

EMI – TEST REPORT

- FCC Part 15.247, RSS247 -

Type / Model Name : HRA 551 FS

Product Description : Wireless Access point for hand wheel system

Applicant : DR. JOHANNES HEIDENHAIN GmbH

Address : Dr.-Johannes-Heidenhain-Strasse 5

83301 TRAUNREUT, GERMANY

Manufacturer : DR. JOHANNES HEIDENHAIN GmbH

Address : Dr.-Johannes-Heidenhain-Strasse 5

83301 TRAUNREUT, GERMANY

Licence holder : DR. JOHANNES HEIDENHAIN GmbH

Address : Dr.-Johannes-Heidenhain-Strasse 5

83301 TRAUNREUT, GERMANY

Test Result according to the standards
listed in clause 1 test standards:

POSITIVE

Test Report No. : **T38868-03-03HS**

22. March 2018

Date of issue



Deutsche
Akkreditierungsstelle
D-PL-12030-01-01
D-PL-12030-01-02

The test report merely corresponds to the test sample.
It is not permitted to copy extracts of these test results
without the written permission of the test laboratory.

Contents

1	<u>TEST STANDARDS</u>	3
2	<u>EQUIPMENT UNDER TEST</u>	4
2.1	Photo documentation of the EUT – Detailed photos see ATTACHMENT B	4
2.2	Equipment type	4
1.1	Short description of the equipment under test (EUT)	4
2.3	Variants of the EUT	4
2.4	Operation frequency and channel plan	4
2.5	Transmit operating modes	5
2.6	Antenna	5
2.7	Power supply system utilised	5
2.8	Peripheral devices and interface cables	5
2.9	Determination of worst case conditions for final measurement	5
3	<u>TEST RESULT SUMMARY</u>	7
3.1	Final assessment	7
4	<u>TEST ENVIRONMENT</u>	8
4.1	Address of the test laboratory	8
4.2	Environmental conditions	8
4.3	Statement of the measurement uncertainty	9
4.4	Measurement protocol for FCC and ISSED	10
5	<u>TEST CONDITIONS AND RESULTS</u>	12
5.1	AC power line conducted emissions	12
5.2	EBW and OBW	16
5.3	Maximum peak conducted output power	19
5.4	Power spectral density	21
5.5	Unwanted emissions	23
5.6	Unwanted emissions in restricted bands, radiated	24
5.7	Band edge compliance	30
5.8	Antenna application	31
6	<u>USED TEST EQUIPMENT AND ACCESSORIES</u>	32

ATTACHMENT B as separate supplement

ATTACHMENT B1 as separate supplement

1 TEST STANDARDS

The tests were performed according to following standards:

FCC Rules and Regulations Part 15, Subpart A - General (September 2016)

Part 15, Subpart A, Section 15.31	Measurement standards
Part 15, Subpart A, Section 15.33	Frequency range of radiated measurements
Part 15, Subpart A, Section 15.35	Measurement detector functions and bandwidths

FCC Rules and Regulations Part 15, Subpart C - Intentional Radiators (September 2016)

Part 15, Subpart C, Section 15.203	Antenna requirement
Part 15, Subpart C, Section 15.204	External radio frequency power amplifiers and antenna modifications
Part 15, Subpart C, Section 15.205	Restricted bands of operation
Part 15, Subpart C, Section 15.207	Conducted limits
Part 15, Subpart C, Section 15.209	Radiated emission limits, general requirements
Part 15, Subpart C, Section 15.247	Operation within the bands 902 - 928 MHz, 2400 - 2483.5 MHz and 5725 - 5850 MHz

ANSI C63.10: 2013	Testing Unlicensed Wireless Devices
ETSI TR 100 028 V1.3.1: 2001-03	Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Uncertainties in the Measurement of Mobile Radio Equipment Characteristics—Part 1 and Part 2
KDB 558074 D01 v04	Guidance for performing compliance measurements on DTS operating under §15.247, April 5, 2017.

2 EQUIPMENT UNDER TEST

2.1 Photo documentation of the EUT – Detailed photos see ATTACHMENT B

2.2 Equipment type

ZigBee device

1.1 Short description of the equipment under test (EUT)

The EUT consists of a mobile wireless controller, hand wheel, and the access point (base station), as interface between mobile controller and CNC machine. The access point is also able to recharge the mobile controller.

Number of tested samples: 1 HRA 551 FS.
 Serial number: HRA 551 FS, X 58 241 190,
 Firmware Channel A: 1199870-01; Channel B: 1199896-01

EUT configuration:

(The CDF filled by the applicant can be viewed at the test laboratory.)

2.3 Variants of the EUT

Device-Name	Comment	Antenna	Part number
HRA 551 FS	Base station, with rear panel	2 Integrated F	1119052-03

2.4 Operation frequency and channel plan

The operating frequency is 2400 MHz to 2483.5 MHz.

Channel plan:

Channel	Frequency	Channel	Frequency
11	2405	19	2445
12	2410	20	2450
13	2415	21	2455
14	2420	22	2460
15	2425	23	2465
16	2430	24	2470
17	2435	25	2475
18	2440	26	2480

Note: The marked frequencies are used for testing.

2.5 Transmit operating modes

The EUT allows the user to switch the transmission on or off. There are no further operating modes.

The EUT use O-QPSK modulation and may provide following data rate:

- 250 kbps (kbps = *kilobits per second*)

2.6 Antenna

The EUT use two integrated PCB-F-antennas.

2.7 Power supply system utilised

Power supply voltage, V_{nom} : Power type, HRA 551 FS, Supplied by the appropriate controller unit

2.8 Peripheral devices and interface cables

The following peripheral devices and interface cables are connected during the measurements:

- Control PC Model : MC8410, No 7781859
- Signal and DC power supply, 2.5 m Model :
- Model :

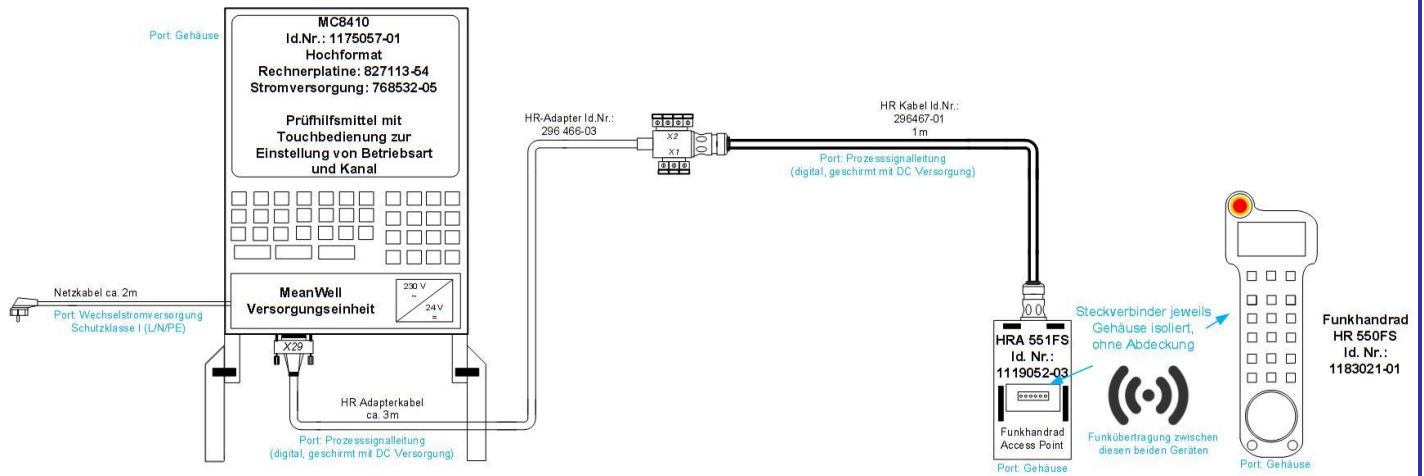
2.9 Determination of worst case conditions for final measurement

The EUT is tested as system, normal transmission is initiated.

IEEE Standard	Available channel	Tested channels	Power setting	Modulation	Modulation type	Data rate
802.15.4	11 to 26	11, 18, 26	Pmax	DSSS	O-QPSK	250 kbps

Note: The 802.15.4 is only used physically. No other common device may connect to.

Schematic test set-up



2.9.1 Test jig

No test jig was used for testing.

2.9.2 Test software

For testing the normal communication is set up between base station and the portable remote.

3 TEST RESULT SUMMARY

IEEE 802.15.4 device using digital modulation:

Operating in the 2400 MHz – 2483.5 MHz:

FCC Rule Part	RSS Rule Part	Description	Result
15.207(a)	RSS Gen, 8.8	AC power line conducted emissions	passed
15.247(a)(2)	RSS247, 5.2(1)	-6 dB EBW	passed
15.247(b)(3)	RSS247, 5.4(4)	Maximum peak conducted output power	passed
15.247(b)(4)	RSS247, 5.4(4)	Defacto limit	passed
15.247(d)	RSS247, 5.5	Unwanted emission, radiated	Not tested
15.247(d)	RSS-Gen, 8.10	Emissions in restricted bands	passed
15.247(e)	RSS247, 5.2(2)	PSD	passed
15.35(c)	RSS-Gen, 6.10	Pulsed operation	passed
15.247(b)(4)	-	Antenna requirement	passed
	RSS-Gen, 6.11	Transmitter frequency stability	Not tested
	RSS-Gen, 6.6	99 % Bandwidth	passed

The mentioned RSS Rule Parts in the above table are related to:
 RSS Gen, Issue 4, November 2014
 RSS 247, Issue 2, February 2017

3.1 Final assessment

The equipment under test fulfills the EMI requirements cited in clause 1 test standards.

