SAR Exemption Justification

Summary

The device has 3 radios as follows:

125 kHz radio operating under 15.209 as detailed in this application

925 MHz radio operating under 15.249 as detailed in this application

Previously certified 802.11 module with FCCID: XF6-RS9113DB

Note: The 2.4GHz operation of this module is not enabled. Only the 5GHz band is used.

The minimum distance between the device and the human body is approx. 25mm.

The sum of the SAR exclusion threshold is as follows per Section 4.3.1 of 447498 D01 General RF Exposure Guidance v06:

$$0.0102 \text{ (125 kHz)} + 0.000777 \text{ (925 MHz)} + 1.558 \text{ (5 GHz)} = 1.57 \leq 3.0$$

The sum of the simultaneous SAR exclusion threshold is as follows per Section 4.3.2 of 447498 D01 General RF Exposure Guidance v06:

$$0.000186 \text{ (125 kHz)} + 0.001 \text{ (925 MHz)} + 0.208 \text{ (5 GHz)} = 0.209 \leq 0.4 \text{ W/kg}$$

Therefore, this device can be considered compliant with the FCC's RF radiation exposure limits for general population with SAR testing.

All calculations for this exemption are detailed in this document.

Formulas Used

Field strength conversion formula (dBuV/m to V/m)

$$\frac{V}{m} = \frac{10^{\frac{dBuV/m}{20}}}{1,000,000} \tag{1}$$

Where:

- dBuV/m is the field strength measurement

EIRP conversion formula (V/m to W) per 412172 D01 – Determining ERP and EIRP v01r01 (August 7, 2015)

$$eirp = p_t \times g_t = \frac{(E * d)^2}{30} \tag{2}$$

Where:
- p_t = transmitter output power in watts,
- g_t = number gain of the transmitting antenna (unitless),
- E = electric field strength in V/m,
- d = measurement distance in meters (m)

SAR test exclusion threshold formula for 100 MHz to 6 GHz and test separation distance $\leq$ 50mm per Section 4.3.1a of 447498 D01 General RF Exposure Guidance v06.

$$\frac{max.\,power\,of\,channel,\,including\,tune-up\,tolerance,\;mW}{min.\,test\,separation\,distance,\,mm} * [\sqrt{f_{GHz}} \leq 3.0 \tag{3}$$

Where:

- f_{GHz} is the RF channel transmit frequency in GHz
- Power and distance are rounded to the nearest mW and mm before calculation $\square$
  The result is rounded to one decimal place for comparison.

SAR test exclusion threshold formula for frequencies $\leq$ 100MHz and test separation distance $\leq$ 50mm per Section 4.3.1 c)2) of 447498 D01 General RF Exposure Guidance v06.

$$max.\,power \leq \left\{ \left[\frac{3.0 * (50)}{\sqrt{0.100}} \right] + \left[(d - 50mm) * \left(\frac{f_{MHz}}{150} \right) \right] \right\} * \left[1 + log \left(\frac{100}{f_{MHz}} \right) \right] * \frac{1}{2} \tag{4}$$

Where:

- d is the test separation distance, in this case 25mm
- f_{MHz} is the frequency in MHz

Rearranged Equation (4) to isolate the threshold value of 3.0 for 1-g SAR.

$$\left\{ \frac{max.\,power}{[1 + log\,(\frac{100}{f_{MHz}})] * \frac{1}{2}} - [(d - 50mm) * (\frac{f_{MHz}}{150})] \right\} * \frac{\sqrt{0.100}}{(50)} \leq 3.0 \qquad (5)$$

Where:

- d is the test separation distance, in this case 25mm • f_{MHz} is the frequency in MHz

Simultaneous SAR test exclusion threshold formula for test separation distances $\leq$ 50 mm per Section 4.3.2 b)1) of 447498 D01 General RF Exposure Guidance v06.

$$\left[\frac{max.power\,of\,channel,including\,tune-up\,tolerance,mW}{min.test\,separation\,distance,mm} \right] * \left[\frac{\sqrt{f_{GHz}}}{x} \right]\,mW/kg \qquad (6)$$

Where:

- f_{GHz} is the RF channel transmit frequency in GHz
- x = 7.5 for 1-g SAR

Calculations

125 kHz

For the 125 kHz radio, the field strength is 100.2 dBuV/m at 3m (Bureau Veritas Test Report EV0616).

