

FCC Measurement/Technical Report on

CAP H 7E/80-85/17E/19

Cellular Repeater

FCC ID: XS5-CAPH7E817E19
IC: 2237E-EH7E817E19

Test Report Reference: MDE_BVNBG_1806_FCCd_REV1

Test Laboratory:

7layers GmbH
Borsigstrasse 11
40880 Ratingen
Germany



Note:

The following test results relate only to the devices specified in this document. This report shall not be reproduced in parts without the written approval of the test laboratory.

7layers GmbH

Borsigstraße 11
40880 Ratingen, Germany
T +49 (0) 2102 749 0
F +49 (0) 2102 749 350

Geschäftsführer/

Managing Directors:

Frank Spiller
Bernhard Retka
Alexandre Norré-Oudard

Registergericht/registered:

Düsseldorf HRB 75554
USt-Id.-Nr./VAT-No. DE203159652
Steuer-Nr./TAX-No. 147/5869/0385

a Bureau Veritas
Group Company

www.7layers.com

Table of Contents

1.1	Applied Standards	3
1.2	FCC-IC Correlation Table	4
1.3	Measurement Summary / Signatures	5
2	Administrative Data	8
2.1	Testing Laboratory	8
2.2	Project Data	8
2.3	Applicant Data	8
2.4	Manufacturer Data	8
3	Test object Data	9
3.1	General EUT Description	9
3.2	EUT Main components	9
3.3	Ancillary Equipment	10
3.4	Auxiliary Equipment	10
3.5	EUT Setups	10
3.6	Operating Modes	11
3.7	Product labelling	11
4	Test Results	12
4.1	Field strength of spurious radiation	12
5	Test Equipment	18
6	Antenna Factors, Cable Loss and Sample Calculations	21
6.1	LISN R&S ESH3-Z5 (150 kHz – 30 MHz)	21
6.2	Antenna R&S HPH2-Z2 (9 kHz – 30 MHz)	22
6.3	Antenna R&S HL562 (30 MHz – 1 GHz)	23
6.4	Antenna R&S HF907 (1 GHz – 18 GHz)	24
6.5	Antenna EMCO 3160-09 (18 GHz – 26.5 GHz)	25
6.6	Antenna EMCO 3160-10 (26.5 GHz – 40 GHz)	26
7	Measurement Uncertainties	27
8	Photo Report	27

Applied Standards and Test Summary

1.1 APPLIED STANDARDS

Type of Authorization

Certification for an Industrial Signal Booster.

Applicable FCC Rules

Prepared in accordance with the requirements of FCC Rules and Regulations as listed in 47 CFR Ch.1 Parts 2 and 20, 24, (10/1/18 Edition). The following subparts are applicable to the results in this test report.

Part 2, Subpart J - Equipment Authorization Procedures, Certification

Part 20, Commercial Mobiles Serviced

§ 20.21 Signal Boosters

Part 24, Subpart E – Broadband PCS

§ 24.232 – Power and antenna height limits

§ 24.235 – Frequency stability

§ 24.238 – Emission limitations for Broadband PCS equipment

The tests were selected and performed with reference to:

- FCC Public Notice 935210 applying “Signal Boosters Basic Certification Requirements” 935210 D02 v04r01, 2018-06-19.
- FCC Public Notice 935210 applying “Measurement guidance for industrial and non-consumer signal booster, repeater and amplifier devices” 935210 D05 v01r02, 2017-10-27.
- FCC Public Notice 971168 applying “Measurement guidance for certification of licensed digital transmitters” 971168 D01 v03r01, 2018-04-09
- ANSI C63.26: 2015

Summary Test Results:

The EUT complied with all performed tests as listed in chapter 1.3 Measurement Summary / Signatures.

1.2 FCC-IC CORRELATION TABLE

Correlation of measurement requirements for Industrial Signal Booster from FCC and ISED Canada

Measurement	FCC reference	ISED reference
Effective radiated power, mean output power and zone enhancer gain	§2.1046 §24.232 KDB 935210 D05 v01r02: 3.5	RSS-GEN Issue 5, 6.12 RSS-133 Issue 6, 6.4 SRSP-510, Issue 7, 5.1.1 RSS-131 Issue 3: 5.2.3
Peak to Average Ratio	§24.232	RSS 133 Issue 6: 6.4
Occupied bandwidth Input-versus-output spectrum	§2.1049 KDB 935210 D05 v01r02: 3.4	RSS-GEN Issue 5, 6.7 RSS-131 Issue 3: 5.2.2
Conducted spurious Emission at Antenna Terminal	§2.1051 §24.238	RSS-GEN Issue 5, 6.13 RSS-133 Issue 6, 6.5
Out-of-band emissions limits	§2.1051 §24.238 KDB 935210 D05 v01r02: 3.6	RSS-GEN Issue 5, 6.13 RSS-133 Issue 6, 6.5
Frequency stability	§2.1055 §24.235	RSS-GEN Issue 5, 6.11 RSS-133 Issue 6: 6.3 RSS-131 Issue 3: 5.2.4
Field strength of spurious radiation	§2.1053 §24.236	RSS-GEN Issue 5, 6.13 RSS-133 Issue 6: 6.5
Out-of-band rejection	KDB 935210 D05 v01r02: 3.3	RSS-131 Issue 3: 5.2.1

1.3 MEASUREMENT SUMMARY / SIGNATURES

47 CFR CHAPTER I FCC PART 24 Subpart E **\$2.1046, §24.232,** **[Base Stations/Repeater]** **KDB 935210 D02 II (p)(4)**

Effective Radiated Power, mean output power and zone enhancer gain

The measurement was performed according to ANSI C63.26, KDB 935210 D05 v01r02: 3.5

Final Result

OP-Mode	Setup	FCC	IC
Frequency Band, Direction, Input Power, Signal Type			
Band 2/25, RF downlink, 0.3 dB < AGC, Narrowband	-	N/P	N/P
Band 2/25, RF downlink, 0.3 dB < AGC, Wideband	-	N/P	N/P
Band 2/25, RF downlink, 3 dB > AGC, Narrowband	-	N/P	N/P
Band 2/25, RF downlink, 3 dB > AGC, Wideband	-	N/P	N/P

47 CFR CHAPTER I FCC PART 24 Subpart E **\$24.232** **[Base Stations/Repeater]**

Peak to Average Ratio

The measurement was performed according to ANSI C63.26

Final Result

OP-Mode	Setup	FCC	IC
Frequency Band, Direction, Input Power, Signal Type			
Band 2/25, RF downlink, 0.3 dB < AGC, Narrowband	-	N/P	N/P
Band 2/25, RF downlink, 0.3 dB < AGC, Wideband	-	N/P	N/P
Band 2/25, RF downlink, 3 dB > AGC, Narrowband	-	N/P	N/P
Band 2/25, RF downlink, 3 dB > AGC, Wideband	-	N/P	N/P

47 CFR CHAPTER I FCC PART 24 Subpart E **\$2.1049,** **[Base Stations/Repeater]** **KDB 935210 D02 II (p)(3)**

Occupied Bandwidth / Input-versus-output Spectrum

The measurement was performed according to ANSI C63.26, KDB 935210 D05 v01r02: 3.4

Final Result

OP-Mode	Setup	FCC	IC
Frequency Band, Direction, Input Power, Signal Type			
Band 2/25, RF downlink, 0.3 dB < AGC, Narrowband	-	N/P	N/P
Band 2/25, RF downlink, 0.3 dB < AGC, Wideband	-	N/P	N/P
Band 2/25, RF downlink, 3 dB > AGC, Narrowband	-	N/P	N/P
Band 2/25, RF downlink, 3 dB > AGC, Wideband	-	N/P	N/P

