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ELECTRICAL TESTING
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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:

ST Engineering Telematics Wireless Ltd

Sienna MX1

Model: SMX1CS

FCC ID: NTASMX1CS

IC: 4732A-SMX1CS

This report is in conformity with ISO/ IEC 17025. The "A2LA Accredited" symbol endorsement applies only to the tests and calibrations that are listed in the scope of Hermon Laboratories accreditation. The test results relate only to the items tested. This test report shall not be reproduced in any form except in full with the written approval of Hermon Laboratories Ltd.

Table of contents

1 Applicant information

Client name:	ST Engineering Telematics Wireless Ltd
Address:	26 Hamelaha street, POB 1911, Holon 5811801, Israel
Telephone:	+972 3557 5700
Fax:	+972 3557 5703
E-mail:	itsikk@tlmw.com
Contact name:	Mr. Itsik Kanner

2 Equipment under test attributes

Product name:	Sienna MX1
Product type:	Transceiver
Model(s):	SMX1CS
Serial number:	8250100917050
Hardware version:	Rev B
Software release:	Fc10
Receipt date	24-Jun-24

3 Manufacturer information

Manufacturer name:	ST Engineering Telematics Wireless Ltd
Address:	26 Hamelaha street, POB 1911, Holon 5811801, Israel
Telephone:	+972 3557 5700
Fax:	+972 3557 5703
E-Mail:	itsikk@tlmw.com
Contact name:	Mr. Itsik Kanner

4 Test details

Project ID:	55429
Location:	Hermon Laboratories Ltd. 66 HaTachana str., P.O. Box 23, Binyamina 3055001, Israel
Test started:	28-Nov-24
Test completed:	25-Feb-25
Test specification(s):	FCC 47CFR part 15 subpart C §15.247 (Hybrid), RSS-247 Issue 3:2023, RSS-Gen Issue 5

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
Unintentional emissions	
Section 107 / ICES-003, Section 6.1 class B, Conducted emission at AC power port	Not required
Section 109 / RSS-Gen, Section 7.3 / ICES-003, Section 6.2 class B, Radiated emission	Pass

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. M. Filobodchenko, test engineer, EMC & Radio Mr. S. Sugatov, test engineer, EMC & Radio	28-Nov-24 – 25-Feb-25	 
Reviewed by:	Mrs. S. Peysahov Sheynin, certification engineer, EMC & Radio	25-Mar-24 – 16-Apr-25	
Approved by:	Mr. M. Nikishin, group leader, EMC & Radio	08-May-25	

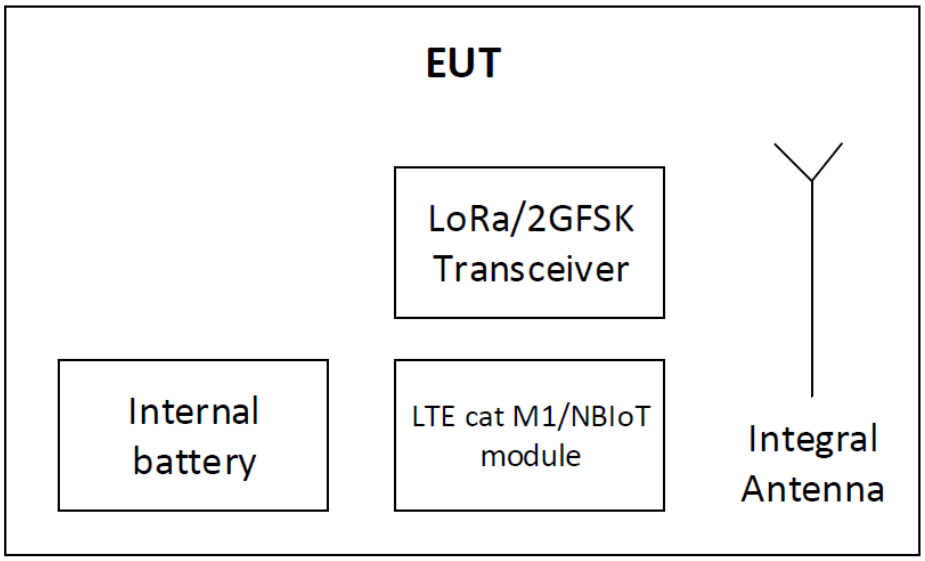
6 EUT description

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

6.1 General information

The EUT Sienna MX1 is a Meter Interface Unit that sends the water meter readings to the water management software either via cellular network or using LoRa/2GFSK modulation, to a mobile drive-by data collector. The Sienna MX1 is wired to a water meter encoder and collects the water meter data. The EUT consists of LoRa/2GFSK transceiver. The EUT is powered by 3.6V battery.

6.2 Test configuration



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**
	fixed	Always at a distance more than 2 m from all people
X	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 – 927.7 MHz

Maximum rated output power	At transmitter 50 Ω RF output connector	20.17 dBm (LoRa) 10.63 dBm (2GFSK)
	Peak output power	

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	X with temporary RF connector
				without temporary RF connector

Antenna/s technical characteristics			
Type	Manufacturer	Model number	Gain
Printed	N/A	N/A	0dBi

Transmitter aggregate data rate/s	1.2 kbps 6.8 kbps
Type of modulation	LoRa, 2GFSK
Modulating test signal (baseband)	PRBS

Transmitter power source					
X	Battery	**Nominal rated voltage**	3.6 VDC	Battery type	Lithium size D
	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 at LoRa		
FHSS	Total number of hops	4-128
	Bandwidth per hop	143.99 kHz
	Max. separation of hops	203.47 kHz

Spread spectrum parameters for transmitters tested per FCC 15.247 only at 2GFSK		
FHSS	Total number of hops	4-128
	Bandwidth per hop	61.54 kHz
	Max. separation of hops	198.5 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):	30-Dec-24		
Temperature: 23 ºC	Relative Humidity: 49 %	Air Pressure: 1013 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 at LoRa modulation

7.1.1 General

This test was performed to measure 20 dB 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

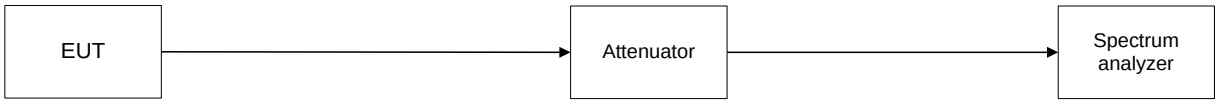
7.1.2.1 The EUT was set up as shown in Figure 7.1.1, energized and its proper operation was checked.

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):	30-Dec-24		
Temperature: 23 ºC	**Relative Humidity:** 49 %	**Air Pressure:** 1013 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
MODULATION ENVELOPE REFERENCE POINTS: 20.0 dBc
FREQUENCY HOPPING: Disabled

Carrier frequency, MHz	Type of modulation	Data rate, kbps	99% OBW kHz	20 dB bandwidth, kHz	Limit, kHz	Margin, kHz	Verdict
Low frequency							
902.3	LoRa	1.2	125.90	140.38	NA	NA	Pass
902.3	LoRa	6.8	126.62	143.99	NA	NA	Pass
Mid frequency							
915.0	LoRa	1.2	126.62	140.38	NA	NA	Pass
915.0	LoRa	6.8	125.90	141.82	NA	NA	Pass
High frequency							
927.7	LoRa	1.2	125.90	139.65	NA	NA	Pass
927.7	LoRa	6.8	125.90	143.99	NA	NA	Pass

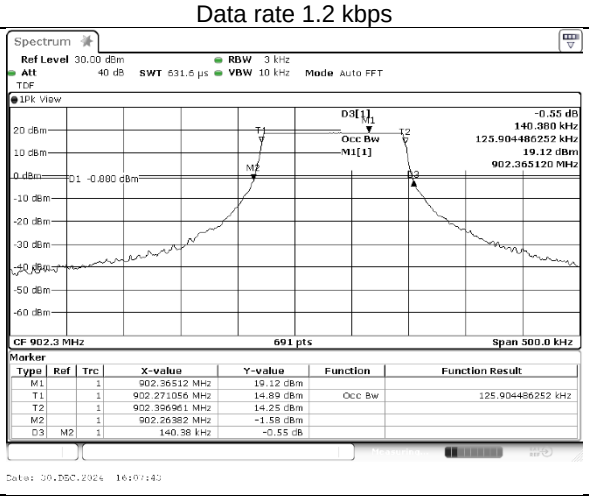
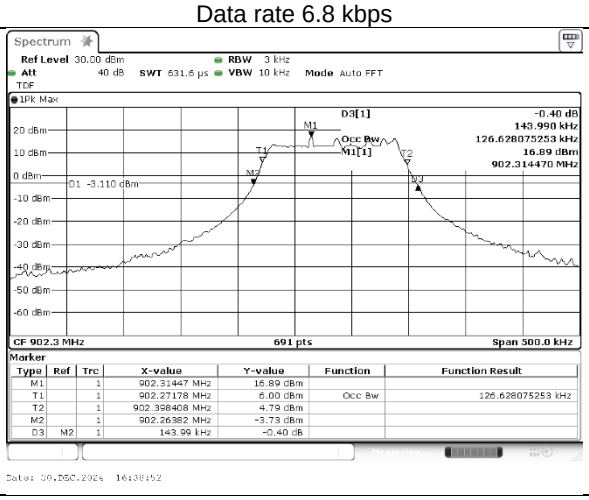
Reference numbers of test equipment used

HL 4355	HL 5601	HL 5637	HL 4136					

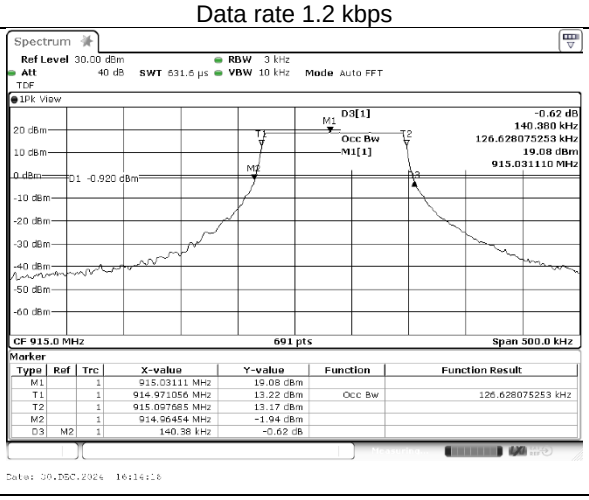
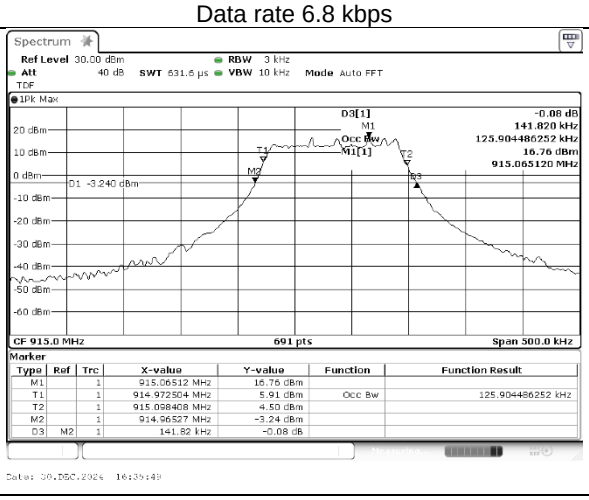
Full description is given in Appendix A.

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):	30-Dec-24		
Temperature: 23 ºC	**Relative Humidity:** 49 %	**Air Pressure:** 1013 hPa	**Power:** 3.6 VDC
Remarks:			

Plot 7.1.1 The 20 dB bandwidth test result at low frequency

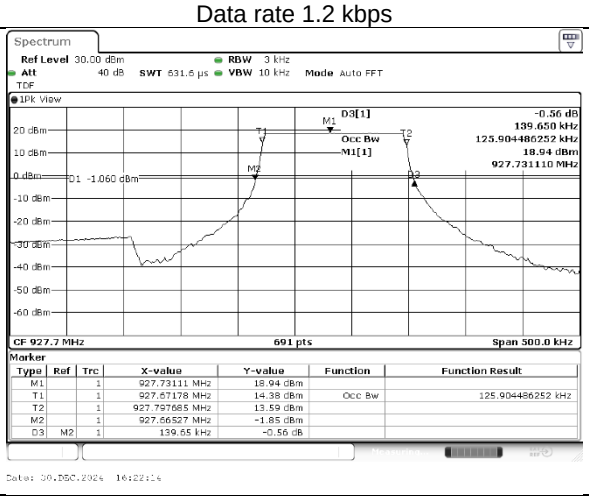
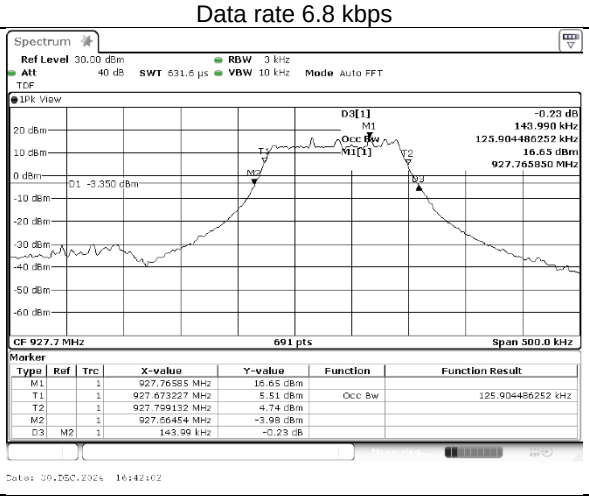
Data rate 1.2 kbps	Data rate 6.8 kbps
	

Plot 7.1.2 The 20 dB bandwidth test result at mid frequency

Data rate 1.2 kbps	Data rate 6.8 kbps
	

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):	30-Dec-24		
Temperature: 23 ºC	**Relative Humidity:** 49 %	**Air Pressure:** 1013 hPa	**Power:** 3.6 VDC
Remarks:			

Plot 7.1.3 The 20dB and 99% bandwidth test result at high frequency

Data rate 1.2 kbps	Data rate 6.8 kbps
	

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):	19-Jan-25		
Temperature: 25 ºC	Relative Humidity: 45 %	Air Pressure: 1017 hPa	Power: 3.6 VDC
Remarks:			

7.2 20 dB bandwidth at 2GFSK modulation

7.2.1 General

This test was performed to measure 20 dB bandwidth of the transmitter hopping channel. Specification test limits are given in Table 7.2.1.

