RF Exposure evaluation

Applicant Data:	u-blox AG Zürcher Strasse 68 8809 Thalwil Switzerland	
Product Data:	*description:*	Host-based automotive module with Wi-Fi and Bluetooth
	product:	JODY-W377-00A; JODY-W377-00B
	trademark:	u-blox
	supported Technologies:	Bluetooth Classic, Bluetooth Low Energy, WLAN 2,4 GHz and WLAN 5 GHz
	device category:	mobile device
	environment:	General Population/Uncontrolled

FCC ID:	XPYJODYW377
IC:	8595A-JODYW377

Standards
OET Bulletin 65 Edition 97-01 August 1997
RSS-102 Issue 5 – March 2015

FCC CFR 47, Part 2.1091: Radiofrequency radiation exposure evaluation: mobile devices.
FCC CFR 47, Part 2.1307: Actions that may have a significant environmental effect, for which Environmental Assessments (EAs) must be prepared.
FCC CFR 47, Part 2.1310: Radiofrequency radiation exposure limits.

RF Exposure evaluation

Maximum Permissible Exposure

As specified in Chapter e(1) of 47 CFR Part 1.1310 – Limits for Maximum Permissible Exposure (MPE)

Table (ii) – Limits for General Population/ Uncontrolled Exposure

Frequency range (MHz)	Power density (mW/cm²)
300 – 1500	f/1500
1500 - 100000	1.0

As specified in Chapter 4 of RSS-102, Issue 5 – Exposure Limits

Table 4 - RF Field Strength Limits for Devices Used by the General Public (Uncontrolled Environment)

Frequency range (MHz)	Power density (W/m²)	Power density (mW/cm²)
300-6000	$0.02619\ f^{0.6834}$	mW/cm²=W/m²*0.1
6000-150000	10	1.0

RF Exposure evaluation

Calculations

Equation OET bulletin 65, page 18, edition 97-01:

$S = P * G / (4 * \pi * R^2)$

$R = \sqrt{} (P * G / S_{lim} * 4 * \pi)$

$G = S_{lim} * 4 * \pi * R^2 / P$

Where:

S = power density (mW/cm²)
P = power input to the antenna (mW)
G = power gain of the antenna (mW)
R = distance to the centre of radiation of the antenna (cm)
S_{lim} = FCC / IC Limit (mW/cm²)

Simultaneous Transmission Considerations

The calculation below is used to consider situations in which simultaneous exposure to fields of different frequencies occur. The calculation is performed by the sum of each relative exposure for each equipment according to the following criteria.

$$\sum_{1}^{N} \frac{S_{eqn}}{S_{Limn}} = \frac{S_{eq1}}{S_{Lim1}} + \frac{S_{eq2}}{S_{Lim2}} + \ldots + \frac{S_{eqN}}{S_{LimN}} \leq 1$$

Where:

S_{eq} = S = power density (mW/cm²)
S_{lim} = FCC / IC Limit (mW/cm²)

RF Exposure evaluation

Assessment

For FCC

With:

G = 2 dBi
R = 20 cm

			G		P		P*G	S	Slim	Seq / Slim	
Operational Bands	Frequency (MHz)	Antenna Gain (dBi)	Antenna Gain -numeric- (mW)	Output Power -conducted- (dBm)	Output Power -conducted- (mW)	Output power (EIRP) (dBm)	Output Power (EIRP) (mW)	Power Density value (mW/cm²)	FCC Limit (mW/cm²)	Relative Power Density value	Margin to FCC Limit (mW/cm²)
Bluetooth	2480	2	1,5849	11,20	13,18	13,20	20,89	0,0042	1,0000	0,0042	0,9958
Bluetooth LE	2480	2	1,5849	8,40	6,92	10,40	10,96	0,0022	1,0000	0,0022	0,9978
802.11b	2462	2	1,5849	21,30	134,90	23,30	213,80	0,0425	1,0000	0,0425	0,9575
802.11g	2462	2	1,5849	18,90	77,62	20,90	123,03	0,0245	1,0000	0,0245	0,9755
802.11n_HT 20	2462	2	1,5849	18,90	77,62	20,90	123,03	0,0245	1,0000	0,0245	0,9755
802.11n_HT 40	2452	2	1,5849	15,50	35,48	17,50	56,23	0,0112	1,0000	0,0112	0,9888
802.11ax_HT 20	2462	2	1,5849	20,00	100,00	22,00	158,49	0,0315	1,0000	0,0315	0,9685
802.11ax_HT 40	2452	2	1,5849	15,90	38,90	17,90	61,66	0,0123	1,0000	0,0123	0,9877
802.11a	5240	2	1,5849	18,10	64,57	20,10	102,33	0,0204	1,0000	0,0204	0,9796
802.11a	5320	2	1,5849	18,70	74,13	20,70	117,49	0,0234	1,0000	0,0234	0,9766
802.11a	5700	2	1,5849	18,30	67,61	20,30	107,15	0,0213	1,0000	0,0213	0,9787
802.11a	5825	2	1,5849	17,80	60,26	19,80	95,50	0,0190	1,0000	0,0190	0,9810
802.11n 20M	5240	2	1,5849	18,30	67,61	20,30	107,15	0,0213	1,0000	0,0213	0,9787
802.11n 20M	5320	2	1,5849	20,70	117,49	22,70	186,21	0,0370	1,0000	0,0370	0,9630
802.11n 20M	5700	2	1,5849	20,70	117,49	22,70	186,21	0,0370	1,0000	0,0370	0,9630
802.11n 20M	5825	2	1,5849	19,60	91,20	21,60	144,54	0,0288	1,0000	0,0288	0,9712
802.11n 40M	5230	2	1,5849	18,20	66,07	20,20	104,71	0,0208	1,0000	0,0208	0,9792
802.11n 40M	5310	2	1,5849	19,60	91,20	21,60	144,54	0,0288	1,0000	0,0288	0,9712
802.11n 40M	5670	2	1,5849	19,50	89,13	21,50	141,25	0,0281	1,0000	0,0281	0,9719
802.11n 40M	5795	2	1,5849	18,20	66,07	20,20	104,71	0,0208	1,0000	0,0208	0,9792
802.11ac 20M	5240	2	1,5849	18,30	67,61	20,30	107,15	0,0213	1,0000	0,0213	0,9787
802.11ac 20M	5320	2	1,5849	20,70	117,49	22,70	186,21	0,0370	1,0000	0,0370	0,9630
802.11ac 20M	5700	2	1,5849	20,60	114,82	22,60	181,97	0,0362	1,0000	0,0362	0,9638
802.11ac 20M	5825	2	1,5849	19,60	91,20	21,60	144,54	0,0288	1,0000	0,0288	0,9712
802.11ac 40M	5230	2	1,5849	18,10	64,57	20,10	102,33	0,0204	1,0000	0,0204	0,9796
802.11ac 40M	5310	2	1,5849	19,80	95,50	21,80	151,36	0,0301	1,0000	0,0301	0,9699
802.11ac 40M	5670	2	1,5849	19,30	85,11	21,30	134,90	0,0268	1,0000	0,0268	0,9732
802.11ac 40M	5795	2	1,5849	18,20	66,07	20,20	104,71	0,0208	1,0000	0,0208	0,9792
802.11ac 80M	5210	2	1,5849	16,50	44,67	18,50	70,79	0,0141	1,0000	0,0141	0,9859
802.11ac 80M	5290	2	1,5849	15,80	38,02	17,80	60,26	0,0120	1,0000	0,0120	0,9880
802.11ac 80M	5690	2	1,5849	19,10	81,28	21,10	128,82	0,0256	1,0000	0,0256	0,9744
802.11ac 80M	5775	2	1,5849	18,10	64,57	20,10	102,33	0,0204	1,0000	0,0204	0,9796
802.11ax 20M	5240	2	1,5849	18,20	66,07	20,20	104,71	0,0208	1,0000	0,0208	0,9792
802.11ax 20M	5320	2	1,5849	19,10	81,28	21,10	128,82	0,0256	1,0000	0,0256	0,9744
802.11ax 20M	5700	2	1,5849	18,90	77,62	20,90	123,03	0,0245	1,0000	0,0245	0,9755
802.11ax 20M	5825	2	1,5849	17,90	61,66	19,90	97,72	0,0194	1,0000	0,0194	0,9806
802.11ax 40M	5230	2	1,5849	17,60	57,54	19,60	91,20	0,0181	1,0000	0,0181	0,9819
802.11ax 40M	5310	2	1,5849	18,80	75,86	20,80	120,23	0,0239	1,0000	0,0239	0,9761
802.11ax 40M	5670	2	1,5849	18,80	75,86	20,80	120,23	0,0239	1,0000	0,0239	0,9761
802.11ax 40M	5795	2	1,5849	17,90	61,66	19,90	97,72	0,0194	1,0000	0,0194	0,9806
802.11ax 80M	5210	2	1,5849	15,50	35,48	17,50	56,23	0,0112	1,0000	0,0112	0,9888
802.11ax 80M	5290	2	1,5849	15,10	32,36	17,10	51,29	0,0102	1,0000	0,0102	0,9898
802.11ax 80M	5690	2	1,5849	18,40	69,18	20,40	109,65	0,0218	1,0000	0,0218	0,9782
802.11ax 80M	5775	2	1,5849	17,40	54,95	19,40	87,10	0,0173	1,0000	0,0173	0,9827

