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ELECTRICAL TESTING
0839.01

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TEST REPORT

ACCORDING TO: FCC 47CFR part 15 subpart C §15.247 (Hybrid), RSS-247 Issue 3:2023, RSS-Gen Issue 5

FOR:

ARAD TECHNOLOGIES

AT57-7

Models:

AT57-7-21-5-P

AT57-7-21-5-OM

AT57-7-22-5-OM

FCC ID: 2A7AA-SON2LR9INT

IC: 28664-SON2LR9INT

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1 Applicant information

Client name:	ARAD TECHNOLOGIES
Address:	POB 537, HaMada 4, Yokneam Ind. Zone, Yokneam Ilit 20692, Israel
Telephone:	04-9935222, Ext: 271
Fax:	04-9935227
E-mail:	viorel.negreanu@aradtec.com
Contact name:	Mr. Vily Negreanu

2 Equipment under test attributes

Product name:	AT57-7
Product type:	Transceiver
Model(s):	AT57-7-21-5-P AT57-7-21-5-OM AT57-7-22-5-OM
Serial number:	80E12696CC1C
Hardware version:	PCB00280
Software release:	72.1.8.0
Receipt date	05-Aug-24

3 Manufacturer information

Manufacturer name:	ARAD TECHNOLOGIES
Address:	POB 537, HaMada 4, Yokneam Ind. Zone, Yokneam Ilit 20692, Israel
Telephone:	04-9935222, Ext: 271
Fax:	04-9935227
E-Mail:	viorel.negreanu@aradtec.com
Contact name:	Mr. Vily Negreanu

4 Test details

Project ID:	54871
Location:	Hermon Laboratories Ltd. 66 HaTachana str., P.O. Box 23, Binyamina 3055001, Israel
Test started:	24-Sep-24
Test completed:	13-Nov-24
Test specification(s):	FCC 47CFR part 15 subpart C §15.247 (Hybrid), RSS-247 Issue 3:2023, RSS-Gen Issue 5

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5 Tests summary

Test	Status
Transmitter characteristics	
Section 15.247(a)1 / RSS-247 section 5.1(c), 20 dB bandwidth	Pass*
Section 15.247(b) / RSS-247 section 5.4(a), Peak output power	Pass
Section 15.247(e)/ RSS-247 section 5.4(1), Peak spectral density	Pass*
Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions	Pass*
Section 15.247(a)1 / RSS-247 section 5.1(b), Frequency separation	Pass*
Section 15.247(a)1 / RSS-247 section 5.1(c), Number of hopping frequencies	Pass*
Section 15.247(a)1 / RSS-247 section 5.1(c), Average time of occupancy	Pass*
Section 15.247(i)5 / RSS-102 section 2.5, RF exposure	Pass, the exhibit to the application of certification is provided
Section 15.247(d) / RSS-247 section 5.5, Emissions at band edges	Pass*
Section 15.207(a) / RSS-Gen section 8.8, Conducted emission	Not required
Section 15.203 / RSS-Gen section 8.3, Antenna requirements	Pass*

* According to manufacturer's declaration provided in Appendix G the possible variants of the AT57-7-21-5-P and AT57-7-21-5-OM and AT57-7-22-5-OM fully identical and the only difference is a material that the pipe is made of and dimeter. Therefore, only the model AT57-7-21-5-P delivering the worst ERP was tested.

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Testing was completed against all relevant requirements of the test standard. The results obtained indicate that the product under test complies in full with the requirements tested.
The test results relate only to the items tested. Pass/ fail decision was based on nominal values.

	Name and Title	Date	Signature
Tested by:	Mr. S. Sugatov, test engineer, EMC & Radio Mrs. N. Lenkina, test engineer, EMC & Radio	29-Sep-24 - 13-Nov-24	
Reviewed by:	Mrs. S. Peysahov Sheynin, certification engineer, EMC & Radio	16-Nov-24	
Approved by:	Mr. M. Nikishin, group leader, EMC & Radio	23-Dec-24	

6 EUT description

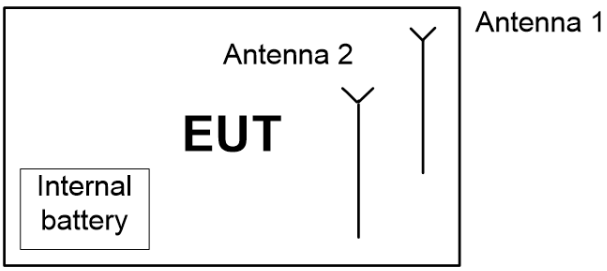
Note: The following data in this clause is provided by the customer and represents his sole responsibility

6.1 General information

The AT57-7 LoRa water meter is a fully integrated radio and antenna solution.
It is a battery-operated radio transceiver designed for automated water meter reading. The AT57-7 provides optional online data of all kinds (water consumption, temperature, Alerts, Tampering, back flow …) It uses LoRaWAN radio for relaying water consumption data to the utility.

AT57-7 Integrate Bluetooth Low energy for field maintenance.

6.2 Test configuration



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6.3 Transmitter characteristics

Type of equipment	
X	Stand-alone (Equipment with or without its own control provisions)
	Combined equipment (Equipment where the radio part is fully integrated within another type of equipment)
	Plug-in card (Equipment intended for a variety of host systems)

Intended use		**Condition of use**
X	fixed	Always at a distance more than 2 m from all people
	mobile	Always at a distance more than 20 cm from all people
	portable	May operate at a distance closer than 20 cm to human body

Assigned frequency ranges	902 – 928 MHz	
Operating frequencies	902.3 – 903.7 MHz	
Maximum rated output power	At transmitter 50 Ω RF output connector	dBm
	Peak output power	8.32 dBm

Is transmitter output power variable?	X	No		
		Yes		continuous variable
				stepped variable with stepsize	dB
			minimum RF power	dBm
			maximum RF power	dBm

Antenna connection				
unique coupling	standard connector	X	integral	with temporary RF connector
				X without temporary RF connector

Antenna/s technical characteristics			
Type	Manufacturer	Model number	Gain
Intergrated	Inhouse design	N/A	0dBi

Transmitter aggregate data rate/s	980bps 5470bps
Type of modulation	Chirp Spread Spectrum CSS
Modulating test signal (baseband)	LoRa

Transmitter power source					
X	Battery	**Nominal rated voltage**	3.6 VDC	Battery type	Lithium Inorganic battery
	DC	**Nominal rated voltage**			
	AC mains	**Nominal rated voltage**		Frequency	

Common power source for transmitter and receiver	X	yes	no

Spread spectrum technique used		Frequency hopping (FHSS)
		Digital transmission system (DTS)
	X	Hybrid

Spread spectrum parameters for transmitters tested per FCC 15.247 only		
FHSS	Total number of hops	8
	Bandwidth per hop	145.40 kHz
	Max. separation of hops	199.2 kHz

Test specification:	**Section 15.247(a)1, RSS-247 section 5.1(3), 20 dB bandwidth**		
Test procedure:	ANSI C63.10, section 7.8.7		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	02-Sep-24		
Temperature: 23 ºC	**Relative Humidity:** 58 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

7 Transmitter tests according to 47CFR part 15 subpart C and RSS-247 requirements

7.1 20 dB bandwidth

7.1.1 General

This test was performed to measure the 20dB bandwidth of the transmitter hopping channel. Specification test limits are given in Table 7.1.1.

Table 7.1.1 The 20 dB bandwidth limits

Assigned frequency, MHz	Maximum bandwidth, kHz	Modulation envelope reference points*, dBc
902.0 – 928.0	**No Requirements**	**20**

* - Modulation envelope reference points provided in terms of attenuation below the peak of modulated carrier.

7.1.2 Test procedure

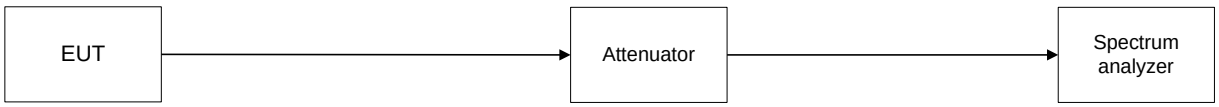
7.1.2.1 The EUT was set up as shown in Figure 7.1.1, energized and its proper operation was checked.

7.1.2.2 The EUT was set to transmit modulated carrier at maximum data rate.

7.1.2.3 The transmitter bandwidth was measured with spectrum analyzer as frequency delta between reference points on modulation envelope and provided in Table 7.1.2 and associated plot.

7.1.2.4 The test was repeated for each data rate and each modulation format.

Figure 7.1.1 The 20 dB bandwidth test setup



Test specification:	**Section 15.247(a)1, RSS-247 section 5.1(3), 20 dB bandwidth**		
Test procedure:	ANSI C63.10, section 7.8.7		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	02-Sep-24		
Temperature: 23 ºC	**Relative Humidity:** 58 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

Table 7.1.2 The 20 dB bandwidth test results

ASSIGNED FREQUENCY BAND: 902-928 MHz
DETECTOR USED: Peak
SWEEP TIME: Auto
VIDEO BANDWIDTH: ≥ RBW
FREQUENCY HOPPING: Disabled

Carrier frequency, MHz	Type of modulation	Data rate, bps	99% OBW kHz	20 dB bandwidth, kHz	Limit, kHz	Margin, kHz	Verdict
Low frequency							
902.3	LoRa	980	126.12	138.20	NA	NA	Pass
		5470	126.56	145.00	NA	NA	Pass
Mid frequency							
902.9	LoRa	980	125.97	138.10	NA	NA	Pass
		5470	126.14	144.20	NA	NA	Pass
High frequency							
903.7	LoRa	980	126.22	139.00	NA	NA	Pass
		5470	126.84	145.40	NA	NA	Pass

Reference numbers of test equipment used

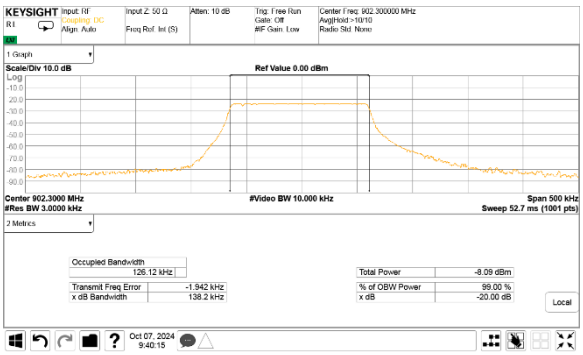
HL 5376	HL 3434	HL 6105	HL 4135					

Full description is given in Appendix A.

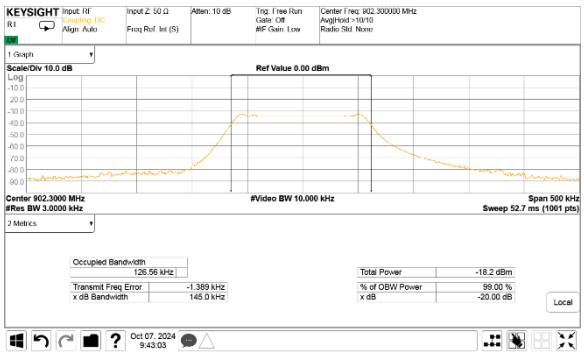
Test specification:	**Section 15.247(a)1, RSS-247 section 5.1(3), 20 dB bandwidth**		
Test procedure:	ANSI C63.10, section 7.8.7		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	02-Sep-24		
Temperature: 23 ºC	**Relative Humidity:** 58 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

Plot 7.1.1 20 dB bandwidth test result at low frequency

Data rate 980 bps

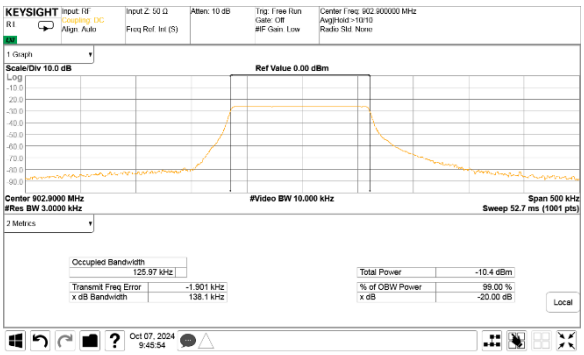


Data rate 5470 bps

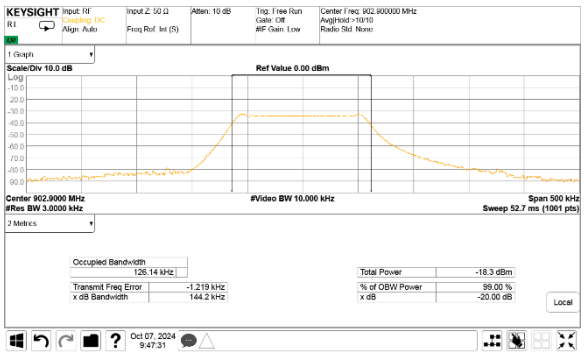


Plot 7.1.2 The 20 dB bandwidth test result at mid frequency

Data rate 980 bps

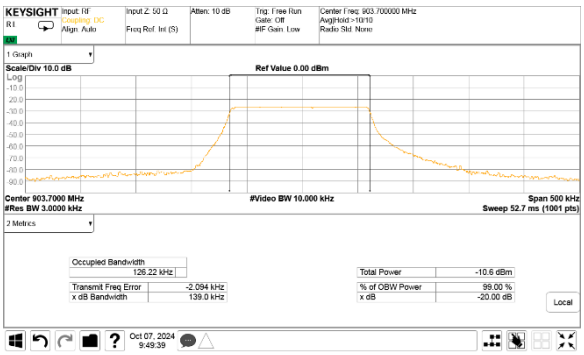


Data rate 5470 bps

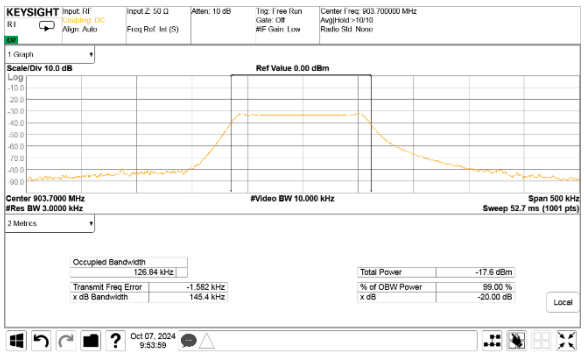


Plot 7.1.3 The 20 dB bandwidth test result at high frequency

Data rate 980 bps



Data rate 5470 bps



Test specification:	**Section 15.247(a)1, RSS-247 section 5.1(3), 20 dB bandwidth**		
Test procedure:	ANSI C63.10, section 7.8.7		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	02-Sep-24		
Temperature: 23 ºC	**Relative Humidity:** 58 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

Test specification:	**Section 15.247(a)1, RSS-247 section 5.1(2), Frequency separation**		
Test procedure:	ANSI C63.10, section 7.8.2		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	07-Oct-24		
Temperature: 24 ºC	**Relative Humidity:** 49 %	**Air Pressure:** 1002 hPa	**Power:** 3.7 VDC
Remarks:			

7.2 Carrier frequency separation

7.2.1 General

This test was performed to measure frequency separation between the peaks of adjacent channels. Specification test limits are given in Table 7.2.1.

Table 7.2.1 Carrier frequency separation limits

Assigned frequency range, MHz	Carrier frequency separation	
	Output power 30 dBm	Output power 21 dBm
902.0 – 928.0	**25 kHz or 20 dB bandwidth of the hopping channel, whichever is greater**	25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater
2400.0 – 2483.5		
5725.0 – 5850.0		

7.2.2 Test procedure

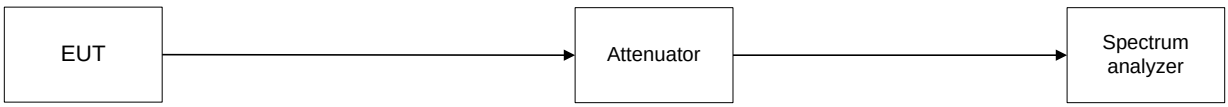
7.2.2.1 The EUT was set up as shown in Figure 7.2.1, energized with frequency hopping function enabled and its proper operation was checked.

7.2.2.2 The spectrum analyzer span was set to capture the carrier frequency and both of adjacent channels, the lower and the higher. The resolution bandwidth was set wider than 1 % of the frequency span.

7.2.2.3 The spectrum analyzer was set in max hold mode and allowed trace to stabilize.

7.2.2.4 The frequency separation between the peaks of adjacent channels was measured as provided in Table 7.2.2 and associated plots.

Figure 7.2.1 Carrier frequency separation test setup



Test specification:	**Section 15.247(a)1, RSS-247 section 5.1(2), Frequency separation**		
Test procedure:	ANSI C63.10, section 7.8.2		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	07-Oct-24		
Temperature: 24 ºC	**Relative Humidity:** 49 %	**Air Pressure:** 1002 hPa	**Power:** 3.7 VDC
Remarks:			

Table 7.2.2 Carrier frequency separation test results

ASSIGNED FREQUENCY: 902.0-928.0 MHz
MODULATION: LoRa
DETECTOR USED: Peak
RESOLUTION BANDWIDTH: ≥ 1% of the span
VIDEO BANDWIDTH: ≥ RBW
FREQUENCY HOPPING: Enabled

BIT RATE: 980 bps
20 dB BANDWIDTH: 139.00 kHz

Carrier frequency separation, kHz	Limit, kHz	Margin, kHz*	Verdict
193.8	139.0	-54.8	Pass

BIT RATE: 5470 bps
20 dB BANDWIDTH: 145.40kHz

Carrier frequency separation, kHz	Limit, kHz	Margin, kHz*	Verdict
199.2	145.4	-53.8	Pass

* - Margin = Carrier frequency separation – specification limit.