Table 7.2.1 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.

7.2.2 Test procedure

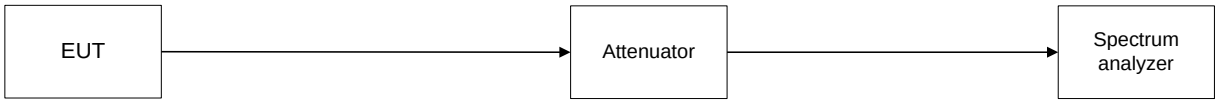
7.2.2.1 The EUT was set up as shown in Figure 7.2.1, energized and its proper operation was checked.

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

7.2.2.3 The transmitter bandwidth was measured with spectrum analyzer as frequency delta between reference points on modulation envelope and provided in Table 7.2.2 and associated plot.

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

Figure 7.2.1 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):	19-Jan-25		
Temperature: 25 ºC	Relative Humidity: 45 %	Air Pressure: 1017 hPa	Power: 3.6 VDC
Remarks:			

Table 7.2.2 The 20 dB bandwidth test results

ASSIGNED FREQUENCY BAND: 902.0 – 928.0 MHz
DETECTOR USED: Peak
SWEEP TIME: Auto
VIDEO BANDWIDTH: ≥ RBW
MODULATION ENVELOPE REFERENCE POINTS: 20.0 dBc
FREQUENCY HOPPING: Disabled

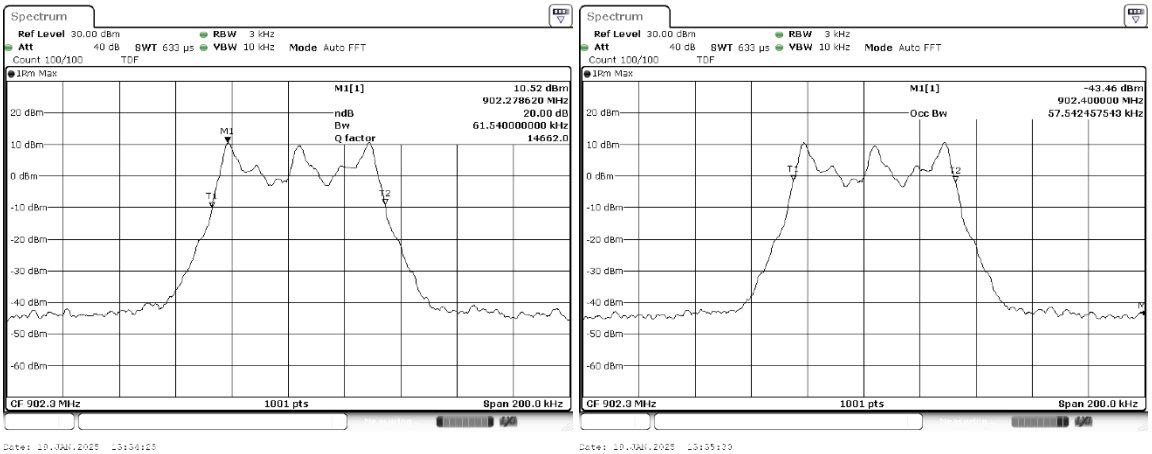
Carrier frequency, MHz	Type of modulation	Data rate, kbps	99% OBW kHz	20 dB bandwidth, kHz	Limit, kHz	Margin, kHz	Verdict
Low frequency							
902.3	2GFSK	50	57.54	61.54	NA	NA	Pass
Mid frequency							
915.0	2GFSK	50	57.74	61.54	NA	NA	Pass
High frequency							
927.7	2GFSK	50	57.34	61.34	NA	NA	Pass

Reference numbers of test equipment used

HL 3440	HL 4135	HL 4355	HL 5642	HL 5933	HL 7523			

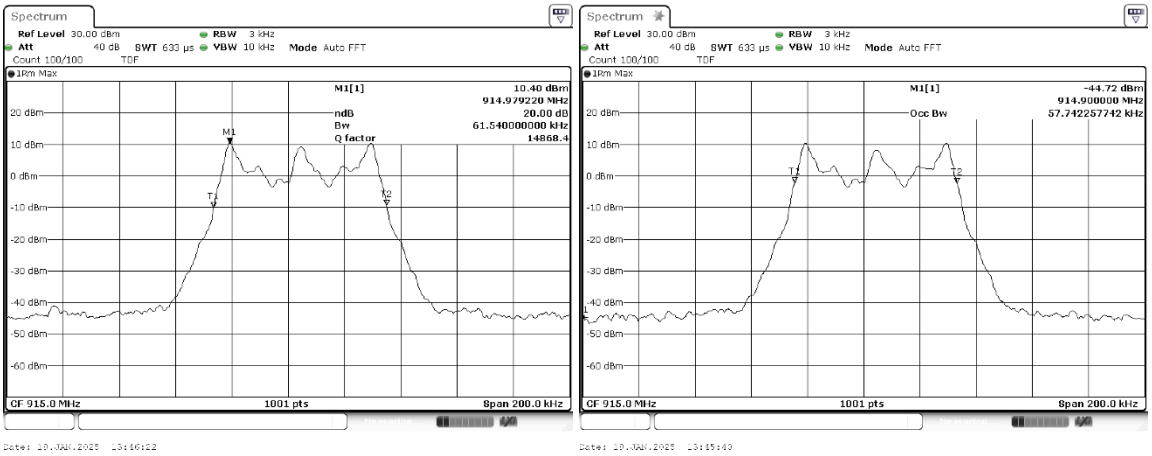
Full description is given in Appendix A.

Plot 7.2.1 The 20 dB and 99% bandwidth test result at low frequency

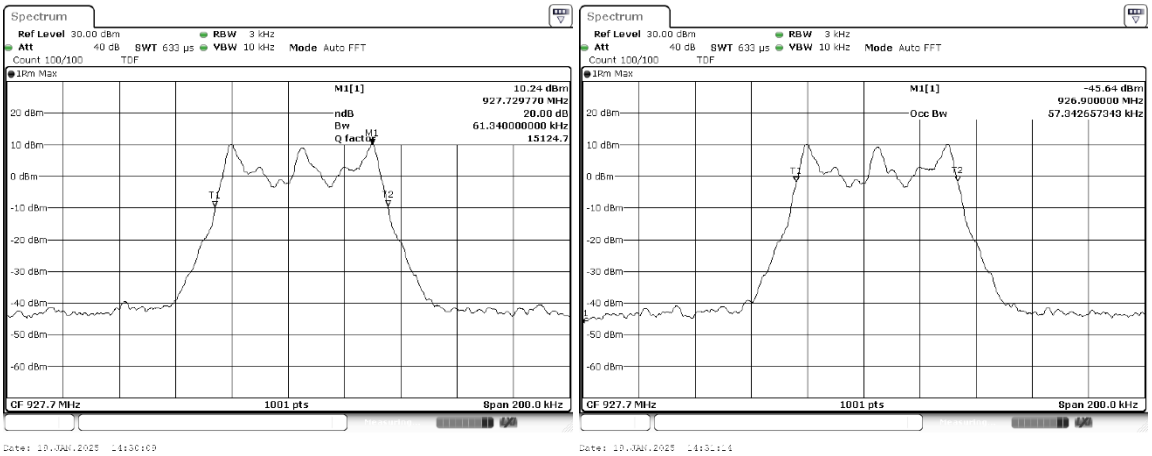


Test specification:	Section 15.247(a)1, RSS-247 section 5.1(3), 20 dB bandwidth		
Test procedure:	ANSI C63.10, section 7.8.7		
Test mode:	Compliance	Verdict:	PASS
Date(s):	19-Jan-25		
Temperature: 25 ºC	Relative Humidity: 45 %	Air Pressure: 1017 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.2.2 The 20 dB and 99% bandwidth test result at mid frequency



Plot 7.2.3 The 20 dB and 99% bandwidth test result at high frequency



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):	20-Jan-25		
Temperature: 25 ºC	Relative Humidity: 41 %	Air Pressure: 1016 hPa	Power: 3.6 VDC
Remarks:			

7.3 Carrier frequency separation at LoRa modulation

7.3.1 General

This test was performed to measure frequency separation between the peaks of adjacent channels. Specification test limits are given in Table 7.3.1.

Table 7.3.1 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		

7.3.2 Test procedure

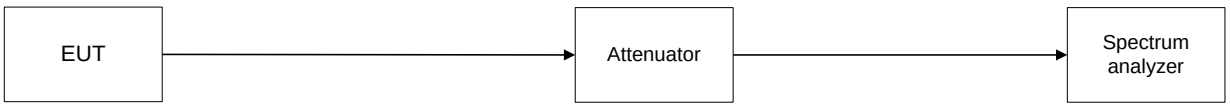
7.3.2.1 The EUT was set up as shown in Figure 7.3.1, energized with frequency hopping function enabled and its proper operation was checked.

7.3.2.2 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.

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

7.3.2.4 The frequency separation between the peaks of adjacent channels was measured as provided in Table 7.3.2 and associated plots.

Figure 7.3.1 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):	20-Jan-25		
Temperature: 25 ºC	Relative Humidity: 41 %	Air Pressure: 1016 hPa	Power: 3.6 VDC
Remarks:			

Table 7.3.2 Carrier frequency separation test results

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

MODULATION: LoRa 125 kHz
20 dB BANDWIDTH: 140.38 kHz
BIT RATE: 1.2 kbps

Carrier frequency separation, kHz	Limit, kHz	Margin*	Verdict
203.47	140.38	63.09	Pass

MODULATION: LoRa 125 kHz
20 dB BANDWIDTH: 143.99kHz
BIT RATE: 6.8 kbps

Carrier frequency separation, kHz	Limit, kHz	Margin*	Verdict
203.47	143.99	59.48	Pass

* - Margin = Carrier frequency separation – specification limit.

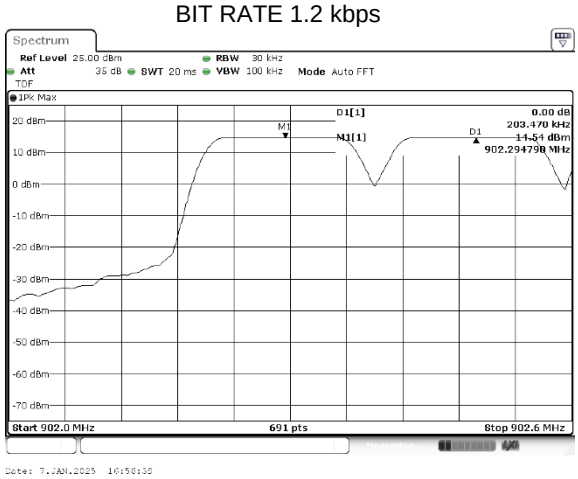
Reference numbers of test equipment used

HL 3440	HL 4136	HL 4355	HL 5637	HL 5933			

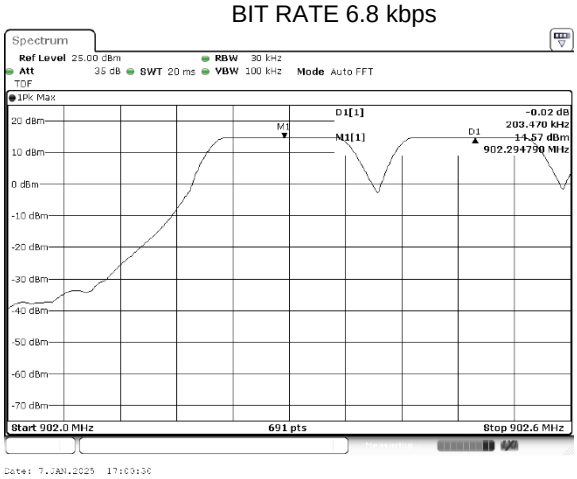
Full description is given in Appendix A.

Plot 7.3.1 Carrier frequency separation at LoRa modulation

BIT RATE 1.2 kbps



BIT RATE 6.8 kbps



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):	20-Jan-25		
Temperature: 25 ºC	Relative Humidity: 41 %	Air Pressure: 1016 hPa	Power: 3.6 VDC
Remarks:			

7.4 Carrier frequency separation at 2GFSK modulation

7.4.1 General

This test was performed to measure frequency separation between the peaks of adjacent channels. Specification test limits are given in Table 7.4.1.

Table 7.4.1 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		

7.4.2 Test procedure

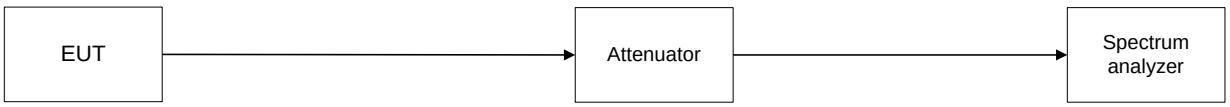
7.4.2.1 The EUT was set up as shown in Figure 7.4.1, energized with frequency hopping function enabled and its proper operation was checked.

7.4.2.2 The spectrum analyzer span was set to 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.

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

7.4.2.4 The frequency separation between the peaks of adjacent channels was measured as provided in Table 7.4.2 and associated plots.