47 CFR CHAPTER I FCC PART 24 Subpart E
[Base Stations/Repeater]

§2.1051, §24.238

Conducted spurious emissions at antenna terminals

The measurement was performed according to ANSI C63.26

Final Result

OP-Mode

Frequency Band, Test Frequency, Direction, Signal Type

Band 2/25, high, RF downlink, Narrowband

Setup

S01_AA01

FCC

Passed

IC

Passed

Band 2/25, high, RF downlink, Wideband

S01_AA01

Passed

Passed

Band 2/25, low, RF downlink, Narrowband

S01_AA01

Passed

Passed

Band 2/25, low, RF downlink, Wideband

S01_AA01

Passed

Passed

Band 2/25, mid, RF downlink, Narrowband

S01_AA01

Passed

Passed

Band 2/25, mid, RF downlink, Wideband

S01_AA01

Passed

Passed

47 CFR CHAPTER I FCC PART 24 Subpart E
[Base Stations/Repeater]

§2.1053, §24.238,
KDB 935210 D02 II (p)(3)

Out-of-band emission limits/Intermodulation

The measurement was performed according to ANSI C63.26, KDB
 935210 D05 v01r02: 3.6

Final Result

OP-Mode

Band Edge, Frequency Band, Number of signals, Direction,
 Input Power, Signal Type

Lower, Band 2/25, 1, RF downlink, 0.3 dB < AGC, Narrowband

Setup

-

FCC

N/P

IC

N/P

Lower, Band 2/25, 1, RF downlink, 0.3 dB < AGC, Wideband

-

N/P

N/P

Lower, Band 2/25, 1, RF downlink, 3 dB > AGC, Narrowband

-

N/P

N/P

Lower, Band 2/25, 1, RF downlink, 3 dB > AGC, Wideband

-

N/P

N/P

Lower, Band 2/25, 2, RF downlink, 0.3 dB < AGC, Narrowband

-

N/P

N/P

Lower, Band 2/25, 2, RF downlink, 0.3 dB < AGC, Wideband

-

N/P

N/P

Lower, Band 2/25, 2, RF downlink, 3 dB > AGC, Narrowband

-

N/P

N/P

Lower, Band 2/25, 2, RF downlink, 3 dB > AGC, Wideband

-

N/P

N/P

Upper, Band 2/25, 1, RF downlink, 0.3 dB < AGC, Narrowband

-

N/P

N/P

Upper, Band 2/25, 1, RF downlink, 0.3 dB < AGC, Wideband

-

N/P

N/P

Upper, Band 2/25, 1, RF downlink, 3 dB > AGC, Narrowband

-

N/P

N/P

Upper, Band 2/25, 1, RF downlink, 3 dB > AGC, Wideband

-

N/P

N/P

Upper, Band 2/25, 2, RF downlink, 0.3 dB < AGC, Narrowband

-

N/P

N/P

Upper, Band 2/25, 2, RF downlink, 0.3 dB < AGC, Wideband

-

N/P

N/P

Upper, Band 2/25, 2, RF downlink, 3 dB > AGC, Narrowband

-

N/P

N/P

Upper, Band 2/25, 2, RF downlink, 3 dB > AGC, Wideband

-

N/P

N/P

47 CFR CHAPTER I FCC PART 24 Subpart E
[Base Stations/Repeater]

KDB 935210 D02 II (p)(2)

Out-of-band rejection

The measurement was performed according to ANSI C63.26

Final Result

OP-Mode

Frequency Band, Direction

Band 2/25, RF downlink

Setup

-

FCC

N/P

IC

N/P

47 CFR CHAPTER I FCC PART 24 Subpart E
[Base Stations/Repeater]

§2.1053, §22.917

Field strength of spurious radiation

The measurement was performed according to ANSI C63.26

Final Result

OP-Mode

Frequency Band, Test Frequency, Direction

Band 2/25, high, RF downlink

Band 2/25, low, RF downlink

Band 2/25, mid, RF downlink

Setup

S01_AA01

S01_AA01

S01_AA01

FCC

Passed

Passed

Passed

IC

Passed

Passed

Passed

N/A: Not applicable

N/P: Not performed

Not all tests applicable for the EUT have been performed. The built-in radio module for this band have been already tested in the cellular repeater CAP H 17E/17E/19/19 F-AC-F1-APE (FCC ID: XS5-CAPH17E19, IC Number: 2237E-EH17E19). These results will be reused in accordance with KDB 484596 D01, v01.

For details please see 7layers test report:MDE_BVNBG_1806_FCCa.

Due to this fact, only the test case:

- Field strength of spurious radiation

has been performed, to check the behaviour of the radio module in the different housing.

The test case frequency stability was not performed, since the EUT is not equipped with signal processing capabilities.

Report version control			
Version	Release date	Change Description	Version validity
initial	2019-03-11	--	invalid
REV1	2019-04-10	• Page 5-7: References to KDB document 935210 D02 added in test summary where applicable. • Page 6: "Intermodulation" added in name to test case "out-of-band emission limits". • Page 7: FCC / IC ID of the referenced device for test results added. • Page 7: Reference to KDB 484595 D01 v01 "Reuse of test results" added.	valid



7 layers GmbH, Borsigstr. 11
 40880 Ratingen, Germany
 Phone +49 (0)2102 749 0

M. Kullik

(responsible for accreditation scope)
 Dipl.-Ing. Marco Kullik

D. Gall

(responsible for testing and report)
 Dipl.-Ing. Daniel Gall

2 ADMINISTRATIVE DATA

2.1 TESTING LABORATORY

Company Name: 7layers GmbH
Address: Borsigstr. 11
40880 Ratingen
Germany

The test facility is accredited by the following accreditation organisation:

Laboratory accreditation no: DAKKS D-PL-12140-01-00
FCC Designation Number: DE0015
FCC Test Firm Registration: 929146
ISED CAB Identifier: DE0007; ISED#:3699A
Responsible for accreditation scope: Dipl.-Ing. Marco Kullik
Report Template Version: 2019-03-11

2.2 PROJECT DATA

Responsible for testing and report: Dipl.-Ing. Daniel Gall
Employees who performed the tests: documented internally at 7Layers
Date of Report: 2019-04-10
Testing Period: 2019-02-19 to 2019-02-21

2.3 APPLICANT DATA

Company Name: Commscope
Andrew Wireless Systems GmbH
Address: Industriering 10
86675 Buchdorf
Germany
Contact Person: Mr. Frank Futter

2.4 MANUFACTURER DATA

Company Name: please see applicant data
Address:

Contact Person:

3 TEST OBJECT DATA

3.1 GENERAL EUT DESCRIPTION

Kind of Device product description	Cellular Repeater
Product name	
Type	ION-E System CAP H 7E/80-85/17E/19
Declared EUT data by the supplier	
General Product Description	The EUT is an industrial signal booster supporting the followings: Band 2/25 / 1900 PCS Band 4/10/66 / AWS 1 Band 5 / 850 Band 12 / 700 a Band 13 / 700 c Band 14 / 700 PS Band 26 / 850+ A RF operation is only supported for the downlink.
Booster Type	Industrial Signal Booster
Voltage Type	AC
Voltage Level	100 – 240 V, 50 – 60 Hz
Maximum Output Donor Port [Uplink]	-
Maximum Output Server Port [Downlink]	Band 2/25 / 1900 PCS: 43.0 dBm
Maximum Gain [Uplink]	-
Maximum Gain [Downlink]	Band 2 / 1900 PCS: 28.0 dB

The main components of the EUT are listed and described in chapter 3.2 EUT Main components.