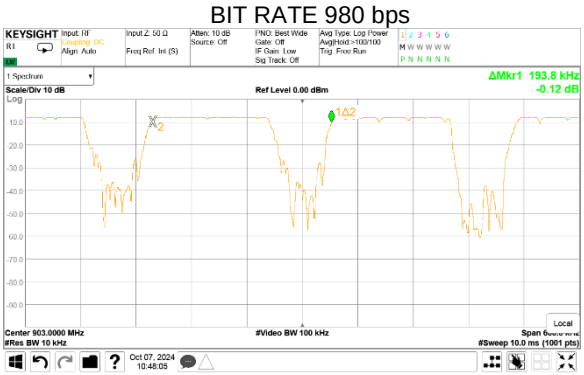
Reference numbers of test equipment used

HL 5376	HL 3434	HL 6105	HL 4135	HL 7546			

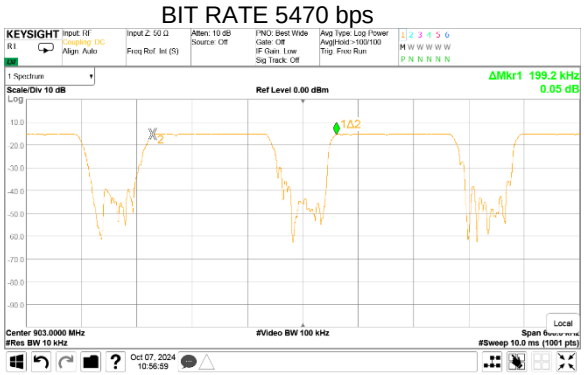
Full description is given in Appendix A.

Plot 7.2.1 Carrier frequency separation

BIT RATE 980 bps



BIT RATE 5470 bps



Test specification:	Section 15.247(a)1, RSS-247 section 5.1(3), Number of hopping frequencies		
Test procedure:	Public notice DA 00-705		
Test mode:	Compliance	Verdict:	PASS
Date(s):	07-Oct-24		
Temperature: 24 ºC	Relative Humidity: 49 %	Air Pressure: 1002 hPa	Power: 3.6 VDC
Remarks:			

7.3 Number of hopping frequencies

7.3.1 General

This test was performed to calculate the number of hopping frequencies used by the EUT. Specification test limits are given in Table 7.3.1.

Table 7.3.1 Minimum number of hopping frequencies

Assigned frequency range, MHz	Number of hopping frequencies
902.0 – 928.0	No Requirements

7.3.2 Test procedure

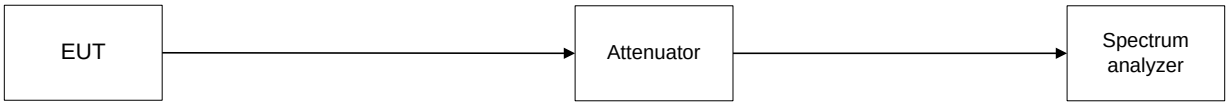
7.3.2.1 The EUT was set up as shown in Figure 7.3.1, energized with frequency hopping function enabled and its proper operation was checked.

7.3.2.2 Initially the spectrum analyzer span was set equal to frequency band of operation and the resolution bandwidth was set wider than 1 % of the frequency span. If the separate hopping channels were not clearly resolved the frequency band of operation was broken to sections and the resolution bandwidth was set wider than 1 % of the frequency span of each section.

7.3.2.3 The spectrum analyzer was set in max hold mode and allowed trace to stabilize.

7.3.2.4 The number of frequency hopping channels was calculated as provided in Table 7.3.2 and associated plots.

Figure 7.3.1 Hopping frequencies test setup



Test specification:	**Section 15.247(a)1, RSS-247 section 5.1(3), Number of hopping frequencies**		
Test procedure:	Public notice DA 00-705		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	07-Oct-24		
Temperature: 24 ºC	**Relative Humidity:** 49 %	**Air Pressure:** 1002 hPa	**Power:** 3.6 VDC
Remarks:			

Table 7.3.2 Hopping frequencies test results

ASSIGNED FREQUENCY: 902.0 – 928.0 MHz
MODULATION: LoRa
DETECTOR USED: Peak
RESOLUTION BANDWIDTH: ≥ 1% of the span
VIDEO BANDWIDTH: ≥ RBW
FREQUENCY HOPPING: Enabled

BIT RATE: 980 bps

Number of hopping frequencies	Minimum number of hopping frequencies	Margin*	Verdict
8	NA	NA	Pass

BIT RATE: 5470 bps

Number of hopping frequencies	Minimum number of hopping frequencies	Margin*	Verdict
8	NA	NA	Pass

* - Margin = Number of hopping frequencies – Minimum number of hopping frequencies.

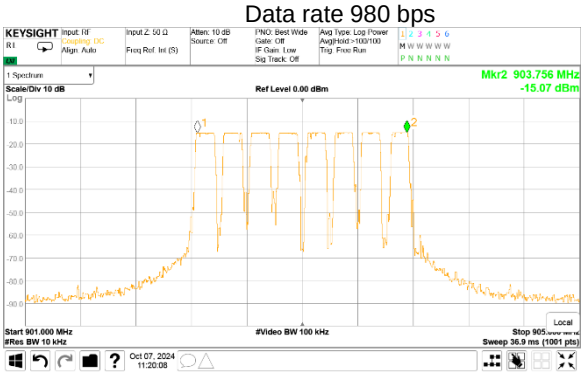
Reference numbers of test equipment used

HL 5376	HL 3434	HL 6105	HL 4135	HL 7546			

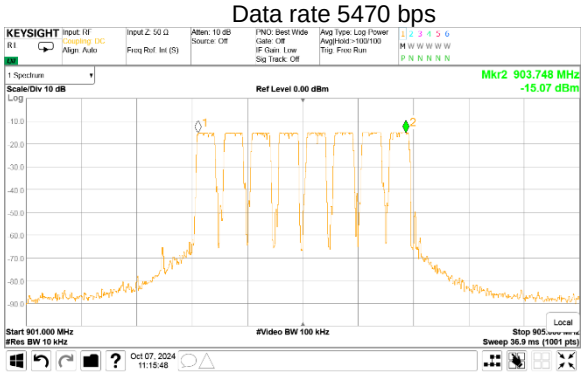
Full description is given in Appendix A.

Plot 7.3.1 Number of hopping frequencies

Data rate 980 bps



Data rate 5470 bps



Test specification:	Section 15.247(a)1, Average time of occupancy		
Test procedure:	Public notice DA 00-705		
Test mode:	Compliance	Verdict:	PASS
Date(s):	07-Oct-24		
Temperature: 24 ºC	Relative Humidity: 49 %	Air Pressure: 1002 hPa	Power: 3.6 VDC
Remarks: Hybrid			

7.4 Average time of occupancy

7.4.1 General

This test was performed to calculate the average time of occupancy (dwell time) on any frequency channel of the EUT. Specification test limits are given in Table 7.4.1.

Table 7.4.1 Average time of occupancy limits

Assigned frequency range, MHz	Maximum average time of occupancy, s	Investigated period, s*
902.0 – 928.0	0.4	3.2

*The Investigared Period equal to the number of hopping frequencies employed multiplied by 0.4.

7.4.2 Test procedure

7.4.2.1 The EUT was set up as shown in Figure 7.4.1, energized with frequency hopping function enabled and its proper operation was checked.

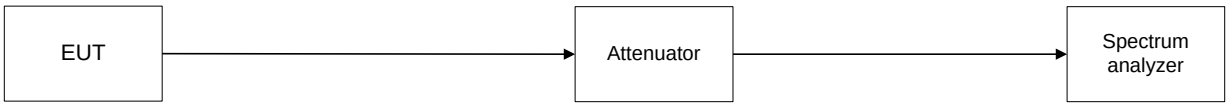
7.4.2.2 The spectrum analyzer span was set to zero centered on a hopping channel.

7.4.2.3 The single transmission duration and period were measured with oscilloscope.

7.4.2.4 The average time of occupancy was calculated as the single transmission time multiplied by the investigated period and divided by the single transmission period.

7.4.2.5 The test was repeated at each data rate and modulation type as provided in Table 7.4.2 and associated plots.

Figure 7.4.1 Average time of occupancy test setup



Test specification:	**Section 15.247(a)1, Average time of occupancy**		
Test procedure:	Public notice DA 00-705		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	07-Oct-24		
Temperature: 24 ºC	**Relative Humidity:** 49 %	**Air Pressure:** 1002 hPa	**Power:** 3.6 VDC
Remarks: Hybrid			

Table 7.4.2 Average time of occupancy test results

ASSIGNED FREQUENCY: 902.0-928.0 MHz
MODULATION: LoRa
DETECTOR USED: Peak
NUMBER OF HOPPING FREQUENCIES: 8
INVESTIGATED PERIOD: 3.2 s
FREQUENCY HOPPING: Enabled

Carrier frequency, MHz	Single transmission duration, s	Single transmission period, s	Average time of occupancy*, s	Bit rate, Mbps	Limit, s	Margin, s**	Verdict
902.3	0.37	3.2	0.37	980	0.4	-0.03	Pass
903.7	0.37	3.2	0.37	5470	0.4	-0.03	Pass

* - Average time of occupancy = (Single transmission duration × Investigated period) / (Single transmission period × number of hopping channels).
** - Margin = Average time of occupancy – specification limit.

Reference numbers of test equipment used

HL 5376	HL 3434	HL 6105	HL 7546	HL 4135			

Full description is given in Appendix A.

Plot 7.4.1 Single transmission duration

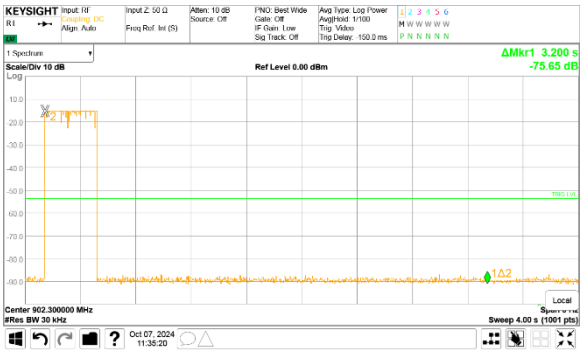
Data rate 980 bps

Data rate 5470 bps

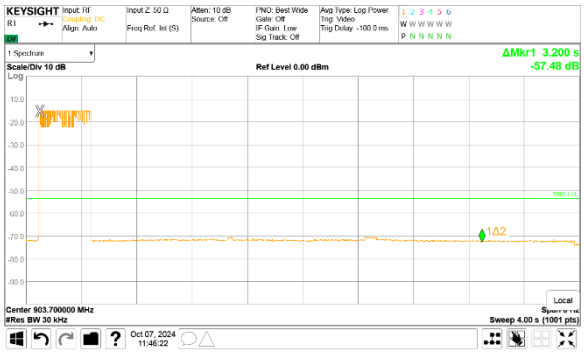
Test specification:	**Section 15.247(a)1, Average time of occupancy**		
Test procedure:	Public notice DA 00-705		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	07-Oct-24		
Temperature: 24 ºC	**Relative Humidity:** 49 %	**Air Pressure:** 1002 hPa	**Power:** 3.6 VDC
Remarks: Hybrid			

Plot 7.4.2 Number of transmissions within investigated period

Data rate 980 bps



Data rate 5470 bps



Test specification:	Section 15.247(b), RSS-247 section 5.4(1), Peak output power		
Test procedure:	ANSI C63.10, section 7.8.5		
Test mode:	Compliance	Verdict:	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	Relative Humidity: 48 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

7.5 Peak output power

7.5.1 General

This test was performed to measure the maximum peak output power radiated by transmitter. Specification test limits are given in Table 7.5.1.

Table 7.5.1 Peak output power limits

Assigned frequency range, MHz	Peak output power*		Equivalent field strength limit @ 3m, dB(μV/m)*	Maximum antenna gain, dBi
	W	dBm		
902.0 – 928.0	**0.25 (<50 hopping channels)** 1.0 (≥50 hopping channels)	**24.0(<50 hopping channels)** 30.0 (≥50 hopping channels)	**125.2 (<50 hopping channels)** 131.2 (≥50 hopping channels)	**6.0***

*- The limit is provided in terms of conducted RF power at the antenna connector. If transmitting antennas of directional gain greater than 6 dBi are used, the peak output power limit shall be reduced below the stated value as follows:

by 1 dB for every 3 dB that the directional gain of antenna exceeds 6 dBi for fixed point-to-point transmitters operate in 2400-2483.5 MHz band;
without any corresponding reduction for fixed point-to-point transmitters operate in 5725-5850 MHz band;
by the amount in dB that the directional gain of antenna exceeds 6 dBi for the rest of transmitters.

**- Equivalent field strength limit was calculated from the peak output power as follows: E=sqrt(30×P×G)/r, where P is peak output power in Watts, r is antenna to EUT distance in meters and G is transmitter antenna gain in dBi.

7.5.2 Test procedure

7.5.2.1 The EUT was set up as shown in Figure 7.5.1, energized and its proper operation was checked.

7.5.2.2 The EUT was adjusted to produce maximum available to end user RF output power.

7.5.2.3 The resolution bandwidth of spectrum analyzer was set wider than 6 dB bandwidth of the EUT and the field strength of the EUT carrier frequency was measured with antenna connected to spectrum analyzer/ EMI receiver. To find maximum radiation the turntable was rotated 360^0 and the measuring antenna height was swept in both vertical and horizontal polarizations.

7.5.2.4 The maximum field strength of the EUT carrier frequency was measured as provided in Table 7.5.2 and associated plots.

7.5.2.5 The maximum peak output power was calculated from the field strength of carrier as follows:

$$P = (E \times d)^2 / (30 \times G),$$

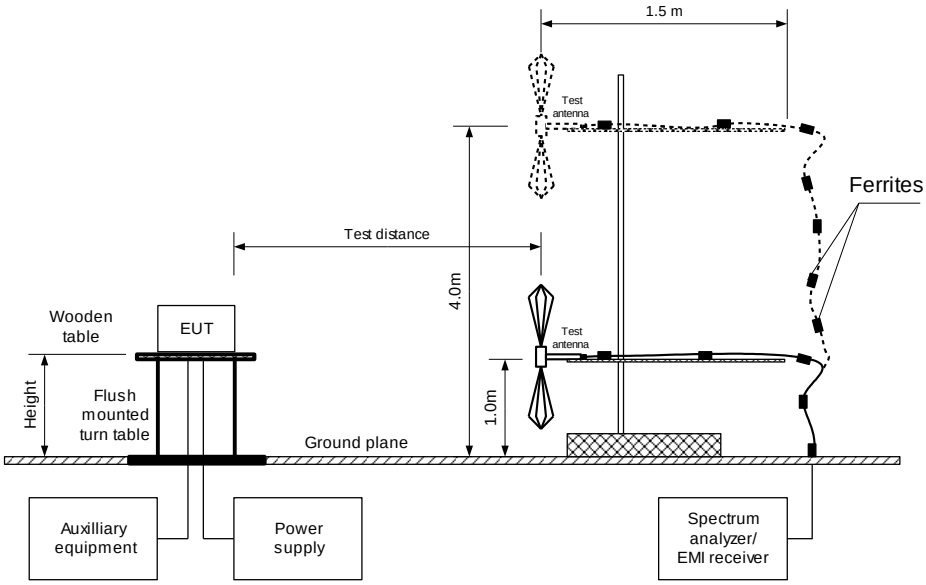
where P is the peak output power in W, E is the field strength in V/m, d is the test distance and G is the transmitter numeric antenna gain over an isotropic radiator.
The above equation was converted in logarithmic units for 3 m test distance:

Peak output power in dBm = Field strength in dB(μV/m) - Transmitter antenna gain in dBi – 95.2 dB

7.5.2.6 The worst test results (the lowest margins) were recorded in Table 7.5.2.

Test specification:	**Section 15.247(b), RSS-247 section 5.4(1), Peak output power**		
Test procedure:	ANSI C63.10, section 7.8.5		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

Figure 7.5.1 Setup for carrier field strength measurements



Test specification:	**Section 15.247(b), RSS-247 section 5.4(1), Peak output power**		
Test procedure:	ANSI C63.10, section 7.8.5		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

Table 7.5.2 Peak output power test results

ASSIGNED FREQUENCY:	902 - 928 MHz
TEST DISTANCE:	3 m
TEST SITE:	Semi anechoic chamber
EUT HEIGHT:	0.8 m
DETECTOR USED:	Peak
TEST ANTENNA TYPE:	Biconilog (30 MHz – 1000 MHz)
LORA	LORA
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum
DETECTOR USED:	Peak
EUT 6 dB BANDWIDTH:	300 kHz
RESOLUTION BANDWIDTH:	1 MHz

EUT: BRASS
BIT RATE: 980 bps

Frequency, MHz	Field strength, dB(μV/m)	Antenna polarization	Antenna height, m	Azimuth, degrees*	EUT antenna gain, dBi	Peak output power, dBm**	Limit, dBm	Margin, dB***	Verdict
902.3	102.88	V	1.1	-160	0	7.68	24	-16.32	Pass
902.9	103.48	V	1.1	-160	0	8.28	24	-15.72	Pass
903.7	103.38	V	1.1	180	0	8.18	24	-15.82	Pass

BIT RATE: 5470 bps

Frequency, MHz	Field strength, dB(μV/m)	Antenna polarization	Antenna height, m	Azimuth, degrees*	EUT antenna gain, dBi	Peak output power, dBm**	Limit, dBm	Margin, dB***	Verdict
902.3	103.52	V	1.1	-150	0	8.32	24	-15.68	Pass
902.9	103.25	V	1.1	-180	0	8.05	24	-15.95	Pass
903.7	103.42	V	1.1	-160	0	8.22	24	-15.78	Pass

EUT: POLYMER
BIT RATE: 980 bps

Frequency, MHz	Field strength, dB(μV/m)	Antenna polarization	Antenna height, m	Azimuth, degrees*	EUT antenna gain, dBi	Peak output power, dBm**	Limit, dBm	Margin, dB***	Verdict
902.3	101.46	V	1.1	180	0	6.26	24	-17.74	Pass
902.9	102.20	V	1.1	-110	0	7.00	24	-17.00	Pass
903.7	101.91	V	1.1	-140	0	6.71	24	-17.29	Pass

BIT RATE: 5470 bps

Frequency, MHz	Field strength, dB(μV/m)	Antenna polarization	Antenna height, m	Azimuth, degrees*	EUT antenna gain, dBi	Peak output power, dBm**	Limit, dBm	Margin, dB***	Verdict
902.3	102.18	V	1.15	-100	0	6.98	24	-17.02	Pass
902.9	102.09	V	1.15	-130	0	6.89	24	-17.11	Pass
903.7	102.11	V	1.20	-120	0	6.91	24	-17.09	Pass

*****- EUT front panel refer to 0 degrees position of turntable.
******- Peak output power was calculated from the field strength of carrier as follows: $P = (E \times d)^2 / (30 \times G)$,
where P is the peak output power in W, E is the field strength in V/m, d is the test distance in meters and G is the transmitter numeric antenna gain over an isotropic radiator. The above equation was converted in logarithmic units for 3 m test distance: *Peak output power in dBm = Field strength in dB(μV/m) - Transmitter antenna gain in dBi – 95.2 dB*
***- Margin = Peak output power – specification limit.
Note: Maximum peak output power was obtained at Unom (115%Unom, 85%Unom) input power voltage.