The dBuV/m conversation to V/m is determined by using Equation (1):

$$\frac{V}{m} = \frac{10^{\frac{dBuV/m}{20}}}{1,000,000} = \frac{10^{\frac{100.2}{20}}}{1,000,000} = \mathbf{0.102\ V/m} \tag{7}$$

The EIRP of the transmitter is determined by using Equation (2):

$$eirp = p_t \times g_t = \frac{(E*d)^2}{30} = \frac{(0.102*3.0)^2}{30} = 0.00312\ W = \mathbf{3.12\ mW} \tag{8}$$

Using Formula 4 and 5 for the stand-alone SAR test exclusion threshold is as follows:

This calculation shows that at 125 kHz at a separation distance of 25mm, the maximum permissible power is 925mW.

$$max.\,power \leq \mathbf{925\ mW} \leq \left\{ \left[\frac{3.0*(50)}{\sqrt{0.100}} \right] + \left[(25-50mm)*\left(\frac{\mathbf{0.125}}{150}\right) \right] \right\} * \left[1 + log\left(\frac{100}{\mathbf{0.125}}\right) \right] * \frac{1}{2} \tag{9}$$

This calculation shows that the device is operating at a level below the SAR test exemption threshold.

$$\left\{ \frac{max.\,power,\,mW}{\left[1 + log\left(\frac{100}{\mathbf{0.125}}\right) \right] * \frac{1}{2}} - \left[(25-50mm)*\left(\frac{\mathbf{0.125}}{150}\right) \right] \right\} * \frac{\sqrt{0.100}}{(50)} \leq \mathbf{0.0120} \leq 3.0 \tag{10}$$

Using Formula 6 for simultaneous SAR test exclusion threshold is as follows:

$$\left[\frac{max.\,power,\,mW}{test\ sepration\ distance,\,mm} \right] * \left[\frac{\sqrt{f_{GHz}}}{x} \right] = \left[\frac{3.12mW}{25mm} \right] * \left[\frac{\sqrt{0.0001234}}{7.5} \right] = \mathbf{0.000186} \leq 0.40\ W/kg \tag{11}$$

925MHz

For the 925MHz radio, the field strength is 88.3dBuV/m at 3m (Bureau Veritas Test Report EV0616).

The dBuV/m conversation to V/m is determined by using Equation (1):

$$\frac{V}{m} = \frac{10^{\frac{dBuV/m}{20}}}{1,000,000} = \frac{10^{\frac{88.3}{20}}}{1,000,000} = 0.026 V/m \tag{12}$$

The EIRP of the transmitter is determined by using Equation 2:

$$eirp = p_t \times g_t = \frac{(E * d)^2}{30} = \frac{(0.026 * 3.0)^2}{30} = 0.000202 W = \mathbf{0.202 mW} \tag{13}$$

Using Formula 3 for the stand-alone SAR test exclusion threshold is as follows:

$$\frac{max.power, \ mW}{test \ separation \ distance, mm} * [\sqrt{f_{GHz}} = \frac{0.202 \ mW}{25 \ mm} * \sqrt{0.925} = \boxed{\mathbf{0.00777}} \leq 3.0 \tag{14}$$

Using Formula 6 for simultaneous SAR test exclusion threshold is as follows:

$$\left[\frac{max.power, \ mW}{test \ separation \ distance, mm}\right] * \left[\frac{\sqrt{f_{GHz}}}{x}\right] = \left[\frac{0.202 \ mW}{25mm}\right] * \left[\frac{\sqrt{0.925}}{7.5}\right] = \boxed{\mathbf{0.001}} \ W/kg \tag{15}$$

5GHz

For the 5GHz 802.11 module (FCC ID: XF6-RS9113DB), the power level listed in the FCC grant is as:
5180-5240MHz = 15.34mW   5745-5825MHz = 16.14mW
Separation distance = 25mm

Using Formula 3 for the stand-alone SAR test exclusion threshold is as follows:

$$\frac{max.\,power,\; mW}{test\; separation\; distance, mm} * [\sqrt{f_{GHz}} = \frac{16.14\; mW}{25\; mm} * \sqrt{5.825} = \boxed{1.558} \leq 3.0 \tag{16}$$

Using Formula 6 for simultaneous SAR test exclusion threshold is as follows:

$$\left[\frac{max.\,power,\; mW}{test\; separation\; distance, mm}\right] * \left[\frac{\sqrt{f_{GHz}}}{x}\right] = \left[\frac{16.14 mW}{25 mm}\right] * \left[\frac{\sqrt{5.825}}{7.5}\right] = \boxed{0.208}\, W/kg \tag{17}$$

Sources –

412172 D01 – Determining ERP and EIRP v01r01 (August 7, 2015)
447498 D01 – General RF Exposure Guidance V06 (October 23, 2015)