EMC TEST REPORT

Applicant	Espressif Systems (Shanghai) Co.,Ltd.
FCC ID	2AC7Z-ESPPICOMINI
Product	Wi-Fi & Bluetooth Internet of Things Module
Brand	ESPRESSIF
Model	ESP32-PICO-MINI-02; ESP32-PICO-MINI-02U
Report No.	R2106A0560-E1
Issue Date	September 24, 2021

TA Technology (Shanghai) Co., Ltd. tested the above equipment in accordance with the requirements in **FCC Code CFR47 Part15B (2020)/ ANSI C63.4 (2014)**. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Wei Liu

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Summary of measurement results

Number	Test Case	Clause in FCC Rules	Conclusion
1	Radiated Emission	FCC Part15.109, ANSI C63.4-2014	PASS
2	Conducted Emission	FCC Part15.107, ANSI C63.4-2014	PASS
Date of Testing: June 29, 2021 and September 15, 2021 Date of Sample Received: June 26, 2021			
Note: All indications of Pass/Fail in this report are opinions expressed by TA Technology (Shanghai) Co., Ltd. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only.			

1 Test Laboratory

1.1 Notes of the Test Report

This report shall not be reproduced in full or partial, without the written approval of **TA technology (shanghai) co., Ltd.** The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. Measurement Uncertainties were not taken into account and are published for informational purposes only. This report is written to support regulatory compliance of the applicable standards stated above.

1.2 Test facility

FCC (Designation number: CN1179, Test Firm Registration Number: 446626)

TA Technology (Shanghai) Co., Ltd. has been listed on the US Federal Communications Commission list of test facilities recognized to perform measurements.

A2LA (Certificate Number: 3857.01)

TA Technology (Shanghai) Co., Ltd. has been listed by American Association for Laboratory Accreditation to perform measurement.

1.3 Testing Location

Company:	TA Technology (Shanghai) Co., Ltd.
Address:	No.145, Jintang Rd, Tangzhen Industry Park, Pudong Shanghai, China
City:	Shanghai
Post code:	201201
Country:	P. R. China
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E-mail:	fanguangchang@ta-shanghai.com

2 General Description of Equipment under Test

2.1 Applicant and Manufacturer Information

Applicant	Espressif Systems (Shanghai) Co.,Ltd.
Applicant address	Suite 204, Block 2, 690 Bibo Road, Zhang Jiang Hi-Tech Park, Shanghai, China
Manufacturer	Espressif Systems (Shanghai) Co.,Ltd.
Manufacturer address	Suite 204, Block 2, 690 Bibo Road, Zhang Jiang Hi-Tech Park, Shanghai, China

2.2 General information

EUT Description			
Device Type	Module Device		
Model	ESP32-PICO-MINI-02; ESP32-PICO-MINI-02U		
Lab internal SN	R2106A0560/S01		
HW Version	V1.0		
SW Version	V179		
Connecting I/O Port(s)	Please refer to the User's Manual.		
Antenna Type	ESP32-PICO-MINI-02: PCB Antenna ESP32-PICO-MINI-02U: External Antenna		
Frequency	Band	Tx (MHz)	Rx (MHz)
	Bluetooth	2400 ~ 2483.5	2400 ~ 2483.5
	WIFI 2.4G	2400 ~ 2483.5	2400 ~ 2483.5
Auxiliary test equipment			
PC	PC Manufacturer: Microsoft Corporation Model: L20170076		
Note: 1. The EUT is sent from the applicant to TA and the information of the EUT is declared by the applicant.			

Differences between the two models		
Model	ESP32-PICO-MINI-02	ESP32-PICO-MINI-02U
Antenna	PCB Antenna	External Antenna
Antenna Gain	3.96dBi	2.33dBi
Others	The same	The same

2.3 Applied Standards

According to the specifications of the manufacturer, it must comply with the requirements of the following standards:

Test standards
FCC Code CFR47 Part15B (2020)
ANSI C63.4 (2014)

2.4 Test Mode

Test Mode	
Mode 1	External Power Supply + PCB Layout + EUT + Bluetooth/ WLAN Receiver
Mode 2	External Power Supply + PCB Layout + EUT + Bluetooth/ WLAN Traffic

During the test, mode 1 is selected as the worst condition for Radiated Emission and mode 2 is selected as the worst condition for Conducted Emission. The test data of the worst-case condition was recorded in this report.