Reference numbers of test equipment used

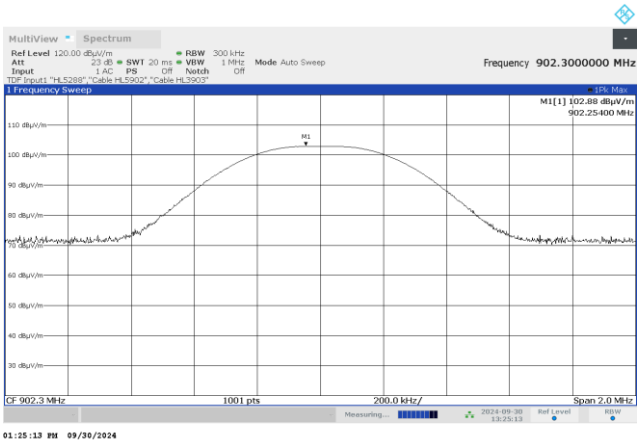
HL 3903	HL 5288	HL 5902	HL 7585				

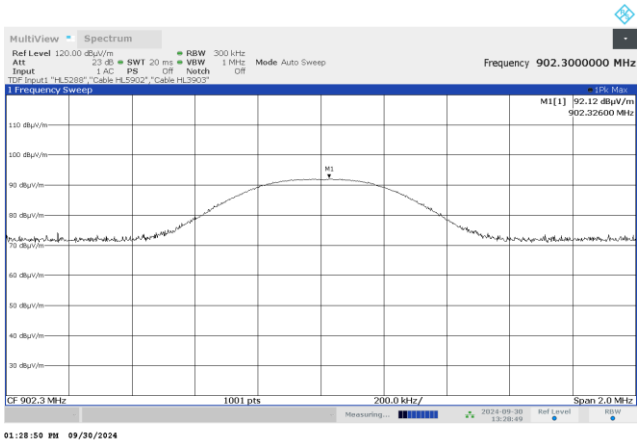
Full description is given in Appendix A.

Test specification:	**Section 15.247(b), RSS-247 section 5.4(1), Peak output power**		
Test procedure:	ANSI C63.10, section 7.8.5		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

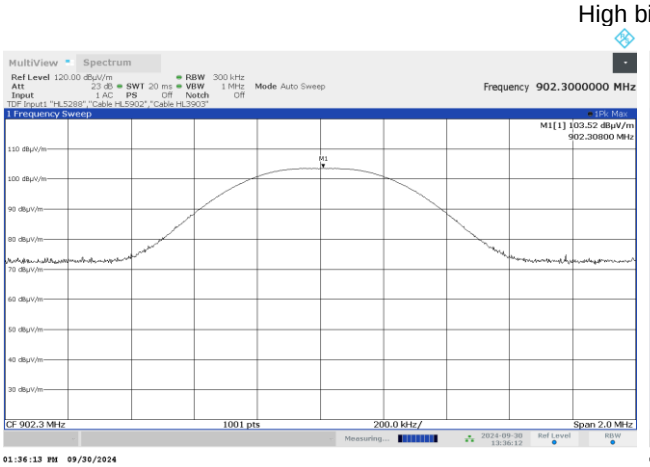
Plot 7.5.1 Field strength of carrier at low frequency (BRASS)

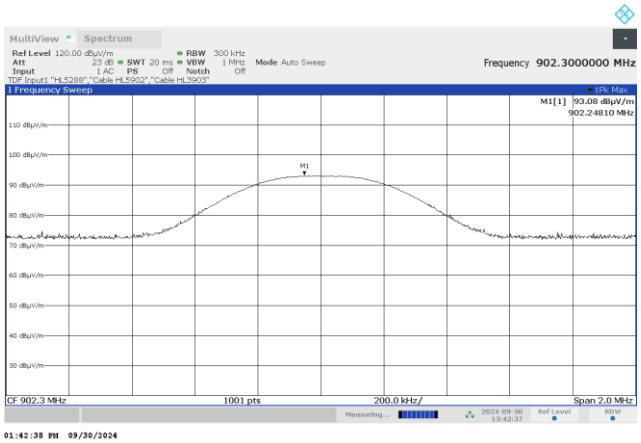
Low bit rate





High bit rate

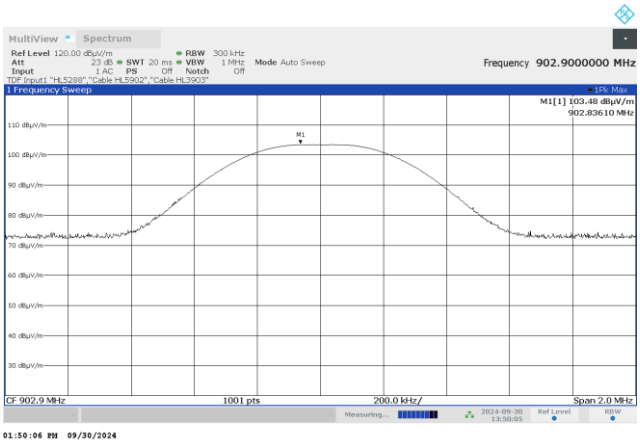


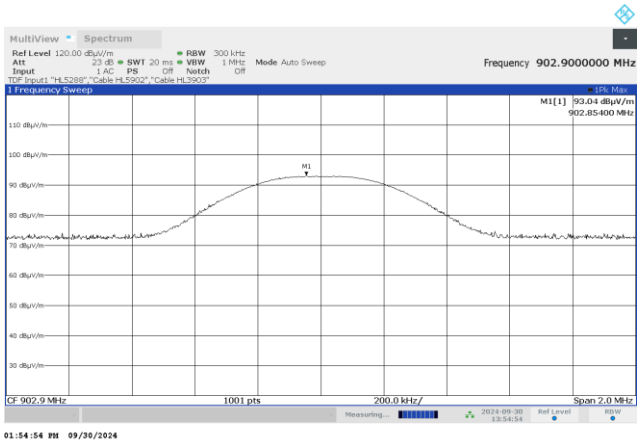


Test specification:	**Section 15.247(b), RSS-247 section 5.4(1), Peak output power**		
Test procedure:	ANSI C63.10, section 7.8.5		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

Plot 7.5.2 Field strength of carrier at mid frequency (BRASS)

Low bit rate





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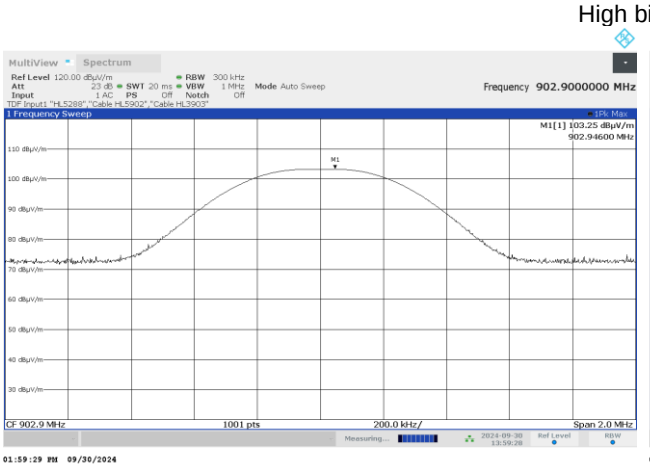
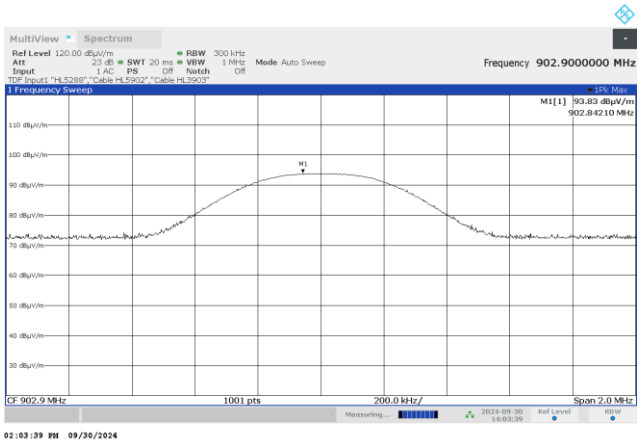
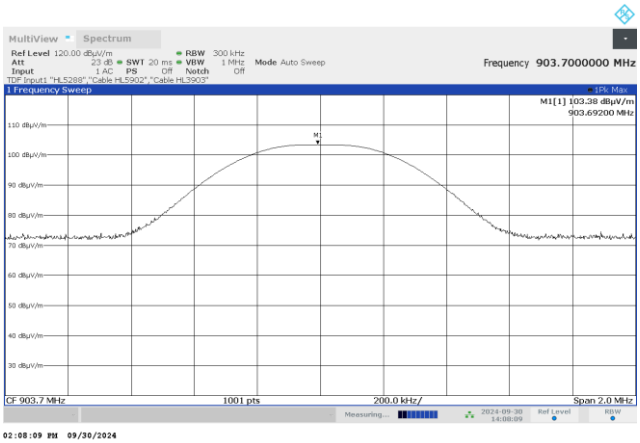


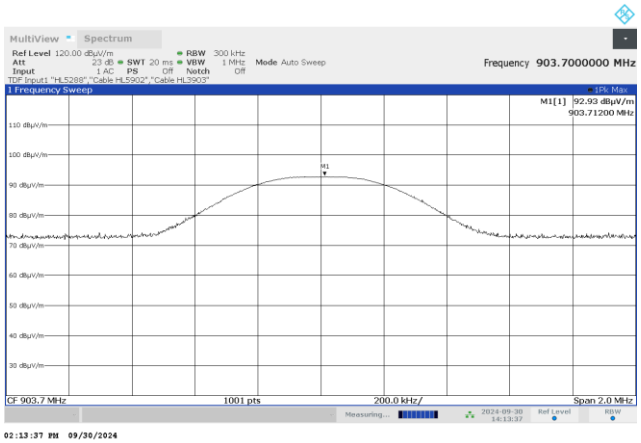


Test specification:	**Section 15.247(b), RSS-247 section 5.4(1), Peak output power**		
Test procedure:	ANSI C63.10, section 7.8.5		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

Plot 7.5.3 Field strength of carrier at high frequency (BRASS)

Low bit rate





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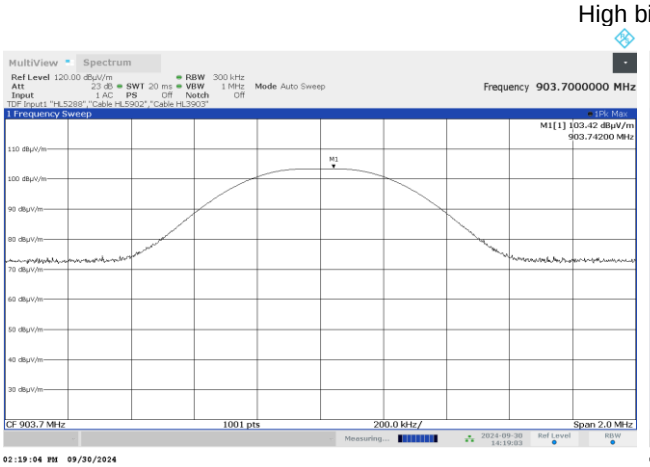
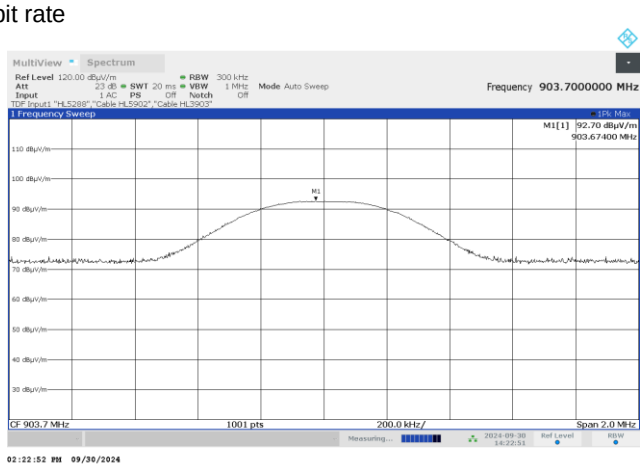
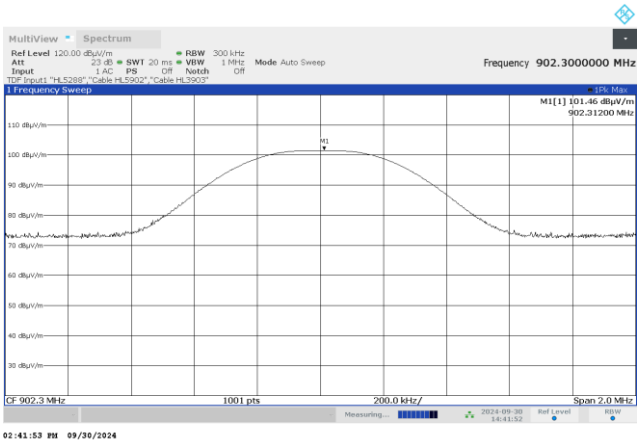


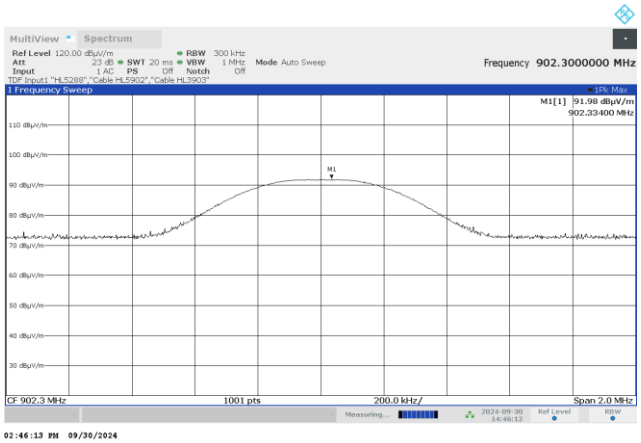


Test specification:	**Section 15.247(b), RSS-247 section 5.4(1), Peak output power**		
Test procedure:	ANSI C63.10, section 7.8.5		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

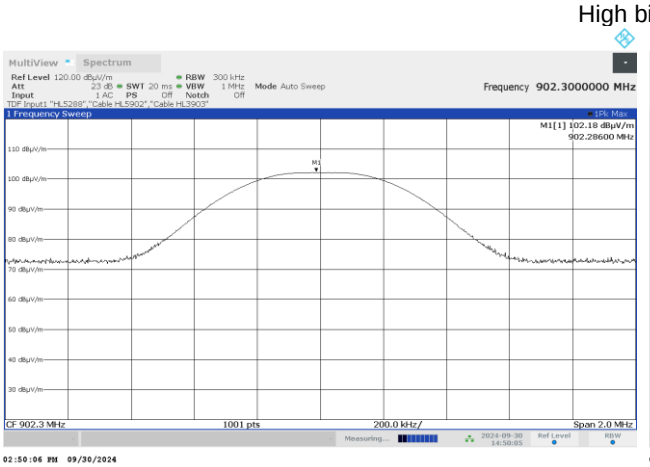
Plot 7.5.4 Field strength of carrier at low frequency (POLYMER)

