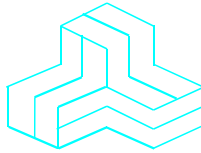


ENGINEERING TEST REPORT



LS4550 Combi Master
Model: LS4550
FCC ID: PQG-LS4550

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.: 19LYI172_FCC15C231E

This Test report is Issued under the Authority of
Tri M. Luu
Vice President of Engineering
UltraTech Group of Labs

Date: February 20, 2019

Report Prepared by: Dan Huynh

Tested by: Hung Trinh

Issued Date: February 20, 2019

Test Dates:
March 16 - 26, 2018
February 7, 2019

- *The results in this Test Report apply only to the sample(s) tested, and the sample tested is randomly selected.*
- *This report must not be used by the client to claim product endorsement by any agency of the US Government.*
- *This test report shall not be reproduced, except in full, without a written approval from UltraTech*

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Korea KCC-RRR

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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	2018	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
Contact Person:	Donald Ferguson Phone #: 905-501-1533 Fax #: 905-501-1538 Email Address: dfe@lyngsoesystems.com

Manufacturer	
Name:	Lyngsoe Systems Ltd.
Address:	101 Simona Dr., Unit 2 Bolton, Ontario Canada L7E 4E8
Contact Person:	Donald Ferguson Phone #: 905-501-1533 Fax #: 905-501-1538 Email Address: dfe@lyngsoesystems.com

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:	LS4550 Combi Master
Model Name or Number:	LS4550
Serial Number:	Test sample
Type of Equipment:	RFID Device
Input Power Supply Type:	24V DC, from external certified AC adapter
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 EXB45)	
Equipment Type:	Base station
Intended Operating Environment:	Commercial, light industry & heavy industry
Power Supply Requirement:	24V DC, from external certified AC adapter
RF Output Power Rating:	125 kHz Tx: 98.31 dB μ V/m peak (98.24dB μ V/m average) at 10m distance 433.92 MHz Tx: 89.44 dB μ V/m peak (70.54 dB μ V/m average) at 3m distance
Operating Frequency Range:	125 kHz & 433.92 MHz Note: other non-LS transmitters are: Digi CC IMX6UL 2.4 and 5.4GHz (FCC ID: MCQ-CCIMX6UL IC: 1846A-CCIMX6UL); Impinj R420 915MHz (FCC ID: TWYIPJREV and IC:6324A-IPJREV)
Duty Cycle:	9.50 % (for 433.92 MHz transmitter)
Modulation Type:	OOK (LF) & FSK (UHF)
Oscillator Frequencies:	LS board with transmitters: EXB45 clocks 13.56MHz & 20MHz; Other LS boards (no transmitters): RDB45 clocks 32.768kHz, 4.9152MHz, 25MHz SUP45 clock 16MHz
Antenna Connector Type:	Integral
Antenna Description:	Manufacturer: Lyngsoe Systems Type: Two loops 40 x 40cm, 16 turns each for 125 kHz; PCB loop Antenna for 433.92 MHz Model: N/A Frequency Range: 125 kHz; 433.92 MHz Gain: Not applicable for near field operation @ 125 kHz; -17.2 dBi @ 433.92 MHz
Receiver (Reader Board RDB45)	
Equipment Type:	Base Station (fixed use)
Power Supply Requirement:	24V DC, from external certified AC adapter
Operating Frequency Range:	433.92 MHz
RF Output Impedance:	50 Ω
Antenna Connector Type:	MCX

2.4. ASSOCIATED ANTENNA DESCRIPTIONS

Manufacturer	Antenna Type	Model	Frequency Range	Maximum Gain
Lyngsoe	Inductive Loops – two pcs, used for the EXB45 transmitter	500439Rev0-0, 500804Rev0-0	125kHz	N/A
Lyngsoe	PCB Antenna – on the EXB45 transmitter	N/A	434MHz	-17.2 dBi
Linx Technologies Inc.	Whip, Center-Fed Double – two pcs, used for the RDB45 receiver	ANT433OEMLNG001v2	434MHz	1.2 dBi
Laird	Patches, left and right polarization – two pcs, used for the Impinj passive reader	S9028PCLJ36RTNB, S9028PCRJ36RTNB	902-928MHz	9 dBic
Ethertronics/AVX	PCB Antenna – used for the Digi computer with dual band wifi modem	1001932PT-AA10L0100	2.400–2.485GHz & 5.150–5.825 GHz	2.5 dBi & 4.4 dBi

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	Power Input 24Vdc	2	Molex 3 pins	Included in the external AC adapter, shielded
2	LF Sync IN/OUT	2	RJ45	Patch cable, shielded, max 100m

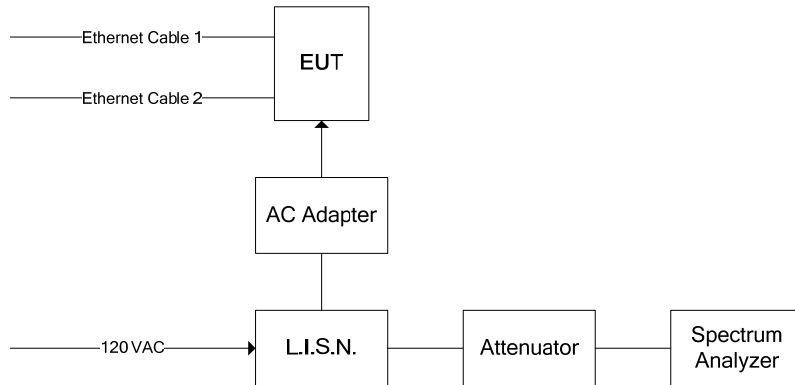
2.6. ANCILLARY EQUIPMENT

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:	VEC50US24
Serial Number:	N/A
Connected to EUT's Port:	Power Input

