Test Report No. 9912313707

Applicant: **Stratasys Ltd.**

Equipment Under Test: **RFID reader system for Material Cabinet ASY-18130**

Model: **RFID reader BRD-18020, antenna board BRD-03012**
FCC ID: YH6- DUPCAB1

Issued by:
The Standards Institution of Israel
Industry Division
Electronics & Telematics Laboratory
EMC Branch

ANAB ACCREDITED ISO/IEC 17025 TESTING LABORATORY
Certificate Number:AT-1359

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Applicant:	Stratasys Ltd.
Address:	1 Holtzman St., Science Park, P.O. Box 2496, Rehovot 7670401, Israel
Sample for test selected by:	The customer
The date of test:	11, 12 November 2019

Description of Equipment under Test (EUT):	RFID reader system for Material Cabinet ASY-18130
Model:	RFID reader BRD-18020, antenna board BRD-03012
Software version of radio unit:	1.1
Hardware version of radio unit:	A
Manufactured by:	Stratasys Ltd.

Reference Documents:

❖	CFR 47 FCC:	Rules and Regulations: Part 15. “Radio frequency devices”, Subpart B: Unintentional radiators Section 15.109. Radiated emission limits. Subpart C: “Intentional radiators”, Section 15.207. Conducted limits Section 15.209. “Radiated emission limits, general requirements”.

This Test Report contains 19 pages and may be used only in its entirety.	This Test Report applies only to the specimen tested and may not be applied to other specimens of the same product.

Table of Contents

1. Summary of Test Results

Test Description	FCC Part 15 Reference section	Test result
Radiated emission	Subpart C Section 15.209.	Complies
Radiated emission	Subpart B Section 15.109 class A	Complies
Conducted emission test	Subpart C Section 15.207	Complies

Name: Eng. Yuri Rozenberg
Position: Head of EMC Branch

Electronics and Telematics Laboratory
November, 2019

Tested by: Michael Feldman
Position: Testing Engineer

2. EUT Description

Note: All information in this section was provided by the customer.

2.1. General description:

The Equipment under Test (hereinafter: EUT) is a RFID transceiver on MSC2 board installed inside the Material Cabinet model ASY-18130.
The ASY-18130 Material cabinet contains 4 boards and 16 antennas. Product's main functions are read and write data from material container protected by RFID identification tags attached to the resin material container. Its intended use is to identify the type of resin.
The RFID unit voltage is 5V (produced from the main 24VDC). Through RS-232 interface the RFID MCU (PIC16F876A) gets commands: Number of channel, read or write etc.
The RFID signal is generated by the RFID chip (HTRC11001).
This RF signal from RFID chip is directed to a MUX chip that switches the RF energy to only one of the four channel antennas at certain time.
RS-232 interface connected internally inside a 3D printer.
The test was done by simulating all antennas at maximum duty cycle.

Transmit frequency:	125 kHz
Type of modulation:	AM
Antenna type:	Loop coil mfr. Stratasys model. BRD-03012

2.2. Potential emission sources:

Table 1. Potential emission sources

Frequency	Location
125 kHz	RFID
16 MHz crystal	RFID
16MHz , 500KHz	HF READER ,MULTIPLEXED INPUTS
33MHz, 1MHz	MSC2 board
100KHz	I2C

2.3. EUT setup and operation:

Measurements were performed in continue transmition mode by simulating all channel antennas and using Max Hold mode.