3 Test Case Results

3.1 Radiated Emission

Ambient condition

Temperature	Relative humidity	Pressure
15°C~35°C	30%~60%	101.5kPa

Methods of Measurement

The EUT is placed on a non-metallic table 0.8m above the horizontal metal reference ground plane. The distance between EUT and receive antenna should be 3 meters. During the test, the EUT was operating in its typical mode. The test method is according to ANSI C63.4-2014. Sweep the whole frequency band through the range from 30MHz to the 5th harmonic of the carrier. During the test, the height of receive antenna shall be moved from 1 to 4 meters, and the antenna shall be performed under horizontal and vertical polarization. The turn table shall be rotated from 0 to 360 degrees for detecting the maximum of radiated signal level.
The data of cable loss and antenna factor has been calibrated in full testing frequency range before the testing. During the test, the EUT is worked at maximum output power.
Set the spectrum analyzer in the following:

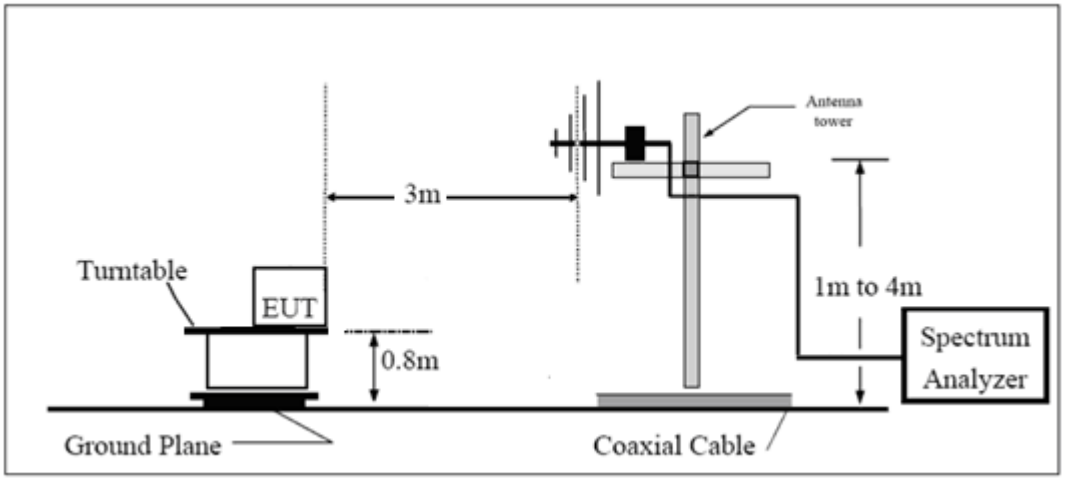
Below 1GHz:
RBW=100 kHz / VBW=300 kHz / Sweep=AUTO
Above 1GHz:
(a) PEAK Detector: RBW=1MHz / VBW=3MHz/ Sweep=AUTO
(b) AVERAGE Detector: RBW=1MHz / VBW=3MHz / Sweep=AUTO

The radiated emission was measured in the following position: EUT stand-up position (Z axis), lie-down position (X, Y axis). The worst emission was found in lie-down position (X axis) and the worst case was recorded.

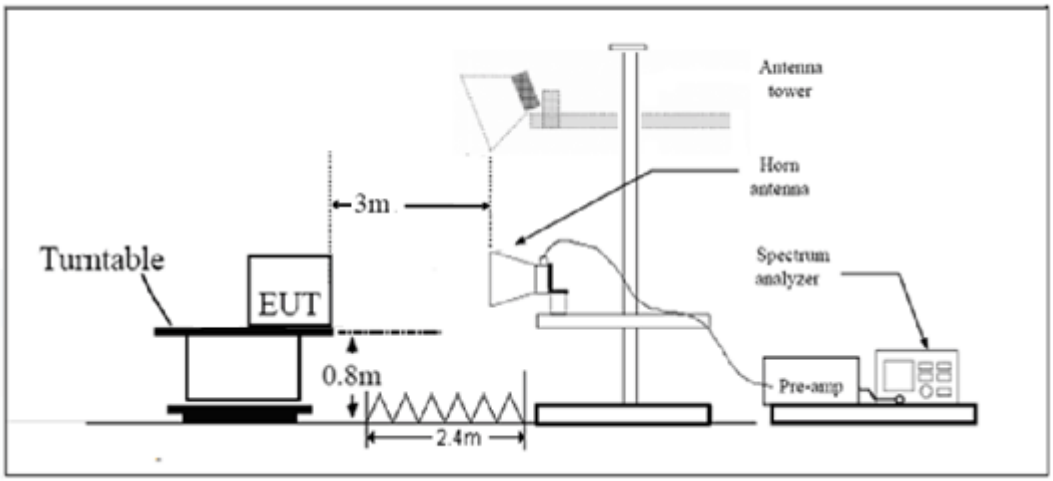
During the test, EUT is connected to a laptop via a USB cable in the case of power supply.

Test Setup

Below 1GHz



Above 1GHz



Note: Area side: 2.4mX3.6m

Antenna Tower meets ANSI C63.4 requirements for measurements above 1 GHz by keeping the antenna aimed at the EUT during the antenna's ascent/ descent along the antenna mast.

