

FCC RF Exposure Evaluation

Report Number:

F241686E3

Equipment under Test (EUT):

**AIS Class B SOTDMA Transponder with antenna splitter and with Wi-Fi
B650WS**

Applicant:

Alltek Marine Electronics Corporation

Manufacturer:

Alltek Marine Electronics Corporation



Deutsche
Akkreditierungsstelle
D-PL-17186-01-00

References

- [1] **CFR 47 Rule part 1** Practice and Procedure
- [2] **CFR 47 Rule part 2** Frequency Allocations and Radio Treaty Matters; General Rules and Regulations
- [3] **KDB 447498 D04** Interim General RF Exposure Guidance v01

Assessed and
written by:

Signature

Reviewed and
approved by:

Signature

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1 Identification

1.1 Applicant

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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
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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 antenna splitter and with /without Wi-Fi		
Model name: *	B650WS		
FCC ID: *	WZ7AIS-B650S		
Serial number: *	00002		
PCB identifier: *	M-PCB-B650MBV2, M-PCB-B650IOBV2, M-PCB-B650USBV2 M-PCB-WFB002V2		
Software version: *	V2		
Lowest internal frequency: *	32.768 kHz		
Power supply: *	External DC power supply		
Supply voltage: *	$U_{\text{Nom}} = 12.0 \text{ V}_{\text{DC}}$	$U_{\text{Min}} = 9.6 \text{ V}_{\text{DC}}$	$U_{\text{Max}} = 31.2 \text{ V}_{\text{DC}}$
Temperature range: *	-25 °C to 55 °C		

*: 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

AIS Part of the EUT	
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

*: Declared by the applicant.

WLAN part			
Fulfills WLAN specification: *	IEEE 802.11™ (b/g/n)		
Operating frequency range: *	2412 to 2462 MHz		
Number of channels: *	11		
Type of modulation: *	IEEE 802.11 b: DSSS (1Mbps DBPSK, 2Mbps DQPSK, 5.5/11Mbps CCK) IEEE 802.11 g: OFDM (6/9Mbps BPSK, 12/18Mbps QPSK, 24/36Mbps 16-QAM, 48/54Mbps 64-QAM) IEEE 802.11n (HT20): OFDM (BPSK, QPSK, 16-QAM, 64-QAM) IEEE 802.11n (HT40): OFDM (BPSK, QPSK, 16-QAM, 64-QAM)		
Supply voltage WLAN module: *	$U_{nom} = 3.3 \text{ V}_{DC}$	$U_{min} = 3.0 \text{ V}_{DC}$	$U_{max} = 3.6 \text{ V}_{DC}$
Antenna type: *	Dipole		
Antenna name: *	GY196HT695-001 by WIESON TECHNOLOGIES CO., LTD.		
Antenna gain: *	2.94 dBi		
Antenna connector: *	U.FL on carrier PCB (Wi-Fi board)		

*: 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
VHF Radio	SO-239	N-Connector	None (terminated directly)

2 Evaluation Methods

2.1 RF exposure test exemptions for single sources

2.1.1 General exemption CFR 47 §1.1307(b)(3)(i)(A)

The available maximum time-averaged power is no more than 1 mW, regardless of separation distance. This exemption may not be used in conjunction with other exemption criteria other than those in paragraph (b)(3)(ii)(A) of this section. Medical implant devices may only use this exemption and that in paragraph (b)(3)(ii)(A).

2.1.2 SAR based exemption CFR 47 §1.1307(b)(3)(i)(B)

The available maximum time-averaged power of effective radiated power (ERP), whichever is greater, is less than or equal to the threshold P_{th} (mW) described in the following formula. This method shall only be used at separation distances (cm) from 0.5 cm to 40 cm and at frequencies from 0.3 GHz to 6 GHz inclusive.

For the following separation distances [d] and frequency ranges P_{th} is given by the following formulas

	0.5 cm $\leq d \leq 20$ cm	20 cm $< d \leq 40$ cm
0.2 GHz $\leq f < 1.5$ GHz	$P_{th}(mW) = ERP_{20cm} \left(\frac{d}{20} \right)^x$ $ERP_{20cm} (mW) = 2040f$ $x = -\log_{10} \left(\frac{60}{ERP_{20cm} \sqrt{f}} \right)$	$P_{th}(mW) = ERP_{20cm}$ $ERP_{20cm} (mW) = 2040f$
1.5 GHz $\leq f \leq 6$ GHz	$P_{th}(mW) = ERP_{20cm} \left(\frac{d}{20} \right)^x$ $ERP_{20cm} (mW) = 3060$ $x = -\log_{10} \left(\frac{60}{ERP_{20cm} \sqrt{f}} \right)$	$P_{th}(mW) = ERP_{20cm}$ $ERP_{20cm} (mW) = 3060$

2.1.3 MPE based exemption CFR 47 §1.1307(b)(3)(i)(C)

By using Table 1 and the minimum separation distance (d in meters) from the body of a nearby person for the frequency (f in MHz) at which the source operates, the ERP (watts) is no more than the calculated value prescribed for that frequency. For the exemption in Table 1 to apply, d must be at least $\lambda/2\pi$, where λ is the free-space operating wavelength in meters. If the ERP of a single RF source is not easily obtained, then the available maximum time-averaged power may be used in lieu of ERP if the physical dimensions of the radiating structure(s) do not exceed the electrical length of $\lambda/4$ or if the antenna gain is less than that of a half-wave dipole (1.64 linear value).

