

# RangeLINK

## RF Exposure Analysis

### Summary

The RangeLINK meets all SAR test exclusion guidelines and SAR testing is not required.

### Introduction

#### RangeLINK Radio Configuration

The RangeLINK contains 3 intentional radiators:

1. The long-range RangeTAG communications radio at 917.4MHz.
2. The Bluetooth Module at 2.4GHz, modular ID: 2ADHKSAMB11
3. The WIFI Module at 2.4GHz, either of the following:
  - a. modular ID: 2ADUIESP-12
  - b. modular ID: 2ADUIESP-12-F

#### Operating Modes

The Bluetooth and WIFI modules are always enabled when the device is turned on, therefore there are two possible transmitter operating modes:

1. Bluetooth and WIFI (2ADUIESP-12) enabled, long-range radio disabled
2. Bluetooth and WIFI (2ADUIESP-12) enabled, long-range radio enabled.
3. Bluetooth and WIFI (2ADUIESP-12-F) enabled, long-range radio disabled
4. Bluetooth and WIFI (2ADUIESP-12-F) enabled, long-range radio enabled.

#### Antenna Location

The RangeLINK is designed to be mounted on a post or pole with the Bluetooth and WIFI antennas in the RangeLINK housing, and the long-range radio antenna either mounted to the RangeLINK housing, or extended to a higher location using an antenna with an attached cable. The mounting location of the RangeLINK will not be mounted to the body, but may be transmitting when the user is near the device. Therefore 1-g limits and 75mm as a conservative minimum separation distance will be used for SAR test exclusion calculations.

## SAR Test Exclusion Guidelines

For standalone transmitters, SAR test exclusion guidelines are given in KDB 447498 Chapter 4.3.1:

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

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

- $f(\text{GHz})$  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 values 3.0 and 7.5 are referred to as *numeric thresholds* in step b) below

b) For 100 MHz to 6 GHz and test separation distances  $> 50$  mm, the 1-g and 10-g SAR test exclusion thresholds are determined by the following (also illustrated in Appendix B):

1.  $\{[\text{Power allowed at numeric threshold for 50 mm in step a)}] + [(\text{test separation distance} - 50 \text{ mm}) \cdot (f(\text{MHz})/150)]\}$  mW, for 100 MHz to 1500 MHz
2.  $\{[\text{Power allowed at numeric threshold for 50 mm in step a)}] + [(\text{test separation distance} - 50 \text{ mm}) \cdot 10]\}$  mW, for  $> 1500$  MHz and  $\leq 6$  GHz

Test exclusions for each transmitter will be analyzed independently using standard SAR exclusion thresholds as defined in KDB 447498 Chapter 4.3.1.b.

For simultaneous transmitting transmitters, guidelines for SAR test exclusion are found in KDB 447498 Chapter 4.3.2, in which the pertinent paragraphs are as follows:

Simultaneous transmission SAR test exclusion is determined for each operating configuration and exposure condition according to the reported standalone SAR of each applicable simultaneous transmitting antenna. When the sum of 1-g or 10-g SAR of all simultaneously transmitting antennas in an operating mode and exposure condition combination is within the SAR limit, SAR test exclusion applies to that simultaneous transmission configuration.

And sub-section b) in the same chapter

When an antenna qualifies for the standalone SAR test exclusion of 4.3.1 and also transmits simultaneously with other antennas, the standalone SAR value must be estimated according to the following to determine the simultaneous transmission SAR test exclusion criteria:

- 1)  $\left[ \frac{\text{max. power of channel, including tune-up tolerance, mW}}{(\text{min. test separation distance, mm}) \cdot \left[ \sqrt{f(\text{GHz})/x} \right] \text{ W/kg}} \right]$ , for test separation distances  $\leq 50$  mm; where  $x = 7.5$  for 1-g SAR and  $x = 18.75$  for 10-g SAR.
- 2) 0.4 W/kg for 1-g SAR and 1.0 W/kg for 10-g SAR, when the test separation distance is  $> 50$  mm.<sup>37</sup>

Test exclusion for the RangeLINK's simultaneously-transmitting transmitters, KDB 447498 Chapter 4.3.2.b.2 will be followed to obtain SAR values, which will be summed and compared to the SAR limit, which per §1.1310(c) is 1.6W/kg for 1-g SAR.