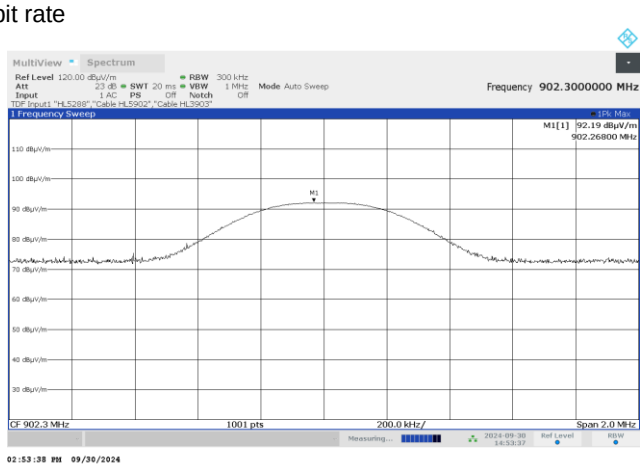
Low bit rate





High bit rate

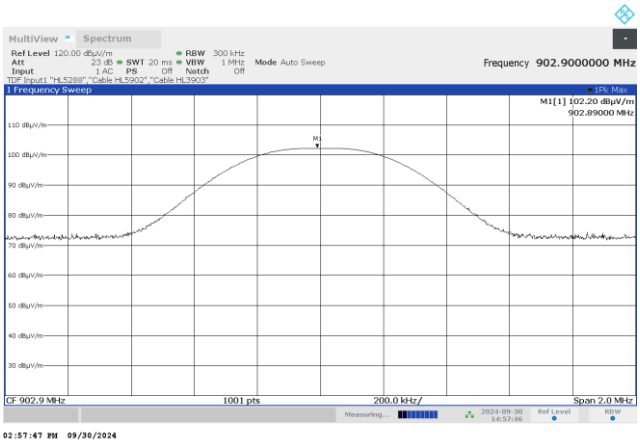


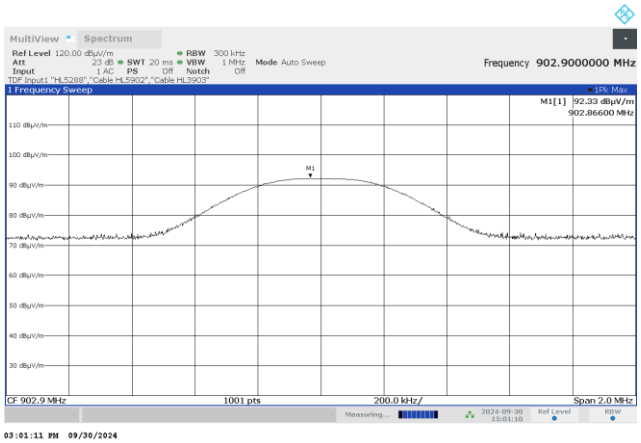


Test specification:	**Section 15.247(b), RSS-247 section 5.4(1), Peak output power**		
Test procedure:	ANSI C63.10, section 7.8.5		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

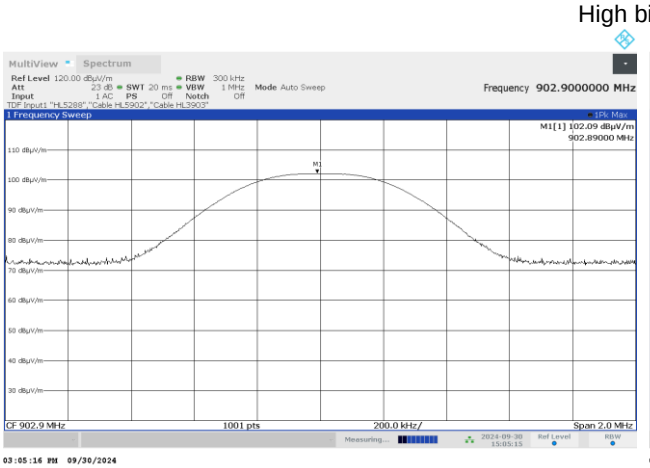
Plot 7.5.5 Field strength of carrier at mid frequency (POLYMER)

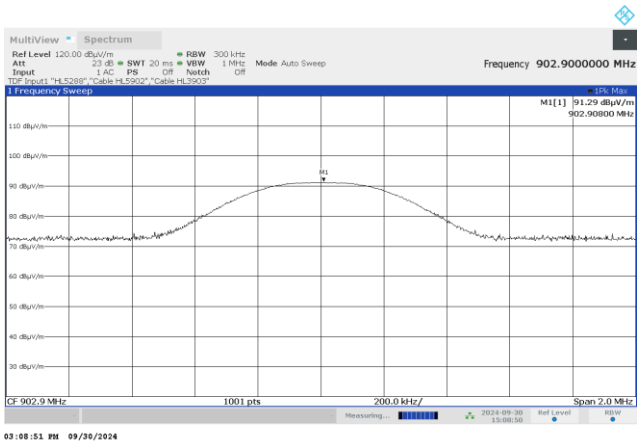
Low bit rate





High bit rate

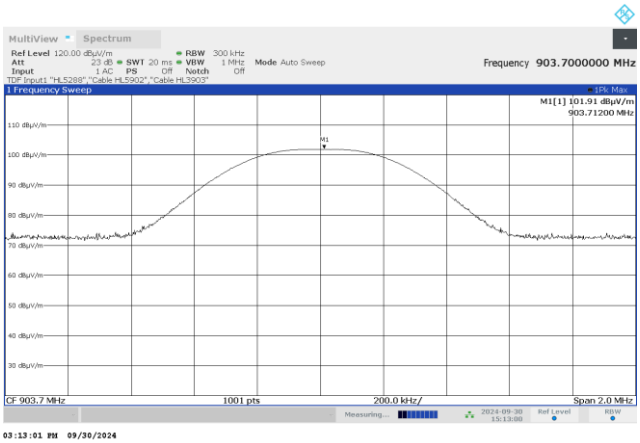


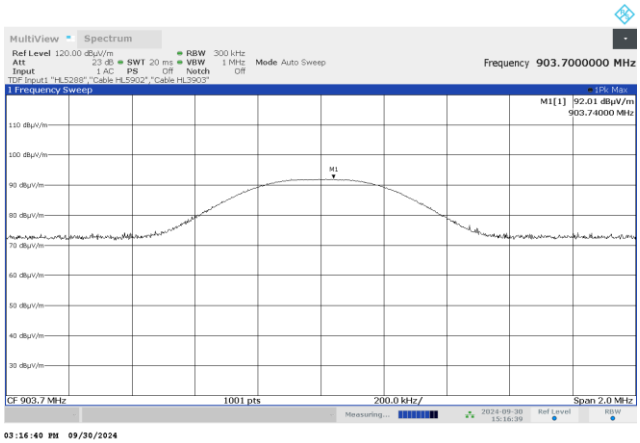


Test specification:	**Section 15.247(b), RSS-247 section 5.4(1), Peak output power**		
Test procedure:	ANSI C63.10, section 7.8.5		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

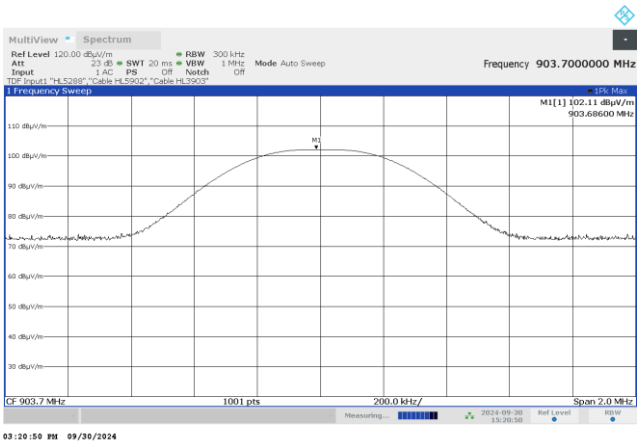
Plot 7.5.6 Field strength of carrier at high frequency (POLYMER)

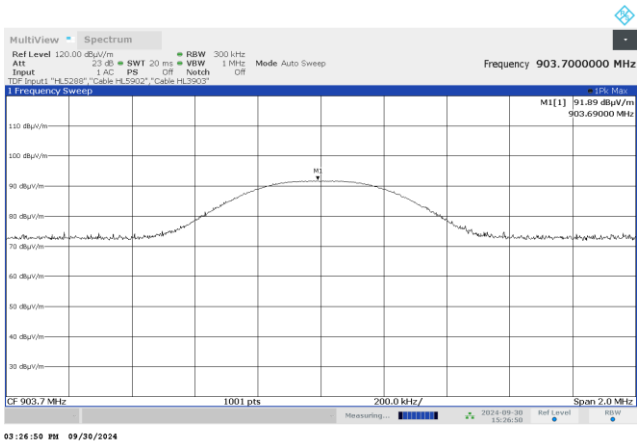
Low bit rate





High bit rate





Test specification:	Section 15.247(e) / RSS-247 section 5.2(2), Maximum power spectral density		
Test procedure:	ANSI C63.10 section 11.10.2		
Test mode:	Compliance	Verdict:	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	Relative Humidity: 48 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks: Hybrid			

7.6 Peak spectral power density

7.6.1 General

This test was performed to measure the maximum peak output power radiated by transmitter. Specification test limits are given in Table 7.6.1.

Table 7.6.1 Peak spectral power density limits

Assigned frequency range, MHz	Measurement bandwidth, kHz	Peak spectral power density, dBm	Equivalent field strength limit @ 3m, dB(μV/m)*
902.0 – 928.0	3.0	8.0	103.2
2400.0 – 2483.5			
5725.0 – 5850.0			

* - Equivalent field strength limit was calculated from the peak spectral power density as follows: E=sqrt(30×P)/r, where P is peak spectral power density and r is antenna to EUT distance in meters.

7.6.2 Test procedure for field strength measurements

7.6.2.1 The EUT was set up as shown in Figure 7.6.1, energized and its proper operation was checked.

7.6.2.2 The EUT was adjusted to produce maximum available to end user RF output power.

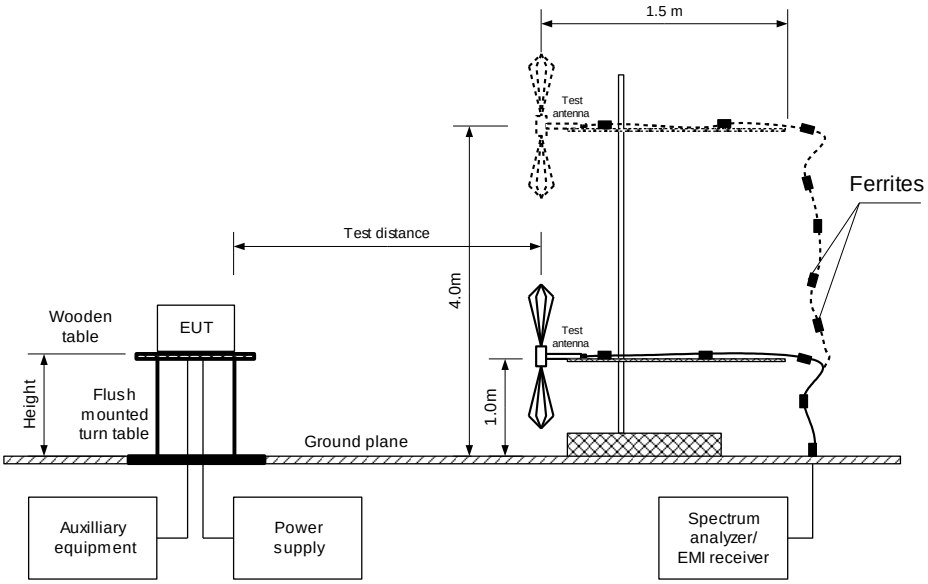
7.6.2.3 The field strength of the EUT carrier frequency was measured with antenna connected to spectrum analyzer/ EMI receiver. To find maximum radiation the turntable was rotated 360^0 and the measuring antenna height was swept in both vertical and horizontal polarizations.

7.6.2.4 The frequency span of spectrum analyzer was set to capture the entire 6 dB band of the transmitter, in peak hold mode with resolution bandwidth set to 3.0 kHz, video bandwidth wider than resolution bandwidth, auto sweep time and sufficient number of sweeps was allowed for trace stabilization. The spectrum lines spacing was verified to be wider than 3 kHz. Otherwise the resolution bandwidth was reduced until individual spectrum lines were resolved and the power of individual spectrum lines was integrated over 3 kHz band.

7.6.2.5 The peak of emission was zoomed with span set just wide enough to capture the emission peak area and sweep time was set equal to span width divided by resolution bandwidth. Spectrum analyzer was set in peak hold mode, sufficient number of sweeps was allowed for trace stabilization and peak spectral power density was measured as provided in Table 7.6.2 and associated plots.

Test specification:	**Section 15.247(e) / RSS-247 section 5.2(2), Maximum power spectral density**		
Test procedure:	ANSI C63.10 section 11.10.2		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks: Hybrid			

Figure 7.6.1 Setup for carrier field strength measurements



Test specification:	**Section 15.247(e) / RSS-247 section 5.2(2), Maximum power spectral density**		
Test procedure:	ANSI C63.10 section 11.10.2		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks: Hybrid			

Table 7.6.2 Field strength measurement of peak spectral power density

ASSIGNED FREQUENCY:	902 - 928 MHz
TEST DISTANCE:	3 m
TEST SITE:	Semi anechoic chamber
EUT HEIGHT:	0.8 m
DETECTOR USED:	Peak
RESOLUTION BANDWIDTH:	3 kHz
VIDEO BANDWIDTH:	10 kHz
TEST ANTENNA TYPE:	Biconilog
MODULATION:	LORA

EUT: BRASS
BIT RATE: 980 bps

Frequency, MHz	Field strength, dB(µV/m)	EUT antenna gain, dBi	Limit, dB(µV/m)	Margin, dB*	Antenna polarization	Antenna height, m	Turn-table position**, degrees
902.3	101.50	0	103.2	-1.7	V	1.10	-120
902.9	101.90	0	103.2	-1.3	V	1.08	-120
903.7	101.78	0	103.2	-1.42	V	1.10	-120

EUT: BRASS
BIT RATE: 5470 bps

Frequency, MHz	Field strength, dB(µV/m)	EUT antenna gain, dBi	Limit, dB(µV/m)	Margin, dB*	Antenna polarization	Antenna height, m	Turn-table position**, degrees
902.3	100.83	0	103.2	-2.37	V	1.10	-120
902.9	99.72	0	103.2	-3.48	V	1.10	-120
903.7	99.88	0	103.2	-3.32	V	1.10	-120

EUT: POLYMER
BIT RATE: 980 bps

Frequency, MHz	Field strength, dB(µV/m)	EUT antenna gain, dBi	Limit, dB(µV/m)	Margin, dB*	Antenna polarization	Antenna height, m	Turn-table position**, degrees
902.3	101.70	0	103.2	-1.50	V	1.10	-120
902.9	101.62	0	103.2	-1.58	V	1.10	-120
903.7	101.64	0	103.2	-1.56	V	1.10	-120

EUT: POLYMER
BIT RATE: 5470 bps:

Frequency, MHz	Field strength, dB(µV/m)	EUT antenna gain, dBi	Limit, dB(µV/m)	Margin, dB*	Antenna polarization	Antenna height, m	Turn-table position**, degrees
902.3	99.60	0	103.2	-3.60	V	1.10	-120
902.9	99.33	0	103.2	-3.87	V	1.10	-120
903.7	99.79	0	103.2	-3.41	V	1.10	-120

*****- Margin = Field strength - EUT antenna gain - calculated field strength limit.
******- EUT front panel refer to 0 degrees position of turntable.

Reference numbers of test equipment used

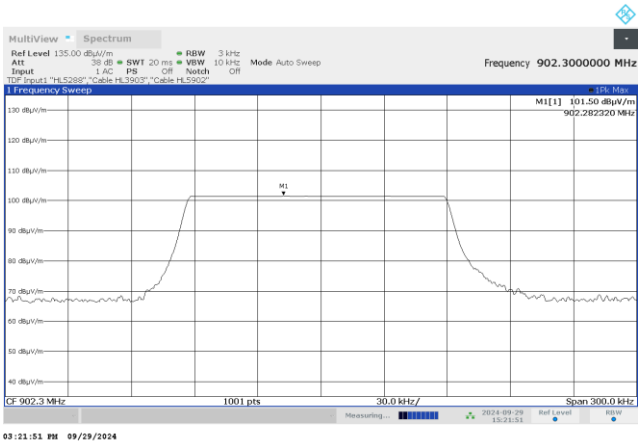
HL 3903	HL 5288	HL 5902	HL 7585				

Full description is given in Appendix A.

