

Test Report

Report Number:

F241685E2

Equipment under Test (EUT):

**AIS Class B SOTDMA Transponder without / with Wi-Fi
B650 / B650W**

Applicant:

Alltek Marine Electronics Corporation

Manufacturer:

Alltek Marine Electronics Corporation



Deutsche
Akkreditierungsstelle
D-PL-17186-01-00

References

- [1] **ANSI C63.26-2015**, American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services
- [2] **FCC CFR 47 Part 80**, Stations In The Maritime Services
- [3] **FCC CFR 47 Part 2**, Frequency allocations and radio treaty matters; general rules and regulations
- [4] **RSS-182 Issue 6 Amendment 2 (August 2024)**, Maritime Radio Transmitters and Receivers in the Band 156 – 162.5 MHz
- [5] **RSS-Gen Issue 5 Amendment 2 (February 2021)**, General Requirements for Compliance of Radio Apparatus
- [6] **KDB 971168 D01 V03R01 April 2018**, Measurement Guidance for Certification of Licensed Digital Transmitters

Test Result

The requirements of the tests performed as shown in the overview (clause 4) were fulfilled by the equipment under test. The complete test results are presented in the following.

“Passed” indicates that the equipment under test conforms with the relevant limits of the testing standard without taking any measurement uncertainty into account as stated in clause 1.3 of ANSI C63.26 (2015). However, the measurement uncertainty is calculated and shown in this test report.

Tested and
written by:

Signature

Reviewed and
approved by:

Signature

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The test results herein refer only to the tested sample. PHOENIX TESTLAB GmbH is not responsible for any generalisations or conclusions drawn from these test results concerning further samples. Any modification of the tested samples is prohibited and leads to the invalidity of this test report. Each page necessarily contains the PHOENIX TESTLAB Logo and the TEST REPORT NUMBER.

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1 Identification

1.1 Applicant

Name:	Alltek Marine Electronics Corporation
Address:	14F-2, No. 237, Sec. 1, Datong Rd., Xizhi Dist., New Taipei City, 22161
Country:	Taiwan
Name for contact purposes:	Mr. H.A. CHEN
eMail Address:	ch@alltekmarine.com
Applicant represented during the test by the following person:	---

1.2 Manufacturer

Name:	Alltek Marine Electronics Corporation
Address:	14F-2, No. 237, Sec. 1, Datong Rd., Xizhi Dist., New Taipei City, 22161
Country:	Taiwan
Name for contact purposes:	Mr. H.A. CHEN
eMail Address:	ch@alltekmarine.com
Manufacturer represented during the test by the following person:	---

1.3 Test laboratory

The tests were carried out at: **PHOENIX TESTLAB GmbH**
Königswinkel 10
32825 Blomberg
Germany

accredited by *Deutsche Akkreditierungsstelle GmbH (DAkkS)* according to DIN EN ISO/IEC 17025:2018.
The accreditation is only valid for the scope of accreditation listed in the annex of the certificate D-PL-17186-01-00. FCC Test Firm Designation Number DE0004, FCC Test Firm Registration Number 469623, CAB Identifier DE0003 and ISED# 3469A.

1.4 EUT (Equipment Under Test)

Test object: *	AIS Class B SOTDMA Transponder without / with Wi-Fi
PMN: *	B650 (without Wi-Fi) / B650W (with Wi-Fi)
HVIN: *	B650
FCC ID: *	WZ7AIS-B650
IC: *	9547A-AISB650
Serial number: *	00001
PCB identifier: *	M-PCB-B650MBV2, M-PCB-B650IOBV2, M-PCB-B650USBV2, B650W only: M-PCB-WFB002V2
FVIN: *	V2
Lowest internal frequency: *	32.768 kHz

*: Declared by the applicant.

One sample was used for the tests.

Note: PHOENIX TESTLAB GmbH does not take samples. The samples used for tests are provided exclusively by the applicant.

1.5 Technical data of equipment

Power supply: *	External DC power supply		
Supply voltage: *	$U_{Nom} = 12.0 \text{ V}_{DC}$	$U_{Min} = 9.6 \text{ V}_{DC}$	$U_{Max} = 31.2 \text{ V}_{DC}$
Alignment range: *	156.025 to 162.025 MHz		
Switching range: *	156.025 to 162.025 MHz		
Channel separation: *	25 kHz		
Type of modulation:	GMSK		
Data rate: *	9600 bps per channel		
Rated RF output power: *	1 W and 5 W / 30 dBm and 37 dBm		
Antenna connector: *	SO-239		
VHF antenna gain: *	2.9 dBi 0.75 dBd		
Temperature range: *	-25 °C to 55 °C		

*: Declared by the applicant.

Ports/Connectors

Identification	Connector		Length (during test)
	EUT	Ancillary	
PWR/DATA	12-pin connector	None	2.0 m
GNSS	TNC	-	Not used
Antenna	SO-239	N-Connector	0.5 m
NMEA 2000	5-pin connector	-	Not used
USB	USB-C	USB-C	Not used

Equipment used for testing	
Laptop computer* ²	Laptop PC with B620_TestProgram_20240709.exe * ¹
RS422 to USB converter board * ¹	-
Bosch GPS antenna* ²	-

*¹ Provided by the applicant

*² Provided by the laboratory

1.6 Dates

Date of receipt of test sample:	12.07.2024
Start of test:	17.01.2025
End of test:	04.02.2025

2 Operational states

The EUT is an AIS class B transceiver. It contains two AIS and DSC receivers, which are continuously receiving on a certain frequency and an AIS transmitter, which operates on one channel.

If not otherwise stated, for the documented receiver tests the receivers were set as follows: receiver A receiving on 156.025 MHz and receiver B receiving on 162.025 MHz. The EUT was supplied with 12 V_{DC} by an external power supply.

