

ETSI EN 301 489-1 V2.2.3 (2019-11)
ETSI EN 301 489-17 V3.2.0 (2017-03)

TEST REPORT

For

ESPRESSIF SYSTEMS (SHANGHAI) CO., LTD

Suite 204, Block 2, 690 Bibo Road, Zhang Jiang Hi-Tech Park, Shanghai, China

Tested Model: ESP32-WROOM-32E

| | |
|---|--|
| Report Type: Original Report | Product Type: Wi-Fi & Bluetooth Internet of Things Module |
| Test Engineer: Tina Li | Tina Li |
| Report Number: RSHD200218007-02 | |
| Report Date: 2020-03-13 | |
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GENERAL INFORMATION

Product Description for Equipment under Test (EUT)

| | |
|-----------------------------|---|
| Applicant | ESPRESSIF SYSTEMS (SHANGHAI) CO., LTD |
| Test Model | ESP32-WROOM-32E |
| Product | Wi-Fi & Bluetooth Internet of Things Module |
| Highest Operation Frequency | 2480 MHz |
| Rate Voltage | DC 3.3V |

**All measurement and test data in this report was gathered from production sample serial number: 20200218007.
(Assigned by the BACL. The EUT supplied by the applicant was received on 2020-02-18)*

Objective

This test report is prepared on behalf of *ESPRESSIF SYSTEMS (SHANGHAI) CO., LTD* in accordance with:

ETSI EN 301 489-1 V2.2.3 (2019-11), ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements.

ETSI EN 301489-17 V3.2.0 (2017-03), ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 17: Specific conditions for Broadband Data Transmission Systems.

The objective is to determine compliance with ETSI EN 301 489-1 V2.2.3 (2019-11), ETSI EN 301489-17 V3.2.0 (2017-03).

Test Methodology

All measurements contained in this report were conducted with ETSI EN 301 489-1 V2.2.3 (2019-11).

Test Facility

The test site used by Bay Area Compliance Laboratories Corp. (Kunshan) to collect test data is located on the No.248 Chenghu Road, Kunshan, Jiangsu province, China.

Bay Area Compliance Laboratories Corp. (Kunshan) Lab is accredited to ISO/IEC 17025 by A2LA (Lab code: 4323.01) and the FCC designation No. CN1185 under the FCC KDB 974614 D01. The facility also complies with the radiated and AC line conducted test site criteria set forth in ANSI C63.4-2014.

SYSTEM TEST CONFIGURATION

Description of Test Configuration

The system was configured for testing in a typical fashion (as normally used by a typical user)

Test mode: Wi-Fi link & BT link transmission

EUT Exercise Software

No software was used to test.

Equipment Modifications

No modifications were made to the EUT.

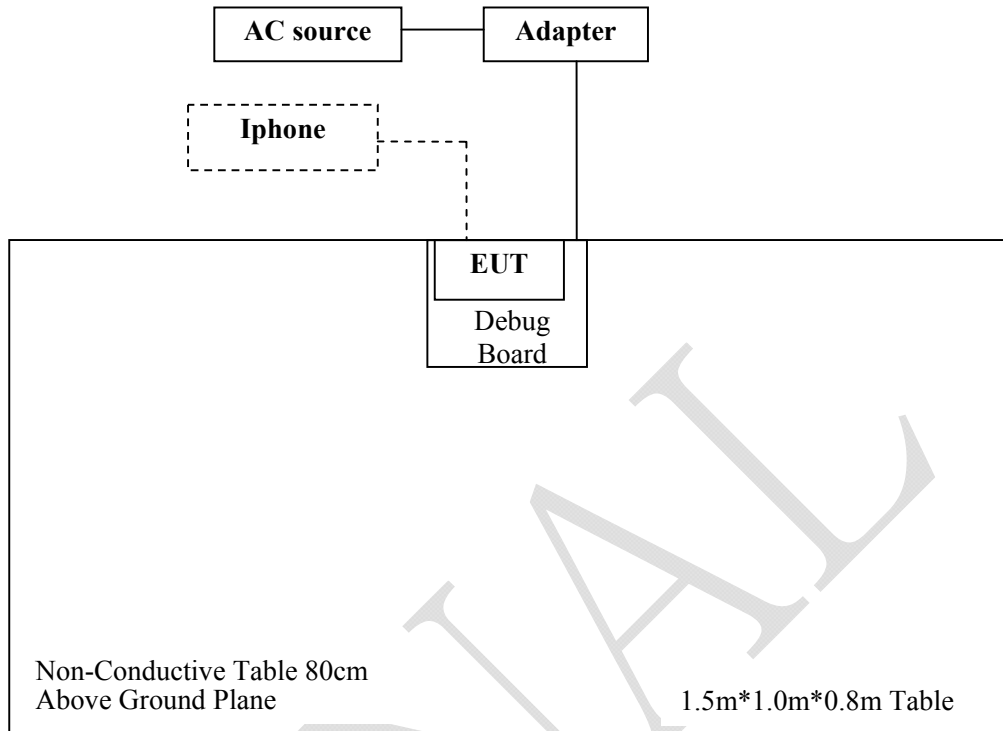
Support Equipment List and Details

| Manufacturer | Description | Model | Serial Number |
|--------------|-------------|-----------|---------------|
| Apple | Iphone | ML7J2CH/A | FK2QFTJ4GRYD |
| / | Debug Board | / | / |

External I/O Cable

| Cable Description | Length (m) | From/Port | To |
|-------------------|------------|-------------|---------|
| Power Cable | 1.0 | Debug Board | Adapter |

