Test Report

of the accredited Testing Laboratory
0274 – TÜV AUSTRIA GMBH – Location Vienna - EMC Electromagnetic Compatibility

Order Confirmation Number: 2024-AT-TC-EEE-1-EX-0-000099

About

the EMC - test listed below

Applicant:	YUNEX GmbH Otto-Hahn-Ring 6 D-81739 München
Test object:	ITS On Board Unit 'OBU2X'
FCC ID:	2BGULOBU2X
IC ID:	Not decided yet
Manufacturer:	Yunex LLC 9225 Bee Cave Road Austin, TX 78733
Accredited regulation:	FCC: 47 CFR Part 15 (eCFR 20.06.2024) RSS-102 Issue 6, Dember 2023
Non-accredited regulations:	KDB 447498 D04 v01

Andreas Malek

Examined by / Testing Laboratory
TÜV AUSTRIA GMBH

Michael Emminger

Approved by / Testing Laboratory
TÜV AUSTRIA GMBH

The results of this test report only refer to the provided equipment.

Issued on 09.07.2024 in Vienna / TIC

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1. Applicant

Company:	Yunex GmbH
Department:	
Address:	Otto-Hahn-Ring 6; D- 81739 München
Contact person:	Mr. Thomas Jatschka
EUT received on:	/
Calculations were performed on:	09.07.2024

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2. Description of EUT

EUT:	ITS On Board Unit 'OBU2X'
Manufacturer:	Yunex LLC 9225 Bee Cave Road Austin, TX 78733
Description:	YUNEX GmbH provided the following documents for the calculations: Bluetooth and BLE test report Test report no. 2023-IN-AT-TICL-E-EX-0-000131-FG-001-Rev1 C-V2X test report Test report no. 2023-IN-AT-TICL-E-EX-0-000131-FG-002-Rev2 ME910G1-W3 licensed module MPE report FCC ID: RI7ME910G1W3; IC: 5131A-ME910G1W3 Test report no. CN21FZKJ 002 MobileMark WG-313 Multiband Surface Mount Antenna, datasheet Taoglas SDCP.5900 5.9GHz DSRC Circular Polarized Embedded SMD 12*12*4mm Patch Antenna, datasheet Part no. SDCP.5900.12.4.A.40 OBU2X-US AUT-Report v0.2.0
Operating mode:	The exemption calculations consider conservative exposure assumptions as described below.

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3. Standards / Final result

Name	Title	Deviation	Result
Title 47 CFR Part 15 eCFR 20.06.2024	RADIO FREQUENCY DEVICES	only RF Exposure	OK
447498 D04 v01	Interim General RF Exposure Guidance	none	OK
RSS-102 Issue 6, December 2023	Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)	none	OK

Result: Opinions and interpretation of testing laboratory
OK: EUT passed
NOK: EUT failed

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4. Test results

4.1 TEST OBJECT DATA

General EUT Description

This On Board Unit for C-V2X Operation contains various transmitter parts:

C-V2X at 5915 MHz center frequency with 20 MHz channel bandwidth (see test report 2023-IN-AT-TICL-E-EX-0-000131-FG-002-Rev2)
Bluetooth/BLE (see test report 2023-IN-AT-TICL-E-EX-0-000131-FG-001-Rev1)
and an LTE module FCC ID: RI7ME910G1W3, IC: 5131A-ME910G1W3
For simultaneous transmission tests of all three radios and Part 15B compliance see test report 2023-IN-AT-TICL-E-EX-0-000131-FG-003-Rev1.

Calculations were performed on: July 9th, 2024.

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4.2 RF Exposure **KDB 447498 D04 §1.1307(b)(3)(ii)(B)**

according to KDB 447498 D04 Interim General RF Exposure Guidance v01 “RF EXPOSURE PROCEDURES AND EQUIPMENT AUTHORIZATION POLICIES FOR MOBILE AND PORTABLE DEVICES”.

