ENGINEERING TEST REPORT

Lyngsoe RTLS RFID Portal
Model: LS4550 G3 NA LTE
FCC ID: PQG-LS4550G3

Applicant:

Lyngsoe Systems Ltd.
101 Simona Dr., Unit 2
Bolton, Ontario
Canada L7E 4E8

In Accordance With
Federal Communications Commission (FCC)
Part 15, Subpart C, Sections 15.209 & 15.231(e)
Low Power Transmitter & Momentarily Operation (125 kHz & 433.92 MHz)

UltraTech's File No.: 23LYI209_FCC15C231E

This Test report is Issued under the Authority of Tri M. Luu Vice President of Engineering UltraTech Group of Labs Date: November 8, 2023	
Report Prepared by: Dan Huynh Issued Date: November 8, 2023	Tested by: Nimisha Desai Test Dates: December 20, 2022 January 25, 26 & 27, 2023 March 1, 2023

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EXHIBIT 1. INTRODUCTION

1.1. SCOPE

Reference:	FCC Part 15, Subpart C, Sections 15.209 and 15.231
Title:	Code of Federal Regulations (CFR), Title 47, Telecommunication - Part 15
Purpose of Test:	Equipment Certification for FCC Parts 15C and 15.231(e)
Test Procedures:	▪ ANSI C63.4 ▪ ANSI C63.10
Environmental Classification:	Commercial, industrial or business environment

1.2. RELATED SUBMITTAL(S)/GRANT(S)

None.

1.3. NORMATIVE REFERENCES

Publication	Year	Title
FCC 47 CFR 15	2023	Code of Federal Regulations, Title 47 – Telecommunication, Part 15 - Radio Frequency Devices
ANSI C63.4	2014	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 KHz to 40 GHz
ANSI C63.10	2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1. CLIENT INFORMATION

Applicant	
Name:	Lyngsoe Systems Ltd.
Address:	101 Simona Dr., Unit 2 Bolton, Ontario Canada L7E 4E8

Manufacturer	
Name:	Lyngsoe Systems Ltd.
Address:	101 Simona Dr., Unit 2 Bolton, Ontario Canada L7E 4E8

2.2. EQUIPMENT UNDER TEST (EUT) INFORMATION

The following information (with the exception of the Date of Receipt) has been supplied by the applicant.

Brand Name:	Lyngsoe Systems Ltd.
Product Name:	Lyngsoe RTLS RFID Portal
Model Name or Number:	LS4550 G3 NA LTE
Serial Number:	A208253
Type of Equipment:	RFID Device
Input Power Supply Type:	120 VAC 60 Hz
Primary User Functions of EUT:	Fully automated RFID data collection, no user interaction after installation. Automatic tracking of active and passive RFID transponders.

2.3. EUT'S TECHNICAL SPECIFICATIONS

Transmitter (Exciter Board EXB46)	
Equipment Type:	Base station
Intended Operating Environment:	Commercial, light industry & heavy industry
Power Supply Requirement:	110-240V 50-60Hz max 45W power outlet
RF Output Power Rating:	125 kHz Tx: 111.89 dBµV/m peak (111.88 dBµV/m average) at 10m distance 433.92 MHz Tx: 92.93 dBµV/m peak (67.93 dBµV/m average) at 3m distance
Operating Frequency Range:	125 kHz & 433.92 MHz
Duty Cycle:	5.63 % (for 433.92 MHz transmitter)
Modulation Type:	OOK (LF) & FSK (UHF)
Antenna Connector Type:	Integral
Antenna Description:	Manufacturer: Lyngsoe Systems Type: Two wire loops for 125 kHz; PCB trace for 433.92 MHz Model: N/A Frequency Range: 125 kHz; 434 MHz Gain: Not applicable for near field operation at 125 kHz; -17.2 dBi at 433.92 MHz
Receiver (Reader Board RDB46)	
Equipment Type:	Base Station (fixed use)
Power Supply Requirement:	+24VDC
Operating Frequency Range:	434 MHz
RF Output Impedance:	50 Ω

2.4. ASSOCIATED ANTENNA DESCRIPTIONS

Manufacturer	Antenna Type	Model	Frequency Range	Maximum Gain
Lyngsoe	Two wire loops	N/A	125kHz	N/A
Lyngsoe	PCB trace	N/A	434MHz	-17.2 dBi
TE Connectivity	Patch antenna – circular polarized	*S9028PCRJ / S9028PCLJ	902-928MHz	6.9 dBi
Laird	2 x Flex PIFA Antennas	EFB2455A3S-20MHF	2.4GHz, 5GHz Wi-Fi bands	3 dBi
Ethertronics/ AVX	2 x Isolated Magnetic Dipole (IMD) antennas	1002089	700 / 750 / 850 / 900 / 1800 / 1900 / 2100 / 2700 MHz	5.1 dBi (698-960MHz); 4.9dBi (1710-2700MHz)

* P/N: 9028PCRJ36RTNB / S9028PCLJ36RTNB

2.5. LIST OF EUT'S PORTS

Port Number	EUT's Port Description	Number of Identical Ports	Connector Type	Cable Type (Shielded/Non-shielded)
1	110/220V Power Input	1	NEMA 1-15 ungrounded (Type A), CEE 7/16 Alternative II "Europlug" (Type C)	Non-shielded
2	Sync IN/OUT	2	RJ45	Shielded
3	Ethernet data in/out	1	RJ45	Shielded

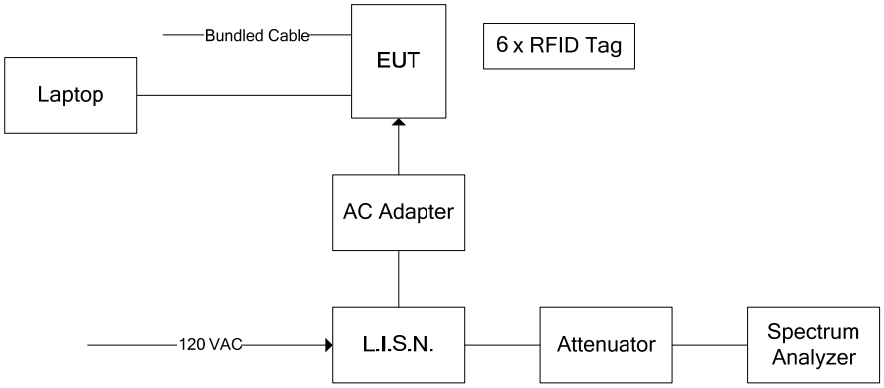
2.6. ANCILLARY EQUIPMENT

The EUT was tested while connected to the following representative configuration of ancillary equipment necessary to exercise the ports during tests:

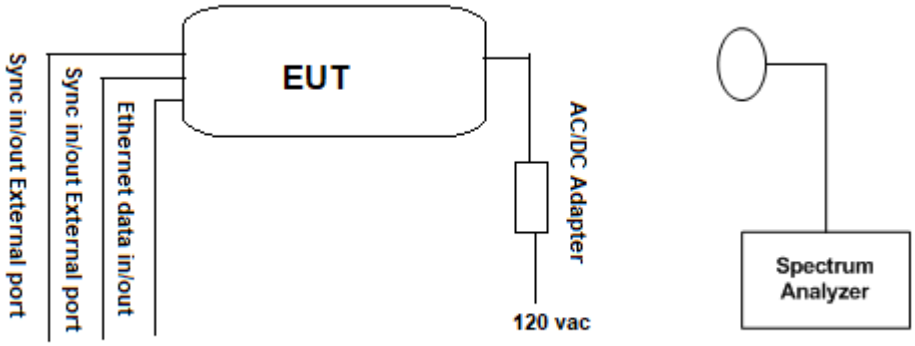
Ancillary Equipment # 1	
Description:	AC/DC Adapter
Brand name:	XP Power
Model Name or Number:	AKM45US24C2-XZ1317
Serial Number:	2215-00728
Connected to EUT's Port:	Power Input