Figure 7.4.1 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):	20-Jan-25		
Temperature: 25 ºC	Relative Humidity: 41 %	Air Pressure: 1016 hPa	Power: 3.6 VDC
Remarks:			

Table 7.4.2 Carrier frequency separation test results

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

MODULATION: 2GFSK
20 dB BANDWIDTH: 61.54 kHz
BIT RATE: 50 kbps

Carrier frequency separation, kHz	Limit, kHz	Margin*	Verdict
198.5	61.54	136.96	Pass

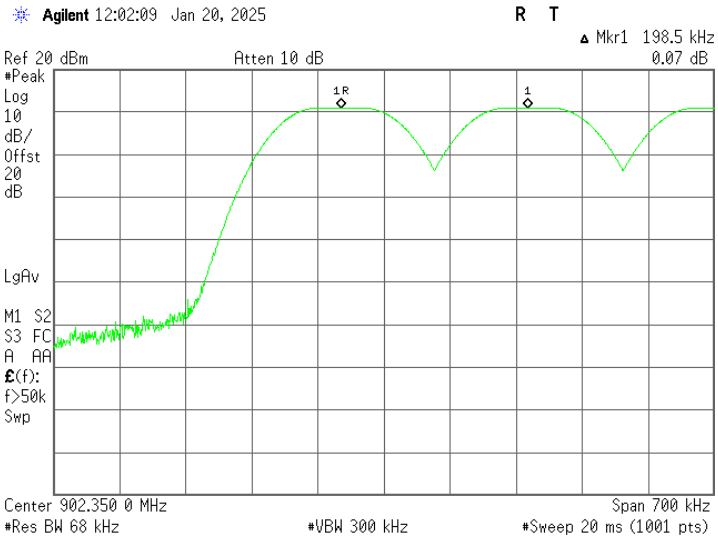
* - Margin = Carrier frequency separation – specification limit.

Reference numbers of test equipment used

HL 3440	HL 3818	HL 3901	HL 4135	HL 5933	HL 7523		

Full description is given in Appendix A.

Plot 7.4.1 Carrier frequency separation at 2GFSK modulation



Test specification:	Section 15.247(a)1, RSS-247 section 5.1(c), Number of hopping frequencies		
Test procedure:	ANSI C63.10, section 7.8.3		
Test mode:	Compliance	Verdict:	PASS
Date(s):	28-Nov-24		
Temperature: 25 ºC	Relative Humidity: 45 %	Air Pressure: 1019 hPa	Power: 3.6 VDC
Remarks:			

7.5 Number of hopping frequencies at LoRa modulation

7.5.1 General

This test was performed to calculate the number of hopping frequencies used by the EUT. Specification test limits are given in Table 7.5.1.

Table 7.5.1 Minimum number of hopping frequencies

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

7.5.2 Test procedure

The EUT was set up as shown in

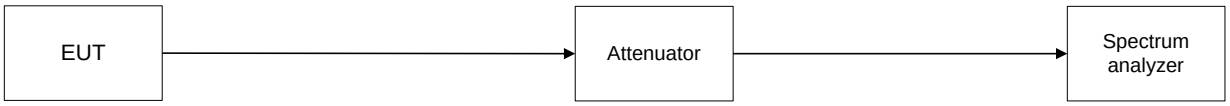
7.5.2.1 Figure 7.5.1, energized with frequency hopping function enabled and its proper operation was checked.

7.5.2.2 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.

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

7.5.2.4 The number of frequency hopping channels was calculated as provided in Table 7.5.2 and associated plots.

Figure 7.5.1 Hopping frequencies test setup



Test specification:	**Section 15.247(a)1, RSS-247 section 5.1(c), Number of hopping frequencies**		
Test procedure:	ANSI C63.10, section 7.8.3		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	28-Nov-24		
Temperature: 25 ºC	**Relative Humidity:** 45 %	**Air Pressure:** 1019 hPa	**Power:** 3.6 VDC
Remarks:			

Table 7.5.2 Hopping frequencies test results

ASSIGNED FREQUENCY: 902.0 – 928.0 MHz
MODULATION: LoRa 125 kHz
DETECTOR USED: Peak
RESOLUTION BANDWIDTH: ≥ 1% of the span
VIDEO BANDWIDTH: ≥ RBW
FREQUENCY HOPPING: Enabled
BIT RATE: **1.2 kbps**

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

BIT RATE: **6.8 kbps**

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

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

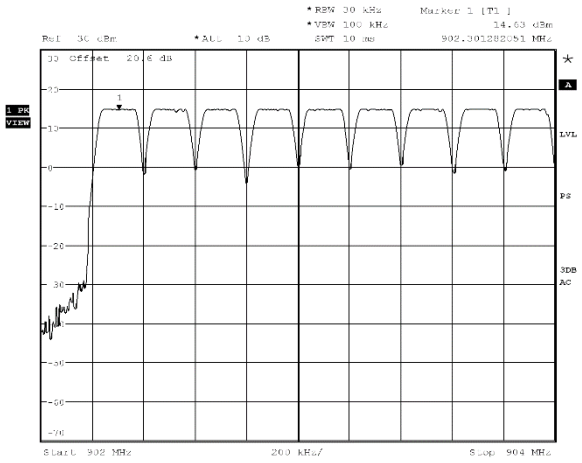
Reference numbers of test equipment used

HL 3230	HL 3434	HL 3440	HL 4360	HL 5933			

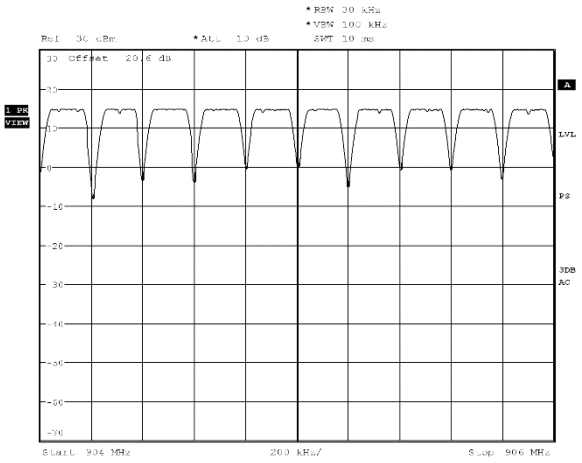
Full description is given in Appendix A.

Test specification:	**Section 15.247(a)1, RSS-247 section 5.1(c), Number of hopping frequencies**		
Test procedure:	ANSI C63.10, section 7.8.3		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	28-Nov-24		
Temperature: 25 ºC	**Relative Humidity:** 45 %	**Air Pressure:** 1019 hPa	**Power:** 3.6 VDC
Remarks:			

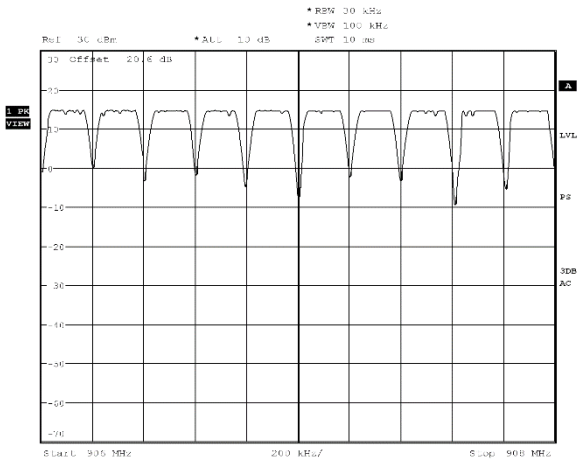
Plot 7.5.1 Number of hopping frequencies at LoRa modulation with bit rate 1.2 kbps



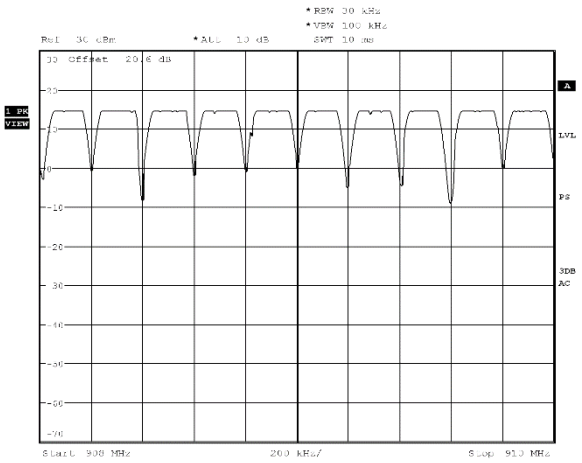
3
Date: 28.NOV.2024 18:01:12



3
Date: 28.NOV.2024 18:09:00



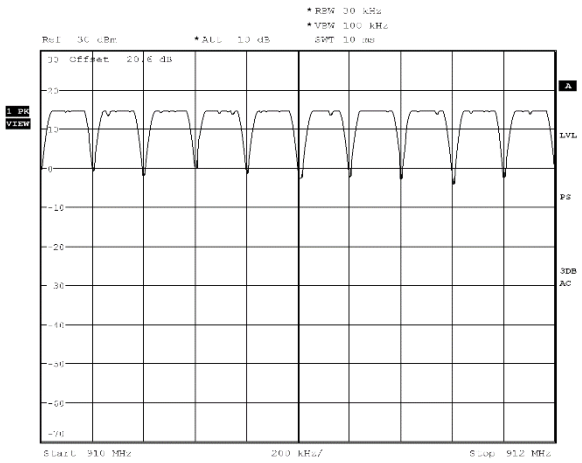
3
Date: 28.NOV.2024 18:07:08



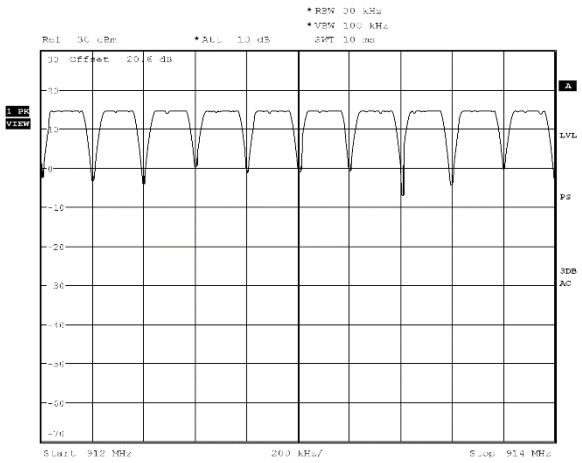
3
Date: 28.NOV.2024 18:11:56

Test specification:	**Section 15.247(a)1, RSS-247 section 5.1(c), Number of hopping frequencies**		
Test procedure:	ANSI C63.10, section 7.8.3		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	28-Nov-24		
Temperature: 25 ºC	**Relative Humidity:** 45 %	**Air Pressure:** 1019 hPa	**Power:** 3.6 VDC
Remarks:			

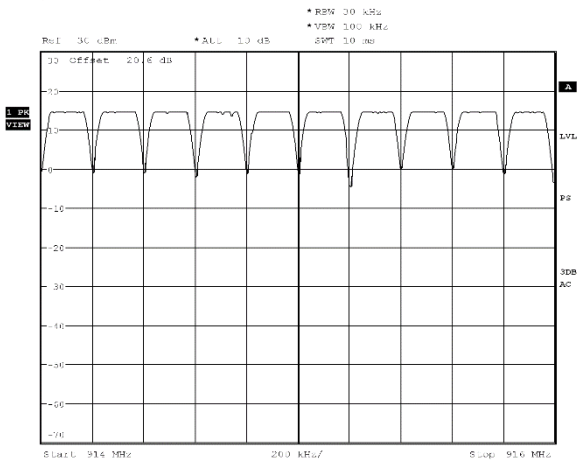
Plot 7.5.2 Number of hopping frequencies at LoRa modulation with bit rate 1.2 kbps (continuation)



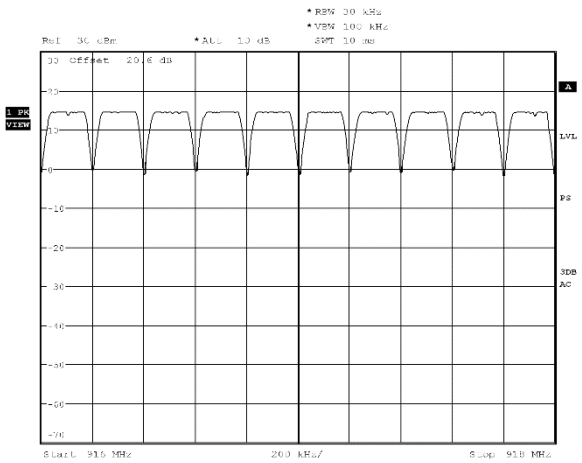
3
Date: 28.NOV.2024 18:14:07



3
Date: 28.NOV.2024 18:17:18



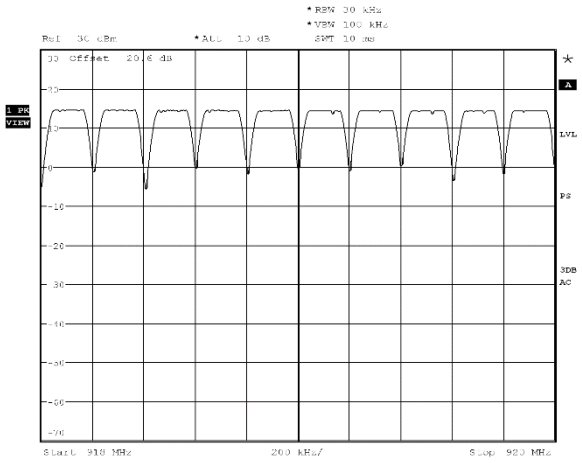
3
Date: 28.NOV.2024 18:19:45



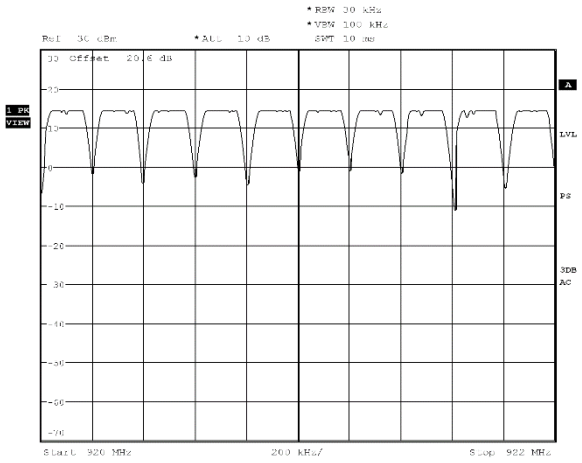
3
Date: 28.NOV.2024 18:24:03

Test specification:	**Section 15.247(a)1, RSS-247 section 5.1(c), Number of hopping frequencies**		
Test procedure:	ANSI C63.10, section 7.8.3		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	28-Nov-24		
Temperature: 25 ºC	**Relative Humidity:** 45 %	**Air Pressure:** 1019 hPa	**Power:** 3.6 VDC
Remarks:			