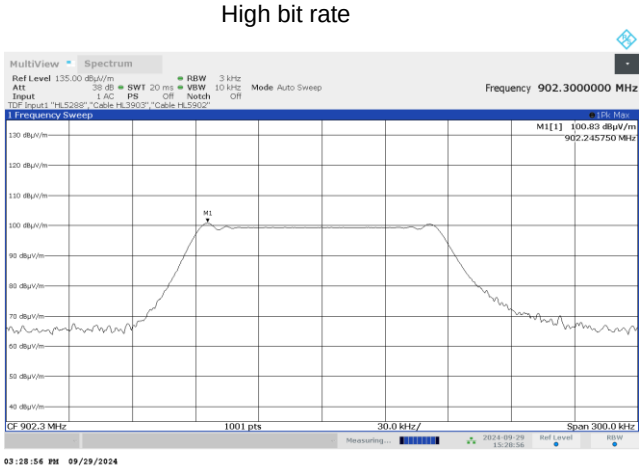
Test specification:	**Section 15.247(e) / RSS-247 section 5.2(2), Maximum power spectral density**		
Test procedure:	ANSI C63.10 section 11.10.2		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks: Hybrid			

Plot 7.6.1 Peak spectral power density at low frequency (BRASS)

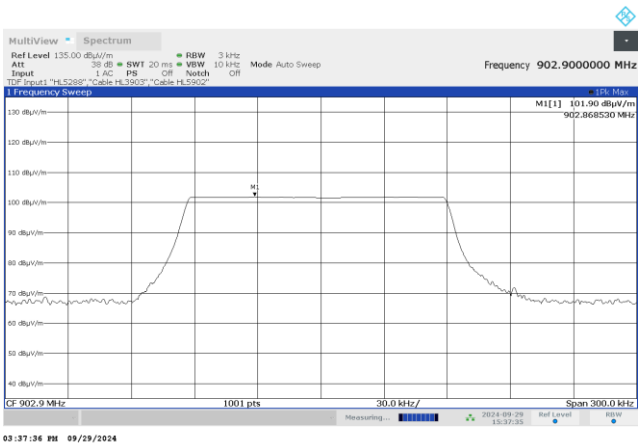
Low bit rate

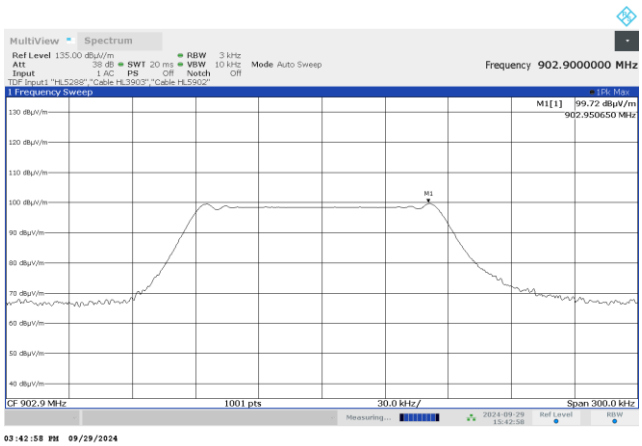


High bit rate



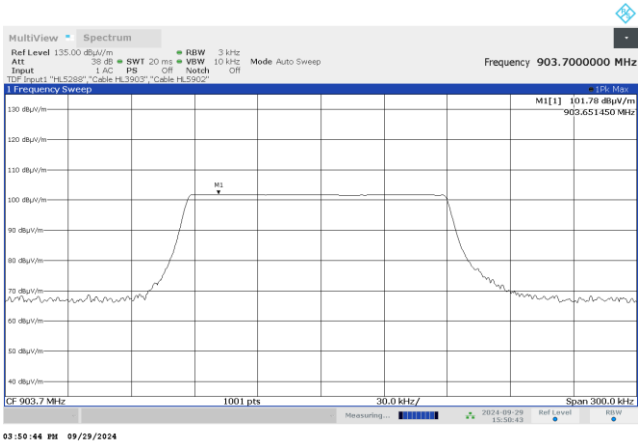
Plot 7.6.2 Peak spectral power density at mid frequency (BRASS)

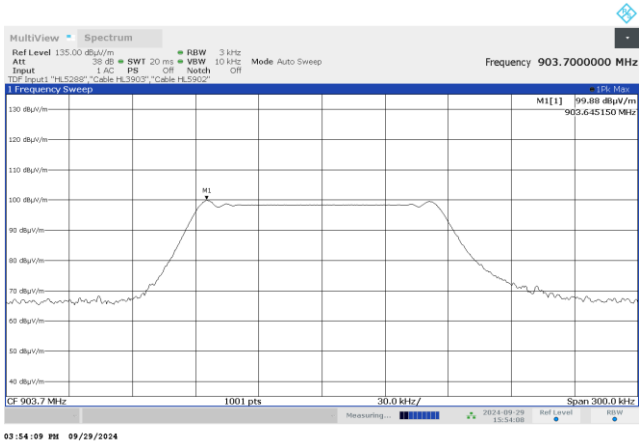




Test specification:	**Section 15.247(e) / RSS-247 section 5.2(2), Maximum power spectral density**		
Test procedure:	ANSI C63.10 section 11.10.2		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks: Hybrid			

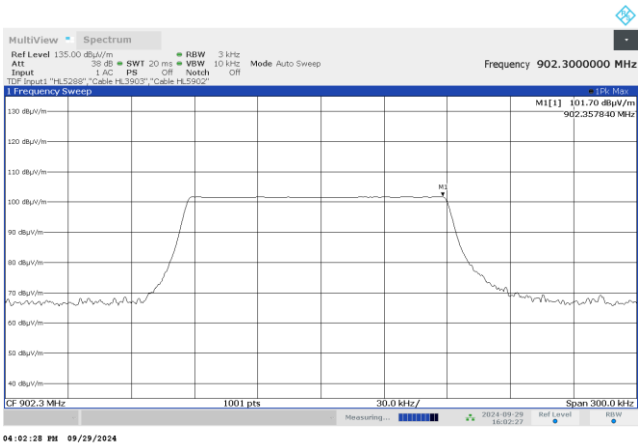
Plot 7.6.3 Peak spectral power density at high frequency (BRASS)



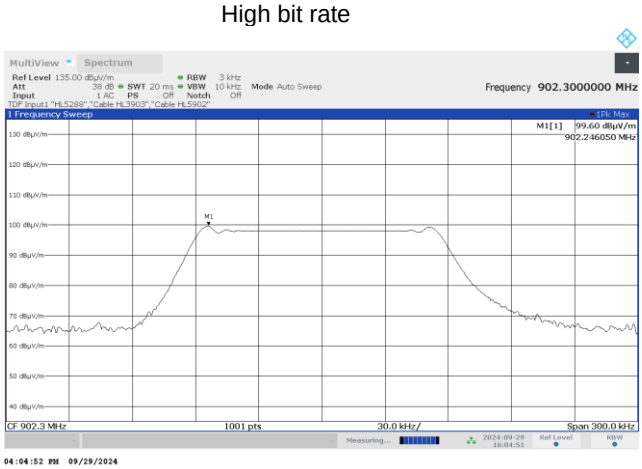


Plot 7.6.4 Peak spectral power density at low frequency (POLYMER)

Low bit rate



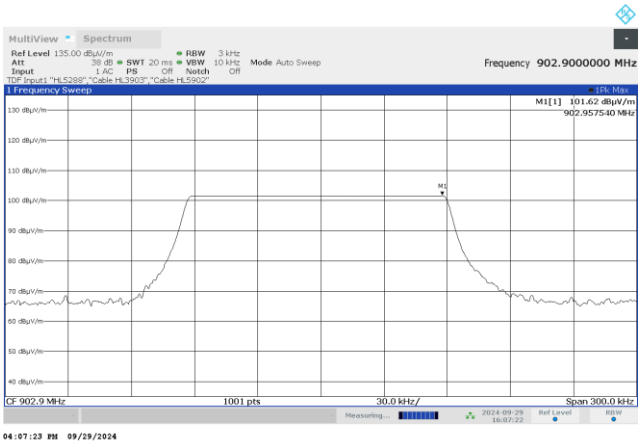
High bit rate



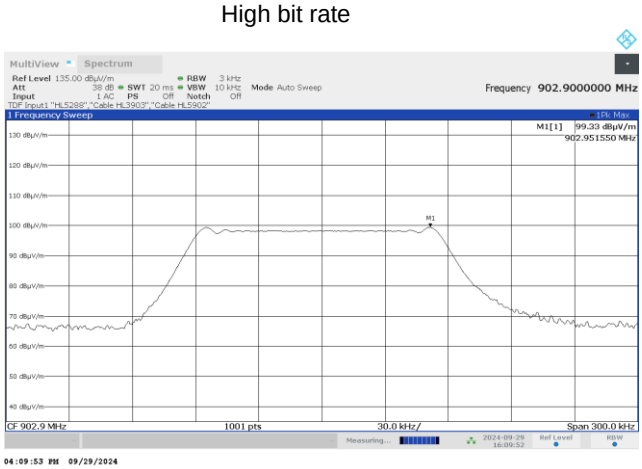
Test specification:	**Section 15.247(e) / RSS-247 section 5.2(2), Maximum power spectral density**		
Test procedure:	ANSI C63.10 section 11.10.2		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks: Hybrid			

Plot 7.6.5 Peak spectral power density at mid frequency (POLYMER)

Low bit rate

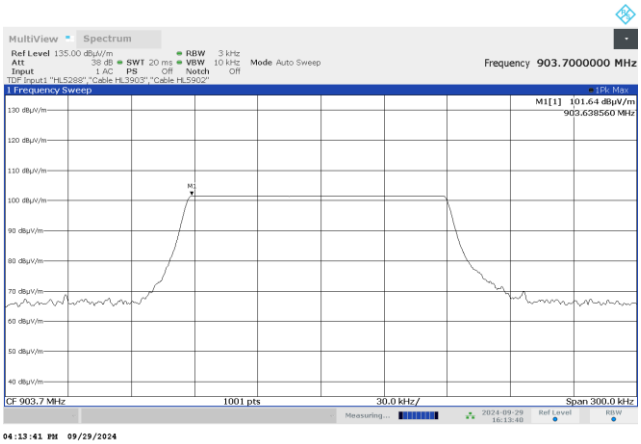


High bit rate

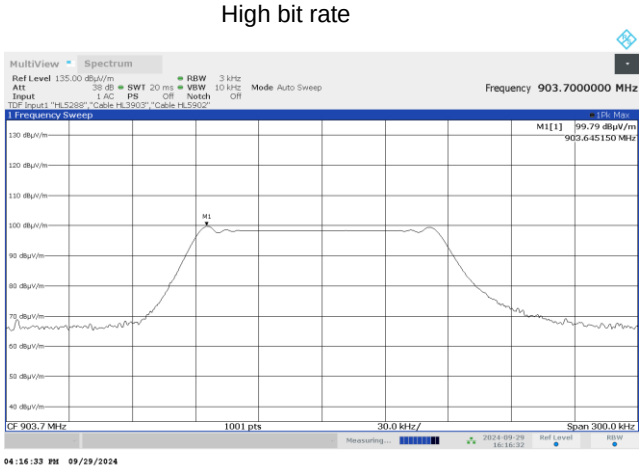


Plot 7.6.6 Peak spectral power density at high frequency (POLYMER)

Low bit rate



High bit rate



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

7.7 Field strength of spurious emissions

7.7.1 General

This test was performed to measure field strength of spurious emissions from the EUT. Specification test limits are given in Table 7.7.1.

Table 7.7.1 Radiated spurious emissions limits

Frequency, MHz	Field strength at 3 m within restricted bands, dB(μV/m)***			Attenuation of field strength of spurious versus carrier outside restricted bands, dBc***
	Peak	Quasi Peak	Average	
0.009 – 0.090	148.5 – 128.5	NA	128.5 – 108.5**	20.0
0.090 – 0.110	NA	108.5 – 106.8**	NA	
0.110 – 0.490	126.8 – 113.8	NA	106.8 – 93.8**	
0.490 – 1.705	NA	73.8 – 63.0**	NA	
1.705 – 30.0*		69.5		
30 – 88		40.0		
88 – 216		43.5		
216 – 960		46.0		
960 - 1000		54.0		
1000 – 10th harmonic	74.0	NA	54.0	

*- The limit for 3 m test distance was calculated using the inverse square distance extrapolation factor as follows:

$$Lim_{S2} = Lim_{S1} + 40 \log (S_1/S_2),$$

where S_1 and S_2 – standard defined and test distance respectively in meters.
**- The limit decreases linearly with the logarithm of frequency.
*** - The field strength limits applied from the lowest radio frequency generated in the device, without going below 9 kHz up to the tenth harmonic of the highest fundamental frequency.

7.7.2 Test procedure for spurious emission field strength measurements in 9 kHz to 30 MHz band

7.7.2.1 The EUT was set up as shown in Figure 7.7.1, energized and the performance check was conducted.

7.7.2.2 The specified frequency range was investigated with antenna connected to spectrum analyzer/ EMI receiver. To find maximum radiation the turntable was rotated 360^0 and the measuring antenna was rotated around its vertical axis.

7.7.2.3 The worst test results (the lowest margins) were recorded and shown in the associated plots.

7.7.3 Test procedure for spurious emission field strength measurements above 30 MHz

The EUT was set up as shown in Figure 7.7.2,

Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

7.7.3.1 Figure 7.7.3, energized and the performance check was conducted.

7.7.3.2 The specified frequency range was investigated with antenna connected to spectrum analyzer/ EMI receiver. To find maximum radiation the turntable was rotated 360^0, the measuring antenna height was changed from 1 to 4 m, its polarization was switched from vertical to horizontal.

7.7.3.3 The worst test results (the lowest margins) were recorded and shown in the associated plots.

Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

Figure 7.7.1 Setup for spurious emission field strength measurements below 30 MHz

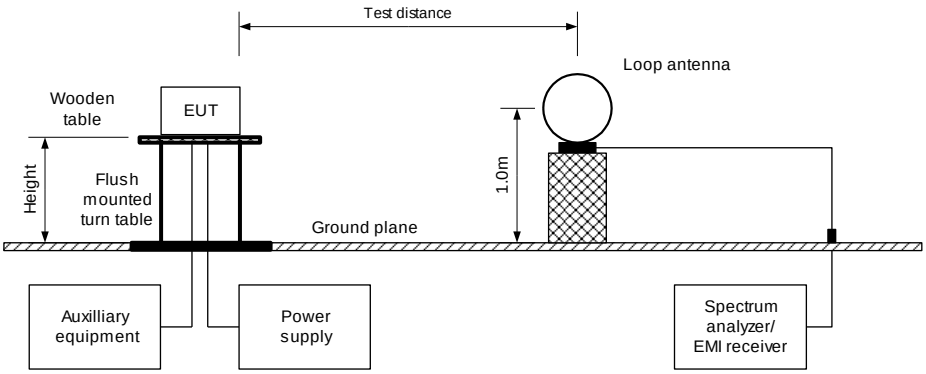
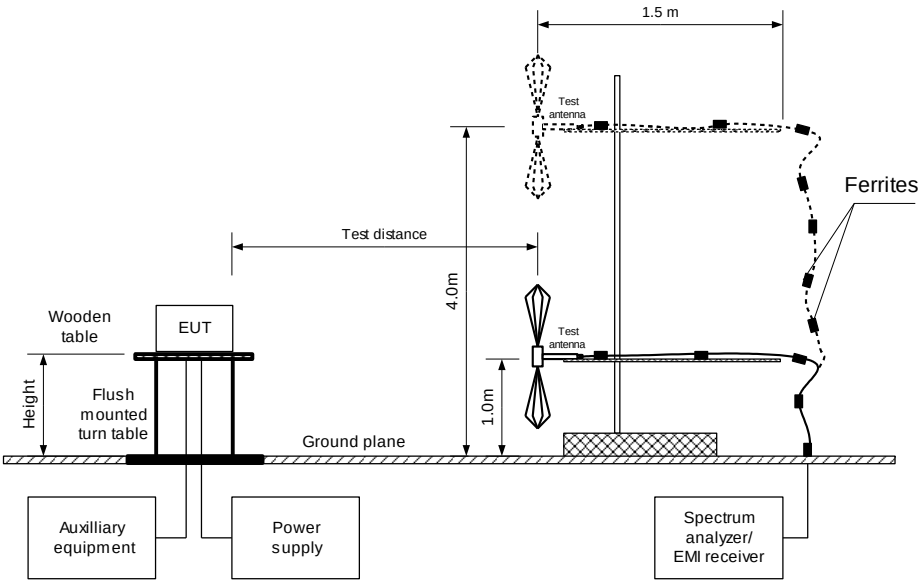
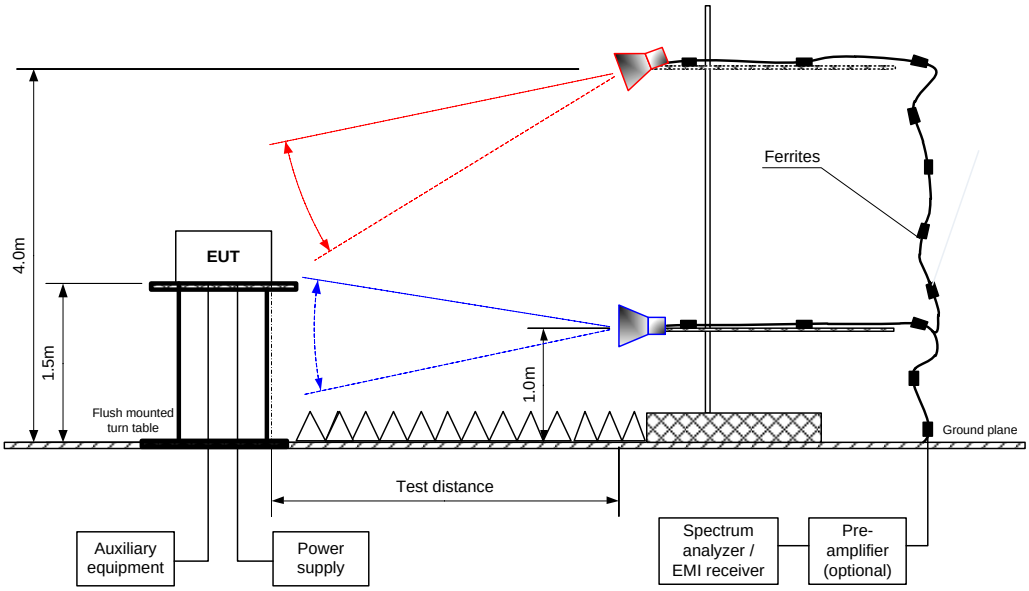


Figure 7.7.2 Setup for spurious emission field strength measurements from 30 to 1000 MHz



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

Figure 7.7.3 Setup for spurious emission field strength measurements above1000 MHz



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

Table 7.7.2 Field strength of emissions outside restricted bands

ASSIGNED FREQUENCY:	902-928 MHz
INVESTIGATED FREQUENCY RANGE:	0.009 -9500 MHz
TEST DISTANCE:	3 m
DUTY CYCLE:	100 %
MODULATION:	CSS
RESOLUTION BANDWIDTH:	100 kHz
VIDEO BANDWIDTH:	300 kHz
TEST ANTENNA TYPE:	Active loop (9 kHz – 30 MHz) Biconilog (30 MHz – 1000 MHz) Double ridged guide (above 1000 MHz)
FREQUENCY HOPPING:	Disabled

Frequency, MHz	Field strength of spurious, dB(μV/m)	Antenna polarization	Antenna height, m	Azimuth, degrees*	Field strength of carrier, dB(μV/m)	Attenuation below carrier, dBc	Limit, dBc	Margin, dB**	Verdict
Low carrier frequency									
1804.6	44.1	Vertical	1.45	20	124.8	80.7	20	60.7	Pass
Mid carrier frequency									
1817.4	44.8	Vertical	1.50	-41	125.1	80.6	20	60.6	Pass
High carrier frequency									
1829.8	47.3	Vertical	1.60	86	124.7	77.4	20	57.4	Pass
6404.3	54.6	Vertical	1.50	-90		70.1		50.1	Pass

*****- EUT front panel refers to 0 degrees position of turntable.
******- Margin = Attenuation below carrier – specification limit.

Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

Table 7.7.3 Field strength of spurious emissions above 1 GHz within restricted bands

ASSIGNED FREQUENCY: 902-928 MHz
INVESTIGATED FREQUENCY RANGE: 1000 - 9500 MHz
TEST DISTANCE: 3 m
MODULATION: CSS
DUTY CYCLE: 100 %
TRANSMITTER OUTPUT POWER SETTINGS: Maximum
DETECTOR USED: Peak
RESOLUTION BANDWIDTH: 1000 kHz
TEST ANTENNA TYPE: Double ridged guide
FREQUENCY HOPPING: Disabled

Frequency, MHz	Antenna		Azimuth, degrees*	Peak field strength			Average field strength				Verdict
	Polarization	Height, m		Measured, dB(μV/m)	Limit, dB(μV/m)	Margin, dB**	Measured, dB(μV/m)	Calculated, dB(μV/m)	Limit, dB(μV/m)	Margin, dB***	
Low carrier frequency											
2706.9	Vertical	1.5	60	43.6	74	-30.4	43.6	NA	54	-10.4	Pass
3609.2	Vertical	1.5	180	44.9	74	-29.1	44.9	NA	54	-9.1	Pass
Mid carrier frequency											
2726.1	Vertical	1.5	72	45.4	74	-28.6	45.4	NA	54	-8.6	Pass
3634.8	Vertical	1.5	180	44.3	74	-29.7	44.9	NA	54	-9.7	Pass
High carrier frequency											
2744.7	Vertical	1.5	80	46.8	74	-27.2	46.8	NA	54	-7.2	Pass
4574.5	Vertical	1.5	180	47.7	74	-26.3	47.7	NA	54	-6.3	Pass

*****- EUT front panel refers to 0 degrees position of turntable.
******- Margin = Measured field strength - specification limit.
***- Margin = Calculated field strength - specification limit,
where Calculated field strength = Measured field strength + average factor.

Table 7.7.4 Average factor calculation

Transmission pulse		Transmission burst		Transmission train duration, ms	Average factor, dB
Duration, ms	Period, ms	Duration, ms	Period, ms		
NA	NA	NA	NA	NA	NA

*- Average factor was calculated as follows

for pulse train shorter than 100 ms: $$Average\ factor = 20 \times \log_{10}\left(\frac{Pulse\ duration}{Pulse\ period} \times \frac{Burst\ duration}{Train\ duration} \times Number\ of\ bursts\ within\ pulse\ train\right)$$

for pulse train longer than 100 ms: $$Average\ factor = 20 \times \log_{10}\left(\frac{Pulse\ duration}{Pulse\ period} \times \frac{Burst\ duration}{100\ ms} \times Number\ of\ bursts\ within\ 100\ ms\right)$$

Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

Table 7.7.5 Field strength of spurious emissions below 1 GHz within restricted bands

ASSIGNED FREQUENCY:	902-928 MHz
INVESTIGATED FREQUENCY RANGE:	0.009 – 1000 MHz
TEST DISTANCE:	3 m
MODULATION:	CSS
DUTY CYCLE:	100 %
RESOLUTION BANDWIDTH:	0.2 kHz (9 kHz – 150 kHz) 9.0 kHz (150 kHz – 30 MHz) 120 kHz (30 MHz – 1000 MHz)
VIDEO BANDWIDTH:	> Resolution bandwidth
TEST ANTENNA TYPE:	Active loop (9 kHz – 30 MHz) Biconilog (30 MHz – 1000 MHz)
FREQUENCY HOPPING:	Disabled

Frequency, MHz	Peak emission, dB(μV/m)	Quasi-peak			Antenna polarization	Antenna height, m	Turn-table position**, degrees	Verdict
		Measured emission, dB(μV/m)	Limit, dB(μV/m)	Margin, dB*				
Low, Mid, High carrier frequency								
No emissions were found								Pass

*****- Margin = Measured emission - specification limit.
******- EUT front panel refer to 0 degrees position of turntable.

Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

Table 7.7.6 Restricted bands according to FCC section 15.205

MHz	MHz	MHz	MHz	MHz	GHz
0.09 - 0.11	8.37625 - 8.38675	73 - 74.6	399.9 - 410	2690 - 2900	10.6 - 12.7
0.495 - 0.505	8.41425 - 8.41475	74.8 - 75.2	608 - 614	3260 - 3267	13.25 - 13.4
2.1735 - 2.1905	12.29 - 12.293	108 - 121.94	960 - 1240	3332 - 3339	14.47 - 14.5
4.125 - 4.128	12.51975 - 12.52025	123 - 138	1300 - 1427	3345.8 - 3358	15.35 - 16.2
4.17725 - 4.17775	12.57675 - 12.57725	149.9 - 150.05	1435 - 1626.5	3600 - 4400	17.7 - 21.4
4.20725 - 4.20775	13.36 - 13.41	156.52475 - 156.52525	1645.5 - 1646.5	4500 - 5150	22.01 - 23.12
6.215 - 6.218	16.42 - 16.423	156.7 - 156.9	1660 - 1710	5350 – 5460	23.6 - 24
6.26775 - 6.26825	16.69475 - 16.69525	162.0125 - 167.17	1718.8 - 1722.2	7250 - 7750	31.2 - 31.8
6.31175 - 6.31225	16.80425 - 16.80475	167.72 - 173.2	2200 - 2300	8025 – 8500	36.43 - 36.5
8.291 - 8.294	25.5 - 25.67	240 - 285	2310 - 2390	9000 - 9200	Above 38.6
8.362 - 8.366	37.5 - 38.25	322 - 335.4	2483.5 - 2500	9300 - 9500	

Table 7.7.7 Restricted bands according to RSS-Gen

MHz	MHz	MHz	MHz	MHz	GHz
0.09 - 0.11	8.291 - 8.294	16.80425 - 16.80475	399.9 - 410	3260 - 3267	10.6 - 12.7
2.1735 - 2.1905	8.362 - 8.366	25.5 - 25.67	608 - 614	3332 – 3339	13.25 - 13.4
3.020 – 3.026	8.37625 - 8.38675	37.5 - 38.25	960 – 1427	3345.8 – 3358	14.47 – 14.5
4.125 – 4.128	8.41425 - 8.41475	73 - 74.6	1435 – 1626.5	3500 – 4400	15.35 – 16.2
4.17725 – 4.17775	12.29 – 12.293	74.8 - 75.2	1645.5 – 1646.5	4500 – 5150	17.7 – 21.4
4.20725 – 4.20775	12.51975 – 12.52025	108 – 138	1660 - 1710	5350 – 5460	22.01 – 23.12
5.677 – 5.683	12.57675 – 12.57725	156.52475 – 156.52525	1718.8 - 1722.2	7250 - 7750	23.6 - 24
6.215 - 6.218	13.36 – 13.41	156.7 - 156.9	2200 - 2300	8025 – 8500	31.2 - 31.8
6.26775 - 6.26825	16.42 - 16.423	240 - 285	2310 - 2390	9000 - 9200	36.43 - 36.5
6.31175 - 6.31225	16.69475 - 16.69525	322 - 335.4	2655 - 2900	9300 - 9500	Above 38.6

Reference numbers of test equipment used

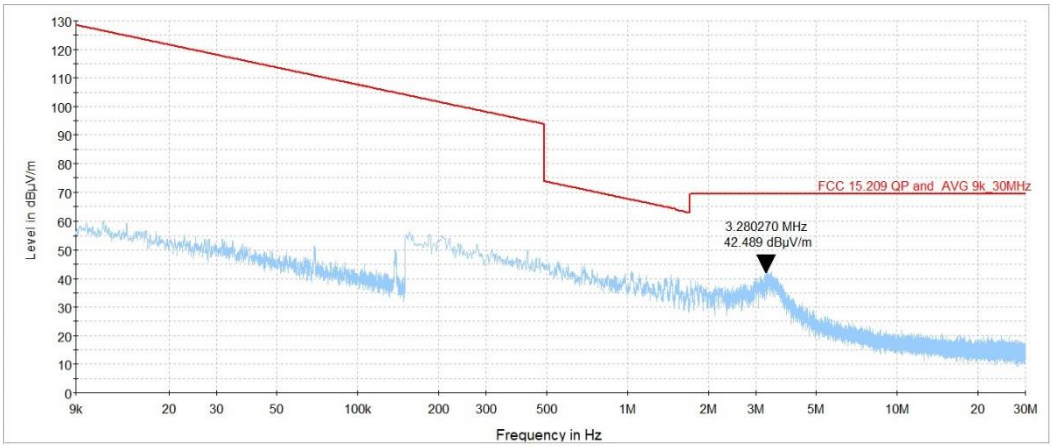
HL 466	HL5288	HL4933	HL 7585	HL 6252	HL 3903	HL 5902	HL 4339

Full description is given in Appendix A.

Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

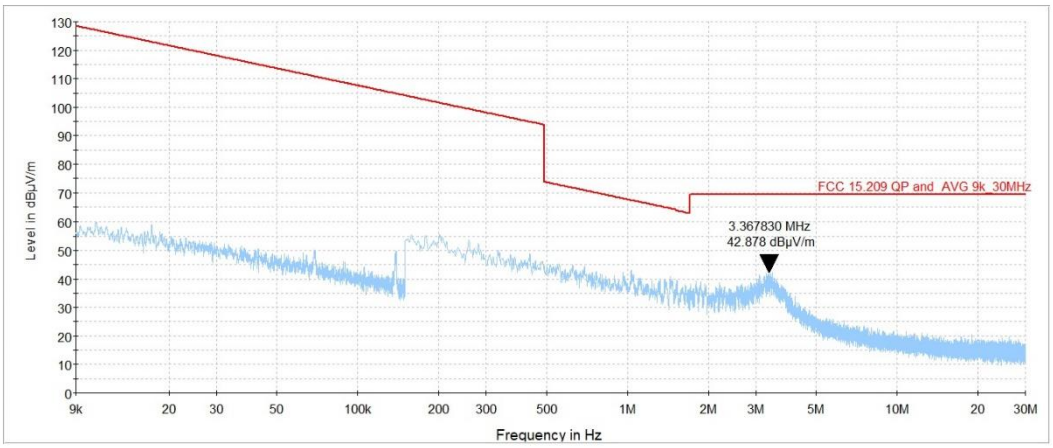
Plot 7.7.1 Radiated emission measurements from 9 kHz to 30 MHz at the low carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical



Plot 7.7.2 Radiated emission measurements from 9 kHz to 30 MHz at the mid carrier frequency

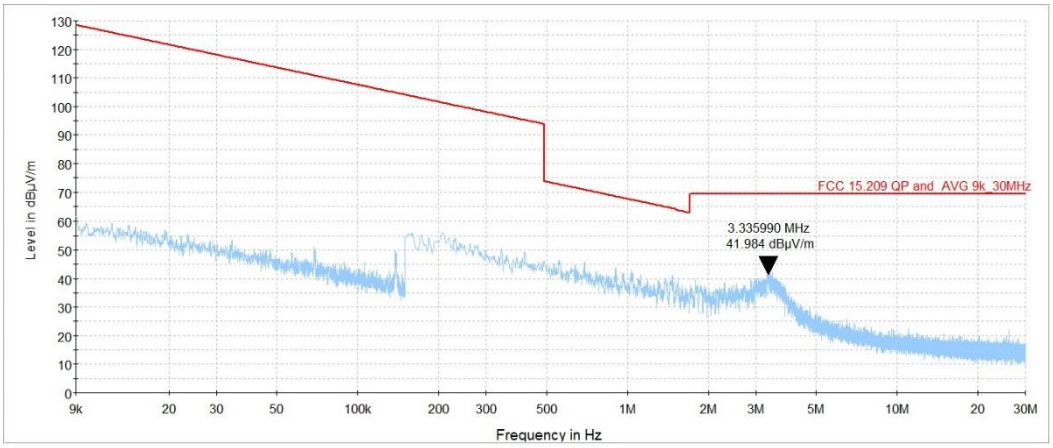
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

Plot 7.7.3 Radiated emission measurements from 9 kHz to 30 MHz at the high carrier frequency

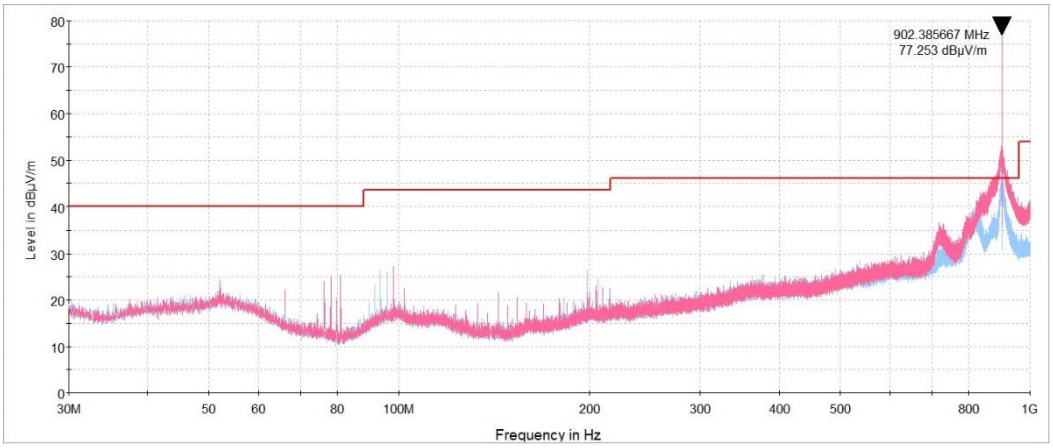
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical

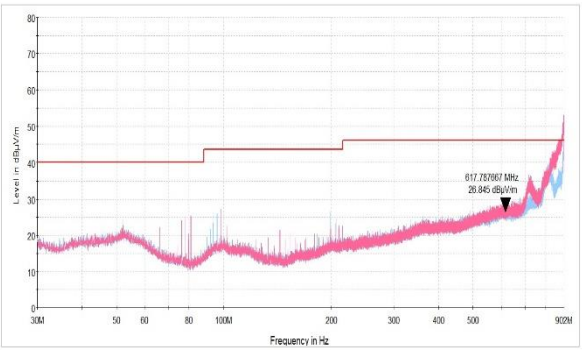


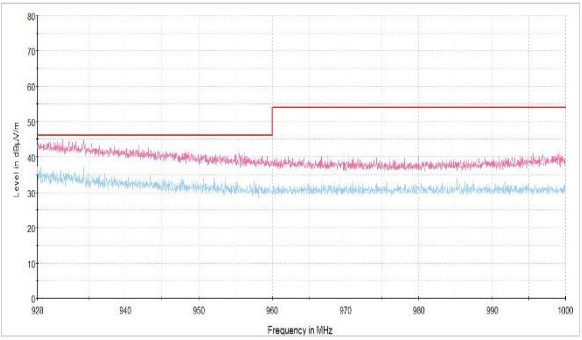
Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

Plot 7.7.4 Radiated emission measurements from 30 to 1000 MHz at the low carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



