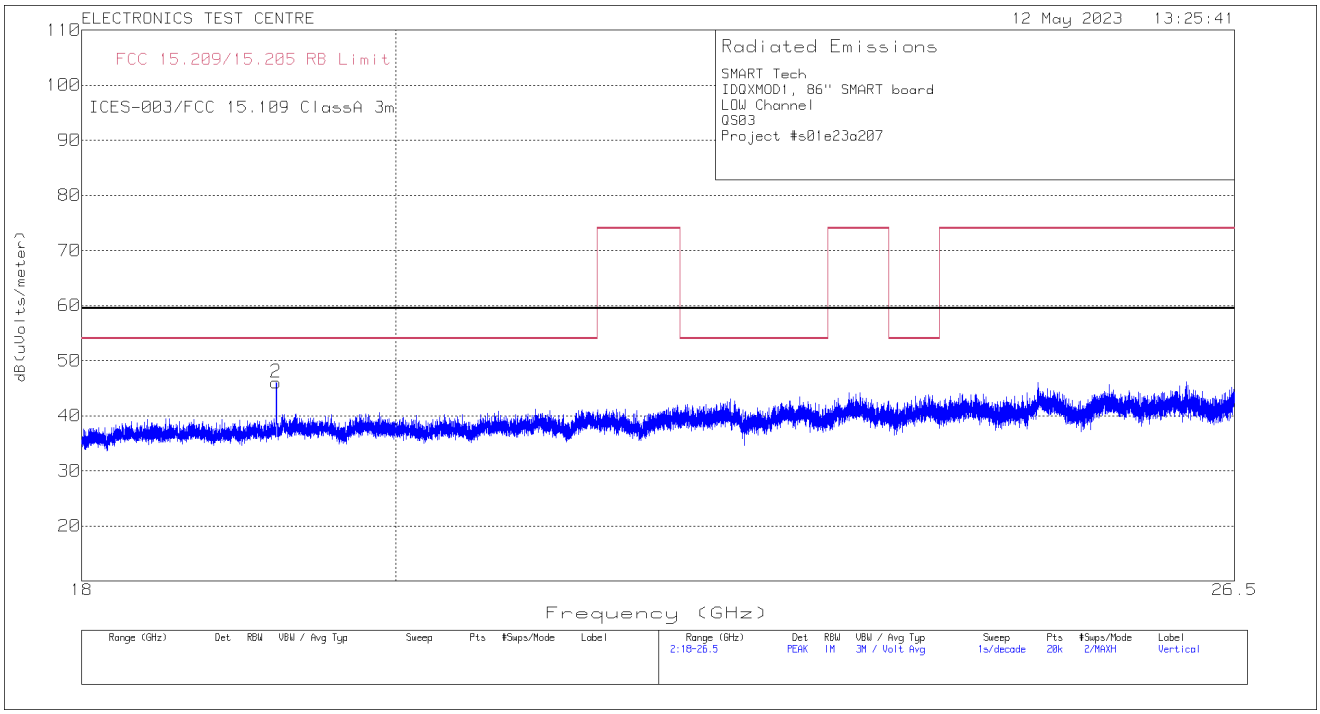
Plot of Radiated Emissions: Vertical polarization, 1-18GHz



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



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



2.2.7 Radiated Emissions Maximized Data (MID 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.

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	7.3208	33.1	AV	36.4	-26.8	42.7	54	-11.30	275	339	Horizontal
		42.99	PK			52.59	74	-21.41			
2	9.7607	25.61	AV	37.8	-24.6	38.81	54	-15.19	241	258	Horizontal
		37.81	PK			51.01	74	-22.99			
3	5.3152	23.3	AV	33.7	-29.6	27.4	54	-26.60	113	208	Vertical
		48.5	PK			52.6	74	-21.40			
4	7.3208	36.22	AV	36.4	-26.8	45.82	54	-8.18	313	207	Vertical
		45.27	PK			54.87	74	-19.13			
5	9.7607	30.74	AV	37.8	-24.6	43.94	54	-10.06	279	168	Vertical
		40.42	PK			53.62	74	-20.38			
1	19.52	23.54	AV	34.7	-22.1	36.14	54	-17.86	89	369	Horizontal
		36.35	PK			48.95	74	-25.05			
2	19.52	23.75	AV	34.7	-22.1	36.35	54	-17.65	33	366	Vertical
		36.82	PK			49.42	74	-24.58			

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.
- QP = Quasi-Peak detector; AV = Average detector; PK = Peak detector

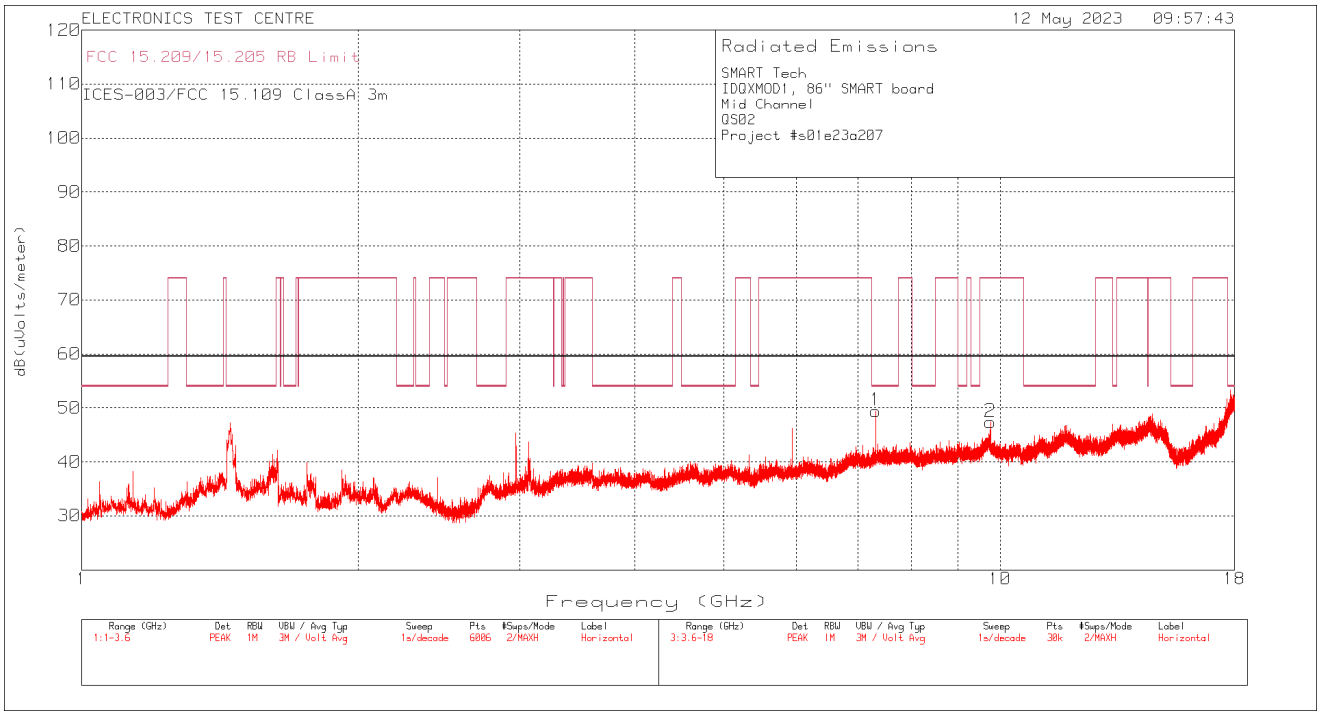
Measured test mode Duty Cycle (D) = 53.4% (.534)
DCCF = 10log (1/D) = 10log (1/.534) = 2.72 dB
Maximum operating duty cycle (D) = 7.5% (0.075)
DCCF = 10log (1/D) = 10log (1/.075) = 11.25 dB

DCCF applied to the Average measurements = (Test mode duty cycle) – (Max operating duty cycle)
DCCF = 2.72 - 11.25
DCCF = -8.53 dB

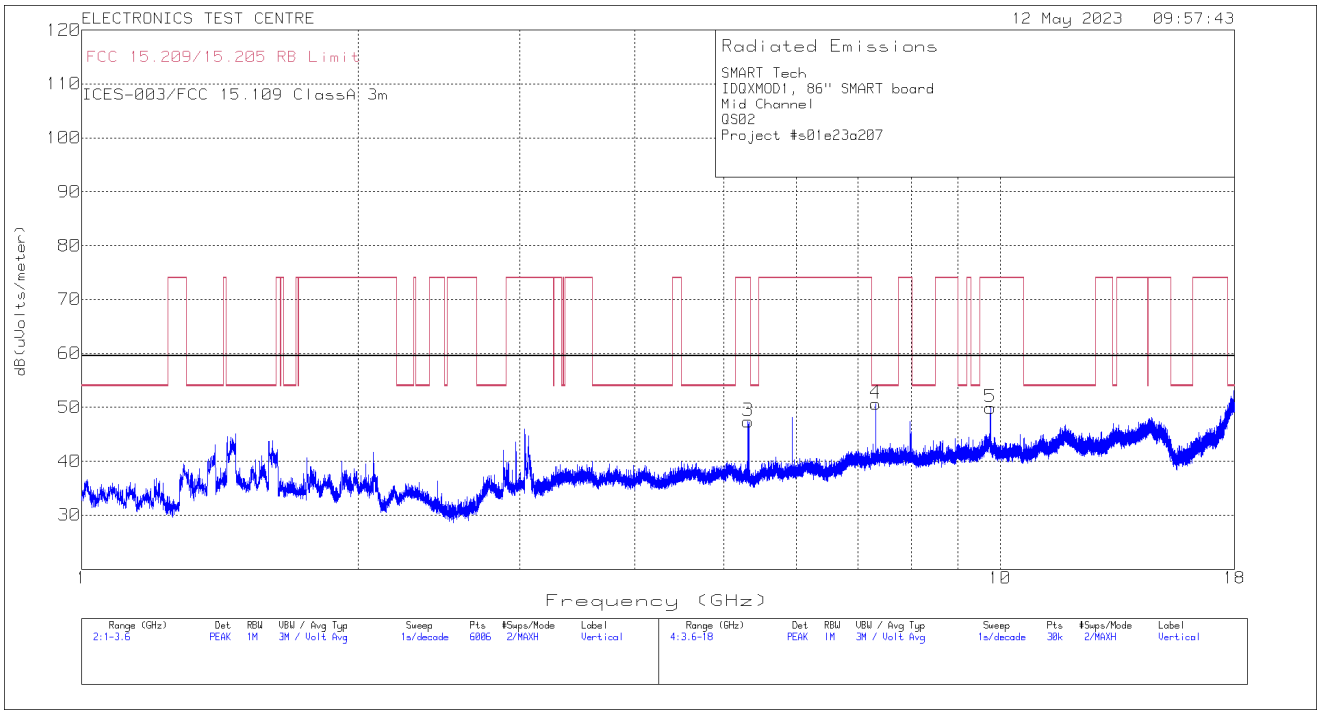
Freq. Marker	Freq. [GHz]	Measured AVG Value [dBµV/m]	D.C Correction Factor (dB)	Corrected Average Value [dBµV/m]	RSS-GEN FCC 15.209 Limit [dBµV/m]	Delta [dB]	Polarization
1	7.3208	42.7	-8.53	34.17	54	-19.83	Horizontal
2	9.7607	38.81	-8.53	30.28	54	-23.72	Horizontal
3	7.3208	45.82	-8.53	37.29	54	-16.71	Vertical
4	9.7607	43.94	-8.53	35.41	54	-18.59	Vertical
1	19.52	36.14	-8.53	27.61	54	-26.39	Horizontal
2	19.52	36.35	-8.53	27.82	54	-26.18	Vertical

Negative values for Delta indicate compliance.