2.7. TEST SETUP BLOCK DIAGRAM

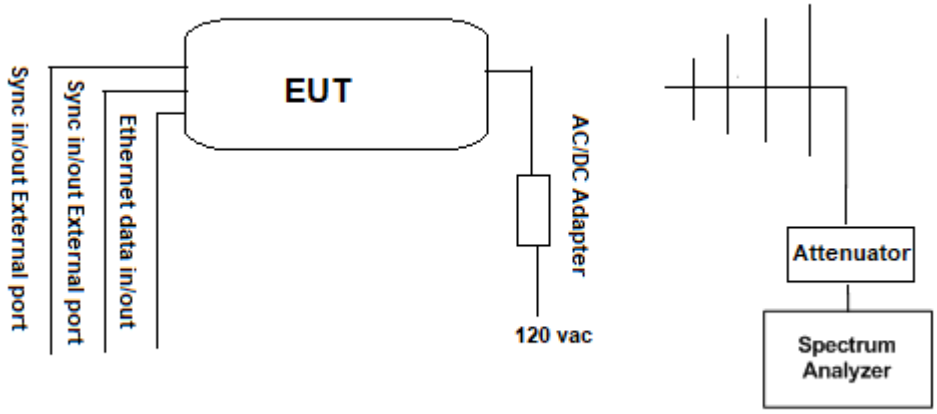
AC Power-line Conducted Emissions



125 kHz Tx Radiated Emissions, Spurious Emissions and Bandwidth Measurements



433.92 MHz Tx Radiated Emissions, Duty Cycle and Bandwidth Measurements



433.92 MHz Tx Radiated Spurious Emissions

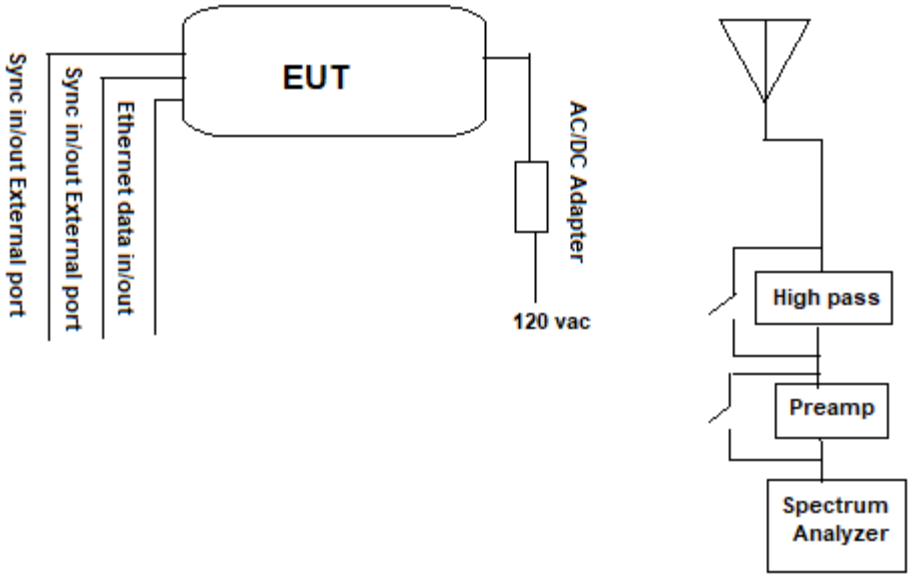


EXHIBIT 3. EUT OPERATING CONDITIONS AND CONFIGURATIONS DURING TESTS

3.1. CLIMATE TEST CONDITIONS

The climate conditions of the test environment are as follows:

Temperature:	21 to 23 °C
Humidity:	45 to 58%
Pressure:	102 kPa
Power input source:	120 VAC 60 Hz

3.2. OPERATIONAL TEST CONDITIONS & ARRANGEMENT FOR TESTS

Operating Modes:	Each channel frequency transmits continuously for emissions measurements.
Special Test Software:	Special software provided by the Applicant to operate the EUT at each channel frequency continuously and in the range of typical modes of operation.
Special Hardware Used:	N/A
Transmitter Test Antenna:	Tx antenna is integral, Rx antenna connector terminated to 50 Ω load as described with the test results.

Transmitter Test Signals	
Frequency Band(s):	125 kHz and 433.92 MHz
Test Frequency(ies):	125 kHz and 433.92 MHz
RF Power Output:	125 kHz Tx: 111.89 dBµV/m peak (111.88 dBµV/m average) at 10m distance 433.92 MHz Tx: 92.93 dBµV/m peak (67.93 dBµV/m average) at 3m distance
Normal Test Modulation:	OOK and FSK
Modulating Signal Source:	Internal

EXHIBIT 4. SUMMARY OF TEST RESULTS

4.1. LOCATION OF TESTS

All of the measurements described in this report were performed at Ultratech Group of Labs located in the city of Oakville, Province of Ontario, Canada.

- AC Power Line Conducted Emissions were performed in UltraTech's shielded room, 24'(L) by 16'(W) by 8'(H).
- Radiated Emissions were performed at the Ultratech's 3-10 TDK Semi-Anechoic Chamber situated in the Town of Oakville, province of Ontario. This test site been calibrated in accordance with ANSI C63.4, and found to be in compliance with the requirements of Sec. 2.948 of the FCC Rules. The descriptions and site measurement data of the Oakville 3-10 TDK Semi-Anechoic Chamber has been filed with ANAB File No.: AT-1945.

4.2. APPLICABILITY & SUMMARY OF EMC EMISSION TEST RESULTS

FCC Section(s)	Test Requirements	Compliance (Yes/No)
15.203	Antenna Requirement	Yes*
15.207(a)	AC Power Line Conducted Emissions	Yes
15.231(e) 15.209	Transmitter Radiated Emissions - Fundamental, Harmonic and Spurious Emissions	Yes
15.231(c)	20 dB Bandwidth	Yes
15.231(d)	Frequency Tolerance for Devices Operating within the Frequency Band 40.66-40.70 MHz	N/A

* The EUT complies with the requirement; it employs integral antenna.

4.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

None.