3.2 EUT MAIN COMPONENTS

Sample Name	Sample Code	Description
EUT A	DE1277008aa01	FCC sample
Sample Parameter	Value	
Serial Number	BGCHDA1851001	
HW Version	7825719-0001 CAP H 7E/80-85/17E/19	
SW Version	7694174-12 SW V2.6.0.106	
Comment	-	

NOTE: The short description is used to simplify the identification of the EUT in this test report.

3.3 ANCILLARY EQUIPMENT

For the purposes of this test report, ancillary equipment is defined as equipment which is used in conjunction with the EUT to provide operational and control features to the EUT. It is necessary to configure the system in a typical fashion, as a customer would normally use it. But nevertheless Ancillary Equipment can influence the test results.

Device	Details (Manufacturer, Type Model, OUT Code)	Description
-	-	-

3.4 AUXILIARY EQUIPMENT

For the purposes of this test report, auxiliary equipment is defined as equipment which is used temporarily to enable operational and control features especially used for the tests of the EUT which is not used during normal operation or equipment that is used during the tests in combination with the EUT but is not subject of this test report. It is necessary to configure the system in a typical fashion, as a customer would normally use it. But nevertheless Auxiliary Equipment can influence the test results.

Device	Details (Manufacturer, HW, SW, S/N)	Description
-	-	-

3.5 EUT SETUPS

This chapter describes the combination of EUTs and equipment used for testing. The rationale for selecting the EUTs, ancillary and auxiliary equipment and interconnecting cables, is to test a representative configuration meeting the requirements of the referenced standards.

Setup	Combination of EUTs	Description and Rationale
S01_AA01	EUT A	Setup for all tests

3.6 OPERATING MODES

This chapter describes the operating modes of the EUTs used for testing.

3.6.1 TEST CHANNELS

Band	Direction	Lower Frequency Band Edge [MHz]	Upper Frequency Band Edge [MHz]	Center Frequency [MHz]	Port
2/25	downlink	1930.00	1995.00	1962.50	Donor

3.6.2 AUTOMATIC GAIN CONTROL LEVELS

AGC Levels							
Band	Direction	Signal Type	AGC Start Pin [dBm]	AGC Start Pin -0.3 dB [dBm]	AGC Start Pin +3 dB [dBm]	Frequency [MHz]	Frequency
2/25	downlink	Narrowband	0.0	-	-	1962.5	Mid
2/25	downlink	Wideband	-	-	-	-	
2/25	downlink	Narrowband	1.0	-	-	1930.0	Low
2/25	downlink	Wideband	-	-	-	-	
2/25	downlink	Narrowband	1.2	-	-	1995.0	High
2/25	downlink	Wideband	-	-	-	-	
2/25	downlink	Narrowband	-	-	-	-	Max. Power
2/25	downlink	Wideband	-	-	-	-	

3.7 PRODUCT LABELLING

3.7.1 FCC ID LABEL

Please refer to the documentation of the applicant.

3.7.2 LOCATION OF THE LABEL ON THE EUT

Please refer to the documentation of the applicant.

4 TEST RESULTS

4.1 FIELD STRENGTH OF SPURIOUS RADIATION

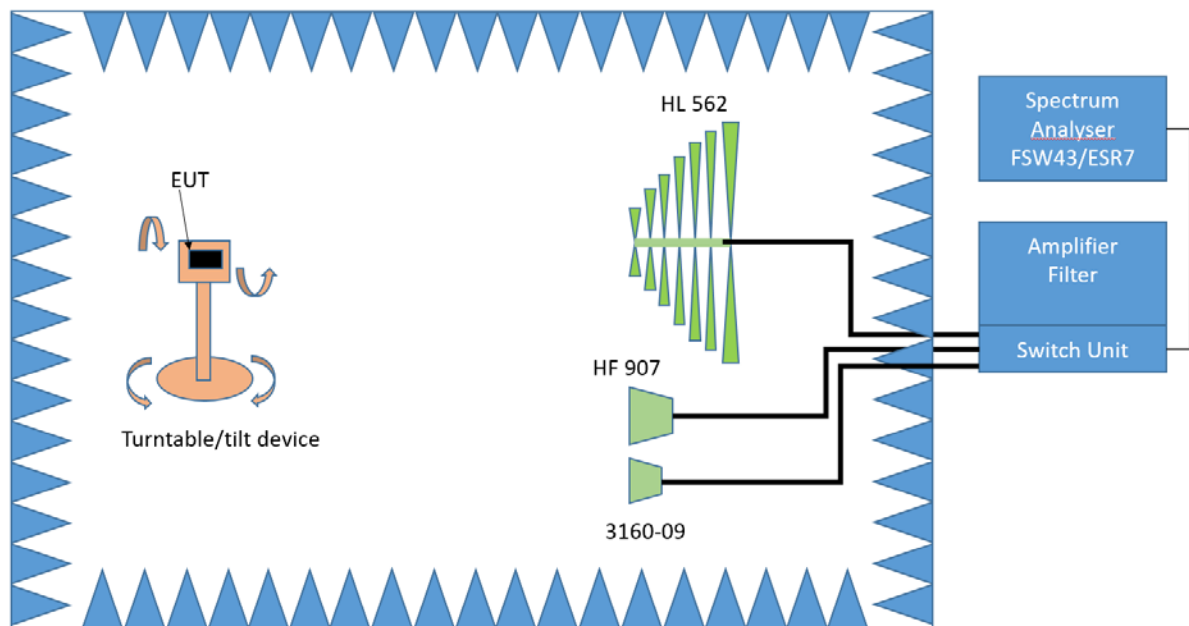
Standard FCC Part 24, §24.238

The test was performed according to:
ANSI C63.26

4.1.1 TEST DESCRIPTION

This test case is intended to demonstrate compliance to the applicable radiated spurious emission measurements per § 2.1053

The EUT was connected to the test setup according to the following diagram:



FCC Part 22/24/27/90; Industrial Signal Booster – Test Setup; Field Strength of Spurious Radiation

The test set-up was made in accordance to the general provisions of ANSI C63.4 in a typical installation configuration. The Equipment Under Test (EUT) was set up on a non-conductive table 1.0 x 2.0 m² in the semi-anechoic chamber. The influence of the EUT support table that is used between 30–1000 MHz was evaluated.

The measurement procedure is implemented into the EMI test software EMC32 from R&S. Exploratory tests are performed at 3 orthogonal axes to determine the worst-case orientation of a body-worn or handheld EUT. The final test on all kind of EUTs is also performed at 3 axes. A pre-check is performed while the EUT is powered from a DC power source.

1. Measurement above 30 MHz and up to 1 GHz

Step 1: Preliminary scan

This is a preliminary test to identify the highest amplitudes relative to the limit. Settings for step 1:

- Antenna distance: 3 m
- Detector: Peak-Maxhold / Quasipeak (FFT-based)
- Frequency range: 30 – 1000 MHz
- Frequency steps: 30 kHz
- IF-Bandwidth: 120 kHz
- Measuring time / Frequency step: 100 ms
- Turntable angle range: -180° to 90°
- Turntable step size: 90°
- Height variation range: 1 – 3 m
- Height variation step size: 2 m
- Polarisation: Horizontal + Vertical

Intention of this step is, to determine the radiated EMI-profile of the EUT. Afterwards the relevant emissions for the final measurement are identified.

Step 2: Adjustment measurement

In this step the accuracy of the turntable azimuth and antenna height will be improved. This is necessary to find out the maximum value of every frequency.

For each frequency, which was determined the turntable azimuth and antenna height will be adjusted. The turntable azimuth will slowly vary by $\pm 45^{\circ}$ around this value. During this action, the value of emission is continuously measured. The turntable azimuth at the highest emission will be recorded and adjusted. In this position, the antenna height will also slowly vary by ± 100 cm around the antenna height determined. During this action, the value of emission is also continuously measured. The antenna height of the highest emission will also be recorded and adjusted.

