



**FCC Part 1 Subpart I  
FCC Part 2 Subpart J  
INDUSTRY CANADA RSS 102 ISSUE 5**

**RF EXPOSURE REPORT**

**FOR**

**2.4 AND 5 GHz WIRELESS MODULE**

**MODEL NUMBER: 416549**

**FCC ID: A94416549**

**REPORT NUMBER: 14M19686-E9 Revision B**

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# 1. ATTESTATION OF TEST RESULTS

**COMPANY NAME:** BOSE CORPORATION  
100 THE MOUNTAIN ROAD  
FRAMINGHAM, MA, 01701, USA

**EUT DESCRIPTION:** 2.4 AND 5 GHz WIRELESS MODULE

**MODEL:** 416549

**SERIAL NUMBER:** US-1(CONDUCTED), US-R1 (RADIATED)

**DATE TESTED:** JANUARY 20 – FEBRUARY 13, 2015

| APPLICABLE STANDARDS                    |              |
|---|--------------|
| STANDARD                                | TEST RESULTS |
| FCC PART 1 SUBPART I & PART 2 SUBPART J | Pass         |
| INDUSTRY CANADA RSS 102 ISSUE 3         | Pass         |

UL Verification Services Inc. calculated the RF Exposure of the above equipment in accordance with the requirements set forth in the above standards, using test results reported in the test report documents referenced below and/or documentation furnished by the applicant. All indications of Pass/Fail in this report are opinions expressed by UL Verification Services Inc. based on interpretations of these calculations. The results show that the equipment is capable of demonstrating compliance with the requirements as documented in this report.

**Note:** The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by UL Verification Services Inc. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Services Inc. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of any government.

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## 2. TEST METHODOLOGY

All calculations were made in accordance with FCC OET Bulletin 65 Edition 97-01 and IC Safety Code 6.

## 3. REFERENCES

Measurements were made as documented in test report UL Verification Services Inc. Document 14M19686-E2 FCC 2.4 GHz DTS WLAN for operation in the 2.4 GHz band and UL Verification Services Inc. Document 14M19686-E1 FCC UNII Report for operation in the 5 GHz bands.

Measurements were made as documented in test report BOSE Corporation, Document EMC.416549.15.15.1 for operation in the 2.4 GHz. Measurements were made as documented in test report BOSE Corporation, Document EMC.416549.15.20.1 for operation in the 2.4 GHz.

Output power, Duty cycle and Antenna gain data is excerpted from the applicable test reports.

Antenna gain data is excerpted from product documentation provided by the applicant.

## 4. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 47173 Benicia Street, Fremont, California, USA.

UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0. The full scope of accreditation can be viewed at <http://ts.nist.gov/standards/scopes/2000650.htm>.

## 5. MAXIMUM PERMISSIBLE RF EXPOSURE

### 5.1. FCC RULES

§1.1310 The criteria listed in Table 1 shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in §1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of §2.1093 of this chapter.

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

| Frequency range (MHz)                                   | Electric field strength (V/m) | Magnetic field strength (A/m) | Power density (mW/cm <sup>2</sup> ) | Averaging time (minutes) |
|---|-------------------------------|-------------------------------|-------------------------------------|--------------------------|
| (A) Limits for Occupational/Controlled Exposures        |                               |                               |                                     |                          |
| 0.3–3.0 .....   | 614                           | 1.63                          | *(100)                              | 6                        |
| 3.0–30 .....  | 1842/f                        | 4.89/f                        | *(900/f <sup>2</sup> )              | 6                        |
| 30–300 .....  | 61.4                          | 0.163                         | 1.0                                 | 6                        |
| 300–1500 .....  | .....                         | .....                         | f/300                               | 6                        |
| 1500–100,000 .....                                      | .....                         | .....                         | 5                                   | 6                        |
| (B) 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 <sup>2</sup> )              | 30                       |