RF Source frequency [MHz]	Threshold ERP [W]
0.3 - 1.34	$1920 d^2$
1.34 - 30	$3450 d^2/f^2$
30 - 300	$3.83 d^2$
300 - 1500	$0.0128 d^2/f$
1500 - 100000	$19.2 d^2$

d: Minimal separation distance from antenna to the user

2.1.4 Stand alone MPE evaluation limits

The human exposure to RF emissions from such devices could be evaluated based on the MPE limits adopted by the FCC for electric and magnetic field strength and / or power density. The limits for General Population / Uncontrolled Exposure are given in the following table from CFR 47 §1.1310(e)1:

Frequency range [MHz]	Electric field strength (E) [V/m]	Magnetic field strength (H) [A/m]	Power density (S) [mW/cm ²]	Averaging time [min]
(i)Limits for Occupational/Controlled Exposure				
0.3 – 3.0	614	1.63	*(100)	≤6
3.0 – 30	1842/f	4.89/f	*(900/f ²)	<6
30 – 300	61.4	0.163	1.0	<6
300 – 1,500			f/300	<6
1,500 – 100,000			5	<6
(ii)Limits for General Population / Uncontrolled Exposure				
0.3 – 1.34	614	1.63	*(100)	< 30
1.34 – 30	824/f	2.19/f	*(180/f ²)	< 30
30 – 300	27.5	0.073	0.2	< 30
300 – 1500			f/1500	< 30
1500 – 100,000			1.0	< 30

Note: f = frequency in MHz; * Plane – wave equivalent power density

The power density is calculated as follows:

$$S = \frac{P \cdot G \cdot D}{4 \cdot \pi \cdot d^2}$$

Where:

P: conducted power

G: Antenna gain (linear)

D: Duty Cycle

d: Minimal separation distance from antenna to the user

2.2 RF exposure test exemptions for simultaneous transmission sources

2.2.1 1 mW test exemption for simultaneous transmission sources

As discussed in CFR 47 §1.1307(b)(3)(ii)(A) [1] the 1 mW exemption intended for single transmitters may be also applied to simultaneous transmission conditions, within the same host device, according one of the following criteria:

- When the maximum available power each individual transmitting antenna with the same time averaging period is ≤ 1 mW, and the nearest parts of the antenna structures of the simultaneously operating transmitters are separated by at least 2 cm
- When the aggregate maximum available power of all transmitting antennas is ≤ 1 mW in the same time-averaging period

This exemption may not be combined with any other exemption.

2.2.2 Simultaneous transmission SAR based and MPE based test exemptions

Although this is not a module integration in the sense of product approval, the procedure for simultaneous transmission specified in KDB 447498 D04 Interim General RF Exposure Guidance v01 [3] in chapter 2.2 was taken into account:

According to the RF exposure KDB 447498 D04 General RF Exposure Guidance v01 [3] in chapter 2.2.2: This case is described in detail in CFR 47 §1.1307(b)(3)(ii)(B) and covers the situations where both SAR-based and MPE-based exemption may be considered for test exemption in fixed, mobile, or portable device exposure conditions. For these cases, a device with multiple RF sources transmitting simultaneously will be considered an RF exempt device if the condition of the following formula is satisfied.

$$\sum_{i=1}^a \frac{P_i}{P_{th,i}} + \sum_{j=1}^b \frac{ERP_j}{ERP_{th,j}} + \sum_{k=1}^c \frac{Evaluated_k}{Exposure Limit_k} \leq 1$$

For these test exemptions to apply, the maximum output power, duty factor, and other applicable parameters used in the standalone ERP determination tests, must be the same, or corresponding to a more conservative choice, than those required for simultaneous transmission.

Simultaneous transmission MPE test exclusion applies when the sum of the MPE ratios for all simultaneously transmitting antennas incorporated in a host device is ≤ 1.0 , according to calculated/estimated, numerically modelled, or measured field strengths or power density. The MPE ratio of each antenna is determined at the minimum test separation distance required by the operating configurations and exposure conditions of the host device, according to the ratio of field strengths or power density to the MPE limit at the test frequency.

2.2.3 Test exemption based on the SAR to Peak Location Separation Ratio

When the ERP-based condition in the previous section does not apply, a test exemption may be still applicable based on the SAR to peak location separation ratio (SPLSR) procedure.

In this case, the simultaneously transmitting antennas in each operating mode and exposure condition combination must be considered one pair at a time to determine the SPLSR that qualifies for the additional test exemption.

This ratio is defined as:

$$SPLSR = (SAR_1 + SAR_2)^{\frac{1.5}{R_i}}$$

Where: SAR_1 and SAR_2 = highest reported SAR or estimated SAR values for the two sources in the pair i , and R_i is their distance in mm.