- Detector: Peak – Maxhold
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 100 ms
- Turntable angle range: $\pm 45^{\circ}$ around the determined value
- Height variation range: ± 100 cm around the determined value
- Antenna Polarisation: max. value determined in step 1

Step 3: Final measurement with QP detector

With the settings determined in step 3, the final measurement will be performed:

EMI receiver settings for step 4:

- Detector: Quasi-Peak (< 1 GHz)
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 1 s

After the measurement a plot will be generated which contains a diagram with the results of the preliminary scan and a chart with the frequencies and values of the results of the final measurement.

3. Measurement above 1 GHz

The following modifications apply to the measurement procedure for the frequency range above 1 GHz:

Step 1:

The Equipment Under Test (EUT) was set up on a non-conductive support (tilt device) at 1.5 m height in the fully-anechoic chamber.

All steps were performed with one height (1.5 m) of the receiving antenna only.

The EUT is turned during the preliminary measurement across the elevation axis, with a step size of 90° .

The turn table step size (azimuth angle) for the preliminary measurement is 45° .

Step 2:

Due to the fact, that in this frequency range the test is performed in a fully anechoic room, the height scan of the receiving antenna in step 2 is omitted. Instead of this, a maximum search with a step size $\pm 45^\circ$ for the elevation axis is performed.

The turn table azimuth will slowly vary by $\pm 22.5^\circ$.

The elevation angle will slowly vary by $\pm 45^\circ$

EMI receiver settings (for all steps):

- Detector: Peak, Average
- IF Bandwidth = 1 MHz

Step 3:

Spectrum analyser settings for step 3:

- Detector: Peak / Average
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 1 MHz
- Measuring time: 1 s

4.1.2 TEST REQUIREMENTS / LIMITS

FCC Part 2.1053; Measurement required: Field strength of spurious radiation:

Measurements shall be made to detect spurious emissions that may be radiated directly from the cabinet, control circuits, power leads, or intermediate circuit elements under normal conditions of installation and operation. Curves or equivalent data shall be supplied showing the magnitude of each harmonic and other spurious emission. For this test, single sideband, independent sideband, and controlled carrier transmitters shall be modulated under the conditions specified in paragraph (c) of §2.1049, as appropriate.

Part 24, Subpart E – Broadband PCS, Band 2 / 25

§24.238 – Emission limitations for Broadband PCS equipment

(a) *Out of band emissions.* The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least $43 + 10 \log(P)$ dB.

RSS-133; 6.5 Transmitter Unwanted Emissions

6.5.1 Out-of-Block Emissions

Equipment shall comply with the limits in (i) and (ii) below.

- In the 1.0 MHz bands immediately outside and adjacent to the equipment's operating frequency block, the emission power per any 1% of the emission bandwidth shall be attenuated (in dB) below the transmitter output power P (dBW) by at least $43 + 10 \log_{10}(P)$ dB.
- After the first 1.0 MHz, the emission power in any 1 MHz bandwidth shall be attenuated (in dB) below the transmitter output power P (dBW) by at least $43 + 10 \log_{10}(P)$ dB. If the measurement is performed using 1% of the emission bandwidth, power integration over 1.0 MHz is required.

4.1.3 TEST PROTOCOL

Band 2/25, downlink;						
Spurious Freq. [MHz]	Spurious Level [dBm]	Pin [dBm]	Detector	RBW [kHz]	Limit [dBm]	Margin to Limit [dB]
-	-	1.0/0.0/1.2	RMS	100	-13.0	- - -
-	-	1.0/0.0/1.2	RMS	100	-13.0	- - -
-	-	1.0/0.0/1.2	RMS	100	-13.0	- - -
-	-	1.0/0.0/1.2	RMS	100	-13.0	- - -
-	-	1.0/0.0/1.2	RMS	100	-13.0	- - -

Remark: Please see next sub-clause for the measurement plot.

Only module 1 was tested

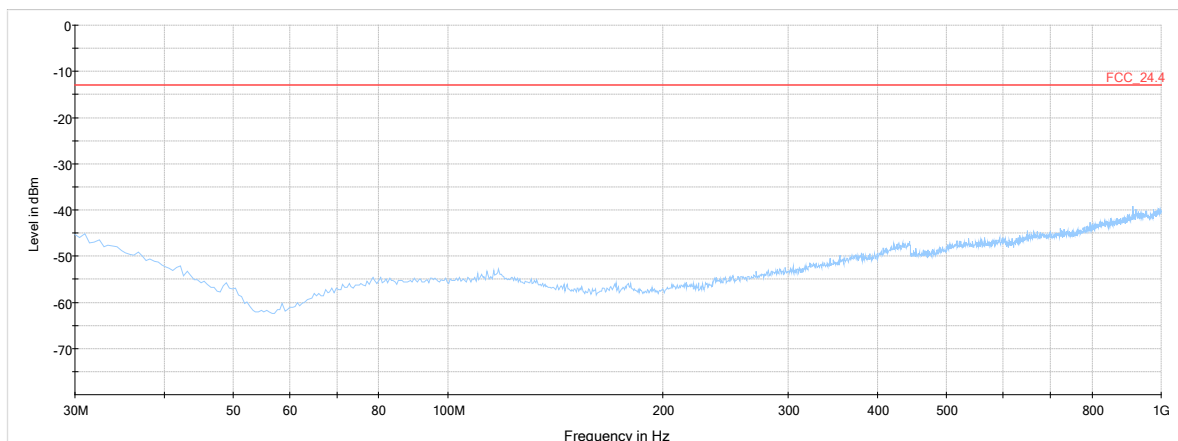
The three required test frequencies (low, mid, high) were injected simultaneously conducted into the EUT.

The RF output ports were terminated with 50 Ohm

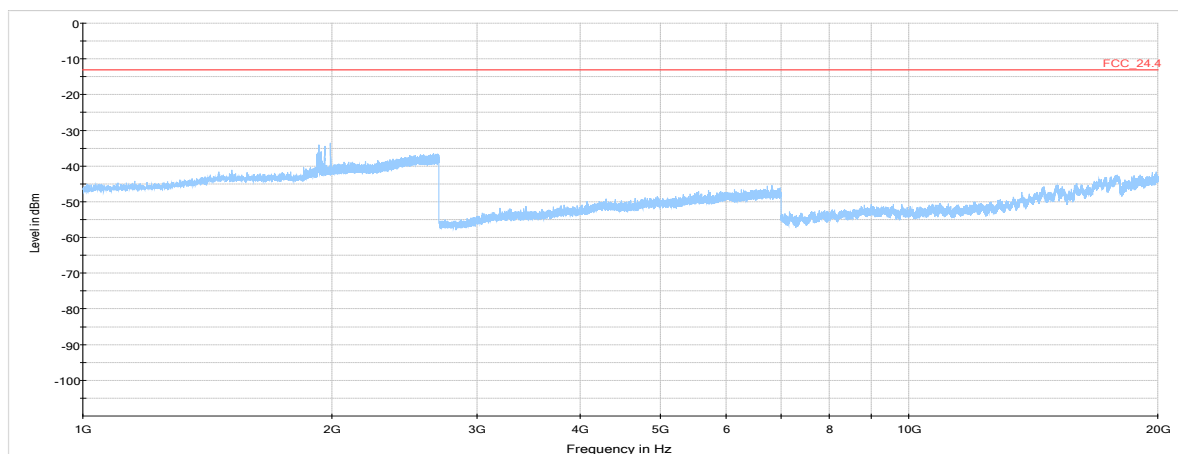
Pin: The single power of each of the three channels (bottom, middle, top).

