TEST REPORT

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Test Report Number: SKT-RFC-180005
Date of issue: November 20, 2018

Applicant:	**DUALi Inc.** 1-309 Innoplex, 552 Woncheon-dong, Youngtong-gu, Suwon, Gyeonggi-do South Korea
Manufacturer:	**DUALi Inc.** 1-309 Innoplex, 552 Woncheon-dong, Youngtong-gu, Suwon, Gyeonggi-do South Korea
Product:	SMART CARD & QR Reader
Model:	**DQ-MINI**
FCC ID:	**SWUDQMINI**
Project number:	SKTEU18-1015
EUT received:	October 12, 2018
Applied standards:	ANSI C63.10-2013 and ANSI C63.4-2014
Rule parts:	FCC Part 15 Subpart C - Intentional radiators
Equipment Class:	DXT - Part 15 Low Power Transceiver, Rx Verified
Remarks to the standards:	None

The above equipment has been tested by SK Tech Co., Ltd., and found compliance with the requirements set forth in the technical standards mentioned above. The results of testing in this report apply only to the product or system, which was tested.

Wonsik Ham / **Testing Engineer**

Jongsoo Yoon / **Technical Manager**

Revision History of Test Report

Rev.	Revisions	Effect page	Approved by	Date
-	Initial issue	All	Jongsoo Yoon	Nov. 20, 2018

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1 Summary of test results

Requirement	CFR 47 Section	Result
Antenna Requirement	15.203	Meets the requirements
Radiated Emissions Field Strength within the band 13.553-13.567 MHz	15.225(a)	Meets the requirements
Field Strength within the bands 13.410-13.553 MHz and 13.567-13.710 MHz 13.110-13.410 MHz and 13.710-14.010 MHz	15.225(b) & (c)	Meets the requirements
Radiated Harmonics and Spurious Emissions Outside of the 13.110 – 14.010 MHz	15.225(d) 15.209(a)	Meets the requirements
Frequency Tolerance of Carrier Signal	15.225(e)	Meets the requirements
AC power line Conducted emissions	15.207(a)	Meets the requirements

2 Description of equipment under test (EUT)

Product:	SMART CARD &QR Reader
Model:	DQ-MINI
Serial number:	None (prototype)

Model differences:

Model name	Difference	Tested (checked)
DQ-MINI	fully tested model that was provided by the applicant	☒

Technical data:

Power source	DC 12 V
Local Oscillator or X-Tal	32.768 kHz, 12 MHz, 27.12 MHz, 168 MHz(CPU)
Transmit Frequency	13.56 MHz
Antenna Type	Internal PCB antenna (66 × 61 mm, 2-turns)
Type of Modulation	ASK

I/O port	Type	Q'ty	Remark
DC input	Jack	1	-
RS-232	RS-232	1	-

Note: *The equipment authorization for FCC Part 15B as a digital device was made under SDoC process with a separate test report number.*

Equipment Modifications

none

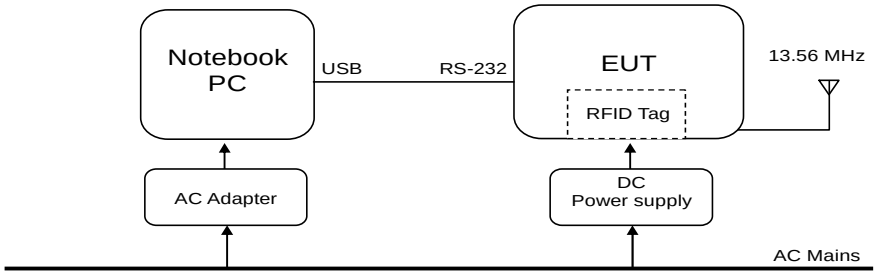
Submitted Documents

Block diagram
Schematic diagram
Parts List
User manual

3 Test and measurement conditions

3.1. Test configuration (arrangement of EUT)

The EUT was tested in the continuous transmitting mode provided by the applicant.
Test software used: DualCard.exe, Ver4.15 (Card Reader Test Program). The duty cycle of the RFID signal was 100 %.



3.2. Description of support units (accessory equipment)

#	Equipment	Manufacturer	Model No.	Serial No.
1	RFID tag(A/B)	N/A	N/A	N/A
2	DC Power supply	HP	6633A	2838A-01000
3	Notebook PC	SAMSUNG Electronics Co., Ltd.	NT500R5W	002C91KJ300210E
4	AC Adapter (for Notebook PC)	SAMSUNG Electronics Co., Ltd.	A13-040N2A	CN60BA4400313ADON871703WW
5	AC Adapter (for EUT)	SHENZHEN RIHUIDA ELECTRONICS CO.,LTD. HONGKONG POWER-TEK INTERNATIONAL CO.,LTD.	SW60-12005000-W	SW60-12005000-WE9

Note: *AC Adapter was used instead of DC Power supply for AC power line Conducted emissions.*

3.3. Interconnection and I/O cables

The following support units or accessories were used to form a representative test configuration during the tests.

#	Start		End		Cable	
	Name	I/O port	Name	I/O port	length (m)	shielded (Y/N)
1	EUT	RS-232	Notebook PC	USB	0.3	Y
2	EUT	DC Input	DC Power supply	DC Output	1.7	N
3	Notebook PC	DC Input	AC Adapter	DC Output	1.7	N
4	AC Adapter	AC Input	AC Mains	AC Mains	1.0	N
5	DC Power supply	AC Input	AC Mains	AC Mains	1.2	N
6	RFID card	-	-	-	-	-

3.4. Measurement Uncertainty (*U*)

Measurement Item	Combined Standard Uncertainty *Uc*	Expanded Uncertainty $U = k \times Uc$ ($k = 2$)
Conducted RF power	±1.49 dB	±2.98 dB
Conducted emissions	±1.42 dB	±2.84 dB
Radiated emissions (9 kHz to 30 MHz)	±2.30 dB	±4.60 dB
Radiated emissions (30 MHz to 1000 MHz)	±2.53 dB	±5.06 dB

3.5. Test date

Date Tested	October 18, 2018 – November 20, 2018

4 Facilities and accreditations

4.1. Facilities

All of the measurements described in this report were performed at SK Tech Co., Ltd
Site I: 88, Geulgaeul-ro 81beon-gil, Wabu-eup, Namyangju-si, Gyeonggi-do, Korea
Site II: 124-8, Geulgaeul-ro, Wabu-eup, Namyangju-si, Gyeonggi-do, Korea

The sites are constructed in conformance with the requirements of ANSI C63.4 and CISPR 16-1-4. The sites comply with the Normalized Site Attenuation requirements given in ANSI C63.4, and site VSWR requirements specified in CISPR 16-1-4. The measuring apparatus and ancillary equipment conform to CISPR 16-1 series.

4.2. Accreditations

The laboratory has been also notified to FCC by RRA as a Conformity Assessment Body, and designated to perform compliance testing on equipment subject to Declaration of Conformity (DOC) and Certification under Parts 15 and 18 of the FCC Rules.

Designation No.	KR0007

4.3. List of test and measurement instruments

No	Description	Model	Manufacturer	Serial No.	Cal. due	Use
1	Spectrum Analyzer	E4405B	Agilent	US40520856	2019.03.05	
2	Spectrum Analyzer	E4440A	Agilent	MY46186322	2019.06.18	☒
3	EMI Test Receiver	ESR26	Rohde&Schwarz	101441	2019.08.29	☒
4	EMI Test Receiver	ESIB40	Rohde&Schwarz	100277	2019.05.08	
5	EMI Test Receiver	PMM9010F	Narda	020WW40105	2019.06.18	☒
6	Pulse limiter	ESH3-Z2	Rohde&Schwarz	100604	2019.06.18	☒
7	AMN (LISN)	ENV 216	Rohde&Schwarz	102047	2019.03.05	☒
8	AMN (LISN)	FCC-LISN-50-32-2-01-480V	FCC	141455	2019.06.20	☒
9	Pre-amplifier	MLA-10K01-B01-27	TSJ	2005350	2019.06.19	☒
10	Pre-amplifier	8447D	HP	2944A07994	2019.06.19	
11	Pre-amplifier	MLA-100M18-B02-38	TSJ	1539546	2019.03.05	
12	Power Meter	E4417A	Agilent	MY45100426	2019.06.20	
13	Power Meter	E4418B	Agilent	US39402176	2019.06.20	
14	Power Sensor	E9327A	Agilent	MY44420696	2019.06.20	
15	Power Sensor	8485A	Agilent	3318A13916	2019.06.20	
16	Attenuator (10dB)	8491B	HP	38072	2019.06.19	☒
17	Attenuator (6dB)	18N5W	API Technology	-	2019.07.20	☒
18	VHF Precision Dipole Antenna (TX/RX)	VHAP	Schwarzbeck	1014 / 1015	2020.09.17	
19	UHF Precision Dipole Antenna (TX/RX)	UHAP	Schwarzbeck	989 / 990	2020.09.17	
20	Loop Antenna	HFH2-Z2	Schwarzbeck	863048/019	2019.12.06	☒
21	BILOG Broadband Antenna	JB1	Sunol Sciences	A060910	2019.11.21	
22	BILOG Broadband Antenna	VULB9168	Schwarzbeck	9168-230	2019.07.20	☒
23	Horn Antenna	BBHA 9120D	Schwarzbeck	9120D-816	2020.03.23	
24	Horn Antenna	BBHA9170	Schwarzbeck	BBHA9170318	2020.07.23	
25	Vector Signal Generator	E4438C	Agilent	MY42080359	2019.03.06	
26	PSG analog signal generator	E8257D	Agilent	MY45141255	2019.06.18	
27	DC Power Supply	6633A	HP	2838A-01000	2019.06.19	☒
28	DC Power Supply	6633A	HP	3325A04972	2019.06.19	
29	Digital Thermo-Hygrometer	608-H1	Testo	-	2019.06.21	☒
30	Temperature/Humidity Chamber	DJ-THC02	DAE JIN ENG	06071	2019.03.07	☒

5 Test and measurements

5.1. Antenna requirement

5.1.1 Regulation

FCC section 15.203, An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of Part 15C. The manufacturer may design the unit so that the user can replace a broken antenna, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of Sections 15.211, 15.213, 15.217, 15.219, or 15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with Section 15.31 (d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this Part are not exceeded.

5.1.2 Result: PASS

The EUT has an integral PCB loop antenna, and meets the requirements of this section.

5.2. Radiated emissions

5.2.1 Regulation

FCC 47CFR15 – 15.225

(a) The field strength of any emissions within the band 13.553-13.567 MHz shall not exceed 15,848 microvolts/meter at 30 meters.

