EMI – TEST REPORT

- FCC Part 15.249, RSS210 -

Type / Model Name	:	PR 30-HVS A12
Product Description	:	Rotating Laser
Applicant	:	Hilti AG
Address	:	Feldkircherstrasse 100
		9494 SCHAAN, LIECHTENSTEIN
Manufacturer	:	HILLOS GmbH
Address	:	Prüssingstraße 41
		07745 JENA, GERMANY
Licence holder	:	Hilti AG
Address	:	Feldkircherstrasse 100
		9494 SCHAAN, LIECHTENSTEIN

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

Test Report No. : T40621-00-01TK	01. August 2016 Date of issue

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

Contents

1 TEST STANDARDS

The tests were performed according to following standards:

FCC Rules and Regulations Part 15, Subpart A - General (September, 2015)

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, 2015)

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 15.249	Operation within the bands 902 - 928 MHz, 2400 - 2483.5 MHz, 5725 - 5875 MHz, and 24.0 - 24.25 GHz
ANSI C63.4: 2014	Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.
ANSI C63.10: 2013	Testing Unlicensed Wireless Devices
ANSI C95.1:2005	IEEE Standard for Safety Levels with respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz
CISPR 16-4-2: 2013	Uncertainty in EMC measurement
CISPR 22: 2008 EN 55022: 2010	Information technology equipment

2 EQUIPMENT UNDER TEST

2.1 Photo documentation of the EUT – Detailed photos see Attachment A

2.2 General Remarks

According to the customers modification a re-test of the EUT was performed to show further compliance. The EUT is modified with a re-design of the DC inverter section. The modification results having no more possibility to connect the device to the mains. The charging mode Therefore testing of AC power line conducted emissions are no longer necessary. A modification of the RF section was not made. All other parts are the same in position and value.

This Test Report shows the further compliance with CFR 47, Part 15.249 by re-measurement of the most concerned tests to the RF-part.

The following tests are selected for re-measurement:

- Equivalent isotropic radiated power
- Transmitter spurious emissions
- Correction for pulse operation (duty cycle)

2.3 Equipment category

WPAN ZigBee device, portable equipment.

2.4 Short description of the equipment under test (EUT)

The EUT is a rotating laser alignment system and is equipped with an RF transceiver operating within the frequency range from 2.4 GHz up to 2.4835 GHz making available to the user to control the whole alignment system remotely. The RF section is not modified.

Number of tested samples	:	1
Serial number	:	176150035
Firmware version	:	Series firmware

Items	Description
IEEE 802.15.4	3 channel WPAN
IEEE 802.15.4 chipset type	Texas Instruments CC2520
Modulation	GFSK
Frequency range	2400 MHz to 2483.5 MHz
Channel numbers	3
Data rate (kbps)	250
Antenna type	PCB

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

2.5 Variants of the EUT

None

2.6 Operation frequency and channel plan

The operating frequency is 2400 MHz to 2483.5 MHz.

Channel plan and tested frequencies:

Channel	Frequency	Channel	Frequency	Channel	Frequency
1	2405	2	2440	3	2480

2.7 Transmit operating modes

The EUT uses GFSK and provide following data rate:

250 kbps (kbps = *kilobits per second)*

2.8 Antenna

The following antennas shall be used with the EUT:

Characteristic	Certification name	Plug	Frequency range (MHz)	Gain
Omni	F-type PCB-antenna	none	2400 -2483.5	N/A

2.9 Power supply system utilised

Power supply voltage, V_{nom} : 12 VDC Lithium accumulator battery
Power supply voltage (alternative) : none

2.10 Peripheral devices and interface cables

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

- Power supply battery Model : B 12 / 2.6 Li-Ion
- _____ Model : _____
- _____ Model : _____

2.11 Determination of worst case conditions for final measurement

Measurements were performed in all three orthogonal axes and the settings of the EUT were changed to locate at which position and at what setting of the EUT produce the maximum of the emissions. For the further measurement the EUT is set in X position with the following settings:

IEEE Standard	Available channel	Tested channels	Power setting	Modulation	Modulation type	Data rate
802.15.1	1, 2, 3	1, 2, 3	+5 dBm	DSSS	GFSK	250 kbps

250 kbps, GFSK with TX continuous modulated.

2.11.1 Test jig

No test jig was used for test.

2.11.2 Test software

No special test software was used.

3 TEST RESULT SUMMERY

Operating in the 2400 MHz – 2483.5 MHz band:

FCC Rule Part	RSS Rule Part	Description	Result
15.35(c)	RSS-Gen, 6.10	Pulsed operation	passed
15.203	RSS Gen, 8.3	Antenna requirement	passed
15.204	RSS Gen, 8.2	External radio frequency power amplifiers	passed
15.205(a)	RSS Gen, 8.1	Emissions in restricted bands	passed
15.207(a)	RSS Gen, 8.8	AC power line conducted emissions	not applicable
15.215(c)	-	EBW	Not tested
-	RSS-Gen, 6.6	OBW	Not tested
15.249(a)	RSS-210, A2.9(a)	Field strength of fundamental	passed
15.249(d)	RSS-210, A2.9(b)	Out-of-band emission, radiated	passed
-	RSS-Gen, 6.11	Transmitter frequency stability	not applicable

The mentioned RSS Rule Parts in the above table are related to:
RSS Gen, Issue 4, November 2014
RSS 210, Issue 8, December 2010

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 : 31 May 2016

Testing concluded on : 29 June 2016

Checked by:

Thomas Weise
I confirm the correctness and integrity of this document
2016.08.01 16:31:13 +02'00'

Thomas Weise
Laboratory Manager

Tested by:

Tobias Kammerer
I´m the author of this document
2016.08.01 15:33:13 +02'00'

Tobias Kammerer
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.

4.4 Measurement protocol for FCC and IC

4.4.1 General information

4.4.1.1 Test methodology

Conducted and radiated disturbance testing is performed according to the procedures set out by the International Special Committee on Radio Interference (CISPR) Publication 22, European Standard EN 55022 as shown under section 1 of this report.