The NMEA0183 interface of the EUT was connected to the RS232 interface of a laptop PC via a NMEA0183 to RS232 converter during all measurements. With the help of a test software (B620_TestProgram_20240709.exe) all used transmitter and receiver operation modes could be adjusted as well as all possible power levels (1 W and 5 W). As pretests have shown, the 5 W setting was the worst case setting for all transmitter test cases, so the documented test results except the transmitter output power test were observed with the transmitter output power set to 5 W / 37 dBm.

Because the EUT will be fixed mounted on a ship, it was classified as other device and not as table-top device according to [1], so it was positioned on the center of the non-conducting support during the radiated measurements.

The radiated measurements inside the semi anechoic chamber were carried out in three orthogonal orientations of the EUT, which were defined as follows:

Position 1: EUT placed flat on the table.

Position 2: EUT placed on its short housing side, the cables showing sideways (horizontal).

Position 3: EUT placed on its long housing side, the cables showing upwards (vertical).

For details of the different positions, please refer annex B of this test report.

The EUT is available as B650 without Wi-Fi and as B650W with Wi-Fi.

The Wi-Fi functionality of the test sample could be activated with the test software (B620_TestProgram_20240709.exe), additionally the Wi-Fi module and its antenna were disconnected and removed for the measurements for the B650 and installed and activated for the measurements for the B650W. In this way, the same AIS part was tested for all test cases. No measurable difference related to the B650 and B650W measurement results have been detected, regardless of whether the Wi-Fi was active and installed or inactive and uninstalled.

Therefore measurement results can be deemed to be applicable for B650 and B650W.

3 Additional information

The tested sample was not labeled as required by the FCC / ISSED.

The B650W contains an Wi-Fi-module, which is not subject of this test report.

4 Overview

Application	Frequency range [MHz]	FCC CFR 47 Part 80 [2] FCC CFR 47 Part 2 [3]	RSS-182 [4] RSS-Gen [5]	Status	Refer page
Bandwidths	156.025 to 162.025	80.205 [2], 2.1049 [3]	5.4 [4], 6.7 [5]	Passed	8 et seq.
Transmitter frequency tolerances	156.025 to 162.025	80.209 [2], 2.1055 [3]	5.1.1 / 5.5 [4], 6.11 [5]	Passed	10 et seq.
Spurious emissions on antenna terminals	0.009 to 2000	80.211 [2], 2.1051 [3]	5.9.1 [4]	Passed	12 et seq.
Modulation requirements	156.025 to 162.025	80.213 [2], 2.1047 [3]	5.4 [4], 5.7 [4]	Passed	14 et seq.
Transmitter power	156.025 to 162.025	80.215 [2], 2.1046 [3]	5.1.2 / 5.6 [4], 6.12 [5]	Passed	16 et seq.
Radiated spurious emissions	30 to 2000	80.211 [2], 2.1051 [3]	6.13 [5]	Passed	17 et seq.
Suppression of interference aboard ships	0.009 to 2000	80.217 (b) [2]	7.4 [5]	Passed	23 et seq.

5 Test results

5.1 Bandwidths

5.1.1 Method of measurement (bandwidths)

The calibration of the spectrum analyser has to be checked with the help of a known signal from a signal generator. The EUT has to be connected to the spectrum analyser via a low loss cable. If the EUT is not equipped with an antenna connector, a temporary antenna connector has to be installed. The EUT has to be switched on and the hopping function has to be disabled, the transmitter shall work with its maximum data rate.

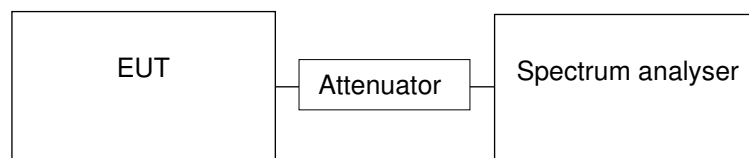
The following spectrum analyser settings according to [1] shall be used:

- Span: App. 1.5 times the OBW, centered on the actual channel.
- Resolution bandwidth: 1 % to 5 % of the OBW.
- Video bandwidth: three times the resolution bandwidth.
- Set the reference level of the instrument either above the measured peak conducted output power level or as required, keeping the signal from exceeding the maximum input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than $10\log(\text{OBW}/\text{RBW})$ below the reference level.
- Sweep: Auto.
- Detector function: Peak.
- Trace mode: Max hold.

26 dB bandwidth: After trace stabilisation the marker shall be set on the signal peak. The first display line has to be set on this value. The second display line has to be set 26 dB below the first line (or the peak marker). The frequency lines shall be set on the intersection points between the second display line and the measured curve.

99 % bandwidth: Use the 99 % power bandwidth function of the instrument.

Test set-up:



5.1.2 Test results (bandwidths)

Ambient temperature:	22 °C
Relative humidity:	22 %

Date:	17.01.2025
Tested by:	Th. KÜHN

Measured conducted at antenna port, modulated with PRBS.

The plots of this measurement are shown in annex A.1 and A.2 of this test report.

26 dB bandwidth			
TX frequency	Bandwidth [kHz]	Limit [kHz]	Test result
156.025 MHz	11.243	20.0	Passed
162.025 MHz	11.179	20.0	Passed
99 % bandwidth [kHz]			
TX frequency	Bandwidth [kHz]	Limit [kHz]	Test result
156.025 MHz	9.220	20.0	Passed
162.025 MHz	9.088	20.0	Passed

Test equipment (please refer to chapter 6 for details)

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5.2 Transmitter frequency tolerances

5.2.1 Method of measurement (transmitter frequency tolerances)

The calibration of the spectrum analyser has to be checked with the help of a known signal from a signal generator. The EUT has to be connected to the spectrum analyser via a low loss cable.