Date of receipt of test sample : acc. to storage records

Testing commenced on : 28 June 2017

Testing concluded on : 03 August 2017

Checked by:



Klaus Gegenfurtner
 I confirm the correctness
 and integrity of this
 document.
 2018.06.05 09:44:19
 +02'00'

Klaus Gegenfurtner
 Teamleader Radio

Tested by:



Hermann Smetana
 I am the author of
 this document.
 2018.03.22 10:34:41
 +01'00'

Hermann Smetana
 Radio Team

4 TEST ENVIRONMENT

4.1 Address of the test laboratory

CSA Group Bayern GmbH
Ohmstrasse 1-4
94342 STRASSKIRCHEN
GERMANY

4.2 Environmental conditions

During the measurement the environmental conditions were within the listed ranges:

Temperature: 15-35 °C

Humidity: 30-60 %

Atmospheric pressure: 86-106 kPa

4.3 Statement of the measurement uncertainty

The data and results referenced in this document are true and accurate. It is noted that the expanded measurement uncertainty corresponds to the measurement results from the standard measurement uncertainty multiplied by the coverage factor $k = 2$. The true value is located in the corresponding interval with a probability of 95 %. The measurement uncertainty was calculated for all measurements listed in this test report acc. to CISPR 16-4-2 / 11.2003 „Uncertainties, statistics and limit modelling – Uncertainty in EMC measurements“ and is documented in the quality system acc. to DIN EN ISO/IEC 17025. For all measurements shown in this report, the measurement uncertainty of the test laboratory, CSA Group Bayern GmbH, is below the measurement uncertainty as defined by CISPR. Therefore, no special measures must be taken into consideration with regard to the limits according to CISPR. Furthermore, component and process variability of devices similar to that tested may result in additional deviation. The manufacturer has the sole responsibility of continued compliance of the device.

Measurement Type	Range	Confidence Level	Calculated Uncertainty
AC power line conducted emissions	0.15 MHz to 30 MHz	95%	± 3.29 dB
EBW and OBW	2400 MHz to 3000 MHz	95%	$\pm 2.5 \times 10^{-7}$
Maximum peak conducted output power	2400 MHz to 3000 MHz	95%	± 0.62 dB
Power spectral density	2400 MHz to 3000 MHz	95%	± 0.62 dB
Conducted Spurious Emissions	9 kHz to 10000 MHz	95%	± 2.15 dB
Conducted Spurious Emissions	10000 MHz to 40000 MHz	95%	± 3.47 dB
Radiated Spurious Emissions	9 kHz to 30 MHz	95%	± 3.53 dB
Radiated Spurious Emissions	30 MHz to 1000 MHz	95%	± 3.71 dB
Radiated Spurious Emissions	1000 MHz to 10000 MHz	95%	± 2.34 dB
Field strength of the fundamental	100 kHz to 100 MHz	95%	± 3.53 dB

4.4 Measurement protocol for FCC and ISED

4.4.1 General information

4.4.1.1 Test methodology

The Open Area test site is a listed Open Site under the Canadian Test-Sites File-No:

IC 3009A-1

The Anechoic chamber is a listed test site under the Canadian Test-Sites File-No:

IC 3009A-2

In compliance with RSS 247 testing for RSS compliance may be achieved by following the procedures set out in ANSI C63.10 and applying the CISPR 22 limits.

4.4.1.2 Justification

The equipment under test (EUT) is configured in a typical user arrangement in accordance with the manufacturer's instructions. A cable is connected to each available port and either terminated with a peripheral using the appropriate impedance characteristic or left unterminated. Where appropriate, cables are manually manipulated with respect to each other thus obtaining maximum disturbances from the unit.

4.4.1.3 General Standard information

In compliance with 47 CFR Part 15 Subpart A, Section 15.38 testing for FCC compliance may be achieved by following the procedures set out in ANSI C63.10 and applying the CISPR 22 limits.

4.4.1.3.1 Radiated emission (electrical field 30 MHz - 1 GHz)

Description of measurement

Spurious emissions from the EUT are measured in the frequency range of 30 MHz to 1000 MHz using a tuned receiver and appropriate broadband linearly polarised antennas. Measurements between 30 MHz and 1000 MHz are made with 120 kHz/6 dB bandwidth and quasi-peak detection. Table top equipment is placed on a 1.0 X 1.5 m non-conducting table 80 centimetres above the ground plane. Floor standing equipment is placed directly on the turntable/ground plane. The setup of the equipment under test is established in accordance with ANSI C63.10. The interface cables that are closer than 40 centimetres to the ground plane are bundled in the center in a serpentine fashion so that they are at least 40 centimetres from the ground plane. Cables to simulators/testers (if used in this test) are routed through the center of the table and to a screened room located outside the test area. The antenna is positioned 3, 10 or 30 metres horizontally from the EUT and is repeated vertically. To locate maximum emissions from the test sample the antenna is varied in height from 1 to 4 metres and the EUT is rotated 360 degrees.

The final level in dBμV/m is calculated by taking the reading from the EMI receiver (Level dBμV) and adding the correction factors and cable loss factor (dB). The FCC or CISPR limit is subtracted from this result in order to provide the limit margin listed in the measurement protocol.

The resolution bandwidth setting:

30 MHz – 1000 MHz: RBW: 120 kHz

Example:

Frequency	Level	+	Factor	=	Level	-	CISPR Limit	=
Delta								
(MHz)	(dBμV)		(dB)		(dBμV/m)		(dBμV/m)	(dB)
719.0	75.0	+	32.6	=	107.6	-	110.0	= -2.4

4.4.1.3.2 Radiated emission (electrical field 1 GHz - 40 GHz)Description of measurement

Radiated emissions from the EUT are measured in the frequency range 1 GHz up to the maximum frequency as specified in 47 CFR Part 15, Subpart A, Section 15.33, using a spectrum analyser and appropriate linearly polarized antennas. Table top equipment is placed on a 1.0 X 1.5 metre non-conducting table, 1.5 metre above the ground plane. Floor standing equipment is placed directly on the turntable/ground plane. The setup of the equipment under test is following set out in ANSI C63.10. The interface cables that are closer than 40 centimetres to the ground plane are bundled in the center in a serpentine fashion so they are at least 40 centimetres from the ground plane. Cables to simulators/testers (if used in this test) are routed through the center of the table and to a screened room located outside the test area. Measurements are made in both the horizontal and vertical polarization planes in a fully anechoic room using a spectrum analyzer set to max peak detector function and a resolution 1 MHz and video bandwidth 3 MHz for peak measurement. The conditions determined as worst case will then be used for the final measurements. When the EUT is larger than the beam width of the measuring antenna it will be moved over the surface for the four sides of the equipment. Where appropriate, the test distance may be reduced in order to detect emissions under better uncertainty and are calculated at the specified test distance.

5 TEST CONDITIONS AND RESULTS

5.1 AC power line conducted emissions

For test instruments and accessories used see section 6 Part A 4.

5.1.1 Description of the test location

Test location: Shielded Room S2

5.1.2 Photo documentation of the test set-up – Detailed photos see ATTACHMENT B1

5.1.3 Applicable standard

According to FCC Part 15, Section 15.207(a):

Except as shown in paragraphs (b) and (c) of this Section, 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 given limits.

5.1.4 Description of Measurement

The measurements are performed following the procedures set out in ANSI C63.10 described under item 4.4.3. If the minimum limit margin appears to be less than 20 dB with a peak mode measurement, the emissions are re-measured using a tuned receiver with quasi-peak and average detection and recorded on the data sheets.

5.1.5 Test result

Frequency range: 0.15 MHz - 30 MHz

Min. limit margin 5.2 dB at 12.476 MHz

Limit according to FCC Part 15, Section 15.207(a):

Frequency of Emission (MHz)	Conducted Limit (dBµV)	
	Quasi-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

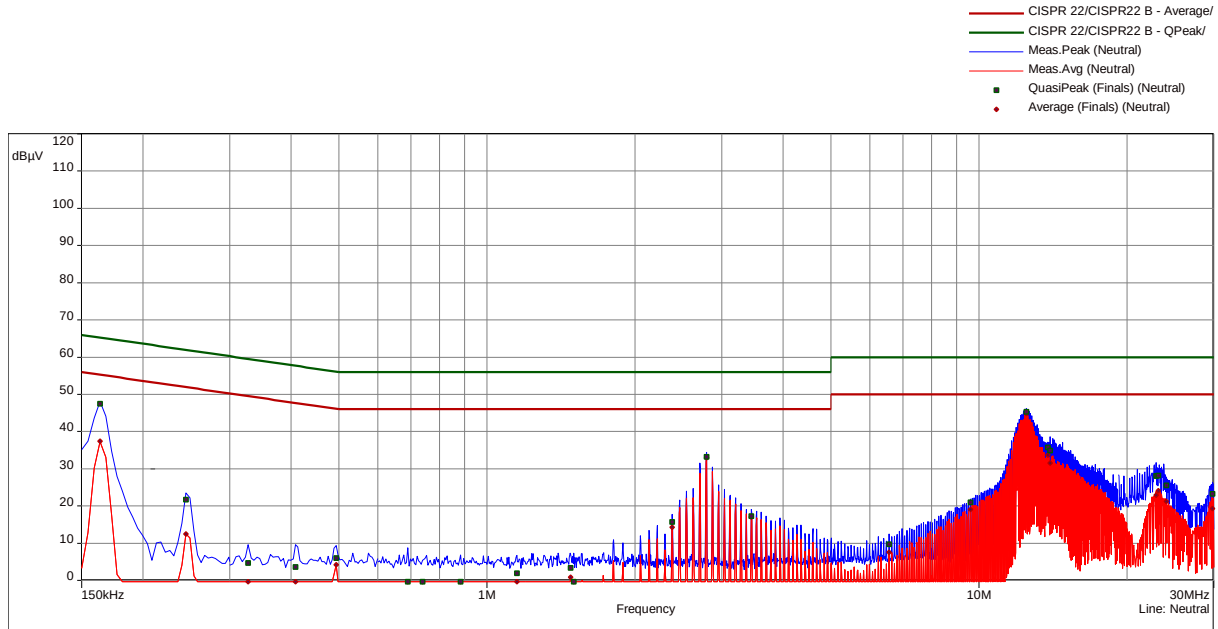
The requirements are **FULFILLED**.