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)—Continued

| Frequency range (MHz) | Electric field strength (V/m) | Magnetic field strength (A/m) | Power density (mW/cm <sup>2</sup> ) | Averaging time (minutes) |
|-----------------------|-------------------------------|-------------------------------|-------------------------------------|--------------------------|
| 30–300 .....          | 27.5                          | 0.073                         | 0.2                                 | 30                       |
| 300–1500 .....        | .....                         | .....                         | f/1500                              | 30                       |
| 1500–100,000 .....    | .....                         | .....                         | 1.0                                 | 30                       |

f = frequency in MHz

\* = Plane-wave equivalent power density

NOTE 1 TO TABLE 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

NOTE 2 TO TABLE 1: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

## 5.2. IC RULES

IC Safety Code 6, Section 2.2.1 (a) A person other than an RF and microwave exposed worker shall not be exposed to electromagnetic radiation in a frequency band listed in Column 1 of Table 5, if the field strength exceeds the value given in Column 2 or 3 of Table 5, when averaged spatially and over time, or if the power density exceeds the value given in Column 4 of Table 5, when averaged spatially and over time.

**Table 5**  
**Exposure Limits for Persons Not Classed As RF and Microwave Exposed Workers (Including the General Public)**

| 1<br>Frequency<br>(MHz) | 2<br>Electric Field<br>Strength; rms<br>(V/m) | 3<br>Magnetic Field<br>Strength; rms<br>(A/m)   | 4<br>Power<br>Density<br>(W/m <sup>2</sup> ) | 5<br>Averaging<br>Time<br>(min)   |
|-------------------------|---|---|--|-----------------------------------|
| 0.003–1                 | 280   | 2.19  |  | 6                                 |
| 1–10                    | 280/ <i>f</i>                                 | 2.19/ <i>f</i>                                  |  | 6                                 |
| 10–30                   | 28  | 2.19/ <i>f</i>                                  |  | 6                                 |
| 30–300                  | 28  | 0.073   | 2*   | 6                                 |
| 300–1 500               | 1.585 <i>f</i> <sup>0.5</sup>                 | 0.0042 <i>f</i> <sup>0.5</sup>                  | <i>f</i> /150                                | 6                                 |
| 1 500–15 000            | 61.4  | 0.163   | 10   | 6                                 |
| 15 000–150 000          | 61.4  | 0.163   | 10   | 616 000 / <i>f</i> <sup>1.2</sup> |
| 150 000–300 000         | 0.158 <i>f</i> <sup>0.5</sup>                 | 4.21 x 10 <sup>-4</sup> <i>f</i> <sup>0.5</sup> | 6.67 x 10 <sup>-5</sup> <i>f</i>             | 616 000 / <i>f</i> <sup>1.2</sup> |

\* Power density limit is applicable at frequencies greater than 100 MHz.

- Notes:**
1. Frequency, *f*, is in MHz.
  2. A power density of 10 W/m<sup>2</sup> is equivalent to 1 mW/cm<sup>2</sup>.
  3. A magnetic field strength of 1 A/m corresponds to 1.257 microtesla (μT) or 12.57 milligauss (mG).

### **5.3. EQUATIONS**

#### **POWER DENSITY**

Power density is given by:

$$S = \text{EIRP} / (4 * \text{Pi} * D^2)$$

Where

S = Power density in mW/cm<sup>2</sup>  
EIRP = Equivalent Isotropic Radiated Power in mW  
D = Separation distance in cm

Power density in units of mW/cm<sup>2</sup> is converted to units of W/m<sup>2</sup> by multiplying by 10.

#### **DISTANCE**

Distance is given by:

$$D = \text{SQRT} (\text{EIRP} / (4 * \text{Pi} * S))$$

Where

D = Separation distance in cm  
EIRP = Equivalent Isotropic Radiated Power in mW  
S = Power density in mW/cm<sup>2</sup>

#### **SOURCE-BASED DUTY CYCLE**

Where applicable (for example, multi-slot cell phone applications) a duty cycle factor may be applied.

$$\text{Source-based time-averaged EIRP} = (\text{DC} / 100) * \text{EIRP}$$

Where

DC = Duty Cycle in %, as applicable  
EIRP = Equivalent Isotropic Radiated Power in W



**MIMO AND COLOCATED TRANSMITTERS (IDENTICAL LIMIT FOR ALL TRANSMITTERS)**

For multiple chain devices, and colocated transmitters operating simultaneously in frequency bands where the limit is identical, the total power density is calculated using the total EIRP obtained by summing the EIRP (in linear units) of each transmitter.

$$\text{Total EIRP} = (\text{EIRP1}) + (\text{EIRP2}) + \dots + (\text{EIRPn})$$

where

EIRPx = Source-based time-averaged EIRP of chain x or transmitter x

The total EIRP is then used to calculate the Power Density or the Distance as applicable.