## Test Conditions

### Long-Range Radio Operating Description

For simplicity, we will use a 100% transmit duty cycle for the SAR calculations. All operations of the long-range radio are 100% transmit duty cycle or less, so one calculation will cover all operating modes and cases.

## Test Calculations

### Measured Values Necessary for Calculations

#### Long-Range Radio:

Conducted Output Power: 18.01 dBm or **63.24 mW**

Max Antenna Gain: **5 dBi**

Effective EIRP(mW), with 100% duty-cycle: 23.01 dBm or **200 mW**

#### Bluetooth Module:

Effective EIRP(mW), with 100% duty-cycle: 3.04 dBm or **2.01 mW**

#### WIFI Module (2ADUIESP-12):

Conducted Output Power: 15.61 dBm or **36.39 mW**

Max Antenna Gain: **1 dBi**

Effective EIRP(mW), with 100% duty-cycle: 16.61 dBm or **45.8 mW**

#### WIFI Module (2ADUIESP-12-F):

Conducted Output Power: 16.0 dBm or **39.8 mW**

Max Antenna Gain: **1.258 dBi**

Effective EIRP(mW), with 100% duty-cycle: 17.258 dBm or **53.2 mW**

## SAR Value Calculation

### Long-Range Radio:

To use the formula for standalone transmitters given in KDB 447498 Chapter 4.3.1.b (subsection 1, as the frequency falls between 100MHz and 1500MHz), first the Power allowed at numeric threshold for 50mm in step 4.3.1.a is calculated. The numeric threshold is 3.0 for 1-g SAR.

Power allowed at numeric threshold for 50 mm in step 4.3.1.a is 156.6mW, as shown below:

$$\frac{3}{\sqrt{0.9175 \text{ GHz}}} * 50\text{mm} = 156.6\text{mW}$$

This value (rounded to the nearest mW for the next calculation) is used in part b (subsection 1) as shown below to calculate the maximum power allowed:

$$157\text{mW} + [(75\text{mm} - 50\text{mm}) * (\frac{917.5}{150})] = 309.9\text{mW}$$

The SAR exclusion condition is fulfilled because the output power of 200mW for the RangeLINK long-range radio is less than the calculated threshold of 309.9mW, and so SAR test exclusion criteria are met, and evaluation is not required for this transmitter.

### Bluetooth Module:

To use the formula for standalone transmitters given in KDB 447498 Chapter 4.3.1.b (subsection 2, as the frequency falls between 1500MHz and 6GHz), first the Power allowed at numeric threshold for 50mm in step 4.3.1.a is calculated. The numeric threshold is 3.0 for 1-g SAR.

Power allowed at numeric threshold for 50 mm in step 4.3.1.a is 95.3mW, as shown below:

$$\frac{3}{\sqrt{2.48 \text{ GHz}}} * 50\text{mm} = 95.3\text{mW}$$

This value (rounded to the nearest mW for the next calculation) is used in part b (subsection 2) as shown below to calculate the maximum power allowed:

$$95\text{mW} + [(75\text{mm} - 50\text{mm}) * 10] = 345\text{mW}$$

The SAR exclusion condition is fulfilled because the output power of 2.01mW for the Bluetooth module is less than the calculated threshold of 345mW, and so SAR test exclusion criteria are met, and evaluation is not required for this transmitter.

**WIFI Module (2ADUIESP-12):**

To use the formula for standalone transmitters given in KDB 447498 Chapter 4.3.1.b (subsection 2, as the frequency falls between 1500MHz and 6GHz), first the Power allowed at numeric threshold for 50mm in step 4.3.1.a is calculated. The numeric threshold is 3.0 for 1-g SAR.

