# FCC Maximum Permissible RF Exposure (MPE) Estimation Report

**In accordance with the requirements of**

**FCC 47 CFR Part 2(2.1091), ANSI/IEEE C95.1-1992 and**

**KDB 447498 D01**

| | |
|---|---|
| **Product Name:** | 802.11ac WiFi Module |
| **Trademark:** | Actiontec |
| **Model Name:** | 802C2447 |
| **Family Model:** | N/A |
| **Report No.:** | S18122100301003 |
| **FCC ID:** | LNQ802C2447 |

**Prepared for**

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**Prepared by**

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# TEST RESULT CERTIFICATION

**Applicant's name** ..... : Actiontec Electronics Inc

Address ..... : 3301 Olcott St Santa Clara, CA 95054 United States

**Manufacturer's Name** ..... : Actiontec Electronics Inc

Address ..... : 3301 Olcott St Santa Clara, CA 95054 United States

**Product description**

Product name ..... : 802.11ac WiFi Module

Trademark ..... : Actiontec

Model and/or type reference : 802C2447

Family Model ..... : N/A

**Standards** ..... : FCC 47 CFR Part 1(1.1310)
FCC 47 CFR Part 2(2.1091)
ANSI/IEEE C95.1-1992
KDB 447498 D01

This device described above has been tested by Shenzhen NTEK. Testing has shown that this device is capable of compliance with MPE specified in FCC 47 CFR Part 2(2.1091) and ANSI/IEEE C95.1-1992. The test results in this report apply only to the tested sample of the stated device/equipment. Other similar device/equipment will not necessarily produce the same results due to production tolerance and measurement uncertainties.

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**Date of Test**

Date (s) of performance of tests ..... : 27 Dec. 2018 ~ 11 Mar. 2019

Date of Issue ..... : 12 Mar. 2019

Test Result ..... : **Pass**

Prepared By (Test Engineer) : Cheng Jiawen

(Cheng Jiawen)

Approved By (Lab Manager) : Sam Chen

(Sam Chen)

## ※ ※ Revision History ※ ※

| REV. | DESCRIPTION | ISSUED DATE | REMARK |
|---|---|---|---|
| Rev.1.0 | Initial Test Report Release | Mar. 12, 2019 | Cheng Jiawen |
| | | | |
| | | | |
| | | | |

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# 1 General Information

## 1.1 RF Exposure Requirements

### 1.1.1 RF Exposure Limits

**Table - Limits For Maximum Permissible Exposure (MPE)**

| Frequency range (MHz) | Electric field strength (V/m) | Magnetic field strength (A/m) | Power density ($mW/cm^2$) | Averaging time (minutes) |
|---|---|---|---|---|
| (A) Limits for Occupational/Controlled Exposure | | | | |
| 0.3-3.0 | 614 | 1.63 | *100 | 6 |
| 3.0-30 | 1842/f | 4.89/f | $*900/f^2$ | 6 |
| 30-300 | 61.4 | 0.163 | 1.0 | 6 |
| 300-1,500 | | | f/300 | 6 |
| 1,500-100,000 | | | 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 | $*180/f^2$ | 30 |
| 30-300 | 27.5 | 0.073 | 0.2 | 30 |
| 300-1,500 | | | f/1500 | 30 |
| 1,500-100,000 | | | 1.0 | 30 |
| f = frequency in MHz * = Plane-wave equivalent power density | | | | |

A rough estimation of the expected exposure in power flux density on a given point can be made with the following equation:

$$S = \frac{P_t * G_t}{4 * \pi * R^2}$$

Where:

S = Power density ($mW/cm^2$)
$P_t$ = Conducted output power (dBm)
$G_t$ = numeric gain of the antenna in the direction of interest relative to an isotropic radiator (dBi)
R= distance to the centre of radiation of the antenna (cm)
EIRP = $P_t * G_t$

The antenna of the product, under normal use condition is at least 20 cm away from the body of the user. Warning statement to the user for keeping at least 20cm separation distance and the prohibition of operating to a person has been printed on the user's manual. Therefore, the S of the device is calculated with R=20cm, and if it is below the limit S, then we can conclude the device complies with the rules.

### 1.1.2 Additional Description

An estimation of MPE in this application for product is used to ensure if it complies to the rules of the standard in the regulation list above.

Maximum permissible exposure (MPE) refers to the RF energy that is acceptable for human exposure. It is broken down into two categories, Occupational/controlled and General population/uncontrolled.