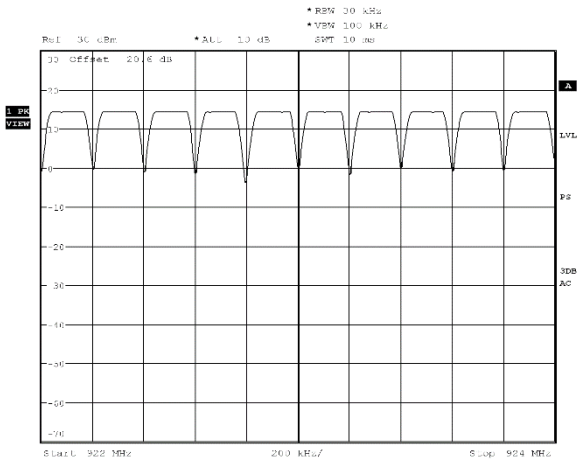
Plot 7.5.3 Number of hopping frequencies at LoRa modulation with bit rate 1.2 kbps (continuation)



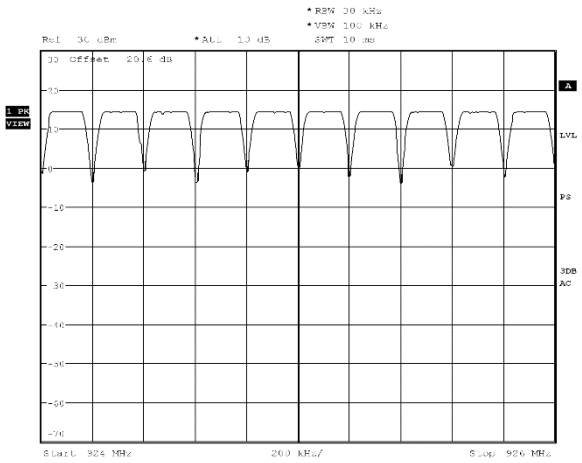
3
Date: 28.NOV.2024 18:26:37



3
Date: 28.NOV.2024 18:28:26



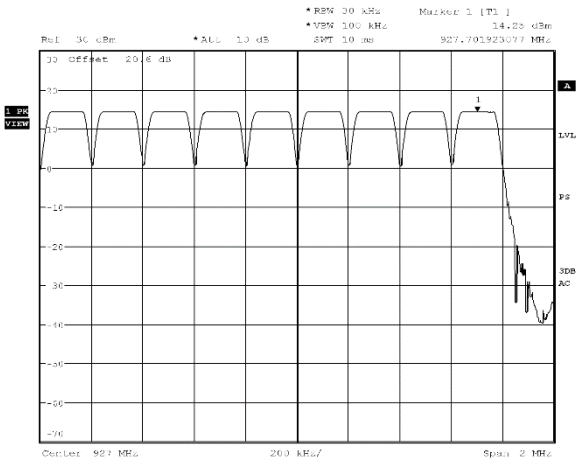
3
Date: 28.NOV.2024 18:32:00



3
Date: 28.NOV.2024 18:34:53

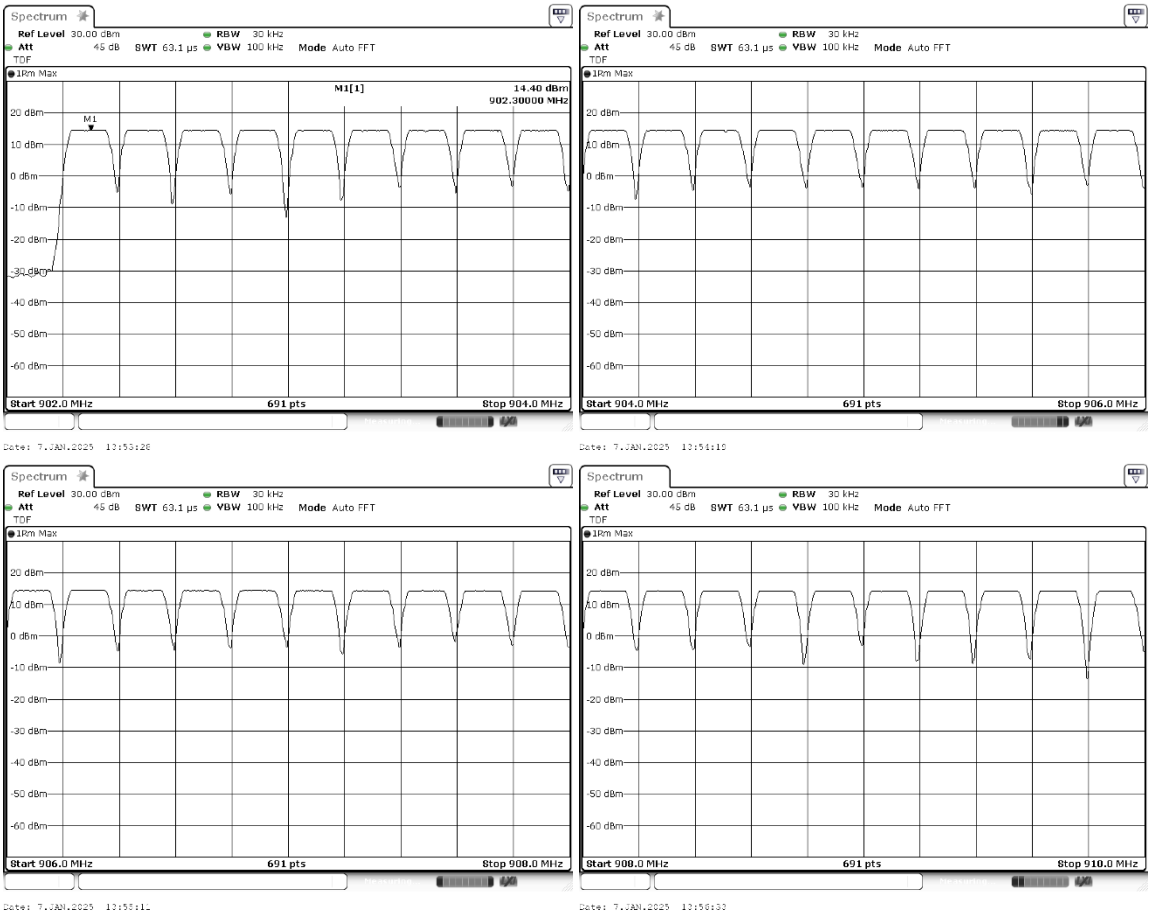
Test specification:	**Section 15.247(a)1, RSS-247 section 5.1(c), Number of hopping frequencies**		
Test procedure:	ANSI C63.10, section 7.8.3		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	28-Nov-24		
Temperature: 25 ºC	**Relative Humidity:** 45 %	**Air Pressure:** 1019 hPa	**Power:** 3.6 VDC
Remarks:			

Plot 7.5.4 Number of hopping frequencies at LoRa modulation with bit rate 1.2 kbps (continuation)



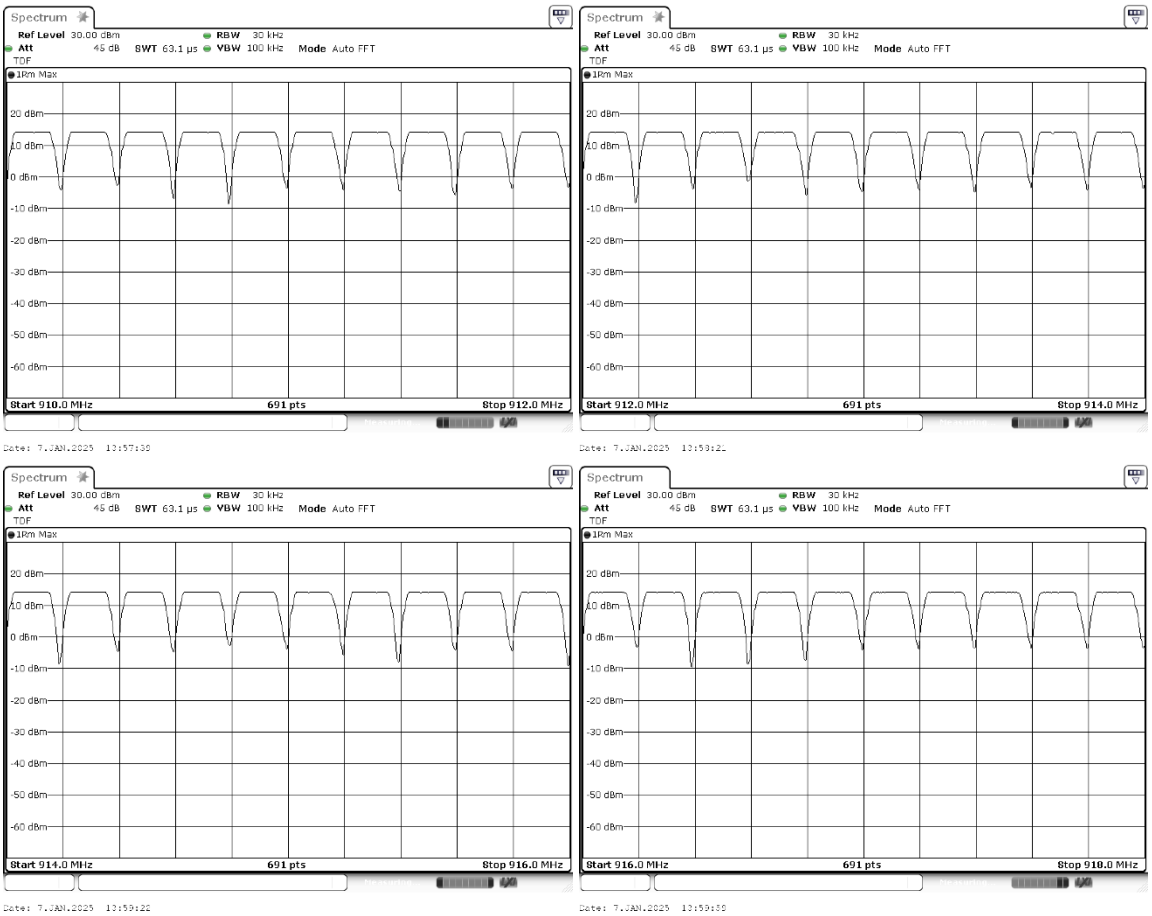
Test specification:	**Section 15.247(a)1, Number of hopping frequencies**		
Test procedure:	Public notice DA 00-705		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	07-Jan-25		
Temperature: 25 ºC	**Relative Humidity:** 31 %	**Air Pressure:** 1021 hPa	**Power:** 3.6 VDC
Remarks: LoRa 125 kHz 6.8 kbps			

Plot 7.5.5 Number of hopping frequencies at LoRa modulation with bit rate 6.8 kbps



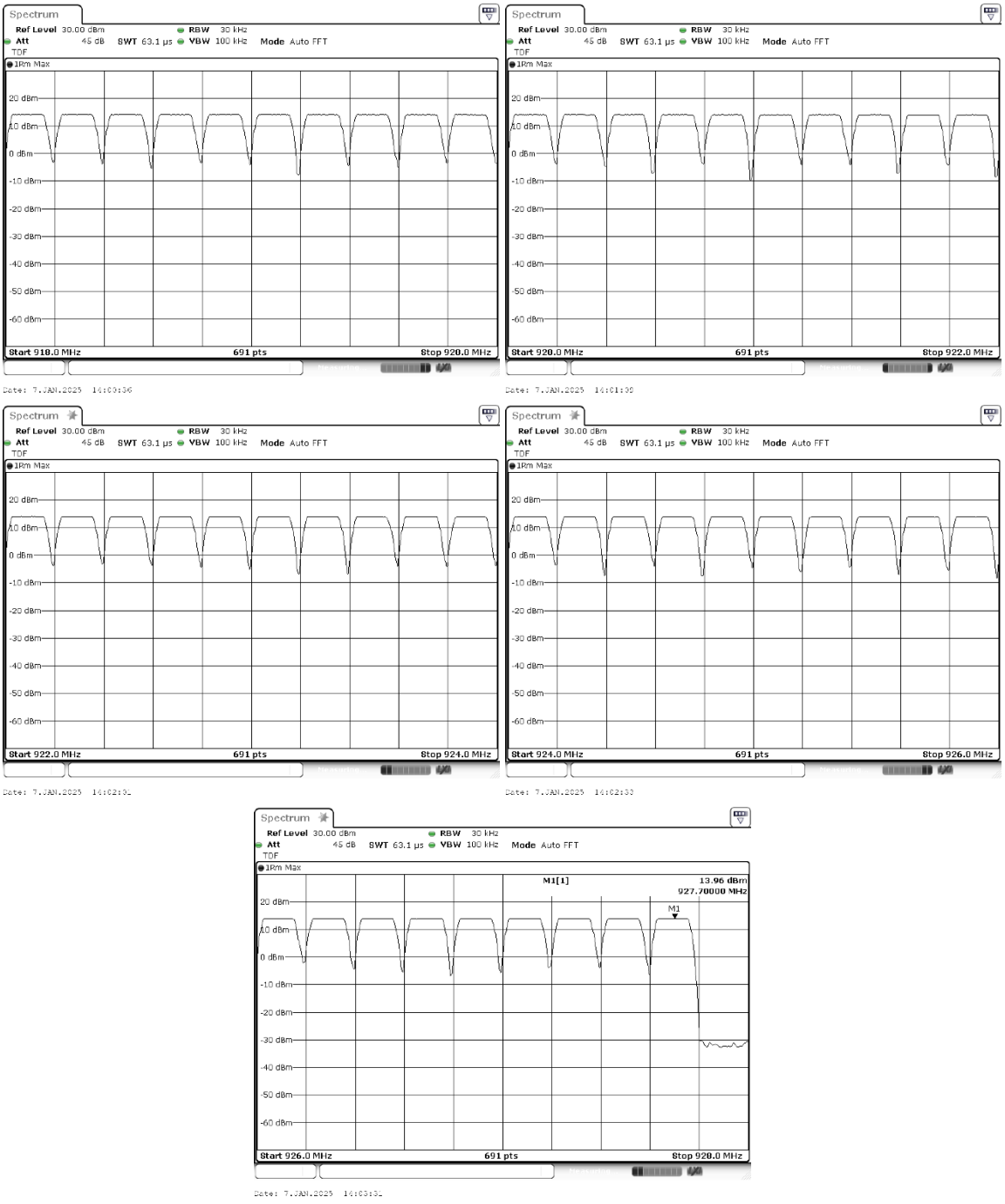
Test specification:	**Section 15.247(a)1, Number of hopping frequencies**		
Test procedure:	Public notice DA 00-705		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	07-Jan-25		
Temperature: 25 ºC	**Relative Humidity:** 31 %	**Air Pressure:** 1021 hPa	**Power:** 3.6 VDC
Remarks: LoRa 125 kHz 6.8 kbps			