(b) Within the bands 13.410-13.553 MHz and 13.567-13.710 MHz, the field strength of any emissions shall not exceed 334 microvolts/meter at 30 meters.

(c) Within the bands 13.110-13.410 MHz and 13.710-14.010 MHz the field strength of any emissions shall not exceed 106 microvolts/meter at 30 meters.

(d) The field strength of any emissions appearing outside of the 13.110-14.010 MHz band shall not exceed the general radiated emission limits in § 15.209.

Frequency (MHz)	Field strength limit (μV/m) @ 30 m	Field strength limit (dBμV/m) @ 30 m	Field strength limit (dBμV/m) @ 3 m
13.110 – 13.410	106	40.5	80.5
13.410 – 13.553	334	50.5	90.5
13.553 – 13.567	15,848	84.0	124.0
13.567 – 13.710	334	50.5	90.5
13.710 – 14.010	106	40.5	80.5

FCC 47CFR15 – 15.209

(a) Except as provided elsewhere in this Subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field strength limit (μV/m)	Field strength limit (dBμV/m)	Measurement Distance (m)
0.009 – 0.490	2400/F (kHz) = 266.7 – 4.9	48.5 – 13.8	300
0.490 – 1.705	24000/F (kHz) = 49.0 – 14.1	33.8 – 23.0	30
1.705 – 30.0	30	29.5	30
30 – 88	100	40.0	3
88 – 216	150	43.5	3
216 – 960	200	46.0	3
Above 960	500	54.0	3

* The emission limits shown in the above table are based on measurement instrumentation employing a CISPR quasi-peak detector. For the frequency bands 9 – 90 kHz, 110 – 490 kHz and above 1000 MHz, the radiated emission limits are based on measurements employing an average detector.

* The lower limit shall apply at the transition frequencies.

5.2.2 Measurement Procedure

Radiated Emissions Test, 9 kHz to 30 MHz (Magnetic Field Test)

1. The preliminary radiated measurements were performed to determine the frequency producing the maximum emissions at a distance of 1 meter or 3 meters according to Section 15.31(f)(2).
2. The EUT was placed on the top of the 0.8-meter height, 1 × 1.5 meter non-metallic table.
3. Emissions from the EUT are maximized by adjusting the orientation of the Loop antenna and rotating the EUT on the turntable. Manipulating the system cables also maximizes EUT emissions if applicable.
4. To obtain the final measurement data, each frequency found during preliminary measurements was re-examined and investigated. The test-receiver system was set up to average, peak, and quasi-peak detector function with specified bandwidth.

Radiated Emissions Test, above 30 MHz

1. The preliminary radiated measurements were performed to determine the frequency producing the maximum emissions in an anechoic chamber at a distance of 3 meters.
2. The EUT was placed on the top of the 0.8-meter height, 1 × 1.5 meter non-metallic table. To find the maximum emission levels, the height of a measuring antenna was changed and the turntable was rotated 360˚.
3. The antenna polarization was also changed from vertical to horizontal. The spectrum was scanned from 30 to 1000 MHz using the broadband antenna.
4. Each frequency found during preliminary measurements was re-examined and investigated. The test-receiver system was set up to average, peak, and quasi-peak detector function with specified bandwidth.
6. The EUT is situated in three orthogonal planes (if appropriate)

Measurement software: TEPTO-DV/RE_Version: 3.1.0044

5.2.3 Calculation of the field strength limits below 30 MHz

1. No special calculation for obtaining the field strength in dBμV/m is necessary, because the EMI receiver and the active loop antenna operate as a system, where the reading gives directly the field strength result (dBμV/m). The antenna factors and cable losses are already taken into consideration.
2. For test distance other than what is specified, but fulfilling the requirements of section 15.31 (f) (2) the field strength is calculated by adding additionally an extrapolation factor of 40dB/decade (inverse linear distance for field strength measurements).
3. All following emission measurements were performed using the test receiver's average, peak, and quasi-peak detector function with specified bandwidth.
4. The basic equation is as follows;

FS= RA + DF

Where

FS = Field strength in dBμV/m

RA = Receiver Amplitude in dBμV/m

DF = Distance Extrapolation Factor in dB

Where DF = 40log(D_{TEST} / D_{SPEC}) where D_{TEST} = Test Distance and D_{SPEC} = Specified Distance

DF = 40log(3m/300m) = -80 dB, for frequency band: 0.009 to 0.490 MHz

DF = 40log(3m/30m) = -40 dB, for frequency band: 0.490 to 30 MHz

5.2.4 Test Results: **PASS**

Table 1: Field strength below 30 MHz (RFID card type A)								
Frequency [MHz]	RBW [kHz]	Reading [dBμV]	AF [dB/m]	Cable Loss [dB]	Actual [dBμV/m]	Limit (at 3m) [dBμV/m]	Margin [dB]	Axis
Emissions Quasi-peak DATA under 15.225(a), (b)&(c)								
13.560 0	9	57.39	19.34	0.3	77.03	124.0	46.97	Z-axis
13.348 7	9	---	19.36	0.3	---	80.5	---	Z-axis
13.481 4	9	---	19.35	0.3	---	90.5	---	
13.693 1	9	---	19.34	0.3	---	90.5	---	
13.771 0	9	---	19.32	0.3	---	80.5	---	
Emissions Quasi-peak DATA under 15.225(d), 15.209								
27.12	9	---	19.69	0.3	---	69.5	---	Z-axis

Table 2: Field strength below 30 MHz (RFID card type B)								
Frequency [MHz]	RBW [kHz]	Reading [dBμV]	AF [dB/m]	Cable Loss [dB]	Actual [dBμV/m]	Limit (at 3m) [dBμV/m]	Margin [dB]	Axis
Emissions Quasi-peak DATA under 15.225(a), (b)&(c)								
13.560 0	9	54.56	19.34	0.3	74.20	124.0	49.80	Z-axis
13.406 8	9	---	19.36	0.3	---	80.5	---	Z-axis
13.504 1	9	---	19.35	0.3	---	90.5	---	
13.610 7	9	---	19.34	0.3	---	90.5	---	
13.718 2	9	---	19.33	0.3	---	80.5	---	
Emissions Quasi-peak DATA under 15.225(d), 15.209								
27.12	9	---	19.69	0.3	---	69.5	---	Z-axis

Actual (dBμV/m) = Reading + AF + Cable Loss
Margin (dB) = Limit – Actual
NOTE: These test results were measured at the 3 m distance.
Remark:"---" means the emission level was too low to be measured or in the noise floor.

Table 3: Field strength below 30 MHz (Without RFID card)								
Frequency [MHz]	RBW [kHz]	Reading [dBμV]	AF [dB/m]	Cable Loss [dB]	Actual [dBμV/m]	Limit (at 3m) [dBμV/m]	Margin [dB]	Axis
Emissions Quasi-peak DATA under 15.225(a), (b)&(c)								
13.560 0	9	57.71	19.34	0.3	77.35	124.0	46.65	Z-axis
13.402 2	9	---	19.36	0.3	---	80.5	---	Z-axis
13.504 4	9	---	19.35	0.3	---	90.5	---	
13.610 0	9	---	19.34	0.3	---	90.5	---	
13.718 9	9	---	19.33	0.3	---	80.5	---	
Emissions Quasi-peak DATA under 15.225(d), 15.209								
27.12	9	---	19.69	0.3	---	69.5	---	Z-axis

Actual (dBμV/m) = Reading + AF + Cable Loss

Margin (dB) = Limit – Actual

NOTE: These test results were measured at the 3 m distance.

Remark:"---" means the emission level was too low to be measured or in the noise floor.

Table 4: Measured values of the Field strength (above 30 MHz) - (RFID card type A)										
Frequency [MHz]	RBW [kHz]	POL [V/H]	ANT [m]	Reading [dBμV]	AMP [dB]	AF [dB/m]	CL [dB]	Actual [dBμV/m]	Limit [dBμV/m]	Margin [dB]
RFID card type A – Z-axis										
168.760	120	H	2.15	41.1	30.0	18.4	1.8	31.3	43.5	12.2
170.941	120	H	3.04	39.2	30.0	18.3	1.8	29.3	43.5	14.2
241.510	120	H	1.36	42.4	29.9	17.5	2.1	32.1	46.0	13.9
262.518	120	H	1.22	36.9	30.0	18.2	2.2	27.3	46.0	18.7
283.490	120	H	1.16	48.3	30.0	18.9	2.3	39.5	46.0	6.5
493.466	120	V	2.78	29.7	30.4	23.7	3.0	26.0	46.0	20.0
493.524	120	H	2.22	32.1	30.4	23.7	3.0	28.4	46.0	17.6

Table 5: Measured values of the Field strength (above 30 MHz) - (RFID card type B)										
Frequency [MHz]	RBW [kHz]	POL [V/H]	ANT [m]	Reading [dBμV]	AMP [dB]	AF [dB/m]	CL [dB]	Actual [dBμV/m]	Limit [dBμV/m]	Margin [dB]
RFID card type B – Y-axis										
40.682	120	V	1.00	46.5	30.6	19.4	0.9	36.2	40.0	3.8
158.788	120	H	1.95	29.1	30.0	19.1	1.7	19.9	43.5	23.6
167.988	120	H	1.81	50.7	30.0	18.5	1.8	41.0	43.5	2.5
170.619	120	H	2.25	41.3	30.0	18.3	1.8	31.4	43.5	12.1
262.540	120	H	1.01	42.2	30.0	18.2	2.2	32.6	46.0	13.4
283.480	120	H	1.19	52.7	30.0	18.9	2.3	43.9	46.0	2.1
493.481	120	H	2.12	30.9	30.4	23.7	3.0	27.2	46.0	18.8

Table 6: Measured values of the Field strength (above 30 MHz) - (Without RFID card)										
Frequency [MHz]	RBW [kHz]	POL [V/H]	ANT [m]	Reading [dBμV]	AMP [dB]	AF [dB/m]	CL [dB]	Actual [dBμV/m]	Limit [dBμV/m]	Margin [dB]
Without RFID card – Y-axis										
149.331	120	H	2.20	34.1	30.0	18.9	1.7	24.7	43.5	18.8
167.995	120	V	1.00	44.0	30.0	18.5	1.8	34.3	43.5	9.2
168.007	120	H	1.88	43.6	30.0	18.5	1.8	33.9	43.5	9.6
177.310	120	H	1.94	34.9	30.0	17.8	1.8	24.5	43.5	19.0
284.778	120	H	1.19	43.4	30.0	19.0	2.3	34.7	46.0	11.3
290.257	120	H	1.19	40.3	30.0	19.2	2.3	31.8	46.0	14.2