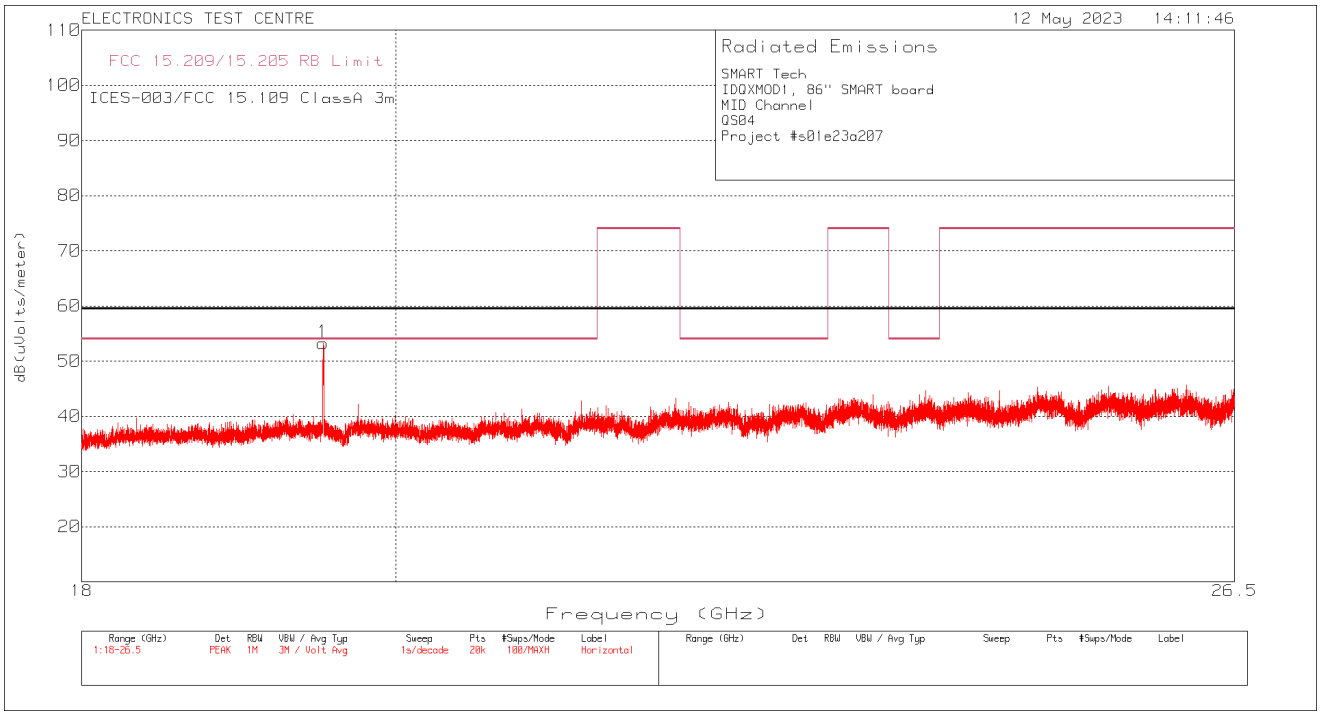
Plot of Radiated Emissions: Horizontal polarization, 1-18GHz



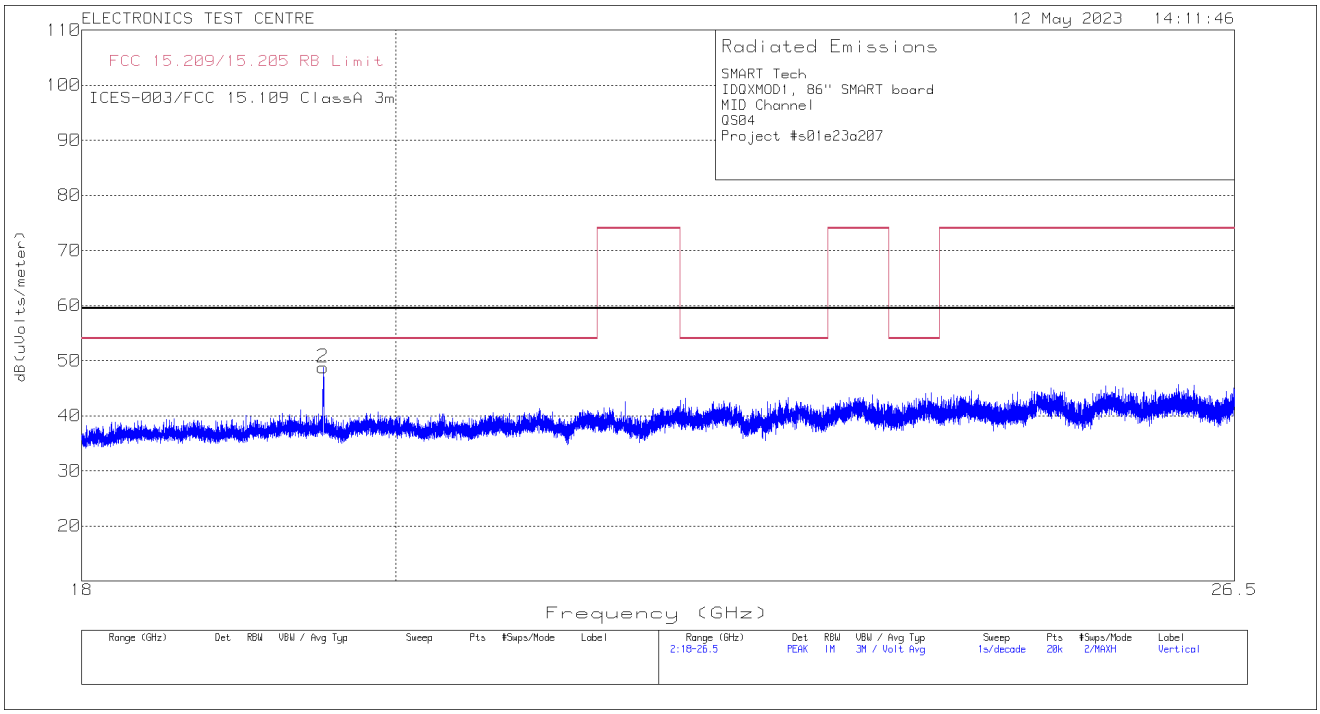
Plot of Radiated Emissions: Vertical polarization, 1-18GHz



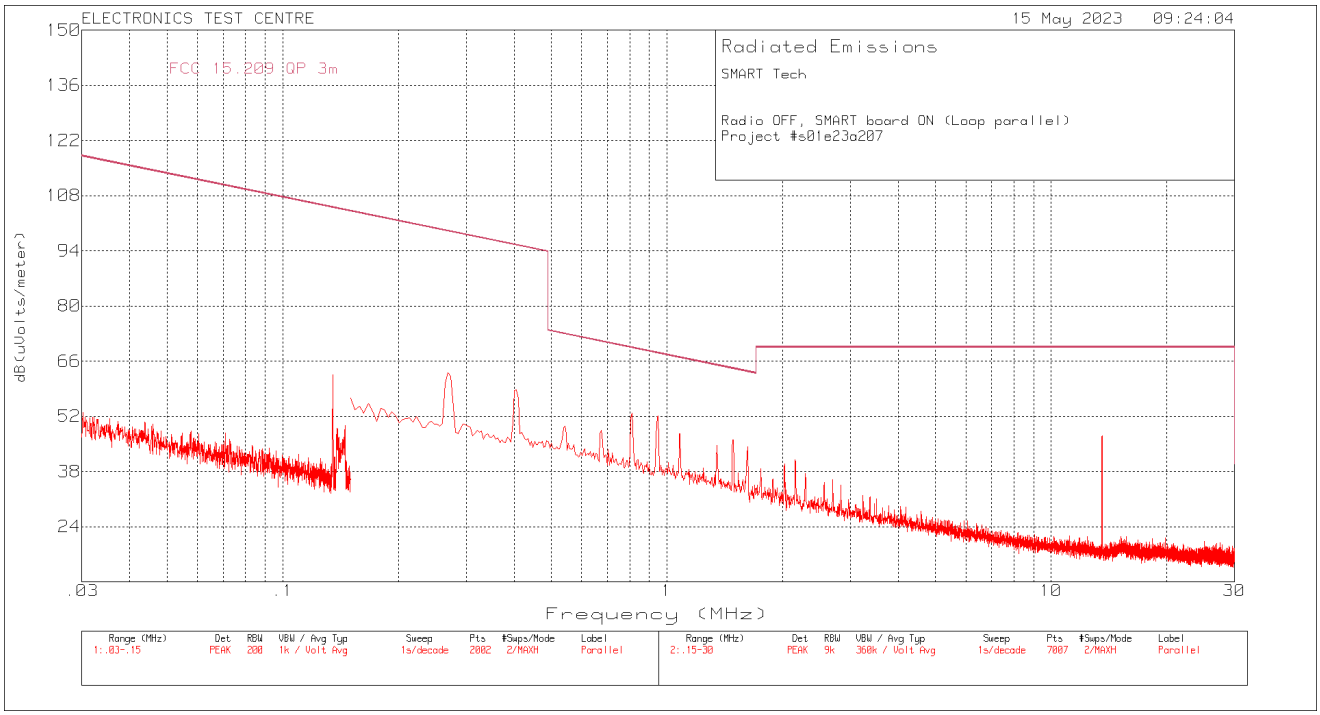
Plot of Radiated Emissions: Horizontal polarization, 18-26.5GHz



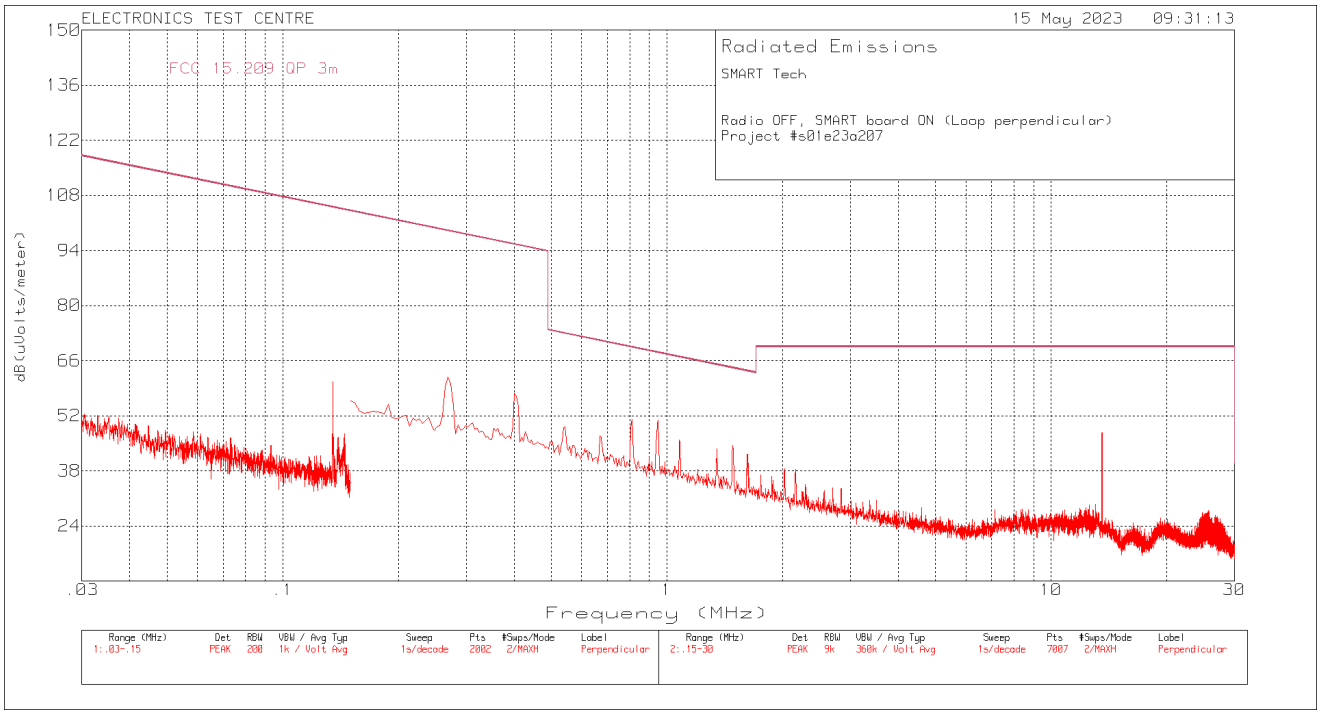
Plot of Radiated Emissions: Vertical polarization, 18-26.5GHz