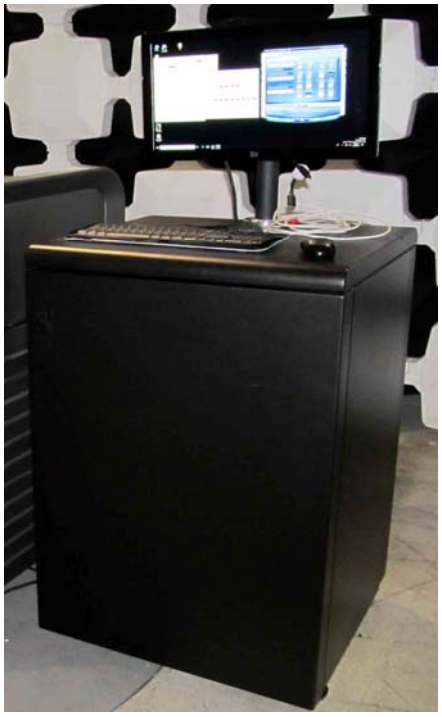


Figure 1. Material Cabinet view

3. Measurements, examinations and derived results

3.1. Location of the Test Site:

All tests were carried out in the EMC laboratory of the Standards Institution of Israel in Tel-Aviv.

3.2. Test conditions:

Temperature: 22°C.
Humidity: 53 %.
Atmospheric pressure: 1009 mbar.

3.3. Radiated Emission test summary

Reference: FCC Part 15 subpart B Section15.109
FCC Part 15 subpart C Section 15.209 (a).

Test Procedure:

The radiated emission measurements were conducted in 3-m semi-anechoic chamber. The EUT was installed on a turn - table.

The frequency range from 0.009 MHz to 1 GHz was investigated.
Measurements were performed with Active loop antenna at frequencies below 30 MHz and with Biconilog antenna above 30 MHz.
The measurements were performed at each frequency that was founded previously. The levels were maximized by rotating turntable through 360° and changing antenna-to-EUT polarization from vertical to horizontal. The worse case result was noted in tables.

Test Results:

All received emissions from the RFID transmitter were found below FCC Part 15 Subpart C sections 15.209 and below FCC section 15.109 class A limit for EUT digital part.
Final results are presented in table #2 and table #3.

3.4. Field strength emission from intentional radiator

Reference: FCC Part 15 subpart C Section 15.209 (a).

Requirements:

The RFID operation frequency is 125 kHz.
The average field strength emission from intentional radiators operated on this frequency shall comply with the limit of section 15.209 (a).

Emission frequency MHz	Specified Field Strength limit of Fundamental μV/m@300m	Calculated Field Strength limit dBμV/m@3m
0.125	2400/F	105.6

Note: The field strength limit was calculated with 40 dB/decade linear distance extrapolation factor.

The field strength of any unwanted emissions shall not exceed the general radiated emission limits in section 15.209.

Test Procedure:

Per FCC Part 15 subpart C Section 15.209.

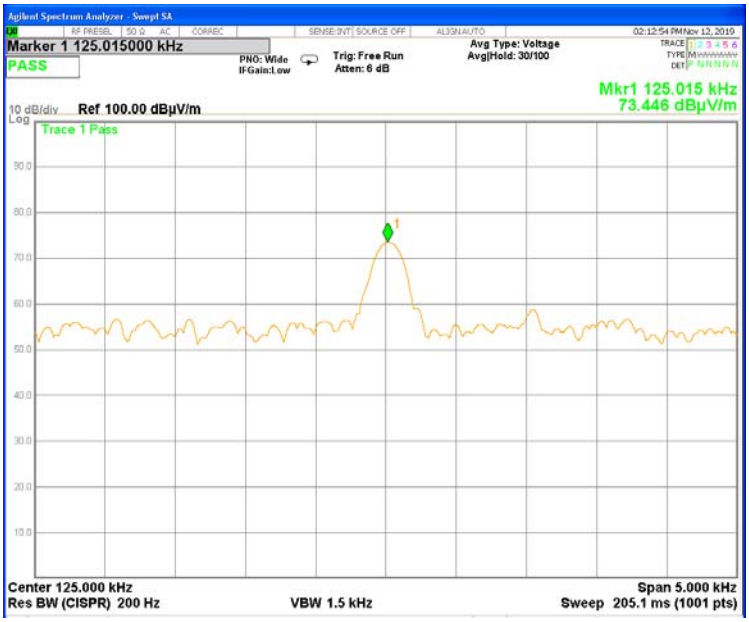
Test Results:

For recorded fundamental frequency result see Table 2 and plot #1.