4.1.4 MEASUREMENT PLOT (SHOWING THE HIGHEST VALUE, "WORST CASE")

Frequency Band = Band 2/25, Test Frequency = high, Direction = RF downlink
(S01_AA01)

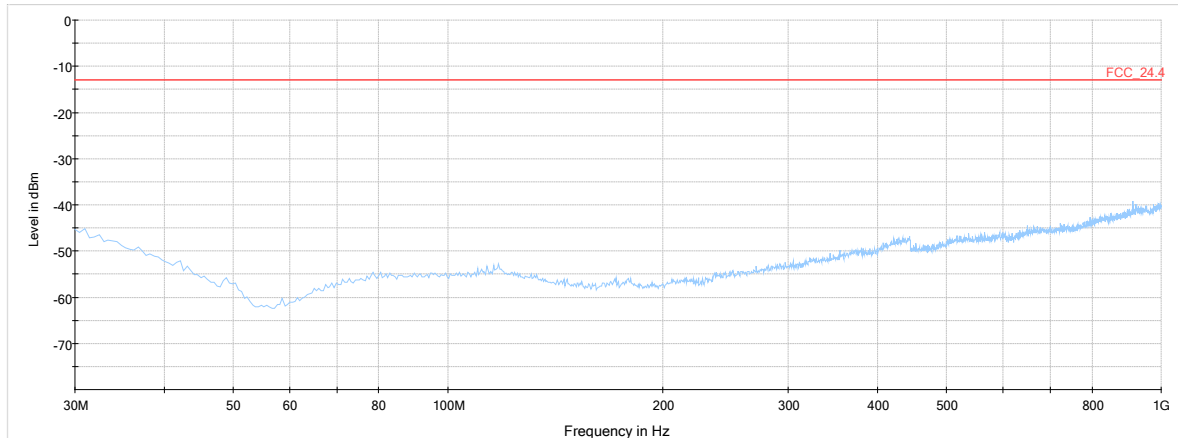


30 MHz - 1 GHz

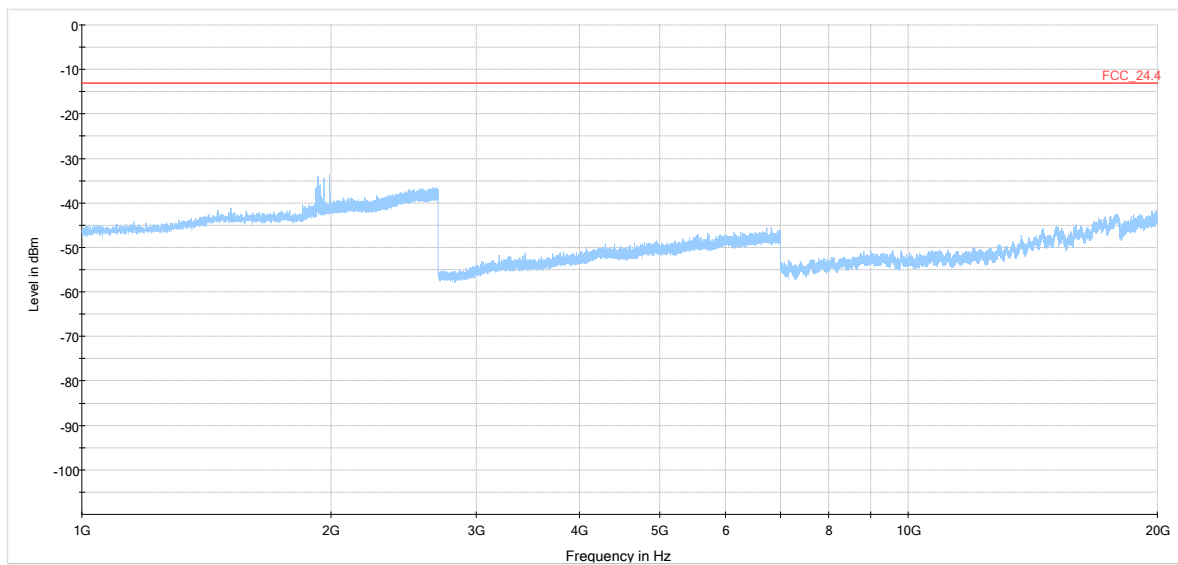


1 GHz - 20 GHz

Frequency Band = Band 2/25, Test Frequency = mid, Direction = RF downlink
(S01_AA01)

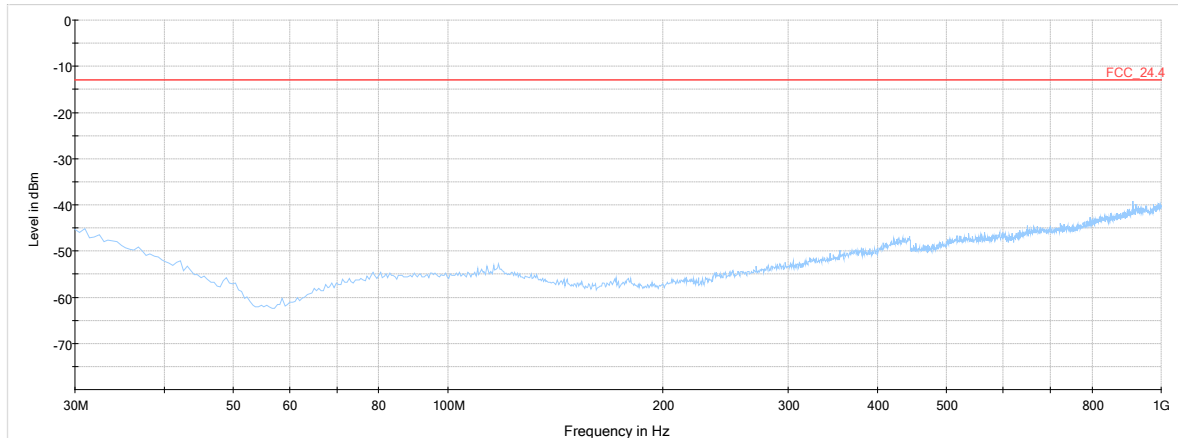


30 MHz - 1 GHz

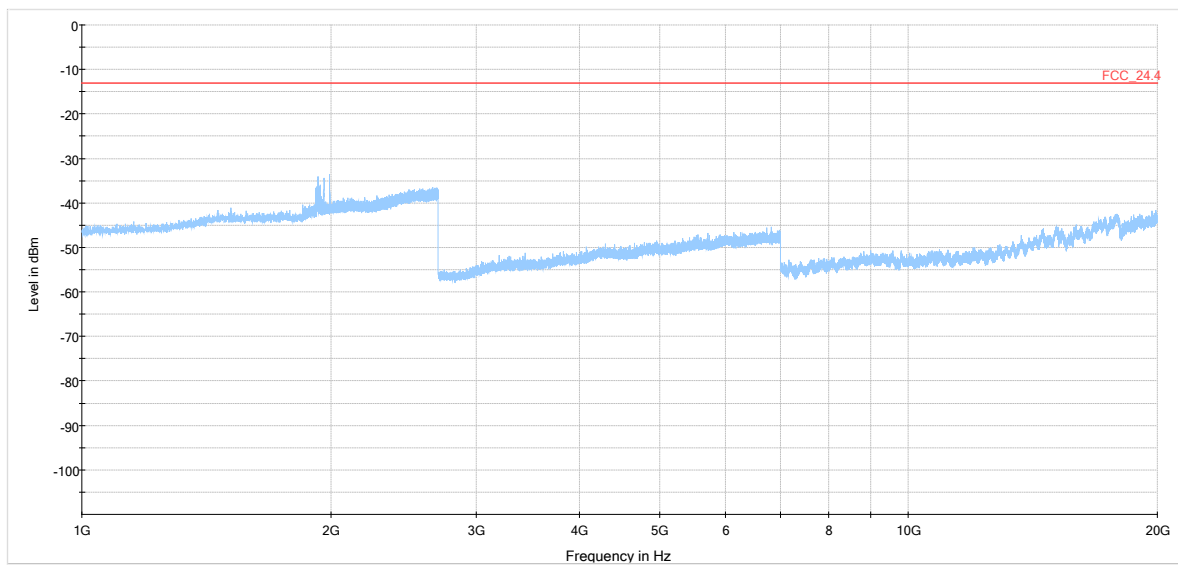


1 GHz - 20 GHz

Frequency Band = Band 2/25, Test Frequency = low, Direction = RF downlink
(S01_AA01)