Plot 7.5.6 Number of hopping frequencies at LoRa modulation with bit rate 6.8 kbps (continuation)



Test specification:	**Section 15.247(a)1, Number of hopping frequencies**		
Test procedure:	Public notice DA 00-705		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	07-Jan-25		
Temperature: 25 ºC	**Relative Humidity:** 31 %	**Air Pressure:** 1021 hPa	**Power:** 3.6 VDC
Remarks: LoRa 125 kHz 6.8 kbps			

Plot 7.5.7 Number of hopping frequencies at LoRa modulation with bit rate 6.8 kbps (continuation)



Test specification:	Section 15.247(a)1, RSS-247 section 5.1(c), Number of hopping frequencies		
Test procedure:	ANSI C63.10, section 7.8.3		
Test mode:	Compliance	Verdict:	PASS
Date(s):	07-Apr-25		
Temperature: 25 ºC	Relative Humidity: 41 %	Air Pressure: 1016 hPa	Power: 3.6 VDC
Remarks:			

7.6 Number of hopping frequencies at 2GFSK modulation

7.6.1 General

This test was performed to calculate the number of hopping frequencies used by the EUT. Specification test limits are given in Table 7.5.1.

Table 7.6.1 Minimum number of hopping frequencies

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

7.6.2 Test procedure

The EUT was set up as shown in

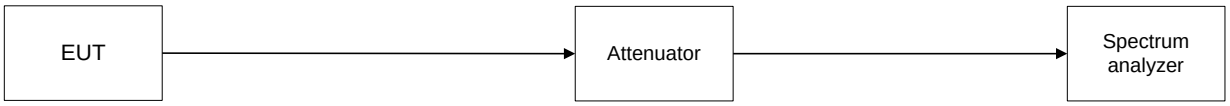
7.6.2.1 Figure 7.5.1, energized with frequency hopping function enabled and its proper operation was checked.

7.6.2.2 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.

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

7.6.2.4 The number of frequency hopping channels was calculated as provided in Table 7.5.2 and associated plots.

Figure 7.6.1 Hopping frequencies test setup



Test specification:	**Section 15.247(a)1, RSS-247 section 5.1(c), Number of hopping frequencies**		
Test procedure:	ANSI C63.10, section 7.8.3		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	07-Apr-25		
Temperature: 25 ºC	**Relative Humidity:** 41 %	**Air Pressure:** 1016 hPa	**Power:** 3.6 VDC
Remarks:			

Table 7.6.2 Hopping frequencies test results

ASSIGNED FREQUENCY: 902.0 – 928.0 MHz
MODULATION: 2GFSK 125 kHz
MODULATING SIGNAL: PRBS
BIT RATE: **50 kbps**
DETECTOR USED: Peak
RESOLUTION BANDWIDTH: ≥ 1% of the span
VIDEO BANDWIDTH: ≥ RBW
FREQUENCY HOPPING: Enabled

Number of hopping frequencies	Minimum number of hopping frequencies	Margin*	Verdict
128	50	78	Pass

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

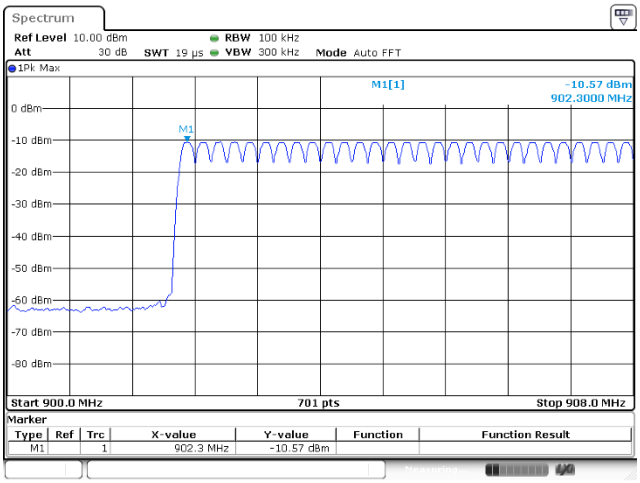
Reference numbers of test equipment used

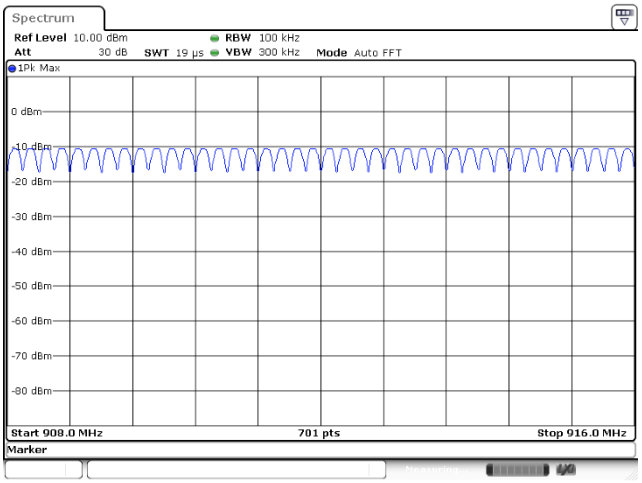
HL 3440	HL 3818	HL 3901	HL 4135	HL 5933	HL 7523		

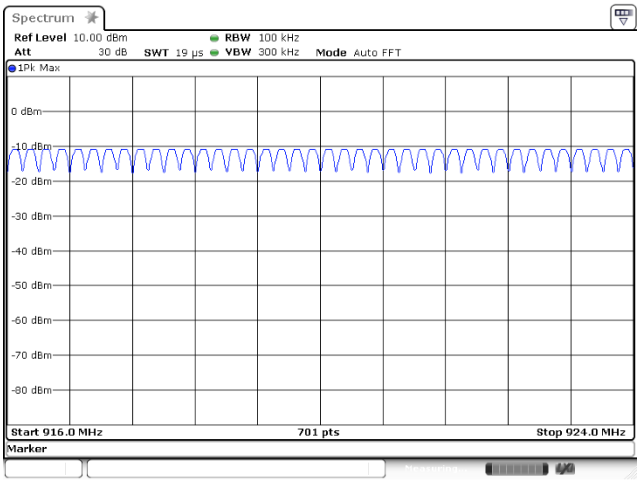
Full description is given in Appendix A.

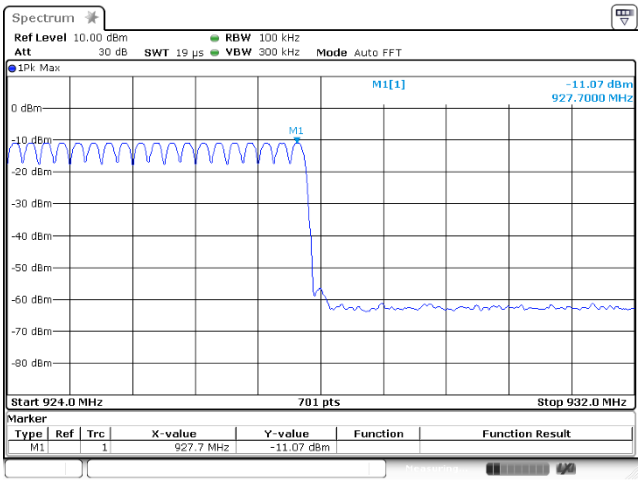
Test specification:	Section 15.247(a)1, RSS-247 section 5.1(c), Number of hopping frequencies		
Test procedure:	ANSI C63.10, section 7.8.3		
Test mode:	Compliance	Verdict:	PASS
Date(s):	07-Apr-25		
Temperature: 25 ºC	Relative Humidity: 41 %	Air Pressure: 1016 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.6.1 Number of hopping frequencies at 2GFSK modulation









Test specification:	Section 15.247(a)1, RSS-247 section 5.1(3), Average time of occupancy		
Test procedure:	ANSI C63.10, section 7.8.4		
Test mode:	Compliance	Verdict:	PASS
Date(s):	15-Jan-25 - 09-Jan-25		
Temperature: 23 ºC	Relative Humidity: 49 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

7.7 Average time of occupancy at LoRa modulation

7.7.1 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 7.7.1.

Table 7.7.1 Average time of occupancy limits

Assigned frequency range, MHz	Maximum average time of occupancy, s	Investigated period, s*
902.0 – 928.0	0.4	20.0

7.7.2 Test procedure

7.7.2.1 The EUT was set up as shown in Figure 7.7.1, energized with frequency hopping function enabled and its proper operation was checked.

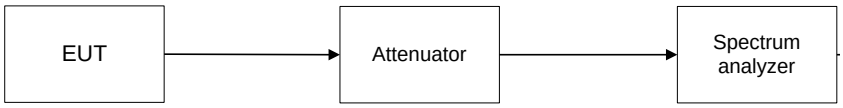
7.7.2.2 The spectrum analyzer span was set to zero centered on a hopping channel.

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

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

7.7.2.5 The test was repeated at each data rate and modulation type as provided in Table 7.7.2 and associated plots.

Figure 7.7.1 Average time of occupancy test setup



Test specification:	Section 15.247(a)1, RSS-247 section 5.1(3), Average time of occupancy		
Test procedure:	ANSI C63.10, section 7.8.4		
Test mode:	Compliance	Verdict:	PASS
Date(s):	15-Jan-25 - 09-Jan-25		
Temperature: 23 ºC	Relative Humidity: 49 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

Table 7.7.2 Average time of occupancy test results

ASSIGNED FREQUENCY: 902-928 MHz
MODULATION: LoRa
DETECTOR USED: Peak
RESOLUTION BANDWIDTH: 30 kHz
VIDEO BANDWIDTH: 100 kHz
NUMBER OF HOPPING FREQUENCIES: 128
INVESTIGATED PERIOD: 20 s
FREQUENCY HOPPING: Enabled

Carrier frequency, MHz	Single transmission duration, ms	Number of transmission within investigated period	Average time of occupancy*, s	Bit rate, kbps	Symbol rate, Msymbol/s	Limit, s	Margin, s**	Verdict
902.3	371.0	1	0.371	1.2	NA	0.4	-0.029	Pass
902.3	61.2	1	0.062	6.8	NA	0.4	-0.338	Pass

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

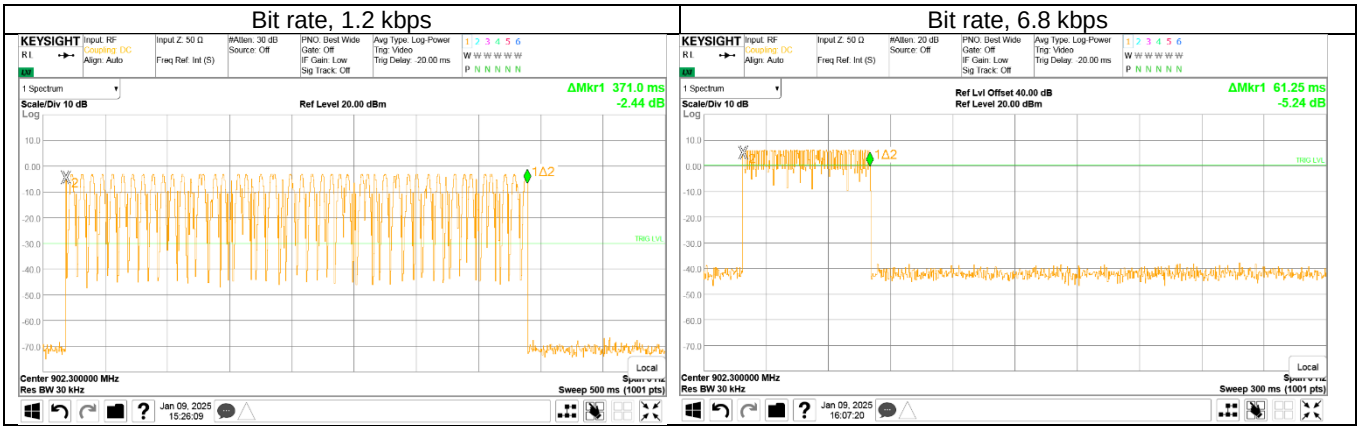
Reference numbers of test equipment used

HL 5376	HL 5638	HL 4135					

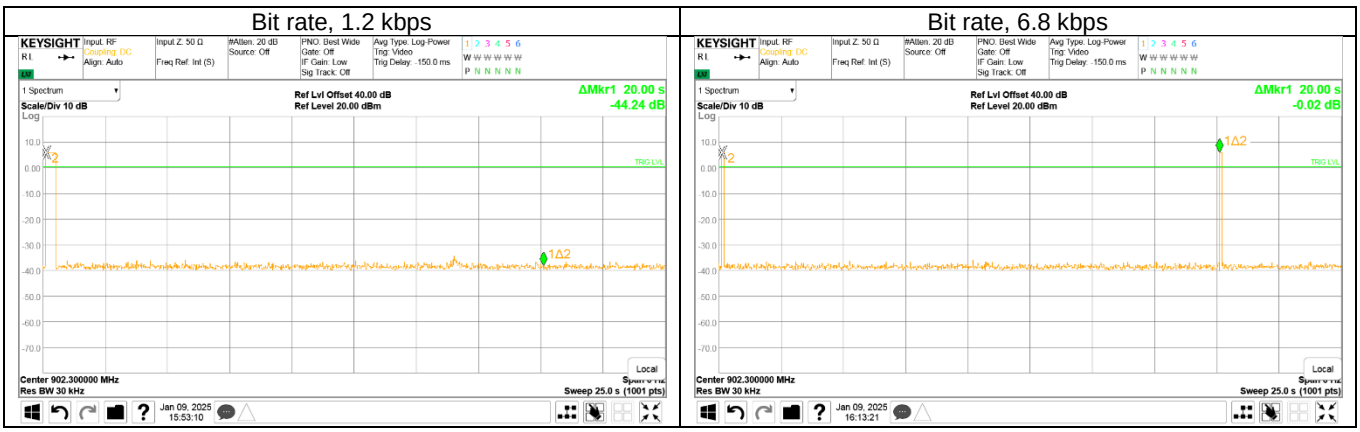
Full description is given in Appendix A.