EXHIBIT 5. TEST DATA

5.1. POWER LINE CONDUCTED EMISSIONS [§15.107(b)]

5.1.1. Limit(s)

The equipment shall meet the limits of the following table:

Frequency of emission (MHz)	Conducted Limits (dBμV)	
	Quasi-peak	Average
0.15–0.5 .....……..	66 to 56*	56 to 46*
0.5–5 .....……..	56	46
5-30 ……..	60 ...……..	50

*Decreases linearly with the logarithm of the frequency

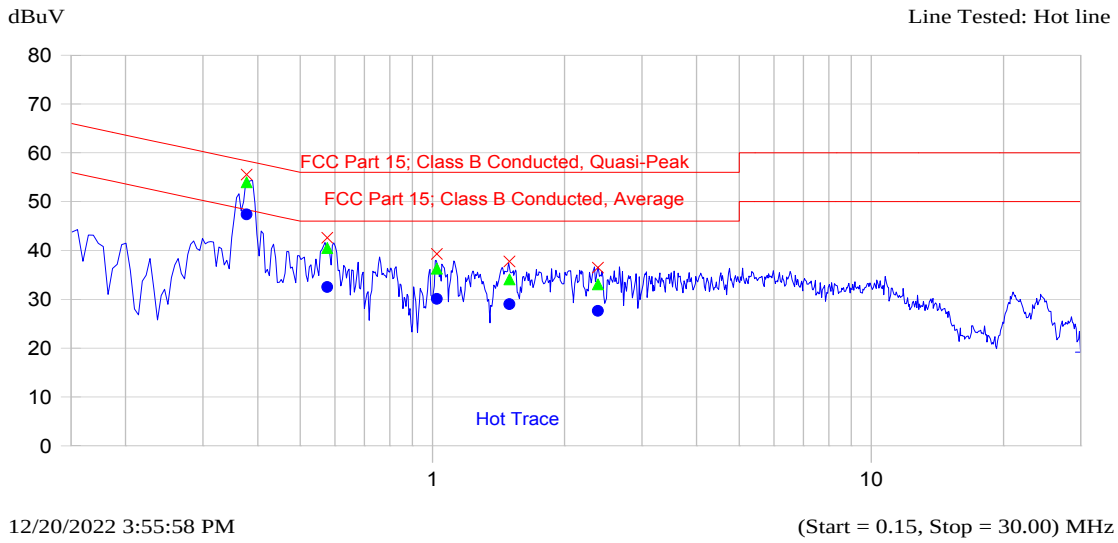
5.1.2. Method of Measurements

ANSI C63.4

5.1.3. Test Data

Plot 5.1.3.1. Power Line Conducted Emissions
Line Voltage: 120 VAC 60 Hz; Line Tested: Hot

Current Graph

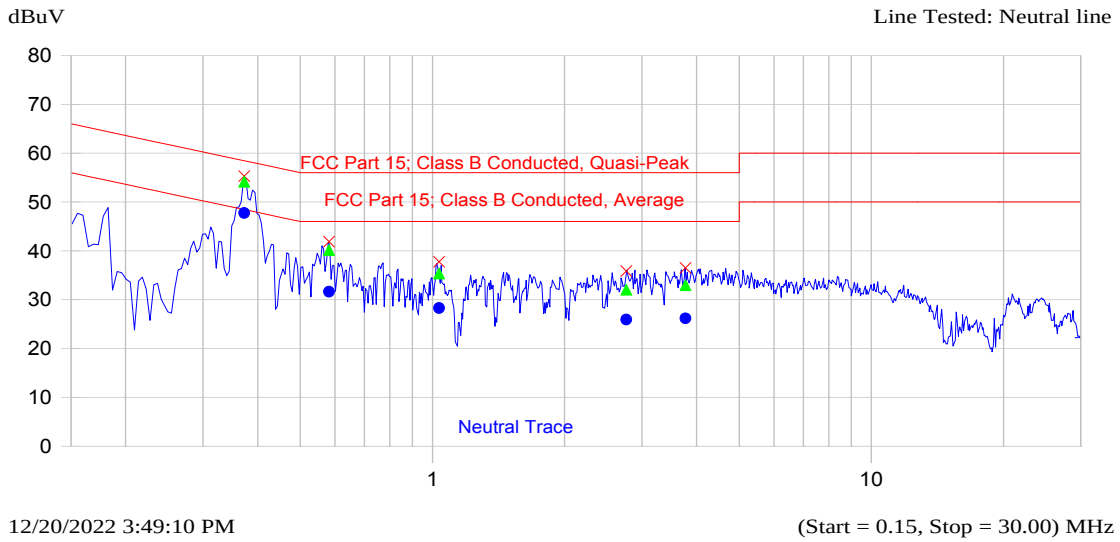


Current List

Frequency MHz	Peak dBuV	QP dBuV	QP-QP Limit dB	Avg dBuV	Avg-Avg Limit dB	Trace Name
0.378	55.5	54.0	-4.4	47.4	-0.9	Hot Trace
0.576	42.6	40.5	-15.5	32.5	-13.5	Hot Trace
1.023	39.3	36.3	-19.7	30.1	-15.9	Hot Trace
1.498	37.7	34.1	-21.9	29.0	-17.0	Hot Trace
2.381	36.5	33.1	-22.9	27.6	-18.4	Hot Trace

Plot 5.1.3.2. Power Line Conducted Emissions
Line Voltage: 120 VAC 60 Hz; Line Tested: Neutral

Current Graph



Current List

Frequency MHz	Peak dBuV	QP dBuV	QP-QP Limit dB	Avg dBuV	Avg-Avg Limit dB	Trace Name
0.373	55.3	54.2	-4.3	47.7	-0.7	Neutral Trace
0.581	41.9	40.1	-15.9	31.6	-14.4	Neutral Trace
1.035	37.8	35.4	-20.6	28.3	-17.7	Neutral Trace
2.765	35.9	32.1	-23.9	25.9	-20.1	Neutral Trace
3.769	36.5	33.0	-23.0	26.2	-19.8	Neutral Trace

5.2. TRANSMITTER RADIATED EMISSIONS [47 CFR §§ 15.231(e), 15.209 & 15.205]

5.2.1. Limit(s)

47 CFR 15.231

(e) Intentional radiators may operate at a periodic rate exceeding that specified in paragraph (a) of this section and may be employed for any type of operation, including operation prohibited in paragraph (a) of this section, provided the intentional radiator complies with the provisions of paragraphs (b) through (d) of this section, except the field strength table in paragraph (b) of this section is replaced by the following:

Fundamental frequency (MHz)	Field strength of fundamental (microvolts/meter)	Field strength of spurious emission (microvolts/meter)
40.66-40.70	1,000	100
70-130	500	50
130-174	500 to 1,500[1]	50 to 150[1]
174-260	1,500	150
260-470	1,500 to 5,000[1]	150 to 500[1]
Above 470	5,000	500

[1]Linear interpolations.

(b)(1) The above field strength limits are specified at a distance of 3 meters. The tighter limits apply at the band edges.

(b)(2) Intentional radiators operating under the provisions of this Section shall demonstrate compliance with the limits on the field strength of emissions, as shown in the above table, based on the average value of the measured emissions. As an alternative, compliance with the limits in the above table may be based on the use of measurement instrumentation with a CISPR quasi-peak detector. The specific method of measurement employed shall be specified in the application for equipment authorization. If average emission measurements are employed, the provisions in Section 15.35 for averaging pulsed emissions and for limiting peak emissions apply. Further, compliance with the provisions of Section 15.205 shall be demonstrated using the measurement instrumentation specified in that section.

(b)(3) The limits on the field strength of the spurious emissions in the above table are based on the fundamental frequency of the intentional radiator. Spurious emissions shall be attenuated to the average (or, alternatively, CISPR quasi-peak) limits shown in this table or to the general limits shown in Section 15.209, whichever limit permits a higher field strength.

47 CFR 15.205(a) Restricted Bands of Operation

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])
13.36–13.41.			