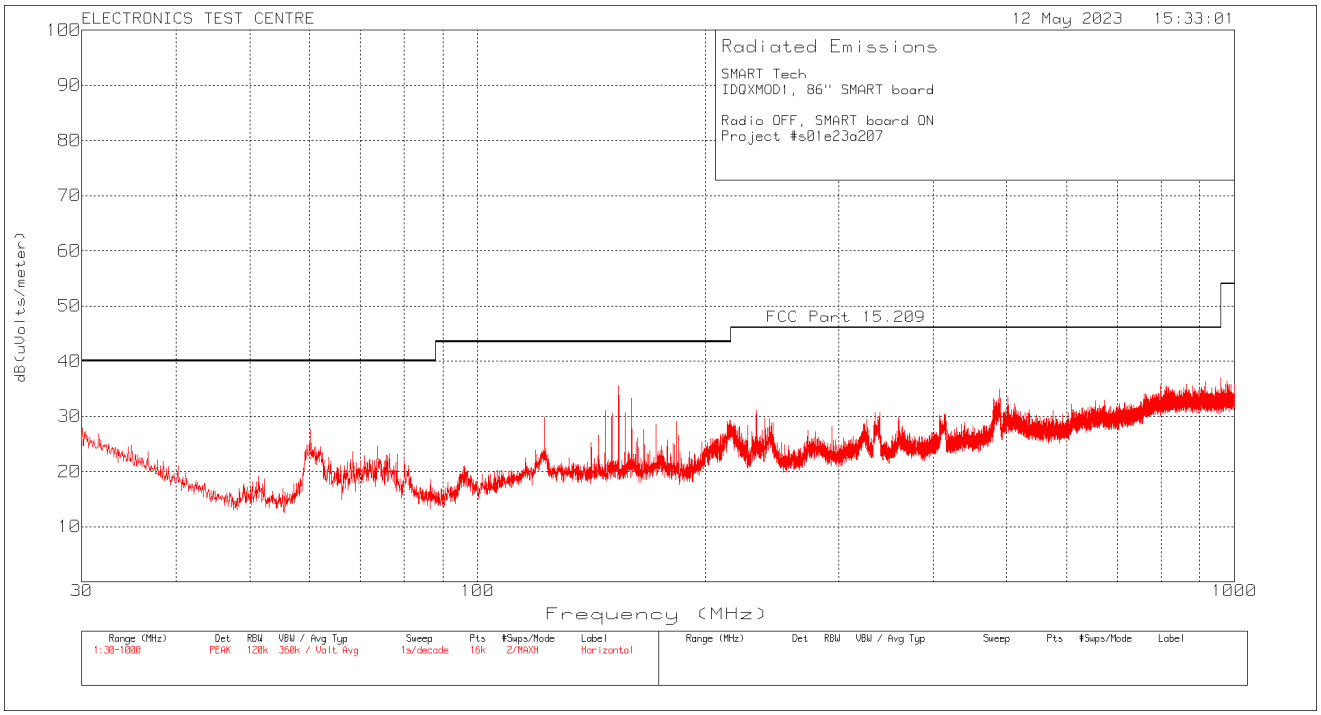
Plot of Radiated Emissions: BLE Radio OFF, Display ON, Parallel polarization, 30k-30MHz



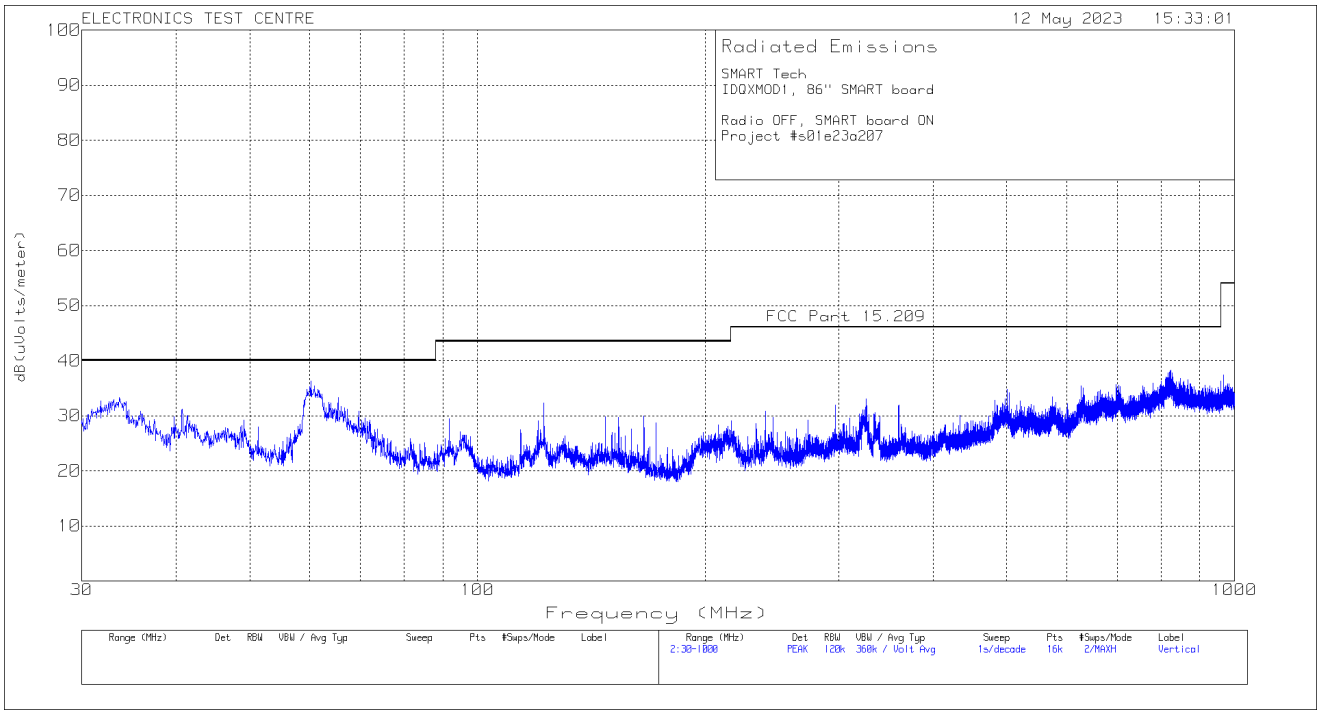
Plot of Radiated Emissions: BLE Radio OFF, Display ON, Perpendicular polarization, 30k-30MHz



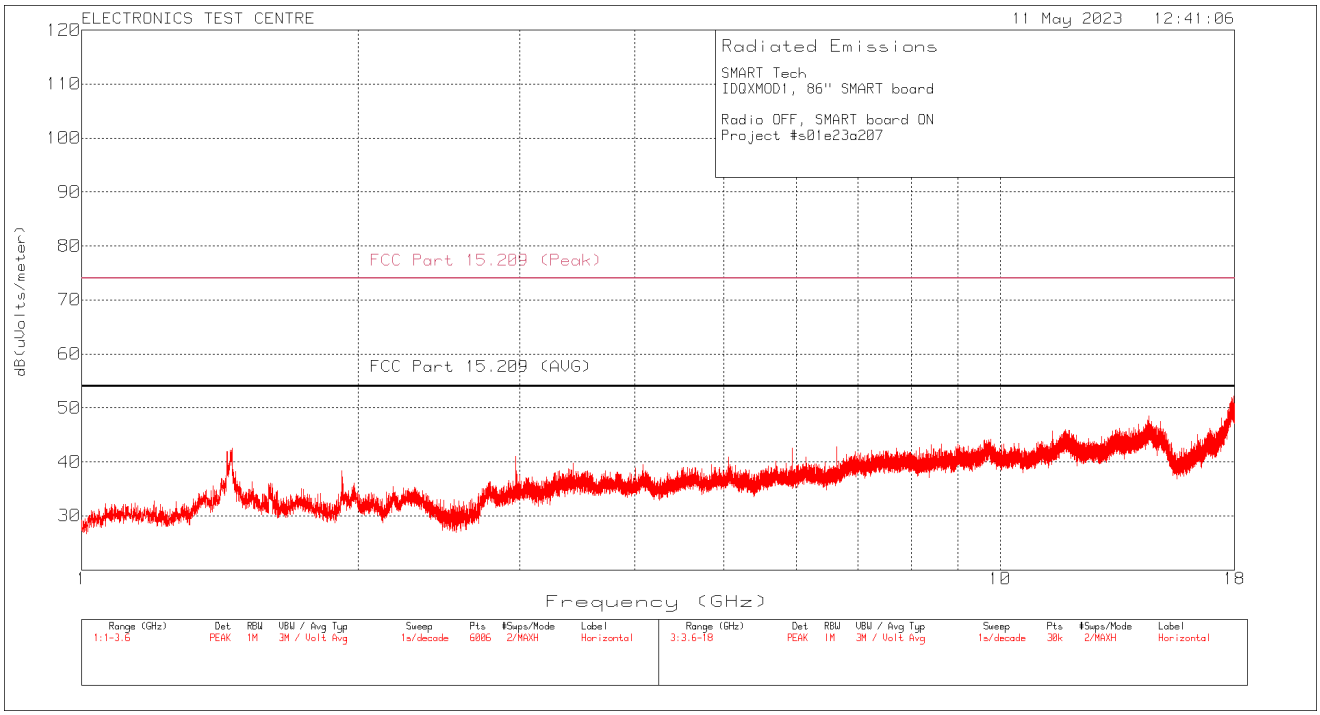
Plot of Radiated Emissions: BLE Radio OFF, Display ON, Horizontal polarization, 30M-1GHz



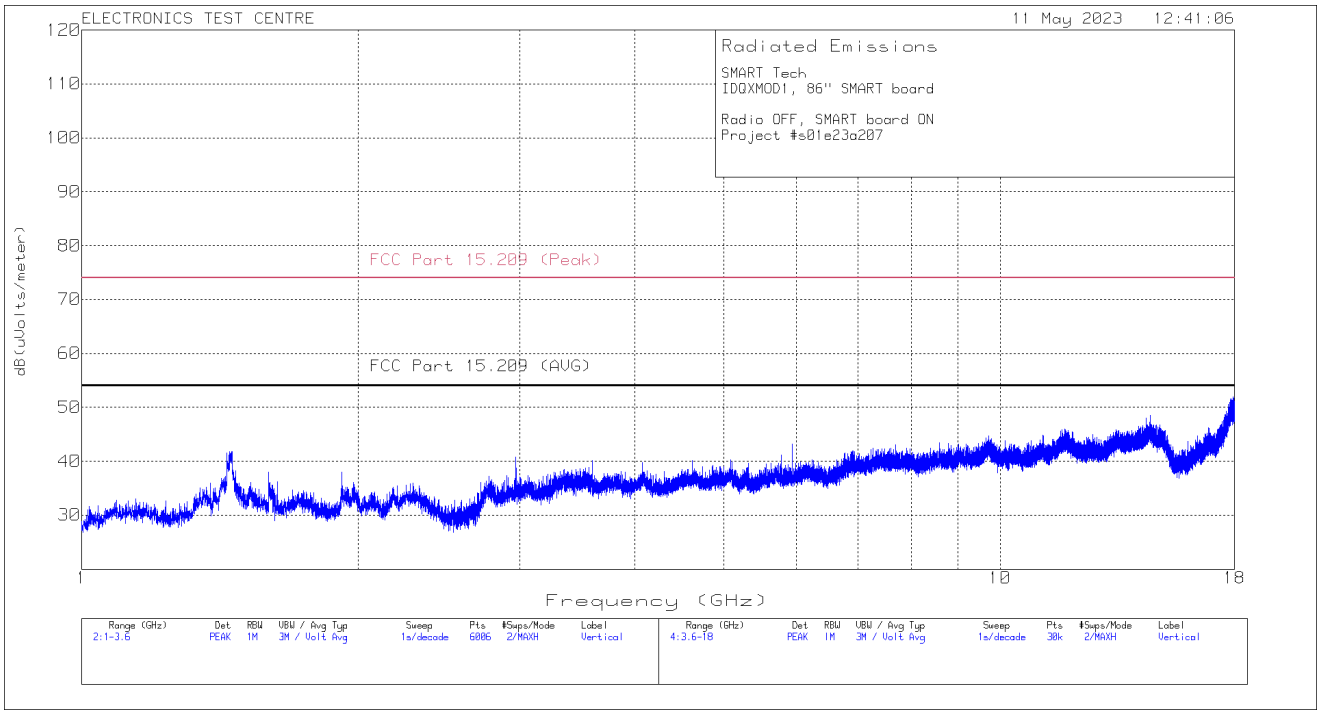
Plot of Radiated Emissions: BLE Radio OFF, SE ON, Vertical polarization, 30M-1GHz