Title 47 §1.1307(b)(3)(ii)(B):

For multiple RF sources: Multiple RF sources are exempt if:

(B) in the case of fixed RF sources operating in the same time-averaging period, or of multiple mobile or portable RF sources within a device operating in the same time averaging period, if the sum of the fractional contributions to the applicable thresholds is less than or equal to 1 as indicated in the following equation.

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

Where:

a = number of fixed, mobile, or portable RF sources claiming exemption using paragraph (b)(3)(i)(B) of this section for Pth, including existing exempt transmitters and those being added.

b = number of fixed, mobile, or portable RF sources claiming exemption using paragraph (b)(3)(i)(C) of this section for Threshold ERP, including existing exempt transmitters and those being added.

c = number of existing fixed, mobile, or portable RF sources with known evaluation for the specified minimum distance including existing evaluated transmitters.

P_i = the available maximum time-averaged power or the ERP, whichever is greater, for fixed, mobile, or portable RF source i at a distance between 0.5 cm and 40 cm (inclusive).

$P_{th,i}$ = the exemption threshold power (P_{th}) according to paragraph (b)(3)(i)(B) of this section for fixed, mobile, or portable RF source i.

ERP_j = the ERP of fixed, mobile, or portable RF source j.

$ERP_{th,j}$ = exemption threshold ERP for fixed, mobile, or portable RF source j, at a distance of at least $\lambda/2\pi$ according to the applicable formula of paragraph (b)(3)(i)(C) of this section.

$Evaluated_k$ = the maximum reported SAR or MPE of fixed, mobile, or portable RF source k either in the device or at the transmitter site from an existing evaluation at the location of exposure.

$Exposure\ Limit_k$ = either the general population/uncontrolled maximum permissible exposure (MPE) or specific absorption rate (SAR) limit for each fixed, mobile, or portable RF source k, as applicable from § 1.1310 of this chapter.

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Title 47 §1.1307(b)(3)(i)(B):

(3) Determination of exemption. (i) For single RF sources (i.e., any single fixed RF source, mobile device, or portable device, as defined in paragraph (b)(2) of this section): A single RF source is exempt if:

(B) Or the available maximum time-averaged power or effective radiated power (ERP), whichever is greater, is less than or equal to the threshold Pth (mW) described in the following formula. This method shall only be used at separation distances (cm) from 0.5 centimeters to 40 centimeters and at frequencies from 0.3 GHz to 6 GHz (inclusive). Pth is given by:

$$P_{th}\ (\text{mW}) = \begin{cases} ERP_{20\ cm}(d/20\ \text{cm})^{x} & d \le 20\ \text{cm} \\ ERP_{20\ cm} & 20\ \text{cm} < d \le 40\ \text{cm} \end{cases}$$

Where

$$x = -\log_{10}\left(\frac{60}{ERP_{20\ cm}\sqrt{f}}\right) \text{ and } f \text{ is in GHz;}$$

and

$$ERP_{20\ cm}\ (\text{mW}) = \begin{cases} 2040f & 0.3\ \text{GHz} \le f < 1.5\ \text{GHz} \\ 3060 & 1.5\ \text{GHz} \le f \le 6\ \text{GHz} \end{cases}$$

d = the separation distance (cm);

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BT BDR, BT EDR and BLE transmitter, Title 47 §1.1307(b)(3)(i)(B):

Max. EIRP values are taken from test report 2023-IN-AT-TICL-E-EX-0-000131-FG-001-Rev1
Max. gain values are taken from AUT report v0.2.0
Calculations are done for mobile exposure with separaton distance of 20 cm.
Duty cycle was not measured, factor 1 is a worst case assumption.
Max. production variance was declared by the manufacturer as +2,7 dB, see operational description.

