THE STANDARDS INSTITUTION OF ISRAEL

Electronics & Telematics Laboratory

Test Report No. 9512306145

Applicant: Stratasys Ltd.

Equipment Under Test:

RFID reader system for Duplex Material Cabinet

From The Standards Institution
Of Israel
Industry Division
Electronics & Telematics Laboratory
EMC Branch

ANAB ACCREDITED ISO/IEC 17025 TESTING LABORATORY

Certificate Number: AT-1359

Test Report No.: 9512306145 **Page 1 of 18 pages**

Title: RFID reader system for Duplex Material Cabinet
Model: RFID reader BRD-08015, antenna board BRD-03012

Applicant:	Stratasys Ltd.
Address:	2 Holzman St., Science Park, P.O.B 2496, Rehovot 76124, Israel
Sample for test selected by:	The customer
The date of test:	22 February 2015

Description of Equipment Under Test (EUT):	RFID reader system for Duplex Material Cabinet
Model:	RFID reader BRD-08015, antenna board BRD-03012
Hardware version of radio unit	A
Software version of radio unit	1.1
Manufactured by:	Stratasys Ltd.

Reference Documents:

- CFR 47 FCC: Rules and Regulations; Part 15. "Radio frequency devices";
  Subpart B: "Unintentional radiators" (2014).
  Section 15.109. Radiated emission limits.
  Subpart C: "Intentional radiators" (2014),
  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 full.	This Test Report applies only to the specimen tested and may not be applied to other specimens of the same product.

1. Test summary

Parameter	FCC Part 15 Reference paragraph	Verdict
Radiated emission test.	Subpart C Section 15.209.	Comply
Radiated emission test.	Subpart B Section 15.109 class A	Comply
Conducted emissions test	Subpart C Section 15.207	Comply

Electronics and
Telematics Laboratory
July 2015

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

Name: Michael Feldman
Position: Test Technician

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

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2. EUT Description and operation

2.1. General description:

* Note: the customer supplied all information in clause below.

The EUT is RFID transceiver on MSC2 board installed inside material resin cabinet of 3D printer. The Duplex 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

The Duplex Material Cabinet and RFID unit block diagrams are shown in Figures 1 and 2.
The EUT's views are shown in photos below.

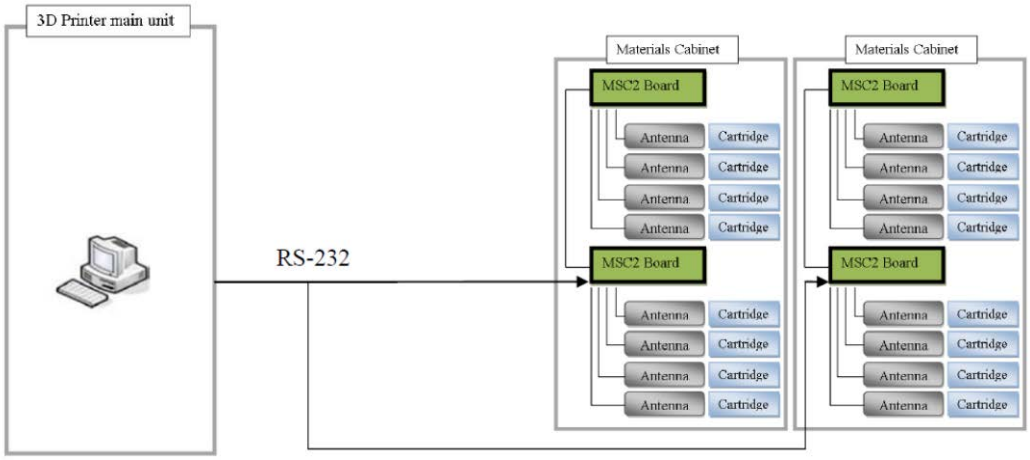


Figure 1. Duplex cabinet block diagram.

