

Test report No:
3809ERM.006

Assessment report RF EXPOSURE REPORT ACCORDING TO FCC 47 CFR Part 2.1093

(*) Identification of item under evaluation	Telematics Control Unit)
(*) Trademark	Zoox L5 TCU
(*) Model and /or type reference	L5 TCU
(*) Other identification of the product	FCC ID: 2AHPN-BE2873 HW version: C3 SW version: S7.8
(*) Features	UMTS, LTE, 4G, Wi-Fi (802.11 b,g,n,ac,ax)
(*) Manufacturer	Harman International. 30001 Cabot Drive Novi, MI 48377 USA
Test method requested, standard	FCC 47 CFR Part 2.1093. Radiofrequency radiation exposure evaluation: portable devices
Summary	IN COMPLIANCE
Approved by (name / position & signature)	Domingo Galvez EMC&RF Lab Manager
Date of issue	03-05-2024
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Data provided by the client

The following data has been provided by the client:

1. Information relating to the description of the sample ("Identification of the item tested", "Trademark", "Model and/or type reference tested").
2. The sample consists of a Telematics control unit developed by Harman for Zoox. Enables connectivity to the Zoox robotaxi.

DEKRA declines any responsibility with respect to the information provided by the client and that may affect the validity of results.

Identification of the client

Harman International
30001 Cabot Drive. Novi, MI 48377, USA

Document history

Report number	Date	Description
3809ERM.006	03-05-2024	First release.

Appendix A: FCC RF Exposure assessment result

General description of the device under evaluation

The device under evaluation consists of a Telematics control unit developed by Harman for Zoox. Enables connectivity to the Zoox robotaxi.

According to the manufacturer, during its normal use, the separation distance between the radiating structures of the device and nearby users will be greater than 20cm. In order to perform the assessment a conservative evaluation distance of 20 cm has been used.

As stated into DEKRA Certification Inc. test reports num. 3809ERM.002A2 for Wi-Fi 2.4GHz, 3809ERM.003A2 for Wi-Fi 5 GHz and FCC Identifier T8GSAN9001 used for UMTS and LTE, the maximum measured output power levels for each supported technology shown in the table below. Wi-Fi 2.4 GHz worst case scenario was in SISO transmitting configuration, and Wi-Fi 5 GHz worst case scenario was in MIMO transmitting configuration.

The evaluation was performed under the System configuration of the Telematics Control Units, the Mohawk antennas, and the internal Wi-Fi antennas as described in the Vehicle Level Block Diagram of the Operational description document:

Technology / Mode	Operating Band	Frequency under evaluation (MHz)	Transmitting configuration	Maximum Conducted Output Power (Incl. Tune-Up) (dBm)	Duty Cycle (%)	Time Averaged Conducted Power (dBm)	Antenna 1 peak gain (dBi)	Antenna 2 peak gain (dBi)	Maximum Averaged E.R.P (dBm)	Maximum Averaged E.R.P (mW)	Maximum Averaged E.I.R.P (dBm)	Maximum Averaged E.I.R.P (mW)
UMTS	II	1850 - 1910	SISO	24.05	100.00	24.05	2.92	-	24.82	303.39	26.97	497.74
UMTS	IV	1710 - 1755	SISO	23.92	100.00	23.92	3.44	-	25.21	331.89	27.36	544.50
UMTS	V	824 - 849	SISO	24.61	100.00	24.61	1.01	-	23.47	222.33	25.62	364.75
LTE	2	1850 - 1910	SISO	22.77	100.00	22.77	3.60	-	24.22	264.24	26.37	433.51
LTE	4	1710 - 1755	SISO	23.00	100.00	23.00	4.00	-	24.85	305.49	27.00	501.19
LTE	5	824 - 849	SISO	20.73	100.00	20.73	2.20	-	20.78	119.67	22.93	196.34
LTE	7	2500 - 2570	SISO	22.90	100.00	22.90	4.50	-	25.25	334.97	27.40	549.54
LTE	10	1710 - 1770	SISO	23.00	100.00	23.00	4.00	-	24.85	305.49	27.00	501.19
LTE	12	699 - 716	SISO	23.00	100.00	23.00	1.30	-	22.15	164.06	24.30	269.15
LTE	13	777 - 787	SISO	23.00	100.00	23.00	2.30	-	23.15	206.54	25.30	338.84
LTE	17	704 - 716	SISO	23.00	100.00	23.00	1.90	-	22.75	188.36	24.90	309.03
LTE	25	1850 - 1915	SISO	23.79	100.00	23.79	3.80	-	25.44	349.95	27.59	574.12
LTE	26	814 - 849	SISO	23.40	100.00	23.40	2.20	-	23.45	221.31	25.60	363.08
LTE	41	2496 - 2690	SISO	22.58	100.00	22.58	4.30	-	24.73	297.17	26.88	487.53
LTE	66	1710 - 1780	SISO	22.60	100.00	22.60	4.00	-	24.45	278.61	26.60	457.09
LTE	71	663 - 698	SISO	23.00	100.00	23.00	0.50	-	21.35	136.46	23.50	223.87
LTE	2	1850 - 1910	UL MIMO	26.00	100.00	26.00	3.60	2.20	26.81	479.31	28.96	786.35
LTE	4	1710 - 1755	UL MIMO	26.00	100.00	26.00	4.00	2.10	27.00	501.54	29.15	822.83
LTE	7	2500 - 2570	UL MIMO	26.00	100.00	26.00	4.50	3.80	28.01	633.01	30.16	1038.51
LTE	41	2496 - 2690	UL MIMO	26.00	100.00	26.00	4.30	3.50	27.77	598.19	29.92	981.39
LTE	66	1710 - 1780	UL MIMO	26.00	100.00	26.00	4.00	2.20	27.04	506.13	29.19	830.35
802.11b/g/n	2.4 GHz	2412 - 2484	SISO	14.03	99.88	14.02	-	3.50	15.37	34.47	17.52	56.56
802.11b/g/n	2.4 GHz	2412 - 2484	SISO	14.03	99.88	14.02	-	3.50	15.37	34.47	17.52	56.56
802.11a/n/ac/ax	5 GHz	5150 - 5850	UL MIMO	17.16	90.00	16.70	3.50	3.50	18.05	63.86	20.20	104.77
802.11a/n/ac/ax	5 GHz	5150 - 5850	UL MIMO	17.16	90.00	16.70	3.20	3.20	17.75	59.60	19.90	97.78

Table 1: Equipment specifications

RF Exposure Assessment result and verdict

The assessment summary according to the radiofrequency radiation exposure limits defined in FCC 47 CFR § 2.1093 is the following:

Technology / Mode	Operating Band	Frequency under evaluation (MHz)	Transmitting configuration	Distance (cm)	Maximum Averaged E.R.P (mW)	§1.1307(b)(3).i.(C) Exposure Limit (mW)	Verdict for exemption § 1.1307(b)(3).i
UMTS	II	1850 - 1910	SISO	20.0	303.4	768.0	Pass
UMTS	IV	1710 - 1755	SISO	20.0	331.9	768.0	Pass
UMTS	V	824 - 849	SISO	20.0	222.3	421.9	Pass
LTE	2	1850 - 1910	SISO	20.0	264.2	768.0	Pass
LTE	4	1710 - 1755	SISO	20.0	305.5	768.0	Pass
LTE	5	824 - 849	SISO	20.0	119.7	421.9	Pass
LTE	7	2500 - 2570	SISO	20.0	335.0	768.0	Pass
LTE	10	1710 - 1770	SISO	20.0	305.5	768.0	Pass
LTE	12	699 - 716	SISO	20.0	164.1	357.9	Pass
LTE	13	777 - 787	SISO	20.0	206.5	397.8	Pass
LTE	17	704 - 716	SISO	20.0	188.4	360.4	Pass
LTE	25	1850 - 1915	SISO	20.0	349.9	768.0	Pass
LTE	26	814 - 849	SISO	20.0	221.3	416.8	Pass
LTE	41	2496 - 2690	SISO	20.0	297.2	768.0	Pass
LTE	66	1710 - 1780	SISO	20.0	278.6	768.0	Pass
LTE	71	663 - 698	SISO	20.0	136.5	339.5	Pass
LTE	2	1850 - 1910	UL MIMO	20.0	479.3	768.0	Pass
LTE	4	1710 - 1755	UL MIMO	20.0	501.5	768.0	Pass
LTE	7	2500 - 2570	UL MIMO	20.00	633.01	768.00	Pass
LTE	41	2496 - 2690	UL MIMO	20.00	598.19	768.00	Pass
LTE	66	1710 - 1780	UL MIMO	20.00	506.13	768.00	Pass
802.11b/g/n	2.4 GHz	2412 - 2484	SISO	20.00	34.47	768.00	Pass
802.11b/g/n	2.4 GHz	2412 - 2484	SISO	20.00	34.47	768.00	Pass
802.11a/n/ac/ax	5 GHz	5150 - 5850	UL MIMO	20.00	63.86	768.00	Pass
802.11a/n/ac/ax	5 GHz	5150 - 5850	UL MIMO	20.00	59.60	768.00	Pass