Limits

Frequency (MHz)	Field Strength (dBμV/m)	Detector
30 -88	40.0	Quasi-peak
88-216	43.5	Quasi-peak
216 – 960	46.0	Quasi-peak
960-1000	54.0	Quasi-peak
1000-5th harmonic of the highest frequency or 40GHz, which is lower	54 74	Average Peak

Measurement Uncertainty

The assessed measurement uncertainty to ensure 95% confidence level for the normal distribution is with the coverage factor k = 1.96.

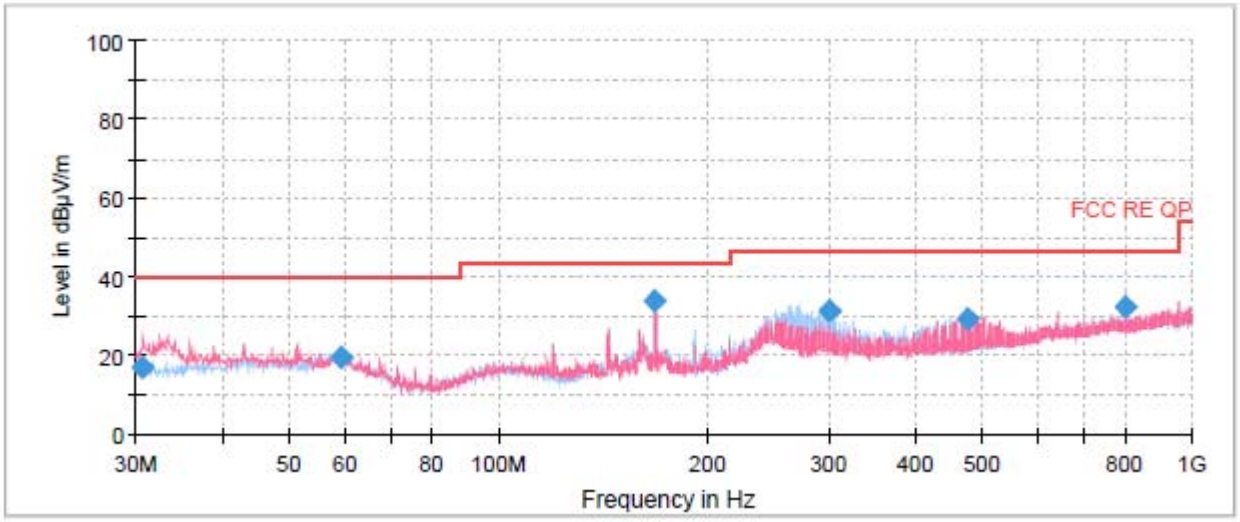
Frequency	Uncertainty
30MHz~200MHz	4.17 dB
200MHz~1000MHz	4.84 dB
1GHz~18GHz	4.35 dB
18GHz~26.5GHz	5.90 dB
26.5GHz~40GHz	5.92 dB

Test Results

Sweep the whole frequency band through the range from 30MHz to the 5th harmonic of the carrier, the Emissions in the frequency band 18GHz – 26.5GHz is more than 20dB below the limit are not reported.

The following graphs display the maximum values of horizontal and vertical by software.
For above 1GHz, Blue trace uses the peak detection, Green trace uses the average detection.