Remarks: For detailed test result please refer to following test protocols

5.1.6 Test protocol

Test point L1
Operation mode: TX
Remarks:

Result: passed

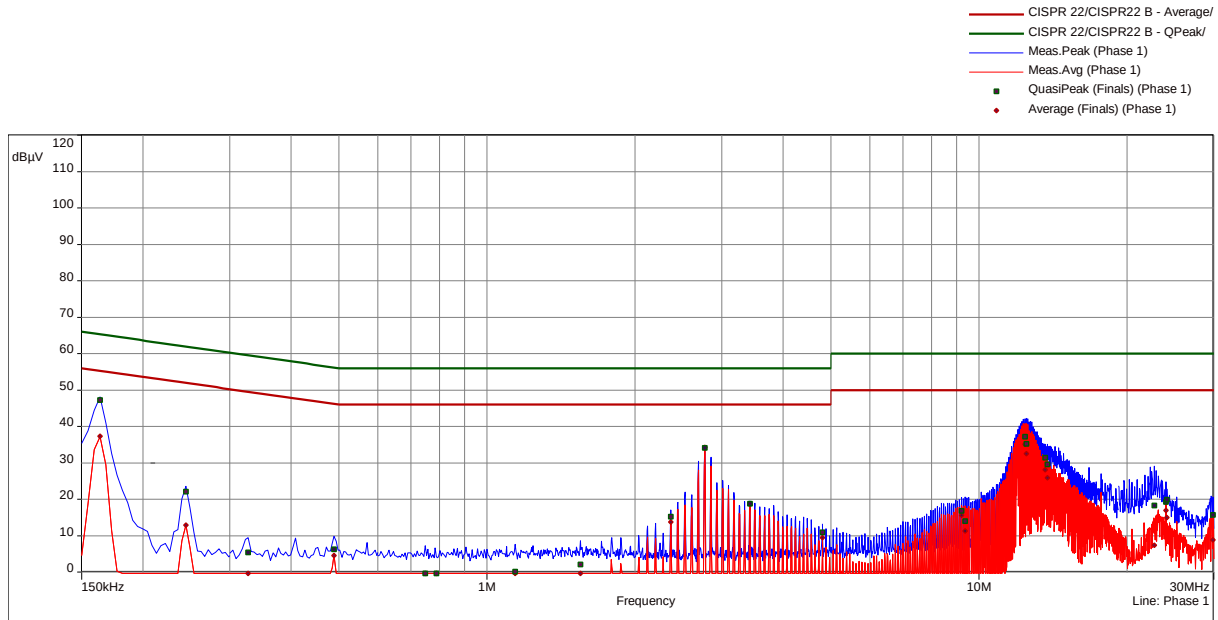


CISPR 22/CISPR22B

freq MHz	SR	QP dB(μV)	margin dB	limit dB	AV dB(μV)	margin dB	limit dB	line	corr dB
0.164	1	47.3	18.0	65.3	37.4	17.9	55.3	Phase 1	10.1
0.245	1	22.0	39.9	61.9	12.9	39.1	51.9	Phase 1	10.1
0.327	2	5.4	54.2	59.5	-0.7	50.3	49.5	Phase 1	10.1
0.489	2	6.2	50.0	56.2	4.6	41.6	46.2	Phase 1	10.2
0.749	3	-1.4	57.4	56.0	-4.4	50.4	46.0	Phase 1	10.2
0.789	3	-1.4	57.4	56.0	-4.4	50.4	46.0	Phase 1	10.2
1.140	3	0.1	55.9	56.0	-3.2	49.2	46.0	Phase 1	10.2
1.547	4	2.1	53.9	56.0	-0.9	46.9	46.0	Phase 1	10.3
2.361	4	15.3	40.7	56.0	13.7	32.3	46.0	Phase 1	10.3
2.769	5	34.1	21.9	56.0	34.2	11.8	46.0	Phase 1	10.4
3.422	5	18.8	37.2	56.0	18.7	27.3	46.0	Phase 1	10.4
4.805	6	10.9	45.1	56.0	9.5	36.5	46.0	Phase 1	10.5
9.206	6	16.9	43.1	60.0	15.5	34.5	50.0	Phase 1	10.8
9.368	6	14.0	46.0	60.0	11.3	38.7	50.0	Phase 1	10.8
12.390	7	37.2	22.8	60.0	35.1	14.9	50.0	Phase 1	11.0
12.471	7	35.2	24.8	60.0	32.5	17.5	50.0	Phase 1	11.0
13.614	7	31.5	28.5	60.0	28.1	21.9	50.0	Phase 1	11.1
13.776	7	29.6	30.4	60.0	25.9	24.1	50.0	Phase 1	11.1
22.719	8	18.3	41.7	60.0	7.4	42.6	50.0	Phase 1	11.6
24.002	8	19.3	40.7	60.0	17.0	33.0	50.0	Phase 1	11.6
24.065	8	19.9	40.1	60.0	15.0	35.1	50.0	Phase 1	11.6
29.856	8	15.7	44.3	60.0	8.9	41.1	50.0	Phase 1	11.6

Test point: N
Operation mode: TX
Remarks:

Result: passed



CISPR 22/CISPR22B

freq	SR	QP	margin	limit	AV	margin	limit	line	corr
MHz		dB(μV)	dB	dB	dB(μV)	dB	dB		dB
0.164	9	47.5	17.7	65.3	37.5	17.8	55.3	Neutral	10.1
0.245	9	21.7	40.3	61.9	12.5	39.5	51.9	Neutral	10.1
0.327	10	4.7	54.9	59.5	-1.3	50.9	49.5	Neutral	10.2
0.408	10	3.6	54.1	57.7	-1.8	49.5	47.7	Neutral	10.2
0.494	10	6.0	50.1	56.1	4.2	41.9	46.1	Neutral	10.2
0.690	11	-1.2	57.2	56.0	-4.3	50.3	46.0	Neutral	10.2
0.740	11	-0.2	56.2	56.0	-3.7	49.7	46.0	Neutral	10.2
0.884	11	-1.4	57.4	56.0	-4.4	50.4	46.0	Neutral	10.2
1.149	11	1.9	54.1	56.0	-1.3	47.3	46.0	Neutral	10.2
1.479	12	3.4	52.6	56.0	0.8	45.2	46.0	Neutral	10.3
1.502	12	-1.2	57.2	56.0	-4.2	50.2	46.0	Neutral	10.3
2.379	12	15.7	40.3	56.0	14.3	31.7	46.0	Neutral	10.3
2.792	13	33.2	22.8	56.0	33.0	13.0	46.0	Neutral	10.4
3.444	13	17.3	38.7	56.0	17.0	29.0	46.0	Neutral	10.4
6.564	14	9.7	50.3	60.0	7.6	42.4	50.0	Neutral	10.7
9.600	14	21.0	39.0	60.0	19.1	30.9	50.0	Neutral	10.9
12.476	15	45.4	14.6	60.0	44.8	5.2	50.0	Neutral	11.1
13.790	15	35.7	24.3	60.0	33.7	16.3	50.0	Neutral	11.3
13.956	15	34.9	25.1	60.0	31.6	18.4	50.0	Neutral	11.3
22.899	16	28.1	31.9	60.0	23.0	27.1	50.0	Neutral	11.9
23.147	16	28.2	31.8	60.0	24.1	25.9	50.0	Neutral	11.9
24.051	16	25.6	34.4	60.0	21.2	28.8	50.0	Neutral	11.9
29.793	16	23.2	36.8	60.0	19.3	30.7	50.0	Neutral	12.0

5.2 EBW and OBW

For test instruments and accessories used see section 6 Part **MB**.

5.2.1 Description of the test location

Test location: Anechoic chamber 1
Test distance: 3 m

5.2.2 Photo documentation of the test set-up – Detailed photos see ATTACHMENT B1

5.2.3 Applicable standard

According to FCC Part 15, Section 15.247(a)(2):

Systems using digital modulation techniques may operate in the 902 - 928 MHz, 2400 – 2483.5 MHz and 5725 – 5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

5.2.4 Description of Measurement

The bandwidth was measured at an amplitude level reduced from the reference level of a modulated channel by a ratio of -6 dB. The reference level is the level of the highest signal amplitude observed at the transmitter at either the fundamental frequency or the first order modulation products in all typical modes of operation, including the unmodulated carrier, even if atypical. An alternative is to use the bandwidth measurement of the analyser.