RF Exposure evaluation

Simultaneous:

	1st Technology e.g. Bluetooth Classic (BT)	2nd Technology WLAN 2,4 GHz (WLAN24)	3rd Technology WLAN 5 GHz (WLAN5)
(S_{eq} / S_{lim})	0.0042	0.0425	0.0370
Sum of (S_{eq} / S_{lim}) BT+WLAN24+WLAN5	0.0837		
Limit	1		
Conclusion	passed		

Note 1: only worst-case values are listed in the tables above
Note 2: the duty cycle correction factor is already included in the measurement values

RF Exposure evaluation

For ISED

With:

G = 2 dBi
R = 20 cm

			G		P		P*G	S	S_{lim}	S_{eq} / S_{lim}	
Operational Bands	Frequency (MHz)	Antenna Gain (dBi)	Antenna Gain -numeric- (mW)	Output Power -conducted- (dBm)	Output Power -conducted- (mW)	Output Power (EIRP) (dBm)	Output Power (EIRP) (mW)	Power Density value (mW/cm²)	IC Limit (mW/cm²)	Relative Power Density value	Margin to IC Limit (mW/cm²)
Bluetooth	2480	2	1,5849	11,20	13,18	13,20	20,89	0,0042	0,5469	0,0076	0,5427
Bluetooth LE	2480	2	1,5849	8,40	6,92	10,40	10,96	0,0022	0,5469	0,0040	0,5447
802.11b	2462	2	1,5849	21,30	134,90	23,30	213,80	0,0425	0,5442	0,0782	0,5016
802.11g	2462	2	1,5849	18,90	77,62	20,90	123,03	0,0245	0,5442	0,0450	0,5197
802.11n_HT 20	2462	2	1,5849	18,90	77,62	20,90	123,03	0,0245	0,5442	0,0450	0,5197
802.11n_HT 40	2452	2	1,5849	15,50	35,48	17,50	56,23	0,0112	0,5427	0,0206	0,5315
802.11ax_HT 20	2462	2	1,5849	20,00	100,00	22,00	158,49	0,0315	0,5442	0,0579	0,5126
802.11ax_HT 40	2452	2	1,5849	15,90	38,90	17,90	61,66	0,0123	0,5427	0,0226	0,5304
802.11a	5240	2	1,5849	18,10	64,57	20,10	102,33	0,0204	0,9119	0,0223	0,8915
802.11a	5320	2	1,5849	18,70	74,13	20,70	117,49	0,0234	0,9213	0,0254	0,8980
802.11a	5700	2	1,5849	18,30	67,61	20,30	107,15	0,0213	0,9658	0,0221	0,9445
802.11a	5825	2	1,5849	17,80	60,26	19,80	95,50	0,0190	0,9803	0,0194	0,9613
802.11n 20M	5240	2	1,5849	18,30	67,61	20,30	107,15	0,0213	0,9119	0,0234	0,8905
802.11n 20M	5320	2	1,5849	20,70	117,49	22,70	186,21	0,0370	0,9213	0,0402	0,8843
802.11n 20M	5700	2	1,5849	20,70	117,49	22,70	186,21	0,0370	0,9658	0,0384	0,9288
802.11n 20M	5825	2	1,5849	19,60	91,20	21,60	144,54	0,0288	0,9803	0,0293	0,9515
802.11n 40M	5230	2	1,5849	18,20	66,07	20,20	104,71	0,0208	0,9107	0,0229	0,8898
802.11n 40M	5310	2	1,5849	19,60	91,20	21,60	144,54	0,0288	0,9202	0,0313	0,8914
802.11n 40M	5670	2	1,5849	19,50	89,13	21,50	141,25	0,0281	0,9624	0,0292	0,9343
802.11n 40M	5795	2	1,5849	18,20	66,07	20,20	104,71	0,0208	0,9768	0,0213	0,9560