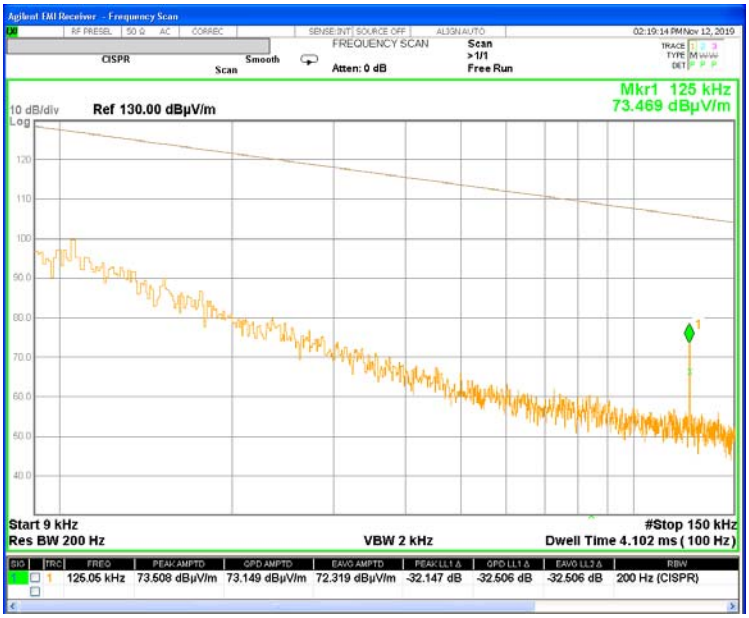
The received radiated emission result was found below the § 15.209 specified limit.
Investigation scans of spurious emission present in plots # 2 and #3

Table # 2. Fundamental frequency test result

Carrier frequency MHz	Peak amplitude dBμV/m	Limit@ 3m dBμV/m
0.125	73.4	105 dBμV/m

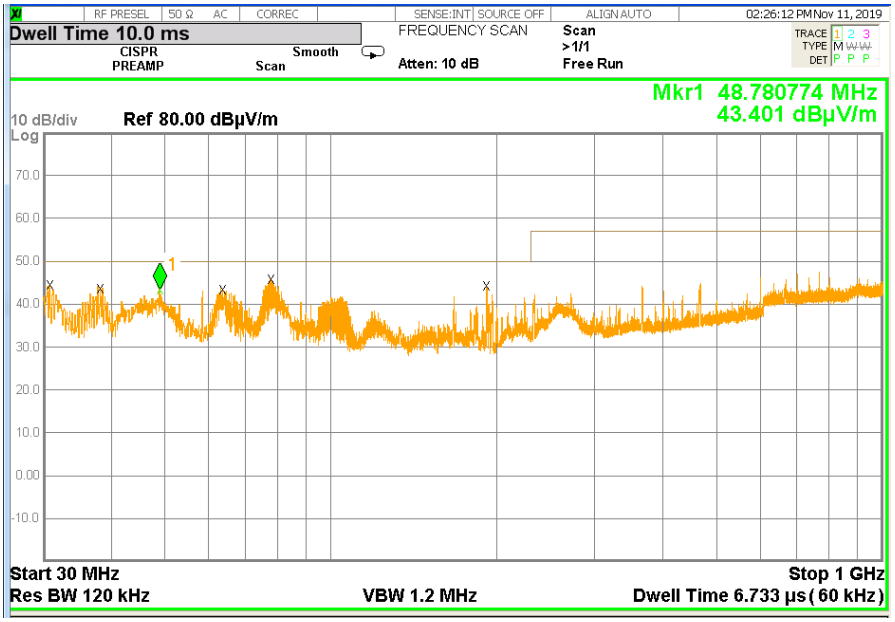


Plot # 1. Field strength of fundamental frequency 125 kHz.



Plot # 2. Frequency scan 9 kHz– 150 kHz. Test distance = 3m.

Plot # 3. Frequency scan 0.15 – 30 MHz. Test distance = 3m.