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

IC 3009A-1

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

IC 3009A-02

In compliance with RSS 210 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

The test methods used comply with CISPR Publication 22, EN 55022 - " Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement" and with ANSI C63.10 “Testing Unlicensed Wireless Devices ". 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.

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: NONE

Remarks: Not applicable, the EUT is battery powered and has no externally connectable cables.

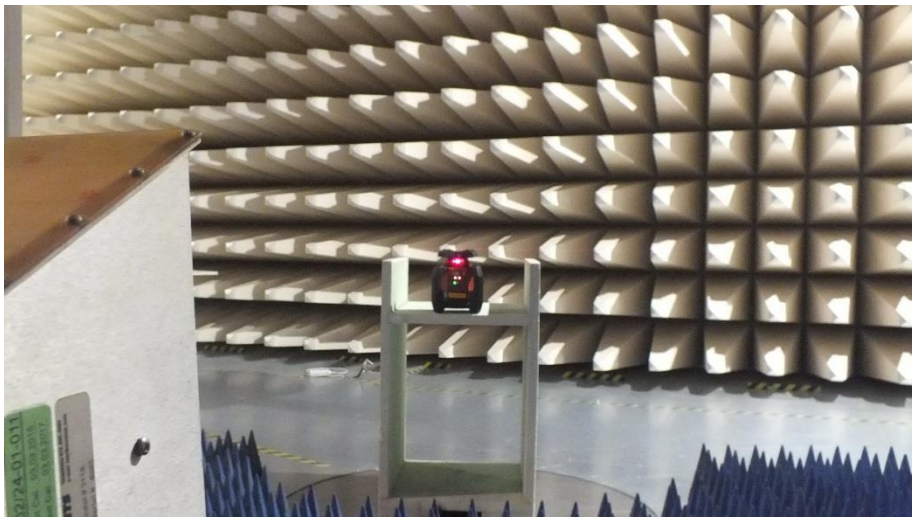
5.2 Field strength of fundamental

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

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



5.2.1 Applicable standard

According to FCC Part 15C, Section 15.249(a):
The field strength of emissions from intentional radiators operated within these frequency bands shall comply with the effective limits.

5.2.2 Description of Measurement

The radiated emission of the fundamental wave from the EUT is measured using a spectrum analyser and appropriate linear polarized antennas. The set up of the EUT and the measurement procedure is in accordance to ANSI C63.10, Item 6.5. The EUT is measured in TX active mode modulated under normal conditions.

Analyser settings:

Peak measurement:	RBW:	1 MHz	VBW:	3 MHz	Detector:	Max peak
AV measurement:	RBW:	1 MHz	VBW:	10 Hz	Detector:	Max peak

5.2.3 Test result

Frequency	Reading level PK	Bandwidth	Correction factor	Corrected level PK	Limit PK	Duty cycle correction factor K_E	Corrected level AV	Limit AV
(MHz)	(dBµV)	(kHz)	(dB)	dB(µV/m)	dB(µV/m)	(dB)	dB(µV/m)	dB(µV/m)
2405	116.6	1000	-12.1	104.5	114	-35.8	68.7	94
2440	114.3	1000	-10.9	103.4	114	-35.8	67.6	94
2480	112.5	1000	-10.9	101.6	114	-35.8	65.8	94
Measurement uncertainty				±2.34 dB				

Note: The correction factor includes cable loss and antenna factor.

Average-Limit according to FCC Part 15C, Section 15.249(a):

Frequency	Field strength of fundamental	
(MHz)	(mV/m)	dB(µV/m)
902 - 928	50	94
2400 - 2483.5	**50**	**94**
5725-5875	50	94
24000 - 24250	250	108

Peak-Limit according to FCC Part 15C, Section 15.249(e):
However the peak fieldstrength shall not exceed the maximum permitted average limit by more than 20 dB.