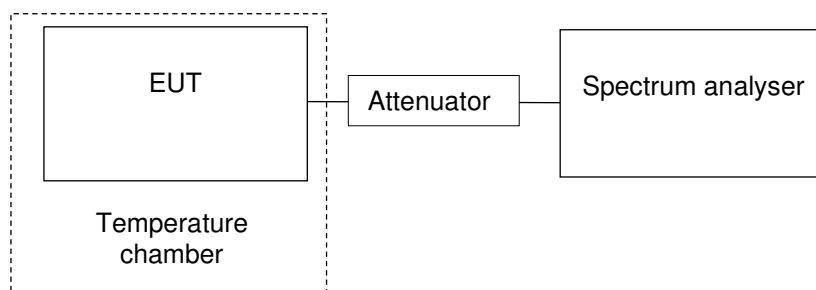
The following spectrum analyser settings according to [1] shall be used:

- Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation.
- Span: 10 kHz.
- Resolution bandwidth: 100 Hz.
- Video bandwidth: 300 Hz.
- Sweep time: Auto.
- Detector function: Peak.
- Trace mode: Max hold.

The following procedure in accordance to FCC CFR 47 Part 2.1055 (a) (2) shall be used:

- 1) The EUT has to be placed inside the temperature chamber.
- 2) Start temperature is the highest operating temperature, which is declared by the applicant or 50 °C, whatever is higher.
- 3) After the temperature is stabilized, the EUT has to be switched on. After trace stabilization the one marker shall be set on the signal peak. The transmitting signal shall be documented and the EUT has to be switched off.
- 4) The temperature than shall be changed in 10 deg steps in the temperature range 50 °C to -20 °C and step 3) must be repeated.
- 5) In case the lowest operating temperature declared by the applicant is lower than -20 °C, repeat step 3) for this temperature.

Test set-up:



5.2.2 Test results (transmitter frequency tolerances)

Ambient temperature:	22 °C
Relative humidity:	19 %

Date:	22.01.2025
Tested by:	Th. KÜHN

Position of EUT: The EUT was set-up on a non-conducting support inside the temperature chamber.

Cable guide: For further information of the cable guide refer to the pictures in annex B of this test report.

Supply voltage: During this test the EUT was powered with 9.6 to 31.2 V_{DC} by an external power supply.

Frequency stability							
Test conditions		Nominal frequency 156.025 MHz		Nominal frequency 162.025 MHz		Limit[[ppm]	Test result
Temp.	Voltage	TX frequency [MHz]	Frequency error [ppm]	TX frequency [MHz]	Frequency error [ppm]		
+55 °C	U _{nom} (12.0 V _{DC})	156.025150	0.96	162.025150	0.93	±10	Passed
+50 °C	U _{nom} (12.0 V _{DC})	156.025160	1.03	162.025150	0.93	±10	Passed
+40 °C	U _{nom} (12.0 V _{DC})	156.025150	0.96	162.025140	0.86	±10	Passed
+30 °C	U _{nom} (12.0 V _{DC})	156.025075	0.48	162.025075	0.46	±10	Passed
T _{nom} (20 °C)	U _{nom} (12.0 V _{DC})	156.025130	0.83	162.025060	0.37	±10	Passed
	U _{min} (9.6 V _{DC})	156.025130	0.83	162.025060	0.37	±10	Passed
	U _{max} (31.2 V _{DC})	156.025130	0.83	162.025060	0.37	±10	Passed
+10 °C	U _{nom} (12.0 V _{DC})	156.024965	-0.22	162.024980	-0.12	±10	Passed
0 °C	U _{nom} (12.0 V _{DC})	156.024925	-0.48	162.024945	-0.34	±10	Passed
-10 °C	U _{nom} (12.0 V _{DC})	156.024895	-0.67	162.024891	-0.67	±10	Passed
-20 °C	U _{nom} (12.0 V _{DC})	156.024895	-0.67	162.024954	-0.28	±10	Passed
-25 °C	U _{nom} (12.0 V _{DC})	156.024933	-0.43	162.024937	-0.39	±10	Passed

Test equipment (please refer to chapter 6 for details)

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5.3 Spurious emissions on antenna terminals

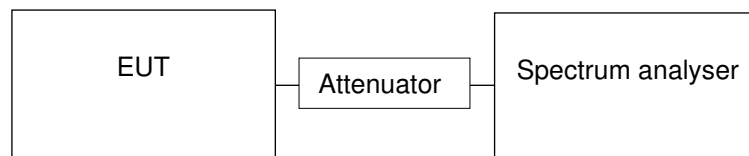
5.3.1 Method of measurement (spurious emissions on antenna terminals)

The calibration of the spectrum analyser has to be checked with the help of a known signal from a signal generator. The EUT has to be connected to the spectrum analyser via a low loss cable.

The following spectrum analyser settings according to [1] shall be used:

- Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation.
- Resolution bandwidth (conducted spurious emissions):
 - 9 kHz to 150 kHz: 1 kHz,
 - 150 kHz to 30 MHz: 30 kHz,
 - 30 MHz to 1 GHz: 30 kHz,
 - 1 GHz to 2 GHz: 30 kHz.Where the RBW above is below 30 kHz, it has to be ensured, that there is at least $10\log(30/\text{RBW})$ of margin between the trace and the limit line, which requires a bandwidth of 30 kHz.
- Resolution bandwidth (spectrum mask): 300 Hz
- Video bandwidth: Three times the RBW.
- Sweep points: At least span / RBW
- Detector function: Peak.
- Trace mode: Max hold.