30 MHz - 1 GHz



1 GHz - 20 GHz

4.1.5 TEST EQUIPMENT USED

- Radiated Emissions

5 TEST EQUIPMENT

1 R&S TS8997
EN300328/301893/FCC cond. Test Lab

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
1.1	SMB100A	Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz	107695	2017-07	2020-07
1.2	MFS	Rubidium Frequency Standard	Datum-Beverly	5489/001	2018-07	2020-07
1.3	1515 / 93459	Broadband Power Divider SMA (Aux)	Weinschel Associates	LN673		
1.4	FSV30	Signal Analyzer 10 Hz - 30 GHz	Rohde & Schwarz	103005	2018-04	2020-04
1.5	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2018-04	2020-04
1.6	VT 4002	Climatic Chamber	Vötsch	58566002150010	2018-04	2020-04
1.7	A8455-4	4 Way Power Divider (SMA)		-		
1.8	Opus10 THI (8152.00)	ThermoHygro Datalogger 03 (Environ)	Lufft Mess- und Regeltechnik GmbH	7482	2017-03	2019-03
1.9	SMBV100A	Vector Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz	259291	2016-10	2019-10
1.10	OSP120	Switching Unit with integrated power meter	Rohde & Schwarz	101158	2018-05	2021-05

2 Radiated Emissions
Lab to perform radiated emission tests

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.1	NRV-Z1	Sensor Head A	Rohde & Schwarz	827753/005	2018-07	2019-07
2.2	MFS	Rubidium Frequency Normal MFS	Datum GmbH	002	2018-10	2020-10
2.3	Opus10 TPR (8253.00)	ThermoAirpressure Datalogger 13 (Environ)	Lufft Mess- und Regeltechnik GmbH	13936	2017-04	2019-04
2.4	ESW44	EMI Test Receiver	Rohde & Schwarz	101603	2018-05	2019-05
2.5	Anechoic Chamber	10.58 x 6.38 x 6.00 m ³	Frankonia	none	2018-06	2020-06
2.6	HL 562	Ultralog new biconicals	Rohde & Schwarz	830547/003	2018-07	2021-07
2.7	5HC2700/12750 -1.5-KK	High Pass Filter	Trilithic	9942012		
2.8	ASP 1.2/1.8-10 kg	Antenna Mast	Maturo GmbH	-		

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.9	Fully Anechoic Room	8.80m x 4.60m x 4.05m (l x w x h)	Albatross Projects	P26971-647-001-PRB	2018-06	2020-06
2.10	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2018-04	2020-04
2.11	JS4-18002600-32-5P	Broadband Amplifier 18 GHz - 26 GHz	Miteq	849785		
2.12	FSW 43	Spectrum Analyzer	Rohde & Schwarz	103779	2019-02	2021-02
2.13	3160-09	Standard Gain / Pyramidal Horn Antenna 26.5 GHz	EMCO Elektronik GmbH	00083069		
2.14	WHKX 7.0/18G-8SS	High Pass Filter	Wainwright	09		
2.15	4HC1600/12750-1.5-KK	High Pass Filter	Trilithic	9942011		
2.16	Chroma 6404	AC Power Source	Chroma ATE INC.	64040001304		
2.17	JS4-00102600-42-5A	Broadband Amplifier 30 MHz - 26 GHz	Miteq	619368		
2.18	TT 1.5 WI	Turn Table	Maturo GmbH	-		
2.19	HL 562 Ultralog	Log.-per. Antenna	Rohde & Schwarz	100609	2016-04	2019-04
2.20	3160-10	Standard Gain / Pyramidal Horn Antenna 40 GHz	EMCO Elektronik GmbH	00086675		
2.21	5HC3500/18000-1.2-KK	High Pass Filter	Trilithic	200035008		
2.22	Opus10 THI (8152.00)	ThermoHygro Datalogger 12 (Environ)	Lufft Mess- und Regeltechnik GmbH	12482	2017-03	2019-03
2.23	ESR 7	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz	101424	2019-01	2020-01
2.24	JS4-00101800-35-5P	Broadband Amplifier 30 MHz - 18 GHz	Miteq	896037		
2.25	AS 620 P	Antenna mast	HD GmbH	620/37		
2.26	Tilt device Maturo (Rohacell)	Antrieb TD1.5-10kg	Maturo GmbH	TD1.5-10kg/024/3790709		
2.27	PAS 2.5 - 10 kg	Antenna Mast	Maturo GmbH	-		
2.28	AM 4.0	Antenna mast	Maturo GmbH	AM4.0/180/11920513		
2.29	HF 907	Double-ridged horn	Rohde & Schwarz	102444	2018-07	2021-07

3 FCC Conducted Base Station / Repeater
EN300328/301893/FCC cond. Test Lab

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
3.1	FSV40	Signal Analyzer 10 Hz - 40 GHz	Rohde & Schwarz	100886	2018-10	2019-10
3.2	SMBV100A	Vector Signal Generator 9 kHz - 6 GHz	Rohde & Schwarz	255975	2017-08	2019-08
3.3	SMIQ	Vector Signal Generator 9 kHz – 3.3 GHz	Rohde & Schwarz	831389/062	2018-10	2020-10

The calibration interval is the time interval between “Last Calibration” and “Calibration Due”

6 ANTENNA FACTORS, CABLE LOSS AND SAMPLE CALCULATIONS

This chapter contains the antenna factors with their corresponding path loss of the used measurement path for all antennas as well as the insertion loss of the LISN.

6.1 LISN R&S ESH3-Z5 (150 KHZ – 30 MHZ)

Frequency		Corr.	LISN insertion loss ESH3- Z5	cable loss (incl. 10 dB atten- uator)
MHz		dB	dB	dB
0.15		10.1	0.1	10.0
5		10.3	0.1	10.2
7		10.5	0.2	10.3
10		10.5	0.2	10.3
12		10.7	0.3	10.4
14		10.7	0.3	10.4
16		10.8	0.4	10.4
18		10.9	0.4	10.5
20		10.9	0.4	10.5
22		11.1	0.5	10.6
24		11.1	0.5	10.6
26		11.2	0.5	10.7
28		11.2	0.5	10.7
30		11.3	0.5	10.8

Sample calculation

$$U_{\text{LISN}} (\text{dB } \mu\text{V}) = U (\text{dB } \mu\text{V}) + \text{Corr. (dB)}$$

U = Receiver reading

LISN Insertion loss = Voltage Division Factor of LISN

Corr. = sum of single correction factors of used LISN, cables, switch units (if used)

Linear interpolation will be used for frequencies in between the values in the table.