Block Diagram of Radiated Test Setup



SUMMARY OF TEST RESULTS

| | Description of Test | Result |
|--|--|-----------------------------|
| Reference to clauses EN 301 489-1 §7.1 | Reference to clauses EN 301 489-1 §8.2 Enclosure of ancillary equipment measured on a stand alone basis | Compliant |
| | Reference to clauses EN 301 489-1 §8.3 DC power input/output ports | Not Applicable ¹ |
| | Reference to clauses EN 301 489-1 §8.4 AC mains power input/output ports | Not Applicable ¹ |
| | Reference to clauses EN 301 489-1 §8.5 Harmonic current emissions (AC mains input port) | Not Applicable ¹ |
| | Reference to clauses EN 301 489-1 §8.6 Voltage fluctuations and flicker (AC mains input port) | Not Applicable ¹ |
| | Reference to clauses EN 301 489-1 §8.7 Wired network ports | Not Applicable ² |
| Reference to clauses EN 301 489-1 §7.2 | Reference to clauses EN 301 489-1 §9.3 Electrostatic discharge (EN 61000-4-2) | Compliant |
| | Reference to clauses EN 301 489-1 §9.2 Radio frequency electromagnetic field (80 MHz to 6000 MHz) (EN 61000-4-3) | Compliant |
| | Reference to clauses EN 301 489-1 §9.4 Fast transients, common mode (EN 61000-4-4) | Not Applicable ¹ |
| | Reference to clauses EN 301 489-1 §9.8 Surges (EN 61000-4-5) | Not Applicable ¹ |
| | Reference to clauses EN 301 489-1 §9.5 Radio frequency, common mode (EN 61000-4-6) | Not Applicable ¹ |
| | Reference to clauses EN 301 489-1 §9.7 Voltage dips and interruptions (EN 61000-4-11) | Not Applicable ¹ |
| | Reference to clauses EN 301 489-1 §9.6 Transients and surges in the vehicular environment(ISO 7637-2) | Not Applicable* |

Note:

Not Applicable¹: The EUT is powered by debug board.

Not Applicable²: There are no wired network ports.

Not Applicable*: This equipment will not in vehicular environment.

Immunity test performance criteria:

“A “ means : CT/CR Reference to clauses EN 301 489-1 §6.1/EN 301 489-17 §6.3 §6.5

“B” means : TT/TR Reference to clauses EN 301 489-1 §6.2/EN 301 489-17 §6.4 §6.6

§8.2 - RADIATED EMISSIONS

Measurement Uncertainty

Compliance or non-compliance with a disturbance limit shall be determined in the following manner:

If U_{lab} is less than or equal to U_{cisp} of Table 1, then:

- compliance is deemed to occur if no measured disturbance level exceeds the disturbance limit;
- Non-compliance is deemed to occur if any measured disturbance level exceeds the disturbance limit.

If U_{lab} is greater than U_{cisp} of Table 1, then:

- compliance is deemed to occur if no measured disturbance level, increased by $(U_{lab} - U_{cisp})$, exceeds the disturbance limit;
- Non-compliance is deemed to occur if any measured disturbance level, increased by $(U_{lab} - U_{cisp})$, exceeds the disturbance limit.

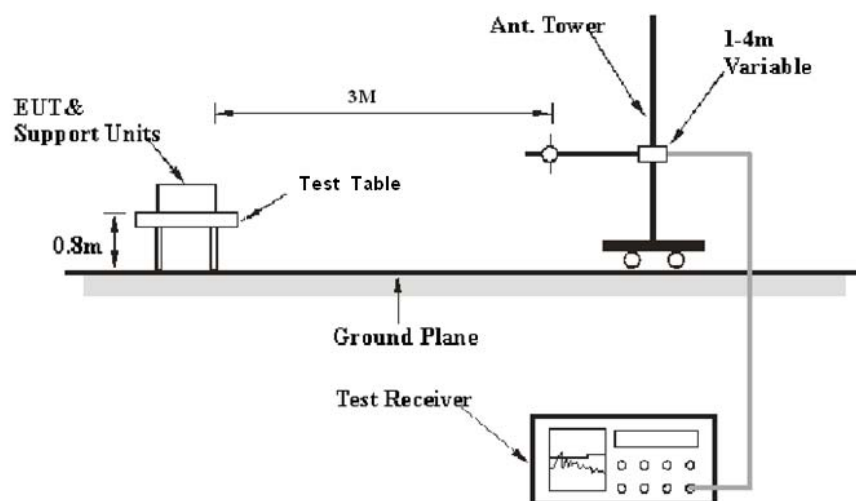
Table 1 – Values of U_{cisp}

| Item | | Measurement Uncertainty | U_{cisp} |
|-------------------|------------|-------------------------|------------|
| Radiated Emission | 30MHz~1GHz | 5.91dB | 6.3 dB |
| | 1GHz~6GHz | 4.68dB | 5.2 dB |

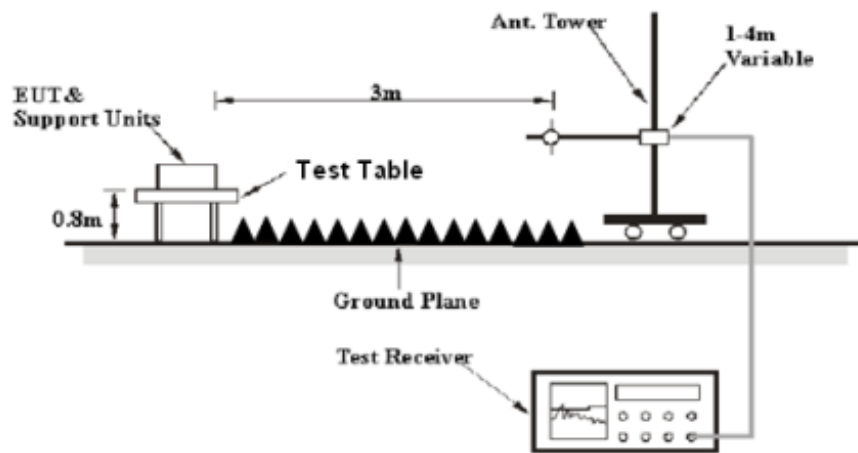
Otherwise required by the applicant or Product Regulations, Decision Rule in this report did not consider the uncertainty.