Test set-up:



5.3.2 Test results (spurious emissions on antenna terminals)

Ambient temperature:	22 °C
Relative humidity:	22 %

Date:	17.01.2025
Tested by:	Th. KÜHN

Measured conducted at antenna port, modulated with PRBS.

The plots for the spectrum mask according to FCC 47 CFR Part 80.211 (f) (1) + (2) [2] and RSS-182, clause 5.9.1 (i) + (ii) [4] are shown in Annex A.3 of this test report.

Test result: Passed

The plots for transmitter spurious emissions to FCC 47 CFR Part 80.211 (f) (3) [2] and RSS-182, clause 5.9.1 (iii) are shown in Annex A.4 of this test report the results are presented below:

Transmitter spurious emissions on antenna port (transmit PRBS on 156.025 MHz)							
Frequency range	Maximum power measured [dBm]	Used RBW [kHz]	Bandwidth correction [dB] *	Corrected maximum power [dBm] **	Limit [dBm]	Margin [dB]	Test result
9 kHz to 150 kHz	-54.6	1	14.8	-39.8	-13.0	26.8	Passed
150 kHz to 30 MHz	-43.2	30	0.0	-43.2	-13.0	30.2	Passed
30 MHz to 1 GHz	-34.5	30	0.0	-34.5	-13.0	21.5	Passed
1 GHz to 2 GHz	-40.9	30	0.0	-40.9	-13.0	27.9	Passed
Transmitter spurious emissions on antenna port (transmit PRBS on 162.025 MHz)							
Frequency range	Maximum power measured [dBm]	Used RBW [kHz]	Bandwidth correction [dB] *	Corrected maximum power [dBm] **	Limit [dBm]	Margin [dB]	Test result
9 kHz to 150 kHz	-54.9	1	14.8	40.1	-13.0	27.1	Passed
150 kHz to 30 MHz	-42.5	30	0.0	-42.5	-13.0	29.5	Passed
30 MHz to 1 GHz	-32.4	30	0.0	-32.4	-13.0	19.4	Passed
1 GHz to 2 GHz	-42.0	30	0.0	-42.0	-13.0	29.0	Passed

*: Bandwidth correction was calculated with $10\log(30/\text{used RBW}[\text{kHz}])$

** : The corrected maximum power was calculated with Maximum power + bandwidth correction

Test equipment (please refer to chapter 6 for details)
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5.4 Modulation characteristics

5.4.1 Method of measurement (modulation characteristics)

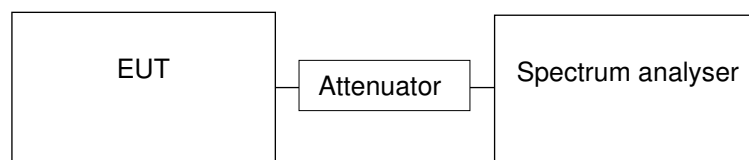
The calibration of the spectrum analyser has to be checked with the help of a known signal from a signal generator.

The following spectrum analyser settings according to [1] shall be used:

- Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation.
- IF-bandwidth: 300 kHz.
- Demodulation-bandwidth: 25 kHz.
- Measuring time: 24 ms.
- Video bandwidth: 300 Hz.
- Sweep mode: Single.
- Detector function: Peak.
- Trace mode: Clear write.
- Range: 1 kHz / division.

The EUT has to transmit either PRBS, 01010101 or 00001111.

Test set-up:



5.4.2 Test results (modulation characteristics)

Ambient temperature:	22 °C
Relative humidity:	22 %

Date:	17.01.2025
Tested by:	Th. KÜHN

Operation mode: Transmit on 156.025 MHz and 162.025 MHz, measured conducted at antenna port.

The plots of this measurement are shown in annex A.5 of this test report.

The modulation index is calculated with the following formular:

η = measured maximum deviation / modulation frequency

With:

The modulation frequency = 9600 bit/s = 9600 Hz

Transmit on 156.025 MHz				
Modulation	Measured maximum deviation	Calculated modulation index (η)	Limit	Result
01010101	2399	0.25	Max. 0.5	Passed
00001111	2339	0.24	Max. 0.5	Passed
PRBS	2407	0.25	Max. 0.5	Passed
Transmit on 162.025 MHz				
Modulation	Measured maximum deviation	Calculated modulation index (η)	Limit	Result
01010101	2374	0.25	Max. 0.5	Passed
00001111	2393	0.25	Max. 0.5	Passed
PRBS	2370	0.25	Max. 0.5	Passed

Test equipment (please refer to chapter 6 for details)
11, 13 – 15

5.5 Transmitter power

5.5.1 Method of measurement (transmitter power)

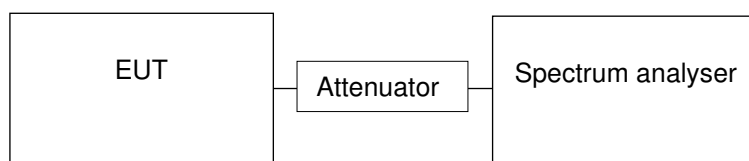
The calibration of the spectrum analyser has to be checked with the help of a known signal from a signal generator. The EUT has to be connected to the spectrum analyser via a low loss cable.

According to [6] the following spectrum analyser settings shall be used:

- Span: $\geq$ two times the OBW.
- Resolution bandwidth: $\geq$ OBW.
- Video bandwidth: $\geq$ three times the RBW.
- Sweep: $\geq$ 10 times (number of sweep points in sweep) x (transmission symbol period).
- Detector function: Peak.
- Trace mode: Max hold.

After trace stabilization the marker shall be set on the signal peak.

Test set-up:



5.5.2 Test results (transmitter power)

Ambient temperature:	22 °C
Relative humidity:	22 %

Date:	17.01.2025
Tested by:	Th. KÜHN

Operation mode: Transmit on 156.025 MHz and 162.025 MHz, measured conducted at antenna port.