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.

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 cannot exercise control over their exposure.

We analysis if it comply with the limits for General population/uncontrolled exposure. The FCC's MPE limits for field strength and power density are given in 47CFR 1.1310(Table below).These limits are generally based on recommended exposure guidelines published by the National Council on Radiation Protection and Measurements (NCRP), and also partly based on guidelines recommended by the American National Standards Institute (ANSI) in Section 4.1 of ANSI/IEEE C95.1.

## 1.2 EUT Description

| | | | |
|---|---|---|---|
| Device Information | | | |
| Product Name | 802.11ac WiFi Module | | |
| Trade Name | Actiontec | | |
| Model Name | 802C2447 | | |
| Family Model | N/A | | |
| FCC ID | LNQ802C2447 | | |
| Device Phase | Identical Prototype | | |
| Exposure Category | General population / Uncontrolled environment | | |
| Antenna Type | Ant 0: PIFA Antenna<br>Ant 1: PIFA Antenna<br>Ant 2: PIFA Antenna | | |
| Antenna Gain | Ant 0: 4.7dBi for WLAN2.4G and 5.5dBi for WLAN5G<br>Ant 1: 3.7dBi for WLAN2.4G and 5.0dBi for WLAN5G<br>Ant 2: 3.6dBi for WLAN2.4G and 5.6dBi for WLAN5G | | |
| Device Operating Configurations | | | |
| Supporting Mode(s) | WLAN 2.4G/5.2G/5.8G | | |
| Test Modulation | WLAN(DSSS/OFDM) | | |
| Operating Frequency Range(s) | Band | Tx (MHz) | Rx (MHz) |
| | WLAN 2.4G | 2412-2462 | |
| | WLAN 5.2G | 5180-5240 | |
| | WLAN 5.8G | 5745-5825 | |

## 1.3 Test specification(s)

| |
|---|
| FCC 47 CFR Part 1(1.1310) |
| FCC 47 CFR Part 2(2.1091) |
| ANSI/IEEE C95.1-1992 |
| KDB 447498 D01 General RF Exposure Guidance |

## 1.4 Ambient Condition

| | |
|---|---|
| Ambient temperature | 20°C – 24℃ |
| Relative Humidity | 30% – 70% |

## 2 RF Output Power

| Test Channel | Frequency (MHz) | Power Setting | Duty Cycle Factor (dB) | Peak Output Power(dBm) | | | Total (dBm) | LIMIT (dBm) | Verdict |
|---|---|---|---|---|---|---|---|---|---|
| | | | | ANT 0 | ANT 1 | ANT 2 | | | |
| **TX 802.11b Mode** | | | | | | | | | |
| 1 | 2412 | Default | 0 | 23.3 | 23.2 | 23.3 | - | 30 | PASS |
| 6 | 2437 | Default | 0 | 23.4 | 23.3 | 23.3 | - | 30 | PASS |
| 11 | 2462 | Default | 0 | 23.5 | 23.4 | 23.4 | - | 30 | PASS |
| **TX 802.11 g Mode** | | | | | | | | | |
| 1 | 2412 | Default | 0 | 18.2 | 18.5 | 18.7 | - | 30 | PASS |
| 6 | 2437 | Default | 0 | 21.1 | 21.2 | 21.0 | - | 30 | PASS |
| 11 | 2462 | Default | 0 | 18.5 | 18.0 | 17.9 | - | 30 | PASS |
| **TX 802.11 n20M Mode(Single TX)** | | | | | | | | | |
| 1 | 2412 | Default | 0 | 16.9 | 16.8 | 17.1 | - | 30 | PASS |
| 6 | 2437 | Default | 0 | 20.8 | 20.7 | 20.6 | - | 30 | PASS |
| 11 | 2462 | Default | 0 | 16.7 | 16.9 | 16.9 | - | 30 | PASS |
| **TX 802.11 n20M Mode(MIMO TX)** | | | | | | | | | |
| 1 | 2412 | Default | 0 | 13.6 | 13.5 | 14.4 | 18.62 | 27.2 | PASS |
| 6 | 2437 | Default | 0 | 19.8 | 20.1 | 20.2 | 24.81 | 27.2 | PASS |
| 11 | 2462 | Default | 0 | 11.4 | 11.5 | 12.1 | 16.45 | 27.2 | PASS |
| **TX 802.11 n40M Mode(Single TX)** | | | | | | | | | |
| 3 | 2422 | Default | 0 | 18.9 | 19.0 | 19.1 | - | 30 | PASS |
| 6 | 2437 | Default | 0 | 20.6 | 20.6 | 20.5 | - | 30 | PASS |
| 9 | 2452 | Default | 0 | 15.0 | 15.3 | 15.2 | - | 30 | PASS |
| **TX 802.11 n40M Mode(MIMO TX)** | | | | | | | | | |
| 3 | 2422 | Default | 0 | 15.4 | 14.9 | 15.7 | 20.12 | 27.2 | PASS |
| 6 | 2437 | Default | 0 | 19.4 | 19.4 | 19.8 | 24.31 | 27.2 | PASS |
| 9 | 2452 | Default | 0 | 10.2 | 10.2 | 10.9 | 15.22 | 27.2 | PASS |