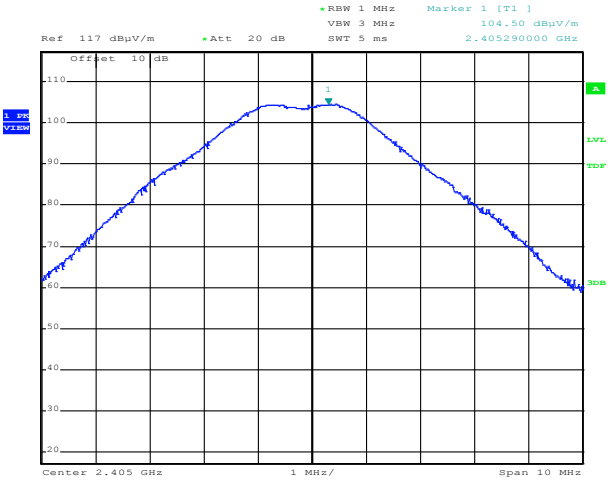
The requirements are **FULFILLED.**

Remarks: _____

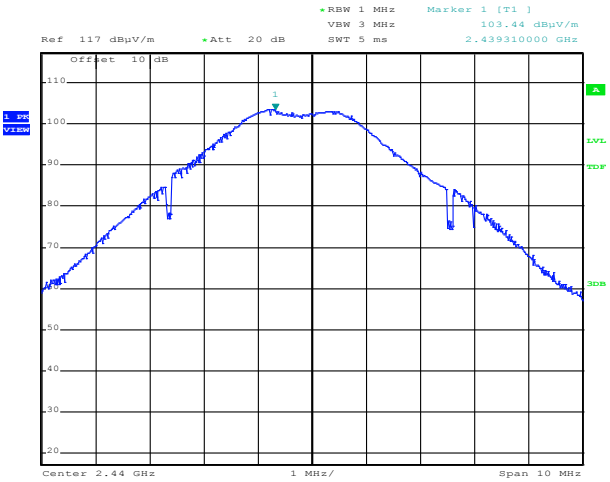
_____

5.2.4 Test protocols

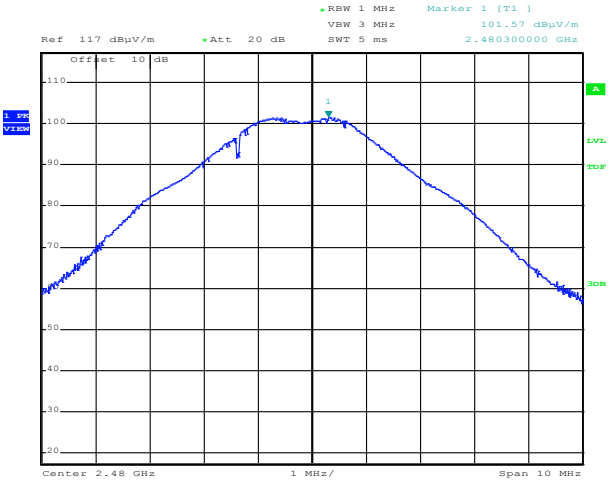
Fundamental wave filedstrength 2405 MHz



Fundamental wave filedstrength 2440 MHz



Fundamental wave filedstrength 2480 MHz



5.3 Out-of-band emission, radiated

For test instruments and accessories used see section 6 Part **SER1, SER 2, SER 3**.

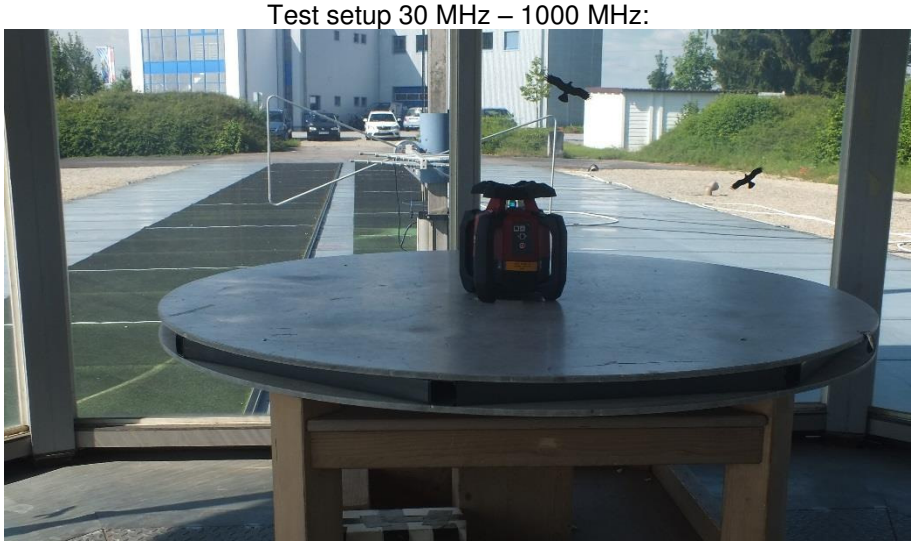
5.3.1 Description of the test location

Test location: OATS 1
Test distance: 3 m

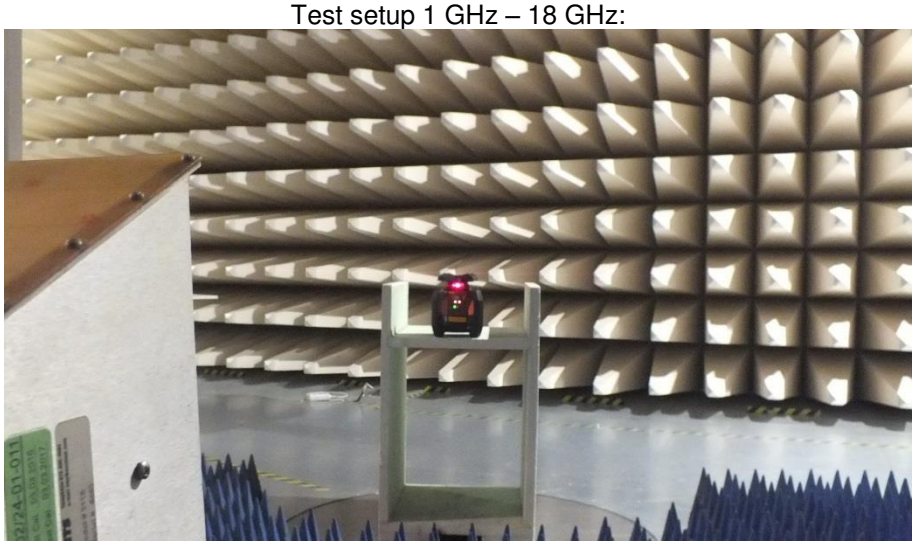
Test location: Anechoic chamber 1
Test distance: 3 m

5.3.2 Photo documentation of the test set-up

Test setup 30 MHz – 1000 MHz:



Test setup 1 GHz – 18 GHz:



5.3.3 Applicable standard

According to FCC Part 15C, Section 15.249 (d):
Emission radiated outside of the specified frequency bands, except harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated limit in FCC Part 15C, Section 15.209, whichever is the lesser attenuation.

5.3.4 Description of Measurement

The radiated emissions from the EUT are measured in the frequency range of 9 kHz to 1000 MHz using a tuned receiver and appropriate broadband linearly polarized antennas. The setup of the EUT and the measurement procedure is in accordance to ANSI C63.10, Item 6.3. In the frequency range above 1 GHz a spectrum analyser is used with appropriate linear polarized antennas. If the emission level in peak mode complies with the average limit testing is stopped and peak values will be reported, otherwise, the emission is measured in average mode again and reported. The EUT is measured in TX continuous mode modulated under normal conditions.

Instrument 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

5.3.1 Test result

Note:
Pre-measurements were performed in the frequency range 9 kHz to 30 MHz and 18 GHz to 25 GHz.
The EUT showed no detectable suspects.