type	f [MHz]	cond. P [mW]	duty cycle [1]	production variance [1]	max. time-averaged power [mW]	EIRP [mW]	ERP [mW]	ERP incl. prod. var. [mW]
BDR	2,402	1,44	1	1,86	2,69	1,95	1,19	2,21
BDR	2,441	2,34	1	1,86	4,35	3,16	1,93	3,59
BDR	2,480	3,46	1	1,86	6,45	4,68	2,85	5,31
EDR	2,402	0,93	1	1,86	1,74	1,26	0,77	1,43
EDR	2,441	2,18	1	1,86	4,06	2,95	1,80	3,35
EDR	2,480	2,81	1	1,86	5,23	3,80	2,32	4,31
BLE	2,402	1,62	1	1,86	3,02	2,19	1,34	2,49
BLE	2,441	2,81	1	1,86	5,23	3,80	2,32	4,31
BLE	2,480	5,48	1	1,86	10,21	7,41	4,52	8,41

type	Frequency range (see 4.1 and 4.2)	max(max. time avg. P, ERP) [mW]	§1.1307(b)(3)(i)(B) limit (P_{th}) [mW]	P / Pth [1]	< 1 ?
BDR	2,402	2,69	3060	0,0009	yes
BDR	2,441	4,35	3060	0,0014	yes
BDR	2,480	6,45	3060	0,0021	yes
EDR	2,402	1,74	3060	0,0006	yes
EDR	2,441	4,06	3060	0,0013	yes
EDR	2,480	5,23	3060	0,0017	yes
BLE	2,402	3,02	3060	0,0010	yes
BLE	2,441	5,23	3060	0,0017	yes
BLE	2,480	10,21	3060	0,0033	yes

P / Pth is smaller than 1.

The transmitter can not transmit in the different modes simultaneously. As a conservative approach, the worst-case emission (BLE at 2,480 GHz) with the highest P/Pth (0,0033) is further used for the simultaneous transmission calculation.

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C-V2X transmitter, Title 47 §1.1307(b)(3)(i)(B):

The C-V2X transmitter can be used with the internal antenna or with an external antenna.

Max. EIRP for the internal antenna is taken from test report 2023-IN-AT-TICL-E-EX-0-000131-FG-002-Rev2
Max. cond. TxP for the external antenna is taken from test report 2023-IN-AT-TICL-E-EX-0-000131-FG-002-Rev2
Max. gain values of the external antenna MobileMark SMWG-313 are taken from the datasheet
Max. gain values of the internal antenna Taoglas SDCP.5900 are taken from the datasheet
Calculations are done for mobile exposure with separaton distance of 20 cm (for the external antenna this is a conservative assumption as it will likely be mounted outside the vehicle).
Duty cycle was not measured, factor 1 is a worst case assumption.
Max production variance was declared by the manufacturer as 1,165 dB, see operational description.

type	f [MHz]	cond. P [mW]	duty cycle [1]	production variance [1]	max. time-averaged power [mW]	EIRP [mW]	ERP [mW]	ERP incl. prod. var. [mW]
internal	5,915	72,44	1	1,31	94,73	229,09	139,69	182,67
external	5,915	47,86	1	1,31	62,59	139,32	84,95	111,09

type	Frequency range (see 4.1 and 4.2)	max(max. time avg. P, ERP) [mW]	§1.1307(b)(3)(i)(B) limit (P_{th}) [mW]	P / Pth [1]	< 1 ?
internal	5,915	182,67	3060	0,0597	yes
external	5,915	111,09	3060	0,0363	yes

P / Pth is smaller than 1.

The transmitter can not transmit on the two antennas simultaneously. As a conservative approach, the worst-case emission (interanal antenna) with the highest P/Pth (0,0597) is further used for the simultaneous transmission calculation.