| Test Channel | Frequency | Maximum output power. Antenna port (AV) (dBm) | | | Total Power (AV) | LIMIT | Result |
|---|---|---|---|---|---|---|---|
| | (MHz) | ANT 0 | ANT 1 | ANT 2 | dBm | dBm | |
| **TX 802.11a Mode** | | | | | | | |
| CH36 | 5180 | 17.4 | 17.6 | 18.3 | - | 30 | Pass |
| CH40 | 5200 | 18.6 | 17.9 | 18.8 | - | 30 | Pass |
| CH48 | 5240 | 18.4 | 18.2 | 18.7 | - | 30 | Pass |
| **TX 802.11 n20M Mode(Single TX)** | | | | | | | |
| CH36 | 5180 | 16.6 | 17.1 | 18.4 | - | 30 | Pass |
| CH40 | 5200 | 18.4 | 17.3 | 18.4 | - | 30 | Pass |
| CH48 | 5240 | 18.4 | 18.0 | 18.5 | - | 30 | Pass |
| **TX 802.11 n40M Mode(Single TX)** | | | | | | | |
| CH38 | 5190 | 15.6 | 15.3 | 15.1 | - | 30 | Pass |
| CH46 | 5230 | 17.0 | 16.9 | 17.1 | - | 30 | Pass |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **TX 802.11 AC20M Mode(Single TX)** | | | | | | | |
| CH36 | 5180 | 16.5 | 17.5 | 18.3 | - | 30 | Pass |
| CH40 | 5200 | 18.2 | 17.5 | 18.2 | - | 30 | Pass |
| CH48 | 5240 | 18.3 | 17.7 | 18.2 | - | 30 | Pass |
| **TX 802.11 AC40M Mode(Single TX)** | | | | | | | |
| CH38 | 5190 | 15.7 | 15.3 | 15.1 | - | 30 | Pass |
| CH46 | 5230 | 16.5 | 17.1 | 17.1 | - | 30 | Pass |
| **TX 802.11 AC80M Mode(Single TX)** | | | | | | | |
| CH42 | 5210 | 14.2 | 13.8 | 14.3 | - | 30 | Pass |

| Test Channel | Frequency | Maximum output power. Antenna port | | | Total Power | LIMIT | Result |
|---|---|---|---|---|---|---|---|
| | | (AV) (dBm) | | | (AV) | | |
| | (MHz) | ANT 0 | ANT 1 | ANT 2 | dBm | dBm | |
| **TX 802.11 n20M Mode(MIMO TX)** | | | | | | | |
| CH36 | 5180 | 15.9 | 16.0 | 15.1 | 20.46 | 25.66 | Pass |
| CH40 | 5200 | 15.3 | 15.3 | 14.6 | 19.85 | 25.66 | Pass |
| CH48 | 5240 | 15.3 | 16.0 | 14.8 | 20.17 | 25.66 | Pass |
| **TX 802.11 n40M Mode(MIMO TX)** | | | | | | | |
| CH38 | 5190 | 15.8 | 15.1 | 15.2 | 20.15 | 25.66 | Pass |
| CH46 | 5230 | 16.9 | 17.1 | 16.7 | 21.67 | 25.66 | Pass |
| **TX 802.11 AC20M Mode(MIMO TX)** | | | | | | | |
| CH36 | 5180 | 14.9 | 14.9 | 14.2 | 19.45 | 25.66 | Pass |
| CH40 | 5200 | 15.6 | 15.9 | 15.2 | 20.35 | 25.66 | Pass |
| CH48 | 5240 | 15.5 | 15.6 | 14.7 | 20.06 | 25.66 | Pass |
| **TX 802.11 AC40M Mode(MIMO TX)** | | | | | | | |
| CH38 | 5190 | 15.0 | 14.9 | 15.5 | 19.91 | 25.66 | Pass |
| CH46 | 5230 | 16.7 | 17.0 | 16.6 | 21.54 | 25.66 | Pass |
| **TX 802.11 AC80M Mode(MIMO TX)** | | | | | | | |
| CH42 | 5210 | 13.8 | 13.9 | 13.3 | 18.45 | 25.66 | Pass |