The plots of this measurement are shown in annex A.6 of this test report.

TX frequency	Maximum transmitter power		Limit according to [2]	Limit according to [4]	Result
	Measured	Rated			
156.025 MHz	36.7 dBm / 4.68 W	37 dBm / 5.0 W	Up to 25 W	Up to 25 W, ± 1 dB of the rated power	Passed
162.025 MHz	36.7 dBm / 4.68 W	37 dBm / 5.0 W			Passed

Test equipment (please refer to chapter 6 for details)
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5.6 Radiated emissions

5.6.1 Method of measurement (radiated emissions)

The EUT is measured in the frequency range from 30 MHz to 2 GHz in a semi anechoic chamber with a metal ground plane, which was covered by pyramid absorbers for measurements above 1 GHz. The test site has been validated to the requirements of ANSI C63.4. The EUT was placed on a non-conducting support with a height of 80 cm (below 1 GHz) and 1.5 m (above 1 GHz) respectively and was measured in three orthogonal orientations. It was placed at a distance of 3 meters from the receiving antenna. Both polarizations (vertical and horizontal) have been evaluated and the turn table has been turned to 360° to maximize the emissions.

The receiving antenna is raised from 1 to 4 m below 1 GHz and 1 to 2.5 m above 1 GHz and tilted for measurements above 1 GHz.

The frequency range from 30 MHz to 2 GHz has been measured using the field strength method [1]. The measured field strength using the field strength method is then converted to an ERP or EIRP [dBm] using the formula:

$E \text{ [dB}\mu\text{V/m]} = \text{EIRP [dBm]} - 20\log(d) + 104.8$ according to chapter 5.2.7 (c) [1].

➔ $\text{EIRP} = E - 95.25$ ($d = 3 \text{ m}$ measuring distance)

$\text{ERP [dBm]} = \text{EIRP} - 2.15 \text{ dB}$

Level (dBm) $\triangleq$ ERP (below 1GHz) or EIRP (above 1 GHz)

Procedure preliminary measurement:

The following procedure is used:

1. Set the measurement antenna to 1 m height.
2. Monitor the frequency range at vertical polarisation and a EUT azimuth of 0 °.
3. Rotate the EUT by 360° to maximize the detected signals.
4. Repeat 1) to 2) with the horizontal polarisation of the measuring antenna.
5. Increase the height of the antenna for 0.5 m and repeat steps 2 – 4 until the final height is reached.
6. The highest values for each frequency will be saved by the software, including the antenna height, measurement antenna polarization and turntable azimuth for that value.
7. Repeat 1. to 6. with for three orthogonal orientations of the EUT.

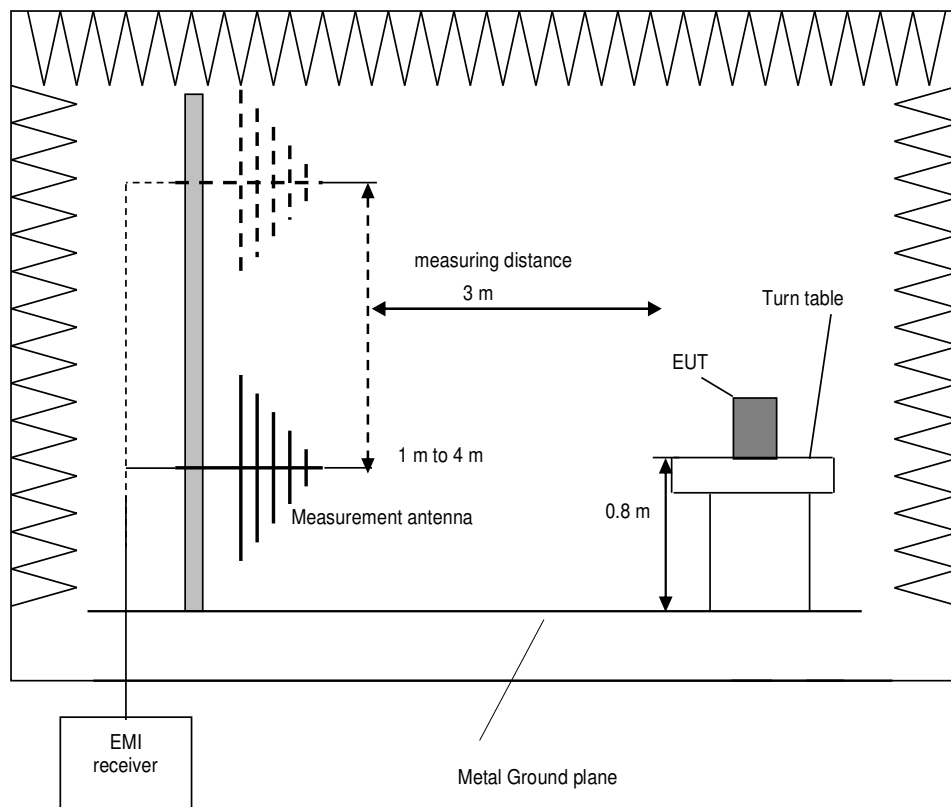
Procedure final measurement:

The following procedure is used:

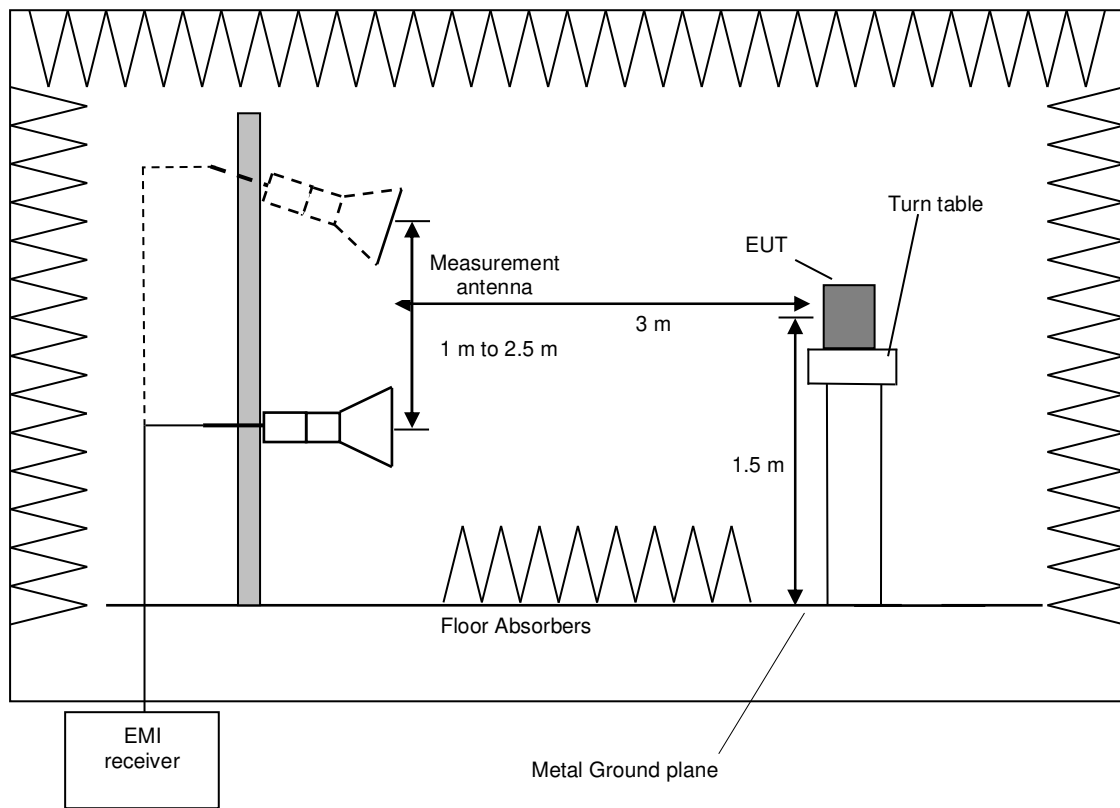
1. Select the highest frequency peaks to the limit for the final measurement.
2. The software will determine the exact peak frequencies by doing a partial scan with reduced RBW with +/- 10 times the RBW of the pre-scan of the selected peaks.
3. The worst measurement antenna height is found by the measurement software by varying the measurement antenna height by +/- 0.5 m from the value obtained in the preliminary measurement, and to monitor the emission level.
4. The worst azimuth turntable position is found by varying the turntable azimuth by +/- 25° from the value obtained in the preliminary measurement, and to monitor the emission level.
5. The final measurement is performed at the worst-case antenna height and the worst-case turntable azimuth
6. Steps 2 – 6 will be repeated for each frequency peak selected in step 1.
7. Repeat 1. to 6. with for three orthogonal orientations of the EUT.

The resolution bandwidth of the EMI Receiver will be set to the following values:

Frequency range	Resolution bandwidth
30 MHz to 1 GHz	100 kHz
1 GHz to 2 GHz	1 MHz



Test setup for measurements below 1 GHz



Test setup for measurements above 1 GHz

5.6.2 Test results (radiated emissions)

5.6.2.1 Preliminary radiated emission measurement (30 MHz to 2 GHz)

Ambient temperature:	22 °C
Relative humidity:	13 % to 16 %

Date:	03.02.2025, 04.02.2025
Tested by:	Th. KÜHN

Position of EUT: The EUT was set-up on a non-conducting support of a height of 0.8 m (30 MHz to 1 GHz) or a non-conducting support of a height of 1.5 m (1 GHz to 2 GHz) on a turntable. The distance between EUT and antenna was 3 m. The EUT was positioned in three orthogonal orientations. Because the EUT will be fixed mounted on a ship, it was classified as other device and not as table-top device according to [1], so it was positioned on the middle of the non-conducting support during this measurement.

Cable guide: For detail information of test set-up, the used positions and the cable guide refer to the pictures in annex B of this test report.

Test record: The plots of this measurement are documented in annex A, clause 3 of this test report.

Supply voltage: During this test the EUT was powered with 12 V_{DC} by an external power supply.

Frequency range: The preliminary measurement was carried out in the frequency range 30 MHz to 2 GHz, according to [2] / [4].

Operation mode: Transmit on 156.025 MHz and 162.025 MHz, modulated with PRBS, antenna port terminated with 50 Ω.

The plots of this measurement are shown in annex A.7 of this test report.

Except the wanted signal, the following frequencies were found during the preliminary radiated emission measurement with the EUT transmit on 156.025 MHz:

- 312.050 MHz, 468.075 MHz, 1608.250 MHz and 1809.250MHz

Except the wanted signal, the following frequencies were found during the preliminary radiated emission measurement with the EUT transmit on 162.025 MHz:

- 207.025 MHz, 486.075 MHz and 1863.250 MHz.

On these frequencies a final measurement has to be carried out. The result of this final measurement is shown in the following.

All other emissions in both operation modes are at least 20 dB below the limit, so no further final measurements were carried out.