Test specification:	Section 15.247(a)1, RSS-247 section 5.1(3), Average time of occupancy		
Test procedure:	ANSI C63.10, section 7.8.4		
Test mode:	Compliance	Verdict:	PASS
Date(s):	15-Jan-25 - 09-Jan-25		
Temperature: 23 ºC	Relative Humidity: 49 %	Air Pressure: 1012 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.7.1 Single transmission duration



Plot 7.7.2 Single transmission period



Test specification:	Section 15.247(a)1, RSS-247 section 5.1(3), Average time of occupancy		
Test procedure:	ANSI C63.10, section 7.8.4		
Test mode:	Compliance	Verdict:	PASS
Date(s):	20-Jan-25		
Temperature: 25 ºC	Relative Humidity: 41 %	Air Pressure: 1016 hPa	Power: 3.6 VDC
Remarks:			

7.8 Average time of occupancy at 2GFSK modulation

7.8.1 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 7.7.1.

Table 7.8.1 Average time of occupancy limits

Assigned frequency range, MHz	Maximum average time of occupancy, s	Investigated period, s*
902.0 – 928.0	0.4	1.6

7.8.2 Test procedure

7.8.2.1 The EUT was set up as shown in Figure 7.7.1, energized with frequency hopping function enabled and its proper operation was checked.

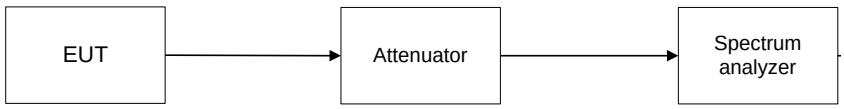
7.8.2.2 The spectrum analyzer span was set to zero centered on a hopping channel.

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

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

7.8.2.5 The test was repeated at each data rate and modulation type as provided in Table 7.7.2 and associated plots.

Figure 7.8.1 Average time of occupancy test setup



Test specification:	Section 15.247(a)1, RSS-247 section 5.1(3), Average time of occupancy		
Test procedure:	ANSI C63.10, section 7.8.4		
Test mode:	Compliance	Verdict:	PASS
Date(s):	20-Jan-25		
Temperature: 25 ºC	Relative Humidity: 41 %	Air Pressure: 1016 hPa	Power: 3.6 VDC
Remarks:			

Table 7.8.2 Average time of occupancy test results

ASSIGNED FREQUENCY:	902-928 MHz
MODULATION:	2GFSK
DETECTOR USED:	Peak
RESOLUTION BANDWIDTH:	30 kHz
VIDEO BANDWIDTH:	100 kHz
NUMBER OF HOPPING FREQUENCIES:	4
INVESTIGATED PERIOD:	1.6 s
FREQUENCY HOPPING:	Enabled

Carrier frequency, MHz	Single transmission duration, ms	Number of transmission within investigated period	Average time of occupancy*, s	Bit rate, kbps	Symbol rate, Msymbol/s	Limit, s	Margin, s**	Verdict
902.3	12.55	1	0.01255	50	NA	0.4	-0.388	Pass

** - Margin = Average time of occupancy – specification limit.

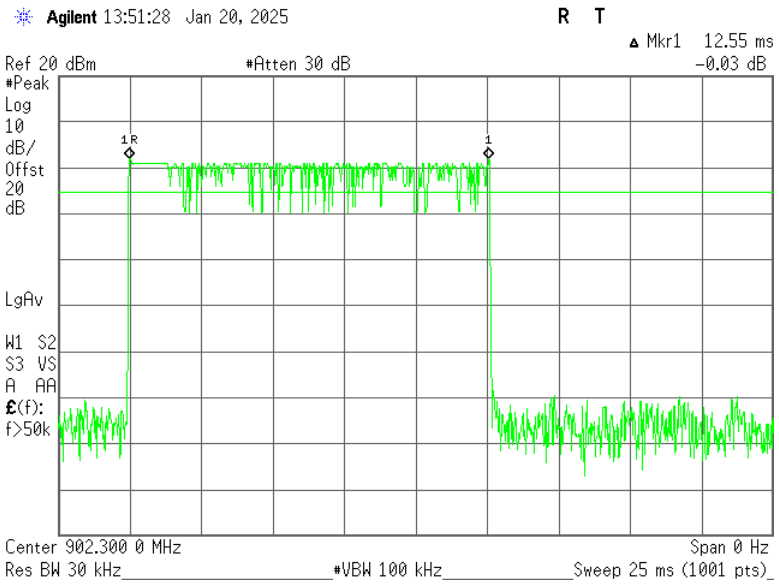
Reference numbers of test equipment used

HL 3440	HL 3818	HL 3901	HL 4135	HL 5933	HL 7523		

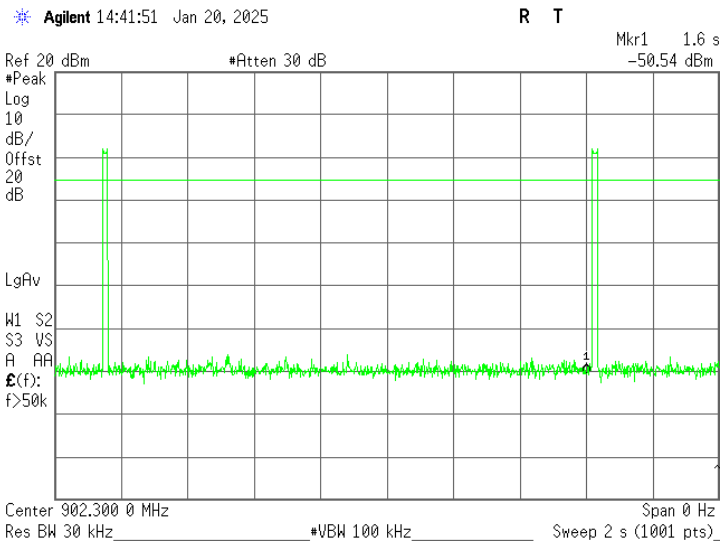
Full description is given in Appendix A.

Test specification:	Section 15.247(a)1, RSS-247 section 5.1(3), Average time of occupancy		
Test procedure:	ANSI C63.10, section 7.8.4		
Test mode:	Compliance	Verdict:	PASS
Date(s):	20-Jan-25		
Temperature: 25 ºC	Relative Humidity: 41 %	Air Pressure: 1016 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.8.1 Single transmission duration



Plot 7.8.2 Single transmission period



Test specification:	Section 15.247(b)2, RSS-247 section 5.4(a), Peak output power		
Test procedure:	ANSI C63.10, section 11.9.2.2.4		
Test mode:	Compliance	Verdict:	PASS
Date(s):	05-Jan-25 - 07-Jan-25		
Temperature: 23 ºC	Relative Humidity: 35 %	Air Pressure: 1011 hPa	Power: 3.6 VDC
Remarks:			

7.9 Peak output power at LoRa modulaion

7.9.1 General

This test was performed to measure the maximum peak output power at the transmitter RF antenna connector. Specification test limits are given in Table 7.9.1.

Table 7.9.1 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*

*- 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.

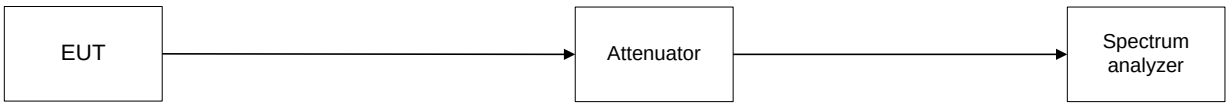
7.9.2 Test procedure

7.9.2.1 The EUT was set up as shown in Figure 7.9.1, energized and its proper operation was checked.

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

7.9.2.3 The frequency span of spectrum analyzer was set approximately 5 times wider than 20 dB bandwidth of the EUT and the resolution bandwidth was set wider than 20 dB bandwidth of the EUT. The spectrum analyzer trace was allowed to stabilize and the maximum peak output power was measured as provided in Table 7.9.2 and associated plots.

Figure 7.9.1 Peak output power test setup



Test specification:	**Section 15.247(b)2, RSS-247 section 5.4(a), Peak output power**		
Test procedure:	ANSI C63.10, section 11.9.2.2.4		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	05-Jan-25 - 07-Jan-25		
Temperature: 23 ºC	**Relative Humidity:** 35 %	**Air Pressure:** 1011 hPa	**Power:** 3.6 VDC
Remarks:			

Table 7.9.2 Peak output power test results

ASSIGNED FREQUENCY:	902-928 MHz
MODULATION:	LoRa
TRANSMITTER OUTPUT POWER SETTINGS:	Maximum
DETECTOR USED:	Average
EUT 20 dB BANDWIDTH:	143.99 kHz
RESOLUTION BANDWIDTH:	1000 kHz
VIDEO BANDWIDTH:	3000 kHz
FREQUENCY HOPPING:	Disabled

BIT RATE: 1.2 kbps

Carrier frequency, MHz	Spectrum analyzer reading, dBm	External attenuation, dB	DC factor, dB	Peak output power**, dBm	Limit, dBm	Margin*, dB	Verdict
902.3	18.13	Included	1.98	20.11	30.00	-9.89	Pass
915.0	17.84	Included	1.98	19.82	30.00	-10.18	Pass
927.7	17.86	Included	1.98	19.84	30.00	-10.16	Pass

BIT RATE: 6.8 kbps

Carrier frequency, MHz	Spectrum analyzer reading, dBm	External attenuation, dB	DC factor, dB	Peak output power**, dBm	Limit, dBm	Margin*, dB	Verdict
902.3	13.06	Included	7.08	20.14	30.00	-9.86	Pass
915.0	13.00	Included	7.08	20.08	30.00	-9.92	Pass
927.7	13.10	Included	7.08	20.18	30.00	-9.82	Pass

* - Margin = Peak output power – specification limit.
** - Peak output power = SA reading + DC factor, where
DC Factor = 10*log (1/(Txon / Txon+Txoff)

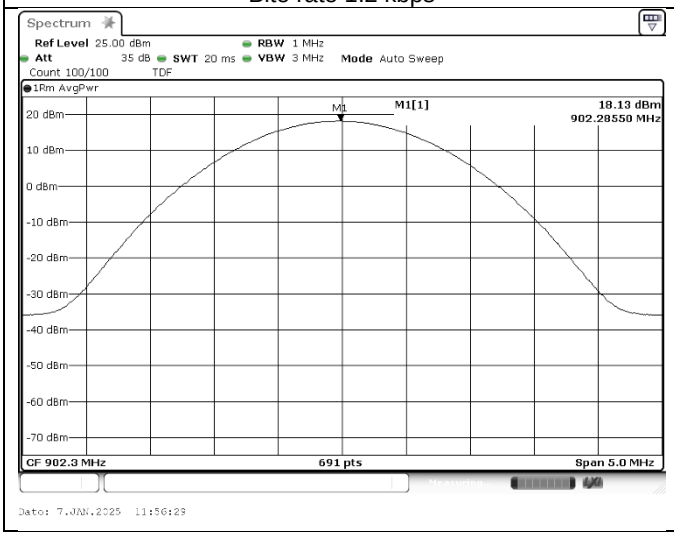
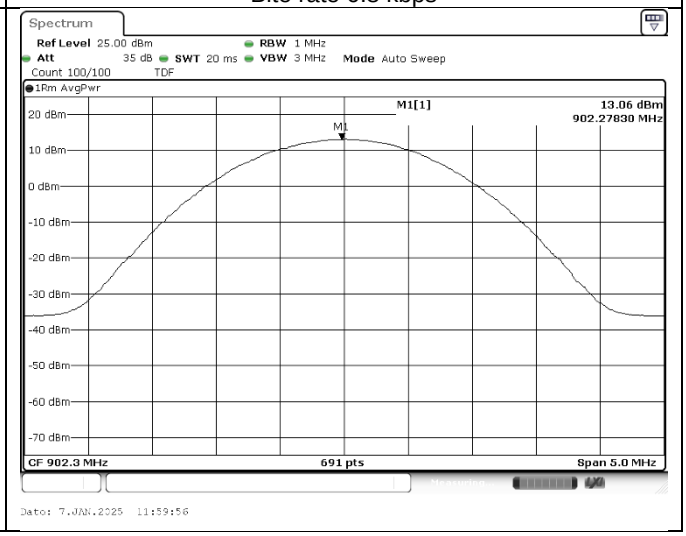
Reference numbers of test equipment used

HL 3440	HL 4136	HL 4355	HL 5376	HL 5637	HL 5933	HL 7546	

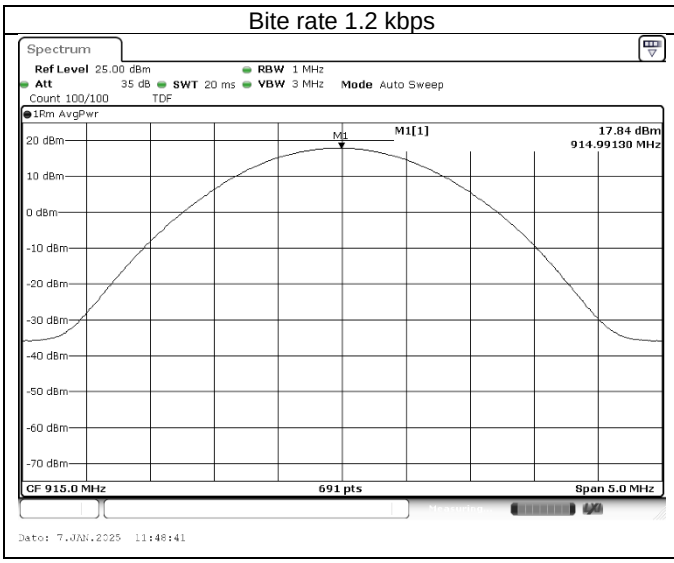
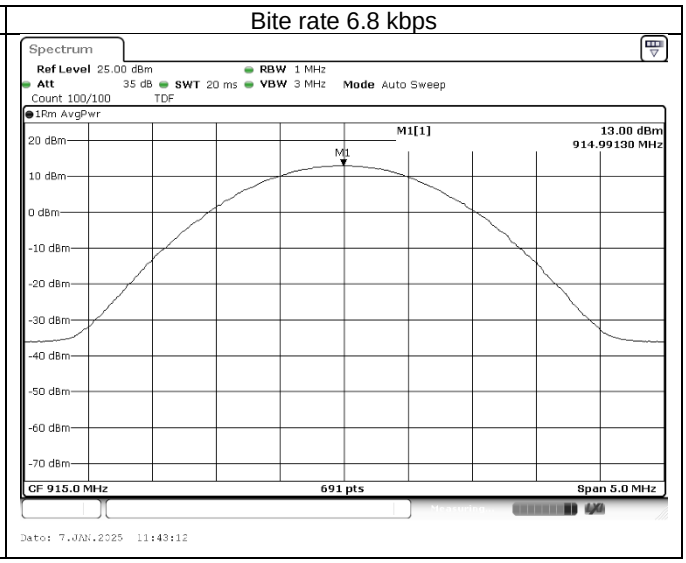
Full description is given in Appendix A.