6.2 ANTENNA R&S HFH2-Z2 (9 KHZ – 30 MHZ)

Frequency	AF HFH-Z2)	Corr.	cable loss 1 (inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit)	cable loss 4 (to receiver)	distance corr. (-40 dB/ decade)	d _{Limit} (meas. distance (limit))	d _{used} (meas. distance (used))
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	m	m
0.009	20.50	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.01	20.45	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.015	20.37	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.02	20.36	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.025	20.38	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.03	20.32	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.05	20.35	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.08	20.30	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.1	20.20	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.2	20.17	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.3	20.14	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.49	20.12	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.490001	20.12	-39.6	0.1	0.1	0.1	0.1	-40	30	3
0.5	20.11	-39.6	0.1	0.1	0.1	0.1	-40	30	3
0.8	20.10	-39.6	0.1	0.1	0.1	0.1	-40	30	3
1	20.09	-39.6	0.1	0.1	0.1	0.1	-40	30	3
2	20.08	-39.6	0.1	0.1	0.1	0.1	-40	30	3
3	20.06	-39.6	0.1	0.1	0.1	0.1	-40	30	3
4	20.05	-39.5	0.2	0.1	0.1	0.1	-40	30	3
5	20.05	-39.5	0.2	0.1	0.1	0.1	-40	30	3
6	20.02	-39.5	0.2	0.1	0.1	0.1	-40	30	3
8	19.95	-39.5	0.2	0.1	0.1	0.1	-40	30	3
10	19.83	-39.4	0.2	0.1	0.2	0.1	-40	30	3
12	19.71	-39.4	0.2	0.1	0.2	0.1	-40	30	3
14	19.54	-39.4	0.2	0.1	0.2	0.1	-40	30	3
16	19.53	-39.3	0.3	0.1	0.2	0.1	-40	30	3
18	19.50	-39.3	0.3	0.1	0.2	0.1	-40	30	3
20	19.57	-39.3	0.3	0.1	0.2	0.1	-40	30	3
22	19.61	-39.3	0.3	0.1	0.2	0.1	-40	30	3
24	19.61	-39.3	0.3	0.1	0.2	0.1	-40	30	3
26	19.54	-39.3	0.3	0.1	0.2	0.1	-40	30	3
28	19.46	-39.2	0.3	0.1	0.3	0.1	-40	30	3
30	19.73	-39.1	0.4	0.1	0.3	0.1	-40	30	3

Sample calculation

$E \text{ (dB } \mu\text{V/m)} = U \text{ (dB } \mu\text{V)} + AF \text{ (dB 1/m)} + Corr. \text{ (dB)}$

U = Receiver reading

AF = Antenna factor

Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)

distance correction = $-40 * \text{LOG} (d_{\text{Limit}} / d_{\text{used}})$

Linear interpolation will be used for frequencies in between the values in the table.

Table shows an extract of values

6.3 ANTENNA R&S HL562 (30 MHz – 1 GHz)

($d_{\text{Limit}} = 3 \text{ m}$)

Frequency	AF R&S HL562	Corr.
MHz	dB (1/m)	dB
30	18.6	0.6
50	6.0	0.9
100	9.7	1.2
150	7.9	1.6
200	7.6	1.9
250	9.5	2.1
300	11.0	2.3
350	12.4	2.6
400	13.6	2.9
450	14.7	3.1
500	15.6	3.2
550	16.3	3.5
600	17.2	3.5
650	18.1	3.6
700	18.5	3.6
750	19.1	4.1
800	19.6	4.1
850	20.1	4.4
900	20.8	4.7
950	21.1	4.8
1000	21.6	4.9

cable loss 1 (inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit)	cable loss 4 (to receiver)	distance corr. (-20 dB/ decade)	d_{Limit} (meas. distance (limit))	d_{used} (meas. distance (used))
dB	dB	dB	dB	dB	m	m
0.29	0.04	0.23	0.02	0.0	3	3
0.39	0.09	0.32	0.08	0.0	3	3
0.56	0.14	0.47	0.08	0.0	3	3
0.73	0.20	0.59	0.12	0.0	3	3
0.84	0.21	0.70	0.11	0.0	3	3
0.98	0.24	0.80	0.13	0.0	3	3
1.04	0.26	0.89	0.15	0.0	3	3
1.18	0.31	0.96	0.13	0.0	3	3
1.28	0.35	1.03	0.19	0.0	3	3
1.39	0.38	1.11	0.22	0.0	3	3
1.44	0.39	1.20	0.19	0.0	3	3
1.55	0.46	1.24	0.23	0.0	3	3
1.59	0.43	1.29	0.23	0.0	3	3
1.67	0.34	1.35	0.22	0.0	3	3
1.67	0.42	1.41	0.15	0.0	3	3
1.87	0.54	1.46	0.25	0.0	3	3
1.90	0.46	1.51	0.25	0.0	3	3
1.99	0.60	1.56	0.27	0.0	3	3
2.14	0.60	1.63	0.29	0.0	3	3
2.22	0.60	1.66	0.33	0.0	3	3
2.23	0.61	1.71	0.30	0.0	3	3

($d_{\text{Limit}} = 10 \text{ m}$)

30	18.6	-9.9
50	6.0	-9.6
100	9.7	-9.2
150	7.9	-8.8
200	7.6	-8.6
250	9.5	-8.3
300	11.0	-8.1
350	12.4	-7.9
400	13.6	-7.6
450	14.7	-7.4
500	15.6	-7.2
550	16.3	-7.0
600	17.2	-6.9
650	18.1	-6.9
700	18.5	-6.8
750	19.1	-6.3
800	19.6	-6.3
850	20.1	-6.0
900	20.8	-5.8
950	21.1	-5.6
1000	21.6	-5.6

0.29	0.04	0.23	0.02	-10.5	10	3
0.39	0.09	0.32	0.08	-10.5	10	3
0.56	0.14	0.47	0.08	-10.5	10	3
0.73	0.20	0.59	0.12	-10.5	10	3
0.84	0.21	0.70	0.11	-10.5	10	3
0.98	0.24	0.80	0.13	-10.5	10	3
1.04	0.26	0.89	0.15	-10.5	10	3
1.18	0.31	0.96	0.13	-10.5	10	3
1.28	0.35	1.03	0.19	-10.5	10	3
1.39	0.38	1.11	0.22	-10.5	10	3
1.44	0.39	1.20	0.19	-10.5	10	3
1.55	0.46	1.24	0.23	-10.5	10	3
1.59	0.43	1.29	0.23	-10.5	10	3
1.67	0.34	1.35	0.22	-10.5	10	3
1.67	0.42	1.41	0.15	-10.5	10	3
1.87	0.54	1.46	0.25	-10.5	10	3
1.90	0.46	1.51	0.25	-10.5	10	3
1.99	0.60	1.56	0.27	-10.5	10	3
2.14	0.60	1.63	0.29	-10.5	10	3
2.22	0.60	1.66	0.33	-10.5	10	3
2.23	0.61	1.71	0.30	-10.5	10	3

Sample calculation

$E \text{ (dB } \mu\text{V/m)} = U \text{ (dB } \mu\text{V)} + \text{AF (dB 1/m)} + \text{Corr. (dB)}$
 U = Receiver reading
 AF = Antenna factor
 Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
 $\text{distance correction} = -20 * \text{LOG} (d_{\text{Limit}} / d_{\text{used}})$
 Linear interpolation will be used for frequencies in between the values in the table.
 Tables show an extract of values.