Test equipment (please refer to chapter 6 for details)
1 – 10, 12, 13, 17

5.6.2.2 Final radiated emission measurement (30 MHz to 1 GHz)

Ambient temperature:	22 °C
Relative humidity:	13 %

Date:	03.02.2025
Tested by:	Th. KÜHN, S. KREHS

Position of EUT: The EUT was set-up on a non-conducting support of a height of 0.8 m on a turntable. The distance between EUT and antenna was 3 m. The EUT was positioned in three orthogonal orientations. Because the EUT will be fixed mounted on a ship, it was classified as other device and not as table-top device according to [1], so it was positioned on the middle of the non-conducting support during this measurement.

Cable guide: For detail information of test set-up and the cable guide refer to the pictures in annex B of this test report.

Test record: All results are shown in the following.

Supply voltage: During this test the EUT was powered with 12 VDC by an external power supply.

Operation mode: Transmit on 156.025 MHz and 162.025 MHz, modulated with PRBS, antenna port terminated with 50 Ω.

The measurement time with the final detector is 1 second.

Result measured with the peak detector:

Transmit on 156.025 MHz										
Frequency [MHz]	Height [cm]	Azimuth [deg]	Polarisation	Position	Result [dBμV/m]	Reading [dBμV]	Correction [dB/m]	Limit [dBμV/m]	Margin [dB]	Test result
312.050	101	162	Horizontal	1	60.0	40.7	19.3	82.3	22.3	Passed
468.075	177	147	Horizontal	2	60.6	37.0	23.6	82.3	21.7	Passed

Transmit on 162.025 MHz										
Frequency [MHz]	Height [cm]	Azimuth [deg]	Polarisation	Position	Result [dBμV/m]	Reading [dBμV]	Correction [dB/m]	Limit [dBμV/m]	Margin [dB]	Test result
486.075	168	164	Horizontal	2	60.8	36.9	23.9	82.3	21.5	Passed
207.025	137	249	Horizontal	3	60.5	44.4	16.1	82.3	21.8	Passed

The result was calculated with the following formula according to clause 5.2.7 (a) [1]

$$E \text{ (dBμV/m)} = \text{Reading [dBμV]} + \text{Correction (Cable Loss [dB]} + \text{Antenna Factor [dB/m])}$$

The Limit was calculated with the following formula according to clause 5.2.7 (d) [1]

$$E \text{ (dBμV/m)} = \text{EIRP (dBm)} - 20\log(d) + 104.8$$

with a measurement distance of 3 m and a limit of -13 dBm

$$E \text{ (dBμV/m)} = -13 \text{ dBm} - 9.5 + 104.8 = 82.3 \text{ dBμV/m}$$

Test equipment (please refer to chapter 6 for details)
1 – 7, 9, 10, 12, 13, 17

5.6.2.3 Final radiated emission measurement (1 GHz to 2 GHz)

Ambient temperature:	22 °C
Relative humidity:	16 %

Date:	04.02.2025
Tested by:	Th. KÜHN, S. KREHS

Position of EUT: The EUT was set-up on a non-conducting support of a height of 1.5 m on a turntable. The distance between EUT and antenna was 3 m. The EUT was positioned in three orthogonal orientations. Because the EUT will be fixed mounted on a ship, it was classified as other device and not as table-top device according to [1], so it was positioned on the middle of the non-conducting support during this measurement.

Cable guide: For detail information of test set-up and the cable guide refer to the pictures in annex B of this test report.

Test record: All results are shown in the following.

Supply voltage: During this test the EUT was powered with 12 VDC by an external power supply.

Operation mode: Transmit on 156.025 MHz and 162.025 MHz, modulated with PRBS, antenna port terminated with 50 Ω.

The measurement time with the final detector is 1 second.

Result measured with the peak detector:

Transmit on 156.025 MHz										
Frequency [MHz]	Height [cm]	Azimuth [deg]	Polarisation	Position	Result [dBμV/m]	Reading [dBμV]	Correction [dB/m]	Limit [dBμV/m]	Margin [dB]	Test result
1608.250	150	251	Horizontal	1	57.6	27.4	30.2	82.3	24.7	Passed
1809.250	110	235	Horizontal	1	58.3	27.2	31.1	82.3	24.0	Passed

Transmit on 162.025 MHz										
Frequency [MHz]	Height [cm]	Azimuth [deg]	Polarisation	Position	Result [dBμV/m]	Reading [dBμV]	Correction [dB/m]	Limit [dBμV/m]	Margin [dB]	Test result
1863.250	100	233	Horizontal	1	59.7	48.3	31.4	82.3	22.6	Passed

The result was calculated with the following formula according to clause 5.2.7 (a) [1]

$$E \text{ (dB}\mu\text{V/m)} = \text{Reading [dB}\mu\text{V]} + \text{Correction (Cable Loss [dB] + Antenna Factor [dB/m])}$$

The Limit was calculated with the following formula according to clause 5.2.7 (d) [1]

$$E \text{ (dB}\mu\text{V/m)} = \text{EIRP (dBm)} - 20\log(d) + 104.8$$

with a measurement distance of 3 m and a limit of -13 dBm

$$E \text{ (dB}\mu\text{V/m)} = -13 \text{ dBm} - 9.5 + 104.8 = 82.3 \text{ dB}\mu\text{V/m}$$

Test equipment (please refer to chapter 6 for details)
1 – 6, 8 – 10, 12, 13, 17

5.7 Suppression of interference aboard ships/Receiver spurious emissions

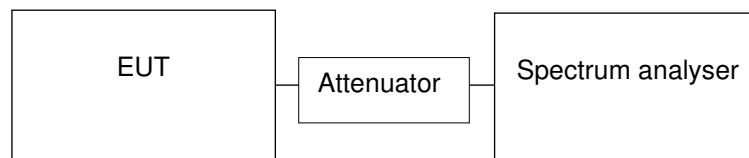
5.7.1 Method of measurement (suppression of interference aboard ships/receiver spurious emissions)

The calibration of the spectrum analyser has to be checked with the help of a known signal from a signal generator. The EUT has to be connected to the spectrum analyser via a low loss cable.