**MIMO AND COLOCATED TRANSMITTERS**

For multiple colocated transmitters operating simultaneously in frequency bands where different limits apply:

The Power Density at the specified separation distance is calculated for each transmitter chain or transmitter.

The fraction of the exposure limit is calculated for each chain or transmitter as (Power Density of chain or transmitter) / (Limit applicable to that chain or transmitter).

The fractions are summed.

Compliance is established if the sum of the fractions is less than or equal to one.

## **5.4. LIMITS AND IC EXEMPTION**

### **VARIABLE LIMITS**

For mobile radio equipment operating in the cellular phone band, the lowest power density limit is calculated using the lowest frequency:

$$824 \text{ MHz} / 1500 = 0.55 \text{ mW/cm}^2 \text{ (FCC)}$$

$$824 \text{ MHz} / 150 = 5.5 \text{ W/m}^2 \text{ (IC).}$$

### **FIXED LIMITS**

For operation in the PCS band, the 2.4 GHz band and the 5 GHz bands:

From FCC §1.1310 Table 1 (B), the maximum value of  $S = 1.0 \text{ mW/cm}^2$

From IC Safety Code 6, Section 2.2 Table 5 Column 4,  $S = 10 \text{ W/m}^2$

### **INDUSTRY CANADA EXEMPTION**

RSS-102 Clause 2.5.2 RF exposure evaluation is required if the separation distance between the user and the device's radiating element is greater than 20 cm, except when the device operates as follows:

- below 1.5 GHz and the maximum e.i.r.p. of the device is equal to or less than 2.5 W;
- at or above 1.5 GHz and the maximum e.i.r.p. of the device is equal to or less than 5 W.

## 6. RF EXPOSURE RESULTS

In the table(s) below, Power and Gain are entered in units of dBm and dBi respectively and conversions to linear forms are used for the calculations.

(Single chain transmitters, no colocation, 20 cm MPE distance)

| Single Chain and non-colocated transmitters |      |                               |                                 |                          |               |                      |              |   |                                      |
|---|------|-------------------------------|---------------------------------|--------------------------|---------------|----------------------|--------------|---|--------------------------------------|
| Band  | Mode | Separatio<br>Distance<br>(cm) | Output<br>AVG<br>Power<br>(dBm) | Antenna<br>Gain<br>(dBi) | EIRP<br>(dBm) | Duty<br>Cycle<br>(%) | EIRP<br>(mW) | FCC Power<br>Density<br>(mW/cm <sup>2</sup> ) | IC<br>Density<br>(W/m <sup>2</sup> ) |
| 2.4 GHz                                     | DTS  | 20                            | 4.26                            | 4.00                     | 8.26          | 64.7                 | 4.3          | 0.0009  | 0.0086                               |
| 2.4 GHz                                     | FHSS | 20                            | 10.34                           | 4.00                     | 14.34         | 77.6                 | 21.1         | 0.0042  | 0.0420                               |
| 2.4 GHz                                     | WLAN | 20                            | 13.44                           | 4.00                     | 17.44         | 50.2                 | 27.8         | 0.0055  | 0.0554                               |
| 5 GHz                                       | WLAN | 20                            | 12.83                           | 4.00                     | 16.83         | 50.2                 | 24.2         | 0.0048  | 0.0481                               |

| Single Chain and non-colocated transmitters |      |                                       |                                    |                                 |                          |               |                      |              |                                |
|---|------|---------------------------------------|------------------------------------|---------------------------------|--------------------------|---------------|----------------------|--------------|--------------------------------|
| Band  | Mode | FCC<br>Limit<br>(mW/cm <sup>2</sup> ) | IC<br>Limit<br>(W/m <sup>2</sup> ) | Output<br>AVG<br>Power<br>(dBm) | Antenna<br>Gain<br>(dBi) | EIRP<br>(dBm) | Duty<br>Cycle<br>(%) | EIRP<br>(mW) | Separation<br>Distance<br>(cm) |
| 2.4 GHz                                     | DTS  | 1.00                                  | 10.0                               | 4.26                            | 4.00                     | 8.26          | 64.7                 | 6.7          | 0.73                           |
| 2.4 GHz                                     | FHSS | 1.00                                  | 10.0                               | 10.34                           | 4.00                     | 14.34         | 77.6                 | 27.2         | 1.47                           |
| 2.4 GHz                                     | WLAN | 1.00                                  | 10.0                               | 13.44                           | 4.00                     | 17.44         | 50.2                 | 55.5         | 2.10                           |
| 5 GHz                                       | WLAN | 1.00                                  | 10.0                               | 12.83                           | 4.00                     | 16.83         | 50.2                 | 48.2         | 1.96                           |