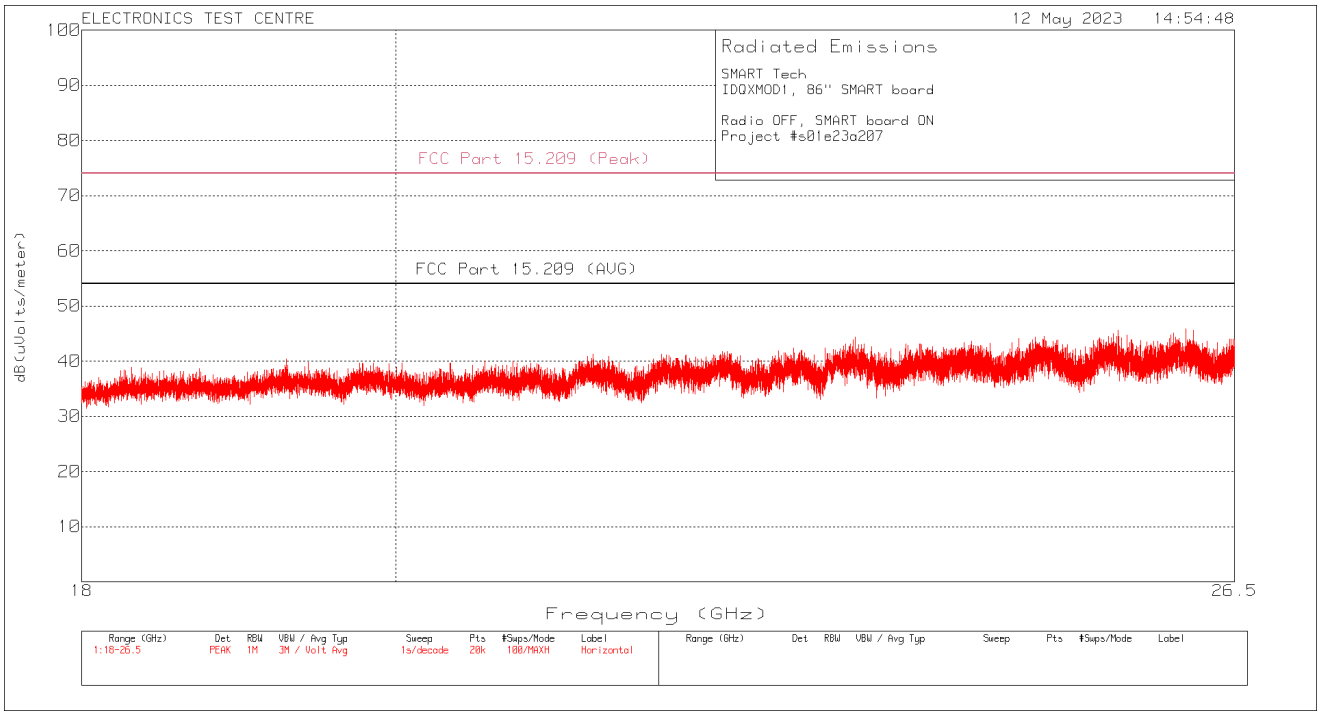
Plot of Radiated Emissions: BLE Radio OFF, Display ON, Horizontal polarization, 1-18GHz



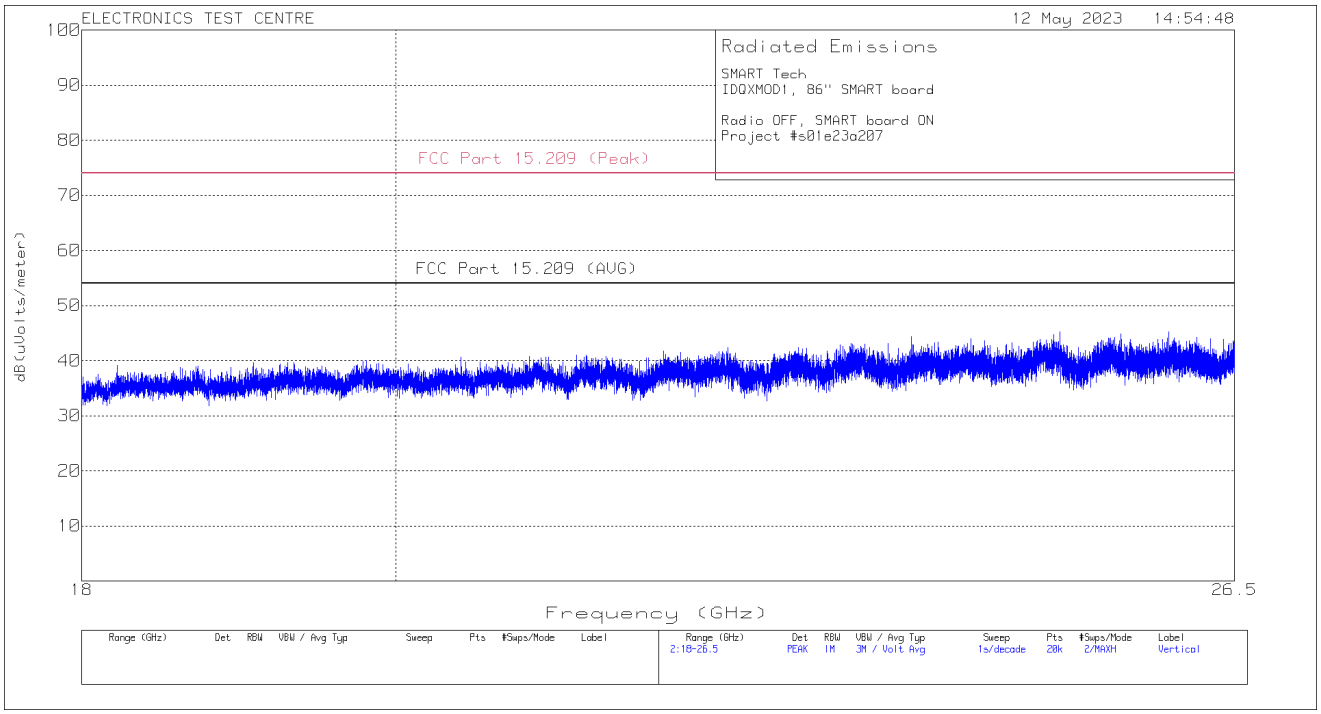
Plot of Radiated Emissions: BLE Radio OFF, Display ON, Vertical polarization, 1-18GHz



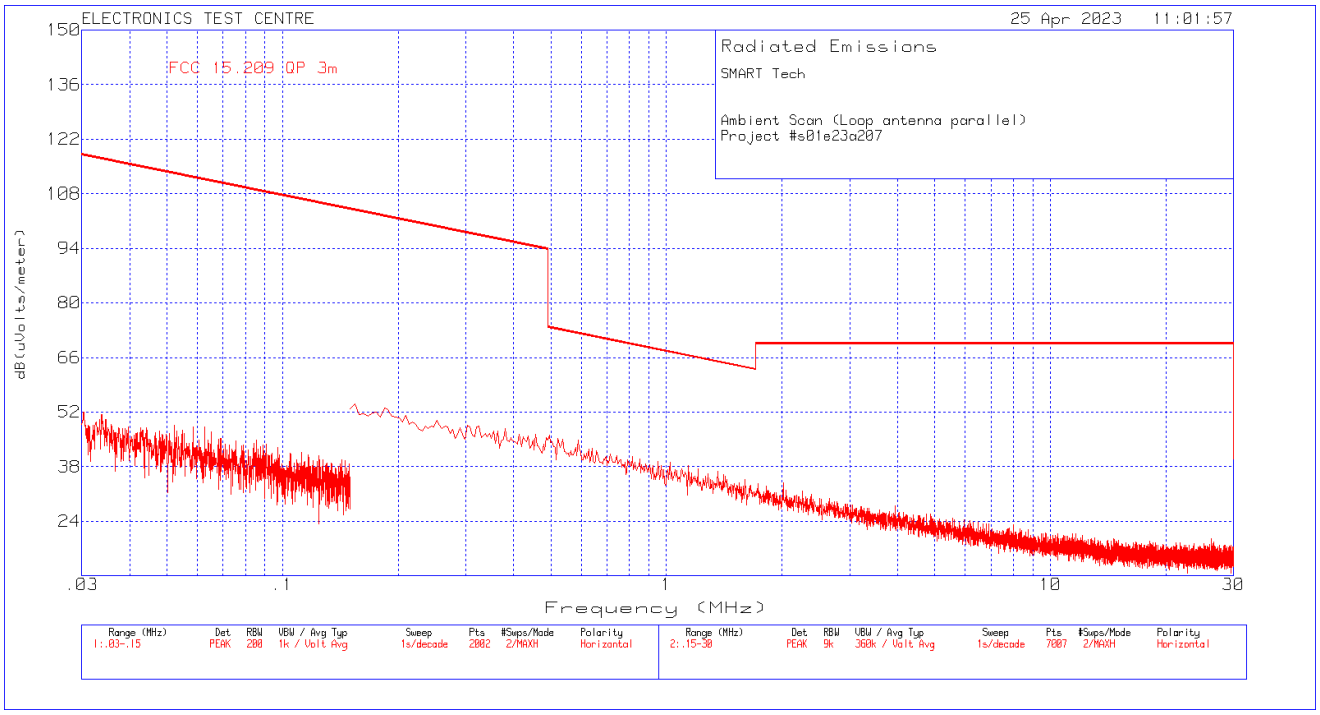
Plot of Radiated Emissions: BLE Radio OFF, Display ON, Horizontal polarization, 18-26.5GHz



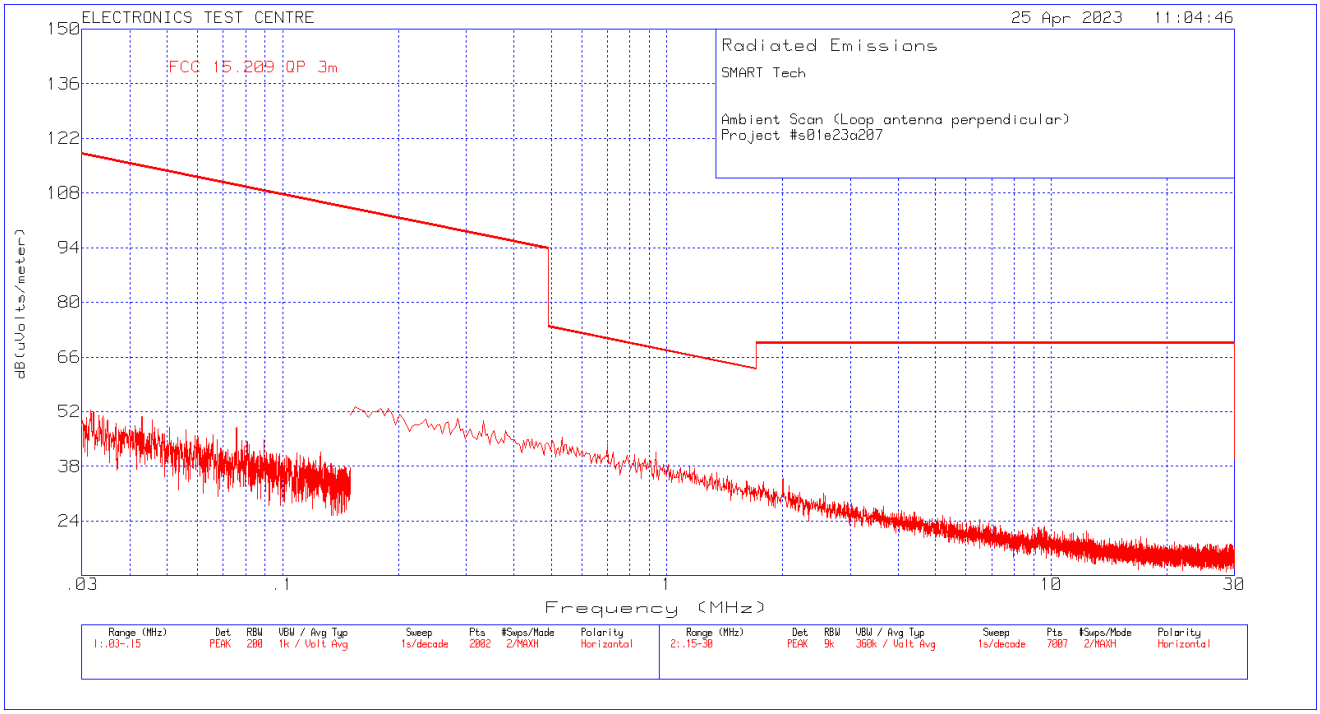
Plot of Radiated Emissions: BLE Radio OFF, Display ON, Vertical polarization, 18-26.5GHz