[1] Until February 1, 1999, this restricted band shall be 0.490–0.510 MHz.
[2] Above 38.6

47 CFR 15.209(a) General Field Strength Limits

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009–0.490	2400/F(kHz)	300
0.490–1.705	24000/F(kHz)	30
1.705–30.0	30	30
30–88	100 **	3
88–216	150 **	3
216–960	200 **	3
Above 960	500	3
** Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this section shall not be located in the frequency bands 54–72 MHz, 76– 88 MHz, 174–216 MHz or 470–806 MHz. However, operation within these frequency bands is permitted under other sections of this part, e.g., §§ 15.231 and 15.241.		

5.2.2. Method of Measurements

ANSI C63.4 and/or ANSI C63.10

5.2.3. Test Data

5.2.3.1. 125 kHz Transmitter

Remarks:

- Exploratory tests were carried out for various EUT orientations (downward-facing, upward-facing and sideward-facing to determine the orientation having the maximum emission level, the final results presented in this table is worst case.
- The measuring receiver shall be tuned over the frequency range 10 kHz to 30 MHz
- Test distance: 0.010 to 30MHz: 10m
- All spurious emissions that are in excess of 20 dB below the specified limit shall be recorded.
- The value measured at 10m shall be extrapolated as applicable to compare with limit and measurement distance specified in section 15.209(a).
- Determine the roll-off factor, P and distance correction factor in dB, DCF using the following equations

Roll-off factor, P = (Level $_{\text{near-distance}}$ – Level $_{\text{far-distance}}$) / 20log(d_{far} / d_{near})
DCF = 20log(d $_{\text{test}}$ / d $_{\text{limit}}$)^{P} = 20Plog(d $_{\text{test}}$ / d $_{\text{limit}}$)

where
distance is in meters
DCF is the distance correction factor in dB
Level is in dB

Maximum field strength level at 100 m distance: 58.1 dBµV/m (measured by Lyngsoe in an open field site)
Maximum field strength level at 40 m distance: 81.4 dBµV/m (measured by Lyngsoe in an open field site)

P = (Level $_{\text{near-distance}}$ – Level $_{\text{far-distance}}$) / 20log(d_{far} / d_{near}) = (81.4 – 58.1) / 20log(100/40) = 2.93
DCF = 20Plog(d $_{\text{test}}$ / d $_{\text{limit}}$) = 20(2.93)log(10 / 300) = -86.56 dB

- For frequency 125 kHz, the measured E-Field at 10m (column 3) will be extrapolated to 300m E-Field Level (column 4) using the DCF of -86.56 dB
- Field strength limit of the fundamental 125 kHz at 300m distance is 20*log(2400/125) = 25.67 dBµV/m

Test Configuration 1: EUT Facing Rx Antenna, TXP 32 Power Setting						
Frequency (MHz)	**RF Peak Level @ 10m (dBµV/m)**	**RF Average Level @ 10m (dBµV/m)**	**Extrapolated RF Level (dBµV/m)**	**Antenna Plane (H/V)**	**§ 15.209 (a) Limits (dBµV/m)**	**Margin (dB)**
Fundamental Emissions						
0.125	111.89	111.88	25.32	V	25.67	-0.35
0.125	97.09	97.04	10.48	H	25.67	-15.19
Harmonic/Spurious Emissions						
0.010 - 0.490	*	*	*	H / V	*	*
0.490 - 1.705	*	*	*	H / V	*	*
1.705 - 30.0	*	*	*	H / V	*	*

* Emissions are more than 20 dB below the limit.

Test Configuration 2: EUT Downward-Facing Direction, TXP 40 Power Setting						
Frequency (MHz)	**RF Peak Level @ 10m (dBµV/m)**	**RF Average Level @ 10m (dBµV/m)**	**Extrapolated RF Level (dBµV/m)**	**Antenna Plane (H/V)**	**§ 15.209 (a) Limits (dBµV/m)**	**Margin (dB)**
Fundamental Emissions						
0.125	96.02	95.61	9.05	V	25.67	-16.62
0.125	89.57	89.18	2.62	H	25.67	-23.05
Harmonic/Spurious Emissions						
0.010 - 0.490	*	*	*	H / V	*	*
0.490 - 1.705	*	*	*	H / V	*	*
1.705 - 30.0	*	*	*	H / V	*	*

* Emissions are more than 20 dB below the limit.

Test Configuration 3: EUT Upward-Facing Direction, TXP 40 Power Setting						
Frequency (MHz)	**RF Peak Level @ 10m (dBµV/m)**	**RF Average Level @ 10m (dBµV/m)**	**Extrapolated RF Level (dBµV/m)**	**Antenna Plane (H/V)**	**§ 15.209 (a) Limits (dBµV/m)**	**Margin (dB)**
Fundamental Emissions						
0.125	96.88	96.74	10.18	V	25.67	-15.49
0.125	89.70	89.58	3.02	H	25.67	-22.65
Harmonic/Spurious Emissions						
0.010 - 0.490	*	*	*	H / V	*	*
0.490 - 1.705	*	*	*	H / V	*	*
1.705 - 30.0	*	*	*	H / V	*	*

* Emissions are more than 20 dB below the limit.

5.2.3.2. 433.92 MHz Transmitter

Remarks:

- The measuring receiver shall be tuned over the frequency range of 30 MHz to the 10th harmonic of the highest fundamental frequency.
- All spurious emissions that are in excess of 20 dB below the specified limit shall be recorded.
- In the restricted band per §15.205: 15.209 (a) limits applied
- Outside the restricted band per § 15.205: § 15.231 (e) limits or § 15.209 (a) applied, whichever allows higher field strength emission.
- Section 15.231(e) field strength limit of the fundamental at 433.92 MHz = 20 log [(16.67 x 433.92) – 2833.33] = 72.9 dBµV/m
- Spurious emissions limit is 20 dB below fundamental limit.
- Duty Cycle: measured maximum duty cycle is 5.625 %.
- The peak-average correction factor = -25.00 dB. See Section 5.2.3.3 for details.

Frequency (MHz)	Peak E-Field @ 3m (dBµV/m)	Average E-Field @ 3m (dBµV/m)	Antenna Plane (H/V)	§ 15.231 (e) Limits @ 3m (dBµV/m)	§ 15.209 (a) Limits @ 3m (dBµV/m)	Margin (dB)	Pass/Fail
Field strength of fundamental							
433.92	83.67	58.67	V	72.9	--	-14.23	Pass
433.92	92.93	67.93	H	72.9	--	-4.97	Pass
Field strength of spurious emission							
867.84	59.58	34.58	H	52.9	46.0	-18.32	Pass