2.7. TEST SETUP BLOCK DIAGRAM

AC Power-line Conducted Emissions



Radiated Emissions

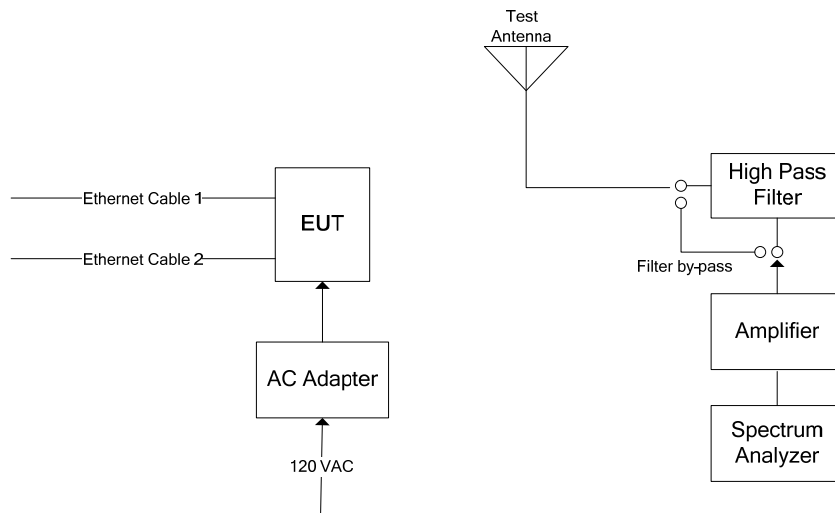


EXHIBIT 3. EUT OPERATING CONDITIONS AND CONFIGURATIONS DURING TESTS

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:	24V DC, from external certified AC adapter

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: 98.31 dB μ V/m peak (98.24dB μ V/m average) at 10m distance 433.92 MHz Tx: 89.44 dB μ V/m peak (70.54 dB μ V/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 Powerline 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 [§15.207(a)]

5.1.1. Limit(s)

The equipment shall meet the limits of the following table:

Frequency of emission (MHz)	Conducted Limits (dB μ V)	
	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