Margin (dB) = Limit – Actual

[Actual = Reading + AF + CL]

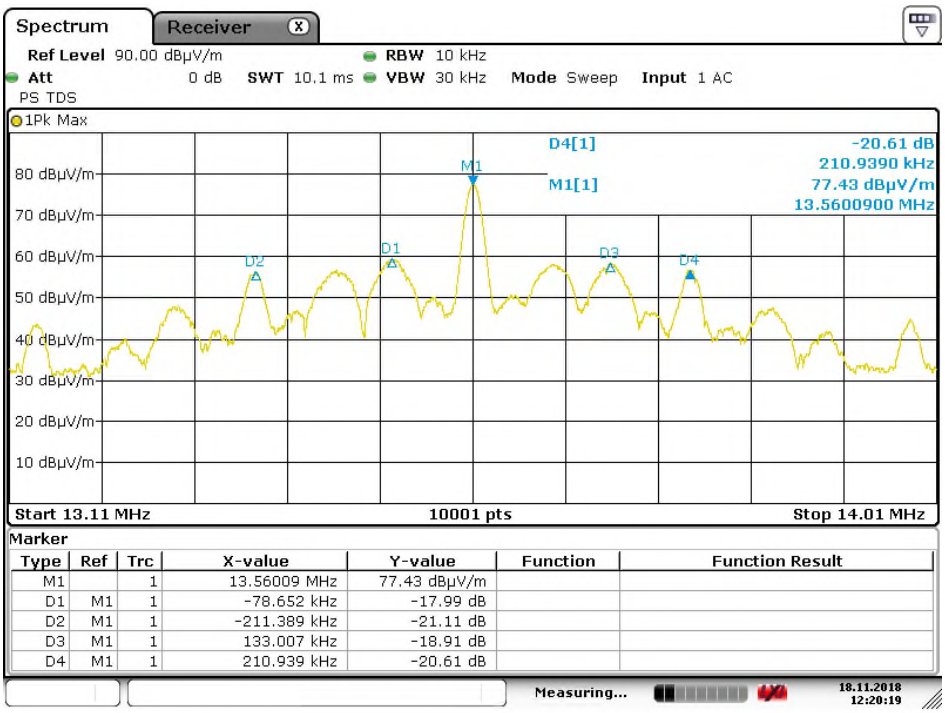
1. H = Horizontal, V = Vertical Polarization
2. AF/CL = Antenna Factor and Cable Loss

NOTE: 1. All emissions not reported were more than 20 dB below the specified limit or in the noise floor.

2. These test results measured at the 3 m distance.

Figure 1. **Plot of the Band edge** (Preliminary measurement in the anechoic chamber at 3 m distance to find out the frequencies, at which the spurious emissions occur, with the peak detector function)

(RFID card type A)



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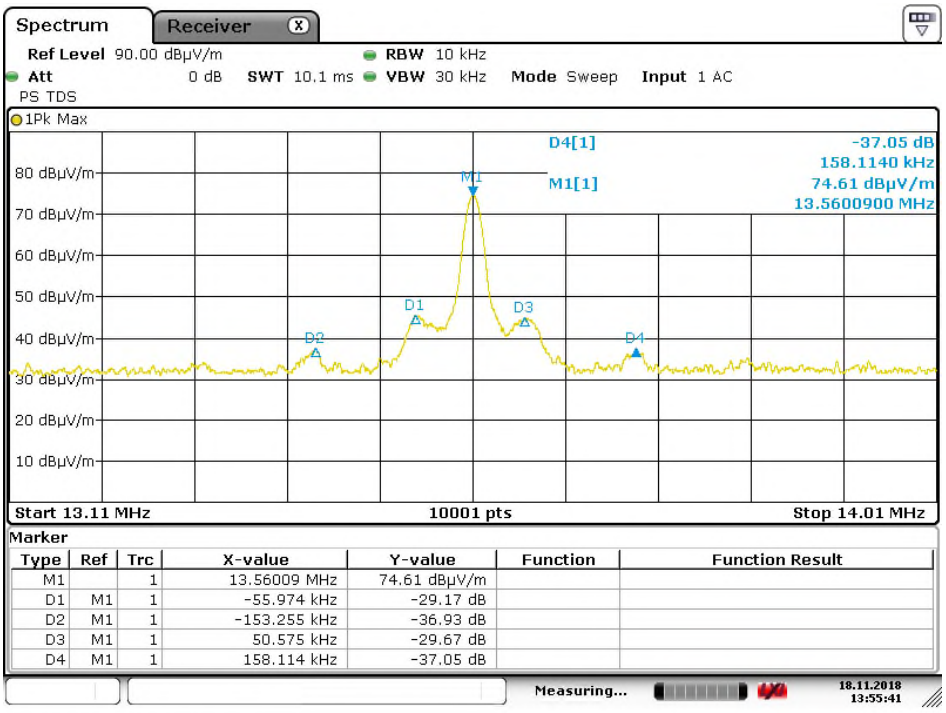
(RFID card type B)



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(Without RFID card)

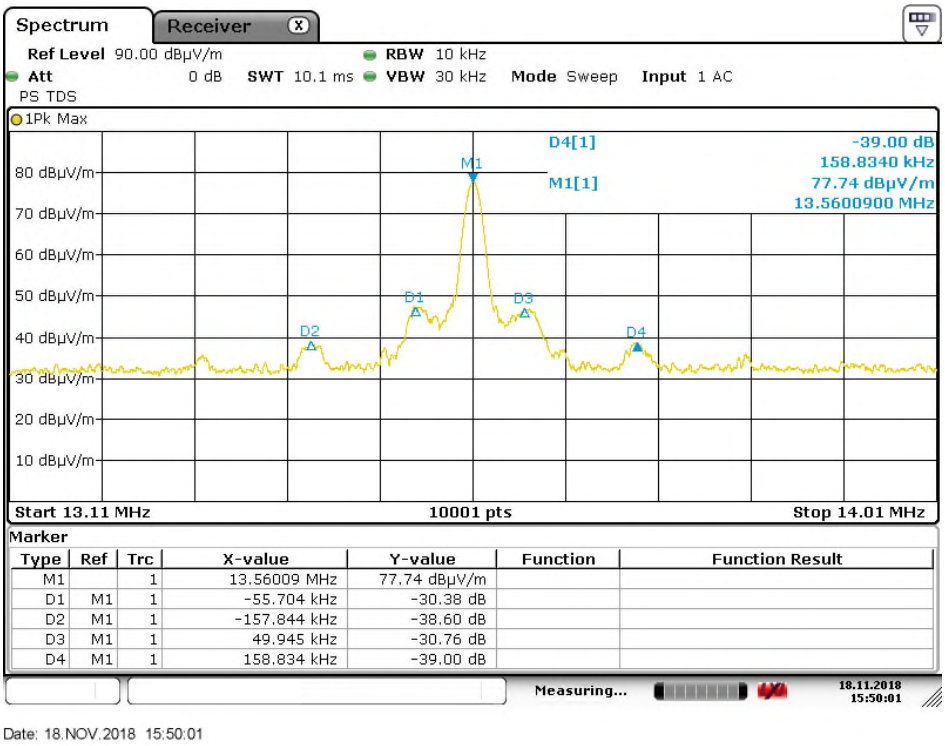

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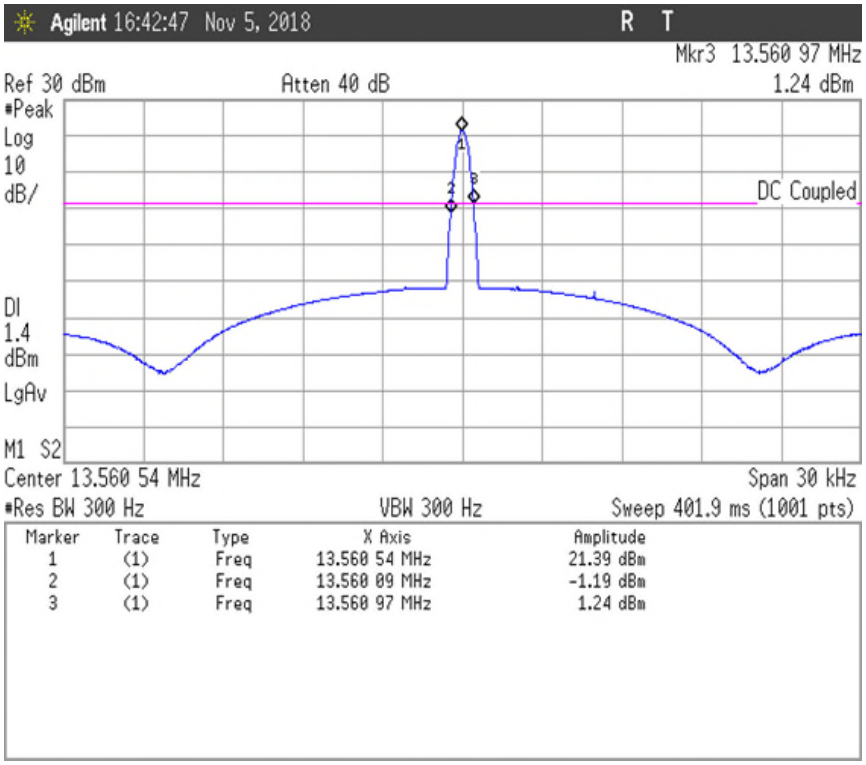
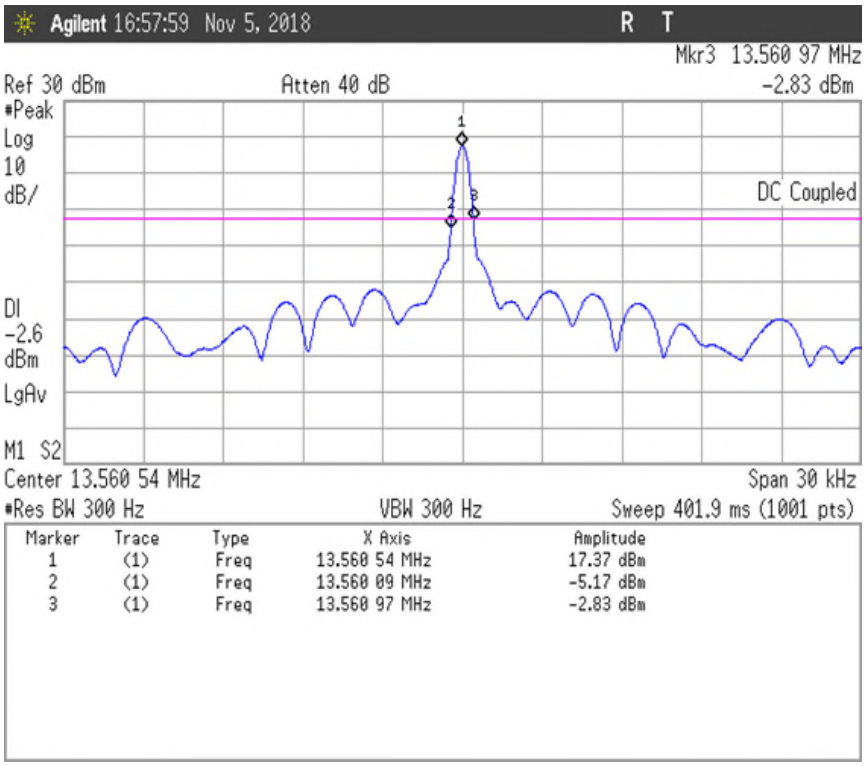
Figure 2. Plot of the 20 dB Bandwidth