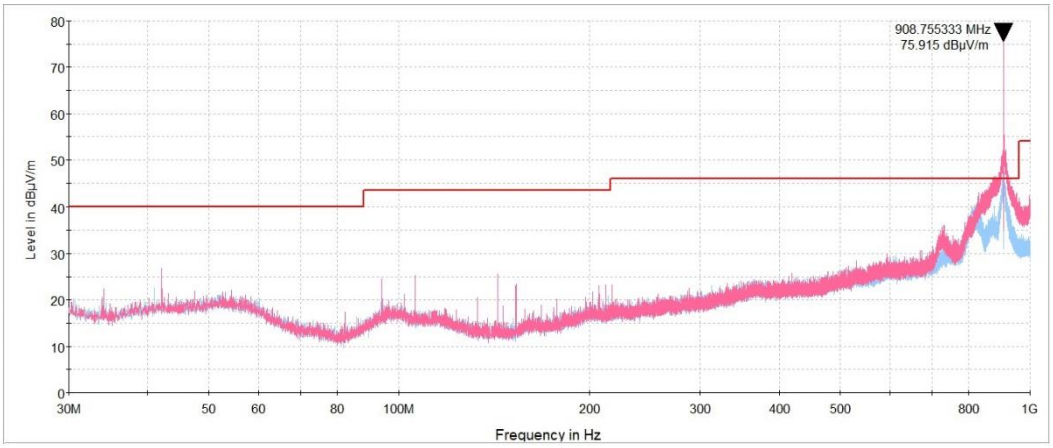


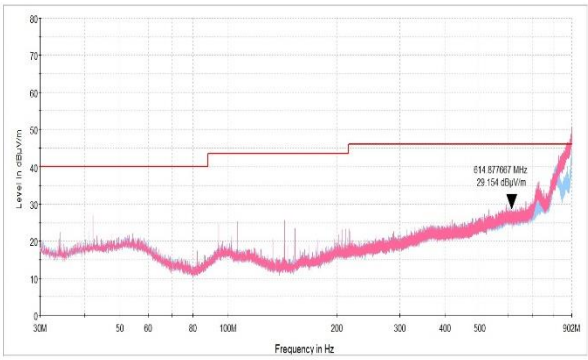


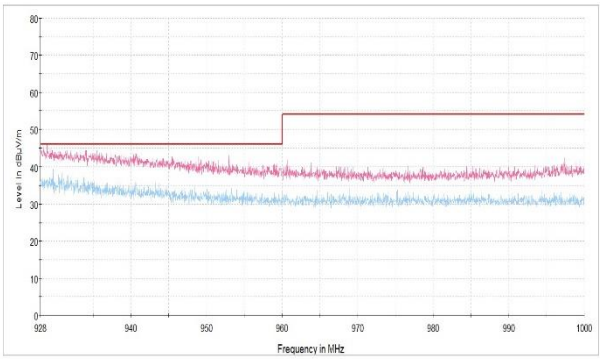
Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

Plot 7.7.5 Radiated emission measurements from 30 to 1000 MHz at the mid carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



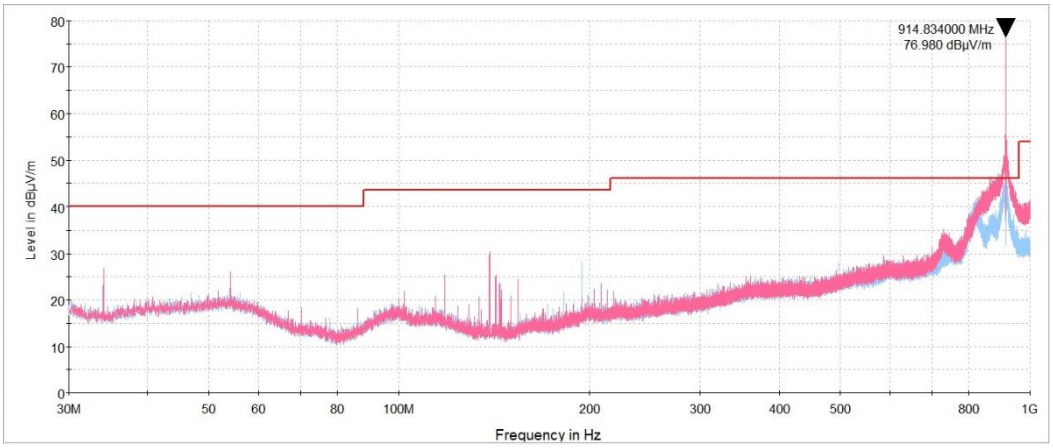


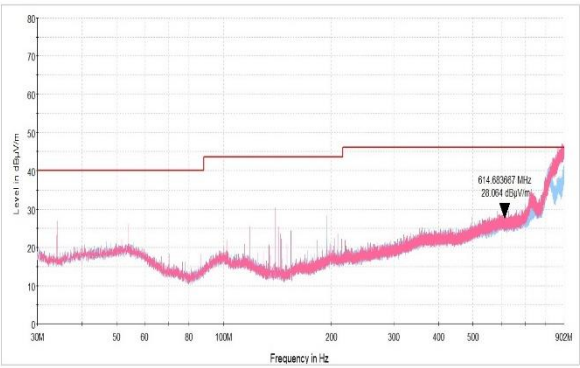


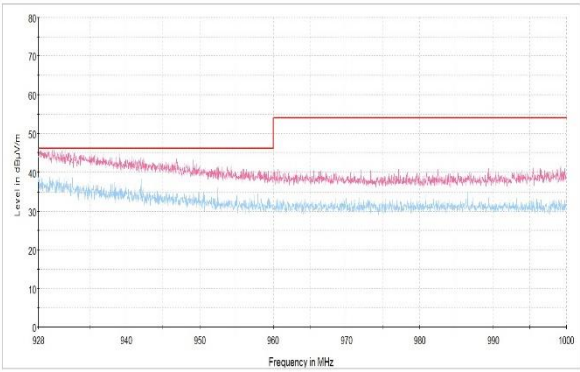
Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

Plot 7.7.6 Radiated emission measurements from 30 to 1000 MHz at the high carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



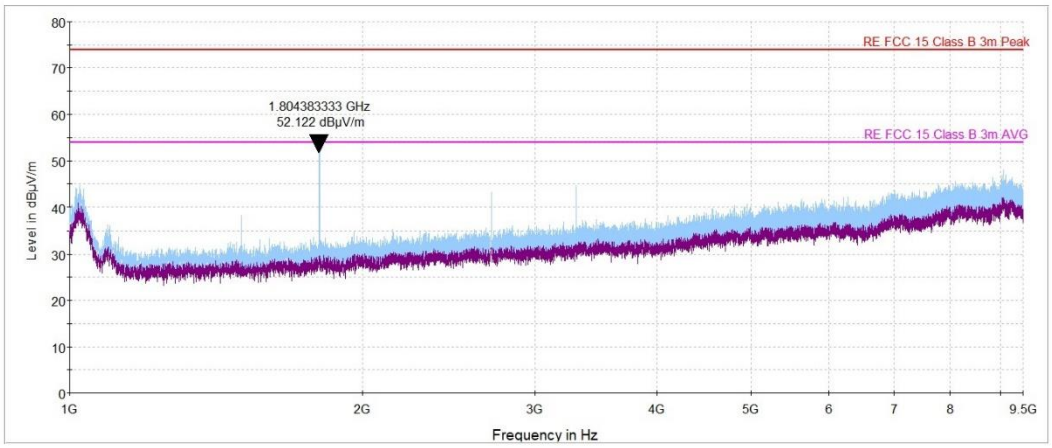




Test specification:	Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	Verdict:	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	Relative Humidity: 48 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

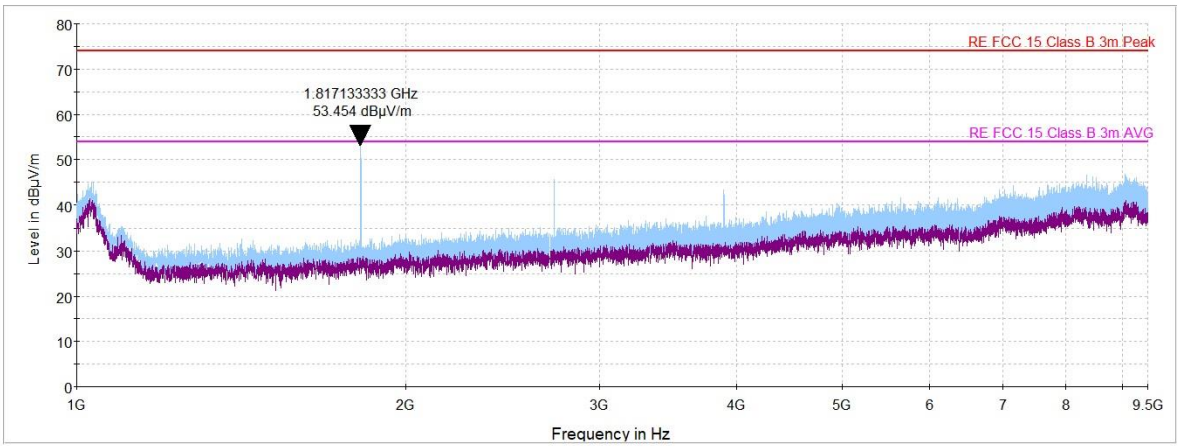
Plot 7.7.7 Radiated emission measurements from 1000 to 9500 MHz at the low carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Plot 7.7.8 Radiated emission measurements from 1000 to 9500 MHz at the mid carrier frequency

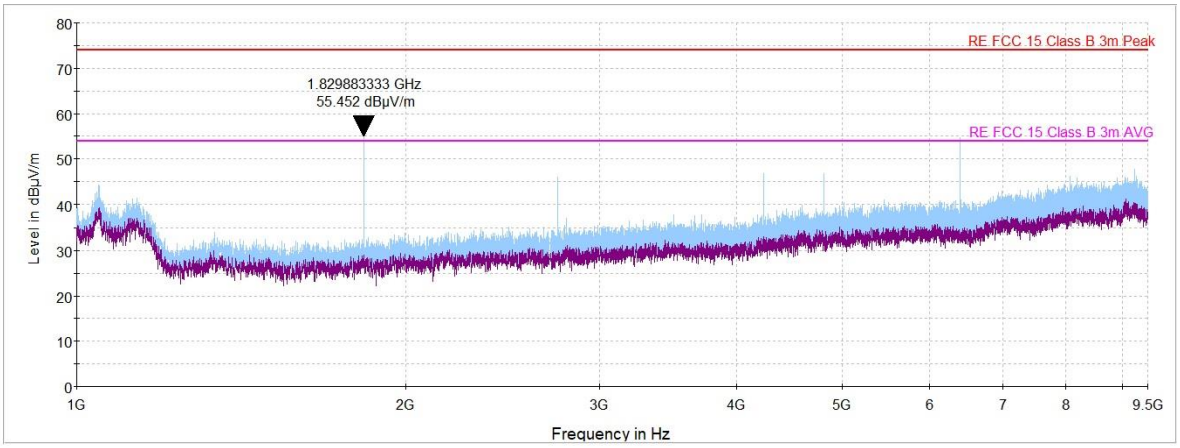
TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Radiated spurious emissions**		
Test procedure:	ANSI C63.10, sections 6.5, 6.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

Plot 7.7.9 Radiated emission measurements from 1000 to 9500 MHz at the high carrier frequency

TEST SITE: Semi anechoic chamber
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical and Horizontal



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Emissions at band edges**		
Test procedure:	ANSI C63.10, section 7.8.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

7.8 Band edge radiated emissions

7.8.1 General

This test was performed to measure emissions, radiated from the EUT at the assigned frequency band edges. Specification test limits are given in Table 7.8.1.

Table 7.8.1 Band edge emission limits

Assigned frequency, MHz	Attenuation below carrier*, dBc
902.0 – 928.0	20.0

* - Band edge emission limit is provided in terms of attenuation below the peak of modulated carrier measured with the same resolution bandwidth.

7.8.2 Test procedure

7.8.2.1 The EUT was set up as shown in Figure 7.8.1, energized normally modulated at the maximum data rate with its hopping function disabled and its proper operation was checked.

7.8.2.2 The EUT was adjusted to produce maximum available to end user RF output power at the lowest carrier frequency.

7.8.2.3 The spectrum analyzer span was set to capture the carrier frequency and associated modulation products. The resolution bandwidth was set wider than 1 % of the frequency span.

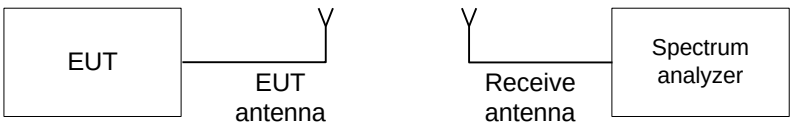
7.8.2.4 The spectrum analyzer was set in max hold mode and allowed trace to stabilize. The highest emission level within the authorized band was measured.

7.8.2.5 The maximum band edge emission and modulation product outside of the band were measured as provided in Table 7.8.2 and associated plots and referenced to the highest emission level measured within the authorized band.

7.8.2.6 The above procedure was repeated with the EUT adjusted to produce maximum RF output power at the highest carrier frequency.

7.8.2.7 The above procedure was repeated with the frequency hopping function enabled.

Figure 7.8.1 Band edge emission test setup



Test specification:	**Section 15.247(d), RSS-247 section 5.5, Emissions at band edges**		
Test procedure:	ANSI C63.10, section 7.8.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

Table 7.8.2 Band edge emission test results

ASSIGNED FREQUENCY RANGE: 902-928 MHz
DETECTOR USED: Peak
RESOLUTION BANDWIDTH: ≥ 1% of the span
VIDEO BANDWIDTH: ≥ RBW

BIT RATE: 980 bps

Frequency, MHz	Band edge emission, dBm	Emission at carrier, dBm	Attenuation below carrier, dBc	Limit, dBc	Margin, dB*	Verdict
Frequency hopping disabled						
902.3	-57.83	-9.60	48.23	20.0	28.23	Pass
903.7	-67.87	-9.83	58.04		38.04	
Frequency hopping enabled						
902.3	-63.30	-12.82	50.48	20.0	30.48	Pass
903.7	-65.76	-12.05	53.71		33.71	

BIT RATE: 5470 bps

Frequency, MHz	Band edge emission, dBm	Emission at carrier, dBm	Attenuation below carrier, dBc	Limit, dBc	Margin, dB*	Verdict
Frequency hopping disabled						
902.3	-57.04	-9.71	47.33	20.0	27.33	Pass
903.7	-66.96	-9.52	57.44		37.44	
Frequency hopping enabled						
902.3	-63.53	-12.89	50.64	20.0	30.64	Pass
903.7	-66.83	-12.36	54.47		34.47	

*****- Margin = Attenuation below carrier – specification limit.

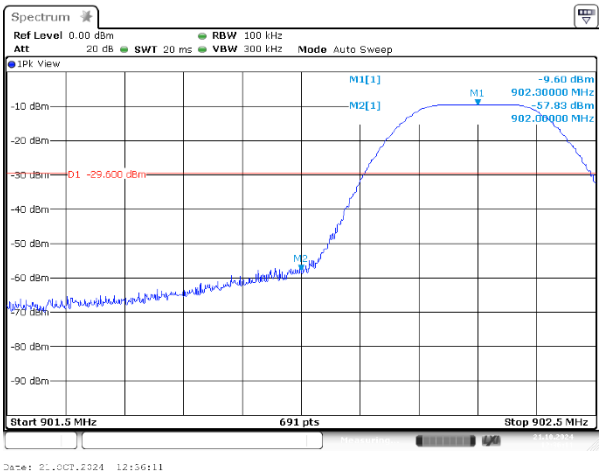
Reference numbers of test equipment used

HL 4355	HL 4136	HL 5397					

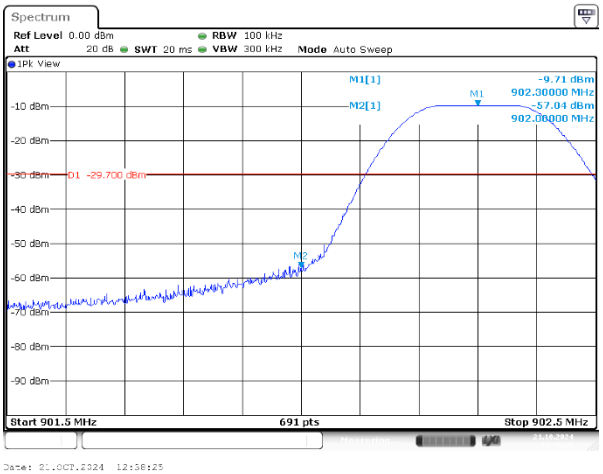
Full description is given in Appendix A.