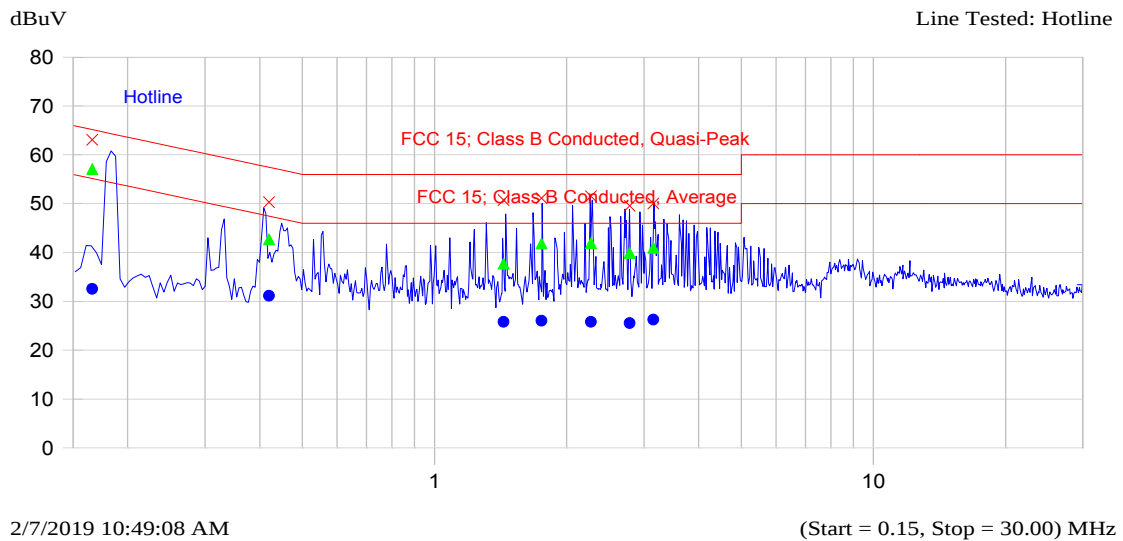
5.1.2. Method of Measurements

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

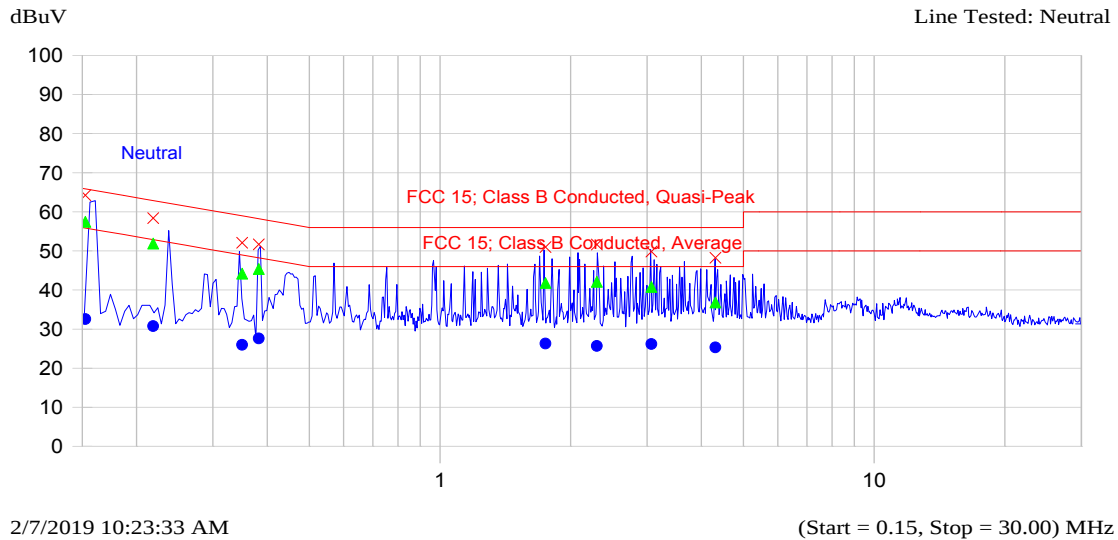


Current List

Frequency MHz	Peak dBuV	QP dBuV	QP-QP Limit dB	Avg dBuV	Avg-Avg Limit dB	Trace Name
0.166	63.1	57.1	-8.1	32.6	-22.6	Hotline
0.420	50.3	42.7	-14.7	31.2	-16.3	Hotline
1.437	50.7	37.7	-18.3	25.8	-20.2	Hotline
1.753	51.1	41.8	-14.2	26.0	-20.0	Hotline
2.272	51.5	41.9	-14.1	25.8	-20.2	Hotline
2.783	49.6	39.9	-16.1	25.5	-20.5	Hotline
3.153	50.0	41.0	-15.0	26.3	-19.7	Hotline

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
0.153	64.3	57.4	-8.4	32.6	-23.3	Neutral
0.219	58.4	51.9	-11.0	30.7	-22.1	Neutral
0.350	52.1	44.2	-14.8	26.0	-23.0	Neutral
0.383	51.7	45.3	-12.9	27.6	-20.6	Neutral
1.750	51.0	41.8	-14.2	26.3	-19.7	Neutral
2.298	51.6	42.1	-13.9	25.7	-20.3	Neutral
3.068	49.8	40.8	-15.2	26.2	-19.8	Neutral
4.306	48.3	36.8	-19.2	25.3	-20.7	Neutral

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

¹Linear 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:

- 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).
- Measurements were performed at 100m and 30m distances to determine the proper extrapolation factor.

Maximum field strength level at 100m distance: 40.53 dB μ V/m

Maximum field strength level at 30m distance: 68.15 dB μ V/m

Extrapolation factor:

Difference of measurement between 100 m & 30 m: $\Delta E = 68.15 - 40.53 = 27.62$ dB

$\Delta E = 20 * \log(100/30)^x = 27.62$ dB or $x = 27.62 / (20 * \log(100/30)) = 2.64 \rightarrow (52.8 \text{ dB/decade})$

- Field strength limit of the fundamental 125 kHz at 300m distance is $20 * \log(2400/125) = 25.7$ dB μ V/m
- For frequency 125 kHz, the measured E-Field at 10m (column 3) will be extrapolated to 300m E-Field Level (column 4) using the extrapolation factor of $52.8 * \log(10/300) = -77.99$ dB

Frequency (MHz)	RF Peak Level @ 10m (dB μ V/m)	RF Average Level @ 10m (dB μ V/m)	Extrapolated RF Level (dB μ V/m)	Antenna Plane (H/V)	§ 15.209 (a) Limits (dB μ V/m)	Margin (dB)
Fundamental Emissions						
0.125	98.31	98.24	20.25	V	25.7	-5.45
0.125	89.76	89.71	11.72	H	25.7	-13.98
Harmonic/Spurious Emissions						
0.010 - 0.490	*	*	*	H / V	*	*
0.490 - 1.705	*	*	*	H / V	*	*
1.705 - 30.0	*	*	*	H / V	*	*

* No emissions component detected.

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 = $20 \log [(16.67 \times 433.92) - 2833.33] = 72.9 \text{ dB}\mu\text{V/m}$
- Spurious emissions limit is 20 dB below fundamental limit.
- Duty Cycle: measured maximum duty cycle is 9.50 %.
- The peak-average correction factor = -20.45 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	83.19	62.74	V	72.9	--	-10.13	PASS
433.92	89.44	68.99	H	72.9	--	-3.88	PASS
Field strength of spurious emission							
867.84	57.04	36.59	V	52.9	46.0	-16.28	PASS
867.84	62.09	41.64	H	52.9	46.0	-11.23	PASS
3471.36	54.58	34.13	V	52.9	54.0	-19.87	PASS
3471.36	56.11	35.66	H	52.9	54.0	-18.34	PASS
3905.28	65.09	44.64	V	52.9	54.0	-9.36	PASS
3905.28	63.95	43.50	H	52.9	54.0	-10.50	PASS
4339.20	56.49	36.04	H	52.9	54.0	-17.96	PASS