(RFID card type A)



(RFID card type B)



(Without RFID card)

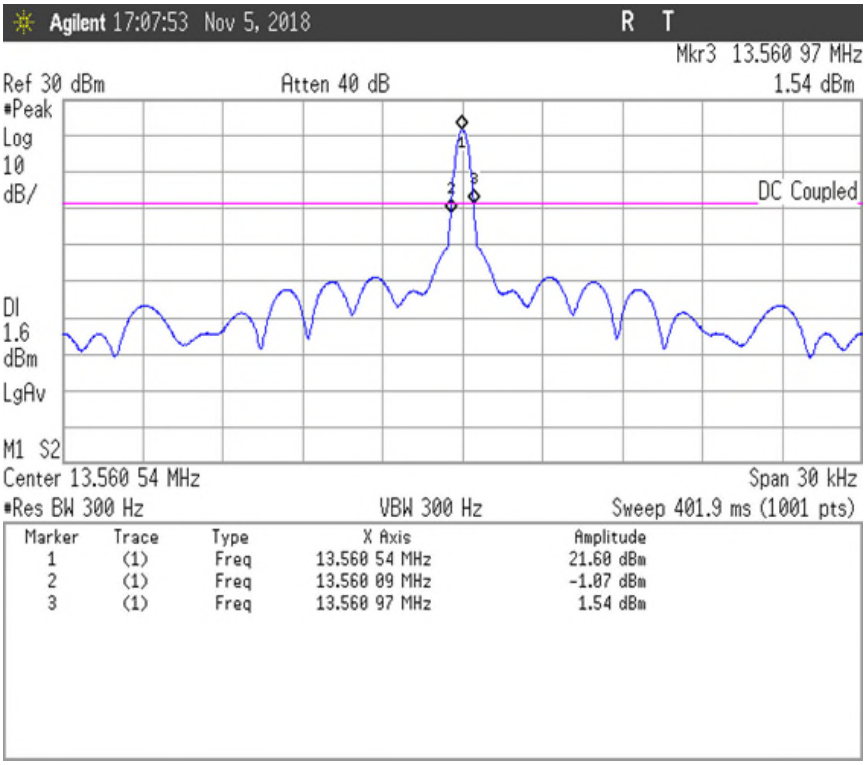
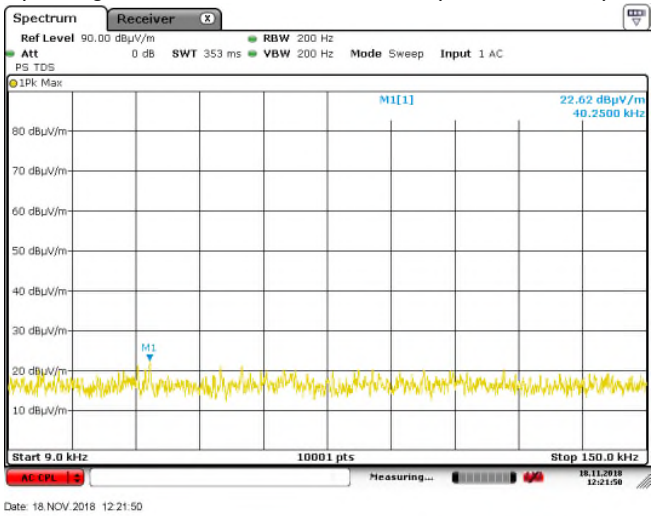


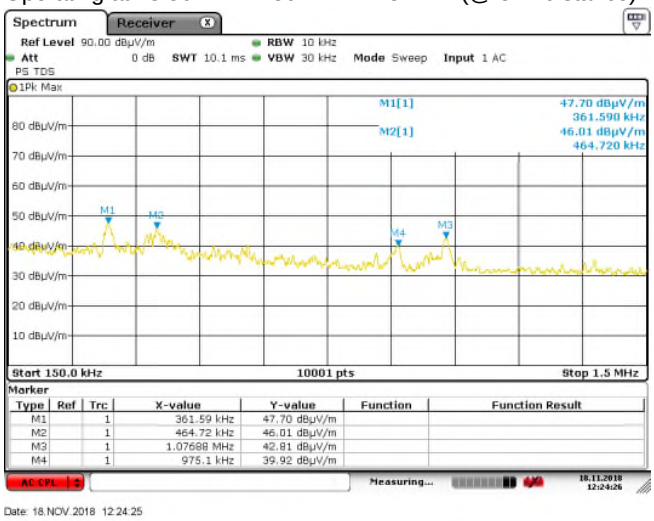
Figure 3. Emission plot for the preliminary radiated measurements

(RFID card type A)

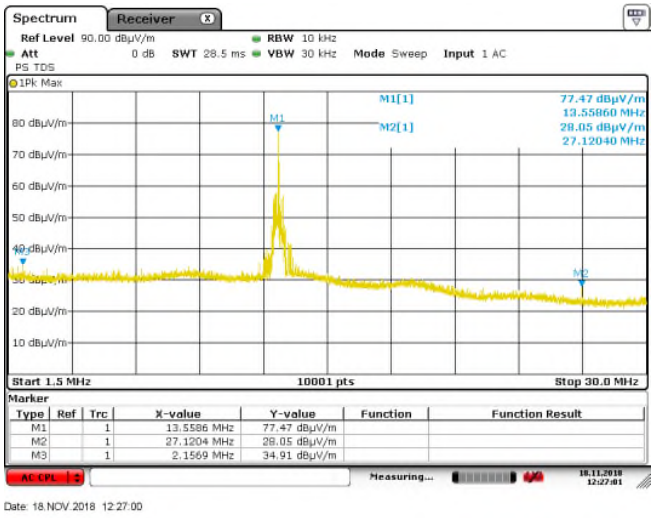
Operating at 13.56 MHz: 9 kHz ~ 150 kHz (@ 3-m distance)



Operating at 13.56 MHz: 150 kHz ~ 1.5 MHz (@ 3-m distance)

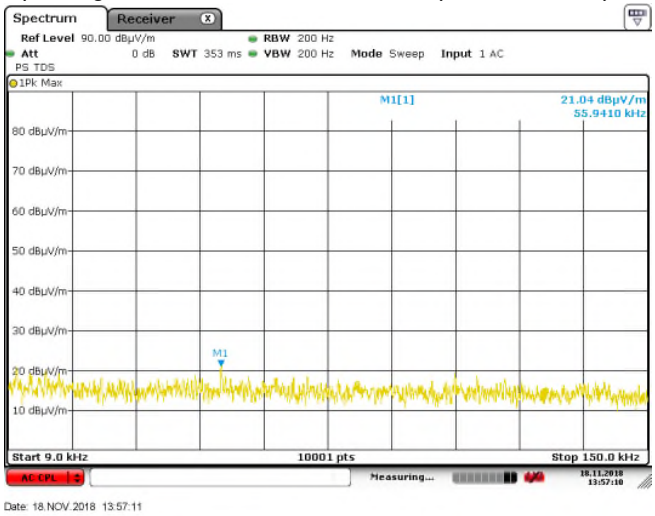


Operating at 13.56 MHz: 1.5 MHz ~ 30 MHz (@ 3-m distance)

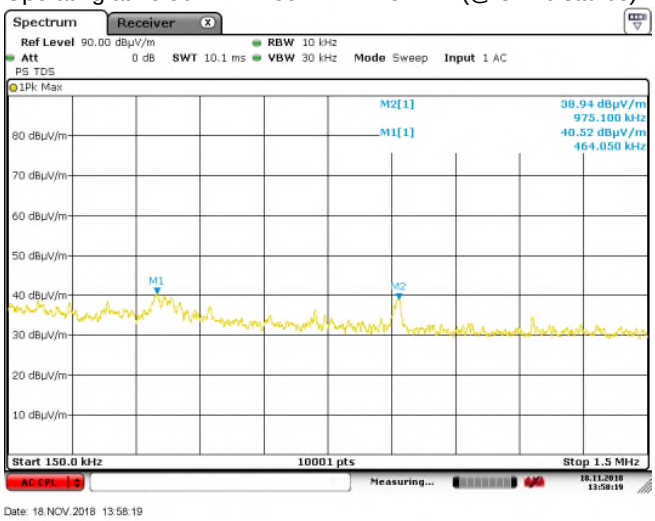


(RFID card type B)

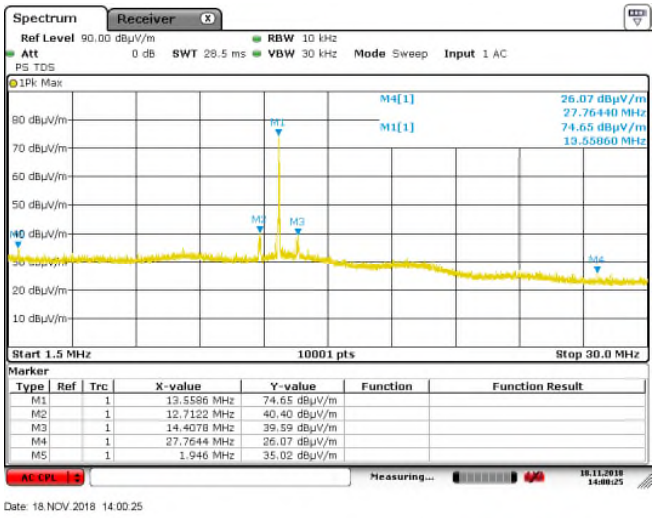
Operating at 13.56 MHz: 9 kHz ~ 150 kHz (@ 3-m distance)