Test System Setup

Below 1GHz:



Above 1GHz:



Radiated Top View:

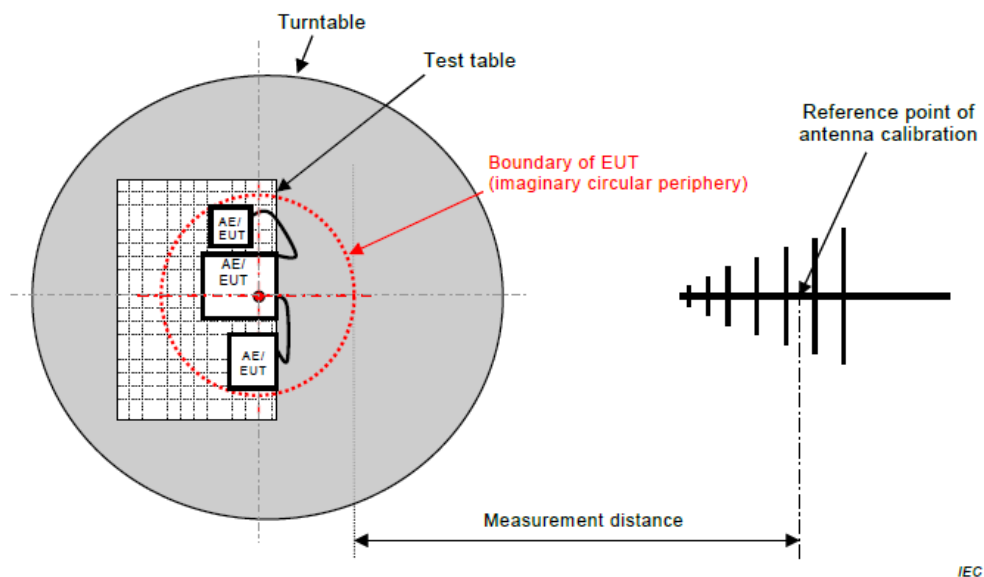


Figure C.1 – Measurement distance

The radiated emission tests were performed in the 3 meters, using the setup accordance with the ETSI EN 301 489-1. The specification used was the ETSI EN 301 489-1 class B limite.

The spacing between the peripherals was 10 cm.

EMI Test Receiver Setup

The system was investigated from 30 MHz to 6 GHz.

During the radiated emission test, the EMI test receiver Setup was set with the following configurations:

| Frequency Range | RBW | Video B/W | IF B/W | Detector Type |
|------------------|---------|-----------|--------|---------------|
| 30MHz – 1000 MHz | 120 kHz | 300 kHz | 120kHz | QP |
| Above 1 GHz | 1MHz | 3 MHz | / | Peak |
| | 1MHz | 3 MHz | 1 MHz | AVG |

Test Equipment List and Details

| Manufacturer | Description | Model | Serial Number | Calibration Date | Calibration Due Date |
|-------------------|--------------------|-----------|---------------|------------------|----------------------|
| Sonoma Instrument | Amplifier | 310N | 185700 | 2019-08-14 | 2020-08-13 |
| Rohde & Schwarz | EMI Test Receiver | ESCI | 100195 | 2019-11-30 | 2020-11-29 |
| Sunol Sciences | Broadband Antenna | JB3 | A090413-1 | 2019-12-26 | 2022-12-25 |
| Champrotek | Chamber | Chamber A | T-KSEMC049 | - | - |
| Champrotek | Chamber | Chamber B | T-KSEMC080 | - | - |
| R&S | Auto test Software | EMC32 | 100361 | - | - |
| ETS | Horn Antenna | 3115 | 6229 | 2019-12-12 | 2022-12-11 |
| Rohde & Schwarz | EMI Receiver | ESU40 | 100207 | 2019-08-27 | 2020-08-26 |
| A.H.Systems, inc | Amplifier | 2641-1 | 491 | 2020-02-20 | 2021-02-19 |
| MICRO-COAX | Coaxial Cable | Cable-8 | 008 | 2019-08-15 | 2020-08-14 |
| MICRO-COAX | Coaxial Cable | Cable-9 | 009 | 2019-08-15 | 2020-08-14 |
| MICRO-COAX | Coaxial Cable | Cable-10 | 010 | 2019-08-15 | 2020-08-14 |
| MICRO-COAX | Coaxial Cable | Cable-4 | 004 | 2019-12-12 | 2020-12-11 |
| MICRO-COAX | Coaxial Cable | Cable-5 | 005 | 2019-12-12 | 2020-12-11 |

* **Statement of Traceability:** Bay Area Compliance Laboratories Corp. (Kunshan) attests that all calibrations have been performed in accordance to requirements that traceable to National Primary Standards and International System of Units (SI).

Test Procedure

During the radiated emissions, the EUT was connected to the DC Source.

Maximizing procedure was performed on the highest emissions to ensure that the EUT complied with all installation combinations.

All data was recorded in the Quasi-peak detection mode from 30MHz to 1GHz, Peak and average detection mode above 1 GHz.

Corrected Amplitude & Margin Calculation

The Corrected Amplitude is calculated by adding the Antenna Factor and Cable Loss, and subtracting the Amplifier Gain from the Meter reading. The basic equation is as follows:

$$\text{Corr. Amp.} = \text{Meter Reading} + \text{Antenna Factor} + \text{Cable Loss} - \text{Amplifier Gain}$$

The “**Margin**” column of the following data tables indicates the degree of compliance with the applicable limit. For example, a margin of 7dB means the emission is 7dB below the limit. The equation for margin calculation is as follows:

$$\text{Margin} = \text{Limit} - \text{Corrected Amp}$$

Test Data

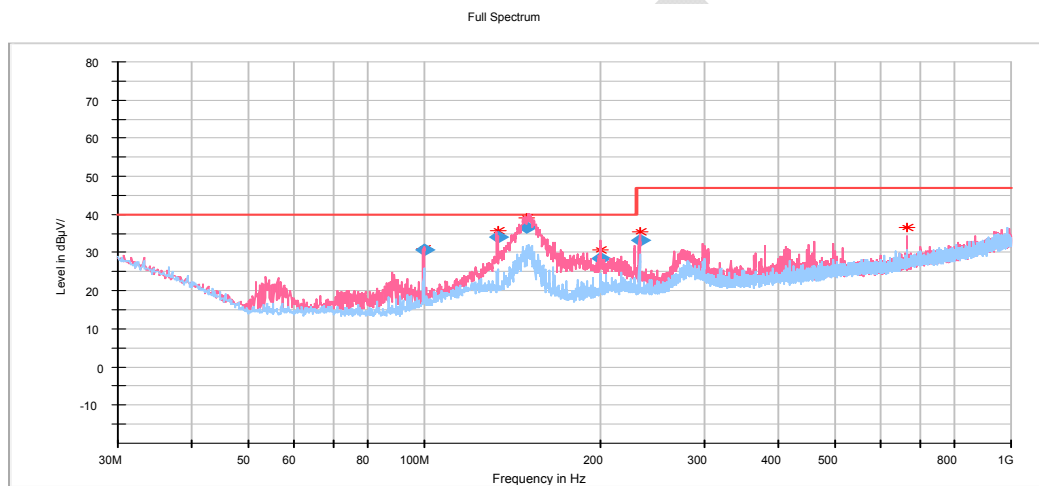
Environmental Conditions

| | |
|--------------------|-----------|
| Temperature: | 23.1 °C |
| Relative Humidity: | 53% |
| ATM Pressure: | 100.7 kPa |

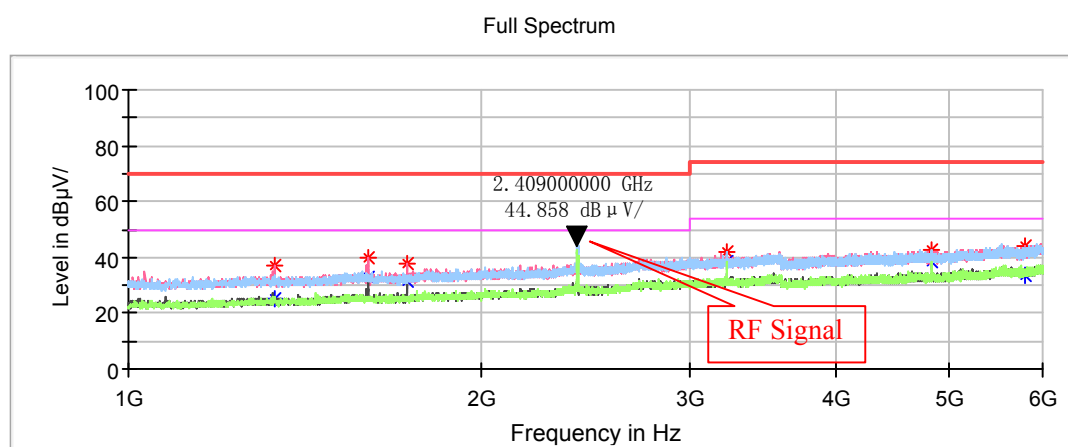
The testing was performed by Tina Li on 2020-03-10.

Test mode: Wi-Fi link & BT link transmission

1) Below 1GHz:



| Frequency (MHz) | QuasiPeak (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB/m) |
|-----------------|--------------------------|----------------------|-------------|-------------|-----|---------------|--------------|
| 99.936800 | 30.61 | 40.00 | 9.39 | 100.0 | V | 303.0 | -14.9 |
| 133.238200 | 33.93 | 40.00 | 6.07 | 100.0 | V | 251.0 | -11.7 |
| 149.596600 | 36.64 | 40.00 | 3.36 | 100.0 | V | 251.0 | -12.3 |
| 199.892700 | 28.46 | 40.00 | 11.54 | 100.0 | V | 344.0 | -12.3 |
| 233.210750 | 33.27 | 47.00 | 13.73 | 100.0 | V | 357.0 | -12.2 |
| 664.668100 | 27.42 | 47.00 | 19.58 | 100.0 | V | 215.0 | -3.9 |

Above 1 GHz:

| Frequency (MHz) | MaxPeak (dB μ V/m) | Average (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB/m) |
|-----------------|------------------------|------------------------|----------------------|-------------|-------------|-----|---------------|--------------|
| 1333.500000 | --- | 25.50 | 50.00 | 24.50 | 100.0 | V | 28.0 | -10.8 |
| 1333.500000 | 37.21 | --- | 70.00 | 32.79 | 100.0 | V | 28.0 | -10.8 |
| 1599.000000 | --- | 32.99 | 50.00 | 17.01 | 200.0 | V | 62.0 | -9.6 |
| 1599.000000 | 39.83 | --- | 70.00 | 30.17 | 200.0 | V | 62.0 | -9.6 |
| 1725.000000 | --- | 31.73 | 50.00 | 18.27 | 100.0 | V | 202.0 | -9.2 |
| 1725.000000 | 37.84 | --- | 70.00 | 32.16 | 100.0 | V | 202.0 | -9.2 |
| 3229.500000 | --- | 38.31 | 54.00 | 15.69 | 200.0 | H | 206.0 | -4.0 |
| 3229.500000 | 42.24 | --- | 74.00 | 31.76 | 200.0 | H | 206.0 | -4.0 |
| 4824.000000 | --- | 38.35 | 54.00 | 15.65 | 200.0 | H | 192.0 | -0.5 |
| 4824.000000 | 42.37 | --- | 74.00 | 31.63 | 200.0 | H | 192.0 | -0.5 |
| 5791.500000 | --- | 33.68 | 54.00 | 20.32 | 100.0 | V | 358.0 | 1.9 |
| 5791.500000 | 44.01 | --- | 74.00 | 29.99 | 100.0 | V | 358.0 | 1.9 |

§9.3 - ELECTROSTATIC DISCHARGE

Measurement Uncertainty

U_{lab} (measurement uncertainty of lab) and U_{EN} (measurement uncertainty of EN 61000-4-2) please refer to the following:

| Parameter | U_{EN} | U_{lab} |
|--------------------|-------------|-----------|
| Rise time t_r | $\leq 15\%$ | 15% |
| Peak current I_p | $\leq 7\%$ | 6.30% |
| Current at 30 ns | $\leq 7\%$ | 6.30% |
| Current at 60 ns | $\leq 7\%$ | 6.30% |

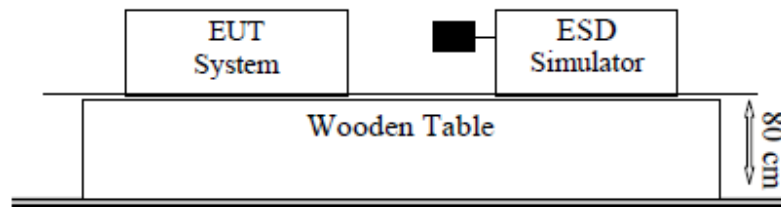
Otherwise required by the applicant or Product Regulations, Decision Rule in this report did not consider the uncertainty.