Table 2: Assessment result and verdict

The computed value(s) are below the limit(s), so according to KDB 447498 D01 – General RF Exposure Guidance, these modes qualify for Standalone SAR test exclusion for 1-g SAR and 10-g Extremity SAR.

Simultaneous transmission assessment:

Simultaneous technologies and modes	Result (\sum of Pout/Pmax ratios)	Verdict ($\sum \leq 1$)
LTE band 7 (SISO) + LTE band 7 (UL MIMO) + 802.11b/g/n 2.4 GHz + 802.11b/g/n 2.4 GHz	0.91	Pass
LTE band 7 (SISO) + LTE band 7 (UL MIMO) + 802.11a/n/ac/ax (UL MIMO) 5 GHz + 802.11a/n/ac/ax (UL MIMO) 5 GHz	0.98	Pass

Table 3: Simultaneous Transmission assessment

Appendix B: FCC RF Exposure information

FCC SAR test exclusion considerations for portable devices

For transmission frequencies below 6GHz, as stated by the FCC (47 CFR §2.1093), human exposure to RF emissions from portable devices, which are defined as transmitting devices to be used so that the radiating structure(s) of the device is/are within 20 centimeters of the body of the user, must be evaluated with respect to the FCC-adopted limits for SAR.

According to FCC OET KDB 447498 D01 General RF Exposure Guidance:

Unless specifically required by the published RF exposure KDB procedures, standalone 1-g head or body and 10-g extremity SAR evaluation for general population exposure conditions, by measurement or numerical simulation, is not required when the corresponding SAR Test Exclusion Threshold condition is satisfied.

- For distances ≤ 50 mm

The 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances ≤ 50 mm are determined by:

$$[(\text{max. power of channel, including tune-up tolerance, mW})/(\text{min. test separation distance, mm})] \cdot [\sqrt{f(\text{GHz})}] \leq 3.0 \text{ for 1-g SAR and } \leq 7.5 \text{ for 10-g extremity SAR}$$

Where

- f(GHz) is the RF channel transmit frequency in GHz
- Power and distance are rounded to the nearest mW and mm before calculation
- The result is rounded to one decimal place for comparison

The test exclusions are applicable only when the minimum test separation distance is ≤ 50 mm and for transmission frequencies between 100 MHz and 6 GHz. When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion.

Approximate SAR Test Exclusion Power Thresholds at Selected Frequencies and Test Separation Distances are illustrated in the following Table:

MHz	5	10	15	20	25	30	35	40	45	50	mm
150	39	77	116	155	194	232	271	310	349	387	SAR Test Exclusion Threshold (mW)
300	27	55	82	110	137	164	192	219	246	274	
450	22	45	67	89	112	134	157	179	201	224	
835	16	33	49	66	82	98	115	131	148	164	
900	16	32	47	63	79	95	111	126	142	158	
1500	12	24	37	49	61	73	86	98	110	122	
1900	11	22	33	44	54	65	76	87	98	109	
2450	10	19	29	38	48	57	67	77	86	96	
3600	8	16	24	32	40	47	55	63	71	79	
5200	7	13	20	26	33	39	46	53	59	66	
5400	6	13	19	26	32	39	45	52	58	65	
5800	6	12	19	25	31	37	44	50	56	62	

