6870 module (EUT) RF Exposure:-

The 6870 module is intended as a mobile device. Instructions to host manufacturer included in the installation manual relate to mobile use and 200mm (0.2metres) distance and the relevant RF exposure requirements.

The module device has three transmitters in it, a ZigBee device with two antennas and two UWB devices with an antenna each. The UWB devices cannot transmit with each other, either one of the UWB devices can transmit at the same time as the ZigBee radio. The ZigBee radio transmits out of one of its antennas only at a time. This evaluation covers the three transmitters operating individually and either of the UWB transmitters operating with the ZigBee transmitter simultaneously.
RF exposure test exemption/calculation is demonstrated using:

KDB 447498 D04 Interim General RF exposure Guidance.

Clause 2.1 RF exposure Test Exemptions for single source

Clause 2.1.4 MPE-Based Exemption
An alternative to the SAR-based exemption is provided in § 1.1307(b)(3)(i)(C), for a much wider frequency range, from 300 kHz to 100 GHz, applicable for separation distances greater or equal to λ/2π, where λ is the free-space operating wavelength in meters. The MPE-based test exemption condition is in terms of ERP, defined as the product of the maximum antenna gain and the delivered maximum time-averaged power.10 For this case, a RF source is an RF exempt device if its ERP (watts) is no more than a frequency-dependent value, as detailed tabular form in Appendix B. These limits have been derived based on the basic specifications on Maximum Permissible Exposure (MPE) considered for the FCC rules in § 1.1310(e)(1).

Clause 2.2 RF Exposure Test Exemptions for Simultaneous Transmission Sources

Clause 2.2.2 Simultaneous Transmission with both SAR-based and MPE-Based Test Exemptions
This case is described in detail in § 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 Formula (1) is satisfied.

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. The power level of the standalone SAR used to qualify for SAR test exemption, or additional test exemption, must be clearly explained in the SAR report. When simultaneous transmission SAR-based test exemptions, or when the SPLSR test exemption [Section 2.2.3] cannot be applied, enlarged zoom scan [Glossary] SAR measurements must be performed at the maximum output power required for the applicable simultaneous transmission scenarios. This power level shall account for the tune-up tolerance [Glossary] requirements of all transmitters, but not more than 2 dB lower than the maximum tune-up tolerance limit.

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

a	number of fixed, mobile, or portable RF sources claiming exemption using the § 1.1307(b)(3)(i)(B) formula for P_{th}, including existing exempt transmitters and those being added.
b	number of fixed, mobile, or portable RF sources claiming exemption using the applicable § 1.1307(b)(3)(i)(C) Table 1 formula 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.
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).
$P_{\text{th},i}$	the exemption threshold power (Pth) according to the § 1.1307(b)(3)(i)(B) formula for fixed, mobile, or portable RF source i.
ERP_j	the available maximum time-averaged power or the ERP, whichever is greater, of fixed, mobile, or portable RF source j.
$ERP_{\text{th},j}$	exemption threshold ERP for fixed, mobile, or portable RF source j, at a distance of at least $\lambda/2\pi$, according to the applicable § 1.1307(b)(3)(i)(C) Table 1 formula at the location in question.
$Evaluated_k$	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.
$Exposure\ Limit_k$	either the general population/uncontrolled maximum permissible exposure (MPE) or specific absorption rate (SAR) limit for each fixed, mobile, or portable sources, as applicable

The sum of the ratios of the applicable terms for SAR-based, MPE-based and measured SAR or MPE shall be less than 1, to determine simultaneous transmission exposure compliance.

Single source ZigBee transmission 2.405 - 2.48 GHz:
Highest ZigBee radiated power 97.38 dBuV/m @ 3m (+2.18 dBm) from middle channel (CH18) 2440 MHz and using antenna 1.
Max 5% duty cycle. So, Max time averaged power = 2.18-13.01 = -10.83 dBm or 0.083 mW.