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Licensed transmitter, Title 47 §1.1307(b)(3)(i)(B):

Max. conducted transmit power values are taken from test report CN21FZKJ 002. Max. gain values are taken from AUT report v0.2.0
Calculations are done for mobile exposure with separaton distance of 20 cm.
Duty cycle was not measured, factor 1 is a worst case assumption.
The transmit power values (all bands assumed as worst-case 25 dBm instead of measured values) include tune-up tolerace, so the tolerance is not listed separately below.

type	f [MHz]	cond. P [mW]	duty cycle [1]	production variance [1]	max. time-averaged power [mW]	EIRP [mW]	ERP [mW]	ERP incl. prod. var. [mW]
B2	1,85	316,23	1	1	316,23	368,98	224,99	224,99
B4	1,71	316,23	1	1	316,23	414,95	253,02	253,02
B5	0,824	316,23	1	1	316,23	608,14	370,81	370,81
B8	0,8975	316,23	1	1	316,23	338,06	206,14	206,14
B12	0,699	316,23	1	1	316,23	90,16	54,97	54,97
B13	0,777	316,23	1	1	316,23	376,70	229,70	229,70
B14	0,788	316,23	1	1	316,23	412,10	251,28	251,28
B25	1,85	316,23	1	1	316,23	368,98	224,99	224,99
B26	0,814	316,23	1	1	316,23	608,14	370,81	370,81
B66	1,71	316,23	1	1	316,23	447,71	273,00	273,00
B85	0,698	316,23	1	1	316,23	90,16	54,97	54,97

type	Frequency range (see 4.1 and 4.2)	max(max. time avg. P, ERP) [mW]	§1.1307(b)(3)(i)(B) limit (P_{th}) [mW]	P / Pth [1]	< 1 ?
B2	1,85	316,23	3060	0,1033	yes
B4	1,71	316,23	3060	0,1033	yes
B5	0,824	370,81	1680,96	0,2206	yes
B8	0,8975	316,23	1830,9	0,1727	yes
B12	0,699	316,23	1425,96	0,2218	yes
B13	0,777	316,23	1585,08	0,1995	yes
B14	0,788	316,23	1607,52	0,1967	yes
B25	1,85	316,23	3060	0,1033	yes
B26	0,814	370,81	1660,56	0,2233	yes
B66	1,71	316,23	3060	0,1033	yes
B85	0,698	316,23	1423,92	0,2221	yes

P / Pth is smaller than 1.

The transmitter can not transmit in the different bands simultaneously. As a conservative approach, the worst-case emission (Band 26) with the highest P/Pth (0,2233) is further used for the simultaneous transmission calculation.

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Multiple RF sources, Title 47 §1.1307(b)(3)(ii)(B).

Simultaneous exposure from all RF sources (C-V2X, BT/BLE, and licensed module) is considered as a worst-case assumption, simultaneous transmission capabilities were not tested and might not occur in practice.

type	Max. P/Pth [1]	< 1 ?
BT/BLE	0,0033	
C-V2X	0,0597	
licensed	0,2233	
Sum	0,2863	yes

The sum of the fractional contributions to the applicable thresholds is less than or equal to 1.

The device is a *SAR exempt RF device* as per Title 47 §1.1307(b)(3)(ii)(B).

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4.3) RF Exposure **RSS-102, Issue 6**

6.6. Field reference level exposure exemption limits

Field reference level (FRL) exposure evaluation is required if the separation distance between the user and/or bystander and the device's radiating element is greater than 20 cm (i.e. mobile devices), except when the device operates as follows:

- below 20 MHz and the source-based, time-averaged maximum EIRP of the device is equal to or less than 1 W (adjusted for tune-up tolerance)
- at or above 20 MHz and below 48 MHz and the source-based, time-averaged maximum EIRP of the device is equal to or less than $4.49/f^{0.5}$ W (adjusted for tune-up tolerance), where f is in MHz
- at or above 48 MHz and below 300 MHz and the source-based, time-averaged maximum EIRP of the device is equal to or less than 0.6 W (adjusted for tune-up tolerance)
- at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum EIRP of the device is equal to or less than $1.31\times10^{-2}f^{0.6834}\,W$ (adjusted for tune-up tolerance), where f is in MHz
- at or above 6 GHz and the source-based, time-averaged maximum EIRP of the device is equal to or less than 5 W (adjusted for tune-up tolerance)

In these cases, the information contained in the RF exposure technical brief may be limited to information that demonstrates how the EIRP was derived.