When $SPLSR \leq 0.0.4$ (rounded to two decimal digits), for all antenna pairs in the configuration, then the device qualifies for 1 g SAR test exemption.

When 10 g SAR applies (e.g. for extremities) the corresponding test exemption condition is $SPLSR \leq 0.10$.

If any antenna pair does not qualify for simultaneous transmission SAR test exemption, then the device must be tested for SAR compliance, according to the enlarged zoom scan and volume scan post-processing procedures in KDB Pub. 865664 D01.

3 Results of evaluation

3.1 Used evaluation methods

RF Exposure test exemptions for single sources			
Used	Method	See sub-clause	Comment
☐	General Exemption acc. CFR 47 §1.1307(b)(3)(i)(A)	2.1.1	-
☐	SAR Based Exemption acc. CFR 47 §1.1307(b)(3)(i)(B)	2.1.2	-
☐	MPE Based Exemption acc. CFR 47 §1.1307(b)(3)(i)(C)	2.1.3	-
☒	MPE Calculation	2.1.4	-

RF Exposure test exemptions for simultaneous transmission sources			
Used	Method	See sub-clause	Comment
☐	Not applicable	-	-
☐	1 mW test Exemption acc. 2.2.1 [3]	2.2.1	-
☐	SAR Based Exemption acc. 2.2.2 [3]	2.2.2	
☒	MPE Based Exemption acc. 2.2.2 [3]	2.2.2	
☐	SAR to Peak location separation ratio acc. 2.2.3 [3]	2.2.3	

3.2 Evaluation distance

According to the applicant's documentation, the separation distance between the user and EUT is 32 cm.

3.3 MPE base exemption for the AIS part

- S: Limit for power density according to CFR Part 47, §1.1310: 2.0 W/m²
- P: 38.6 dBm / 7.24 W (5.13 W (peak value, refer clause 5.5.2 of test report F241686E2) plus 1.5 dB tune up tolerance)
- G: 2.9 dBi = 0.75 dBd = 1.19 (max. antenna gain, declared by the applicant)
- D: Duty cycle: According to the Recommendation ITU-R M.1371-5 (02/2014) the maximum reporting rate for a Class B SOTDMA AIS is 5 s. So, every 5 seconds a 27 ms telegram is transmitted as worst case.

This is equal to a duty cycle of 0.54 % = 0.0054.

- R: Distance in what the limit of S has to be reached: 0.32 m ($>\lambda/2\pi$).

$$S = \frac{P \cdot G \cdot D}{4 \cdot \pi \cdot R^2} \Rightarrow \underline{S} = \frac{7.24 \text{ W} \cdot 1.19 \cdot 0.0054}{4 \cdot \pi \cdot (0.32 \text{ m})^2} = \underline{0.036 \frac{\text{W}}{\text{m}^2}}$$

The value of the power density is below the limit of CFR Part 47, §1.1310 for the “General population / Uncontrolled Exposure”.

Base of the above calculations is the highest output power of the EUT.

3.4 MPE base exemption for the Wi-Fi part

The following information are based on test report F170297E6 of PHOENIX TESTLAB GmbH.

- S: Limit for power density according to
- CFR 47 §1.1310(e)1: 1.0 W/m²
- P: 16.6 dBm = 0.0457 W (15.6 dBm (average value, refer clause 5.2.2 of test report F170297E6) plus 1 dB tune up tolerance)
- G: 2.94 dBi = 1.97 (max. antenna gain, declared by the applicant)
- D: Duty cycle: 100% = 1
- R: Distance in what the limit of S has to be reached: 0.32 m ($>\lambda/2\pi$).

$$S = \frac{P \cdot G \cdot D}{4 \cdot \pi \cdot R^2} \Rightarrow \underline{S} = \frac{0.0457 \text{ W} \cdot 1.97 \cdot 1}{4 \cdot \pi \cdot (0.32 \text{ m})^2} = \underline{0.070 \frac{\text{W}}{\text{m}^2}}$$

The value of the power density is below the limit of CFR Part 47, §1.1310 for the “General population / Uncontrolled Exposure”.

Base of the above calculations is the highest output power of the EUT.

3.5 Simultaneous transmission

The worst case MPE ratios of the stand-alone modules are calculated in the following:

EUT transmitting part	Calculation result	Limit	MPE limit ratio
AIS	0.036 W/m ²	2.0 W/m ²	0.018
Wi-Fi	0.070 W/m ²	1.0 W/m ²	0.070

The Sum of the MPE ratios for the simultaneous transmission with the measured results is:

$$\text{Sum} = 0.018 + 0.070 = 0.088$$

$$\text{Sum} = 0.088 < 1.0$$

4 Conclusion

The B650WS complies in all operational modes to the limits for General Population / Uncontrolled Exposure given in CFR 47 §1.1310(e)1 in a separation distance of 32 cm.

5 Report History

Report Number	Date	Comment
F241686E3	23.07.2025	Initial Test Report
-	-	-
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----- end of evaluation report -----