| Test Channel | Frequency | Maximum output power. Antenna port | | | Total Power | LIMIT | Result |
|---|---|---|---|---|---|---|---|
| | | (AV) (dBm) | | | (AV) | | |
| | (MHz) | ANT 0 | ANT 1 | ANT 2 | dBm | dBm | |
| **TX 802.11a Mode** | | | | | | | |
| CH149 | 5745 | 17.8 | 18.4 | 18.6 | - | 30 | Pass |
| CH157 | 5785 | 17.9 | 18.1 | 18.5 | - | 30 | Pass |
| CH165 | 5825 | 17.9 | 19.8 | 19.0 | - | 30 | Pass |
| **TX 802.11 n20M Mode(Single TX)** | | | | | | | |
| CH149 | 5745 | 18.2 | 18.5 | 18.3 | - | 30 | Pass |
| CH157 | 5785 | 17.6 | 18.7 | 18.6 | - | 30 | Pass |
| CH165 | 5825 | 17.9 | 19.0 | 19.1 | - | 30 | Pass |
| **TX 802.11 n40M Mode(Single TX)** | | | | | | | |
| CH151 | 5755 | 17.0 | 17.9 | 17.8 | - | 30 | Pass |
| CH159 | 5795 | 18.0 | 18.2 | 17.5 | - | 30 | Pass |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **TX 802.11 AC20M Mode(Single TX)** | | | | | | | |
| CH149 | 5745 | 18.1 | 17.9 | 18.9 | - | 30 | Pass |
| CH157 | 5785 | 18.0 | 18.0 | 18.6 | - | 30 | Pass |
| CH165 | 5825 | 17.8 | 19.0 | 19.3 | - | 30 | Pass |
| **TX 802.11 AC40M Mode(Single TX)** | | | | | | | |
| CH151 | 5755 | 17.3 | 17.5 | 17.9 | - | 30 | Pass |
| CH159 | 5795 | 17.5 | 18.1 | 18.5 | - | 30 | Pass |
| **TX 802.11 AC80M Mode(Single TX)** | | | | | | | |
| CH155 | 5775 | 16.7 | 17.4 | 17.7 | - | 30 | Pass |

| Test Channel | Frequency | Maximum output power. Antenna port | | | Total Power | LIMIT | Result |
|---|---|---|---|---|---|---|---|
| | | (AV) (dBm) | | | (AV) | | |
| | (MHz) | ANT 0 | ANT 1 | ANT 2 | dBm | dBm | |
| **TX 802.11 n20M Mode(MIMO TX)** | | | | | | | |
| CH149 | 5745 | 17.8 | 17.9 | 17.9 | 22.64 | 25.66 | Pass |
| CH157 | 5785 | 18.5 | 18.9 | 19.1 | 23.61 | 25.66 | Pass |
| CH165 | 5825 | 18.4 | 18.9 | 18.5 | 23.38 | 25.66 | Pass |
| **TX 802.11 n40M Mode(MIMO TX)** | | | | | | | |
| CH151 | 5755 | 17.2 | 18.1 | 17.3 | 22.32 | 25.66 | Pass |
| CH159 | 5795 | 17.4 | 17.5 | 17.2 | 22.14 | 25.66 | Pass |
| **TX 802.11 AC20M Mode(MIMO TX)** | | | | | | | |
| CH149 | 5745 | 18.6 | 19.3 | 19.0 | 23.75 | 25.66 | Pass |
| CH157 | 5785 | 18.4 | 19.0 | 18.9 | 23.55 | 25.66 | Pass |
| CH165 | 5825 | 17.9 | 18.4 | 18.5 | 23.05 | 25.66 | Pass |
| **TX 802.11 AC40M Mode(MIMO TX)** | | | | | | | |
| CH151 | 5755 | 17.7 | 17.2 | 18.0 | 22.42 | 25.66 | Pass |
| CH159 | 5795 | 17.6 | 18.2 | 17.0 | 22.40 | 25.66 | Pass |
| **TX 802.11 AC80M Mode(MIMO TX)** | | | | | | | |
| CH155 | 5775 | 16.5 | 17.2 | 16.9 | 21.65 | 25.66 | Pass |