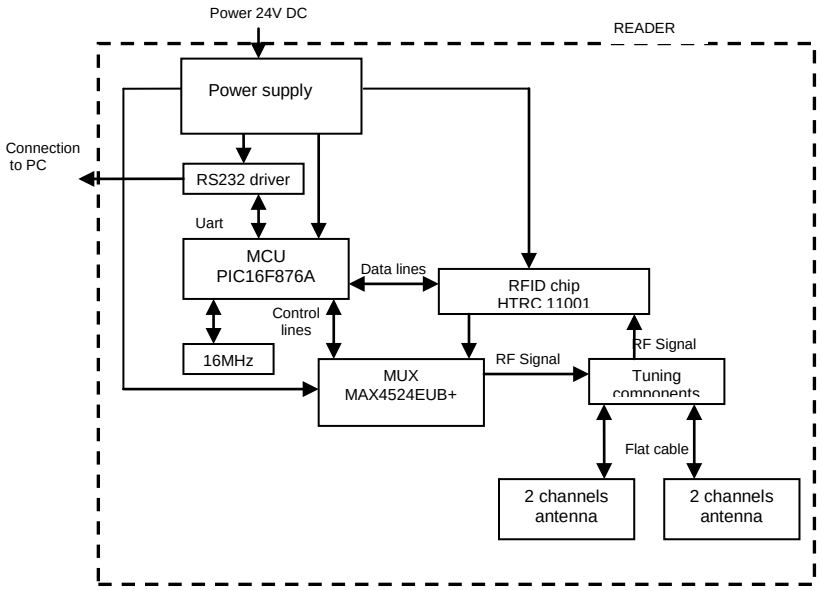


Figure 2. The RFID unit block-diagram.

Photo 1. Duplex cabinet view.

Photo 2. RE test setup

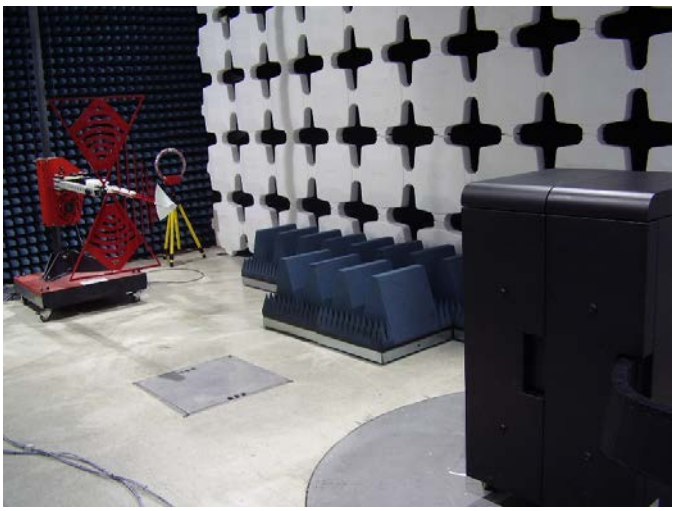


Photo 3. RE test setup

2.2. Potential emission sources:

The potential emission sources are detailed in Table 1.

Table 1. Potential emission sources

Frequency	Location
125 kHz	RFID (derived from 16 MHz)
16 MHz crystal	RFID
33.3 MHz crystal	MSC board (CPLD)

2.3. EUT setup and operation:

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

3. Measurements, examinations and derived results

3.1. Location of the Test Site:

Radiated emission test was conducted at the EMC laboratory of the Standards Institution of Israel in Tel-Aviv.

3.2. Test condition:

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

3.3. Radiated emission test.

3.3.1. General:

Per FCC Part 15 subpart B, C Sections 15.109, 15.209

3.3.2. Radiated emission measurements procedure:

The radiated emission measurements were performed in the semi Anechoic chamber at the 3 m test distance. The EUT was installed on a turn - table. 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.

3.3.3. Radiated emission test results:

All received emissions from the RFID transmitter were found below FCC Part 15 Subpart C sections 15.209 and below FCC part 15.109 class A limit for digital part. Final result measurements are presented in table #2 in section 3.4.5 and table #3 section 3.6.2.

3.4. Test of field strength emission from intentional radiator.

3.4.1. General:

Per FCC Part 15 Subpart C section 15.209 (a).

3.4.2. 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 § 15.209.

3.4.3. Test procedure:

The test was conducted according to clause 15.209.