802.11ac 20M	5240	2	1,5849	18,30	67,61	20,30	107,15	0,0213	0,9119	0,0234	0,8905
802.11ac 20M	5320	2	1,5849	20,70	117,49	22,70	186,21	0,0370	0,9213	0,0402	0,8843
802.11ac 20M	5700	2	1,5849	20,60	114,82	22,60	181,97	0,0362	0,9658	0,0375	0,9296
802.11ac 20M	5825	2	1,5849	19,60	91,20	21,60	144,54	0,0288	0,9803	0,0293	0,9515
802.11ac 40M	5230	2	1,5849	18,10	64,57	20,10	102,33	0,0204	0,9107	0,0224	0,8903
802.11ac 40M	5310	2	1,5849	19,80	95,50	21,80	151,36	0,0301	0,9202	0,0327	0,8901
802.11ac 40M	5670	2	1,5849	19,30	85,11	21,30	134,90	0,0268	0,9624	0,0279	0,9355
802.11ac 40M	5795	2	1,5849	18,20	66,07	20,20	104,71	0,0208	0,9768	0,0213	0,9560
802.11ac 80M	5210	2	1,5849	16,50	44,67	18,50	70,79	0,0141	0,9083	0,0155	0,8942
802.11ac 80M	5290	2	1,5849	15,80	38,02	17,80	60,26	0,0120	0,9178	0,0131	0,9058
802.11ac 80M	5690	2	1,5849	19,10	81,28	21,10	128,82	0,0256	0,9647	0,0266	0,9390
802.11ac 80M	5775	2	1,5849	18,10	64,57	20,10	102,33	0,0204	0,9745	0,0209	0,9541
802.11ax 20M	5240	2	1,5849	18,20	66,07	20,20	104,71	0,0208	0,9119	0,0228	0,8910
802.11ax 20M	5320	2	1,5849	19,10	81,28	21,10	128,82	0,0256	0,9213	0,0278	0,8957
802.11ax 20M	5700	2	1,5849	18,90	77,62	20,90	123,03	0,0245	0,9658	0,0253	0,9414
802.11ax 20M	5825	2	1,5849	17,90	61,66	19,90	97,72	0,0194	0,9803	0,0198	0,9608
802.11ax 40M	5230	2	1,5849	17,60	57,54	19,60	91,20	0,0181	0,9107	0,0199	0,8925
802.11ax 40M	5310	2	1,5849	18,80	75,86	20,80	120,23	0,0239	0,9202	0,0260	0,8962
802.11ax 40M	5670	2	1,5849	18,80	75,86	20,80	120,23	0,0239	0,9624	0,0249	0,9384
802.11ax 40M	5795	2	1,5849	17,90	61,66	19,90	97,72	0,0194	0,9768	0,0199	0,9574
802.11ax 80M	5210	2	1,5849	15,50	35,48	17,50	56,23	0,0112	0,9083	0,0123	0,8971
802.11ax 80M	5290	2	1,5849	15,10	32,36	17,10	51,29	0,0102	0,9178	0,0111	0,9076
802.11ax 80M	5690	2	1,5849	18,40	69,18	20,40	109,65	0,0218	0,9647	0,0226	0,9429
802.11ax 80M	5775	2	1,5849	17,40	54,95	19,40	87,10	0,0173	0,9745	0,0178	0,9572

RF Exposure evaluation

Simultaneous:

	1st Technology e.g. Bluetooth Classic (BT)	2nd Technology WLAN 2,4 GHz (WLAN24)	3rd Technology WLAN 5 GHz (WLAN5)
(S_{eq} / S_{lim})	0.0076	0.0782	0.0402
Sum of (S_{eq} / S_{lim}) BT+WLAN24+WLAN5	0.1260		
Limit	1		
Conclusion	passed		

Note 1: only worst-case values are listed in the tables above
Note 2: the duty cycle correction factor is already included in the measurement values