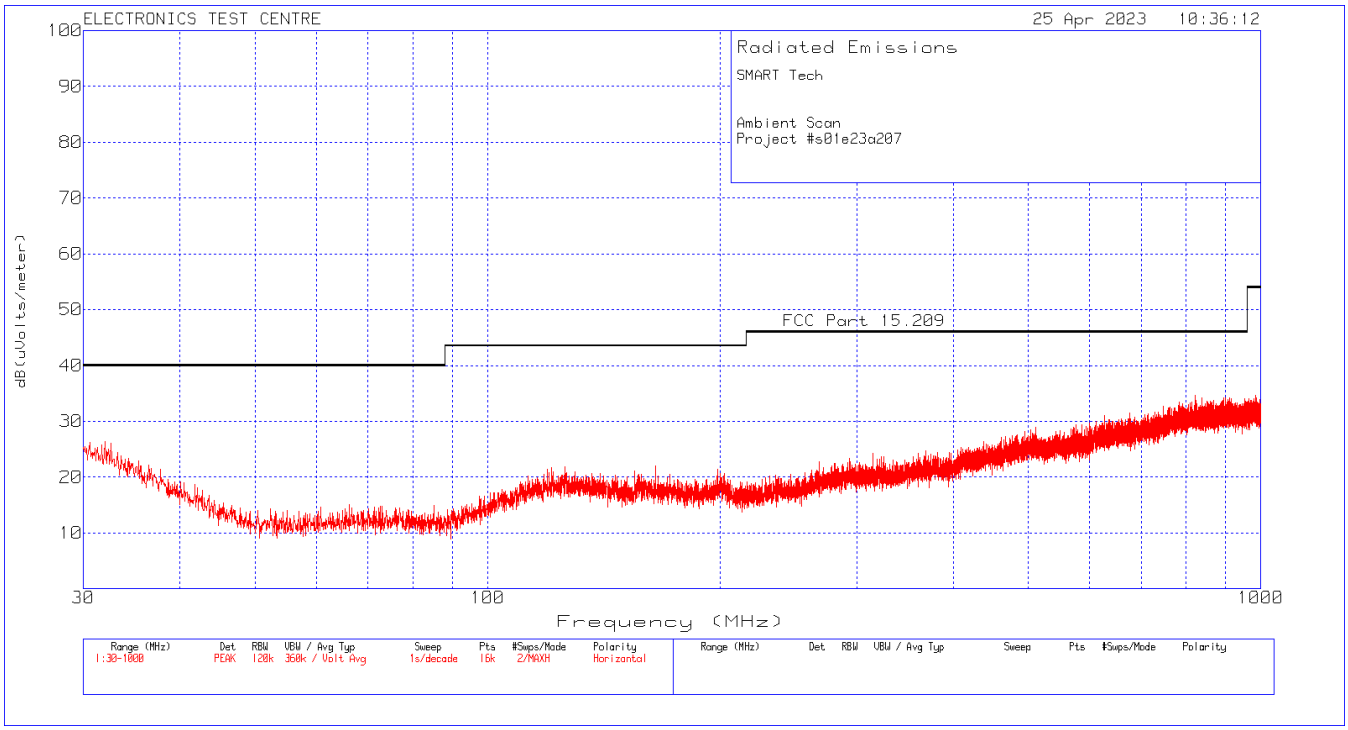
Plot of Test Chamber Ambient: Parallel



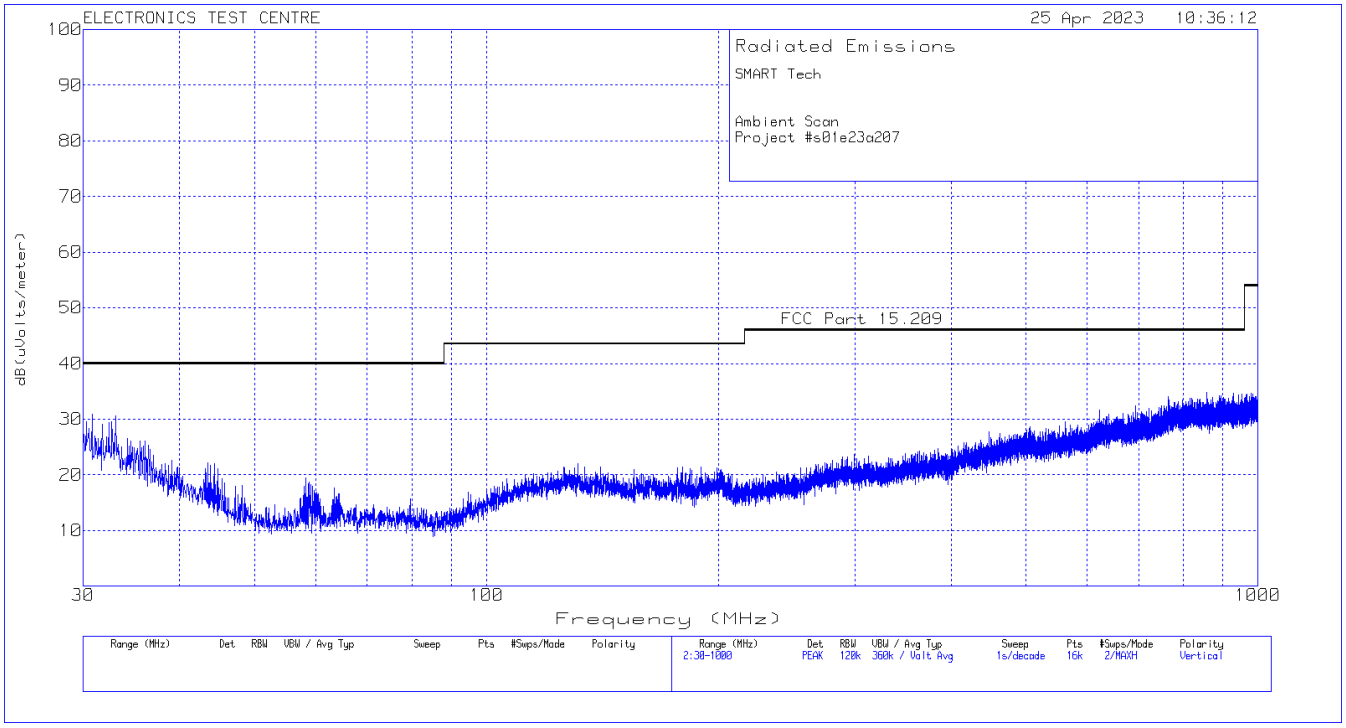
Plot of Test Chamber Ambient: Perpendicular



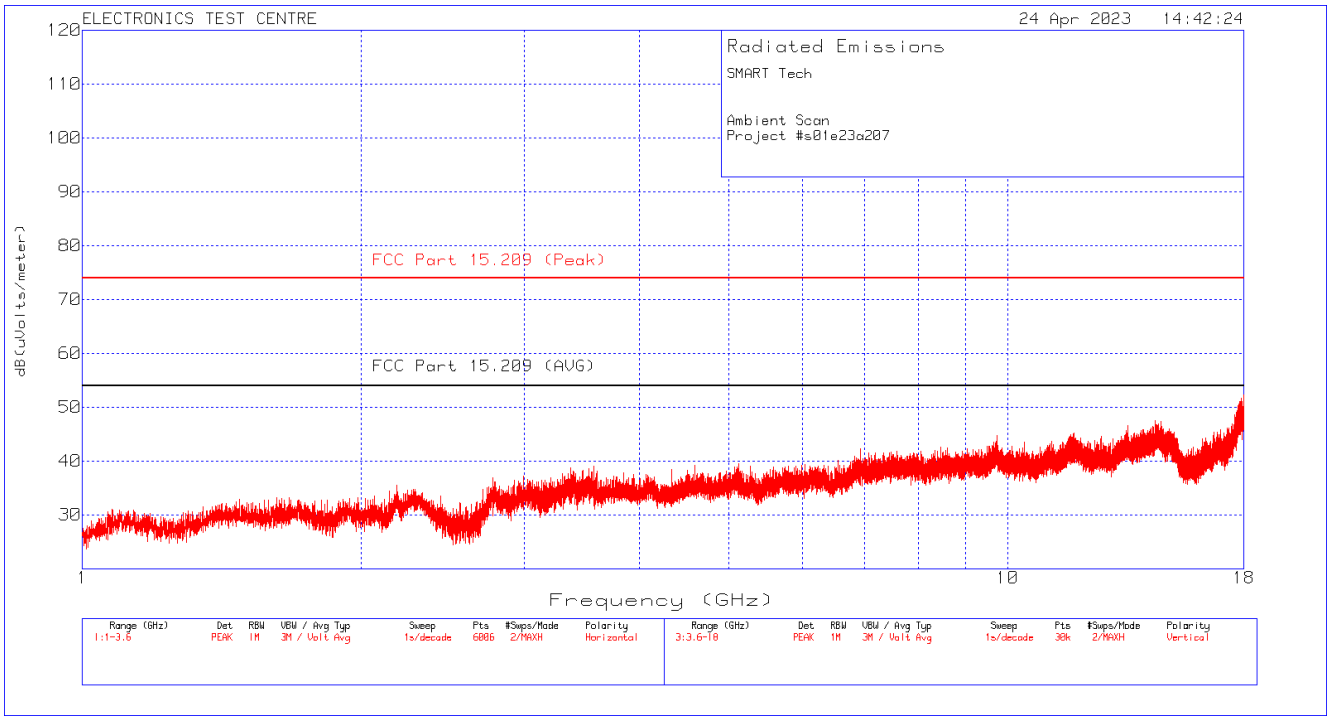
Plot of Test Chamber Ambient: Horizontal polarization



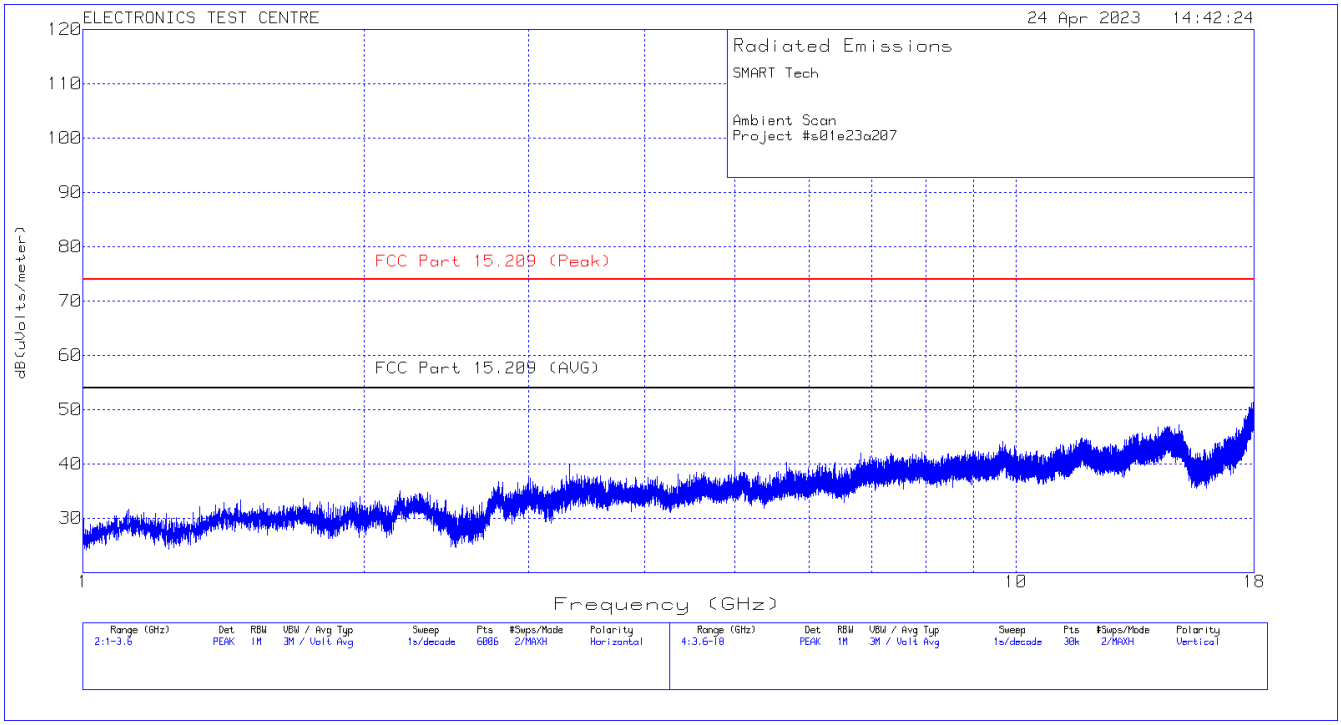
Plot of Test Chamber Ambient: Vertical polarization