Operating at 13.56 MHz: 150 kHz ~ 1.5 MHz (@ 3-m distance)



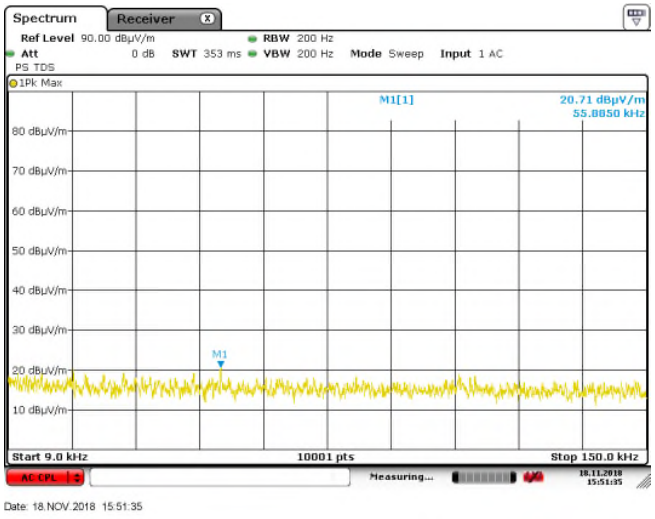
Operating at 13.56 MHz: 1.5 MHz ~ 30 MHz (@ 3-m distance)



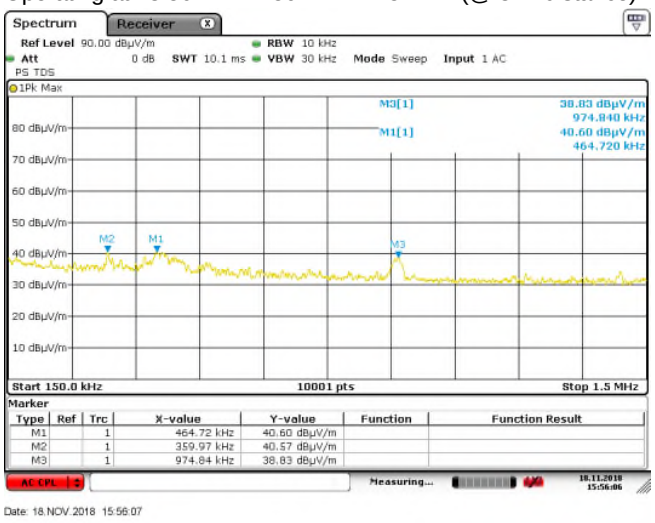
Emission plot for the preliminary radiated measurements (continued)

(Without RFID card)

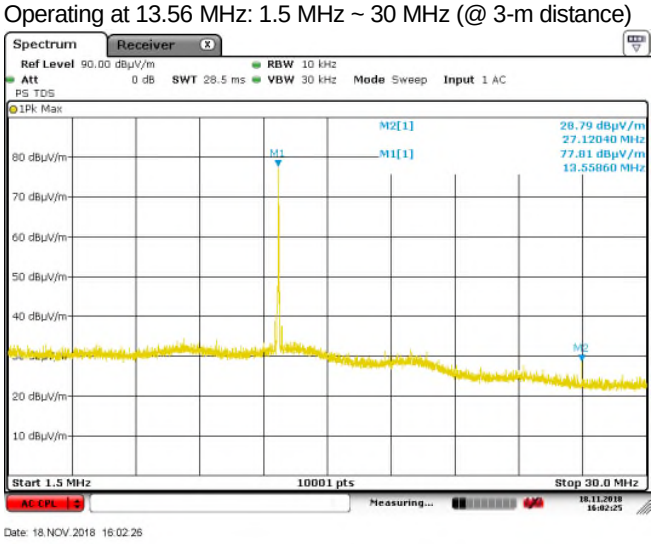
Operating at 13.56 MHz: 9 kHz ~ 150 kHz (@ 3-m distance)



Operating at 13.56 MHz: 150 kHz ~ 1.5 MHz (@ 3-m distance)



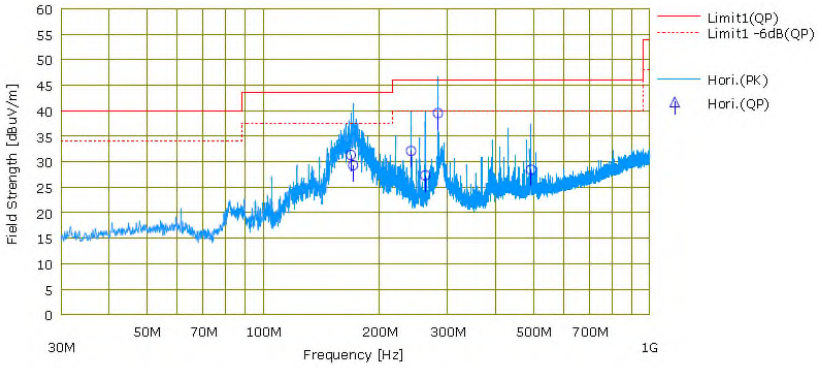
Operating at 13.56 MHz: 1.5 MHz ~ 30 MHz (@ 3-m distance)

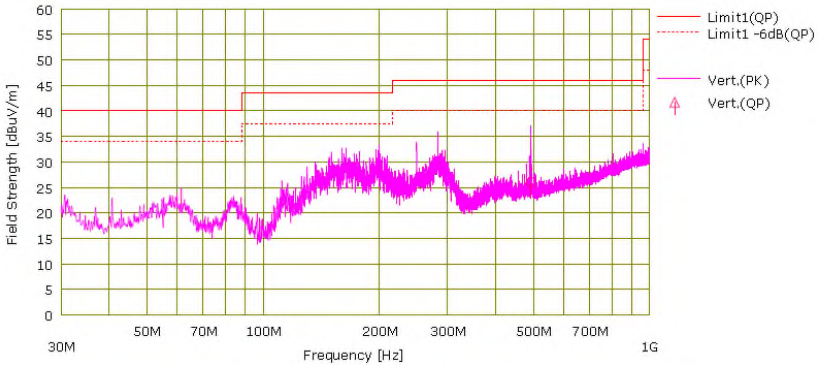


Emission plot for the preliminary radiated measurements *(continued)*

(RFID card type A)

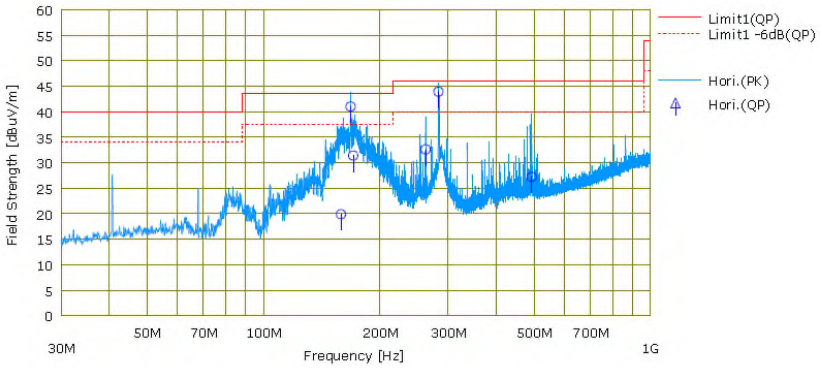
Operating at 13.56 MHz: 30 MHz ~ 1 GHz (@ 3-m distance)

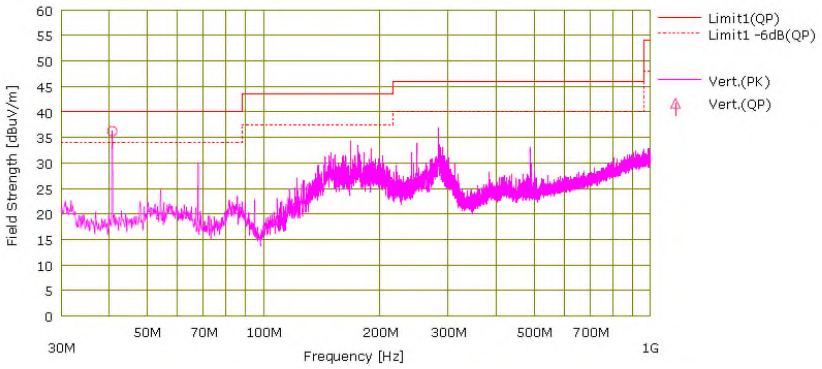




(RFID card type B)

Operating at 13.56 MHz: 30 MHz ~ 1 GHz (@ 3-m distance)

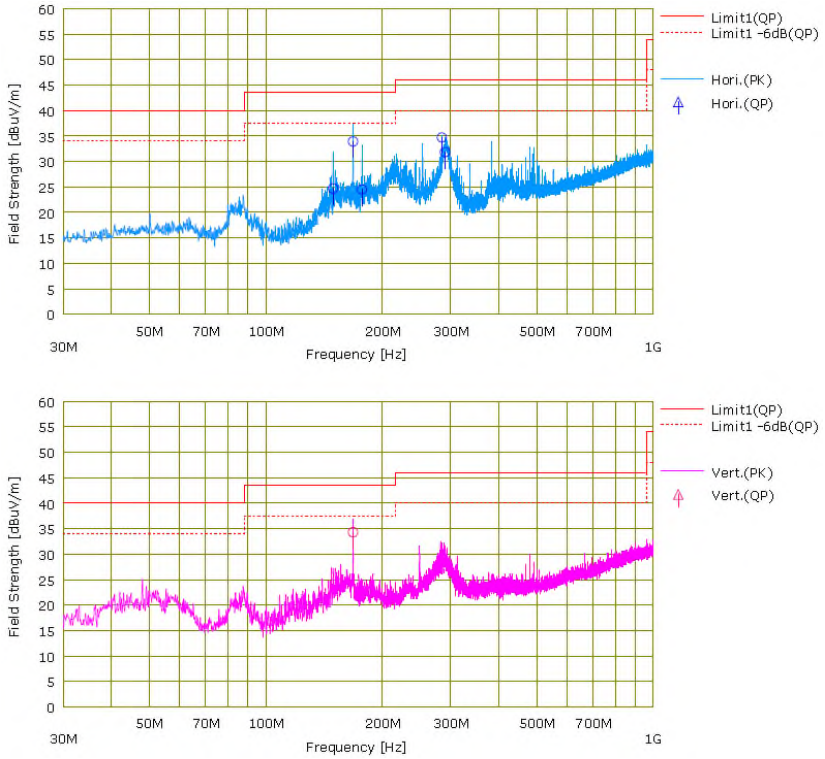




Emission plot for the preliminary radiated measurements *(continued)*

(Without RFID card)

Operating at 13.56 MHz: 30 MHz ~ 1 GHz (@ 3-m distance)



5.3. Frequency tolerance of carrier signal

5.3.1 Regulation

FCC 47CFR15 – 15.225(e)

The frequency tolerance of the carrier signal shall be maintained within +/- 0.01% of the operating frequency over a temperature variation of –20 degrees to +50 degrees C at normal supply voltage, and for a variation in the primary supply voltage from 85% to 115% of the rated supply voltage at a temperature of 20 degrees C. For battery-operated equipment, the equipment tests shall be performed using a new battery.