3.4.4. Test summery:

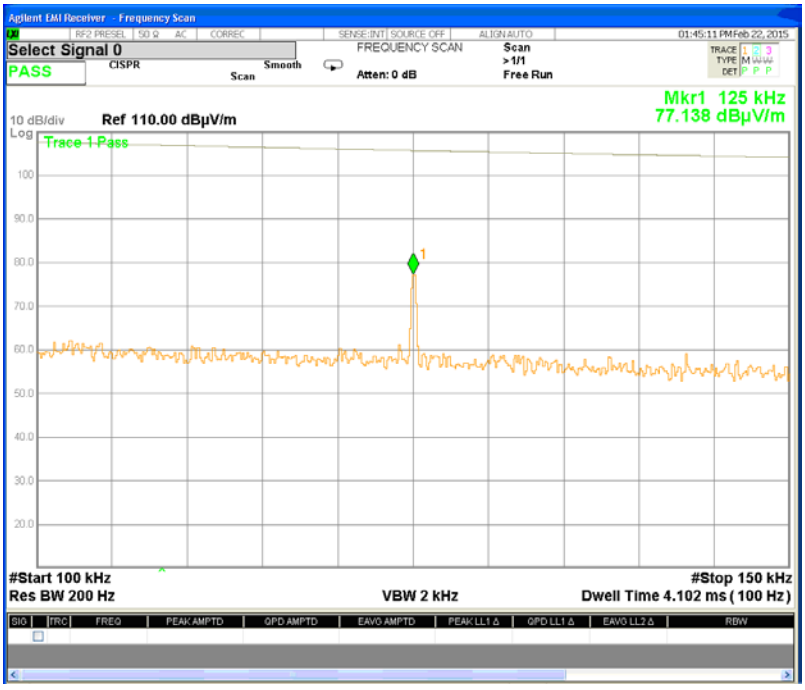
The tested unit meets the standard requirement.

3.4.5. Test results:

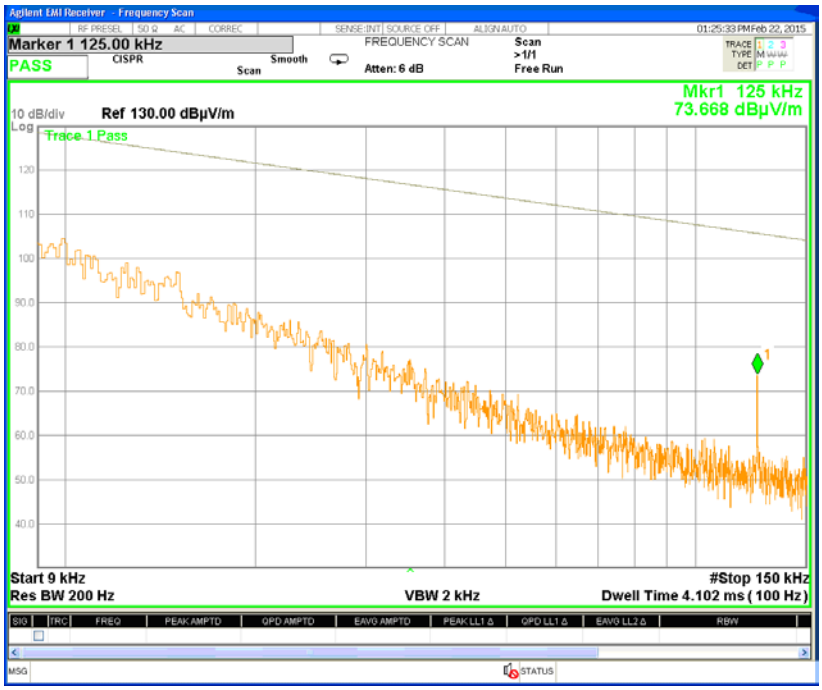
Table # 2. Fundamental frequency test result