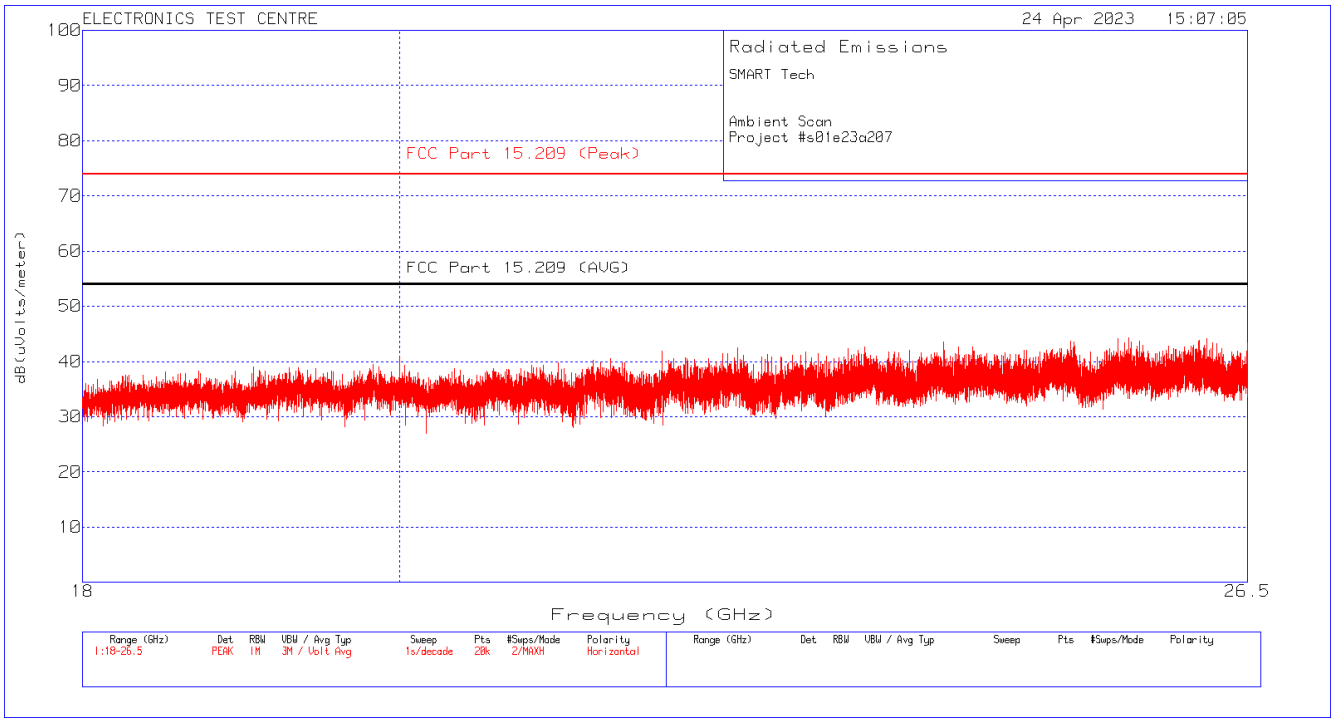
Plot of Test Chamber Ambient: Horizontal polarization