5.3.2 Regulation

Frequency stability versus environmental temperature

1. Supply the EUT with nominal DC voltage.
2. Turn the EUT off, and place it inside an environmental temperature chamber. For devices that are normally operated continuously, the EUT may be energized while inside the test chamber. For devices that have oscillator heaters, energize only the heater circuit while the EUT is inside the chamber.
3. RF output was connected to a frequency counter or other frequency-measuring instrument via feed through attenuators.
4. Set the temperature control on the chamber to the highest specified EUT operating temperature, and allow the temperature inside the chamber to stabilize at the set temperature before starting frequency measurements.
5. While maintaining a constant temperature inside the environmental chamber, turn the EUT on and record the operating frequency at startup and two, five, and ten minutes after the EUT is energized.
6. After all measurements have been made at the highest specified temperature turn the EUT off.
7. Repeat the above measurement process for the EUT with the test chamber set at the appropriate temperature.

Frequency Stability versus Input Voltage

1. At room temperature (20 ± 5) °C supply the EUT with nominal DC voltage.
2. Couple RF output to a frequency counter or other frequency-measuring instrument.
3. Turn the EUT on, and measure the EUT operating frequency at startup and two, five, and ten minutes after startup.
4. Supply it with 85 % of the nominal DC voltage and repeat the above procedure.
5. Supply it with 115 % of the nominal DC voltage and repeat the above procedure.

5.3.3 Test Results: **PASS**

Table 7: Frequency Tolerance - (RFID card type A)

Reference Frequency: 13.5600MHz, LIMIT: within ± 1 356 Hz									
Environment Temperature	Power Supplied	Carrier Frequency Measured with Time Elapsed							
		STARUP		2 minutes		5 minutes		10 minutes	
[°C]	[V_{DC}]	[MHZ]	Err [Hz]	[MHZ]	Err [Hz]	[MHZ]	Err [Hz]	[MHZ]	Err [Hz]
+50	12	13.560549	-549	13.560552	-552	13.560558	-558	13.560565	-565
+40	12	13.560555	-555	13.560547	-547	13.560542	-542	13.560540	-540
+30	12	13.560588	-588	13.560574	-574	13.560561	-561	13.560550	-550
+20	12	13.560543	-543	13.560543	-543	13.560542	-542	13.560541	-541
+10	12	13.560590	-590	13.560585	-585	13.560579	-579	13.560575	-575
0	12	13.560597	-597	13.560593	-593	13.560591	-591	13.560589	-589
-10	12	13.560597	-597	13.560597	-597	13.560596	-596	13.560596	-596
-20	12	13.560575	-575	13.560587	-587	13.560589	-589	13.560593	-593

Reference Frequency: 13.5600MHz, LIMIT: within ± 1 356 Hz								
Power Supplied	Carrier Frequency Measured with Time Elapsed							
	STARUP		2 minutes		5 minutes		10 minutes	
[V_{DC}]	[MHZ]	Err [Hz]	[MHZ]	Err [Hz]	[MHZ]	Err [Hz]	[MHZ]	Err [Hz]
85 %	13.560543	-543	13.560543	-543	13.560542	-542	13.560541	-541
100 %	13.560543	-543	13.560543	-543	13.560542	-542	13.560541	-541
115 %	13.560543	-543	13.560543	-543	13.560542	-542	13.560541	-541

Err [Hz] = Measured carrier frequency (MHz) - Reference Frequency (13.56 MHz)

Table 8: Frequency Tolerance - (RFID card type B)									
Reference Frequency: 13.5600MHz, LIMIT: within ± 1 356 Hz									
Environment Temperature	Power Supplied	Carrier Frequency Measured with Time Elapsed							
		STARUP		2 minutes		5 minutes		10 minutes	
[°C]	[V_{DC}]	[MHZ]	Err [Hz]	[MHZ]	Err [Hz]	[MHZ]	Err [Hz]	[MHZ]	Err [Hz]
+50	12	13.560558	-558	13.560568	-568	13.560576	-576	13.560582	-582
+40	12	13.560540	-540	13.560542	-542	13.560544	-544	13.560546	-546
+30	12	13.560546	-546	13.560543	-543	13.560541	-541	13.560540	-540
+20	12	13.560541	-541	13.560541	-541	13.560541	-541	13.560542	-542
+10	12	13.560576	-576	13.560570	-570	13.560568	-568	13.560566	-566
0	12	13.560593	-593	13.560588	-588	13.560587	-587	13.560586	-586
-10	12	13.560597	-597	13.560597	-597	13.560596	-596	13.560596	-596
-20	12	13.560585	-585	13.560594	-594	13.560594	-594	13.560594	-594

Reference Frequency: 13.5600MHz, LIMIT: within ± 1 356 Hz								
Power Supplied	Carrier Frequency Measured with Time Elapsed							
	STARUP		2 minutes		5 minutes		10 minutes	
[V_{DC}]	[MHZ]	Err [Hz]	[MHZ]	Err [Hz]	[MHZ]	Err [Hz]	[MHZ]	Err [Hz]
85 %	13.560541	-541	13.560541	-541	13.560542	-542	13.560541	-541
100 %	13.560541	-541	13.560541	-541	13.560541	-541	13.560542	-542
115 %	13.560541	-541	13.560541	-541	13.560542	-542	13.560541	-541

Err [Hz] = Measured carrier frequency (MHz) - Reference Frequency (13.56 MHz)

Table 9: Frequency Tolerance - (Without RFID card)

Reference Frequency: 13.5600MHz, LIMIT: within ± 1 356 Hz									
Environment Temperature [°C]	Power Supplied [V_{DC}]	Carrier Frequency Measured with Time Elapsed							
		STARUP		2 minutes		5 minutes		10 minutes	
		[MHZ]	Err [Hz]	[MHZ]	Err [Hz]	[MHZ]	Err [Hz]	[MHZ]	Err [Hz]
+50	12	13.560580	-580	13.560567	-567	13.560563	-563	13.560561	-561
+40	12	13.560546	-546	13.560543	-543	13.560542	-542	13.560541	-541
+30	12	13.560541	-541	13.560544	-544	13.560545	-545	13.560546	-546
+20	12	13.560543	-543	13.560542	-542	13.560543	-543	13.560543	-543
+10	12	13.560568	-568	13.560576	-576	13.560578	-578	13.560579	-579
0	12	13.560588	-588	13.560593	-593	13.560594	-594	13.560594	-594
-10	12	13.560597	-597	13.560597	-597	13.560597	-597	13.560597	-597
-20	12	13.560594	-594	13.560591	-591	13.560587	-587	13.560584	-584

Reference Frequency: 13.5600MHz, LIMIT: within ± 1 356 Hz								
Power Supplied [V_{DC}]	Carrier Frequency Measured with Time Elapsed							
	STARUP		2 minutes		5 minutes		10 minutes	
	[MHZ]	Err [Hz]	[MHZ]	Err [Hz]	[MHZ]	Err [Hz]	[MHZ]	Err [Hz]
85 %	13.560543	-543	13.560542	-542	13.560543	-543	13.560543	-543
100 %	13.560543	-543	13.560542	-542	13.560543	-543	13.560543	-543
115 %	13.560543	-543	13.560542	-542	13.560543	-543	13.560543	-543

Err [Hz] = Measured carrier frequency (MHz) - Reference Frequency (13.56 MHz)

5.4. AC power line Conducted emissions

5.4.1 Regulation

FCC 47CFR15 – 15.207(a)

According to §15.207(a), for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50μH/50Ω line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Frequency of emission (MHz)	Conducted limit (dBμV)	
	Qausi-peak	Average
0.15 – 0.5	66 to 56 *	56 to 46 *
0.5 – 5	56	46
5 – 30	60	50

* Decreases with the logarithm of the frequency.

5.4.2 Test Procedure

1. The EUT and supporting equipment including all I/O cables were set up as per the test configuration to simulate typical usage. If the EUT is a table top system, a wooden table with a height of 0.8 meters is used and is placed on the ground plane. If the EUT is a floor standing equipment, it is placed on the ground plane, which has about 10 mm non-conductive covering to insulate the EUT from the ground plane.
2. Each current-carrying conductor of the EUT power cord(s), except the ground (safety) conductor(s) was individually connected through a 50 Ω/50 μH line impedance stabilization network (LISN) to the input power mains. Emissions were measured on each current carrying line of the EUT using an EMI Test Receiver connected to the LISN powering the EUT.
3. Exploratory measurements were made to identify the frequency of the emission that had the highest amplitude relative to the limit by operating the EUT in a range of typical modes of operation, cable position, and with a typical system equipment configuration and arrangement. Based on the exploratory tests of the EUT, the one EUT cable configuration and arrangement and mode of operation that had produced the emission with the highest amplitude relative to the limit was selected for the final measurement.
4. The final test on all current-carrying conductors of all of the power cords to the equipment that comprises the EUT (but not the cords associated with other non-EUT equipment in the system) was then performed over the frequency range of 0.15 MHz to 30 MHz.
5. The measurements were made with the detector set to peak mode, quasi-peak mode and average mode within a bandwidth of 9 kHz.

