

RF EXPOSURE EVALUATION

According to FCC 1.1310: The criteria listed in the following table shall be used to evaluate the environment impact of human exposure to radio frequency(RF) Radiation as specified in KDB 447498 D01 V06 and §1.1307(b)

CFR Title 47 §2.1091(b): (b) For purposes of this section, a mobile device is defined as a transmitting device designed to be used in other than fixed locations and to generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between the transmitter's radiating structure(s) and the body of the user or nearby persons.

FCC ID: **2AW3M-HC2183T**

EUT Specification

EUT	RoomSign
Frequency band (Operating)	☒ WLAN: 2.412GHz ~ 2.462GHz ☒ WLAN: 5.18GHz ~ 5.24GHz ☒ WLAN: 5.745GHz ~ 5.825GHz ☒ Others: 2.402GHz~2.480GHz BLE ☒ NFC: 13.56MHz ☒ RFID: 125kHz
Device category	☐ Portable (<20cm separation) ☒ Mobile (>20cm separation) ☐ Others ____
Exposure classification	☐ Occupational/Controlled exposure (S = 5mW/cm2) ☒ General Population/Uncontrolled exposure (S=1mW/cm2)
Antenna diversity	☐ Single antenna ☒ Multiple antennas ☐ Tx diversity ☐ Rx diversity ☐ Tx/Rx diversity
Evaluation applied	☒ MPE Evaluation ☐ SAR Evaluation

Limits for Maximum Permissible Exposure(MPE)

TABLE 1 TO § 1.1310(E)(1)—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm ²)	Averaging time (minutes)
(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
300-1,500			f/1500	<30
1,500-100,000			1.0	<30

*f = frequency in MHz. * = Plane-wave equivalent power density.*

Note: Emissions between 100 kHz to 300 kHz should be assessed versus the limits at 300 kHz in Table 1 of Section 1.1310: 614 V/m and 1.63 A/m. AKDB inquiry is required to determine the applicable exposure limits below 100 kHz.

Friis transmission formula: $P_d = (P_{out} * G) / (4 * \pi * R^2)$

Where

P_d = Power density in mW/cm²

P_{out} = output power to antenna in Mw

G = gain of antenna in linear scale

π = 3.1416

R = distance between observation point and center of the radiator in cm

P_d the limit of MPE, 1mW/cm². If we know the maximum gain of the antenna and total power input to the antenna, through the calculation, we will know the distance where the MPE limit is reached.

Measurement Result

NFC:

Mode	Frequency (MHz)	Field strength of fundamental @ 3m		Field strength of fundamental @ 0.2m		Electric Field Strength (V/m)
		(dBuV/m)	V/m	(dBuV/m)	V/m	
ASK	13.56	59.68	0.0010	106.72	0.2168	60.77
Note: 1. $59.68 \text{ dBuV/m@ } 3\text{m}, @ 0.2\text{m}=@3\text{m}+ 40\log (3/0.2)=106.72 \text{ dBuV/m}=0.2168 \text{ V/m}.$ 2. $\text{Field Strength (dB}\mu\text{V/m)} = 20*\log[\text{Field Strength (}\mu\text{V/m)}].$						

RFID:

Mode	Frequency (kHz)	Field strength of fundamental @ 3m		Field strength of fundamental @ 0.2m		Electric Field Strength (V/m)
		(dBuV/m)	V/m	(dBuV/m)	V/m	
ASK	125	55.67	0.0006	102.71	0.1366	614
Note: 1. $55.67 \text{ dBuV/m@ } 3\text{m}, @ 0.2\text{m}=@3\text{m}+ 40\log (3/0.2)=102.71 \text{ dBuV/m}=0.1366 \text{ V/m}.$ 2. $\text{Field Strength (dB}\mu\text{V/m)} = 20*\log[\text{Field Strength (}\mu\text{V/m)}].$						

BT worst case:

Operating Mode	Channel Frequency	Measured Power	Tune up tolerance	Max. Tune up Power	Antenna Gain	Power density at 20cm	Power density Limits (mW/cm ²)
	(MHz)	(dBm)	(dBm)	(dBm)	(dBi)	(mW/ cm ²)	
8DPSK	2441	-1.75	-1.75±1	-0.75	1.86	0.0003	1

BLE worst case:

Operating Mode	Channel Frequency	Measured Power	Tune up tolerance	Max. Tune up Power	Antenna Gain	Power density at 20cm	Power density Limits (mW/cm ²)
	(MHz)	(dBm)	(dBm)	(dBm)	(dBi)	(mW/ cm ²)	
2M	2480	5.52	5.52±1	6.52	1.86	0.0014	1

2.4GHz WiFi worst case:

Operating Mode	Channel Frequency	Measured Power	Tune up tolerance	Max. Tune up Power	Antenna Gain	Power density at 20cm	Power density Limits (mW/cm ²)
	(MHz)	(dBm)	(dBm)	(dBm)	(dBi)	(mW/ cm ²)	
802.11b	2412	15.34	15.34±1	16.34	1.86	0.0131	1

5.1GHz WiFi worst case:

Operating Mode	Channel Frequency	Measured Power	Tune up tolerance	Max. Tune up Power	Antenna Gain	Power density at 20cm	Power density Limits (mW/cm ²)
	(MHz)	(dBm)	(dBm)	(dBm)	(dBi)	(mW/ cm ²)	

802.11n (HT40)	5190	15.58	15.58±1	16.58	2.99	0.0180	1
-------------------	------	-------	---------	-------	------	--------	---

5.8GHz WiFi worst case:

Operating Mode	Channel Frequency	Measured Power	Tune up tolerance	Max. Tune up Power	Antenna Gain	Power density at 20cm	Power density Limits (mW/cm ²)
	(MHz)	(dBm)	(dBm)	(dBm)	(dBi)	(mW/ cm ²)	
802.11n (HT40)	5795	15.14	15.14±1	16.14	1.96	0.0128	1

Evaluate the condition of different modules work simultaneously

The requirement of Simultaneous Transmission evaluation has also been considered and has complied with the following conditions of the worst case:

$$MPE1/Limit1 + MPE2/Limit2 + \dots \leq 1$$

Thus,

$$\begin{array}{cccccc} 0.2168/60.77 & + & 0.1366/614 & + & 0.0014/1 & + & 0.0131/1 & + & 0.0180/1 & + & 0.0128/1 \\ \text{(NFC)} & & \text{(RFID)} & & \text{(BT/BLE)} & & \text{(2.4G WiFi)} & & \text{(5.1G WiFi)} & & \text{(5.8G WiFi)} \end{array}$$

$$= 0.04917 \leq 1$$

It is concluded that no Simultaneous Transmission evaluation is required.