The following spectrum analyser settings according to [1] shall be used:

- Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation.
- Resolution bandwidth (conducted spurious emissions):
 - 9 kHz to 150 kHz: 1 kHz,
 - 150 kHz to 30 MHz: 10 kHz,
 - 30 MHz to 1 GHz: 100 kHz,
 - 1 GHz to 2 GHz: 1 MHz.
- Video bandwidth: Three times the RBW.
- Sweep points: At least span / RBW
- Detector function: Peak.
- Trace mode: Max hold.

Test set-up:



5.7.2 Test results (suppression of interference aboard ships)

Ambient temperature:	22 °C
Relative humidity:	22 %

Date:	17.01.2025
Tested by:	Th. KÜHN

Measured conducted at antenna port, receiver A was receiving 156.025 MHz and receiver B receiving on 162.025 MHz.

The plots of this measurement are shown in annex A.8 of this test report.

Results according to FCC 47 CFR Part 80.217 (b) [2]:

Receiver spurious emissions on antenna port (receive on 156.025 MHz and 162.025 MHz)				
Frequency range	Maximum power measured [dBm]	Limit [dBm]	Margin [dB]	Test result
9 kHz to 150 kHz	-74.0	-4.0	70.0	Passed
150 kHz to 30MHz	-72.6	-4.0	68.6	Passed
30 MHz to 100 MHz	-70.1	6.0	76.1	Passed
100 MHz to 300 MHz	-65.2	16.0	81.2	Passed
300 MHz to 2 GHz	-58.9	26.0	84.9	Passed

Results according to RSS-Gen, clause 7.4 [5]

Receiver spurious emissions on antenna port (receive on 156.025 MHz and 162.025 MHz)				
Frequency range	Maximum power measured [dBm]	Limit [dBm]	Margin [dB]	Test result
30 MHz to 100 MHz	-70.1	-57.0	13.1	Passed
100 MHz to 300 MHz	-65.2	-57.0	12.9	Passed
300 MHz to 1 GHz	-69.7	-57.0	12.7	Passed
1 GHz to 2 GHz	-58.9	-53.0	5.9	Passed

Test equipment (please refer to chapter 6 for details)
11, 13 – 15

6 Test equipment and ancillaries used for tests

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal. due
1	Semi anechoic chamber M276	SAC5-2	Albatross Projects	C62128-A540-A138-10-0006	483227	Calibration not necessary	
2	RF Switch Matrix	OSP220	Rohde & Schwarz	-	482976	Calibration not necessary	
3	Turntable	TT3.0-3t	Maturo	825/2612/.01	483224	Calibration not necessary	
4	Controller	NCD	Maturo	474/2612.01	483226	Calibration not necessary	
5	Antenna support	BAM 4.5-P-10kg	Maturo	222/2612.01	483225	Calibration not necessary	
6	EMC test software	Elektra V5.10.00	Rohde & Schwarz	-	483755	Calibration not necessary	
7	Ultralog antenna	HL562E	Rohde & Schwarz	101079	482978	24.04.2024	04.2027
8	Log.-Per. antenna	HL050	Rohde & Schwarz	100908	482977	22.09.2022	09.2025
9	EMI receiver / Spectrum analyser	ESW44	Rohde & Schwarz	101828	482979	21.02.2024	02.2026
10	Cable C417	Sucoflex 118	Huber+Suhner	500654/118	-	Calibration not necessary	
11	Power supply	TOE8752-32	Toellner	8752	480009	Calibration not necessary	
12	Power supply	TOE8852	Toellner	51712	480233	Calibration not necessary	
13	Multimeter	971A	Hewlett Packard	JP39009358	480721	09.10.2024	10.2025
14	20 dB attenuator	WA8 / 18-20-34	Weinschel	-	481450	Calibration not necessary	
15	Spectrum Analyser	FSU46	Rohde & Schwarz	200125	480956	20.02.2024	02.2025
16	Temperature chamber	MK 240	Binder	08-55251	480972	28.10.2024	10.2026
17	Coaxial termination, 50 Ohm	6506.01.A	Suhner	-	410157	Calibration not necessary	

7 Measurement Uncertainties

Measurement method	Standard used for calculating measurement uncertainty	Expanded measurement uncertainty (95 %) U_{lab}
RF frequency	ETSI TR 100 028	4.5×10^{-8}
RF power	ETSI TR 100 028	0.9 dB
Frequency deviation	ETSI TR 100 028	3.7 %
Conducted spurious emission	ETSI TR 100 028	2.3 dB
Radiated field strength M276		
R&S HL562E @ 3 m 30 MHz – 1 GHz	DIN EN 55016-4-2	4.8 dB
R&S HL050 @ 3 m 1 GHz – 6 GHz	DIN EN 55016-4-2	5.1 dB

8 Test site Validation

Test equipment	PM. No.	Frequency range	Type of validation	According to	Val. Date	Val Due
Semi anechoic chamber M276	483227	30 – 1000 MHz	NSA	ANSI C63.4-2014	01.03.2023	03.2025
Semi anechoic chamber M276 (with floor absorbers)	483227	1 GHz – 2 GHz	SVSWR	CISPR 16-1-4 + Cor1:2010 + A1:2012 +A2:2017	28.02.2023	02.2025

9 Report history

Report Number	Date	Comment
F241685E2	22.07.2025	Document created
-	-	-
-	-	-
-	-	-

10 List of annexes

Annex A	Measurement results	21 pages
Annex B	Test setup photos	11 pages
Annex C	External EUT photos	6 pages
Annex D	Internal EUT photos	16 pages

----- end of test report -----