SAR Test Exclusion Thresholds for 100 MHz – 6 GHz and ≤ 50 mm

- For distances > 50 mm

For 100 MHz to 6 GHz frequencies and for test separation distances > 50 mm, the SAR test exclusion threshold is determined according to the following:

1) [Power allowed at numeric threshold for 50 mm in table 1) + (test separation distance - 50 mm)·(f(MHz)/150)] mW, at 100 MHz to 1500 MHz

2) [Power allowed at numeric threshold for 50 mm in table 1) + (test separation distance - 50 mm)·10] mW, at > 1500 MHz and ≤ 6 GHz

Approximate SAR test exclusion power thresholds at selected frequencies and test separation distances are illustrated in the following table

MHz	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	mm
100	474	481	487	494	501	507	514	521	527	534	541	547	554	561	567	SAR Test Exclusion Threshold (mW)
150	387	397	407	417	427	437	447	457	467	477	487	497	507	517	527	
300	274	294	314	334	354	374	394	414	434	454	474	494	514	534	554	
450	224	254	284	314	344	374	404	434	464	494	524	554	584	614	644	
835	164	220	275	331	387	442	498	554	609	665	721	776	832	888	943	
900	158	218	278	338	398	458	518	578	638	698	758	818	878	938	998	
1500	122	222	322	422	522	622	722	822	922	1022	1122	1222	1322	1422	1522	
1900	109	209	309	409	509	609	709	809	909	1009	1109	1209	1309	1409	1509	
2450	96	196	296	396	496	596	696	796	896	996	1096	1196	1296	1396	1496	
3600	79	179	279	379	479	579	679	779	879	979	1079	1179	1279	1379	1479	
5200	66	166	266	366	466	566	666	766	866	966	1066	1166	1266	1366	1466	
5400	65	165	265	365	465	565	665	765	865	965	1065	1165	1265	1365	1465	
5800	62	162	262	362	462	562	662	762	862	962	1062	1162	1262	1362	1462	

SAR Test Exclusion Thresholds for 100 MHz – 6 GHz and > 50 mm

- For frequencies below 100 MHz

The following may be considered for SAR test exclusion:

1) For test separation distances > 50 mm and < 200 mm, the power threshold at the corresponding test separation distance at 100 MHz in step b) is multiplied by $[1 + \log(100/f(\text{MHz}))]$

2) For test separation distances ≤ 50 mm, the power threshold determined by the equation in c) 1) for 50 mm and 100 MHz is multiplied by ½

Approximate SAR test exclusion power thresholds at selected frequencies and test separation distances are illustrated in the following table

MHz	< 50	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	mm
100	237	474	481	487	494	501	507	514	521	527	534	541	547	554	561	567	mW
50	308	617	625	634	643	651	660	669	677	686	695	703	712	721	729	738	
10	474	948	961	975	988	1001	1015	1028	1041	1055	1068	1081	1095	1108	1121	1135	
1	711	1422	1442	1462	1482	1502	1522	1542	1562	1582	1602	1622	1642	1662	1682	1702	
0.1	948	1896	1923	1949	1976	2003	2029	2056	2083	2109	2136	2163	2189	2216	2243	2269	
0.05	1019	2039	2067	2096	2125	2153	2182	2211	2239	2268	2297	2325	2354	2383	2411	2440	
0.01	1185	2370	2403	2437	2470	2503	2537	2570	2603	2637	2670	2703	2737	2770	2803	2837	

SAR Test Exclusion Thresholds for frequencies < 100 MHz

Simultaneous transmission assessment:

When multiple sources are introduced into an environment, it becomes necessary to address the sources interdependently, since each source will contribute some percentage of the maximum exposure towards the total exposure at a fixed location. The sum of the ratios of the exposure from each source to the corresponding maximum exposure for the frequency of each source must be evaluated.

The exposure complies with the maximum permissible exposure if the sum of the ratios is less than unity:

$$\sum_{i=1}^n \frac{S_i}{P_{\max_i}} < 1$$

Where

S_i is the calculated SAR tests exclusion value of each source.

P_{\max_i} is the SAR test exclusion threshold.