6.4 ANTENNA R&S HF907 (1 GHZ – 18 GHZ)

Frequency	AF R&S HF907	Corr.
MHz	dB (1/m)	dB
1000	24.4	-19.4
2000	28.5	-17.4
3000	31.0	-16.1
4000	33.1	-14.7
5000	34.4	-13.7
6000	34.7	-12.7
7000	35.6	-11.0

cable loss 1 (relay + cable inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit, atten- uator & pre-amp)	cable loss 4 (to receiver)		
dB	dB	dB	dB		
0.99	0.31	-21.51	0.79		
1.44	0.44	-20.63	1.38		
1.87	0.53	-19.85	1.33		
2.41	0.67	-19.13	1.31		
2.78	0.86	-18.71	1.40		
2.74	0.90	-17.83	1.47		
2.82	0.86	-16.19	1.46		

Frequency	AF R&S HF907	Corr.
MHz	dB (1/m)	dB
3000	31.0	-23.4
4000	33.1	-23.3
5000	34.4	-21.7
6000	34.7	-21.2
7000	35.6	-19.8

cable loss 1 (relay inside chamber)	cable loss 2 (inside chamber)	cable loss 3 (outside chamber)	cable loss 4 (switch unit, atten- uator & pre-amp)	cable loss 5 (to receiver)	used for FCC 15.247
dB	dB	dB	dB	dB	
0.47	1.87	0.53	-27.58	1.33	
0.56	2.41	0.67	-28.23	1.31	
0.61	2.78	0.86	-27.35	1.40	
0.58	2.74	0.90	-26.89	1.47	
0.66	2.82	0.86	-25.58	1.46	

Frequency	AF R&S HF907	Corr.
MHz	dB (1/m)	dB
7000	35.6	-57.3
8000	36.3	-56.3
9000	37.1	-55.3
10000	37.5	-56.2
11000	37.5	-55.3
12000	37.6	-53.7
13000	38.2	-53.5
14000	39.9	-56.3
15000	40.9	-54.1
16000	41.3	-54.1
17000	42.8	-54.4
18000	44.2	-54.7

cable loss 1 (relay inside chamber)	cable loss 2 (High Pass)	cable loss 3 (pre- amp)	cable loss 4 (inside chamber)	cable loss 5 (outside chamber)	cable loss 6 (to receiver)
dB	dB	dB	dB	dB	dB
0.56	1.28	-62.72	2.66	0.94	1.46
0.69	0.71	-61.49	2.84	1.00	1.53
0.68	0.65	-60.80	3.06	1.09	1.60
0.70	0.54	-61.91	3.28	1.20	1.67
0.80	0.61	-61.40	3.43	1.27	1.70
0.84	0.42	-59.70	3.53	1.26	1.73
0.83	0.44	-59.81	3.75	1.32	1.83
0.91	0.53	-63.03	3.91	1.40	1.77
0.98	0.54	-61.05	4.02	1.44	1.83
1.23	0.49	-61.51	4.17	1.51	1.85
1.36	0.76	-62.36	4.34	1.53	2.00
1.70	0.53	-62.88	4.41	1.55	1.91

Sample calculation

$$E \text{ (dB } \mu\text{V/m)} = U \text{ (dB } \mu\text{V)} + AF \text{ (dB 1/m)} + Corr. \text{ (dB)}$$

U = Receiver reading

AF = Antenna factor

Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)

Linear interpolation will be used for frequencies in between the values in the table.

Tables show an extract of values.

6.5 ANTENNA EMCO 3160-09 (18 GHZ – 26.5 GHZ)

Frequency	AF EMCO 3160-09	Corr.	cable loss 1 (inside chamber)	cable loss 2 (pre- amp)	cable loss 3 (inside chamber)	cable loss 4 (switch unit)	cable loss 5 (to receiver)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB
18000	40.2	-23.5	0.72	-35.85	6.20	2.81	2.65
18500	40.2	-23.2	0.69	-35.71	6.46	2.76	2.59
19000	40.2	-22.0	0.76	-35.44	6.69	3.15	2.79
19500	40.3	-21.3	0.74	-35.07	7.04	3.11	2.91
20000	40.3	-20.3	0.72	-34.49	7.30	3.07	3.05
20500	40.3	-19.9	0.78	-34.46	7.48	3.12	3.15
21000	40.3	-19.1	0.87	-34.07	7.61	3.20	3.33
21500	40.3	-19.1	0.90	-33.96	7.47	3.28	3.19
22000	40.3	-18.7	0.89	-33.57	7.34	3.35	3.28
22500	40.4	-19.0	0.87	-33.66	7.06	3.75	2.94
23000	40.4	-19.5	0.88	-33.75	6.92	3.77	2.70
23500	40.4	-19.3	0.90	-33.35	6.99	3.52	2.66
24000	40.4	-19.8	0.88	-33.99	6.88	3.88	2.58
24500	40.4	-19.5	0.91	-33.89	7.01	3.93	2.51
25000	40.4	-19.3	0.88	-33.00	6.72	3.96	2.14
25500	40.5	-20.4	0.89	-34.07	6.90	3.66	2.22
26000	40.5	-21.3	0.86	-35.11	7.02	3.69	2.28
26500	40.5	-21.1	0.90	-35.20	7.15	3.91	2.36

Sample calculation

$E \text{ (dB } \mu\text{V/m)} = U \text{ (dB } \mu\text{V)} + AF \text{ (dB 1/m)} + Corr. \text{ (dB)}$

U = Receiver reading

AF = Antenna factor

Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)

Linear interpolation will be used for frequencies in between the values in the table.

Table shows an extract of values.

6.6 ANTENNA EMCO 3160-10 (26.5 GHZ – 40 GHZ)

Frequency	AF EMCO 3160-10	Corr.	cable loss 1 (inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit)	cable loss 4 (to receiver)	distance corr. (-20 dB/ decade)	d _{Limit} (meas. distance (limit)	d _{used} (meas. distance (used)
GHz	dB (1/m)	dB	dB	dB	dB	dB	dB	m	m
26.5	43.4	-11.2	4.4				-15.6	3	0.5
27.0	43.4	-11.2	4.4				-15.6	3	0.5
28.0	43.4	-11.1	4.5				-15.6	3	0.5
29.0	43.5	-11.0	4.6				-15.6	3	0.5
30.0	43.5	-10.9	4.7				-15.6	3	0.5
31.0	43.5	-10.8	4.7				-15.6	3	0.5
32.0	43.5	-10.7	4.8				-15.6	3	0.5
33.0	43.6	-10.7	4.9				-15.6	3	0.5
34.0	43.6	-10.6	5.0				-15.6	3	0.5
35.0	43.6	-10.5	5.1				-15.6	3	0.5
36.0	43.6	-10.4	5.1				-15.6	3	0.5
37.0	43.7	-10.3	5.2				-15.6	3	0.5
38.0	43.7	-10.2	5.3				-15.6	3	0.5
39.0	43.7	-10.2	5.4				-15.6	3	0.5
40.0	43.8	-10.1	5.5				-15.6	3	0.5

Sample calculation

$E \text{ (dB } \mu\text{V/m)} = U \text{ (dB } \mu\text{V)} + AF \text{ (dB 1/m)} + Corr. \text{ (dB)}$

U = Receiver reading

AF = Antenna factor

Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)

Linear interpolation will be used for frequencies in between the values in the table.

distance correction = $-20 * \text{LOG} (d_{\text{Limit}} / d_{\text{used}})$

Linear interpolation will be used for frequencies in between the values in the table.

Table shows an extract of values.

7 MEASUREMENT UNCERTAINTIES

Test Case(s)	Parameter	Uncertainty
- Field strength of spurious radiation	Power	± 5.5 dB
- Out-of-band rejection - Occupied Bandwidth - Input versus output spectrum	Power Frequency	± 2.9 dB ± 11.2 kHz
- Effective radiated power, mean output power and zone enhancer gain - Peak to Average Ratio	Power	± 2.2 dB
- Out-of-band emission limits - Conducted Spurious Emissions at Antenna Terminal	Power Frequency	± 2.2 dB ± 11.2 kHz

8 PHOTO REPORT

Please see separate photo report.