Spectrum analyser settings for EBW:

RBW: 100 kHz, VBW: 300 kHz, Detector: Max peak, Sweep time: 5 s, Span: 2 EBW;

Spectrum analyser settings for OBW:

RBW: 1-5% OBW, VBW: 3 RBW, Detector: Max peak, Sweep time: 5 s, Span: 2 OBW;

5.2.5 Test result

Channel	Centre frequency (MHz)	6 dB bandwidth (MHz)	Minimum limit (MHz)
11	2405	1.601	0.5
18	2440	1.601	0.5
26	2480	1.635	0.5

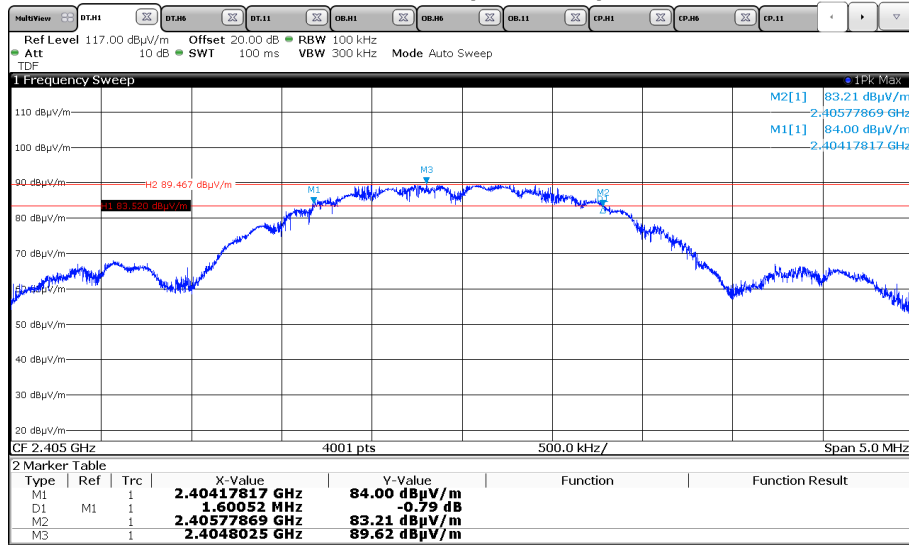
Channel	Centre frequency (MHz)	99 % bandwidth (MHz)
11	2405	2.419
18	2440	2.420
26	2480	2.428

The requirements are **FULFILLED**.

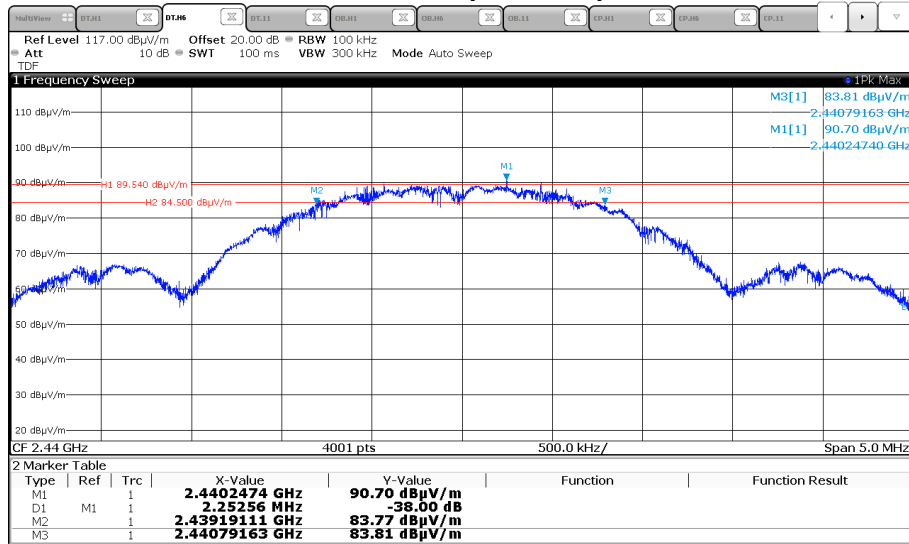
Remarks: For detailed test results please refer to following test protocols. The RSS Gen defines no limit for the occupied bandwidth!

5.2.6 Test protocols EBW

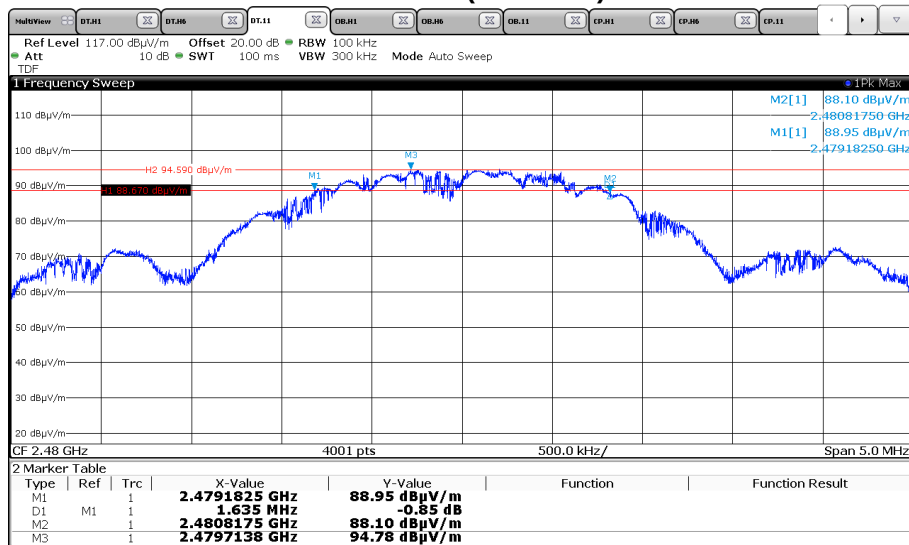
Channel 11 (2405 MHz)



Channel 18 (2440 MHz)

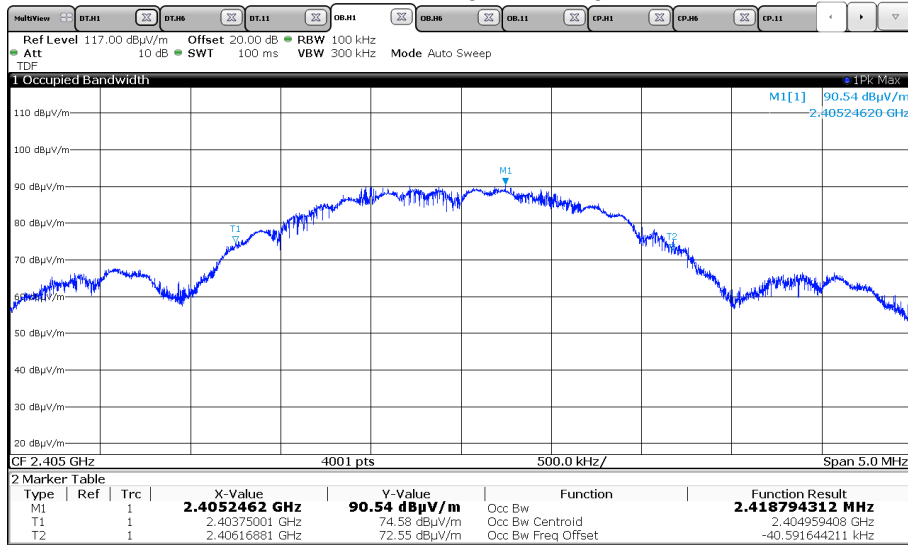


Channel 26 (2480 MHz)