Carrier frequency MHz	Peak amplitude dBµV/m	Limit@ 3m dBµV/m
0.125	77.1	105.6

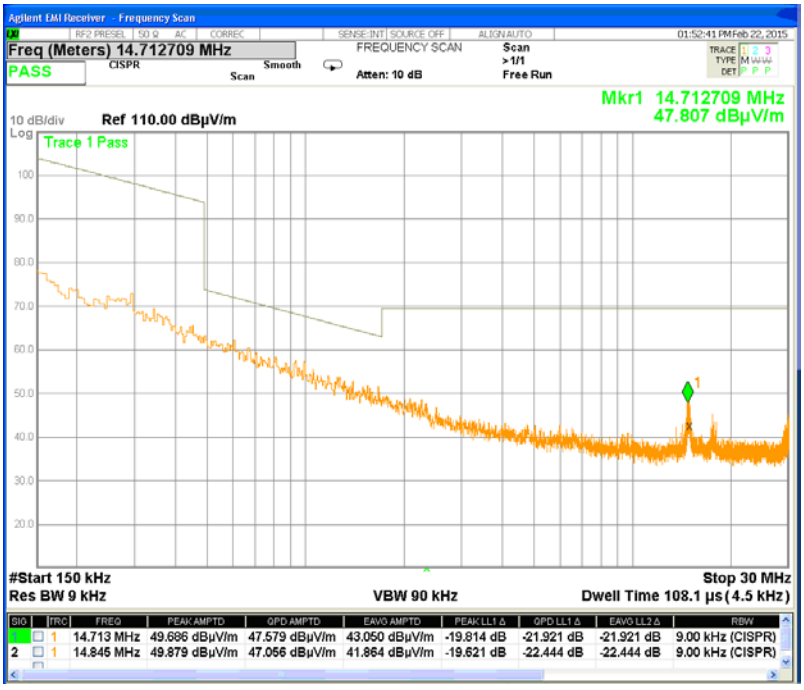
For recorded fundamental frequency result see plot #1.
The received radiated emission result was found below the § 15.209 specified limit.
Investigation scans of spurious emission present in plots ## 2 and 3



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



Plot # 2. Frequency scan 0.009 - 0.15 MHz. Test distance =3m.



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

3.5. AC main conducted emissions test

Per FCC Part 15 subpart B Section 15.207

Test configuration:

The EUT as a part inside 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.

3.5.1. Test procedure:

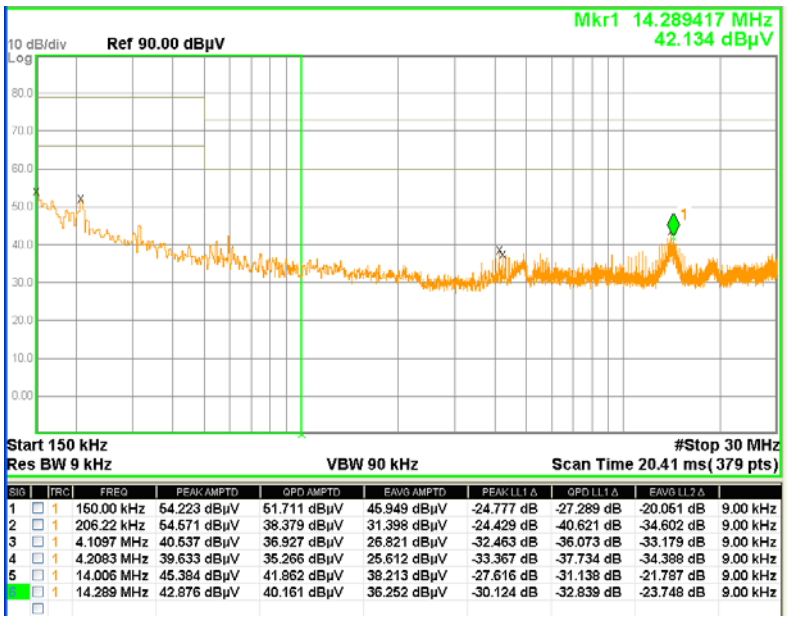
First, initial scans were performed. Final measurements were performed at the frequencies where emission exceeded the tolerance limit.

Test equipment (EMI receiver) setup was as follow:

Initial scan:		**Measurements:**	
Detector type	Peak	Detector type	Quasi-peak (CISPR), Average
Mode	Max hold	Bandwidth	9 kHz
Bandwidth	9 kHz		