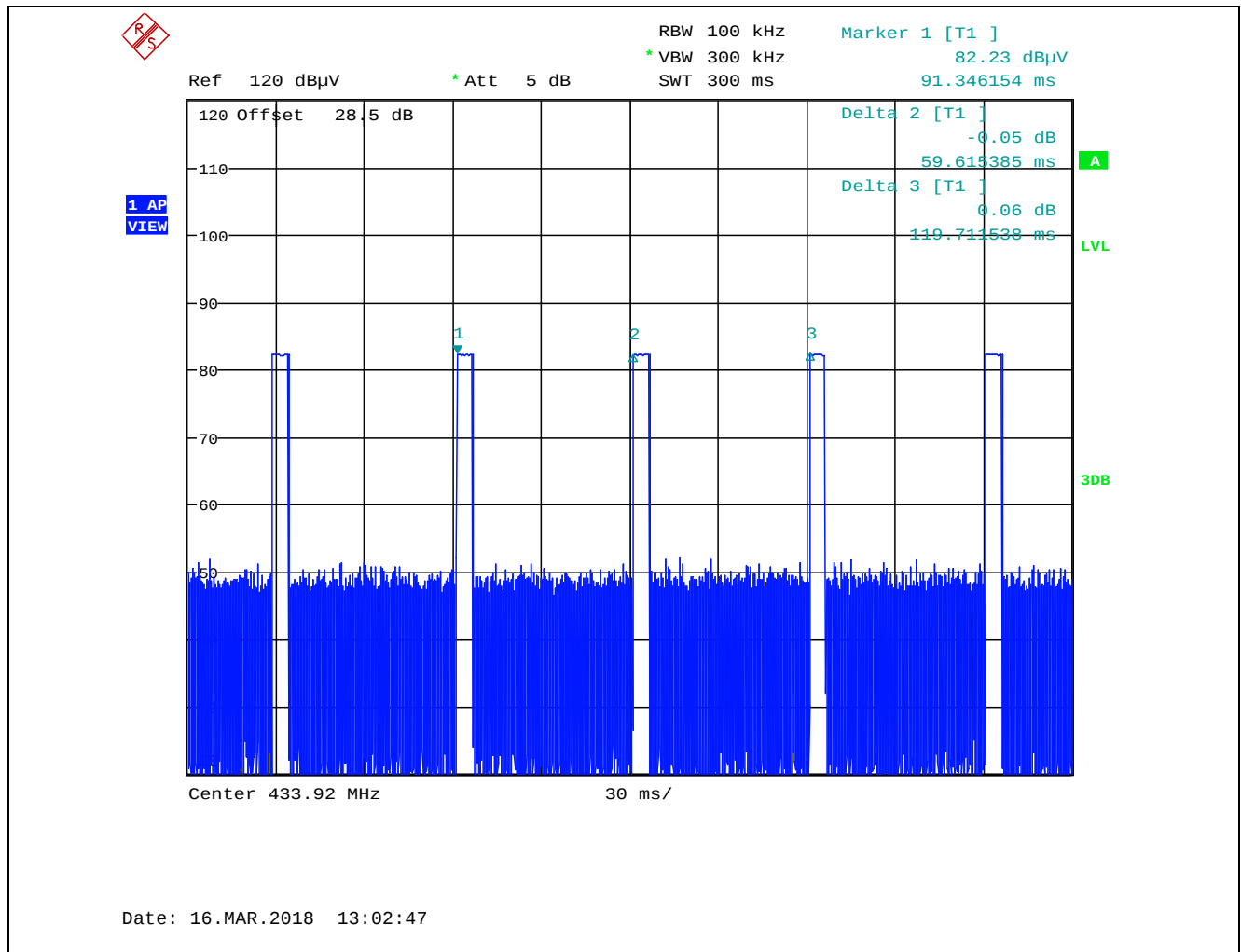
5.2.3.3. Duty-Cycle Correction Factor

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

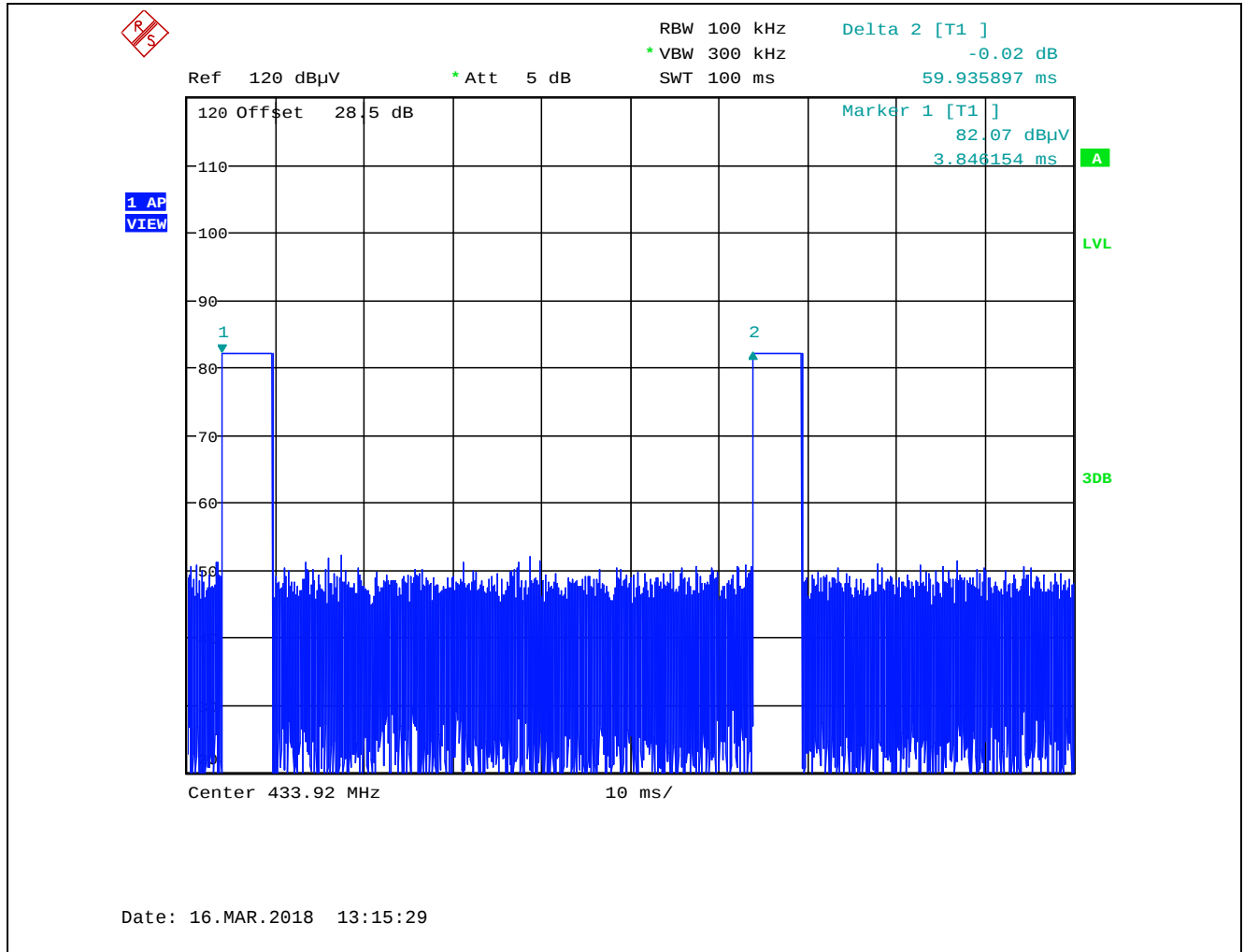
Computation of duty-cycle correction factor