Test Equipment

| Manufacturer | Description | Model | Serial Number | Calibration Date | Calibration Due Date |
|--------------|---------------|-------|---------------|------------------|----------------------|
| EM Test | ESD Simulator | Dito | V0824103870 | 2019-12-01 | 2020-11-30 |

* **Statement of Traceability:** Bay Area Compliance Laboratories Corp. (Kunshan) attests that all calibrations have been performed in accordance to requirements, traceable to National Primary Standards and International System of Units (SI).

Test System Setup



Remark: ■ is the tip of the electrode

EN 61000-4-2 specifies that a tabletop EUT shall be placed on a non-conducting table which is 80 centimeters above a ground reference plane and that floor mounted equipment shall be placed on an insulating support approximately 10 centimeters above a ground plane. During the tests, the EUT is positioned over a ground reference plane in conformance with this requirement.

For EUTop equipment, a 1.6 by 0.8-meter metal sheet (HCP) is placed on the table and connected to the ground plane via a metal strap with two 470 k Ohms resistors in series. The EUT and attached cables are isolated from this metal sheet by 0.5-millimeter thick insulating material. A Vertical Coupling Plane (VCP) grounded on the ground plane through the same configuration as in the HCP is used.

Test Standard

ETSI EN 301 489-1 V2.2.1 (2019-03) / EN 61000-4-2: 2009

Test Level 3 for Air Discharge at ± 8 kVTest Level 2 for Contact Discharge at ± 4 kV**Test Level**

| Level | Test Voltage Contact Discharge (\pm kV) | Test Voltage Air Discharge (\pm kV) |
|-------|---|---|
| 1. | 2 | 2 |
| 2. | 4 | 4 |
| 3. | 6 | 8 |
| 4. | 8 | 15 |
| X. | Special | Special |

Performance Criterion: B**Test Procedure****Air Discharge:**

This test is done on a non-conductive surface. The round discharge tip of the discharge electrode shall be approached as fast as possible to touch the EUT. After each discharge, the discharge electrode shall be removed from the EUT. The generator is then re-triggered for a new single discharge and repeated 10 times for each pre-selected test point. This procedure shall be repeated until all the air discharge completed.

Contact Discharge:

All the procedure shall be same as Section 8.3.1 of EN 61000-4-2, except that the tip of the discharge electrode shall touch the EUT before the discharge switch is operated.

Indirect discharge for horizontal coupling plane

At least 50 single discharges shall be applied to the horizontal coupling plane, at points on each side of the EUT. The discharge electrode positions vertically at a distance of 0.1m from the EUT and with the discharge electrode touching the coupling plane.

Indirect discharge for vertical coupling plane

At least 50 single discharges shall be applied to the center of one vertical edge of the coupling plane. The coupling plane, of dimensions 0.5m * 0.5m, is placed parallel to, and positioned at a distance of 0.1m from the EUT. Discharges shall be applied to the coupling plane, with this plane in sufficient different positions that the four faces of the EUT are completely illuminated.

Test Data**Environmental Conditions**

| | |
|---------------------------|-----------|
| Temperature: | 23.1 °C |
| Relative Humidity: | 53% |
| ATM Pressure: | 100.7 kPa |

The testing was performed by Tina Li on 2020-03-10

Test mode: Wi-Fi link & BT link transmission

Table 1: Electrostatic Discharge Immunity (Air Discharge)

| EN 61000-4-2 Test Points Location | Test Levels | | | | | | | | |
|--------------------------------------|-------------|-------|-------|-------|-------|-------|--------|--------|---|
| | -2 kV | +2 kV | -4 kV | +4 kV | -8 kV | +8 kV | -15 kV | +15 kV | X |
| / | / | / | / | / | / | / | / | / | / |

Table 2: Electrostatic Discharge Immunity (Contact Discharge)

| EN 61000-4-2 Test Points Location | Test Levels | | | | | | | | |
|--------------------------------------|-------------|-------|-------|-------|-------|-------|-------|-------|---|
| | -2 kV | +2 kV | -4 kV | +4 kV | -6 kV | +6 kV | -8 kV | +8 kV | X |
| / | / | / | / | / | / | / | / | / | / |

Table 3: Electrostatic Discharge Immunity (Indirect Contact HCP)

| EN 61000-4-2 Test Points Location | Test Levels | | | | | | | | |
|--------------------------------------|-------------|-------|-------|-------|-------|-------|-------|-------|---|
| | -2 kV | +2 kV | -4 kV | +4 kV | -6 kV | +6 kV | -8 kV | +8 kV | X |
| Front Side | A | A | A | A | / | / | / | / | / |
| Back Side | A | A | A | A | / | / | / | / | / |
| Left Side | A | A | A | A | / | / | / | / | / |
| Right Side | A | A | A | A | / | / | / | / | / |

Table 4: Electrostatic Discharge Immunity (Indirect Contact VCP)

| EN 61000-4-2 Test Points Location | Test Levels | | | | | | | | |
|--------------------------------------|-------------|-------|-------|-------|-------|-------|-------|-------|---|
| | -2 kV | +2 kV | -4 kV | +4 kV | -6 kV | +6 kV | -8 kV | +8 kV | X |
| Front Side | A | A | A | A | / | / | / | / | / |
| Back Side | A | A | A | A | / | / | / | / | / |
| Left Side | A | A | A | A | / | / | / | / | / |
| Right Side | A | A | A | A | / | / | / | / | / |

Note: “A” stands for, during test, operate as intended no loss of function, no degradation of performance, no unintentional transmissions and after test, no degradation of performance, no loss of function, no loss of stored data or user programmable functions.