Plot # 4. Frequency scan 30 MHz – 1GHz. Test distance =3m.

3.5. Radiated emission from unintentional radiator

Reference: FCC Part 15 subpart B Section 15.109.

Test Procedure:

The EUT was operated in normal performance.
Final measurements were performed according to table below.

Initial scan:		Measurements:	
Detector type	Peak	Detector type	Quasi-peak (CISPR)
Mode	Max hold	Bandwidth	120 kHz
Bandwidth	120 kHz		

Test Results:

The test results are shown in Table 4 below.
All received emissions were found below FCC Part 15.109 class A limit.

Table 3. Radiated emission test results.

No	Frequency (MHz)	Antenna Polariz	Antenna Height (m)	Turntable angle (°)	Emission Level (dBμV/m)	Limit @ 3 m (dBμV/m)	Margin (dB)	Results
1	30.8	V	1.0	188	40.6	49.0	-8.4	Complies
2	38.1	V	1.0	195.	39.9	49.0	-9.1	Complies
3	48.7	V	1.0	350	39.1	49.0	-9.9	Complies
4	63.5	V	1.0	17	41.6	49.0	-7.4	Complies
5	77.7	V	1.2	12	45.8	49.0	-3.2	Complies
6	191.0	H	1.4	201	39.4	53.5	-14.1	Complies

Note: Emission level = E Reading (dBμV) + Cable loss (dB) + Antenna Factor (dB/m)
For Cable Loss and Antenna Factor refer to Appendix 2.

3.6. Conducted Emission test summary

Reference: FCC Part 15 subpart C Section 15.207.

Test procedure:

The EUT as a part outside 3D printer was placed in a shielded room on reference ground plane (floor) at 80 cm from the LISN and any other metal part or surface of the room.

Tested line: the 3D Printer AC power Input.

The test was started with an initial scan. Final measurements were performed at the peaks, exceeded the 10 dB tolerance limit.

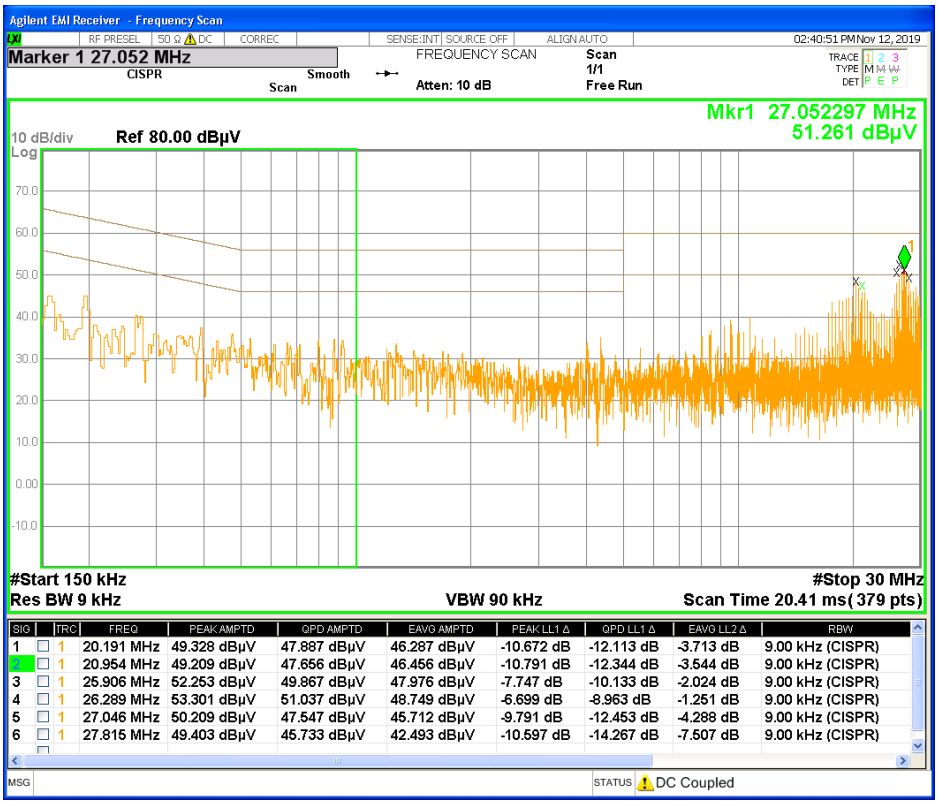
Test equipment (EMI receiver) setup was as follow:

Initial scan:		**Measurements**	
Detector type	Peak	Detectors type	Quasi-peak (CISPR)
Mode	Max hold		Average
Bandwidth	9 kHz	Bandwidth	9 kHz
Step size	Continuous sweep	Observation	>15 seconds
Sweep time	>100 msec		

Test Results:

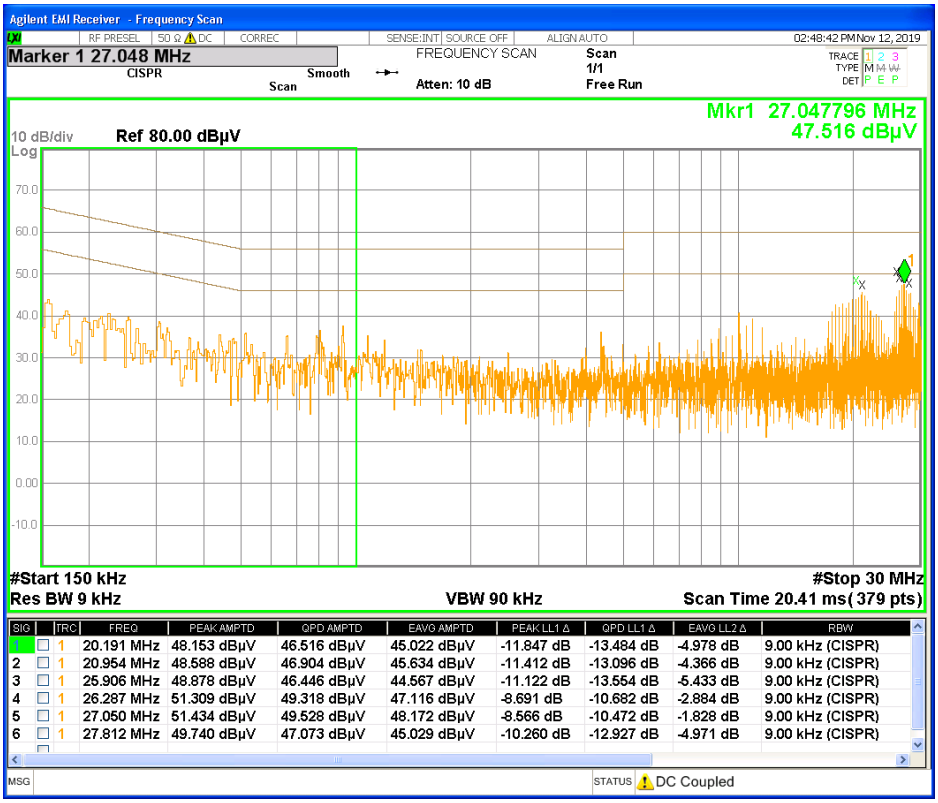
The test results are shown in Plots #5, 6.

All received emissions were found below FCC Part 15.207 limit.