Sub-Pulse	Duration (ms)	Number of pulses	Sub-Pulse “On Time” (ms)
1	5.673	1	5.673
TOTAL ON TIME:			5.673
Duty cycle correction factor: $20 \cdot \log(T_{ON}/\text{Period}) = 20 \cdot \log(5.673\text{ms}/59.936\text{ ms}) = -20.45\text{ dB}$			

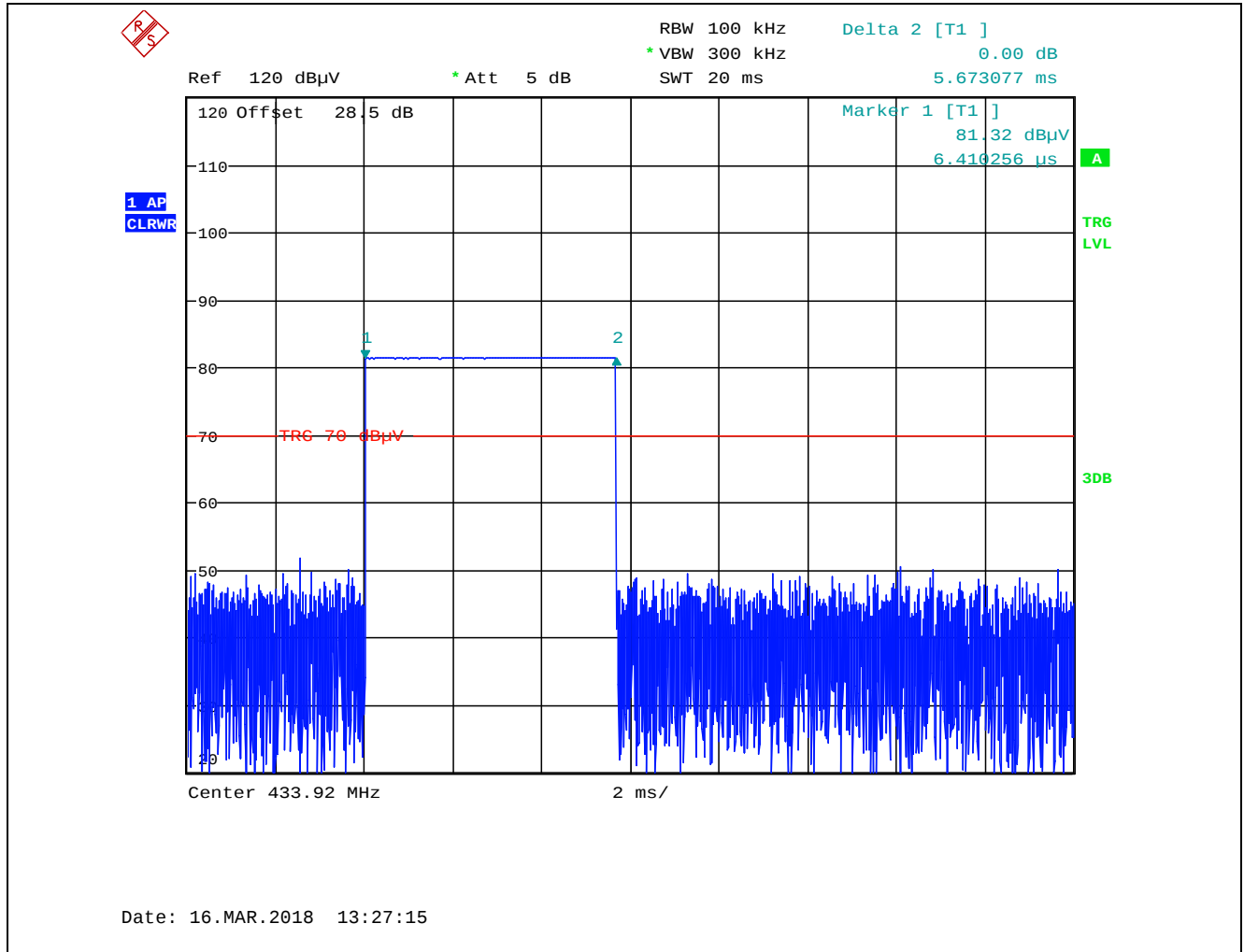
Plot 5.2.3.3.1. Duty Cycle (Pulse Train)



Plot 5.2.3.3.2. Duty Cycle (Period)



Plot 5.2.3.3. Duty Cycle (Pulse)