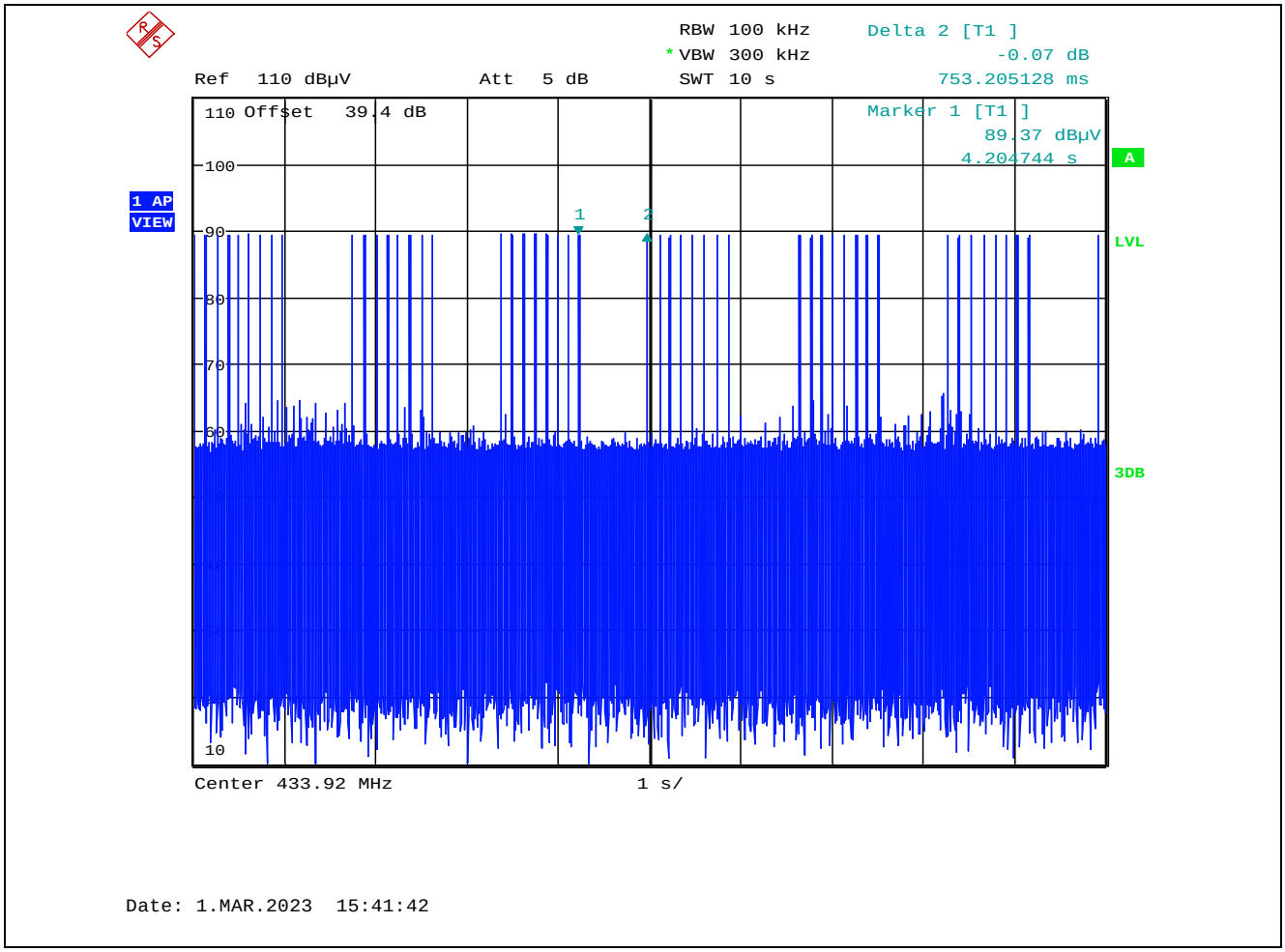
5.2.3.3. Duty-Cycle Correction Factor

The duty cycle correction factor is the total “on time” divided by the period of the pulse train (or 100 ms).

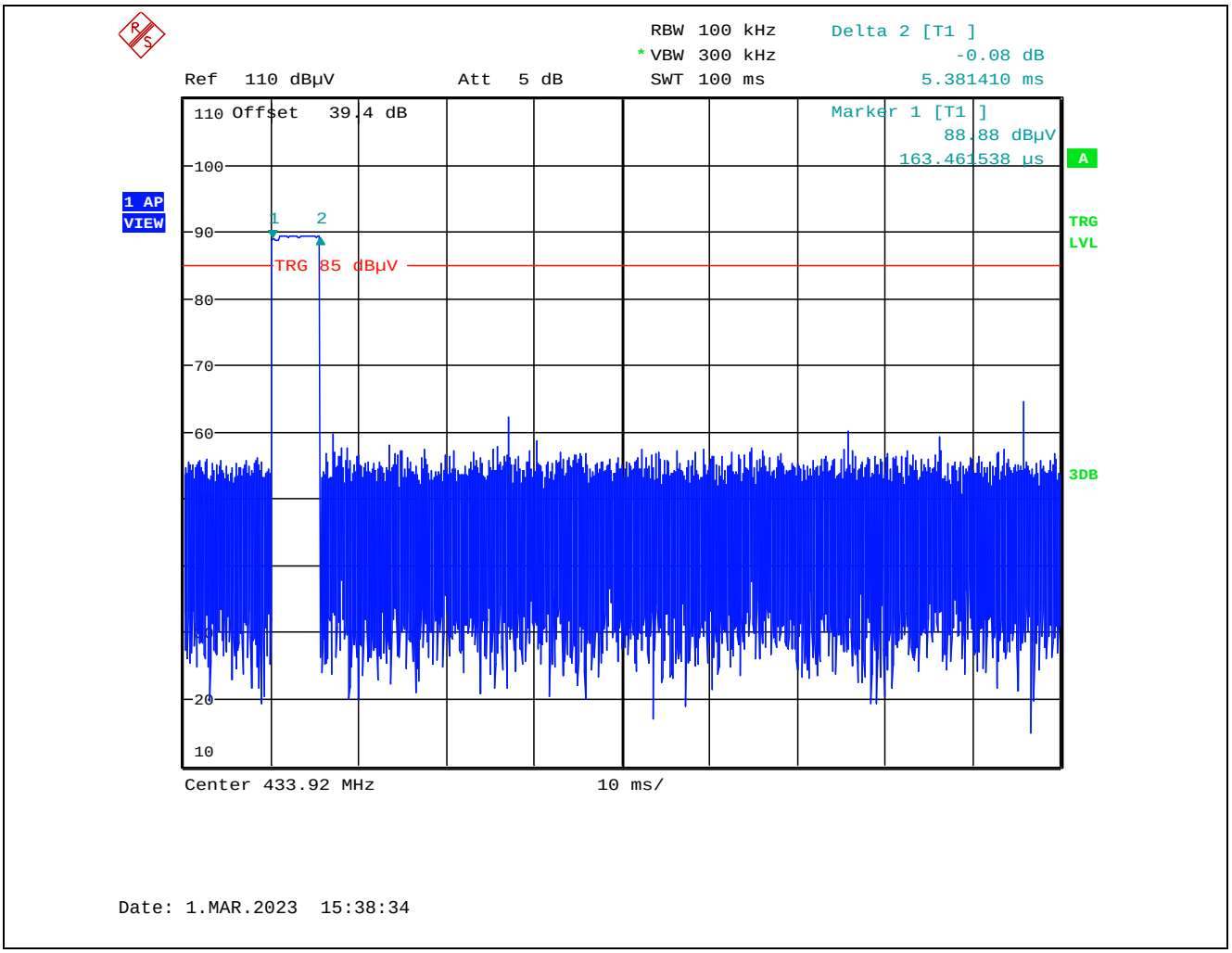
Computation of duty-cycle correction factor

Sub-Pulse	Duration (ms)	Number of pulses	Sub-Pulse “On Time” (ms)
1	5.625	1	5.625
		TOTAL ON TIME:	5.625
Duty cycle correction factor:	20*log (T_{ON}/Period) = 20*log (5.625 ms/ 100 ms) = -25.00 dB		