SIG	TRC	FREQ	PEAK AMPTD	QPD AMPTD	EAVG AMPTD	PEAK LL1 Δ	QPD LL1 Δ	EAVG LL2 Δ	RBW
1	1	20.191 MHz	49.328 dBµV	47.887 dBµV	46.287 dBµV	-10.672 dB	-12.113 dB	-3.713 dB	9.00 kHz (CISPR)
2	1	20.954 MHz	49.209 dBµV	47.656 dBµV	46.456 dBµV	-10.791 dB	-12.344 dB	-3.544 dB	9.00 kHz (CISPR)
3	1	25.906 MHz	52.253 dBµV	49.867 dBµV	47.976 dBµV	-7.747 dB	-10.133 dB	-2.024 dB	9.00 kHz (CISPR)
4	1	26.289 MHz	53.301 dBµV	51.037 dBµV	48.749 dBµV	-6.699 dB	-8.963 dB	-1.251 dB	9.00 kHz (CISPR)
5	1	27.046 MHz	50.209 dBµV	47.547 dBµV	45.712 dBµV	-9.791 dB	-12.453 dB	-4.288 dB	9.00 kHz (CISPR)
6	1	27.815 MHz	49.403 dBµV	45.733 dBµV	42.493 dBµV	-10.597 dB	-14.267 dB	-7.507 dB	9.00 kHz (CISPR)

Plot # 5. 120VAC. Line Phase



SIG	TRC	FREQ	PEAK AMPTD	QPD AMPTD	EAVG AMPTD	PEAK LL1 Δ	QPD LL1 Δ	EAVG LL2 Δ	RBW
1	1	20.191 MHz	48.153 dBµV	46.516 dBµV	45.022 dBµV	-11.847 dB	-13.484 dB	-4.978 dB	9.00 kHz (CISPR)
2	1	20.954 MHz	48.588 dBµV	46.904 dBµV	45.634 dBµV	-11.412 dB	-13.096 dB	-4.366 dB	9.00 kHz (CISPR)
3	1	25.906 MHz	48.878 dBµV	46.446 dBµV	44.567 dBµV	-11.122 dB	-13.554 dB	-5.433 dB	9.00 kHz (CISPR)
4	1	26.287 MHz	51.309 dBµV	49.318 dBµV	47.116 dBµV	-8.691 dB	-10.682 dB	-2.884 dB	9.00 kHz (CISPR)
5	1	27.050 MHz	51.434 dBµV	49.528 dBµV	48.172 dBµV	-8.566 dB	-10.472 dB	-1.828 dB	9.00 kHz (CISPR)
6	1	27.812 MHz	49.740 dBµV	47.073 dBµV	45.029 dBµV	-10.260 dB	-12.927 dB	-4.971 dB	9.00 kHz (CISPR)

Plot # 6. 120VAC. Line Neutral

4. Appendix 1: Test equipment used

All measurements equipment is on SII calibration schedule with a recalibration interval not exceeding one year.

Instrument	MFR	Model	Serial No.	Due calibration date
MXE EMI Receiver 20 Hz -26.5 GHz	Agilent	N9038A	SII 650114	June 2020
Antenna Biconilog 30 – 6000 MHz	ETS-Lindgren	31142D	0146490	December 2019
Spectrum analyzer 20 Hz-40 GHz	Rohde&Schwarz	ESU 40	100168	November 2020
Active Loop antenna 1.0 kHz – 30 MHz	ETS-Lindgren	6507	00143074	February 2020
Cable RF 5m	Harbour Industries	Neoflex LLEF142	1802	July 2020
Cable RF 1 m	Huber-Suhner	Sucoflex 104PE	21325/4PE	October 2020
MXG Signal Generator 100 kHz - 20 GHz	Agilent	N5183A	6501148	May 2020
Attenuator 3 dB DC – 12.4 GHz	HP	8491A	50469	October 2020
Dual display multimeter	FLUKE	Fluke 45	SII4699	April 2020
Set Dipole antennas	Compliance Design Inc.	Roberts	004122	September 2020
Temperature/Humidity cabinet	Weiss Technik	SB22/160/40	SII 4081	December 2019

5. Appendix 2: Antenna Factor and Cable Loss

Cable Loss (Mast 6 m set cable)