Test specification:	Section 15.247(b)2, RSS-247 section 5.4(a), Peak output power		
Test procedure:	ANSI C63.10, section 11.9.2.2.4		
Test mode:	Compliance	Verdict:	PASS
Date(s):	05-Jan-25 - 07-Jan-25		
Temperature: 23 ºC	Relative Humidity: 35 %	Air Pressure: 1011 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.9.1 Average output power at low frequency

Bite rate 1.2 kbps	Bite rate 6.8 kbps
	

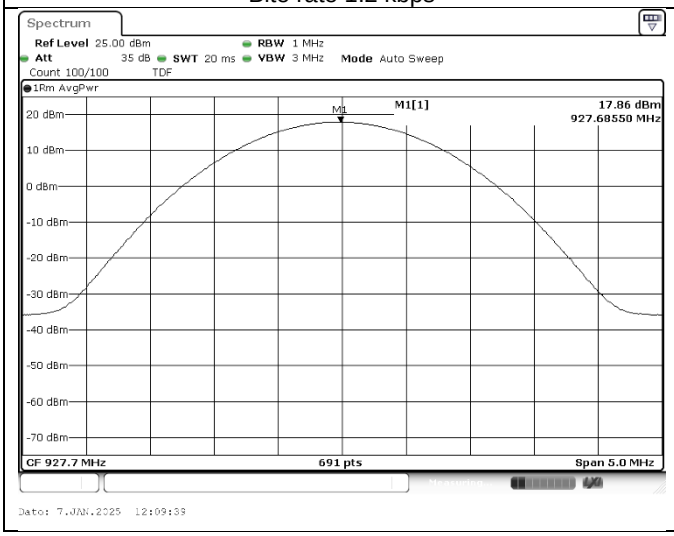
Plot 7.9.2 Average output power at mid frequency

Bite rate 1.2 kbps	Bite rate 6.8 kbps
	

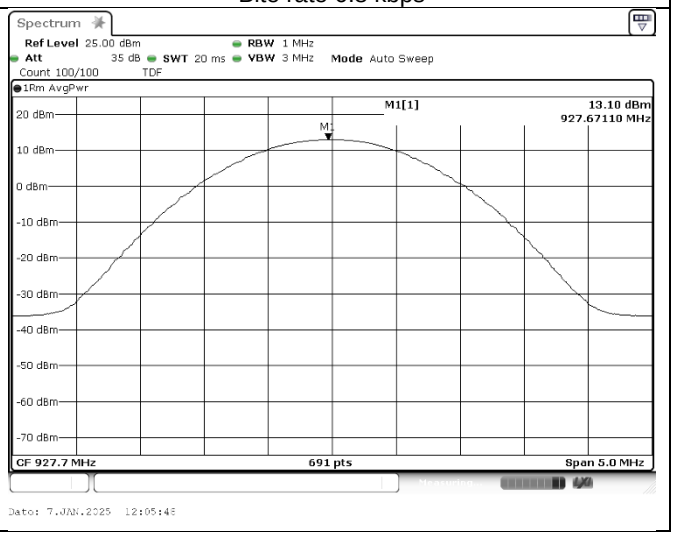
Test specification:	Section 15.247(b)2, RSS-247 section 5.4(a), Peak output power		
Test procedure:	ANSI C63.10, section 11.9.2.2.4		
Test mode:	Compliance	Verdict:	PASS
Date(s):	05-Jan-25 - 07-Jan-25		
Temperature: 23 ºC	Relative Humidity: 35 %	Air Pressure: 1011 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.9.3 Average output power at high frequency

Bite rate 1.2 kbps

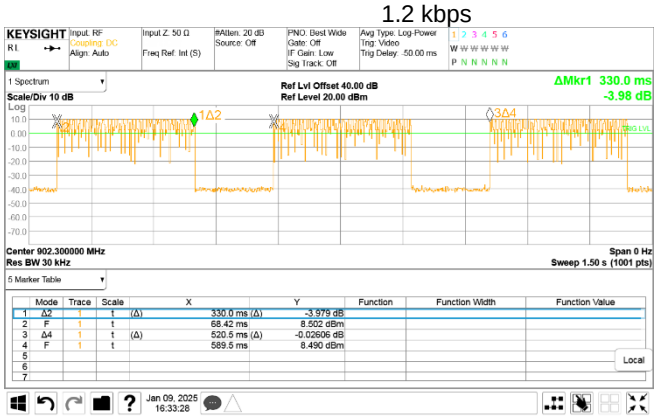


Bite rate 6.8 kbps



Plot 1.1.4 Transmission pulse duration and period

1.2 kbps



6.8 kbps

Test specification:	Section 15.247(b)2, RSS-247 section 5.4(a), Peak output power		
Test procedure:	ANSI C63.10, section 11.9.2.2.4		
Test mode:	Compliance	Verdict:	PASS
Date(s):	09-Jan-25		
Temperature: 23 ºC	Relative Humidity: 47 %	Air Pressure: 1014 hPa	Power: 3.6 VDC
Remarks:			

7.10 Peak output power at 2GFSK modulation

7.10.1 General

This test was performed to measure the maximum peak output power at the transmitter RF antenna connector. Specification test limits are given in Table 7.9.1.

Table 7.10.1 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***

*- 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.

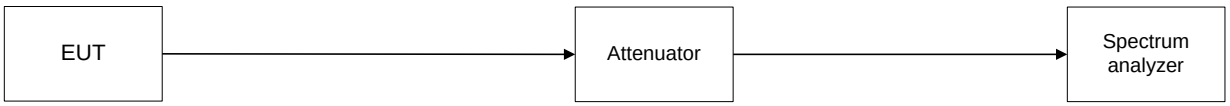
7.10.2 Test procedure

7.10.2.1 The EUT was set up as shown in Figure 7.9.1, energized and its proper operation was checked.

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

7.10.2.3 The frequency span of spectrum analyzer was set approximately 5 times wider than 20 dB bandwidth of the EUT and the resolution bandwidth was set wider than 20 dB bandwidth of the EUT. The spectrum analyzer trace was allowed to stabilize and the maximum peak output power was measured as provided in Table 7.9.2 and associated plots.

Figure 7.10.1 Peak output power test setup



Test specification:	**Section 15.247(b)2, RSS-247 section 5.4(a), Peak output power**		
Test procedure:	ANSI C63.10, section 11.9.2.2.4		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	09-Jan-25		
Temperature: 23 ºC	**Relative Humidity:** 47 %	**Air Pressure:** 1014 hPa	**Power:** 3.6 VDC
Remarks:			

Table 7.10.2 Peak output power test results

ASSIGNED FREQUENCY: 902-928 MHz
MODULATION: 2GFSK
TRANSMITTER OUTPUT POWER SETTINGS: Maximum
DETECTOR USED: Average
EUT 20 dB BANDWIDTH: 61.54 kHz
RESOLUTION BANDWIDTH: 1000 kHz
VIDEO BANDWIDTH: 3000 kHz
FREQUENCY HOPPING: Disabled

BIT RATE: 50 kbps

Carrier frequency, MHz	Spectrum analyzer reading, dBm	External attenuation, dB	Average factor, dB	Peak output power, dBm	Limit, dBm	Margin*, dB	Verdict
902.3	5.16	Included	5.34	10.50	24.00	-13.50	Pass
915.0	5.26	Included	5.34	10.60	24.00	-13.40	Pass
927.7	5.29	Included	5.34	10.63	24.00	-13.37	Pass

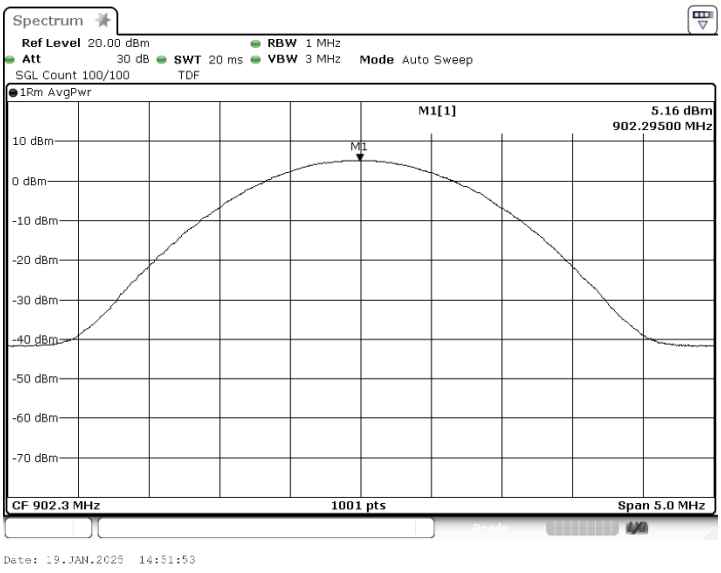
* - Margin = Peak output power – specification limit.
** - Peak output power = SA reading + DC factor, where
DC Factor = 10*log (1/(Txon / Txon+Txoff)

Reference numbers of test equipment used

HL 3440	HL 4135	HL 4355	HL 5642	HL 5933	HL 7523		

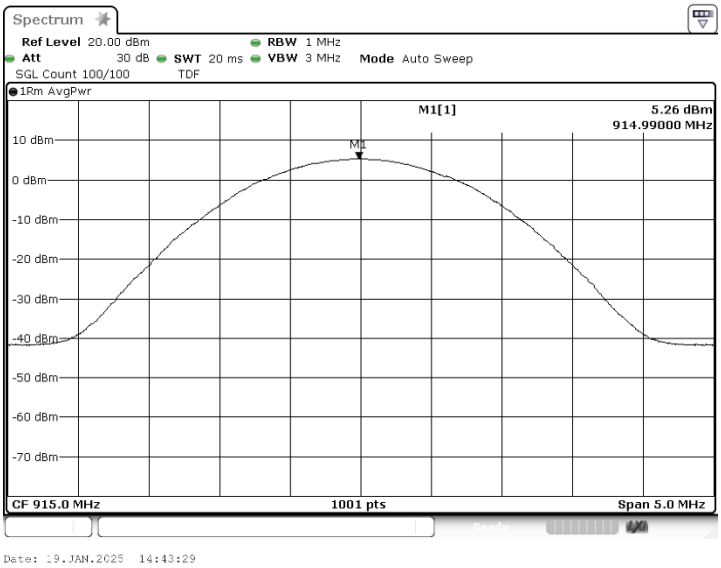
Full description is given in Appendix A.