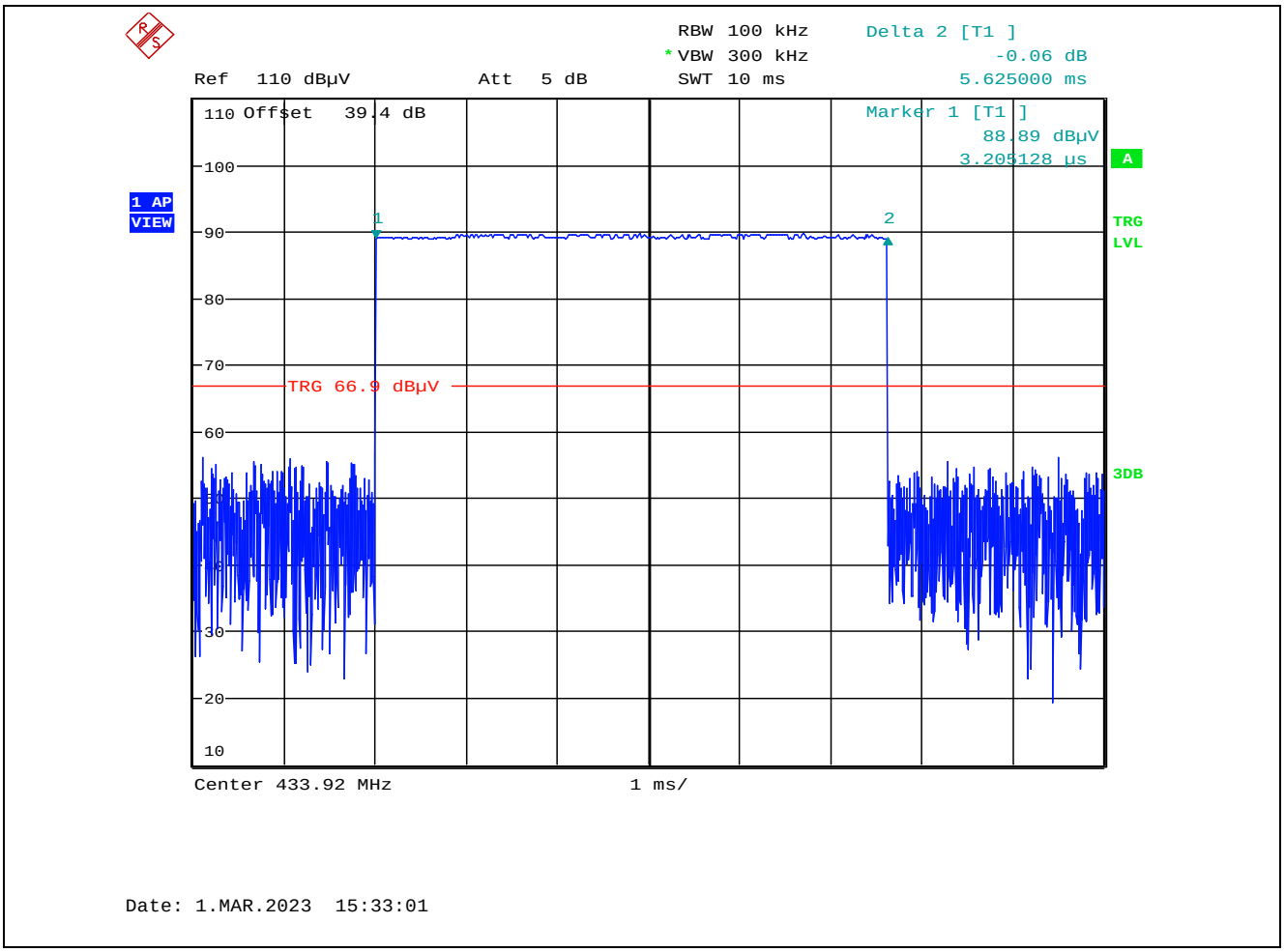
Plot 5.2.3.3.1. Duty Cycle (Pulse Train)



Plot 5.2.3.3.2. Duty Cycle (100 ms)



Plot 5.2.3.3.3. Duty Cycle (Pulse)



5.3. 20 dB BANDWIDTH [47 CFR §§ 15.215(c) & 15.231(c)]

5.3.1. Limit(s)

15.215(c) Emission bandwidth shall not be located in the restricted bands in 15.205 and the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz.

15.231 (c) The bandwidth of the emission shall be no wider than 0.25% of the center frequency for devices operating above 70 MHz and below 900 MHz. For devices operating above 900 MHz, the emission shall be no wider than 0.5% of the center frequency. Bandwidth is determined at the points 20 dB down from the modulated carrier.

5.3.2. Method of Measurements

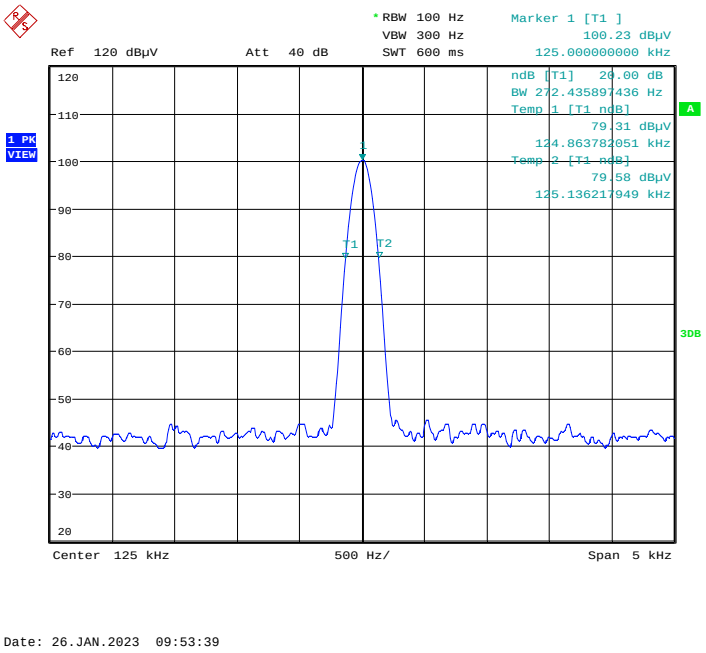
The measurements were performed in accordance with ANSI C63.4

5.3.3. Test Data

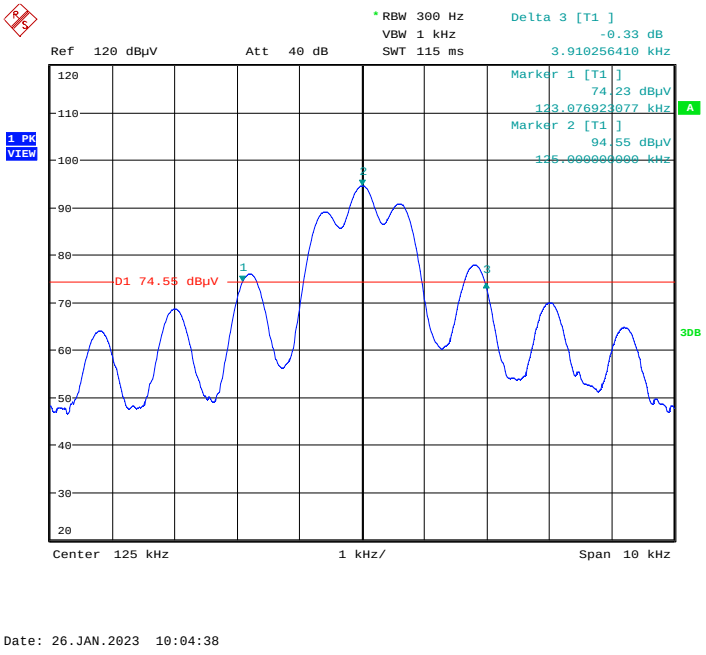
Channel Frequency	Modulation	20 dB Bandwidth	Limit (kHz)
125 kHz	Command SM1, Modulation Constant to "1"	272.44 Hz	--
	Command SM2, OOK Modulation with 600 Hz	123.08 Hz	--
433.92 MHz	FSK modulated with programmed messages (SM6)	42.31 kHz	≤ 1084.8
	FSK modulated with a signal 101010…, 1 b/s (SM5)	28.69 kHz	≤ 1084.8

See the following plots for detail.