5.3.2 Test result f = 30 MHz - 1000 MHz

Frequency (MHz)	Reading Vert. (dBµV)	Reading Hor. (dBµV)	Correct. Vert. (dB)	Correct. Hor. (dB)	Level Vert. (dBµV/m)	Level Hor. (dBµV/m)	Limit (dBµV/m)	Dlimit (dB)
150.00	0.6	-2.5	13.4	14.3	14.0	11.8	43.5	-29.5
300.00	-1.0	1.6	16.5	15.9	15.5	17.5	46.0	-28.5
450.00	-0.2	-0.1	20.4	20.0	20.2	19.9	46.0	-25.8
600.00	-1.3	-0.4	24.1	23.7	22.8	23.3	46.0	-22.7
750.00	-0.6	0.5	26.8	26.3	26.2	26.8	46.0	-19.2
900.00	2.1	0.7	28.9	28.4	31.0	29.1	46.0	-15.0
Measurement uncertainty					±3.71 dB			

Note:
The correction factor includes cable loss and antenna factor. No emission difference could be detected for the intentional radiated frequencies 2405 MHz, 2440 MHz and 2480 MHz within the frequency range from 30 MHz to 1000 MHz.

5.3.3 Test result f > 1 GHz

CH1, 2405 MHz								
Test conditions:								
TX continuous, P = 5 dBm			Test results					
Start requency (MHz)	Stop frequency (MHz)	RBW (kHz)	Maximum emission (MHz)	Maximum emission (dBµV/m)	AV Limit (dBµV/m)	Duty cycle correction (dB)	Margin (dB)	Detector
1000	2400	1000	2400.00	57.1	54.0	-35.8	-32.7	PK
2483.5	4000	1000	3725.89	50.7	54.0	0.0	-3.3	PK
4000	8000	1000	4809.50	48.5	54.0	0.0	-5.5	PK
8000	12000	1000	11988.50	46.9	54.0	0.0	-7.2	PK
12000	18000	1000	16404.75	49.0	54.0	0.0	-5.0	PK
Measurement uncertainty			±6 dB					

CH2, 2440 MHz								
Test conditions:								
TX continuous, P = 5 dBm			Test results					
Start requency (MHz)	Stop frequency (MHz)	RBW (kHz)	Maximum emission (MHz)	Maximum emission (dBµV/m)	AV Limit (dBµV/m)	Duty cycle correction (dB)	Margin (dB)	Detector
1000	2400	1000	1973.35	48.5	54.0	0.0	-5.5	PK
2483.5	4000	1000	3685.33	50.2	54.0	0.0	-3.9	PK
4000	8000	1000	4879.50	46.9	54.0	0.0	-7.1	PK
8000	12000	1000	10808.00	47.2	54.0	0.0	-6.8	PK
12000	18000	1000	16128.75	49.6	54.0	0.0	-4.4	PK
Measurement uncertainty			±6 dB					

CH3, 2480 MHz								
Test conditions:								
TX continuous, P = 5 dBm			Test results					
Start requency (MHz)	Stop frequency (MHz)	RBW (kHz)	Maximum emission (MHz)	Maximum emission (dBµV/m)	AV Limit (dBµV/m)	Duty cycle correction (dB)	Margin (dB)	Detector
1000	2400	1000	1898.45	48.2	54.0	0.0	-5.8	PK
2483.5	4000	1000	2483.50	60.8	54.0	-35.8	-29.0	PK
4000	8000	1000	4959.00	46.9	54.0	0.0	-7.1	PK
8000	12000	1000	10028.00	46.0	54.0	0.0	-8.0	PK
12000	18000	1000	16275.00	48.8	54.0	0.0	-5.2	PK
Measurement uncertainty			±6 dB					

Limit according to FCC Part 15C, Section 15.209:

Frequency (MHz)	15.209 Limits (µV/m)	Measurement distance (m)
0.009 - -0.49	2400/f(kHz)	300
0.49 – 1.705	24000/f(kHz)	30
1.705 – 30.0	30	30
30 - 88	100	3
88 - 216	150	3
216 - 960	200	3
Above 960	500	3

Average limit according to FCC Part 15C, Section 15.249(a):

Fundamental frequency	Field strength of harmonics	
(MHz)	(µV/m)	dB(µV/m)
902 - 928	500	54
2400 - 2483.5	500	54
5725 - 5875	500	54
24000 - 24250	2500	68