Plot of Test Chamber Ambient: Vertical polarization



Plot of Test Chamber Ambient: Horizontal polarization



Plot of Test Chamber Ambient: Vertical polarization

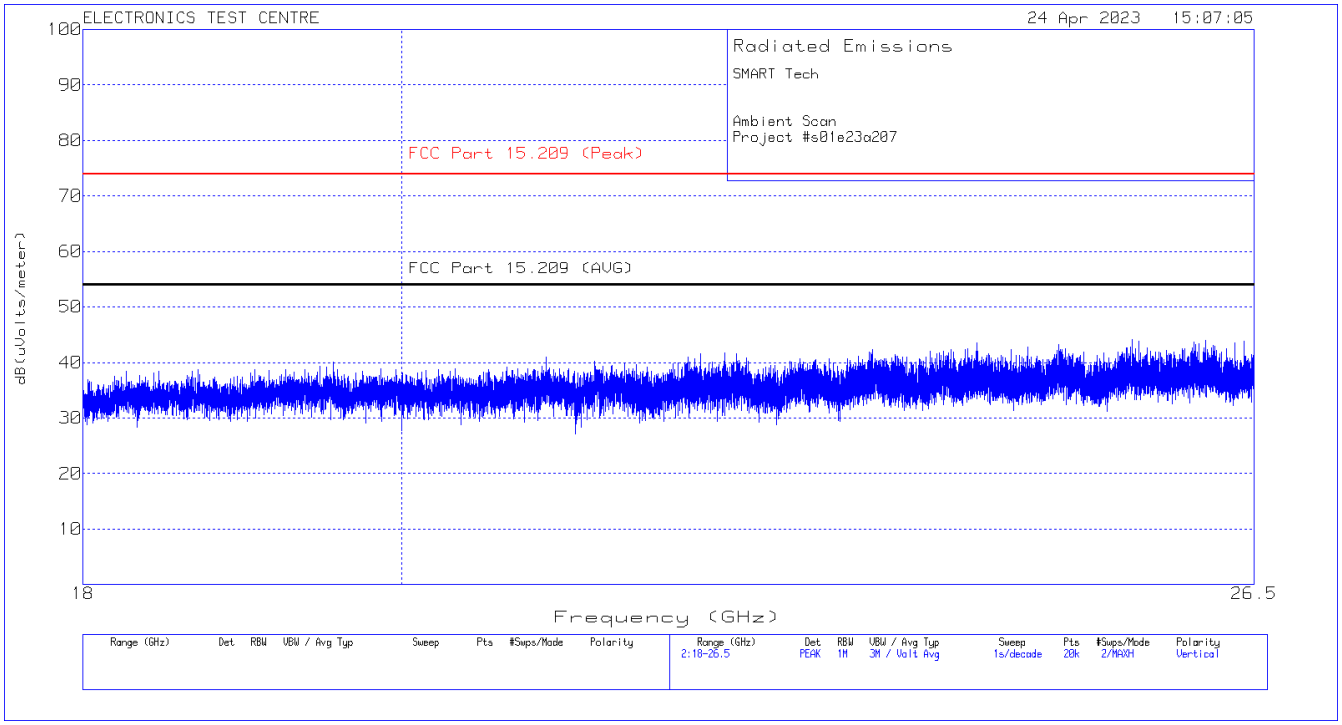


Photo of Radiated Emissions test setup: 30k-30MHz

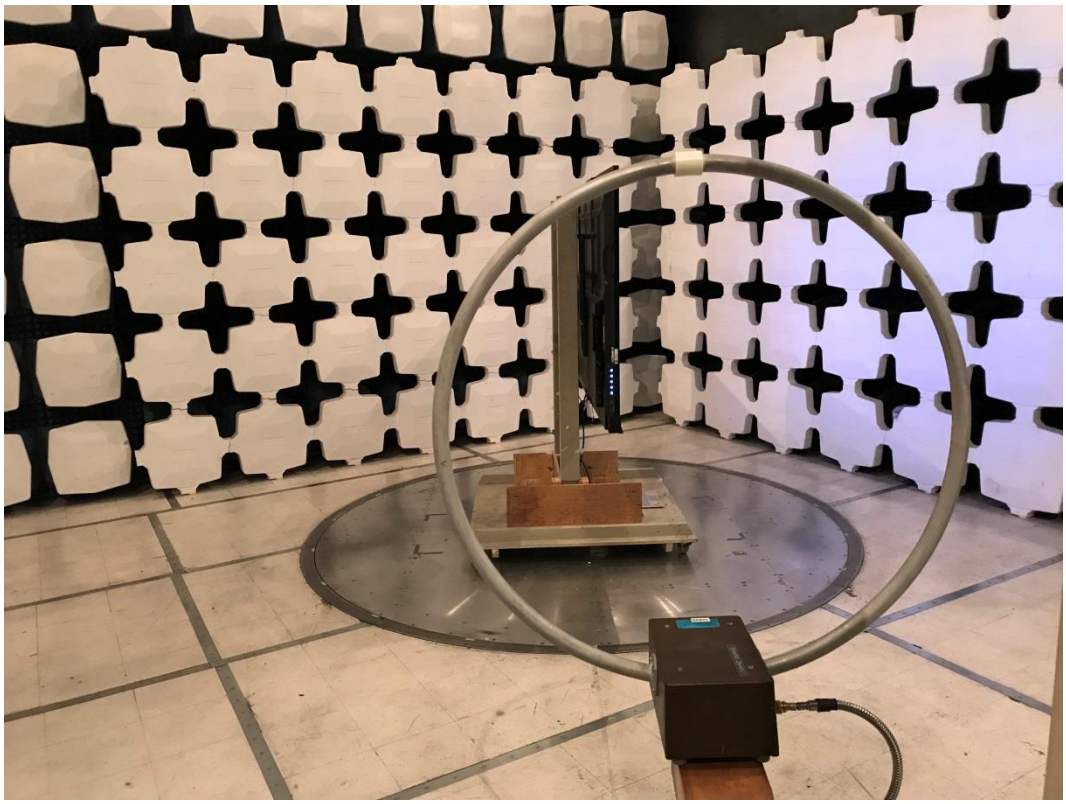


Photo of Radiated Emissions test setup: 30M-1GHz

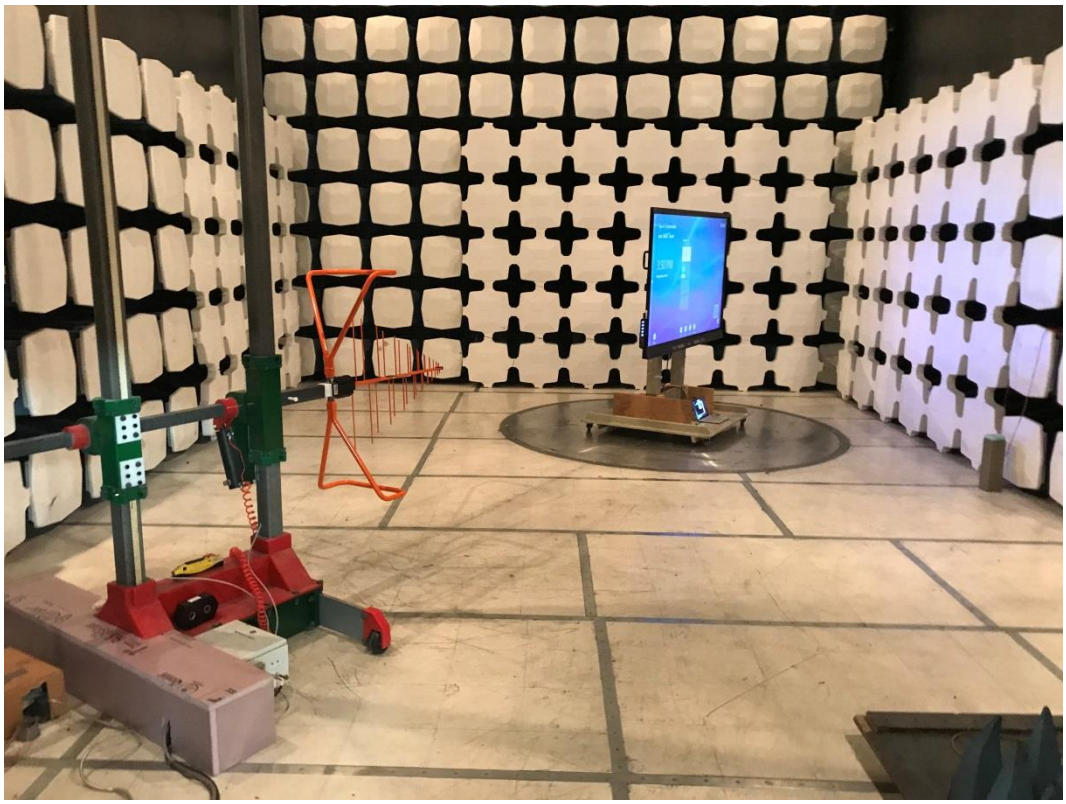
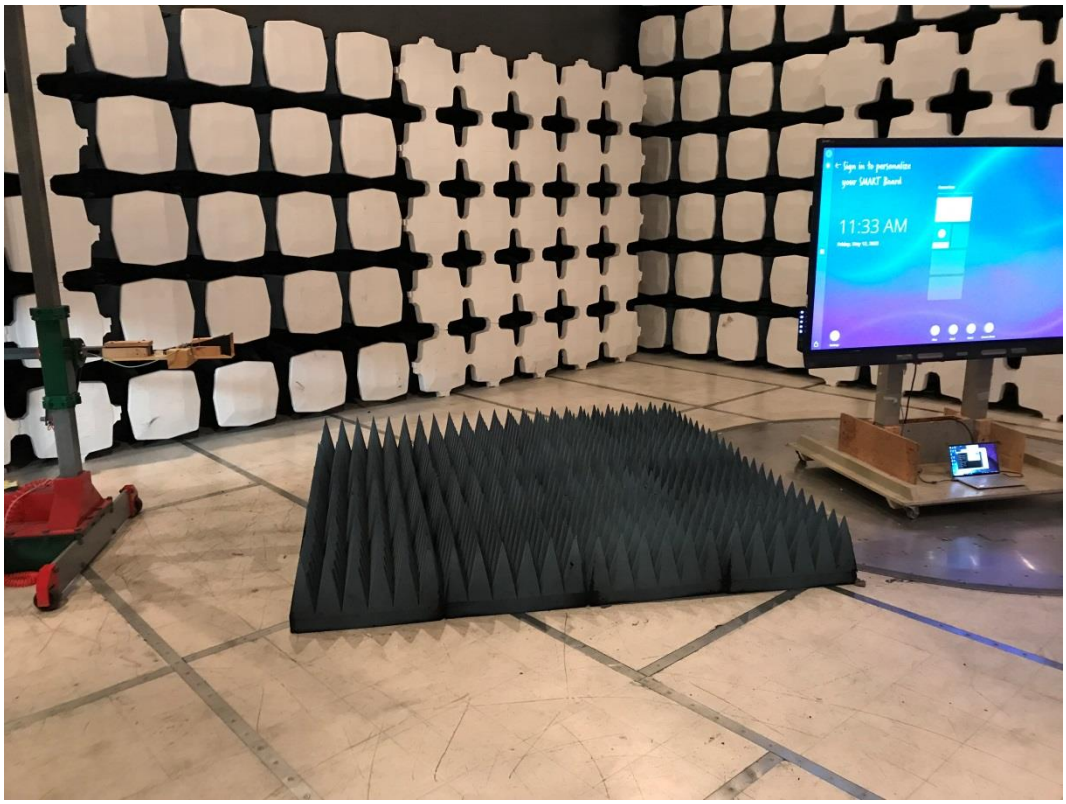


Photo of Radiated Emissions test setup: 1-18GHz

Photo of Radiated Emissions test setup: 18-26.5GHz



2.3 AC Main Conducted Emissions

Test Lab: Electronics Test Centre, Airdrie	**EUT: SMART QX Series BLE Module, Model: IDQXMOD1 (Tool Sense Controller) within 86" QX Series IFP display**
Test Personnel: B. Van Hee	**Standard: FCC Part 15.207, RSS-GEN**
Date:2023/05/15 (21.8°C, 34.3% RH)	**Basic Standard: ANSI C63.10-2013**

EUT status:

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*

2.3.1 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.

2.3.2 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	ETC-SW-EMC 2.1	N/A	
EMI receiver	Agilent	N9038A (FW v. A.25.05)	6130	2022/07/12	2023/07/12
LISN	Com-Power	LI-215A	6180	2022/08/09	2023/08/09
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.

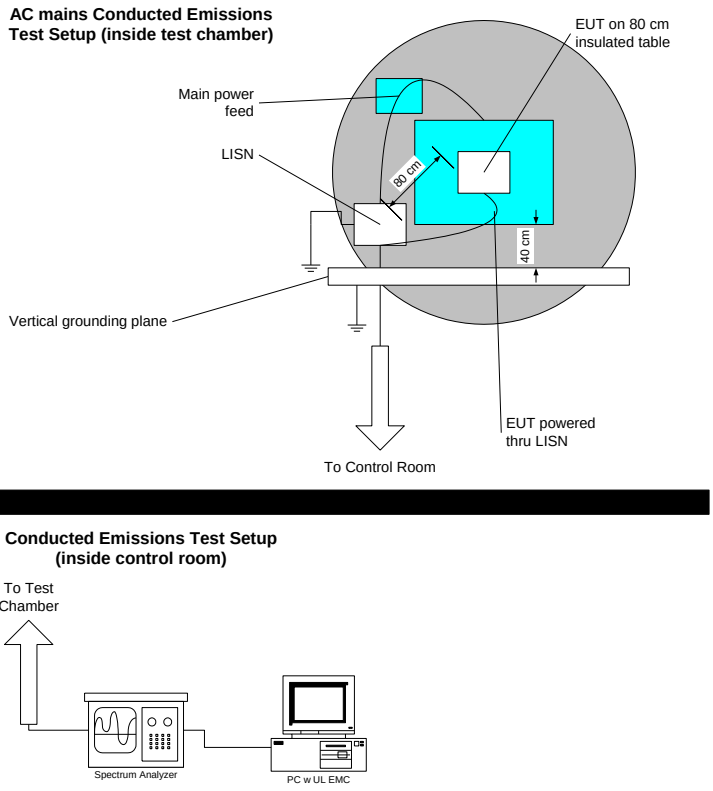
2.3.4 Test Sample Verification, Configuration & Modifications

See diagram in section 0

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:



2.3.5 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)	ICES-003 & FCC 15.107 Class A Limit (dBµV)	Delta (dB)	L / N
1	0.150	29.01	AV	.1	9.8	38.91	55.99	-17.08	Line
2	0.541	18.23	AV	0	9.8	28.03	46	-17.97	Line
3	0.992	18.11	AV	0	9.8	27.91	46	-18.09	Line
4	2.60	15.02	AV	0	9.9	24.92	46	-21.08	Line
5	7.14	22.2	AV	0	10.1	32.3	50	-17.7	Line
6	21.78	17.73	AV	.2	10.8	28.73	50	-21.27	Line
1	0.150	29.12	AV	.1	9.8	39.02	55.99	-16.97	Neutral
2	0.985	16.51	AV	0	9.8	26.31	46	-19.69	Neutral
3	2.16	16.37	AV	0	9.9	26.27	46	-19.73	Neutral
4	2.70	15.17	AV	0	9.9	25.07	46	-20.93	Neutral
5	7.23	23.02	AV	0	10.1	33.12	50	-16.88	Neutral
6	20.59	17.44	AV	0	10.7	28.14	50	-21.86	Neutral

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

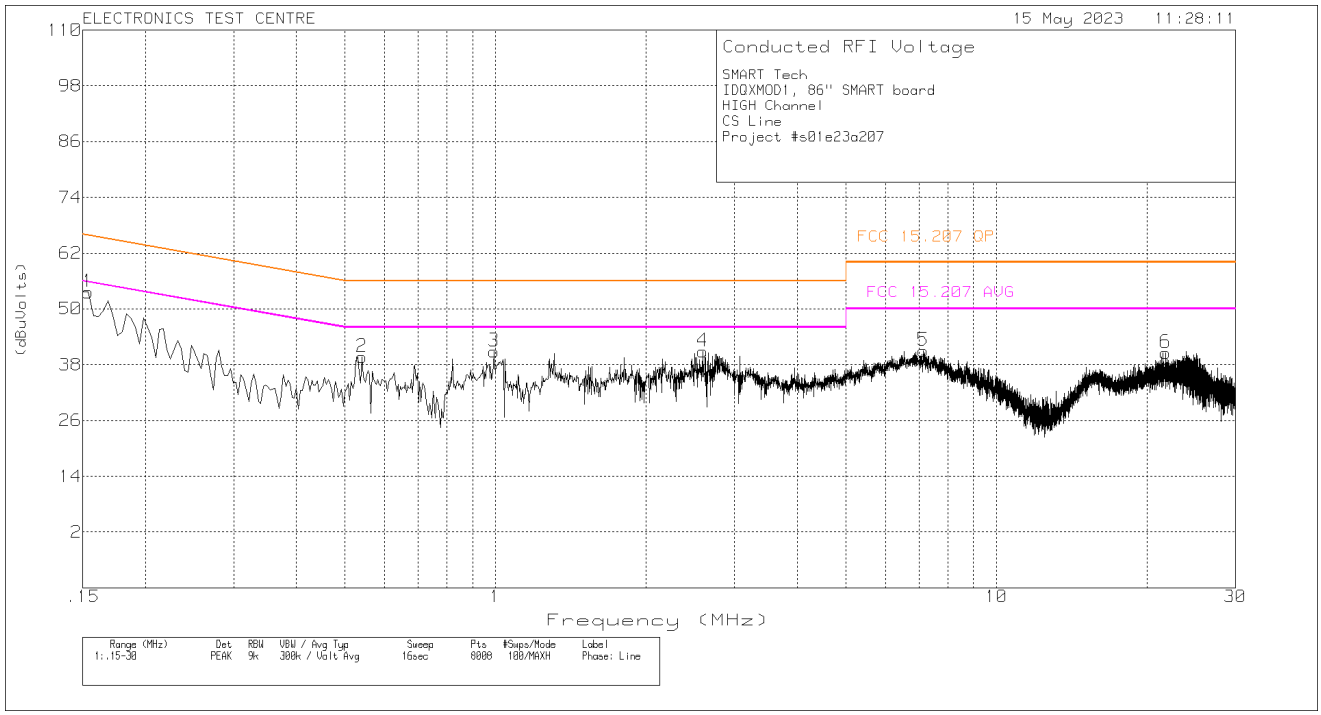
Notes:

- When a preamp is used, the resulting gain is compensated, producing a negative value for the Cable Loss.
- QP = Quasi-Peak detector; AV = Average detector

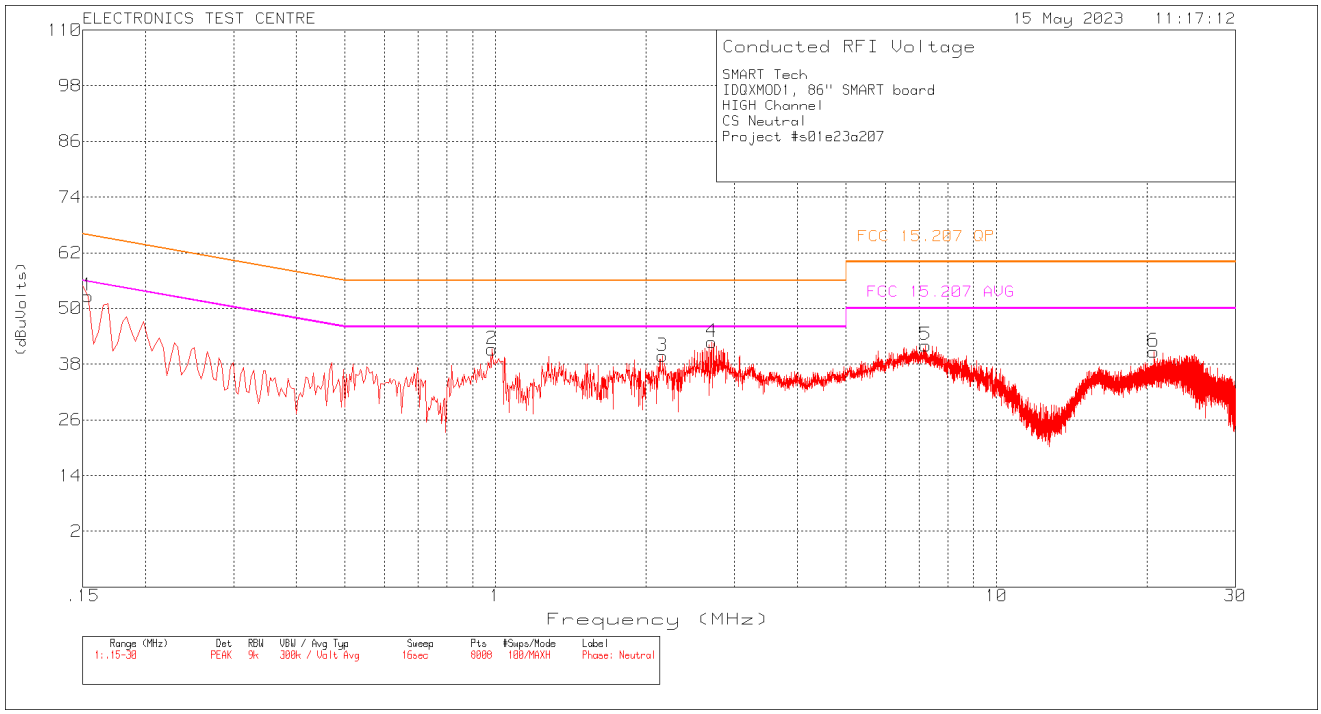
Negative values for Delta indicate compliance.