§9.2 -RF ELECTROMAGNETIC FIELD (80 MHz - 6000MHz)

Measurement Uncertainty

U_{lab} (measurement uncertainty of lab) and U_{EN} (measurement uncertainty of EN 61000-4-3) please refer to the following:

| Parameter | U_{EN} | U_{lab} |
|---------------------|----------|-----------|
| Calibration process | 1.88 dB | 1.88 dB |
| Level setting | 2.19 dB | 2.19 dB |

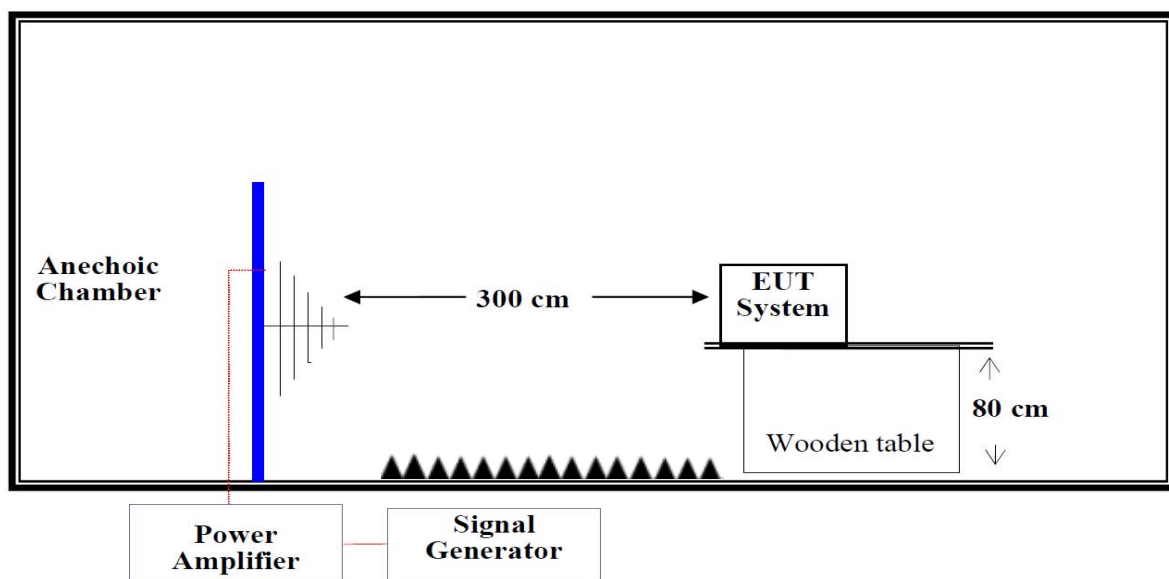
Otherwise required by the applicant or Product Regulations, Decision Rule in this report did not consider the uncertainty.

Test Equipment

| Manufacturer | Description | Model | Serial Number | Calibration Date | Calibration Due Date |
|--------------------|----------------------|-------------|---------------|------------------|----------------------|
| HP | Signal Generator | E4428C | MY49070179 | 2019-11-12 | 2020-11-11 |
| A&R | Power Amplifier | 60S1G6 | 0349442 | NCR | NCR |
| Amplifier Research | Power Amplifier | 200W1000M3A | 18062 | NCR | NCR |
| Ar | Log Periodic Antenna | ATL80M1G | 350122 | NCR | NCR |
| Ar | Log Periodic Antenna | ATT700M12G | 350307 | NCR | NCR |
| Rohde & Schwarz | Signal Analyzer | FSIQ26 | 836131/009 | 2019-11-30 | 2020-11-29 |

* **Statement of Traceability:** Bay Area Compliance Laboratories Corp. (Kunshan) attests that all calibrations have been performed in accordance to requirements that traceable to National Primary Standards and International System of Units (SI).

Test System Setup



Test Standard

ETSI EN 301 489-1 V2.2.1 (2019-03) / EN 61000-4-3:2006+A1:2008+A2:2010
Test Level 2 at 3V/m
Test Levels and Performance Criterion

Test Level

| Level | Field Strength V/m |
|-------|--------------------|
| 1. | 1 |
| 2. | 3 |
| 3. | 10 |
| X. | Special |

Performance Criterion: A**Test Procedure**

The EUT and its simulators are placed on a turn table which is 0.8 meter above the ground. The EUT is set 3 meters away from the transmitting antenna which is mounted on an antenna tower. Both horizontal and vertical polarizations of the antenna are set on test. Each of the four sides of EUT must be faced this transmitting antenna and measured individually.

In order to judge the EUT performance, a CCD camera is used to monitor mobile phone and we observe directly Signal Analyzer outside of the Chamber.

All the scanning conditions are as follows:

| Condition of Test | Remarks |
|----------------------------|--------------------------|
| 1. Field Strength | 3 V/m (Test Level 2) |
| 2. Radiated Signal | 1 kHz, 80% AM, sine wave |
| 3. Scanning Frequency | 80 MHz-6000 MHz |
| 4. Scanning Frequency Step | 1% |
| 5. Dwell Time | 3 Sec. |

Test Data**Environmental Conditions**

| | |
|---------------------------|-----------|
| Temperature: | 23.1 °C |
| Relative Humidity: | 53% |
| ATM Pressure: | 100.7 kPa |

The testing was performed by Tina Li on 2020-03-10.