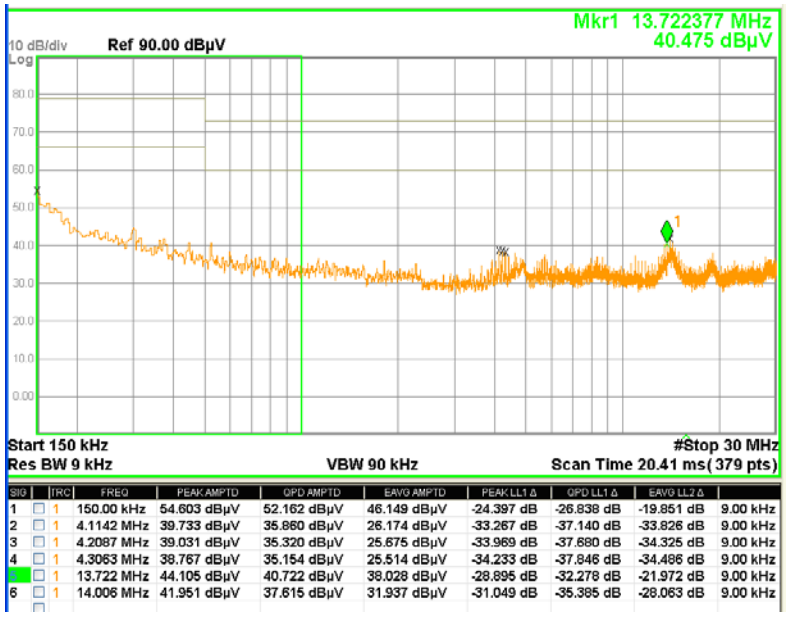
3.5.2. Test results:

All received emissions from EUT were found below FCC Part 15.207 limits (see plots ## 4, 5 below).



SIG	TRC	FREQ	PEAK AMPTD	QPD AMPTD	EAVG AMPTD	PEAK LL1 Δ	QPD LL1 Δ	EAVG LL2 Δ	
1	1	150.00 kHz	54.223 dBµV	51.711 dBµV	45.949 dBµV	-24.777 dB	-27.289 dB	-20.051 dB	9.00 kHz
2	1	206.22 kHz	54.571 dBµV	38.379 dBµV	31.398 dBµV	-24.429 dB	-40.621 dB	-34.602 dB	9.00 kHz
3	1	4.1097 MHz	40.537 dBµV	36.927 dBµV	26.821 dBµV	-32.463 dB	-36.073 dB	-33.179 dB	9.00 kHz
4	1	4.2083 MHz	39.633 dBµV	35.266 dBµV	25.612 dBµV	-33.367 dB	-37.734 dB	-34.388 dB	9.00 kHz
5	1	14.006 MHz	45.384 dBµV	41.862 dBµV	38.213 dBµV	-27.616 dB	-31.138 dB	-21.787 dB	9.00 kHz
1	1	14.289 MHz	42.876 dBµV	40.161 dBµV	36.252 dBµV	-30.124 dB	-32.839 dB	-23.748 dB	9.00 kHz

Plot # 4. 120VAC line Phase.



SIG	TRC	FREQ	PEAK AMPTD	QPD AMPTD	EAVG AMPTD	PEAK LL1 Δ	QPD LL1 Δ	EAVG LL2 Δ	
1	1	150.00 kHz	54.603 dBµV	52.162 dBµV	46.149 dBµV	-24.397 dB	-26.838 dB	-19.851 dB	9.00 kHz
2	1	4.1142 MHz	39.733 dBµV	35.860 dBµV	26.174 dBµV	-33.267 dB	-37.140 dB	-33.826 dB	9.00 kHz
3	1	4.2087 MHz	39.031 dBµV	35.320 dBµV	25.675 dBµV	-33.969 dB	-37.680 dB	-34.325 dB	9.00 kHz
4	1	4.3063 MHz	38.767 dBµV	35.154 dBµV	25.514 dBµV	-34.233 dB	-37.846 dB	-34.486 dB	9.00 kHz
1	1	13.722 MHz	44.105 dBµV	40.722 dBµV	38.028 dBµV	-28.895 dB	-32.278 dB	-21.972 dB	9.00 kHz
6	1	14.006 MHz	41.951 dBµV	37.615 dBµV	31.937 dBµV	-31.049 dB	-35.385 dB	-28.063 dB	9.00 kHz

Plot # 5. 120VAC line Neutral.

3.6. Test of radiated emissions from unintentional radiator

Per FCC Part 15 subpart B Section 15.109

3.6.1. Test procedure:

The EUT was on at normal performance.
First, initial scans were performed. Final measurements were performed according to clause 3.3.2.