Measurement software: PMM Emission Suite_Ref.2.31

5.4.3 Test Results: **PASS**

*** Test condition :** With the antenna connected to determine compliance with Section 15.207 limits outside the transmitter's fundamental emission band

Table 10: Measured values of the Conducted Emissions – (RFID card type A)

Frequency (MHz)	Line (L/N)	CF (dB)	CL (dB)	Actual (dBμV)		Limit (dBμV)		Margin (dB)	
				QP	AV	QP	AV	QP	AV
0.1520	L	9.55	9.89	63.84	46.86	65.89	55.89	2.05	9.03
0.1541	L	9.55	9.89	63.70	45.58	65.78	55.78	2.08	10.20
0.1705	L	9.55	9.89	61.84	42.91	64.94	54.94	3.10	12.03
0.1929	L	9.55	9.89	59.61	41.07	63.91	53.91	4.30	12.84
0.2134	N	9.54	9.89	57.25	37.97	63.07	53.07	5.82	15.10
10.2421	N	9.62	10.11	33.16	27.50	60.00	50.00	26.84	22.50
12.7595	N	9.63	10.14	36.67	31.72	60.00	50.00	23.33	18.28
13.5611	N	9.63	10.15	72.67	72.52	60.00	50.00	-12.67	-22.52

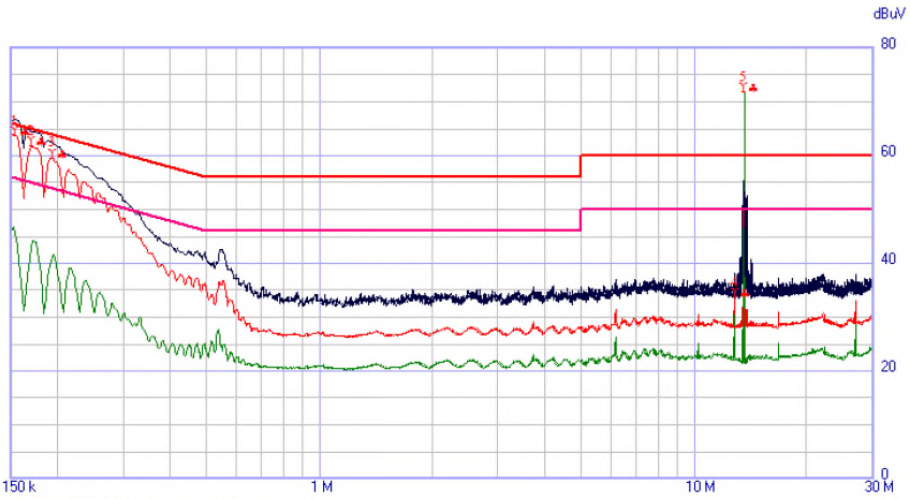
Table 11: Measured values of the Conducted Emissions – (RFID card type B)

Frequency (MHz)	Line (L/N)	CF (dB)	CL (dB)	Actual (dBμV)		Limit (dBμV)		Margin (dB)	
				QP	AV	QP	AV	QP	AV
0.1520	N	9.54	9.89	55.76	32.82	65.89	55.89	10.13	23.07
0.1602	L	9.55	9.89	64.42	46.49	65.45	55.45	1.03	8.96
0.1827	L	9.55	9.89	61.87	43.42	64.36	54.36	2.49	10.94
0.2073	L	9.55	9.89	59.32	41.39	63.31	53.31	3.99	11.92
0.2298	L	9.55	9.89	56.81	38.71	62.46	52.46	5.65	13.75
0.5467	N	9.55	9.91	38.18	25.65	56.00	46.00	17.82	20.35
0.5508	L	9.56	9.91	38.66	26.35	56.00	46.00	17.34	19.65
10.2400	L	9.62	10.11	33.41	27.76	60.00	50.00	26.59	22.24
12.7574	L	9.63	10.14	37.09	31.53	60.00	50.00	22.91	18.47
13.5611	L	9.63	10.15	69.30	69.13	60.00	50.00	-9.30	-19.13

Note: *1) L/N: Line / Neutral*
2) CF and CL: correction factor (LISN) and cable loss
3) Actual = Final measured values after containing CF and CL
4) Margin = Limit - Actual

Plot of the Conducted Emissions - RFID card type A

Line – PE



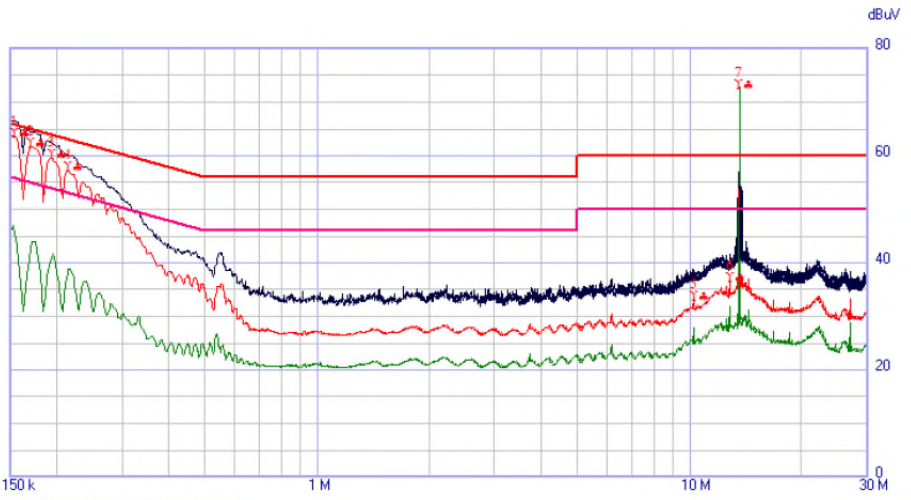
	Start [MHz]	Stop [MHz]	Step	Detector	Hold Time	RBW	Min Att	Pre Amp	Pre Sel	Prompt start	Ancillary
1	0.15	30	AUTO (2.045 kHz)	P Q C 32_QP_B 32_CAV_B	1500 ms	9 kHz	10	OFF	ON	...	...

Ancillary = General
Nr. of Worst = 3
Limits:
32_QP_B
32_CAV_B

Factors:
ENV 216_L_2018.03.05
CL_Pule Limiter_2017.12.19

Peak
QPeak
C-Avg

Neutral – PE



	Start [MHz]	Stop [MHz]	Step	Detector	Hold Time	RBW	Min Att	Pre Amp	Pre Sel	Prompt start	Ancillary
1	0.15	30	AUTO (2.045 kHz)	P Q C 32_QP_B 32_CAV_B	1500 ms	9 kHz	10	OFF	ON	...	...

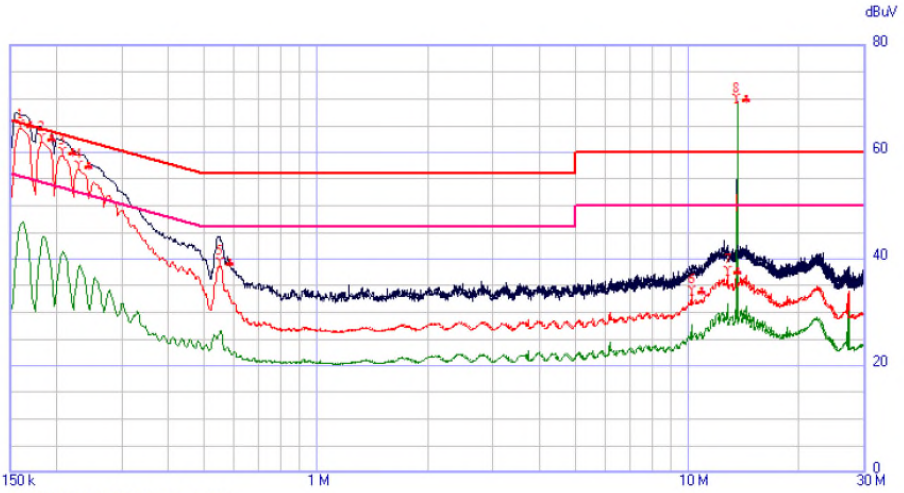
Ancillary = General
Nr. of Worst = 3
Limits:
32_QP_B
32_CAV_B

Factors:
ENV 216_N_2018.03.05
CL_Pule Limiter_2017.12.19

Peak
QPeak
C-Avg

Plot of the Conducted Emissions - RFID card type B

Line – PE



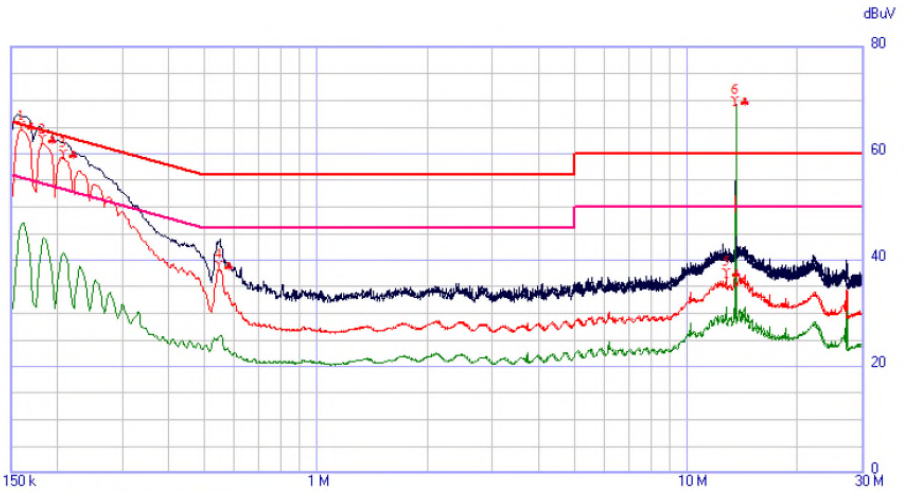
	Start [MHz]	Stop [MHz]	Step	Detector	Hold Time	RBW	Min Att	Pre Amp	Pre Sel	Prompt start	Ancillary
1	0.15	30	AUTO (2.045 kHz)	P Q C 32_QP_B 32_CAV_B	1500 ms	9 kHz	10	OFF	ON	...	...

Ancillary = General
Nr. of Worst = 3
Limits:
32_QP_B
32_CAV_B

Factors:
ENV 216_L_2018.03.05
CL_Pule Limiter_2017.12.19

Peak
QPeak
C-Avg

Neutral – PE



	Start [MHz]	Stop [MHz]	Step	Detector	Hold Time	RBW	Min Att	Pre Amp	Pre Sel	Prompt start	Ancillary
1	0.15	30	AUTO (2.045 kHz)	P Q C 32_QP_B 32_CAV_B	1500 ms	9 kHz	10	OFF	ON	...	...