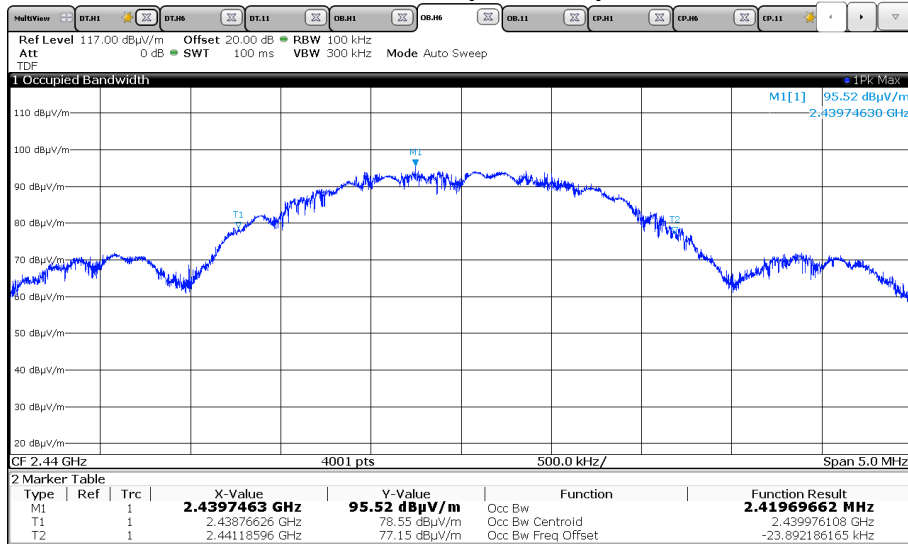


5.2.7 Test protocols OBW

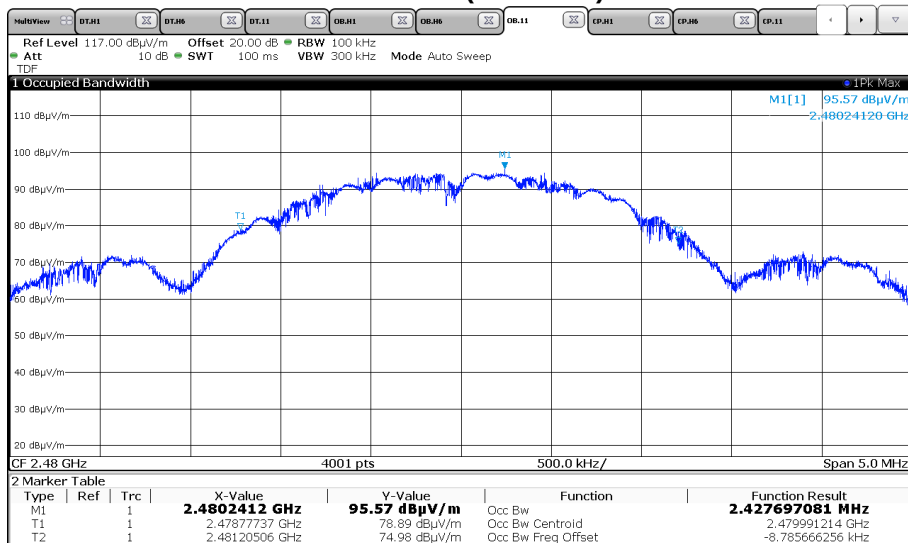
Channel 11 (2405 MHz)



Channel 18 (2440 MHz)



Channel 26 (2480 MHz)



5.3 Maximum peak conducted output power

For test instruments and accessories used see section 6 Part **CPR 3**.

5.3.1 Description of the test location

Test location: Anechoic chamber 1
Test distance: 3 m

5.3.2 Photo documentation of the test set-up – Detailed photos see ATTACHMENT B1

5.3.3 Applicable standard

According to FCC Part 15, Section 15.247(b)(3):

For systems using digital modulation in the 2400 – 2483.5 MHz and 5725 – 5850 MHz bands, the maximum peak output power of the transmitter shall not exceed 1 Watt. The limit is based on transmitting antennas of directional gain that do not exceed 6 dBi.

5.3.4 Description of Measurement

The maximum peak conducted output power is measured using a spectrum analyser following the procedure set out in KDB 558074, item 9.1.1. The EUT is set in TX continuous mode while measuring.

5.3.5 Test result

802.15.4, 250 kbps, TX		Test results radiated			
		Fieldstrength E (dBμV/m)	EIRP (dBm)	EIRP Limit (dBm)	Margin (dB)
Lowest frequency: CH11					
T_{nom}	V_{nom}	105.0	9.7	36.0	-26.3
Middle frequency: CH18					
T_{nom}	V_{nom}	103.4	8.1	36.0	-27.9
Highest frequency: CH26					
T_{nom}	V_{nom}	104.8	9.5	36.0	-26.5

802.15.4, 250 kbps, TX		Test results conducted				
		EIRP (dBm)	Antenna Gain (dBi)	A (dBm)	A Limit (dBm)	Margin (dB)
Lowest frequency: CH11						
T_{nom}	V_{nom}	9.7	3.1	6.6	30.0	-23.4
Middle frequency: CH18						
T_{nom}	V_{nom}	8.1	3.1	5.0	30.0	-25.0
Highest frequency: CH26						
T_{nom}	V_{nom}	9.5	3.1	6.4	30.0	-23.6

Note: The conducted values are calculated using the formula $A = EIRP - \text{Gain}$.

FCC ID: YJKHRAGACZ4**IC: 11148A-HRAGACZ4**

Peak Power Limit according to FCC Part 15, Section 15.247(b)(3):

Frequency (MHz)	Peak Power Limit	
	(dBm)	(Watt)
902-928	30	1.0
2400-2483.5	30	1.0
5725-5850	30	1.0

The requirements are **FULFILLED**.**Remarks:**

5.4 Power spectral density

For test instruments and accessories used see section 6 Part **CPR 3**.

5.4.1 Description of the test location

Test location: Anechoic chamber 1

Test distance: 3 m

5.4.2 Photo documentation of the test set-up – Detailed photos see ATTACHMENT B1

5.4.3 Applicable standard

According to FCC Part 15, Section 15.247(e):

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

5.4.4 Description of Measurement

The measurement is performed using the procedure 10.2 set out in KDB-558074. The power measurement was done as peak power measurement. Therefore the PKPSD is measured. The max peak was located and with the spectrum analyser and a marker set to peak.

Spectrum analyser settings:

RBW: 50 kHz, VBW: 200 kHz, Detector: Peak, Sweep time: 100 ms,

5.4.5 Test result

802.15.1, 1000 kbps, 1 TX		Test results PKPSD radiated			
		PSD [Pmax] (dBμV/m)	PSD [Pmax] (dBm/3kHz)	PSD Limit (dBm/3kHz)	Margin (dB)
Lowest frequency: 2405 MHz					
T_{nom}	V_{nom}	99.1	3.9	14.0	-10.1
Middle frequency: 2440 MHz					
T_{nom}	V_{nom}	94.9	-0.3	14.0	-14.3
Highest frequency: 2480 MHz					
T_{nom}	V_{nom}	97.9	2.7	14.0	-11.3

Power spectral density limit according to FCC Part 15, Section 15.247(e):

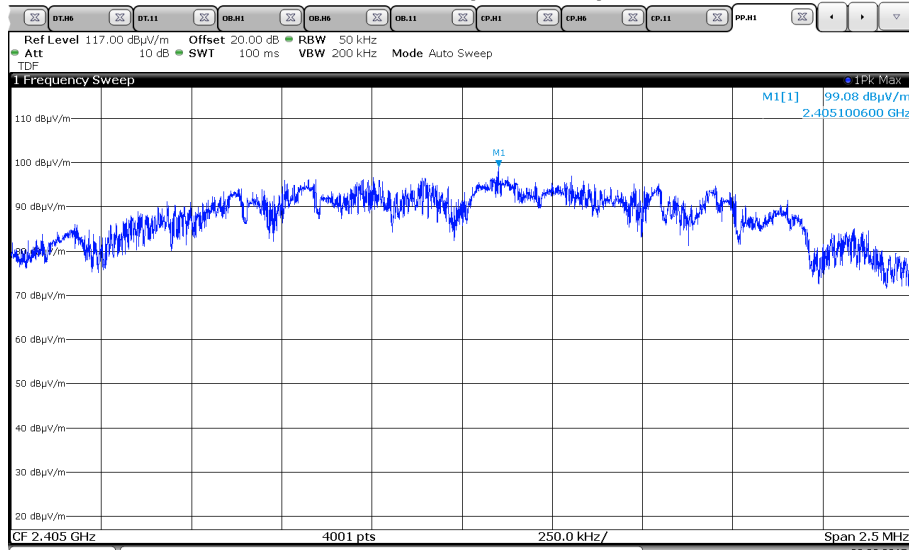
Frequency (MHz)	Power spectral density limit
	(dBm/3 kHz)
2400 - 2483.5	8

The requirements are **FULFILLED**.

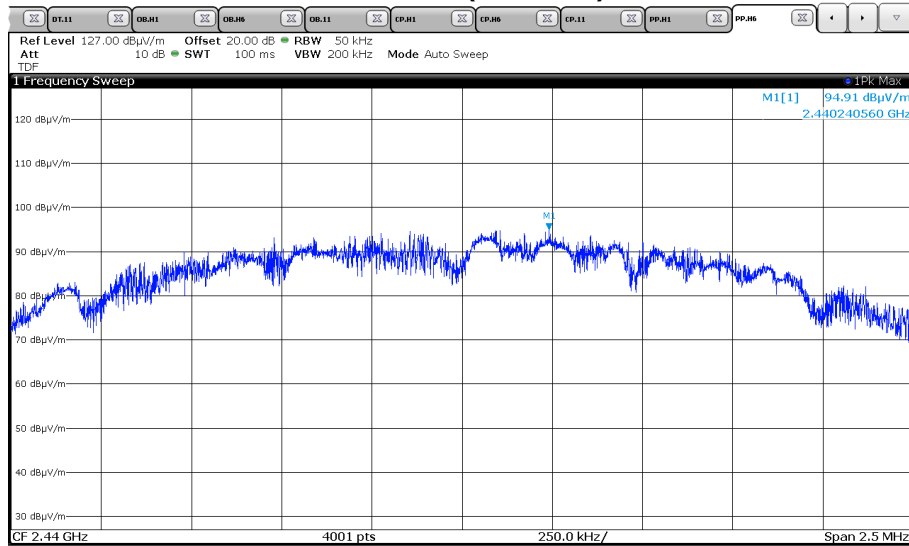
Remarks: For detailed test results please refer to following test protocols.