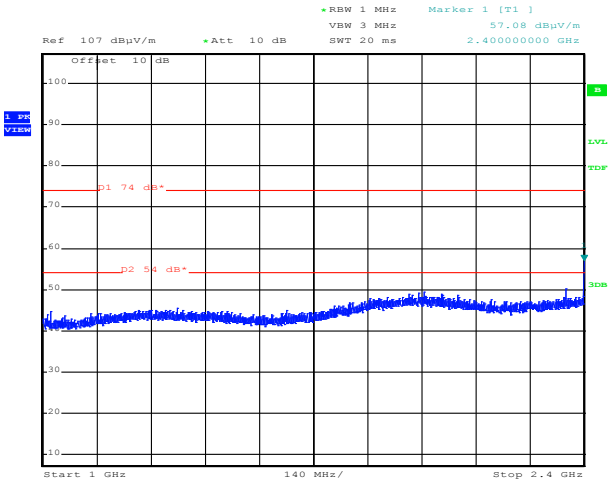
The requirements are **FULFILLED.**

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

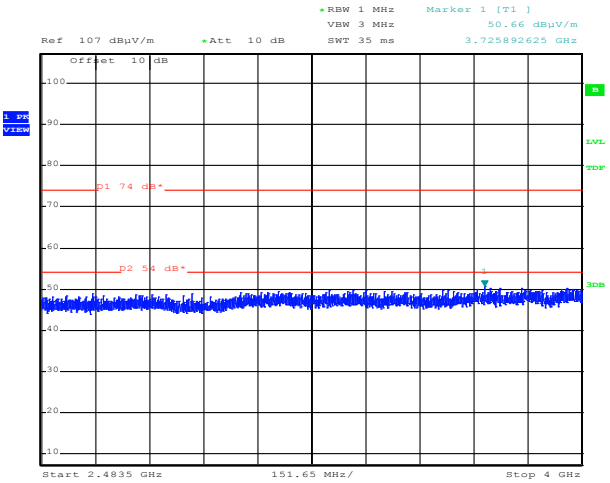
5.3.4 Test protocols

Channel 1, 2405 MHz

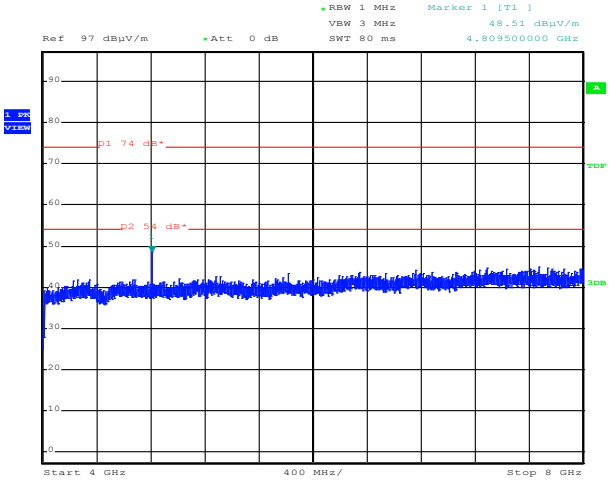
Spurious emissions from 1 to 2.4 GHz



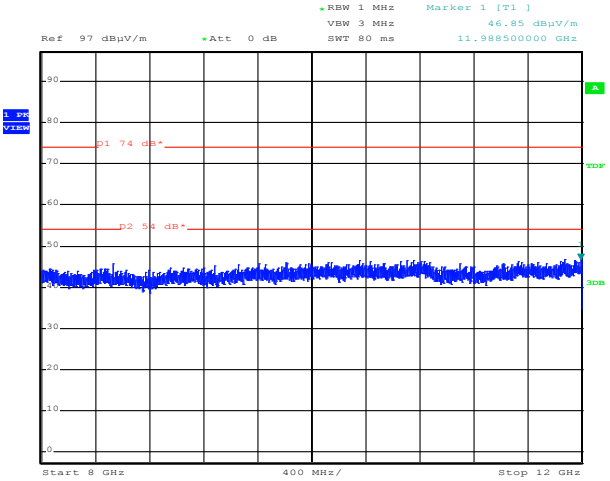
Spurious emissions from 2.4835 to 4 GHz



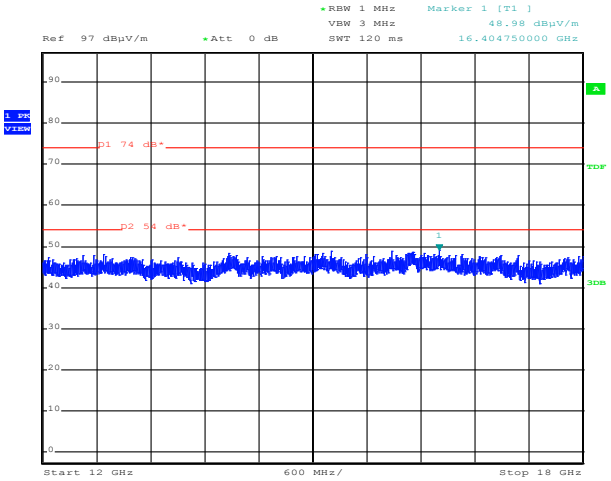
Spurious emissions from 4 to 8 GHz



Spurious emissions from 8 to 12 GHz

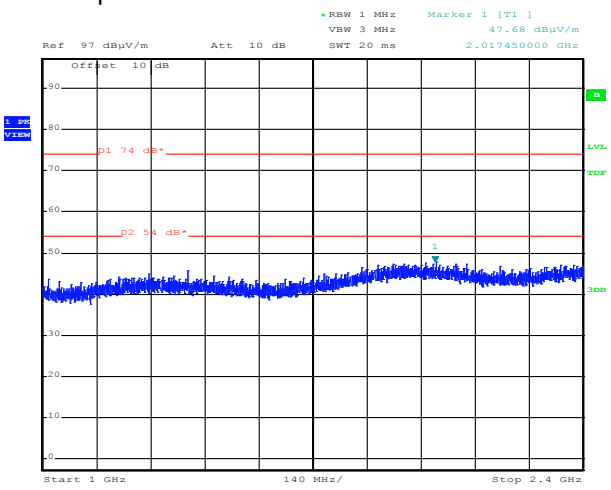


Spurious emissions from 12 to 18 GHz

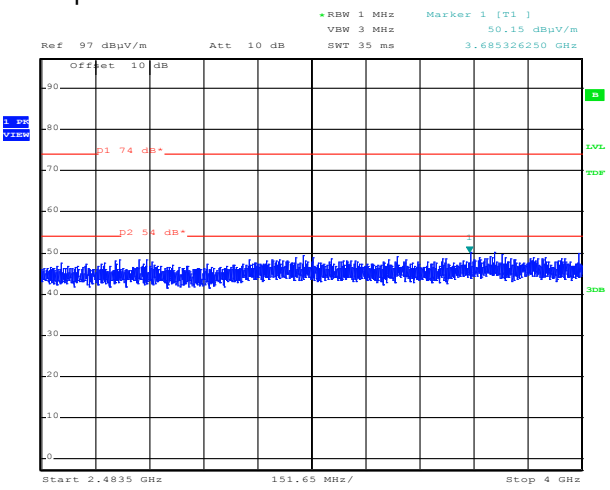


Channel 2, 2440 MHz

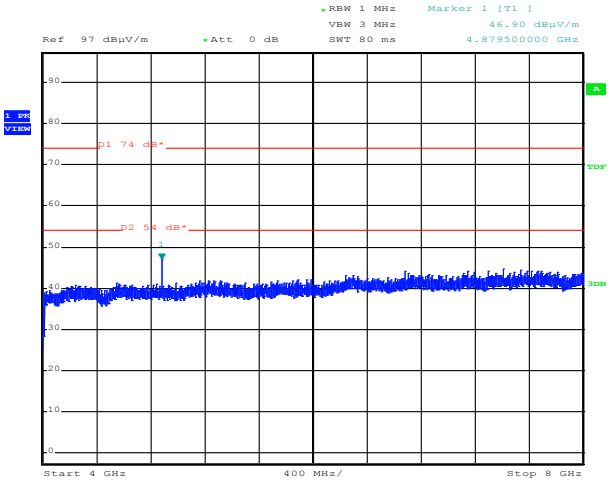
Spurious emissions from 1 to 2.4 GHz



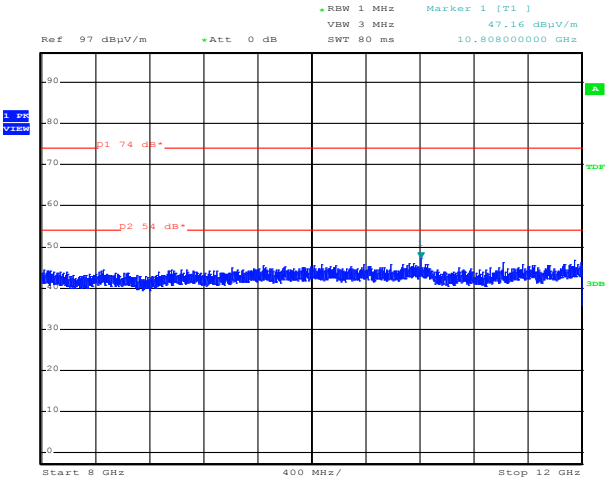
Spurious emissions from 2.4835 to 4 GHz



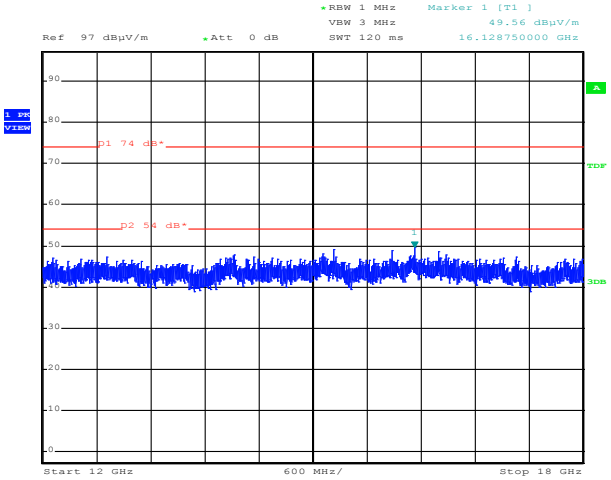
Spurious emissions from 4 to 8 GHz



Spurious emissions from 8 to 12 GHz

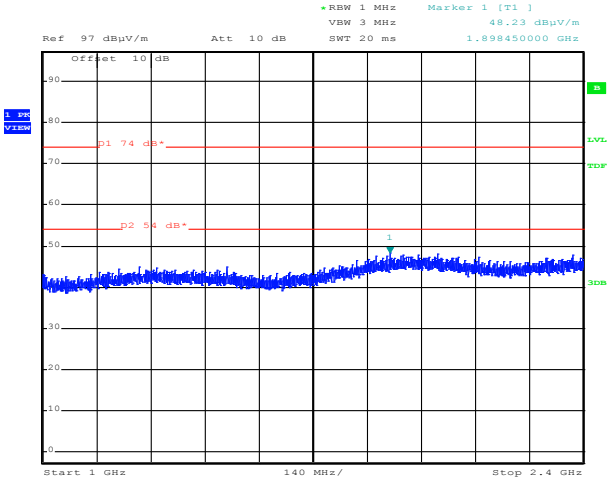


Spurious emissions from 12 to 18 GHz

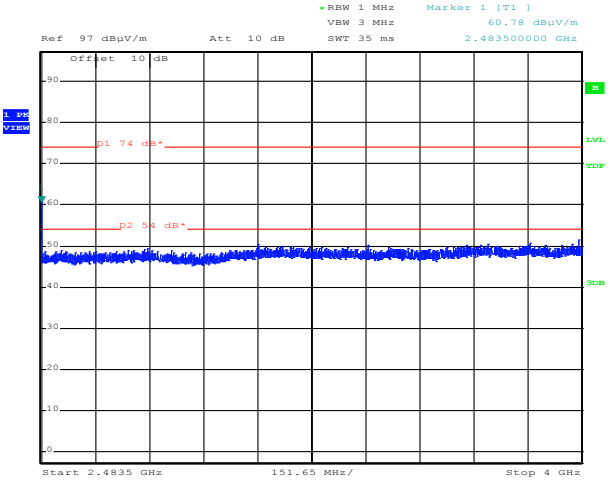