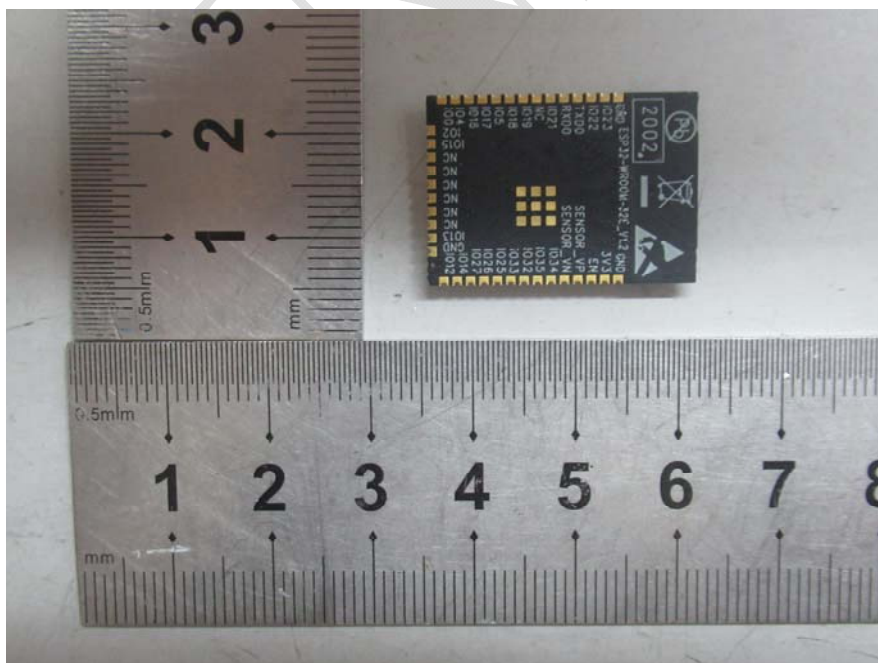
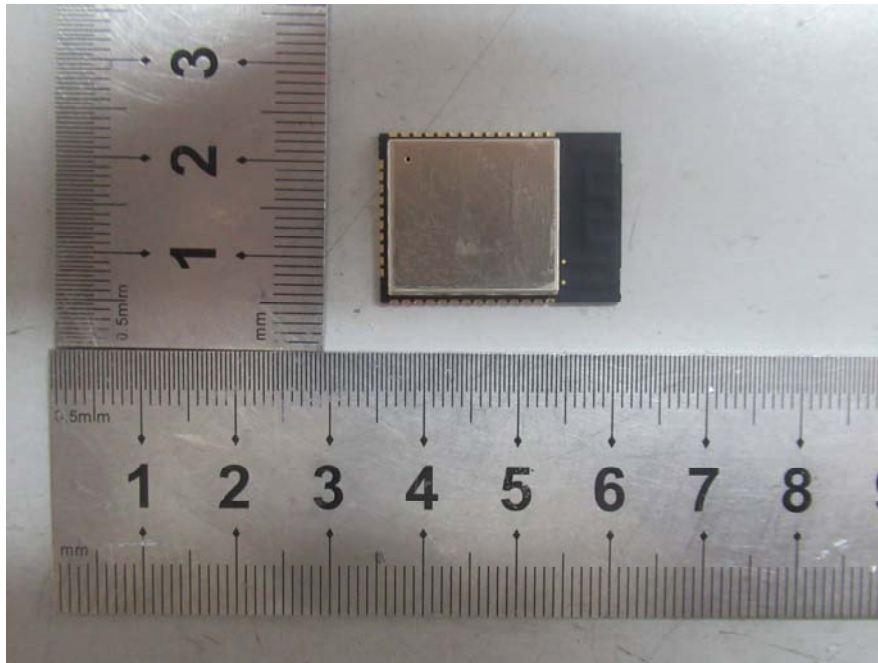
Test mode: Wi-Fi link & BT link transmission

| Frequency Range (MHz) | Front Side (3 V/m) | | Rear Side (3 V/m) | | Left Side (3 V/m) | | Right Side (3 V/m) | |
|--------------------------|-----------------------|------|----------------------|------|----------------------|------|-----------------------|------|
| | VERT | HORI | VERT | HORI | VERT | HORI | VERT | HORI |
| 80-6000 | A | A | A | A | A | A | A | A |

Note:

1. “Wi-Fi link” is to monitor the connection between the EUT and the mobile phone.
2. “BT link” is to monitor the connection between the EUT and the mobile phone.
3. “A” stand for, during test, operate as intended no loss of function, no degradation of performance, no unintentional transmissions and after test, no degradation of performance, no loss of function, no loss of stored data or user programmable functions.