5.4.6 Power spectral density plots

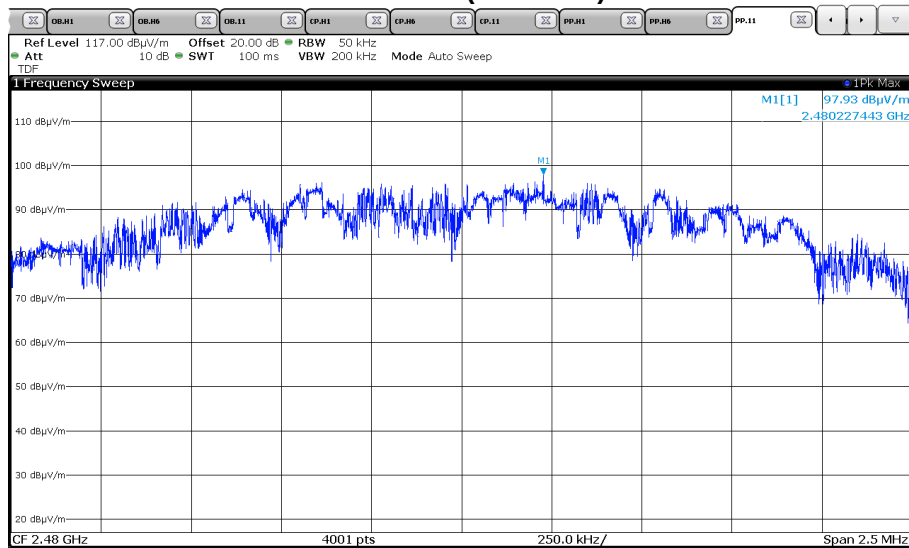
Channel 11 (2405 MHz)



Channel 18 (2440 MHz)



Channel 26 (2480 MHz)



5.5 Unwanted emissions

For test instruments and accessories used see section 6 Part **SER 2**, **SER 3**.

5.5.1 Description of the test location

Test location: NONE

Remarks: Not tested, the EUT holds the general limit under FCC Part 15209. For reference level see plot
under item 5.2.7.

5.6 Unwanted emissions in restricted bands, radiated

For test instruments and accessories used see section 6 Part **SER 2**, **SER 3**.

5.6.1 Description of the test location

Test location: OATS 1
 Test location: Anechoic chamber 2
 Test distance: 3 m

5.6.2 Photo documentation of the test set-up – Detailed photos see ATTACHMENT B1

According to FCC Part 15, Section 15.205(a):

In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limit specified in Section 15.209(a).

5.6.3 Description of Measurement

The restricted bands are measured radiated. The span of the spectrum analyser is set wide enough to capture the restricted band and measure the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products which fall outside of the authorized band of operation. The restricted bands are measured falling emissions into it and the nearest restricted band are checked for emissions also the restricted band for the harmonics of the carrier.

Spectrum analyser settings:

9 kHz – 150 kHz RBW: 200 Hz
 150 kHz - 30 MHz RBW: 9 kHz
 30 MHz – 1000 MHz: RBW: 120 kHz
 1000 MHz – 25 GHz: RBW: 1 MHz, VBW: 3 MHz, Sweep: Auto, Detector function: Peak

5.6.4 Test result

$f < 1 \text{ GHz}$:

Frequency (MHz)	Reading Vert. (dB μ V)	Reading Hor. (dB μ V)	Correct. Vert. (dB)	Correct. Hor. (dB)	Level Vert. (dB μ V/m)	Level Hor. (dB μ V/m)	Limit (dB μ V/m)	Dlimit (dB)
55.24	11.6	6.0	15.0	14.0	26.6	20.0	40.0	-13.4
62.24	18.9	12.0	14.6	13.7	33.5	25.7	40.0	-6.5
296.07	15.3	12.5	16.7	16.3	32.0	28.8	46.0	-14.0
325.00	18.8	13.2	17.6	17.2	36.4	30.4	46.0	-9.6
715.00	17.2	12.1	27.4	26.9	44.6	39.0	46.0	-1.4

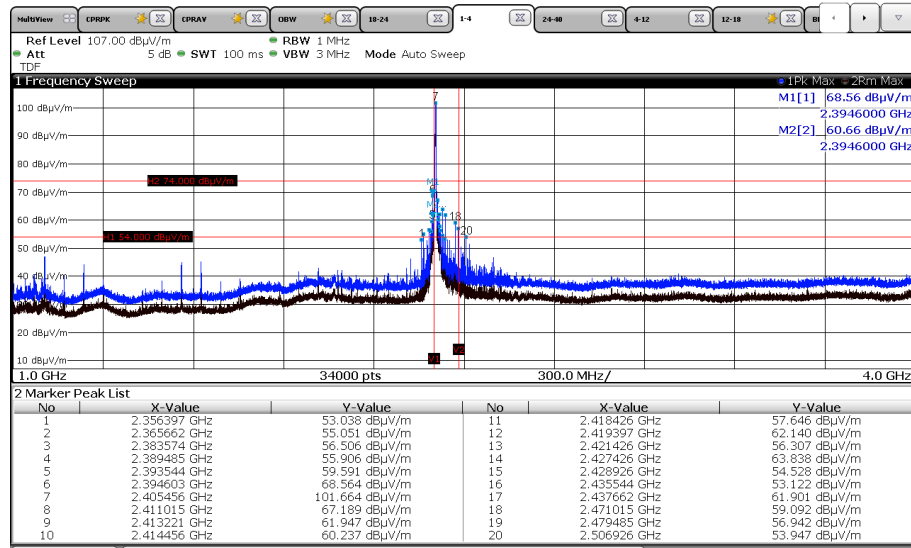
$f > 1 \text{ GHz}$:

Ch11:

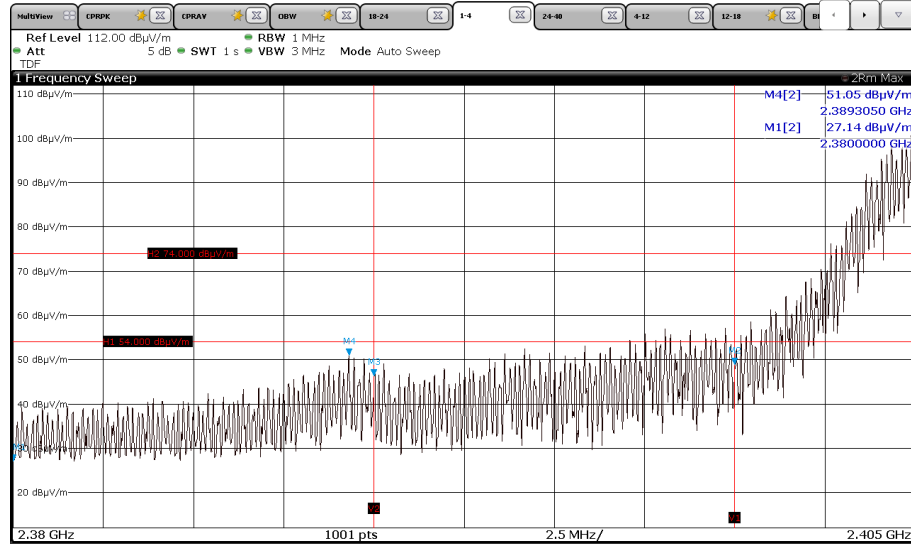
1 GHz to 4 GHz

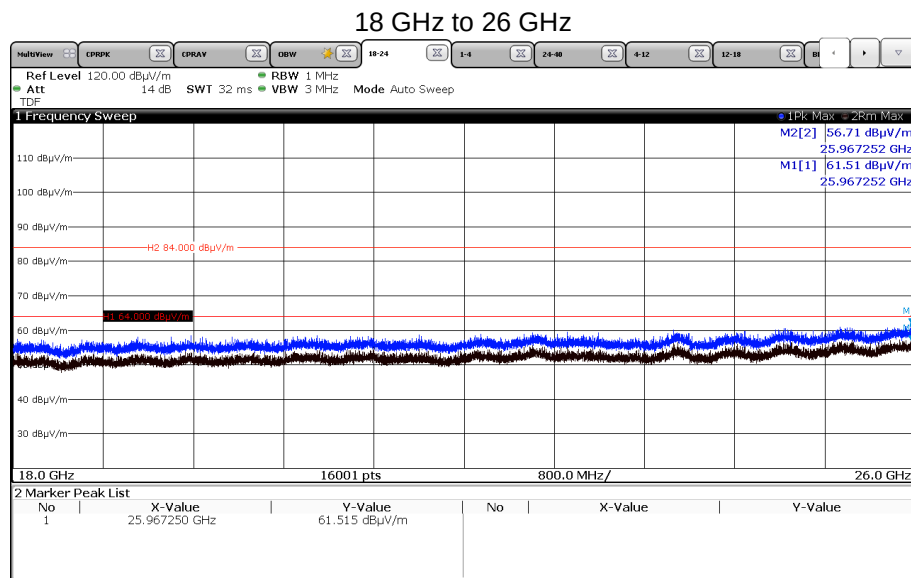
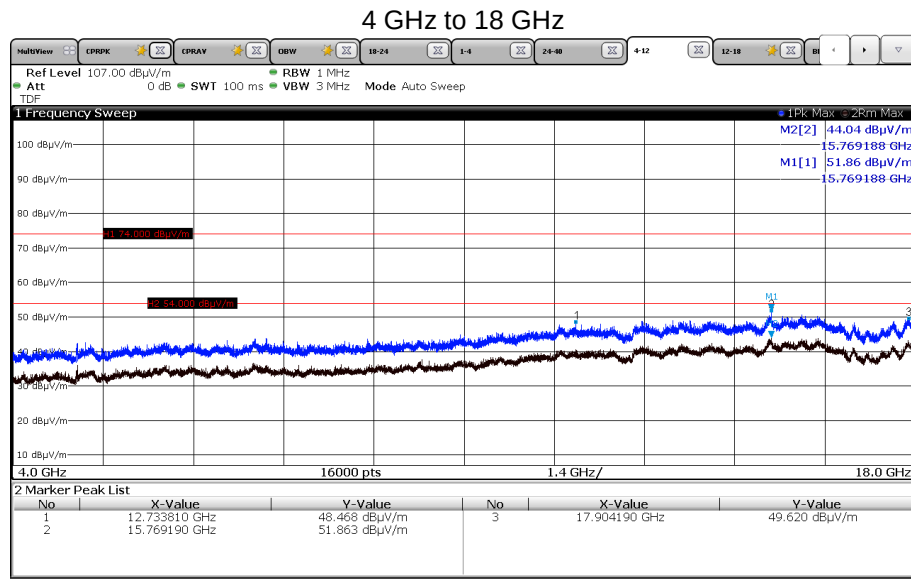
FCC ID: YJKHRAGACZ4