Channel 3, 2480 MHz

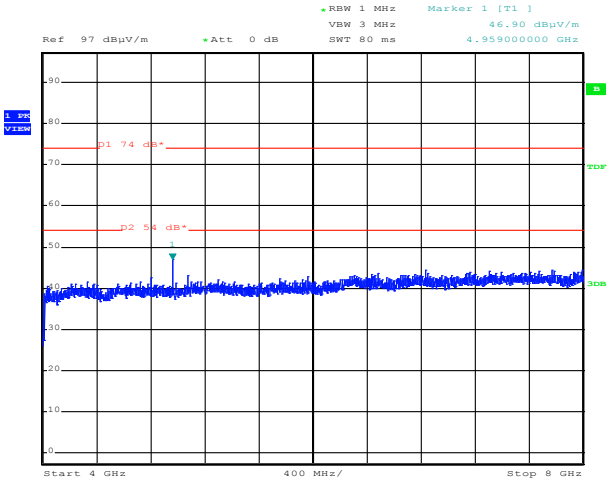
Spurious emissions from 1 to 2.4 GHz



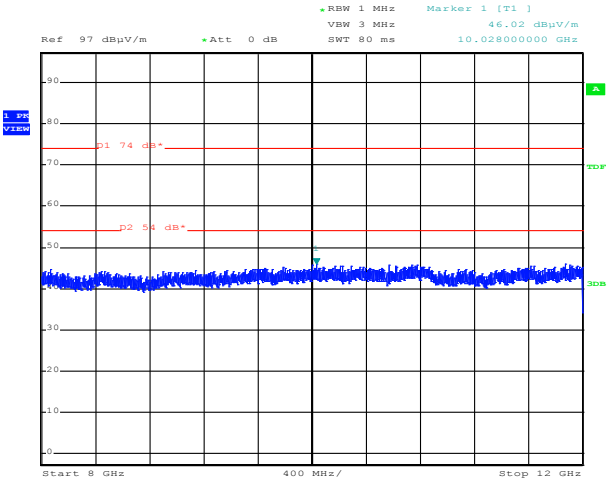
Spurious emissions from 2.4835 to 4 GHz



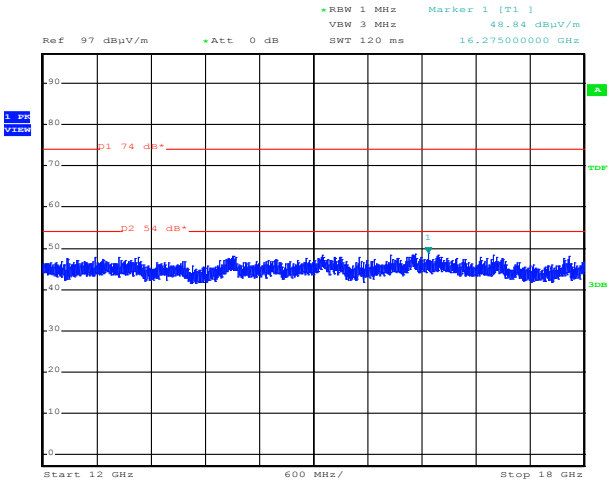
Spurious emissions from 4 to 8 GHz



Spurious emissions from 8 to 12 GHz



Spurious emissions from 12 to 18 GHz



5.4 EBW and OBW

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

5.4.1 Description of the test location

Test location: None

Remarks: Bandwidth tests are not performed.

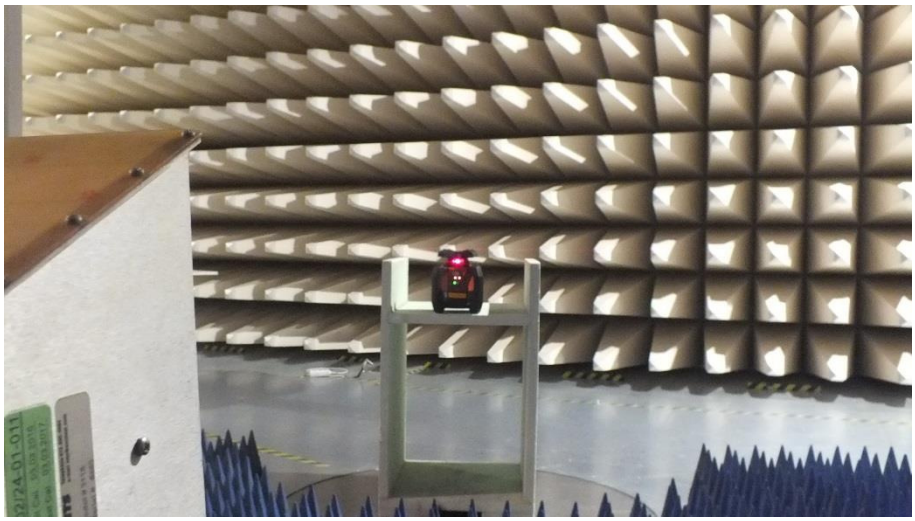
5.5 Correction for pulse operation (duty cycle)

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

5.5.1 Description of the test location

Test location: Anechoic chamber 1

5.5.2 Photo documentation of the test set-up



5.5.3 Applicable standard

According to FCC Part 15A, Section 15.35(c):
When the radiated emission limits are expressed in terms of average value and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete puls train, including blanking intervals, as long as the pulse train does not exceed 0.1s. In cases where the puls train exceeds 0.1s, the measured field strength shall be determined from the average absolute voltage during a 0.1s interval during which the field strength is at its maximum. The exact method of calculating the average field strength shall be submitted.

5.5.4 Description of Measurement

The duty cycle factor (dB) is calculated applying the following formula:

$$K_E = 20 \log \left((t_{iw}/T_w) * (t_{iB}/T_B) \right)$$

K_E: pulse operation correction factor
t_{iw} pulse duration for one complete pulse track
t_{iB} pulse duration for one pulse
T_w a period of the pulse track
T_B a period of one pulse

5.5.5 Test result

Active connection to companion device:

CH	t_{iw} (ms)	T_w (ms)	t_{iB} (ms)	T_B (ms)	K_E (dB)
1	100	100	1.6186	100	-35.8

Remarks: The pulse train (*Tw*) exceeds 100 ms, therefore the duty cycle have been calculated by averaging the sum of the pulse widths over the 100 ms with the highest average value.