The device operates above 1.5 GHz with a maximum EIRP less than or equal to 5 Watts as a mobile device with a minimum separation distance of 20 cm, therefore it is exempt from routine RF Exposure Evaluation under RSS-102.

(MIMO and/or Colocated transmitters all with same Power Density limit, 20 cm MPE distance)

| Multiple chain or colocated transmitters |      |                |                          |                        |                    |                |           |   |                                |
|--|------|----------------|--------------------------|------------------------|--------------------|----------------|-----------|---|--------------------------------|
| Band                                     | Mode | Chain for MIMO | Separation Distance (cm) | Output AVG Power (dBm) | Antenna Gain (dBi) | Duty Cycle (%) | EIRP (mW) | FCC Power Density (mW/cm <sup>2</sup> ) | IC Density (W/m <sup>2</sup> ) |
| 2.4 GHz                                  | WLAN | 0              |                          | 12.34                  | 4.00               | 50.2           | 21.6      |   |                                |
| 2.4 GHz                                  | WLAN | 1              |                          | 10.50                  | 4.00               | 50.2           | 14.2      |   |                                |
| Combined                                 |      |                | 20                       |                        |                    |                | 35.8      | 0.00712                                 | 0.07122                        |

| Multiple chain or colocated transmitters |      |                |                                 |                              |                        |                    |                |           |                          |
|--|------|----------------|---------------------------------|------------------------------|------------------------|--------------------|----------------|-----------|--------------------------|
| Band                                     | Mode | Chain for MIMO | FCC Limit (mW/cm <sup>2</sup> ) | IC Limit (W/m <sup>2</sup> ) | Output AVG Power (dBm) | Antenna Gain (dBi) | Duty Cycle (%) | EIRP (mW) | Separation Distance (cm) |
| 2.4 GHz                                  | WLAN | 0              |                                 |                              | 12.34                  | 4.00               | 50.2           | 21.6      |                          |
| 2.4 GHz                                  | WLAN | 1              |                                 |                              | 10.50                  | 4.00               | 50.2           | 14.2      |                          |
| Combined                                 |      |                | 1.00                            | 10.0                         |                        |                    |                | 35.8      | 1.69                     |

Multiple chain or colocated transmitters

| Band                    | (GHz)                 | 2.4     | 2.4     |
|-------------------------|-----------------------|---------|---------|
| Mode                    |                       | WLAN    | WLAN    |
| Transmitter             |                       | Chain 0 | Chain 1 |
| Separation Distance     | (cm)                  | 20      | 20      |
| Output Power            | (dBm)                 | 12.3    | 10.5    |
| Antenna Gain            | (dBi)                 | 4.0     | 4.0     |
| Duty Cycle              | (%)                   | 78      | 50      |
| Source Based EIRP       | (mW)                  | 33.4    | 14.1    |
| FCC Power Density       | (mW/cm <sup>2</sup> ) | 0.01    | 0.00    |
| FCC Power Density Limit | (mW/cm <sup>2</sup> ) | 1       | 1       |
| IC Power Density        | (W/m <sup>2</sup> )   | 0.066   | 0.028   |
| IC Power Density Limit  | (W/m <sup>2</sup> )   | 10      | 10      |
| Fraction of Limit       | (%)                   | 0.7     | 0.3     |
| Sum of Fractions (%)    | <b>0.9</b>            |         |         |

**Notes:**

- 1) For MPE the new KDB 447498 requires the calculations to use the maximum rated power; that power should be declared by the manufacturer, and should not be lower than the measured power. If the power has a tolerance then we also need to check that the measured power is within the tolerance.
- 2) The manufacturer configures output power so that the maximum power will never exceed the maximum power level measured.
- 3) The output power in the tables above is the maximum power per chain among various channels and various modes within the specific band.
- 4) The antenna gain in the tables above is the maximum antenna gain among various channels within the specified band.