Using clause 2.1.4 MPE-Based Exemption and Table 1 (1.1307(b)(3)(i)(c)

	low channel	Mid channel	High channel
Separation distance R (meters)	0.2	0.2	0.2
f(MHz)	2405	2440	2480
λ/2π (metres)	0.019853007	0.019568231	0.019252614

Table 1 (1.1307(b)(3)(i)(c)

RF Source Frequency (MHz)	Threshold Erp (watts)	Pth (Threshold) Watts ERP
0.3 - 1.34	$1920\ R^2$	N/A
1.34 - 30	$3450\ R^2/f^2$	N/A
30 - 300	$3.83\ R^2$	N/A
300 - 1500	$0.0128\ R^2f$	N/A
1500 - 100000	$19.2\ R^2$	0.768

As the ZigBee device highest ERP is on middle channel and after duty correction is only 0.083 mW, the ZigBee transmitter in the module device meets the exemption from further evaluation as a single source compared to the Pth threshold limit.

Single source UWB transmission 1:
UWB Peak Radiated power -0.15dBm in 50 MHz, Nominal Bandwidth is 666.5 MHz, so power in 666.5 MHz = 10* Log (666.5/50) = 11.25dB correction(addition), therefore:
max UWB power = -0.15+11.25 = 11.09 dBm. Max 10% duty cycle declared. So,
Max time averaged radiated power = 11.09 dBm -10dB = 1.09 dBm or 1.29 mW.

	low channel
Separation distance R (meters)	0.2
f(MHz)	6500
λ/2π (metres)	0.007345613

As the UWB 1 transmitter devices highest ERP on its channel after duty correction is only 1.29 mW, the UWB 1 transmitter in the module device meets the exemption from further evaluation as a single source compared to the Pth threshold limit.

Single source UWB transmission 2:
UWB Peak radiated power -0.39dBm in 50 MHz, Nominal Bandwidth is 666.5 MHz, so power in 666.5 MHz = 10* Log (666.5/50) = 11.25dB correction(addition), therefore:
max UWB power = -0.39+11.25 = 10.86 dBm. Max 10% duty cycle declared. So,
Max time averaged radiated power = 10.86 dBm -10dB = 0.86 dBm or 1.22 mW.

	low channel
Separation distance R (meters)	0.2
f(MHz)	6500
λ/2π (metres)	0.007345613

As the UWB 2 transmitter devices highest ERP on its channel after duty correction is only 1.22 mW, the UWB 2 transmitter in the module device meets the exemption from further evaluation as a single source compared to the Pth threshold limit.

Simultaneous transmission of ZigBee with either UWB1 or UWB2 sources:

Clause 2.2.2 Simultaneous Transmission with both SAR-based and MPE-Based Test Exemptions

ZigBee + UWB 1 simultaneous Transmit

MPE based threshold calculated Pth (Threshold)	**768**	mW	ERP	Ratio compared to threshold
ERP from device 1(ZigBee)	**0.083**	mW	ERP	0.000108073
ERP from device 2(UWB1)	**1.29**	mW	ERP	0.001679688
Ratio Summation device 1 and 2				0.001788

As the sum of the MPE ratios is <1 then the device is compliant with simultaneous transmit RF exposure.

ZigBee + UWB 2 simultaneous Transmit

MPE based threshold calculated Pth (Threshold)	**768**	mW	ERP	Ratio compared to threshold
ERP from device 1(ZigBee)	**0.083**	mW	ERP	0.000108073
ERP from device 3 (UWB2)	**1.22**	mW	ERP	0.001588542
Ratio Summation device 1 and 3				0.001697

As the sum of the MPE ratios is <1 then the device is compliant with simultaneous transmit RF exposure.

This calculation was prepared by Daniel Sims of RN Electronics Ltd, Acting as Agent towards FCC certification of the device.

Date: 29th August 2023

Signed:  (Radio Approvals Manager)