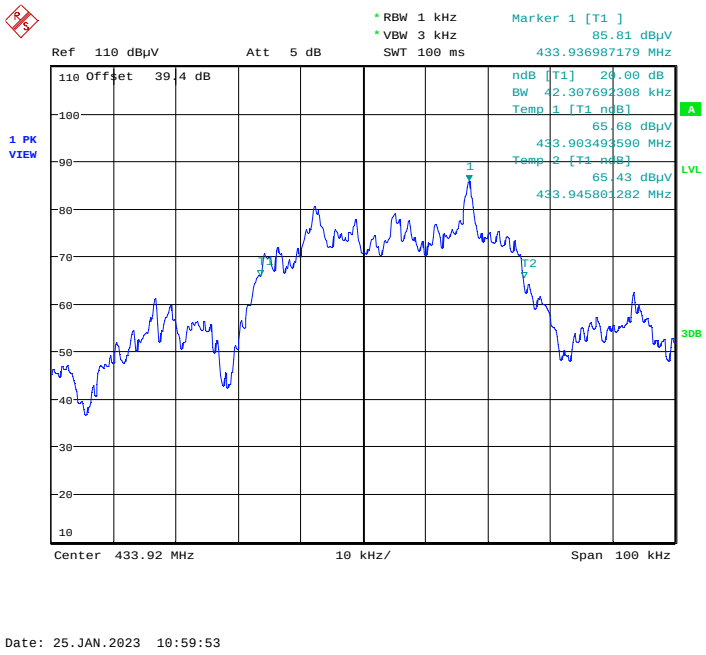
Plot 5.3.3.1. 20 dB Bandwidth, Fc: 125 kHz
Command SM1, Modulation Constant to "1" (SM1)



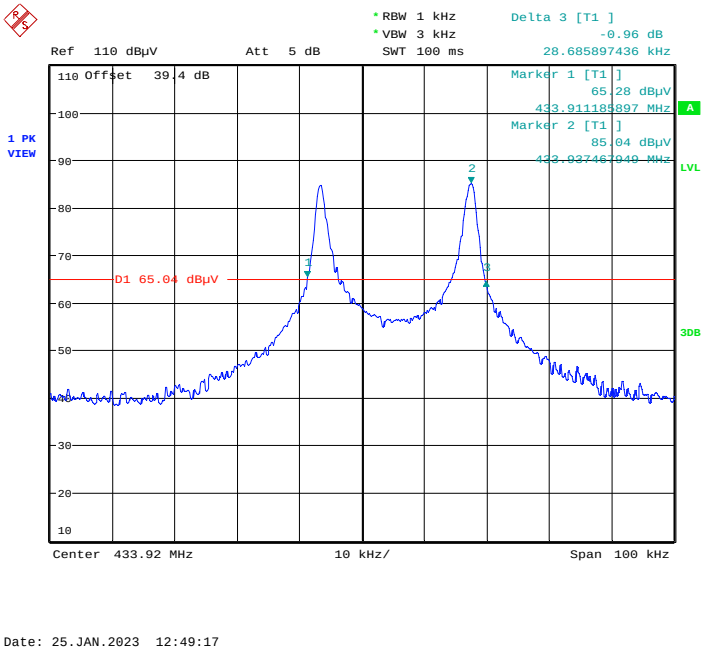
Plot 5.3.3.2. 20 dB Bandwidth, Fc: 125 kHz
Command SM2, OOK Modulation with 600 Hz (SM2)



Plot 5.3.3.3. 20 dB Bandwidth, Fc: 433.92 MHz
FSK modulated with programmed messages (SM6)



Plot 5.3.3.4. 20 dB Bandwidth, Fc: 433.92 MHz
FSK modulated with a signal 101010…, 1 b/s (SM5)



5.4. RF EXPOSURE REQUIRMENTS [§§ 15.247(i), 1.1310 & 2.1091]

§ **1.1310:** The criteria listed in the following table shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in 1.1307(b).

Limits for Maximum Permissible Exposure (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposures				
0.3-3.0	614	1.63	*(100)	6
3.0-30	1842/f	4.89/f	*($900/f^2$)	6
30-300	61.4	0.163	1.0	6
300-1500			f/300	6
1500-100,000			5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*(100)	30
1.34-30	824/f	2.19/f	*($180/f^2$)	30
30-300	27.5	0.073	0.2	30
300-1500			f/1500	30
1500-100,000			1.0	30

f = frequency in MHz
* = Plane-wave equivalent power density

Note 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

Note 2: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

5.4.1. Method of Measurements

Calculation Method of Power Density/RF Safety Distance:

$$S = \frac{PG}{4\pi \cdot r^2} = \frac{EIRP}{4\pi \cdot r^2}$$

Where, P: power input to the antenna in mW
EIRP: Equivalent (effective) isotropic radiated power.
S: power density mW/cm^2
G: numeric gain of antenna relative to isotropic radiator
r: distance to centre of radiation in cm

5.4.2. RF Evaluation

Pursuant to KDB 447498 D01 General RF Exposure Guidance v06, Section 7.2:

Simultaneous transmission MPE test exclusion applies when the sum of the MPE ratios for all simultaneously transmitting antennas incorporated in a host device is ≤ 1.0, according to calculated/estimated, numerically modeled, or measured field strengths or power density.

The EUT is subject to co-location MPE evaluation, below table are the possible option(s):

Source / Option	Lyngsoe Systems Ltd. Active RFID Reader	Lyngsoe Systems Ltd. WiFi and Bluetooth Module (FCC ID: Z64-WL18DBMOD)	Lyngsoe Systems Ltd. UHF RFID Reader Module (FCC ID: PQG-MERCURY6E-M)	Telit Communications S.p.A. Data Terminal Module (FCC ID: RI7LE910CXWWX)
1	X	X	X	--
2	X	X	X	X

Co-location evaluation is evaluated at a separation distance of 55 cm. The table below is the calculation for all the possible options and the sum of the MPE ratios from all sources.

	Maximum MPE Ratio				Sum of MPE ratios from all sources
Source / Option	Lyngsoe Systems Ltd. Active RFID Reader	Lyngsoe Systems Ltd. WiFi and Bluetooth Module (FCC ID: Z64-WL18DBMOD)	Lyngsoe Systems Ltd. UHF RFID Reader Module (FCC ID: PQG-MERCURY6E-M)	Telit Communications S.p.A. Data Terminal Module (FCC ID: RI7LE910CXWWX)	
1	0.00007	0.008	0.169	--	**0.177**
2	0.00007	0.008	0.169	0.133	**0.310**

The sum of the MPE ratios from all sources is < 1. Thus, in compliant with general public (uncontrolled environment) MPE limit.