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File #: 19LYI172_FCC15C231E

February 20, 2019

All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

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

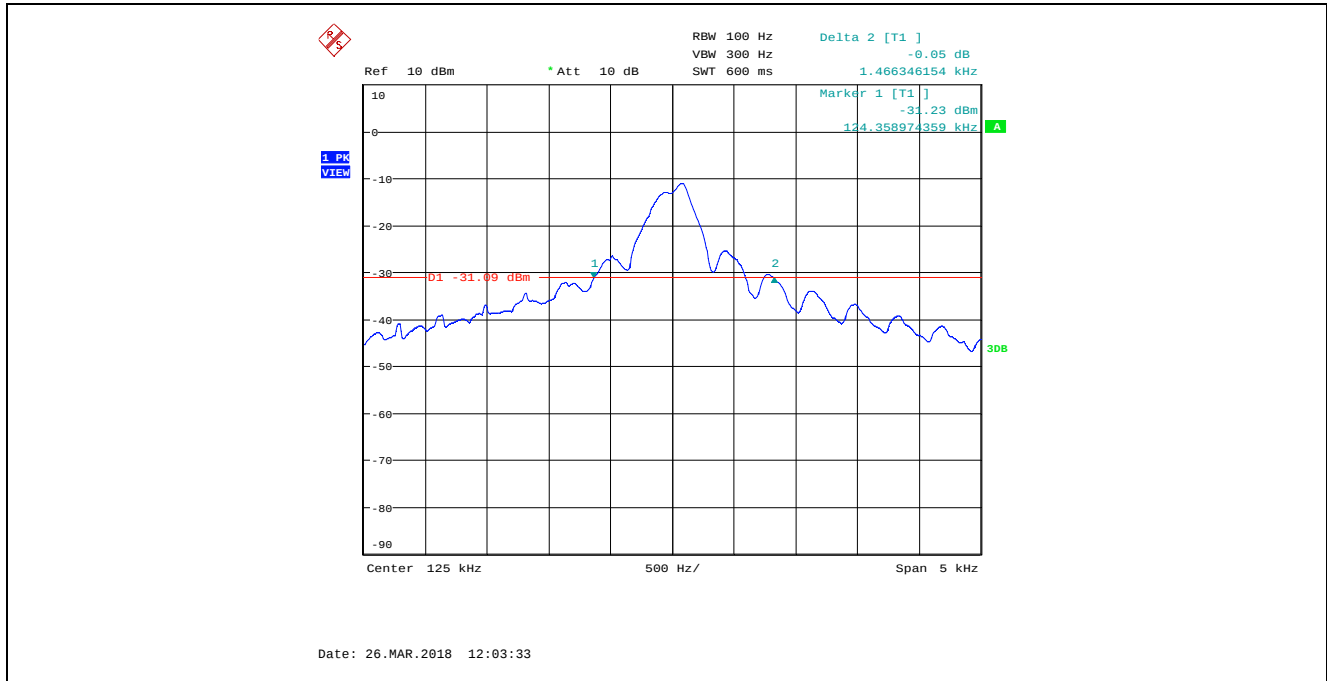
The measurements were performed in accordance with Ultratech Test Procedures, File # ULTR P001-2004 and ANSI C63.4

5.3.3. Test Data

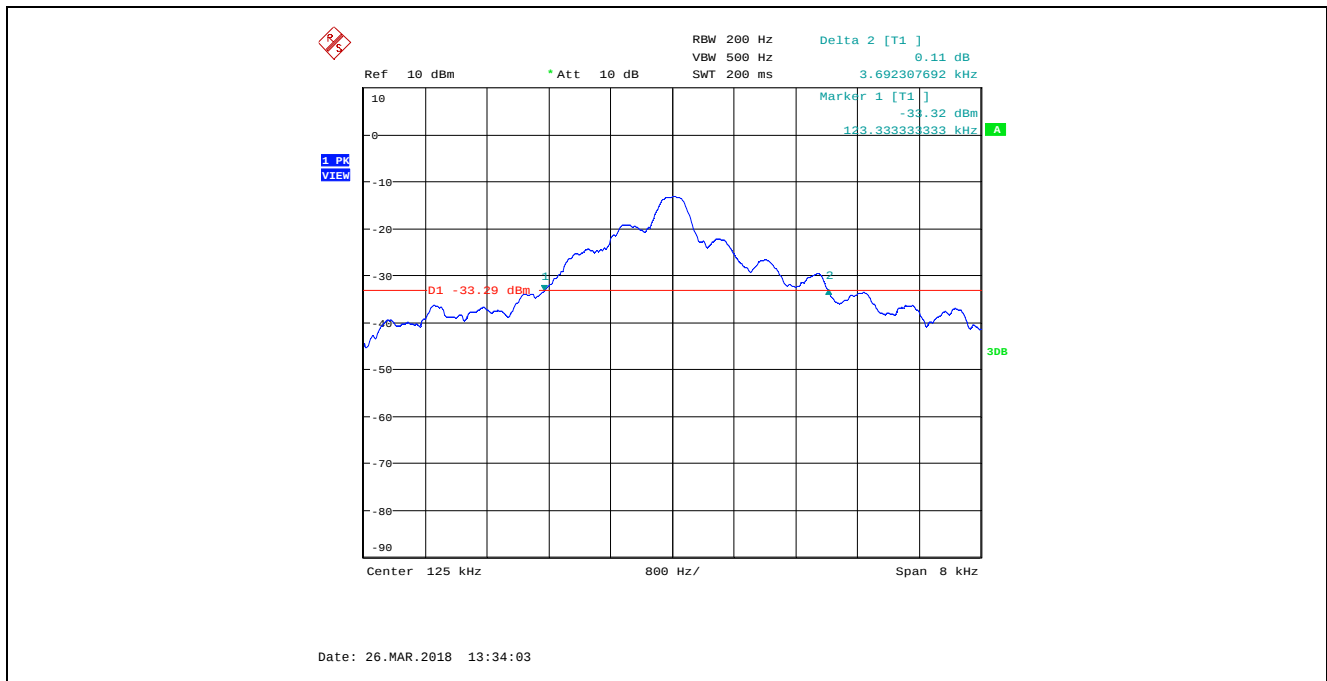
Channel Frequency	Modulation	20 dB Bandwidth (kHz)	Limit (kHz)
125 kHz	Command SM1, Modulation Constant to "1"	1.466	--
	Command SM2, OOK Modulation with 600 Hz	3.692	--
433.92 MHz	FSK modulated with programmed messages	42.788	≤ 1084.8
	FSK modulated with a signal 101010..., 1 b/s	26.058	≤ 1084.8

See the following plots for detail.