Test specification:	**Section 15.247(d), RSS-247 section 5.5, Emissions at band edges**		
Test procedure:	ANSI C63.10, section 7.8.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

Plot 7.8.1 The highest band edge emission at low carrier frequency with hopping function disabled

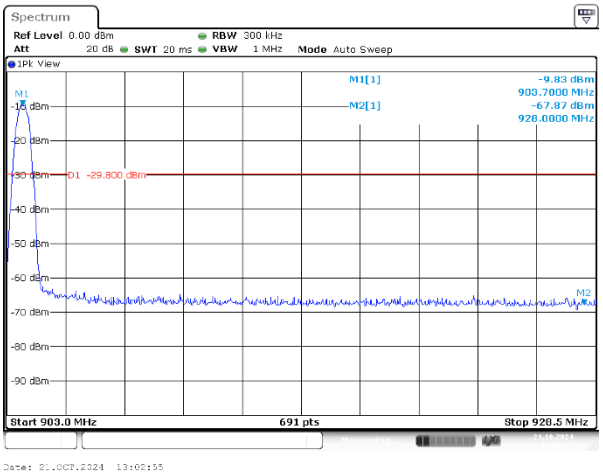


Bit rate 980 bps

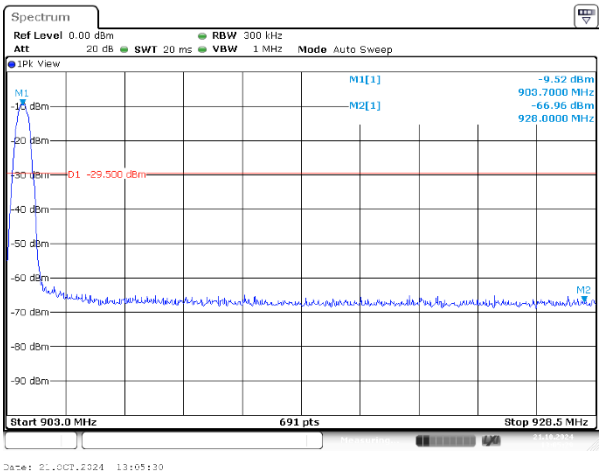


Bit rate 5470 bps

Plot 7.8.2 The highest band edge emission at high carrier frequency with hopping function disabled



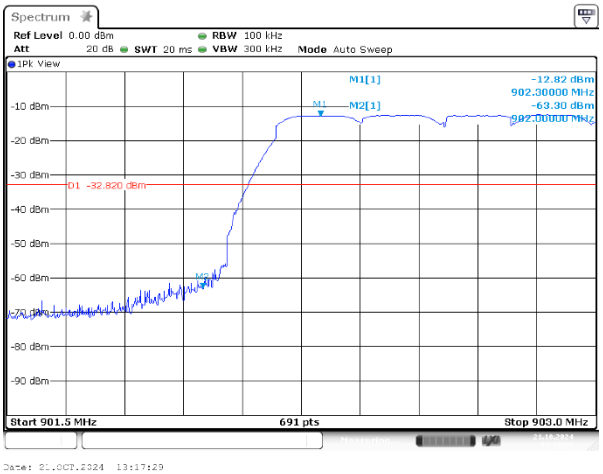
Bit rate 980bps



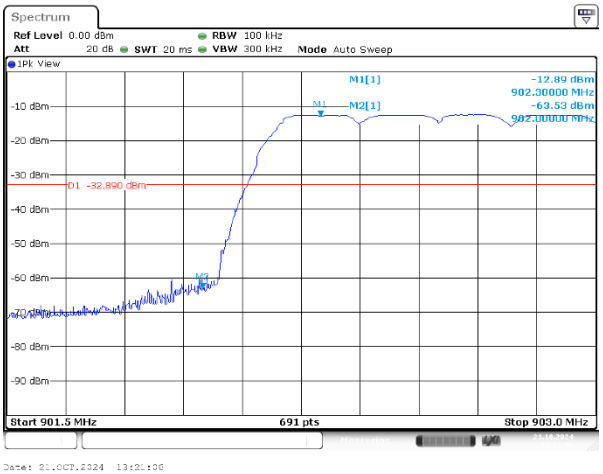
Bit rate 5470 bps

Test specification:	**Section 15.247(d), RSS-247 section 5.5, Emissions at band edges**		
Test procedure:	ANSI C63.10, section 7.8.6		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	21-Oct-24		
Temperature: 23 ºC	**Relative Humidity:** 48 %	**Air Pressure:** 1012 hPa	**Power:** 3.6 VDC
Remarks:			

Plot 7.8.3 The highest band edge emission at low carrier frequency with hopping function enabled

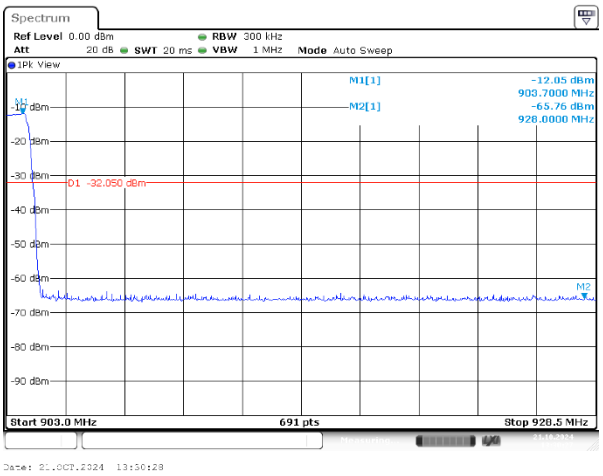


Bit rate 980bps

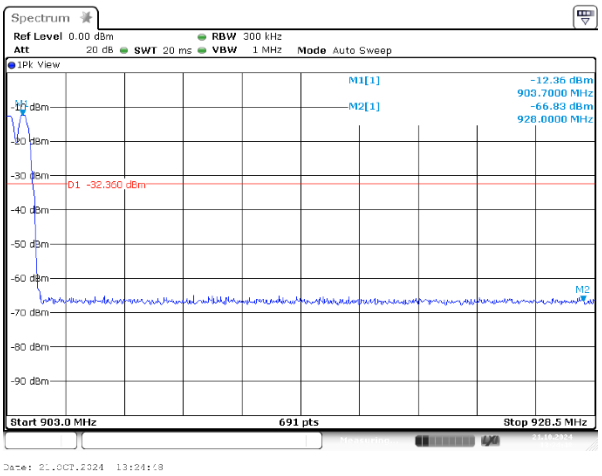


Bit rate 5470 bps

Plot 7.8.4 The highest band edge emission at high carrier frequency with hopping function enabled



Bit rate 980bps



Bit rate 5470 bp

Test specification:	**FCC Section 15.203/ RSS-Gen, Section 7.1.4, Antenna requirement**		
Test procedure:	Visual inspection / supplier declaration		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	14-Oct-24		
Temperature: 24 ºC	**Relative Humidity:** 46 %	**Air Pressure:** 1002 hPa	**Power:** 3.6 VDC
Remarks:			

7.9 Antenna requirements

The EUT was verified for compliance with antenna requirements. A transmitter shall be designed to ensure that no antenna other than that furnished by the responsible party will be used with the device. It may be either permanently attached or employs a unique antenna connector for every antenna proposed for use with the EUT. This requirement does not apply to professionally installed transmitters.
The rationale for compliance with the above requirements was either visual inspection results or supplier declaration. The summary of results is provided in Table 7.9.1.

Table 7.9.1 Antenna requirements

Requirement	Rationale	Verdict
The transmitter antenna is permanently attached	Visual inspection	Comply
The transmitter employs a unique antenna connector	NA	
The transmitter requires professional installation	NA	

8 APPENDIX A Test equipment and ancillaries used for tests

HL No	Description	Manufacturer	Model	Ser. No.	Last Cal./ Check	Due Cal./ Check
0785	Power Supply DC, 60 V, 25 A DC .	Horizon Electronics	SR 60-25	72-7124	26-Mar-24	26-Mar-25
3434	Test Cable , DC-18 GHz, 1.5 m, SMA - SMA	Mini-Circuits	CBL-5FT-SMSM+	25683	06-May-24	06-May-25
3903	Microwave Cable Assembly, 40.0 GHz, 1.5 m, SMA/SMA	Huber-Suhner	SUCOFLEX 102A	1226/2A	06-May-24	06-May-25
4135	Shield Box	TESCOM CO., LTD	TC-5916A	5916A000136	20-May-24	20-May-25
4136	Shield Box	TESCOM CO., LTD	TC-5916A	5916A000137	20-May-24	20-May-25
4339	High pass Filter, 50 Ohm, 1000 to 18000 MHz, SMA-FM / SMA-M	Micro-Tronics	HPM50115-02	001	21-Jun-23	21-Jun-25
4355	Signal and Spectrum Analyzer, 9 kHz to 7 GHz	Rohde & Schwarz	FSV 7	101630	19-Jun-24	19-Jun-25
4933	Active Horn Antenna, 1 GHz to 18 GHz	COM-POWER CORPORATION	AHA-118	701046	20-Feb-24	20-Feb-25
5288	Trilog Antenna, 25 MHz - 8 GHz, 100W	Frankonia	ALX-8000E	00809	24-Mar-22	24-Mar-25
5376	EXA Signal Analyzer, 10 Hz - 32 GHz	Keysight Technologies	N9010B	MY57470404	08-Jan-24	08-Jan-25
5397	H-field near field probe, 3 cm	ETS Lindgren	7405-902	NA	13-Aug-24	13-Aug-25
5902	RF cable, 18 GHz, 6.0m, N-type	Huber-Suhner	SF126EA/11N/11N/6000	NA	19-Nov-23	19-Nov-24
6105	Field Probe Set, 5 un	NA	NA	NA	05-Sep-24	05-Sep-25
6252	Tunable Bandreject Filter 800-1000 MHz	K&L Microwave Inc.	3TNF-800/1000-0.2-N/N	336	07-Nov-23	07-Jun-25
7546	Power supply 60VDC/12.5A	Agilent Technologies	N5747A	US25F6762C	29-May-24	29-May-25
7585	EMI Test Receiver, 1 Hz to 44 GHz	Rohde & Schwarz	ESW44	103130	24-Sep-24	24-Sep-25

9 APPENDIX B Test equipment correction factors

HL 5288: Trilog Antenna
Frankonia, model: ALX-8000E, s/n: 00809
30-1000 MHz

Frequency, MHz	Antenna factor, dB/m	Frequency, MHz	Antenna factor, dB/m
30	14.96	160	12.67
35	15.33	180	13.34
40	16.37	200	15.40
45	17.56	250	16.42
50	17.95	300	17.28
60	16.87	400	19.98
70	13.22	500	21.11
80	10.56	600	22.90
90	13.61	700	24.13
100	15.46	800	25.25
120	14.03	900	26.35
140	12.23	1000	27.18

The antenna factor shall be added to receiver reading in dBμV to obtain field strength in dBμV/m.

above 1000 MHz

Frequency, MHz	Antenna factor, dB/m	Frequency, MHz	Antenna factor, dB/m
1000	26.9	3600	38.9
1100	28.1	3700	39.4
1200	28.4	3800	39.4
1300	29.6	3900	39.6
1400	29.1	4000	39.7
1500	30.4	4100	39.8
1600	30.7	4200	40.5
1700	31.5	4300	40.9
1800	32.3	4400	41.1
1900	32.6	4500	41.4
2000	32.5	4600	41.3
2100	32.9	4700	41.6
2200	33.5	4800	41.9
2300	33.2	4900	42.3
2400	33.7	5000	42.7
2500	34.6	5100	43.0
2600	34.7	5200	42.9
2700	34.6	5300	43.5
2800	35.0	5400	43.6
2900	35.5	5500	44.3
3000	36.2	5600	44.7
3100	36.8	5700	45.0
3200	36.8	5800	45.0
3300	37.0	5900	45.3
3400	37.5	6000	45.9
3500	38.2		

The antenna factor shall be added to receiver reading in dBμV to obtain field strength in dBμV/m.

HL 4933: Active Horn Antenna
COM-POWER CORPORATION, model: AHA-118, s/n 701046

Frequency, MHz	Measured antenna factor (with preamplifier), dB/m
1000	-16.1
1500	-15.1
2000	-10.9
2500	-11.9
3000	-11.1
3500	-10.6
4000	-8.6
4500	-8.3
5000	-5.9
5500	-5.7
6000	-3.3
6500	-4.0
7000	-2.2
7500	-1.7
8000	1.1
8500	-0.8
9000	-1.5
9500	-0.2

Frequency, MHz	Measured antenna factor (with preamplifier), dB/m
10000	1.8
10500	1.0
11000	0.3
11500	-0.5
12000	3.1
12500	1.4
13000	-0.3
13500	-0.4
14000	2.5
14500	2.2
15000	1.9
15500	0.5
16000	2.1
16500	1.2
17000	0.6
17500	3.1
18000	4.2

The antenna factor shall be added to receiver reading in dBμV to obtain field strength in dBμV/m.

10 APPENDIX C Measurement uncertainties

Expanded uncertainty at 95% confidence in Hermon Labs EMC measurements

Test description	Expanded uncertainty
Conducted carrier power at RF antenna connector	Below 12.4 GHz: ± 1.7 dB 12.4 GHz to 40 GHz: ± 2.3 dB
Conducted emissions at RF antenna connector	9 kHz to 2.9 GHz: ± 2.6 dB 2.9 GHz to 6.46 GHz: ± 3.5 dB 6.46 GHz to 13.2 GHz: ± 4.3 dB 13.2 GHz to 22.0 GHz: ± 5.0 dB 22.0 GHz to 26.8 GHz: ± 5.5 dB 26.8 GHz to 40.0 GHz: ± 4.8 dB
Occupied bandwidth	± 8.0 %
Duty cycle, timing (Tx ON / OFF) and average factor measurements	± 1.0 %
Conducted emissions with LISN	9 kHz to 150 kHz: ± 3.9 dB 150 kHz to 30 MHz: ± 3.8 dB
Radiated emissions at 3 m measuring distance Horizontal polarization Vertical polarization	 Biconilog antenna: ± 5.3 dB Biconical antenna: ± 5.0 dB Log periodic antenna: ± 5.3 dB Double ridged horn antenna: ± 5.3 dB Biconilog antenna: ± 6.0 dB Biconical antenna: ± 5.7 dB Log periodic antenna: ± 6.0 dB Double ridged horn antenna: ± 6.0 dB

Hermon Laboratories is accredited by A2LA for calibration according to present requirements of ISO/IEC 17025 and NCSL Z540-1. The accreditation is granted to perform calibration of parameters that are listed in the Scope of Hermon Laboratories Accreditation.

Hermon Laboratories calibrates its reference and transfer standards by calibration laboratories accredited to ISO/IEC 17025 by a mutually recognized Accreditation Body or by a recognized national metrology institute. All reference and transfer standards used in the calibration system are traceable to national or international standards.

In-house calibration of all test and measurement equipment is performed on a regular basis according to Hermon Laboratories calibration procedures, manufacturer calibration/verification procedures or procedures defined in the relevant standards. The Hermon Laboratories test and measurement equipment is calibrated within the tolerances specified by the manufacturers and/or by the relevant standards.

11 APPENDIX D Test laboratory description

Tests were performed at Hermon Laboratories Ltd., which is a fully independent, private, EMC, Radio, Safety, Environmental and Telecommunication testing facility.
Hermon Laboratories is recognized and accredited by the Federal Communications Commission (USA) for relevant parts of Code of Federal Regulations 47 (CFR 47), Test Firm Registration Number is 927748, Designation Number is IL1001; Recognized by Innovation, Science and Economic Development Canada for wireless and terminal testing (ISED), ISED #2186A, CAB identifier is IL1001; Certified by VCCI, Japan (the registration numbers are R-10808 for OATS, R-1082 for anechoic chamber, G-10869 for RE measurements above 1 GHz, C-10845 for conducted emissions site and T-11606 for conducted emissions at telecommunication ports).
The laboratory is accredited by American Association for Laboratory Accreditation (USA) according to ISO/IEC 17025 for electromagnetic compatibility, product safety, telecommunications testing, environmental simulation and calibration (for exact scope please refer to Certificate No. 839.01, 839.03 and 839.04).

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Telephone: +972 4628 8001
Fax: +972 4628 8277
e-mail: mail@hermonlabs.com
website: www.hermonlabs.com

Person for contact: Mr. Michael Nikishin, EMC&Radio group manager

12 APPENDIX E Specification references

FCC 47CFR part 15: 2022	Radio Frequency Devices
ANSI C63.10: 2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
RSS-247 Issue 3: 2023	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence- Exempt Local Area Network (LE-LAN) Devices
RSS-Gen Issue 5 with_amendment_1_2: 2021	General Requirements and Information for the Certification of Radiocommunication Equipment

13 APPENDIX F Abbreviations and acronyms

A	ampere
AC	alternating current
A/m	ampere per meter
AM	amplitude modulation
AVRG	average (detector)
cm	centimeter
dB	decibel
dBm	decibel referred to one milliwatt
dB(μV)	decibel referred to one microvolt
dB(μV/m)	decibel referred to one microvolt per meter
dB(μA)	decibel referred to one microampere
DC	direct current
EIRP	equivalent isotropically radiated power
ERP	effective radiated power
EUT	equipment under test
F	frequency
GHz	gigahertz
GND	ground
H	height
HL	Hermon laboratories
Hz	hertz
k	kilo
kHz	kilohertz
LO	local oscillator
m	meter
MHz	megahertz
min	minute
mm	millimeter
ms	millisecond
μs	microsecond
NA	not applicable
NB	narrow band
OATS	open area test site
Ω	Ohm
PM	pulse modulation
PS	power supply
ppm	part per million (10^{-6})
QP	quasi-peak
RE	radiated emission
RF	radio frequency
rms	root mean square
Rx	receive
s	second
T	temperature
Tx	transmit
V	volt
WB	wideband

14 APPENDIX G Manufacturer's declaration

ARAD TECHNOLOGIES

AT57-7 Declaration

We, the undersigned,

Company Name: Arad Technologies LTD
Address: Hamada 4, Yokneam Ellit
Country: Israel
Telephone number: 972-4-9935222
Fax number: 972-4-9935227

Declare under our sole responsibility that the only change is with mechanical pipeline diameter and material type (see below), no change at all in **AT57-7** electronics.

AT57-7-21-5-P	AT57-7-21-5-OM	AT57-7-22-5-OM	Short description
			Accurate water meter, using the ultrasonic principle.
3/4" Polymer	3/4" Brass	5/8" Brass	Pipeline diameter / material

December 12, 2024

Gilad Eliel
Project Manager

Company Stamp

Arad Technologies Ltd.

Arad Measuring Technologies Ltd. www.arad.co.il 972 4 9935222 P.O.B 537, Yokneam Illit 2069206, Israel A Member of the ARADGROUP Integrated Metering Technologies

END OF DOCUMENT