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RSS-102 Exemption calculation

The device contains three transmitters: BT/BLE, C-V2X and licensed module (IC: 5131A-ME910G1W3).
The modules can not transmit individually in the different bands or modes listed below.
Simultaneous transmission is possible.

BT BDR, BT EDR and BLE transmitter:

Max. EIRP values are taken from test report 2023-IN-AT-TICL-E-EX-0-000131-FG-001-Rev1
Duty cycle was not measured, factor 1 is a worst case assumption.
Max. production variance was declared by the manufacturer as +2,7 dB, see operational description.

type	f [MHz]	duty cycle [1]	max. EIRP [mW]	time-averaged max. EIRP [W]	Limit [W]
BDR	2,402	1	3,63	0,004	2,68
BDR	2,441	1	5,88	0,006	2,71
BDR	2,480	1	8,71	0,009	2,74
EDR	2,402	1	2,35	0,002	2,68
EDR	2,441	1	5,49	0,005	2,71
EDR	2,480	1	7,08	0,007	2,74
BLE	2,402	1	4,08	0,004	2,68
BLE	2,441	1	7,08	0,007	2,71
BLE	2,480	1	13,80	0,014	2,74

Simultaneous transmission of the different modes is not possible.

All emissions are indivually below the limit.

C-V2X transmitter:

Max. EIRP for the internal antenna is taken from test report 2023-IN-AT-TICL-E-EX-0-000131-FG-002-Rev2
Max. cond. TxP for the external antenna is taken from test report 2023-IN-AT-TICL-E-EX-0-000131-FG-002-Rev2
Max. gain values of the external antenna MobileMark SMWG-313 are taken from the datasheet
Max. EIRP for the external antenna is derived from max. cond. TxP from the test report and max. gain from the antenna datasheet.
Duty cycle was not measured, factor 1 is a worst case assumption.

type	f [MHz]	duty cycle [1]	EIRP [mW]	time-averaged max. EIRP [W]	Limit [W]
internal	5,915	1	299,57	0,300	4,95
external	5,915	1	182,18	0,182	4,95

All emissions are indivually below the limit.

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Licensed transmitter:

Max. conducted transmit power values are taken from module MPE report no. CN21FZKJ 002.
Max. gain values are taken from AUT report v0.2.0
Duty cycle was not measured, factor 1 is a worst case assumption.
The max. cond. transmit power values (all bands assumed as worst-case 25 dBm instead of measured values) in test report CN21FZKJ 002 already include tune-up tolerace, so the tolerance is not listed separately below.

type	f [MHz]	duty cycle [1]	EIRP [mW]	time-averaged max. EIRP [W]	Limit [W]
B2	1,85	1	368,98	0,369	2,24
B4	1,71	1	414,95	0,415	2,12
B5	0,824	1	608,14	0,608	1,29
B8	0,8975	1	338,06	0,338	1,37
B12	0,699	1	90,16	0,090	1,15
B13	0,777	1	376,70	0,377	1,24
B14	0,788	1	412,10	0,412	1,25
B25	1,85	1	368,98	0,369	2,24
B26	0,814	1	608,14	0,608	1,28
B66	1,71	1	447,71	0,448	2,12
B85	0,698	1	90,16	0,090	1,15

Simultaneous transmission in the different bands is not possible.

All emissions are indivually below the limit.

Simultaneous transmission:

Simultaneous transmission capabilities of the different transmitters were not tested.
However, with a worst-case consideration that the transmitters are fully able to transmit simultaneously in their individual worst-case bands and modes, their combined EIRP is still below the applicable field reference level exposure exemption limits.

--- END OF TEST REPORT ---

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