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

3.6.2. Radiated emission test results:

All received emissions were found below FCC Part 15 class A limit and presented in table 3 below.

Table 3. Radiated emission test results
Subpart B class A 3 m distance.

Frequency MHz	Antenna Polariz. V/H	Antenna Height m	Turn-table Angle (°)	Emission Level Note 1 dBμV/m	Limit @ 3 m dBμV/m	Margin dB	Results
31.5	V	1.0	249	35.5	49.5	14	Complies
50.0	V	1	241	43.0	49.5	6.5	Complies
55.7	V	1	179	39.7	49.5	9.8	Complies
60.5	V	1	187	41.1	49.5	8.4	Complies
66.2	V	1	282	39.1	49.5	10.4	Complies
170.4	H	1.2	179	33.3	54.0	20.7	Complies

Note 1: Emission level = E Reading (dBμV) + Cable loss (dB) + Antenna Factor (dB/m)
For Cable Loss and Antenna Factor refer to Appendix 2

4. Appendix 1. Test equipment used.

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

Test equipment used

No	Description	Manufacturer information			Due Calibration date
		Name	Model	Serial No	
1	MXE EMI Receiver 20 Hz -26.5 GHz	Agilent	N9038A	SII 650114	February 2016
2	Double Ridged Guide Antenna 0.75 – 18 GHz	ETS-Lindgren	3115	00143138	December 2015
3	Broadband Horn antenna 15 – 40 GHz	Schwarzbeck Mess-Electronik	BBHA 9170	9170-341	December 2015
4	Double Ridged Waveguide Horn Antenna 1 – 18 GHz	ETS-Lindgren	3117	00139055	December 2015
5	Antenna Biconilog 30 – 6000 MHz	ETS-Lindgren	31142D	0146490	December 2015
6	Spectrum analyzer 9 kHz-6.0 GHz	Rohde&Schwarz	FSL	SII5912	May 2015
7	EMI Analyser 9 kHz - 26.5 GHz	HP	E7405A	SII 4944	May 2015
8	Attenuator 3 dB DC – 12.4 GHz	HP	8491A	50469	October 2015
9	LISN 9 kHz – 30 MHz	FCC	LISN 250-32-4-16	SII5023	October 2015
10	Transient limiter 0.009-200 MHz	HP	11947A	3107105	August 2015
11	Cable RF 1m	Huber-Suhner	Sucoflex 104PE	21325/4PE	October 2015
12	Cable RF 4m	Huber-Suhner	Sucoflex 104PE	21329/4PE	October 2015
13	Cable RF 0.5m	Huber-Suhner	Multiflex 141	520201	October 2015
14	Active Loop antenna 1.0 kHz – 30 MHz	ETS-Lindgren	6507	00144641	December 2015

5. Appendix 1: 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, ETS-Lindgren mod. 31142D, S/N: 0146490 3m calibration.

No.	f / MHz	AF / dB/m	f / MHz	AF / dB/m	f / MHz	AF / dB/m
1	30	18.7	250	12.0	2750	31.0
2	35	15.7	300	13.8	3000	31.2
3	40	12.9	400	16.2	3250	32.7
4	45	10.6	500	18.6	3500	34.5
5	50	9.0	600	20.2	3750	34.3
6	60	7.3	700	21.8	4000	34.5
7	70	7.7	800	22.9	4250	35.3
8	80	8.2	900	24.1	4500	35.5
9	90	9.2	1000	24.8	4750	36.1
10	100	9.4	1250	26.9	5000	37.4
11	120	8.5	1500	30.2	5250	38.4
12	140	8.5	1750	28.5	5000	39.9
13	160	9.1	2000	28.9	5750	38.2
14	180	10.5	2250	29.8	6000	39.1
15	200	10.9	2500	32.5		

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: Sucoflex 104PE; Ser.No.21329/4PE; 4 m length

Point	Frequency (GHz)	Cable Loss (dB)
1	0.0-1.0	1.7
2	1.0– 3.5	3.2
3	3.5– 5.5	4.0
4	5.5 – 7.5	4.7
5	7.5 – 9.5	5.3
6	9.5 – 10.5	5.6
7	10.5 – 12.5	6.2
8	12.5 – 14.5	6.8
9	14.5 – 16.5	7.5
10	16.5 – 18.0	8.1