Point	Frequency, MHz	Cable Loss, dB	Point	Frequency, MHz	Cable Loss, dB
1	30	0.3	21	1000	2.5
2	50	0.4	22	1100	2.6
3	100	0.6	23	1200	2.8
4	150	0.8	24	1300	2.9
5	200	1.0	25	1400	3.1
6	250	1.1	26	1500	3.2
7	300	1.2	27	1600	3.3
8	350	1.3	28	1700	3.5
9	400	1.5	29	1800	3.6
10	450	1.6	30	1900	3.7
11	500	1.7	31	2000	3.9
12	550	1.8	32	2100	4.0
13	600	1.9	33	2200	4.1
14	650	1.9	34	2300	4.2
15	700	2.0	35	2400	4.4
16	750	2.1	36	2500	4.6
17	800	2.1	37	2600	4.7
18	850	2.2	38	2700	4.8
19	900	2.3	39	2800	4.9
20	950	2.4	40	2900	5.0

Antenna Factor

Biconilog Antenna Model Number: CBL6112D, S/N: 23181, Alt. ID: 5866, 3 m distance

No.	f / MHz	AF / dB/m	f / MHz	AF / dB/m
1	30	19.7	200	10.1
2	35	16.6	250	12.5
3	40	13.7	300	13.3
4	45	11.9	400	16.4
5	50	8.2	500	17.7
6	60	6.3	600	18.7
7	70	7.1	700	19.5
8	80	9.0	800	21.0
9	90	10.9	900	21.0
10	100	12.2	1000	21.6
11	120	13.3	1250	24.0
12	140	12.2	1500	25.6
13	160	11.1	1750	28.2
14	180	10.5	2000	29.5

Active Loop antenna mfr.ETS-Lindgren mod. 6507 S/N 144641.

Frequency, MHz	Magnetic Antenna factor dBS/m	Electric Antenna factor dB/m
0.009	-20.0	31.5
0.010	-21.0	30.5
0.020	-26.7	24.9
0.075	-32.4	19.1
0.100	-32.7	18.8
0.150	-32.9	18.6
0.250	-33.0	18.5
0.500	-33.0	18.5
0.750	-33.0	18.5
1.000	-32.8	18.7
2.000	-32.7	18.8
3.000	-32.9	18.7
4.000	-33.2	18.3
5.000	-33.4	18.2
10.000	-34.0	17.6
15.000	--34.2	17.3
20.000	-34.4	17.1
25.000	-34.8	16.7
30.000	-35.0	16.5

Cable Loss
Type: Neoflex LLEF142; Ser.No.1802; 5 m length

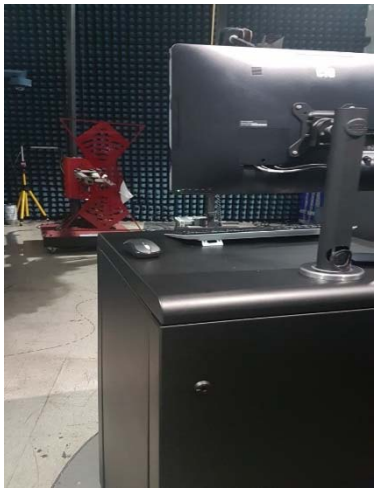
Point	Frequency (GHz)	Cable Loss (dB)
0	0.0-1.0	1.3
1	1.0 – 3.0	2.4
2	3.0 – 5.0	3.2
3	5.0-7.0	4.0
4	7.0-9.0	4.4
5	9.0-10.0	4.7
6	10.0-12.0	5.2
7	12.0-14.0	5.9
8	14.0-16.0	6.1
9	16.2-18.00	6.6

6. Appendix 3: Measurement uncertainty

The test equipment has been calibrated according to its recommended procedures and is within the manufacturer's published limit of error.
The laboratory calibrates its standards by a third party (traceable to NIST, USA) on a regular basis according to equipment manufacturer requirements.
In the following table the uncertainty calculation is given.

Type of disturbance Test description	Calculated uncertainty U_{LAB}
Conducted emissions 150 kHz to 30 MHz	± 2.8 dB
Radiated disturbance electric field strength in a SAR at 3 m distance 30 MHz – 1.0 GHz	±4.32 dB
electric field strength in a FAR at 3 m distance 1.0 GHz – 18 GHz	±4.47 dB

7. Appendix 4: Test illustrations



Picture #1. Radiated emission test setup.

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