Ancillary = General
Nr. of Worst = 3
Limits:
32_QP_B
32_CAV_B

Factors:
ENV 216_N_2018.03.05
CL_Pule Limiter_2017.12.19

Peak
QPeak
C-Avg

*** Test condition :** Remove the antenna and terminate the RF output with a dummy load (100 Ω) to determine compliance with Section 15.207 limits within the transmitter's fundamental emission band

Table 12: Measured values of the Conducted Emissions – (RFID card type A)

Frequency (MHz)	Line (L/N)	CF (dB)	CL (dB)	Actual (dBμV)		Limit (dBμV)		Margin (dB)	
				QP	AV	QP	AV	QP	AV
0.1520	L	9.55	9.89	64.77	45.76	65.89	55.89	1.12	10.13
0.1541	L	9.55	9.89	64.85	47.31	65.78	55.78	0.93	8.47
0.1745	L	9.55	9.89	62.48	43.51	64.74	54.74	2.26	11.23
0.1970	L	9.55	9.89	60.19	41.31	63.73	53.73	3.54	12.42
0.5488	L	9.56	9.91	38.49	25.96	56.00	46.00	17.51	20.04
9.9742	N	9.62	10.11	31.45	24.98	60.00	50.00	28.55	25.02
10.2400	L	9.62	10.11	33.82	28.65	60.00	50.00	26.18	21.35
13.5611	L	9.63	10.15	36.62	31.70	60.00	50.00	23.38	18.30

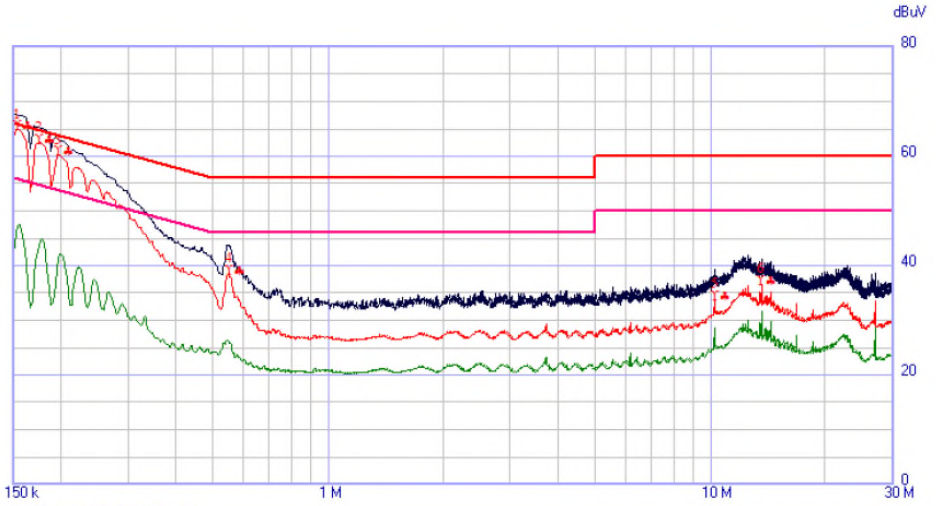
Table 13: Measured values of the Conducted Emissions – (RFID card type B)

Frequency (MHz)	Line (L/N)	CF (dB)	CL (dB)	Actual (dBμV)		Limit (dBμV)		Margin (dB)	
				QP	AV	QP	AV	QP	AV
0.1520	L	9.55	9.89	64.69	46.07	65.89	55.89	1.20	9.82
0.1541	L	9.55	9.89	64.76	47.41	65.78	55.78	1.02	8.37
0.1766	L	9.55	9.89	62.38	44.73	64.64	54.64	2.26	9.91
0.1991	L	9.55	9.89	60.01	42.16	63.65	53.65	3.64	11.49
0.5467	L	9.56	9.91	38.21	26.49	56.00	46.00	17.79	19.51
10.2400	L	9.62	10.11	33.74	28.65	60.00	50.00	26.26	21.35
12.5386	L	9.63	10.14	36.15	30.18	60.00	50.00	23.85	19.82
13.5591	L	9.63	10.15	38.77	35.24	60.00	50.00	21.23	14.76

Note: *1) L/N: Line / Neutral*
2) CF and CL: correction factor (LISN) and cable loss
3) Actual = Final measured values after containing CF and CL
4) Margin = Limit - Actual

Plot of the Conducted Emissions - RFID card type A

Line – PE



SKTEU18-1015_FCC 15C_A_L

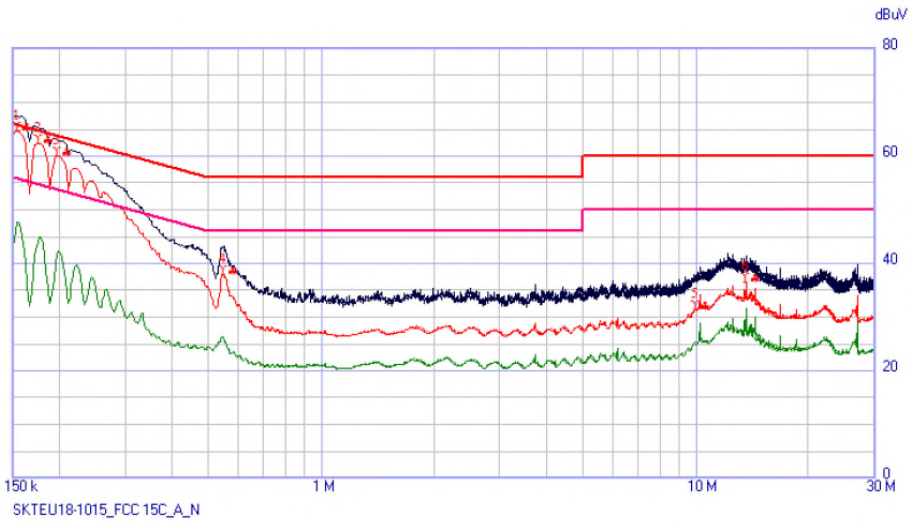
	Start [MHz]	Stop [MHz]	Step	Detector	Hold Time	RBW	Min Att	Pre Amp	Pre Sel	Prompt start	Ancillary
1	0.15	30	AUTO (2.045 kHz)	P Q C 32_QP_B 32_CAV_B	1500 ms	9 kHz	10	OFF	ON	...	...

Ancillary = General
Nr. of Worst = 3
Limits:
32_QP_B
32_CAV_B

Factors:
ENV 216_L_2018.03.05
CL_Pule Limiter_2017.12.19

Peak
QPeak
CAvg

Neutral – PE



SKTEU18-1015_FCC 15C_A_N

	Start [MHz]	Stop [MHz]	Step	Detector	Hold Time	RBW	Min Att	Pre Amp	Pre Sel	Prompt start	Ancillary
1	0.15	30	AUTO (2.045 kHz)	P Q C 32_QP_B 32_CAV_B	1500 ms	9 kHz	10	OFF	ON	...	...

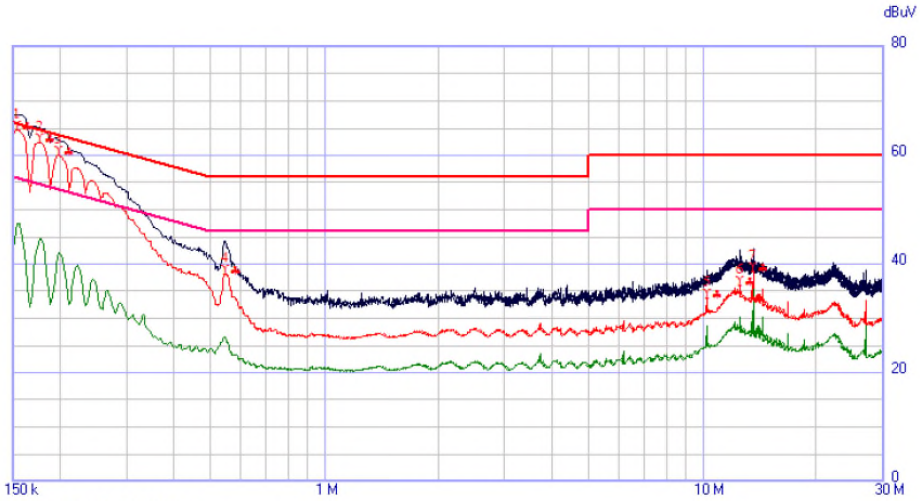
Ancillary = General
Nr. of Worst = 3
Limits:
32_QP_B
32_CAV_B

Factors:
ENV 216_N_2018.03.05
CL_Pule Limiter_2017.12.19

Peak
QPeak
CAvg

Plot of the Conducted Emissions - RFID card type B

Line – PE



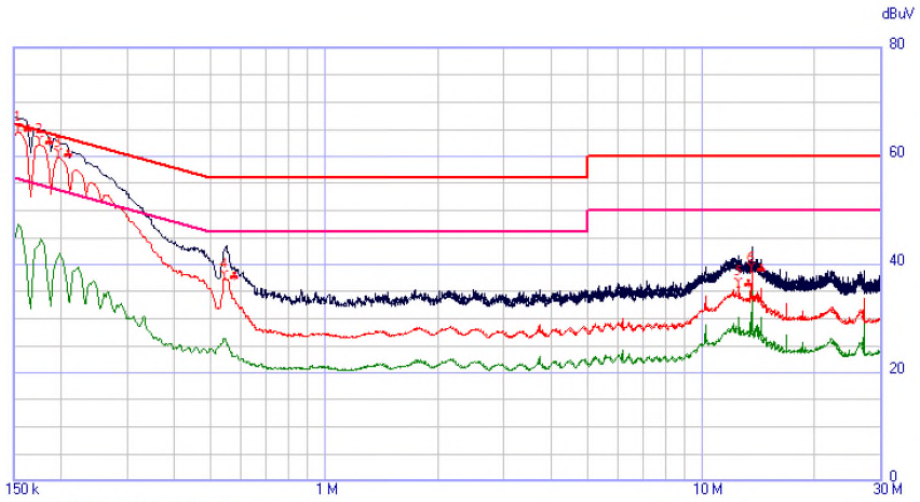
	Start [MHz]	Stop [MHz]	Step	Detector	Hold Time	RBW	Min Att	Pre Amp	Pre Sel	Prompt start	Ancillary
1	0.15	30	AUTO (2.045 kHz)	P Q C 32_QP_B 32_CAV_B	1500 ms	9 kHz	10	OFF	ON	...	...

Ancillary = General
Nr. of Worst = 3
Limits:
32_QP_B
32_CAV_B

Factors:
ENV 216_L_2018.03.05
CL_Pule Limiter_2017.12.19

Peak
QPeak
CAvg

Neutral – PE



	Start [MHz]	Stop [MHz]	Step	Detector	Hold Time	RBW	Min Att	Pre Amp	Pre Sel	Prompt start	Ancillary
1	0.15	30	AUTO (2.045 kHz)	P Q C 32_QP_B 32_CAV_B	1500 ms	9 kHz	10	OFF	ON	...	...

Ancillary = General
Nr. of Worst = 3
Limits:
32_QP_B
32_CAV_B

Factors:
ENV 216_N_2018.03.05
CL_Pule Limiter_2017.12.19

Peak
QPeak
CAvg