

# RangeCOMPANION

## RF Exposure Analysis

### Summary

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

### Introduction

#### RangeCOMPANION Radio Configuration

The RangeCOMPANION contains 2 intentional radiators:

1. The long-range RangeTAG communications radio at 917.4MHz.
2. The Bluetooth Module at 2.4GHz, modular ID: 2ADHKSAMB11

#### Operating Modes

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

1. Bluetooth enabled, long-range radio disabled
2. Bluetooth enabled, long-range radio enabled.

#### Antenna Location

The RangeCOMPANION is designed to be placed in the front shirt pocket. The front of the RangeCOMPANION is labelled “THIS SIDE FACES FORWARD”. The antenna is 5mm away from the back of the case, thus worst case distance from the antenna to the body is 5mm.

#### SAR Test Exclusion Guidelines

For standalone transmitters, SAR test exclusion guidelines are given in KDB 447498 Chapter 4.3.1-1:

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:

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

- $f$ (GHz) is the RF channel transmit frequency in GHz, Power and distance are rounded to the nearest mW and mm before calculation, and the result is rounded to one decimal place for comparison

SAR test exclusion for simultaneous transmission is defined in KDB 447498 Chapter 4.3.2. To wit,

“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.”

Test exclusions for each transmitter will be analyzed independently using standard SAR exclusion thresholds as defined in KDB 447498 Chapter 4.3.1-1. The standalone estimates are then added to determine simultaneous transmission SAR test exclusion. All tests are performed for 1-g exposure limits.

## Test Conditions

### Long-Range Radio Operating Description

The long-range radio on the RangeCOMPANION has two transmit schemes: Tag Inventory Mode, and Tag Communication Mode. Calculations will be provided for both to show SAR compliance.

#### **Tag Inventory Mode:**

In Tag Inventory Mode, the RangeCOMPANION is searching for any RangeTAGs (tags) that are within range. During this search, then RangeCOMPANION will broadcast a signal at 80% duty cycle for 1 second. This is called the “tag alert” signal, and it alerts the tags that they will soon be receiving a command. The end of the 1 second burst includes a short inventory command which tells the tags to respond. The RangeCOMPANION will then wait for all tags to respond. This wait period can be up to 5 minutes, but no less than 5 seconds.

#### **Tag Communication Mode:**

In Tag Communication Mode, the RangeCOMPANION is communicating with each tag individually, instead of broadcasting commands. The RangeCOMPANION starts by transmitting a 1 second “tag alert” signal to alert the tags that they may receive communications soon. The RangeCOMPANION then communicates with each of the tags that it needs to gather the information requested by the user through the phone app. Each tag communication time slot is at least 100ms long consisting of a command transmitted by the RangeCOMPANION (transmit

time 3.3ms), and a response from the tag. In Tag Communication Mode, the RangeCOMPANION is limited to one “tag alert” signal in a 10 second period, to help conserve tag battery.

## Test Calculations

### Measured Values Necessary for Calculations

Conducted Output Power: 16.12 dBm or **40.9 mW**

Max Antenna Gain: **3 dBi**

Effective EIRP(mW), with 100% duty-cycle: 19.12 dBm or **81.5 mW**

### Duty Cycle Calculation

#### Tag Inventory Mode:

For this calculation, the minimum wait period of 5 seconds, thus giving worst-case duty-cycle.

“Tag alert” signal: 1 second at 80% duty cycle

Wait period: 5 seconds at 0% duty cycle

Overall period: 6 seconds

Overall duty cycle calculation:

$$\frac{1}{5} * 0.80 + \frac{4}{5} * 0.00 = 0.1329 \text{ or } 13.29\%$$

#### Tag Communication Mode:

For this calculation, we will assume the RangeCOMPANION is communicating continuously for the full 9 seconds between “Tag Alert” signals, thus giving worst-case duty-cycle.

“Tag alert” signal: 1 second at 80% duty cycle

Communication time slot duty cycle: 3.3ms on time per 100ms time slot = 3.3% duty cycle

Communication Time: 9 seconds at 3.3% duty cycle

Overall Period: 10 seconds

Overall duty cycle calculation:

$$\frac{1}{10} * 0.80 + \frac{9}{10} * 0.033 = 0.1097 \text{ or } 10.97\%$$

### SAR Value Calculation

#### Tag Inventory Mode:

Using the formula for standalone transmitters given in KDB 447498 Chapter 4.3.1-1, and rounding the power output to the nearest mW:

$$Power = 81.5 \text{ mW} * 0.1329 (\text{duty cycle}) = 10.831 \text{ mW}$$

$$\frac{11 \text{ mW}}{5 \text{ mm}} \sqrt{0.9175 \text{ GHz}} = 2.1$$

The SAR exclusion condition is fulfilled because the value 2.1 is less than the threshold of 3.0, and so SAR evaluation is not required for this transmitter.

#### **Tag Communication Mode:**

Using the formula for standalone transmitters given in KDB 447498 Chapter 4.3.1-1, and rounding the power output to the nearest mW:

$$Power = 81.5 \text{ mW} * 0.1097 (\text{duty cycle}) = 8.941 \text{ mW}$$

$$\frac{9 \text{ mW}}{5 \text{ mm}} \sqrt{0.9175 \text{ GHz}} = 1.7$$

The SAR exclusion condition is fulfilled because the value 1.7 is less than the threshold of 3.0, and so SAR evaluation is not required for this transmitter.

#### **Bluetooth Module:**

Using the formula for standalone transmitters given in KDB 447498 Chapter 4.3.1-1, rounding the power output to the nearest mW and using 100% duty cycle for simplicity:

$$\frac{2 \text{ mW}}{5 \text{ mm}} \sqrt{2.48 \text{ GHz}} = 0.63$$

The SAR exclusion condition is fulfilled because the value 0.63 is less than the threshold of 3.0, and so SAR 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 were considered in previous sections.

Bluetooth Enabled, long-range radio disabled:

Bluetooth SAR: 0.63

Total SAR:  $0.63 < 3.0$

Bluetooth Enabled, long-range radio enabled:

Bluetooth SAR: 0.63

Long-Range Radio Tag Inventory Mode SAR: 2.1

Total SAR:  $2.1 + 0.63 = 2.73 < 3.0$

Bluetooth SAR: 0.63

Long-Range Radio Tag Communication Mode SAR: 1.7

Total SAR:  $1.7 + 0.63 = 2.33 < 3.0$

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

## Conclusion

For all operating conditions of the RangeCOMPANION, worst-case maximum duty cycle was used to calculate power values, and the SAR value was calculated. In each scenario, the combined SAR values from all transmitters were summed, and shown to be under the SAR exclusion threshold. Therefore, in all scenarios, the SAR exclusion condition is met, and SAR evaluation is not required for any of the transmitters on the RangeCOMPANION.