IC: 11148A-HRAGACZ4



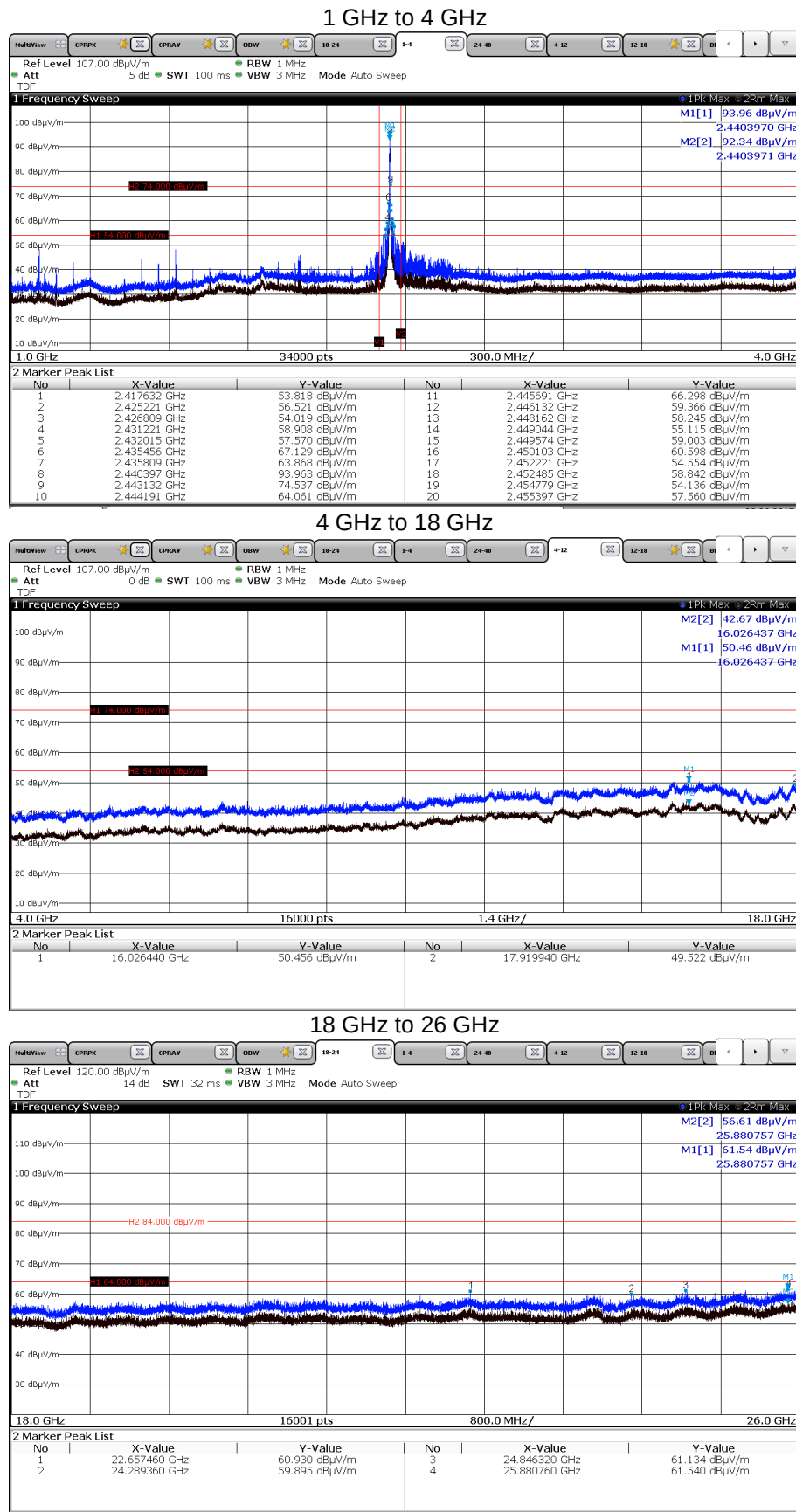
Band edge 2.39 GHz





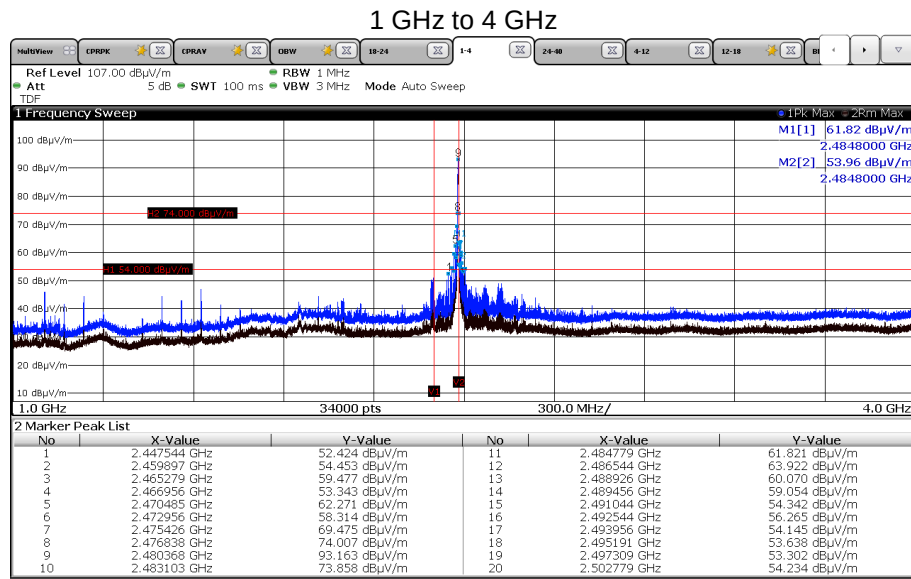
Remark: All peak emissions were below the limits of part 15.209.

Ch18:

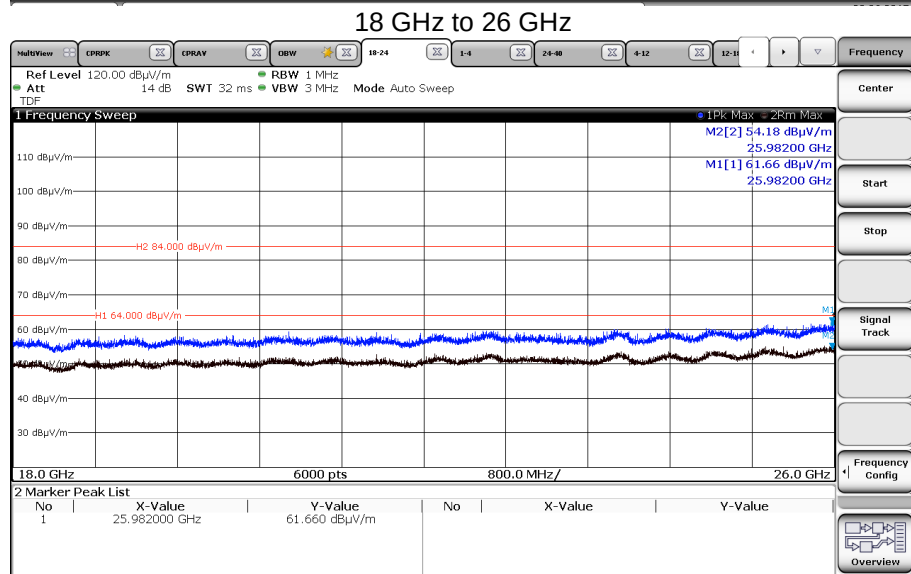
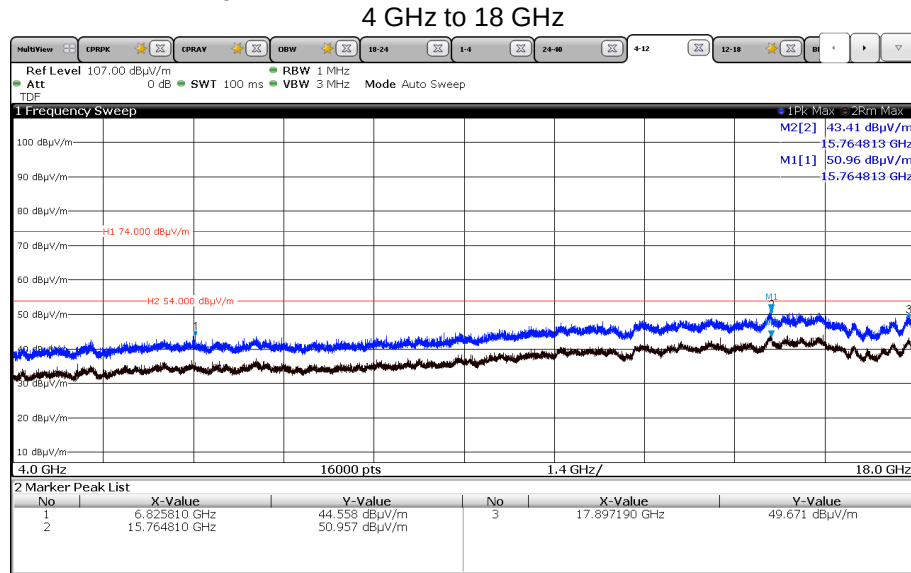


Remark: All peak emissions were below the limits of part 15.209.