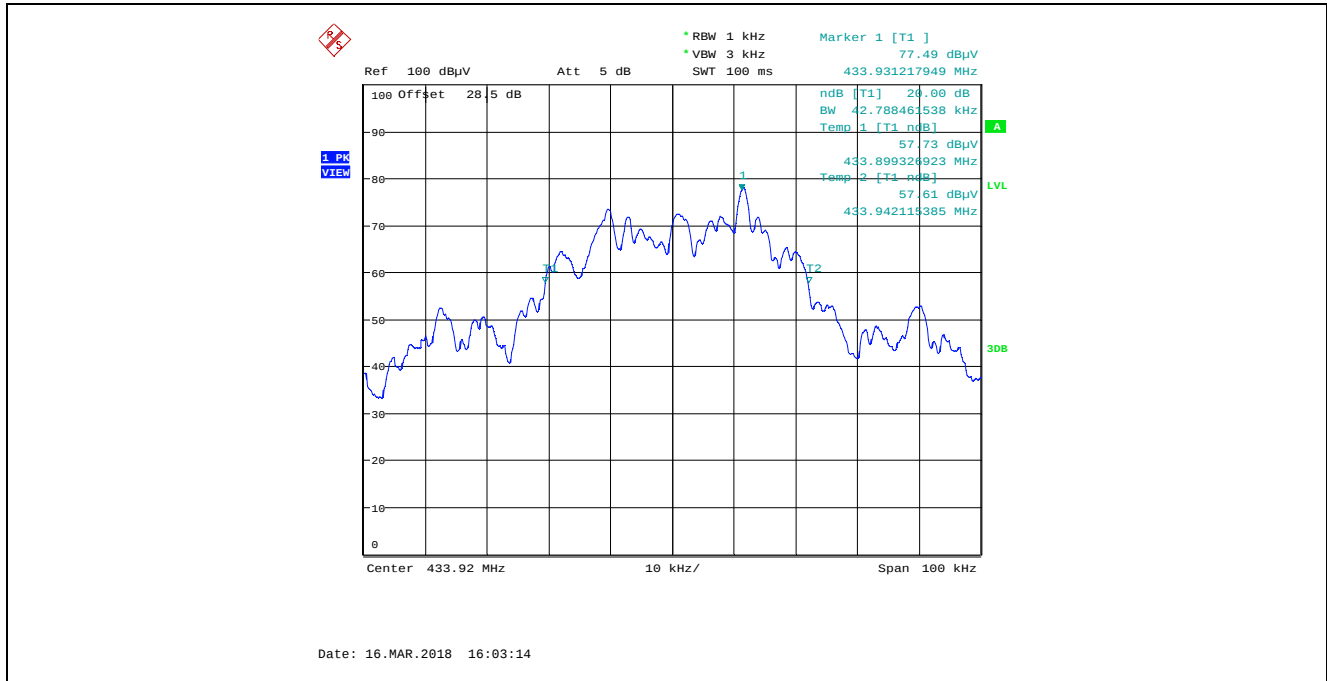
Plot 5.3.3.1. 20 dB Bandwidth, Fc: 125 kHz
 Command SM1, Modulation Constant to "1"



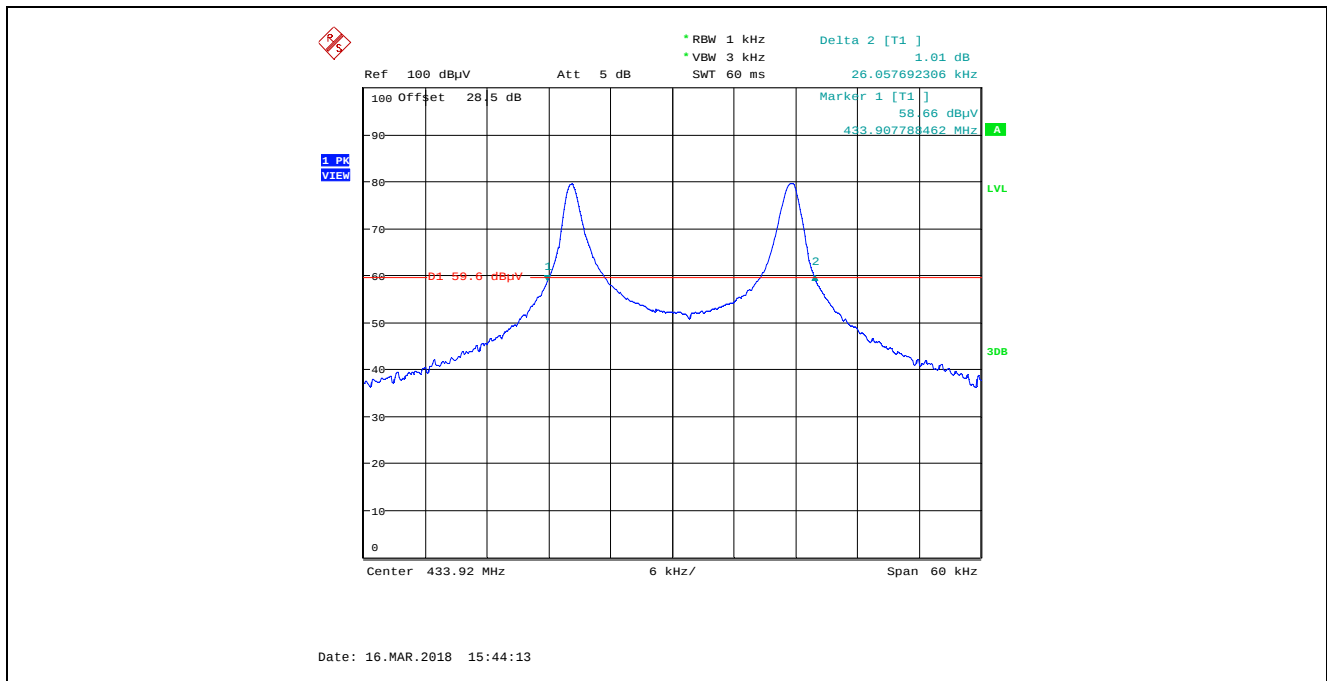
Plot 5.3.3.2. 20 dB Bandwidth, Fc: 125 kHz
 Command SM2, OOK Modulation with 600 Hz