Plot 7.10.1 Average output power at low frequency

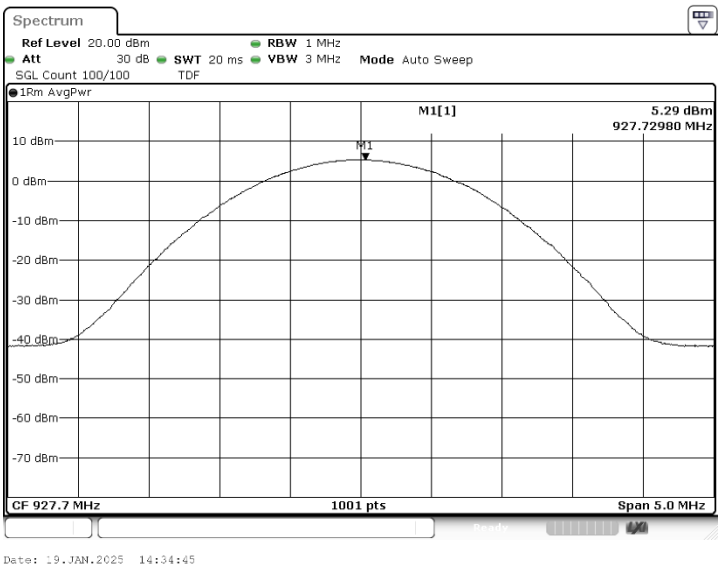


Test specification:	Section 15.247(b)2, RSS-247 section 5.4(a), Peak output power		
Test procedure:	ANSI C63.10, section 11.9.2.2.4		
Test mode:	Compliance	Verdict:	PASS
Date(s):	09-Jan-25		
Temperature: 23 ºC	Relative Humidity: 47 %	Air Pressure: 1014 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.10.2 Average output power at mid frequency

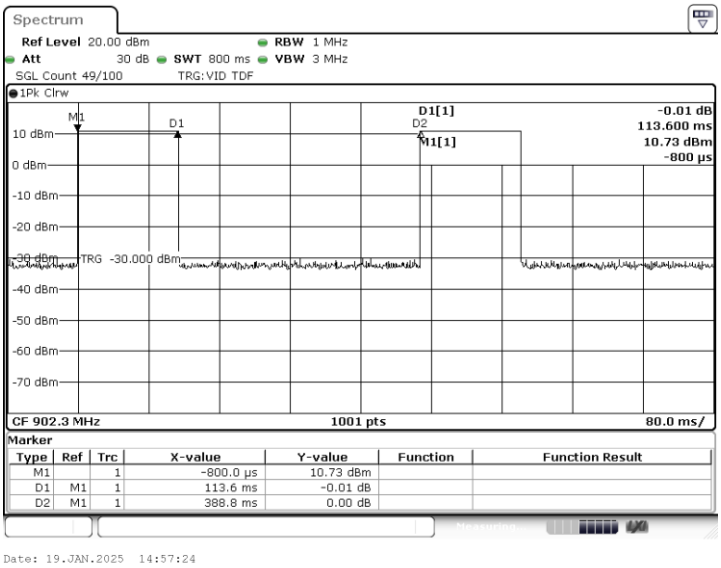


Plot 7.10.3 Average output power at high frequency



Test specification:	Section 15.247(b)2, RSS-247 section 5.4(a), Peak output power		
Test procedure:	ANSI C63.10, section 11.9.2.2.4		
Test mode:	Compliance	Verdict:	PASS
Date(s):	09-Jan-25		
Temperature: 23 ºC	Relative Humidity: 47 %	Air Pressure: 1014 hPa	Power: 3.6 VDC
Remarks:			

Plot 1.1.4 Transmission pulse duration and period



Test specification:	Section 15.247(e), RSS-247 section 5.2(b), Peak power density		
Test procedure:	ANSI C63.10, section 11.10.5		
Test mode:	Compliance	Verdict:	PASS
Date(s):	09-Jan-25		
Temperature: 23 ºC	Relative Humidity: 47 %	Air Pressure: 1014 hPa	Power: 3.6 VDC
Remarks:			

7.11 Maximum power spectral density at LoRa modulation

7.11.1 General

This test was performed to measure the maximum peak output power at the transmitter RF antenna connector. Specification test limits are given in Table 7.9.1.

Table 7.11.1 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			

*- 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.

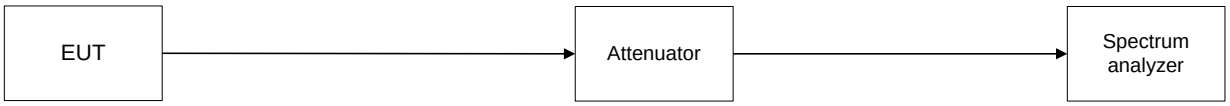
7.11.2 Test procedure

7.11.2.1 The EUT was set up as shown in Figure 7.9.1, energized and its proper operation was checked.

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

7.11.2.3 The frequency span of spectrum analyzer was set approximately 5 times wider than 20 dB bandwidth of the EUT and the resolution bandwidth was set wider than 20 dB bandwidth of the EUT. The spectrum analyzer trace was allowed to stabilize and the maximum peak output power was measured as provided in Table 7.9.2 and associated plots.

Figure 7.11.1 Maximum power spectral density test setup



Test specification:	**Section 15.247(e), RSS-247 section 5.2(b), Peak power density**		
Test procedure:	ANSI C63.10, section 11.10.5		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	09-Jan-25		
Temperature: 23 ºC	**Relative Humidity:** 47 %	**Air Pressure:** 1014 hPa	**Power:** 3.6 VDC
Remarks:			

Table 7.11.2 Maximum power spectral density test results

ASSIGNED FREQUENCY: 902-928 MHz
MODULATION: LoRa
TRANSMITTER OUTPUT POWER SETTINGS: Maximum
DETECTOR USED: Average
EUT 20 dB BANDWIDTH: 144 kHz
RESOLUTION BANDWIDTH: 3 kHz
VIDEO BANDWIDTH: 30 kHz
FREQUENCY HOPPING: Disabled

BIT RATE: **1.2 kbps**

Carrier frequency, MHz	Spectrum analyzer reading, dBm	External attenuation, dB	DC factor, dB	Peak power density, dBm /3 kHz**	Limit, dBm	Margin*, dB	Verdict
902.3	4.19	Included	1.98	6.17	8.00	-1.83	Pass
915.0	4.71	Included	1.98	6.69	8.00	-1.31	Pass
927.7	5.45	Included	1.98	7.43	8.00	-0.57	Pass

BIT RATE: **6.8 kbps**

Carrier frequency, MHz	Spectrum analyzer reading, dBm	External attenuation, dB	DC factor, dB	Peak power density, dBm /3 kHz**	Limit, dBm	Margin*, dB	Verdict
902.3	0.07	Included	7.08	7.15	8.00	-0.85	Pass
915.0	-0.46	Included	7.08	6.62	8.00	-1.38	Pass
927.7	-1.13	Included	7.08	5.95	8.00	-2.05	Pass

* - Margin = Peak output power – specification limit.
** - Peak power density = SA reading + DC factor, where
DC Factor = 10*log(1/(Txon / Txon+Txoff)

Reference numbers of test equipment used

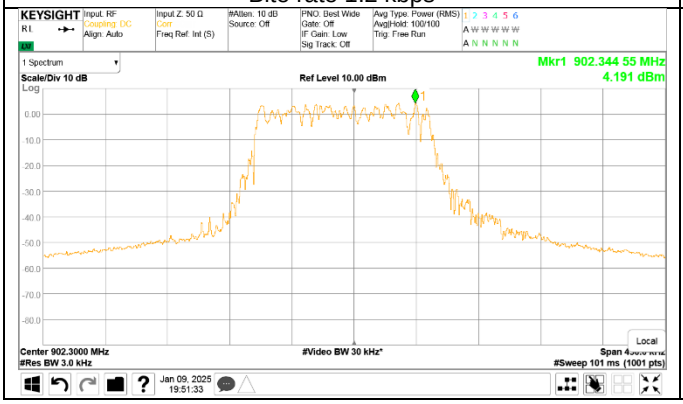
HL 3230	HL 3440	HL 5376	HL 5638	HL 5933			

Full description is given in Appendix A.

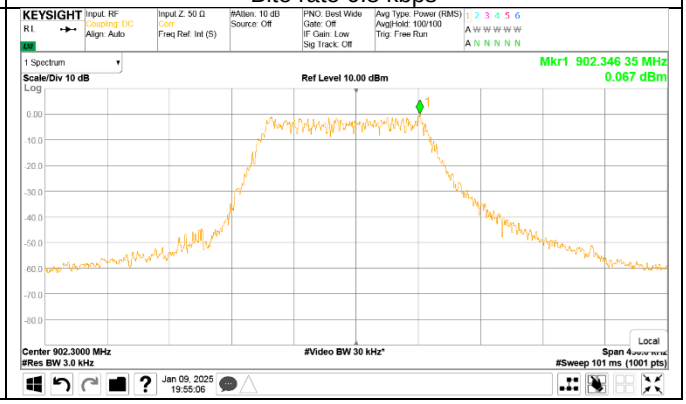
Test specification:	Section 15.247(e), RSS-247 section 5.2(b), Peak power density		
Test procedure:	ANSI C63.10, section 11.10.5		
Test mode:	Compliance	Verdict:	PASS
Date(s):	09-Jan-25		
Temperature: 23 ºC	Relative Humidity: 47 %	Air Pressure: 1014 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.11.1 Average power spectral density at low frequency

Bite rate 1.2 kbps

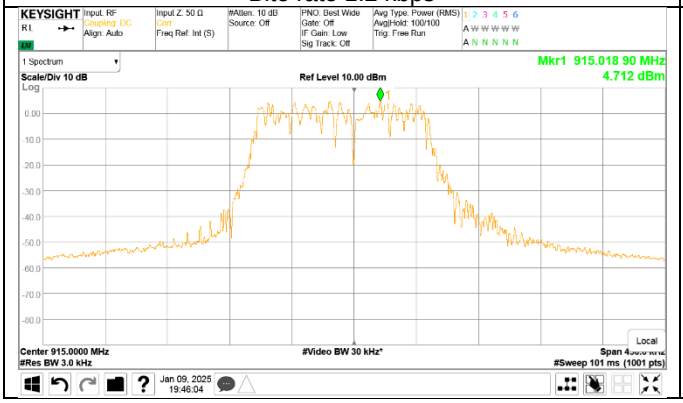


Bite rate 6.8 kbps

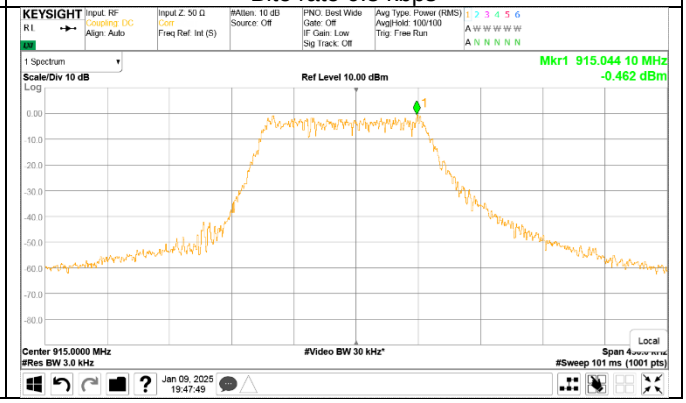


Plot 7.11.2 Average power spectral density at mid frequency

Bite rate 1.2 kbps



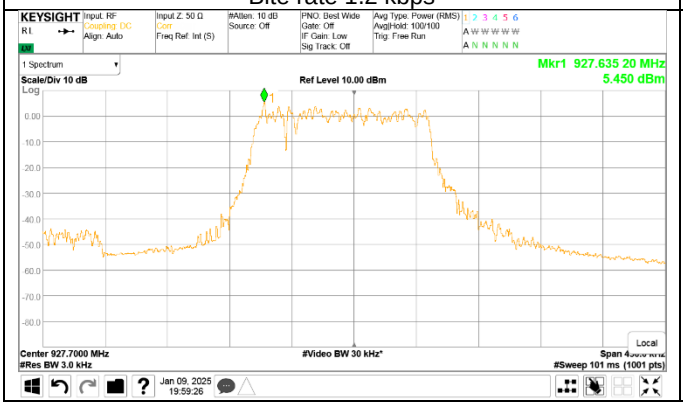
Bite rate 6.8 kbps



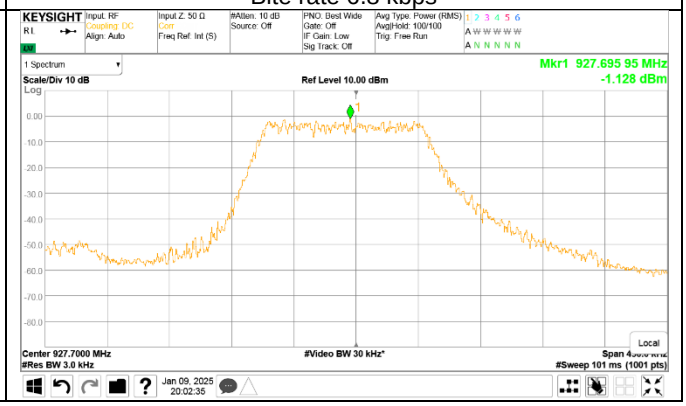
Test specification:	Section 15.247(e), RSS-247 section 5.2(b), Peak power density		
Test procedure:	ANSI C63.10, section 11.10.5		
Test mode:	Compliance	Verdict:	PASS
Date(s):	09-Jan-25		
Temperature: 23 ºC	Relative Humidity: 47 %	Air Pressure: 1014 hPa	Power: 3.6 VDC
Remarks:			

Plot 7.11.3 Average power spectral density at high frequency

Bite rate 1.2 kbps

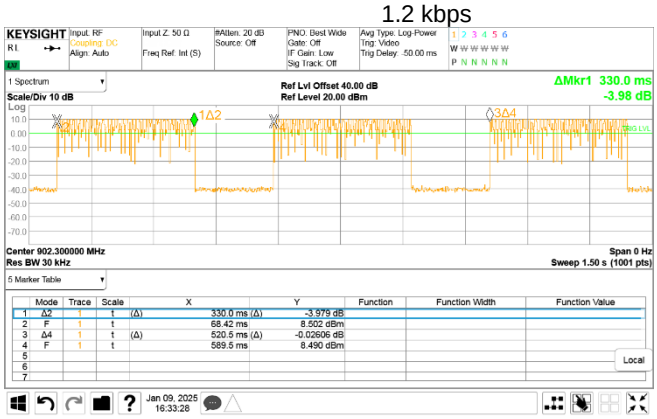


Bite rate 6.8 kbps



Plot 1.1.4 Transmission pulse duration and period

1.2 kbps



6.8 kbps

Test specification:	Section 15.247(e), RSS-247 section 5.2(b), Peak power density		
Test procedure:	ANSI C63.10, section 11.10.5		
Test mode:	Compliance	Verdict:	PASS
Date(s):	19-Jan-25		
Temperature: 22 ºC	Relative Humidity: 41 %	Air Pressure: 1016 hPa	Power: 3.6 VDC
Remarks:			

7.12 Maximum power spectral density at 2GFSK modulation

7.12.1 General

This test was performed to measure the maximum peak output power at the transmitter RF antenna connector. Specification test limits are given in Table 7.9.1.

Table 7.12.1 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			

*- 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.

7.12.2 Test procedure

7.12.2.1 The EUT was set up as shown in Figure 7.9.1, energized and its proper operation was checked.

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

7.12.2.3 The frequency span of spectrum analyzer was set approximately 5 times wider than 20 dB bandwidth of the EUT and the resolution bandwidth was set wider than 20 dB bandwidth of the EUT. The spectrum analyzer trace was allowed to stabilize and the maximum peak output power was measured as provided in Table 7.9.2 and associated plots.

Figure 7.12.1 Maximum power spectral density test setup