EXHIBIT A - EUT PHOTOGRAPHS



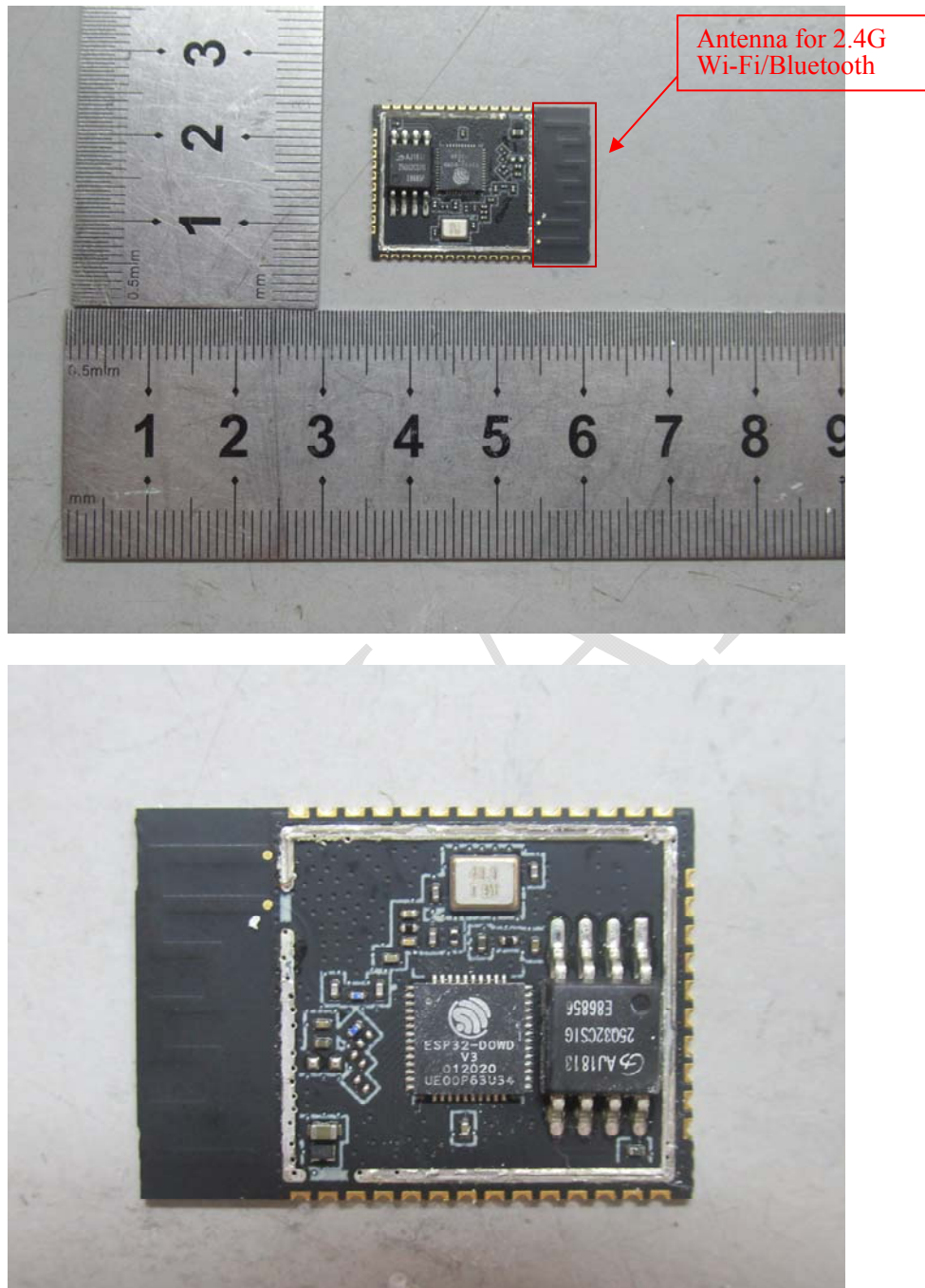


EXHIBIT B – TEST SETUP PHOTOGRAPHS

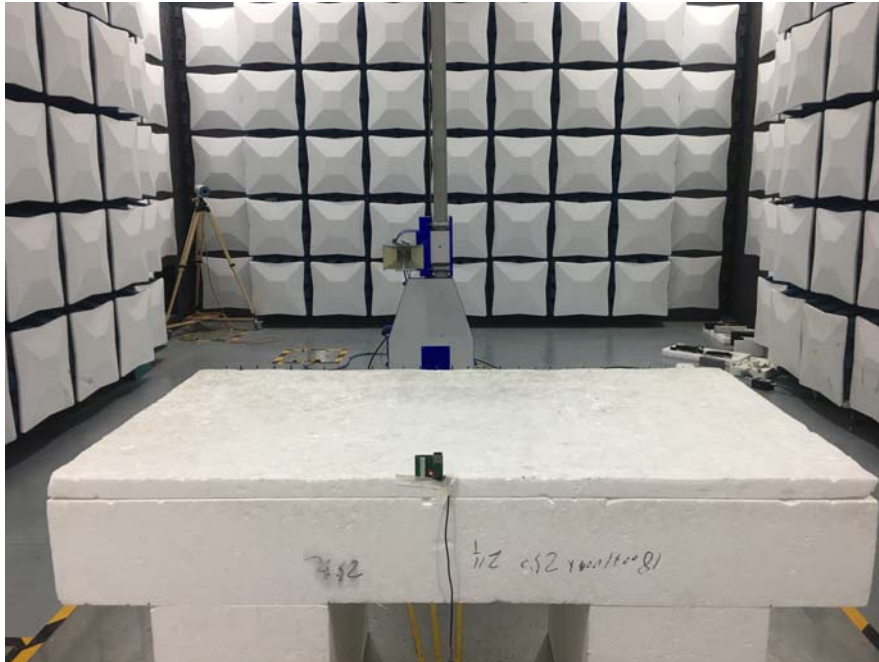
Radiated Emissions - Front View (Below 1GHz)



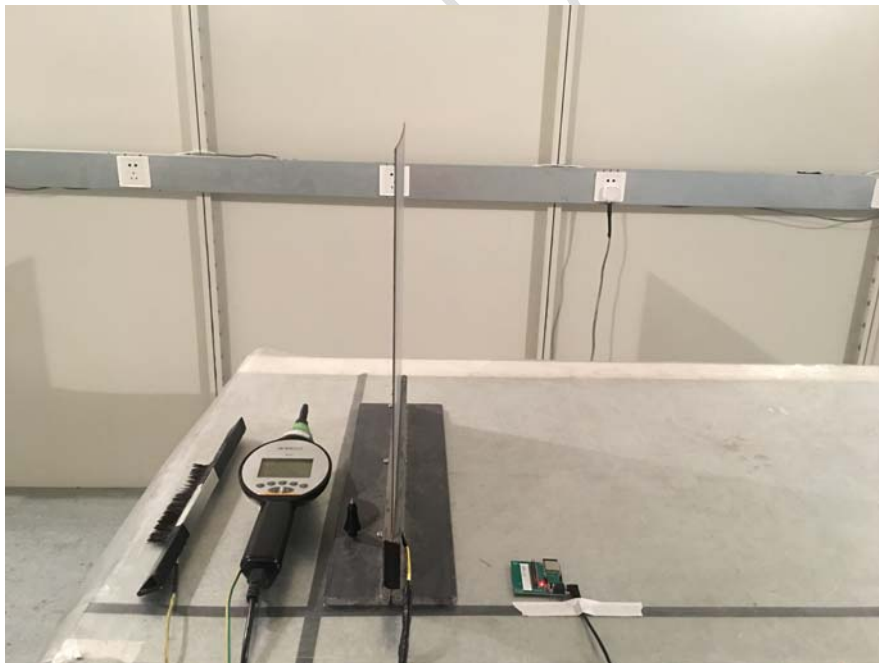
Radiated Emissions - Rear View (Below 1GHz)



Radiated Disturbances Side View (Above 1GHz)



ESD Test Setup Photo



RS Test Setup Photo (Below 1GHz)



RS Test Setup Photo (Above 1GHz)



*******END OF REPORT*******