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

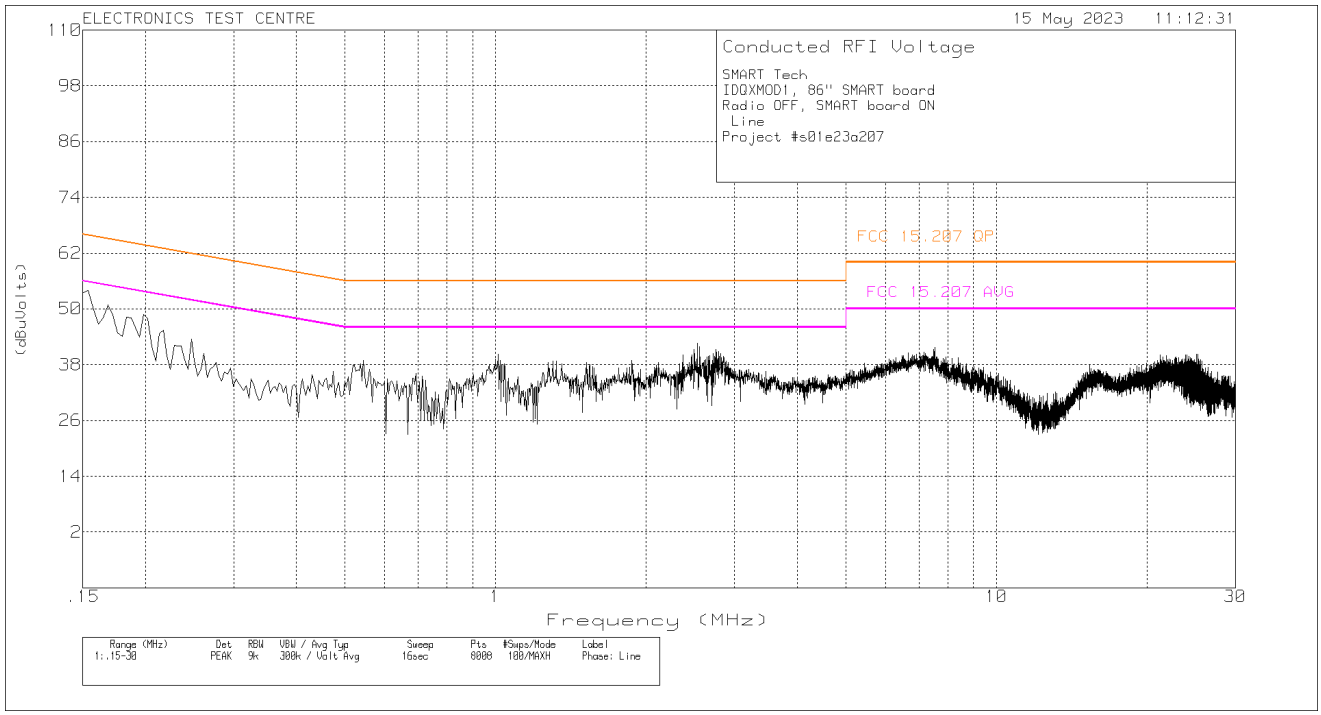
Plot of Conducted Emissions: Line



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

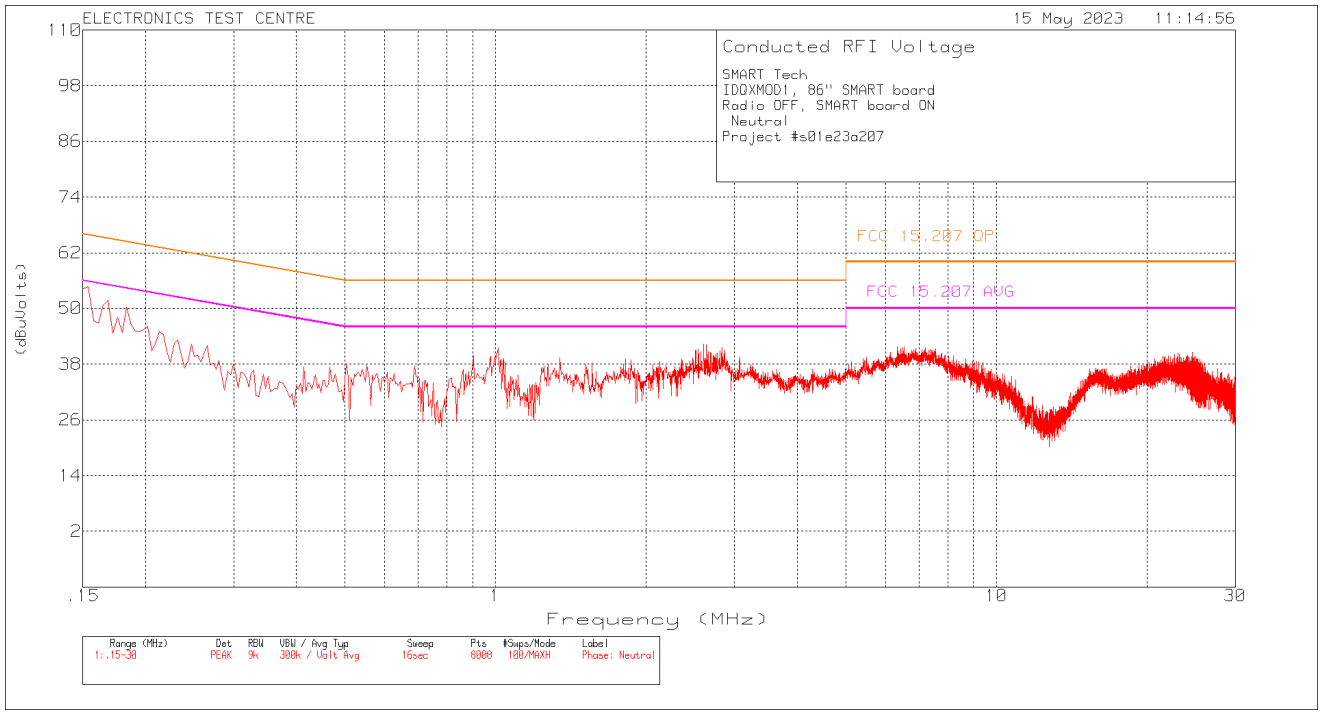
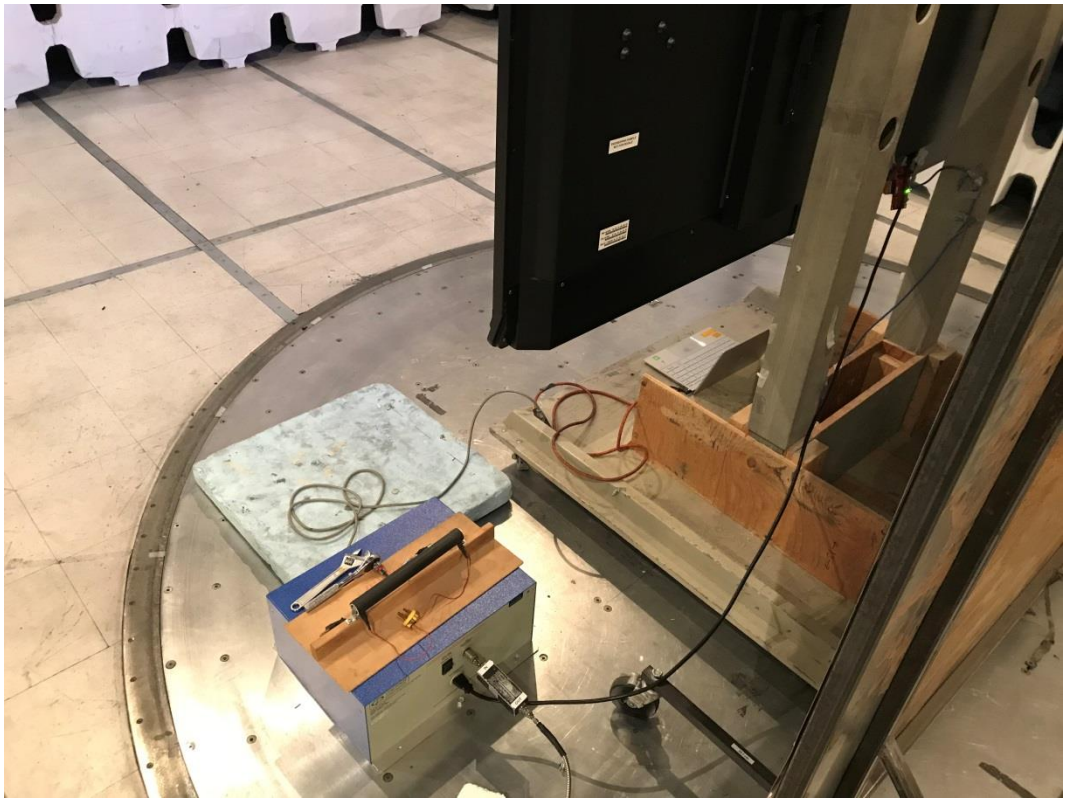


Photo of Conducted Emissions test setup:



3 TEST FACILITY

3.1 Location

The SMART QX Series BLE Module, Model: IDQXMOD1 (Tool Sense Controller) within 86" QX Series IFP display 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

(Information provided by <customer>)

Quotation Number:	s01q23a223	Project Number:	s01e23a207
Company Name :	SMART Technologies	Contact Name :	Sean MacKellar
Address :	3636 Research Rd NW	Phone :	+1 (360) 201-8932
	Calgary, Alberta T2L 1Y1	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**	**Is your product or system considered to be Controlled Good?**
Residential ☐ Industrial ☑ Military ☐	Canada ☑ Other United States of America ☑ _____ European Union ☐ _____	Yes ☐ No ☑

GENERAL INFORMATION REQUIRED FOR ALL PRODUCTS

Dimensions (L x W x H) **4.5cm x 10cm x 0.5cm**	Weight: _10_ (lbs. kgs.)	Engineering Evaluation? **YES** ☐ **NO (compliance test only)** ☑
If compliance testing, to what standards?		

Regulatory Compliance testing: Yes: ☑ No: ☐	For: FCC ☑ Industry Canada ☑ Other ☐ Specify: _____	ETC to do the submission? YES ☐ NO ☑

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)** ☐ Voltage: _____VAC # of AC phases: ___ Current: ____ Amps Frequency: ____ Hz	**DC** ☑ External ☑ Internal Battery ☐ Voltage: __5__ VDC Current: ____ Amps

Duration of self-test : _____	Fault Recovery Time: ____	Reaction Time (delay between fault & alarm): ____
Product Intended Application	BLE radio – Tool Sense Controller installed in QX 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		**Cable 1**	**Cable 2**	**Cable 3**	**Cable 4**
	Type:	**Interface**	**USB**		
	Connectors:	**Flex**	**USB**		
	Terminations :	**Tool Sense Controller > Interface Board**	**Interface Board > Laptop**		
	Shielding:	**No**	**Yes**		
	Length:	**10 cm**	**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 QX Series IFPs, Models: IDQX65-1, IDQX75-1, IDQX86-1. 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

Type of Radio Device (check all applicable Equipment Configurations)							
Intentional transmitter	☑	Receiver	☑	Transceiver	☐		
Type of Radio Operating License							
Unlicensed Personal Communication	☑	Unlicensed National Information Infrastructure	☐	Ultra-Wideband Operation	☐	Licensed	☐
Type of Modulation of Radio Device							
CDMA	☐	TDMA	☐	Other	☐		
Spread Spectrum Technology	☐	Direct sequencer	☐	Frequency hopper	☑		
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** ☑	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	☑	Intermittent	☐	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