# 3 RF Exposure Evaluation

## 3.1 Operation in WLAN 2.4G

**SISO**

| Antenna | Maximum output power (dBm) | Gain (dBi) | EIRP (dBm) | EIRP (mW) | R(cm) | S ($mW/cm^2$) | MPE Limit ($mW/cm^2$) | Conclusion |
|---|---|---|---|---|---|---|---|---|
| Ant 0 | 23.5 | 4.7 | 28.2 | 660.7 | 20 | 0.131 | 1 | Pass |
| Ant 1 | 23.4 | 3.7 | 27.1 | 512.9 | 20 | 0.102 | 1 | Pass |
| Ant 2 | 23.4 | 3.6 | 27.0 | 501.2 | 20 | 0.100 | 1 | Pass |

## 3.2 Operation in WLAN 5G

**SISO**

| Antenna | Maximum output power (dBm) | Gain (dBi) | EIRP (dBm) | EIRP (mW) | R(cm) | S ($mW/cm^2$) | MPE Limit ($mW/cm^2$) | Conclusion |
|---|---|---|---|---|---|---|---|---|
| Ant 0 | 18.6 | 5.5 | 24.1 | 257.0 | 20 | 0.051 | 1 | Pass |
| Ant 1 | 19.8 | 5.6 | 25.4 | 346.7 | 20 | 0.069 | 1 | Pass |
| Ant 2 | 19.3 | 5.6 | 24.9 | 309.0 | 20 | 0.061 | 1 | Pass |

# 4 Exposure calculations for multiple sources

When a number of sources at different frequencies, and/or broadband sources, contribute to the total exposure, it becomes necessary to weigh each contribution relative to the MPE in accordance with the provisions of Table (A) and Table (B). To comply with the MPE, the fraction of the MPE in terms of $E^2$, $H^2$ (or power density) incurred within each frequency interval should be determined and the sum of all such fractions should not exceed unity.

In order to ensure compliance with the MPE for a controlled environment, the sum of the ratios of the power density to the corresponding MPE should not exceed unity. That is

$$\sum_{i=1}^{n} \frac{S_i}{MPE_i}$$

The product also has multiple transmitters The Simultaneous Transmission Possibilities are as below:

| Simultaneous Tx Combination | Configuration |
|---|---|
| 1 | WLAN 2.4G MIMO |
| 2 | WLAN 5.2G MIMO |
| 3 | WLAN 5.8G MIMO |

## 4.1 Estimation for WLAN2.4G MIMO

| Antenna | Tune-up limit (dBm) | Gain (dBi) | EIRP (dBm) | EIRP (mW) | R(cm) | S ($mW/cm^2$) | MPE Limit ($mW/cm^2$) | Calculation result | Conclusion |
|---|---|---|---|---|---|---|---|---|---|
| Ant 0 | 19.8 | 4.7 | 24.5 | 281.8 | 20 | 0.056 | 1 | 0.152 | Pass |
| Ant 1 | 20.1 | 3.7 | 23.8 | 239.9 | 20 | 0.048 | 1 | | |
| Ant 2 | 20.2 | 3.6 | 23.8 | 239.9 | 20 | 0.048 | 1 | | |

## 4.2 Estimation for WLAN5G MIMO

| Antenna | Tune-up limit (dBm) | Gain (dBi) | EIRP (dBm) | EIRP (mW) | R(cm) | S ($mW/cm^2$) | MPE Limit ($mW/cm^2$) | Calculation result | Conclusion |
|---|---|---|---|---|---|---|---|---|---|
| Ant 0 | 18.6 | 5.5 | 24.1 | 257.0 | 20 | 0.051 | 1 | 0.169 | Pass |
| Ant 1 | 19.3 | 5.6 | 24.9 | 309.0 | 20 | 0.061 | 1 | | |
| Ant 2 | 19.0 | 5.6 | 24.6 | 288.4 | 20 | 0.057 | 1 | | |

According to the Table above, we can conclude that the calculation results of all simultaneous transmission possibilities are less than 1, so it is into compliance.
Therefore the product also meets the requirements under multiple sources condition.

----------END----------