Power allowed at numeric threshold for 50 mm in step 4.3.1.a is 95.3mW, as shown below:

$$\frac{3}{\sqrt{2.48 \text{ GHz}}} * 50\text{mm} = 95.3\text{mW}$$

This value (rounded to the nearest mW for the next calculation) is used in part b (subsection 2) as shown below to calculate the maximum power allowed:

$$95\text{mW} + [(75\text{mm} - 50\text{mm}) * 10] = 345\text{mW}$$

The SAR exclusion condition is fulfilled because the output power of 45.8mW for the Bluetooth module is less than the calculated threshold of 345mW, and so SAR test exclusion criteria are met, and evaluation is not required for this transmitter.

**WIFI Module (2ADUIESP-12-F):**

To use the formula for standalone transmitters given in KDB 447498 Chapter 4.3.1.b (subsection 2, as the frequency falls between 1500MHz and 6GHz), first the Power allowed at numeric threshold for 50mm in step 4.3.1.a is calculated. The numeric threshold is 3.0 for 1-g SAR.

Power allowed at numeric threshold for 50 mm in step 4.3.1.a is 95.3mW, as shown below:

$$\frac{3}{\sqrt{2.48 \text{ GHz}}} * 50\text{mm} = 95.3\text{mW}$$

This value (rounded to the nearest mW for the next calculation) is used in part b (subsection 2) as shown below to calculate the maximum power allowed:

$$95\text{mW} + [(75\text{mm} - 50\text{mm}) * 10] = 345\text{mW}$$

The SAR exclusion condition is fulfilled because the output power of 53.2mW for the Bluetooth module is less than the calculated threshold of 345mW, and so SAR test exclusion criteria are met, and evaluation is not required for this transmitter.

**Simultaneous Transmission SAR Evaluation:**

As specified in KDB 447498 Chapter 4.3.2, SAR exclusion for multiple transmitters requires that the sum of all individual SAR estimates remain under the threshold to qualify for SAR exclusion.

Individual transmitter SAR estimates must be used from KDB 447498 Chapter 4.3.2.b.2, as test separation distance is > 50mm.

Since all three transmitters fall under 4.3.2.b.2, 0.4 W/kg will be used as the SAR value for each, and the sum will be compared to 1.6W/kg, as specified in §1.1310(c).

Bluetooth and WIFI (2ADUIESP-12) Enabled, long-range radio disabled:

Bluetooth SAR: 0.4W/kg

WIFI SAR: 0.4W/kg

Total SAR:  $0.4W/kg + 0.4W/kg = 0.8W/kg < 1.6W/kg$

Bluetooth and WIFI (2ADUIESP-12) Enabled, long-range radio enabled:

Bluetooth SAR: 0.4W/kg

WIFI SAR: 0.4W/kg

Long-Range Radio SAR: 0.4W/kg

Total SAR:  $0.4W/kg + 0.4W/kg + 0.4W/kg = 1.2W/kg < 1.6W/kg$

Bluetooth and WIFI (2ADUIESP-12-F) Enabled, long-range radio disabled:

Bluetooth SAR: 0.4W/kg

WIFI SAR: 0.4W/kg

Total SAR:  $0.4W/kg + 0.4W/kg = 0.8W/kg < 1.6W/kg$

Bluetooth and WIFI (2ADUIESP-12-F) Enabled, long-range radio enabled:

Bluetooth SAR: 0.4W/kg

WIFI SAR: 0.4W/kg

Long-Range Radio SAR: 0.4W/kg

Total SAR:  $0.4W/kg + 0.4W/kg + 0.4W/kg = 1.2W/kg < 1.6W/kg$

In all cases, the SAR exclusion condition is met and SAR evaluation is not required for the any of the transmitters on the RangeLINK

## Conclusion

For all operating conditions of the RangeLINK, 100% duty cycle was used to calculate power values, and the SAR value was calculated for each transmitter. Each was shown to be under the SAR test exclusion threshold. In each multiple transmitter scenario, the combined SAR values from all transmitters were summed, and shown to be under the SAR limit. Therefore, in all scenarios, the SAR exclusion condition is met, and SAR evaluation is not required for any of the transmitters on the RangeLINK.