For detailed MPE ratios calculation, refer to the following tables.

Calculated MPE Ratio for Lyngsoe Systems Ltd. Active RFID Reader					
Frequency (MHz)	*EUT EIRP (mW)	Evaluation Distance (cm)	Power Density (mW/cm^2)	MPE Limit (mW/cm^2)	MPE Ratio
0.125	--	--	--	--	**--**
433.92	0.589	55	0.00002	0.289	**0.00007**

*EIRP is calculated from the measured field strength and measurement distance using formula: EIRP = $(E \times d)^2/30$, where: E = electric field strength in V/m and d = measurement distance in meters (m).

Measured max. field strength for 433.92 MHz Tx at 3m = 92.93 dBuV/m = 0.04431 V/m
EIRP = $(E \times d)^2/30 = (0.04431 \times 3)^2/30 = 0.000589$ W = 0.589 mW

Calculated MPE Ratio for Texas Instruments WiFi and Bluetooth Module									
Band	**Frequency (MHz)**	**[2] Antenna Gain (dBi)**	**[1] Maximum Power (dBm)**	**[1] Maximum EIRP (dBm)**	**[1] Maximum EIRP (W)**	**[1] Average EIRP (mW)**	**Power Density at 55cm (mW/cm^2)**	**MPE Limit (mW/cm^2)**	**MPE Ratio**
Bluetooth	2402	3.2	12.5	15.7	0.037	37.154	0.001	1.000	**0.001**
2.4GHz WLAN	2412	3.2	17.5	20.7	0.117	117.49	0.003	1.000	0.003
5GHz WLAN	5180	4.5	19.5	24	0.251	251.189	0.007	1.000	**0.007**
							Sum of MPE Ratios from Bluetooth and 5GHz WLAN:		**0.008**

[1] Data derived from Texas Instruments WiFi and Bluetooth Module RF exposure evaluation test report, Test Report No. FA741330.
[2] Maximum permitted antenna gain.

Calculated MPE Ratio for Lyngsoe Systems Ltd. UHF RFID Reader Module								
Frequency (MHz)	**[1] Maximum Conducted Power (dBm)**	**[1] Antenna Gain (dBi)**	**EIRP (dBm)**	**EIRP (mW)**	**Distance (cm)**	**MPE (mW/cm^2)**	**Limit (mW/cm^2)**	**MPE Ratio**
902.625	29	6.9	35.9	3890.451	55	0.102	0.602	**0.169**

[1] Data derived from Lyngsoe Systems Ltd., UHF RFID Reader Module test report, Test Report No. 23LYI-213_FCC15C247

Calculated MPE Ratio for Telit Communications S.p.A. Data Terminal Module							
Band / Mode	**Frequency (MHz)**	**[1] Max Power (dBm)**	**[1] Maximum Permissive Antenna Gain (dBi)**	**Evaluation Distance (cm)**	**Power Density (mW/cm^2)**	**MPE Limit (mW/cm^2)**	**MPE Ratio**
GSM/GPRS Cell	824.2 - 848.8	27.5	6.91	55	0.073	0.549	**0.133**
EDGE Cell	824.2 - 848.9	22	12.41	55	0.073	0.549	**0.133**
GSM/GPRS PCS	1850.2 - 1909.8	24.5	8.51	55	0.053	1.000	0.053
EDGE PCS	1850.2 - 1909.8	21	12.01	55	0.053	1.000	0.053
WCDMA Cell	826.4 - 846.6	24.5	9.92	55	0.073	0.551	0.132
WCDMA AWS	1712.4 - 1752.6	24.5	5.50	55	0.026	1.000	0.026
WCDMA PCS	1852.4 - 1907.6	24.5	8.51	55	0.053	1.000	0.053
LTE BAND25/2	1850.7 -1914.3	24	9.01	55	0.053	1.000	0.053
LTE BAND4	1710.7 - 1754.3	24	6.00	55	0.026	1.000	0.026
LTE BAND26/5	824.7 - 848.3	24	10.41	55	0.073	0.550	**0.133**
LTE BAND7	2502.5 - 2567.5	24	9.01	55	0.053	1.000	0.053
LTE BAND8	898.2 - 899.8	24	10.79	55	0.079	0.599	0.132
LTE BAND12	699.7 - 715.3	24	9.70	55	0.062	0.466	**0.133**
LTE BAND13	779.5 - 784.5	24	10.17	55	0.069	0.520	**0.133**
LTE BAND14	790.5 - 795.5	24	10.23	55	0.070	0.527	**0.133**
LTE Band26(Part.90)	814.7 - 823.3	24	10.36	55	0.072	0.543	**0.133**

[1] Data derived from Telit Data Terminal Module MPE test report, Test Report No. 1M2106040065-03.RI7.

5.5. TEST EQUIPMENT LIST

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range	Cal. Due Date
EMI Analyzer	Agilent	E7401A	US40240432	9 kHz – 1.5 GHz	26 Oct 2023
LISN	EMCO	3825/2	8907-1531	9 kHz to 100 MHz	17 Feb 2023*
125 kHz Highpass	Rohde & Schwarz	EZ-25	830164/007	150 kHz – 30 MHz	23 Aug 2023
EMI Receiver	Rohde & Schwarz	ESU40	100037	20Hz–40 GHz	26 Sep 2023
Loop Antenna	EMCO	6502	9104-2611	0.009 – 30 MHz	17 Feb 2024
Spectrum Analyzer	Rohde & Schwarz	FSU26	100398	20Hz–26.5 GHz	20 Sep 2023
Log Periodic	ETS-Lindgren	3148	00023845	200-2000 MHz	14 Apr 2023
Attenuator	Radiall	R411.820.121	--	DC-18GHz	See Note 1
Log Periodic	ETS-Lindgren	93148	1101	200-2000 MHz	16 Dec 2023
Biconilog Antenna	EMCO	3142C	00026873	26-2000MHz	16 Dec 2023
Horn Antenna	ETS-Lindgren	3115	9701-5061	1-18GHz	15 Aug 2024
Horn Antenna	ETS-Lindgren	3117	00119425	1-18GHz	20 Jan 2024
Preamplifier	Com-Power	PAM-118A	551016	500MHz-18GHz	01 Mar 2024
Preamplifier	Com-Power	PAM-103	18020181	1-1000MHz	01 Mar 2024
Hi-Pass filter	Mini-Circuit	SHP-600	--	Cut off 600MHz	See Note 1
Note 1: Internal verification/calibration check					

*Equipment used before calibration due date.

EXHIBIT 6. MEASUREMENT UNCERTAINTY

The measurement uncertainties stated were calculated in accordance with the requirements of CISPR 16-4-2 @ IEC:2003 and JCGM 100:2008 (GUM 1995) – Guide to the Expression of Uncertainty in Measurement.

Test description		Uncertainty
Power Line Conducted Emissions		± 2.62
Transmitter/Spurious Radiated Emissions	<30 MHz	± 2.69dB
	30-1000 MHz	± 4.20dB
	>1 GHz	± 2.70dB

All uncertainty values are expanded standard uncertainty to give a confidence level of 95%, based on coverage factor k=2