## 7. STANDALONE SAR TEST EXCLUSION CONSIDERATIONS

### 7.1. FCC

SAR test exclusion in accordance with KDB 447498.

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:

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

- $f_{(\text{GHz})}$  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 test exclusions are applicable only when the minimum test separation distance is  $\leq 50$  mm and for transmission frequencies between 100 MHz and 6 GHz. When the minimum test separation distance is  $< 5$  mm, a distance of 5 mm is applied to determine SAR test exclusion.

SAR Exclusion Calculations Table for Portable Devices (separation distance 20cm)

| Antenna | Tx   | Frequency (MHz) | Avg Output power |    | Separation distances (mm) | Calculated Threshold |
|---------|------|-----------------|------------------|----|---------------------------|----------------------|
|         |      |                 | dBm              | mW |                           |                      |
| 2G1     | WLAN | 2412            | 13.44            | 22 | 21                        | 1.6                  |
| 5G2     | WLAN | 5785            | 12.83            | 19 | 20                        | 2.3                  |
| 2G2     | FHSS | 2402            | 10.34            | 11 | 15                        | 1.1                  |
| 2G2     | DTS  | 2402            | 4.26             | 3  | 8                         | 0.6                  |

Conclusion:

The computed value is  $< 3$ ; therefore, EUT qualifies for Standalone SAR test exclusion.

## 7.2. INDUSTRY CANADA

Industry Canada notice 2013 DRS0911 states that the SAR exclusion limits contained in Draft RSS-102 issue 5 will be accepted prior to its release. The SAR exclusion table from Draft RSS-102 issue 5 is reproduced below:

**Table 1: SAR evaluation - exemption limits for routine evaluation based on frequency and separation distance.**

| Frequency MHz | Exemption Limits (mW)          |                                |                                |                                |                                |
|---------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|
|               | At separation distance of ≤5mm | At separation distance of 10mm | At separation distance of 15mm | At separation distance of 20mm | At separation distance of 25mm |
| ≤300          | 71 mW                          | 101 mW                         | 132 mW                         | 162 mW                         | 193 mW                         |
| 450           | 52 mW                          | 70 mW                          | 88 mW                          | 106 mW                         | 123 mW                         |
| 835           | 17 mW                          | 30 mW                          | 42 mW                          | 55 mW                          | 67 mW                          |
| 1900          | 7 mW                           | 10 mW                          | 18 mW                          | 34 mW                          | 60 mW                          |
| 2450          | 4 mW                           | 7 mW                           | 15 mW                          | 30 mW                          | 52 mW                          |
| 3500          | 2 mW                           | 6 mW                           | 16 mW                          | 32 mW                          | 55 mW                          |
| 5800          | 1 mW                           | 6 mW                           | 15 mW                          | 27 mW                          | 41 mW                          |

| Frequency MHz | Exemption Limits (mW)          |                                |                                |                                |                                 |
|---------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|---------------------------------|
|               | At separation distance of 30mm | At separation distance of 35mm | At separation distance of 40mm | At separation distance of 45mm | At separation distance of ≥50mm |
| ≤300          | 223 mW                         | 254 mW                         | 284 mW                         | 315 mW                         | 345 mW                          |
| 450           | 141 mW                         | 159 mW                         | 177 mW                         | 195 mW                         | 213 mW                          |
| 835           | 80 mW                          | 92 mW                          | 105 mW                         | 117 mW                         | 130 mW                          |
| 1900          | 99 mW                          | 153 mW                         | 225 mW                         | 316 mW                         | 431 mW                          |
| 2450          | 83 mW                          | 123 mW                         | 173 mW                         | 235 mW                         | 309 mW                          |
| 3500          | 86 mW                          | 124 mW                         | 170 mW                         | 225 mW                         | 290 mW                          |
| 5800          | 56 mW                          | 71 mW                          | 85 mW                          | 97 mW                          | 106 mW                          |

The minimum antenna to user distance that will be encountered in normal use is >20mm. This results in an exemption limit of 52mW at 2450 MHz and 41mW at 5800 MHz .

As the maximum output power is 35.8mW at 2450 MHz and 24.2mW at 5800 MHz (mW EIRP) the DUT qualifies for SAR test exclusion.

**END OF REPORT**