Ch26:



Note: The bandedge has to be re-measured under item 5.7.



Radiated limits according to FCC Part 15 Section 15.209(a) for spurious emissions which fall in restricted bands:

Frequency (MHz)	Field strength of spurious emissions		Measurement distance (metres)
	($\mu\text{V/m}$)	dB($\mu\text{V/m}$)	
0.009-0.490	2400/F (kHz)		300
0.490-1.705	24000/F (kHz)		30
1.705-30	30	29.5	30
30-88	100	40	3
88-216	150	43.5	3
216-960	200	46	3
Above 960	500	54	3

Restricted bands of operation:

The field strength of emissions appearing within these frequency bands shall not exceed the limits shown in Section 15.209

MHz	MHz	MHz	GHz
0.090 – 0.110	16.42 – 16.423	399.9 – 410	4.5 – 5.15
0.495 – 0.505	16.69475 – 16.69525	608 – 614	5.35 – 5.46
2.1735 – 2.1905	16.80425 – 16.80475	960 – 1240	7.25 – 7.75
4.125 – 4.128	25.5 – 25.67	1300 – 1427	8.025 – 8.5
4.17725 – 4.17775	37.5 – 38.25	1435 – 1626.5	9.0 – 9.2
4.20725 – 4.20775	73 – 74.6	1645.5 – 1646.5	9.3 – 9.5
6.215 – 6.218	74.8 – 75.2	1660 – 1710	10.6 – 12.7
6.26775 – 6.26825	108 – 121.94	1718.8 – 1722.2	13.25 – 13.4
6.31175 – 6.31225	123 – 138	2200 – 2300	14.47 – 14.5
8.291 – 8.294	149.9 – 150.05	2310 – 2390	15.35 – 16.2
8.362 – 8.366	156.52475 – 156.52525	2483.5 – 2500	17.7 – 21.4
8.37625 – 8.38675	156.7 – 156.9	2690 – 2900	22.01 – 23.12
8.41425 – 8.41475	162.0125 – 167.17	3260 – 3267	23.6 – 24.0
12.29 – 12.293	167.72 – 173.2	3332 – 3339	31.2 – 31.8
12.51975 – 12.52025	240 – 285	3345.8 – 3358	36.43 – 36.5
12.57675 – 12.57725	322 – 335.4	3600 – 4400	Above 38.6

The requirements are **FULFILLED**.

Remarks: The measurement was performed up to the 10th harmonic

5.7 Band edge compliance

For test instruments and accessories used see section 6 Part **MB**.

5.7.1 Description of the test location

Test location: Anechoic chamber 1

Test distance: 3 m

5.7.2 Photo documentation of the test set-up – Detailed photos see ATTACHMENT B1

5.7.3 Applicable standard

According to FCC Part 15C, Section 15.247(d):

In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

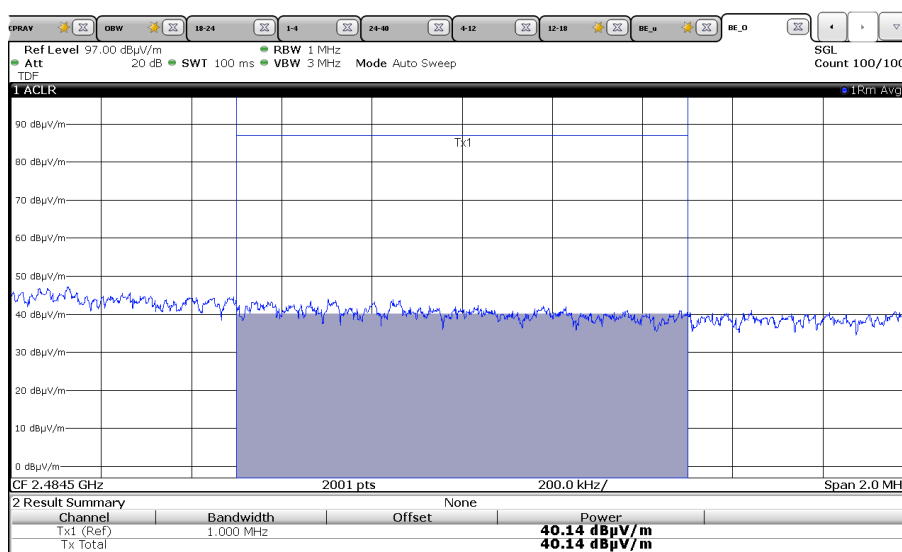
5.7.4 Description of Measurement

A spectrum analyser is connected to the output of the transmitter via a suitable attenuator while EUT was operating in transmit mode at the assigned frequency according OET 558074, 4/5/2017.

Spectrum analyser settings:

RBW: 1 MHz, VBW: 3 MHz, Detector: RMS, Trace: AV, Count 100, Sweep: auto

5.7.5 Test result



Limit according to FCC Subpart 15.247(d):

In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limit specified in §15.209(a) (see §15.205(c)).

The requirements are **FULFILLED**.

Remarks:

5.8 Antenna application

5.8.1 Applicable standard

According to FCC Part 15C, 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 this section. The manufacturer may design the unit that broken antennas can be replaced by the user, but the use of a standard antenna jack is prohibited.

The EUT has an integrated antenna. No other antenna can be used with the device.

All supplied antennas meet the requirements of part 15.203 and 15.204.

5.8.2 Antenna requirements

According to FCC Part 15C, Section 15.247(b)(4):

The conducted output power limit specified in paragraph (b) of 15.247 is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from intentional radiator shall be reduced below the stated values in paragraph (b)(1), (b)(2) and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

Defacto EIRP-Limit:

$$P_{out} = 30 - (G_x - 6);$$

Remarks: No defacto limit results because of antennas smaller than 6 dBi gain.

6 USED TEST EQUIPMENT AND ACCESSORIES

All test instruments used are calibrated and verified regularly. The calibration history is available on request.

Test ID	Model Type	Equipment No.	Next Calib.	Last Calib.	Next Verif.	Last Verif.
A 4	ESCI	02-02/03-15-001	31/05/2018	31/05/2017		
	ESH 2 - Z 5	02-02/20-05-004	26/10/2017	26/10/2015	18/01/2018	18/07/2017
	N-4000-BNC	02-02/50-05-138				
	N-1500-N	02-02/50-05-140				
	ESH 3 - Z 2	02-02/50-05-155	18/11/2019	18/11/2016	21/10/2017	21/04/2017
CPR 3	FSW43	02-02/11-15-001	07/04/2018	07/04/2017		
	JS4-18004000-30-5A	02-02/17-05-017				
	AMF-6D-01002000-22-10P	02-02/17-15-004				
	3117	02-02/24-05-009	10/05/2018	10/05/2017		
	BBHA 9170	02-02/24-05-014	02/06/2018	02/06/2015	09/12/2017	09/12/2016
	KMS102-0.2 m	02-02/50-11-020				
	SF104/11N/11N/300MM	02-02/50-13-008				
	Ultimate 1000W	02-02/50-16-004				
	18N-20	02-02/50-17-003				
	NMS111-GL200SC01-NMS11	02-02/50-17-012				
MB	Bandpass Filter	02-02/50-17-019				
	FSW43	02-02/11-15-001	07/04/2018	07/04/2017		
	JS4-18004000-30-5A	02-02/17-05-017				
	AMF-6D-01002000-22-10P	02-02/17-15-004				
	3117	02-02/24-05-009	10/05/2018	10/05/2017		
	BBHA 9170	02-02/24-05-014	02/06/2018	02/06/2015	09/12/2017	09/12/2016
	KMS102-0.2 m	02-02/50-11-020				
	SF104/11N/11N/300MM	02-02/50-13-008				
	Ultimate 1000W	02-02/50-16-004				
	18N-20	02-02/50-17-003				
SER 2	NMS111-GL200SC01-NMS11	02-02/50-17-012				
	Bandpass Filter	02-02/50-17-019				
	ESVS 30	02-02/03-05-003	12/07/2018	12/07/2017		
	VULB 9168	02-02/24-05-005	12/04/2018	12/04/2017	12/10/2017	12/04/2017
	NW-2000-NB	02-02/50-05-113				
SER 3	KK-EF393/U-16N-21N20 m	02-02/50-12-018				
	KK-SD_7/8-2X21N-33,0M	02-02/50-15-028				
	FSW43	02-02/11-15-001	07/04/2018	07/04/2017		
	JS4-18004000-30-5A	02-02/17-05-017				
	AMF-6D-01002000-22-10P	02-02/17-15-004				
SER 3	3117	02-02/24-05-009	10/05/2018	10/05/2017		
	BBHA 9170	02-02/24-05-014	02/06/2018	02/06/2015	09/12/2017	09/12/2016
	KMS102-0.2 m	02-02/50-11-020				
	SF104/11N/11N/300MM	02-02/50-13-008				
	Ultimate 1000W	02-02/50-16-004				
	18N-20	02-02/50-17-003				
	NMS111-GL200SC01-NMS11	02-02/50-17-012				
	Bandpass Filter	02-02/50-17-019				