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



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



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/cm²
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 following table addresses the co-location of all simultaneous transmitters within the EUT at a minimum separation distance 35 cm

Transmitters	Frequency (MHz)	EUT EIRP (dBm)	EUT EIRP (mW)	Evaluation Distance (cm)	Power Density (mW/cm ²)	FCC MPE Limit (mW/cm ²)	MPE Ratio
Transmitters on EXB45 within EUT	0.125	--	--	35	--	--	--
	433.92	-5.79	0.264	35	0.00002	0.289	0.00007
Impinj, Inc. Speedway Revolution UHF RFID Reader FCC ID: TWYIPJREV IC: 6324A-IPJREV	902.0	--	4000	35	0.260	0.601	0.432
Digi International Inc ConnectCore for i.MX6UL FCC ID: MCQ- CCIMX6UL IC: 1846A-CCIMX6UL	2402	10.6	11.482	35	0.001	1.000	0.001
	2412	22.6	181.97	35	0.012	1.000	0.012
	5180	16.1	40.738	35	0.003	1.000	0.003
Sum of the MPE ratios for all simultaneously transmitting antennas incorporated within the EUT							0.445

Note: The worst-case configuration (maximum MPE ratio) for each radio module derived from the original radio MPE report was used in the computation. Refer to these reports for detail.

Conclusion: The sum of the MPE ratios is $0.445 \leq 1.0$, thus the EUT is in compliance with the RF exposure requirements

5.5. TEST EQUIPMENT LIST

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range	Cal. Due Date
Semi-Anechoic Chamber	TDK	IC: 2049A-3	--	--	03 Mar 2020
EMI Receiver	Rohde & Schwarz	ESU40	100037	20Hz-40 GHz	09 May 2018*
Loop Antenna	EMCO	6502	9104-2611	10 kHz – 30 MHz	15 Dec 2019
Biconilog	EMCO	3142	9601-1005	26-2000 MHz	12 May 2018*
RF Amplifier	Com-Power	PAM-0118A	551052	0.5 – 18 GHz	17 Jul 2018*
Horn Antenna	EMCO	3155	9701-5061	1 – 18 GHz	30 Apr 2020
High Pass Filter	Mini-Circuits	SHP-800	10425	Cut off 400 MHz	See Note 1
Spectrum Analyzer	Hewlett Packard	HP 8593EM	3710A00223	9kHz - 22GHz	22 May 2019
Attenuator	Pasternack	PE7010-20	9	DC TO 2 GHz	13 Mar 2019
LISN	Schwarzbeck	NSLK 8127	8127276	10kHz-30MHz	11 Dec 2019

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.

6.1. LINE CONDUCTED EMISSION MEASUREMENT UNCERTAINTY

	Line Conducted Emission Measurement Uncertainty (9 kHz – 30 MHz):	Measured	Limit
u_c	Combined standard uncertainty: $u_c(y) = \sqrt{\sum_{i=1}^m u_i^2(y)}$	± 1.44	± 1.8
U	Expanded uncertainty U: $U = 2u_c(y)$	± 2.89	± 3.6

6.2. RADIATED EMISSION MEASUREMENT UNCERTAINTY

	Radiated Emission Measurement Uncertainty (10 kHz – 30 MHz):	Measured	Limit
u_c	Combined standard uncertainty: $u_c(y) = \sqrt{\sum_{i=1}^m u_i^2(y)}$	± 1.30	± 2.6
U	Expanded uncertainty U: $U = 2u_c(y)$	± 2.60	± 5.2

	Radiated Emission Measurement Uncertainty @ 3m, Horizontal (30-1000 MHz):	Measured (dB)	Limit (dB)
u_c	Combined standard uncertainty: $u_c(y) = \sqrt{\sum_{i=1}^m u_i^2(y)}$	± 2.15	± 2.6
U	Expanded uncertainty U: $U = 2u_c(y)$	± 4.30	± 5.2

	Radiated Emission Measurement Uncertainty @ 3m, Vertical (30-1000 MHz):	Measured (dB)	Limit (dB)
u_c	Combined standard uncertainty: $u_c(y) = \sqrt{\sum_{i=1}^m u_i^2(y)}$	± 2.14	± 2.6
U	Expanded uncertainty U: $U = 2u_c(y)$	± 4.29	± 5.2

	Radiated Emission Measurement Uncertainty @ 3 m, Horizontal & Vertical (1 – 18 GHz):	Measured (dB)	Limit (dB)
u_c	Combined standard uncertainty: $u_c(y) = \sqrt{\sum_{i=1}^m u_i^2(y)}$	± 1.52	Under consideration
U	Expanded uncertainty U: $U = 2u_c(y)$	± 3.04	Under consideration