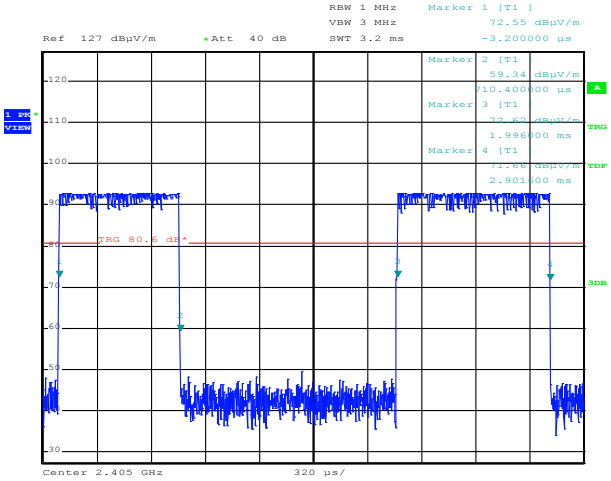
For detailed results, please see the test protocol below.

5.5.6 Test protocol

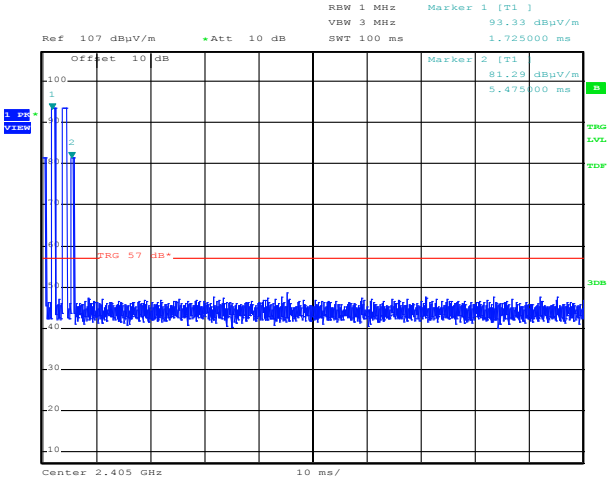
Correction for Pulse Operation (Duty Cycle)
FCC Part 15A, Section 15.35(c)

Active connection to companion device:

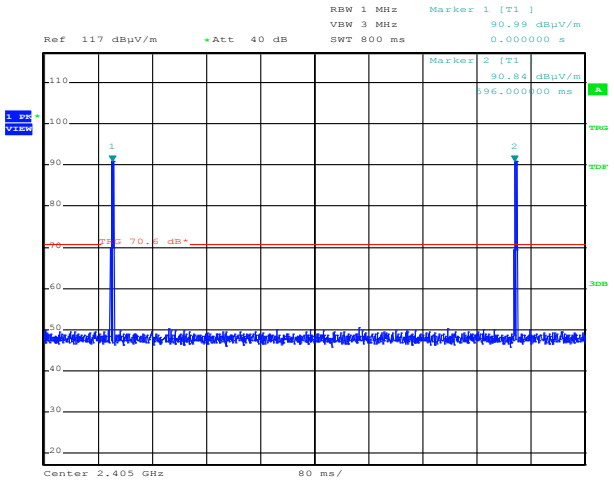
Single burst



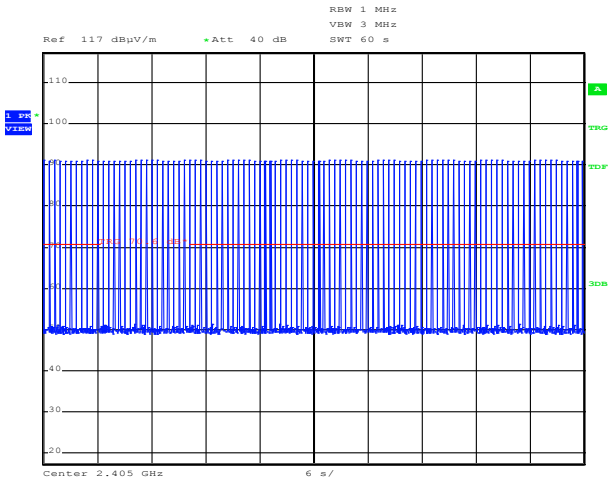
Single burst within 100 ms



Pulse sequence within 800 ms



Pulse sequence within 60 seconds



5.6 Antenna application

5.6.1 Applicable standard

According to FCC Part 15C, Section 15.203(a):
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.

5.6.2 Result

The EUT uses an integrated PCB antenna. No other antenna than the furnished by the responsible party or external power amplifier can be applied by a customer.

The antenna of the EUT meets the requirement of FCC Part 15C, Section 15.203 and 15.204.

The requirements are **FULFILLED.**

Remarks: _____

_____

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.
CPR 3	3115	01-02/24-01-011	03.03.2017	03.03.2016		
	FSP 30	02-02/11-05-001	01.10.2016	01.10.2015		
	AFS5-12001800-18-10P-6	02-02/17-06-002				
	AFS4-01000400-10-10P-4	02-02/17-13-002				
	AMF-4F-04001200-15-10P	02-02/17-13-003				
	Sucoflex N-2000-SMA	02-02/50-05-075				
	SF104/11N/11N/1500MM	02-02/50-13-015				
SER 2	ESVS 30	02-02/03-05-003	09.07.2016	09.07.2015		
	VULB 9168	02-02/24-05-005	20.04.2017	20.04.2016	20.10.2016	20.04.2016
	NW-2000-NB	02-02/50-05-113				
	KK-EF393/U-16N-21N20 m	02-02/50-12-018				
	KK-SD_7/8-2X21N-33,0M	02-02/50-15-028				
SER 3	3115	01-02/24-01-011	03.03.2017	03.03.2016		
	FSP 30	02-02/11-05-001	01.10.2016	01.10.2015		
	AFS5-12001800-18-10P-6	02-02/17-06-002				
	AFS4-01000400-10-10P-4	02-02/17-13-002				
	AMF-4F-04001200-15-10P	02-02/17-13-003				
	WHJS 1000-10EE	02-02/50-05-070				
	Sucoflex N-2000-SMA	02-02/50-05-075				
	WHK 3.0/18G-10EF	02-02/50-05-180				
	SF104/11N/11N/1500MM	02-02/50-13-015				