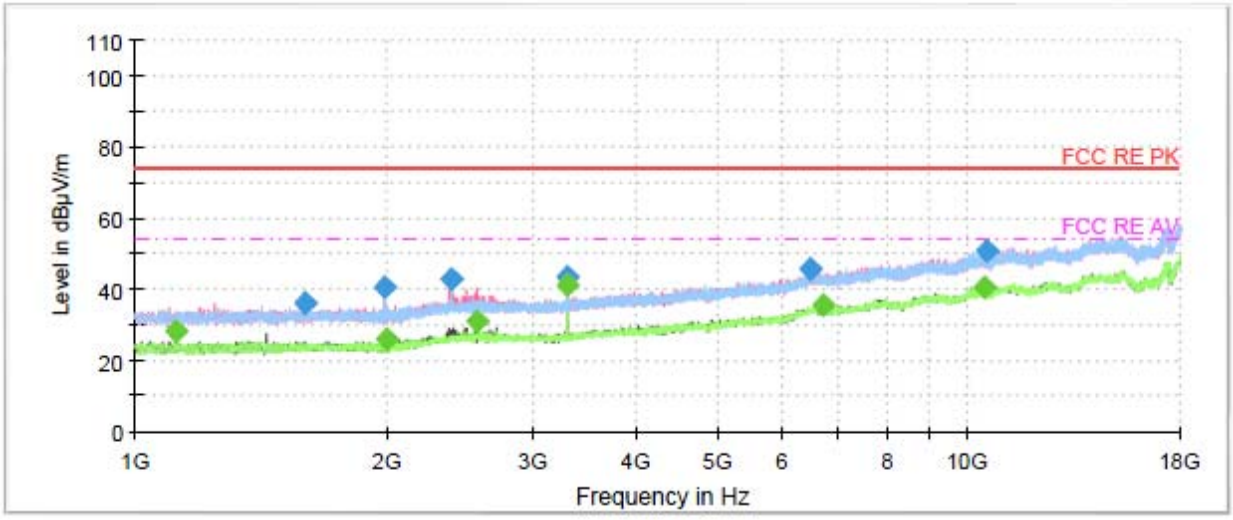
ESP32-PICO-MINI-02



Radiated Emission from 30MHz to 1GHz

Frequency (MHz)	Quasi-Peak (dBuV/m)	Height (cm)	Polarization	Azimuth (deg)	Correct Factor (dB)	Margin (dB)	Limit (dBuV/m)
30.727500	16.67	180.0	V	238.0	12.3	23.33	40.00
59.342500	19.31	220.0	H	349.0	13.9	20.69	40.00
167.982500	33.80	202.0	H	24.0	10.0	9.70	43.50
299.053750	31.29	100.0	H	74.0	15.0	14.71	46.00
475.108750	29.24	100.0	V	122.0	19.0	16.76	46.00
800.058750	32.20	105.0	H	328.0	23.2	13.80	46.00

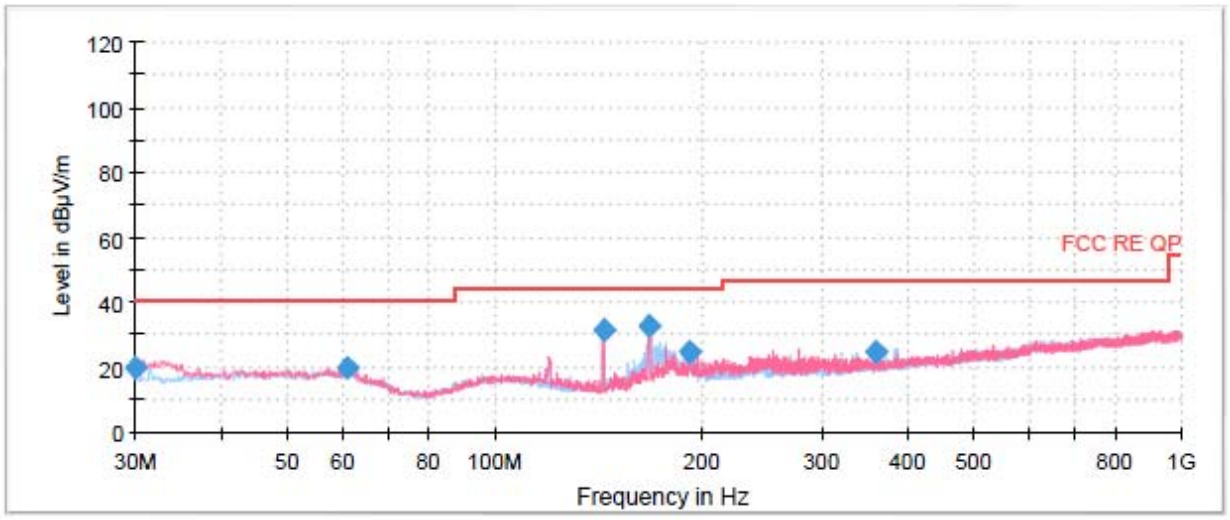
Remark: 1. Correction Factor = Antenna factor + Insertion loss(cable loss+amplifier gain)
2. Margin = Limit – Quasi-Peak



Radiated Emission from 1GHz to 18GHz

Frequency (MHz)	Peak (dBuV/m)	Average (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Height (cm)	Polarization	Azimuth (deg)	Correct Factor (dB)
1119.566667	---	28.39	54.00	25.61	100.0	V	7.0	-20.6
1597.833333	36.37	---	74.00	37.63	200.0	V	334.0	-18.9
1997.900000	40.74	---	74.00	33.26	100.0	V	333.0	-18.2
2004.133333	---	25.92	54.00	28.08	100.0	V	46.0	-18.2
2395.133333	42.81	---	74.00	31.19	100.0	V	2.0	-16.5
2578.733333	---	30.85	54.00	23.15	200.0	V	12.0	-16.1
3312.000000	---	41.40	54.00	12.60	100.0	V	199.0	-15.1
3312.000000	43.63	---	74.00	30.37	200.0	V	44.0	-15.1
6467.766667	45.81	---	74.00	28.19	200.0	V	359.0	-4.0
6690.466667	---	35.61	54.00	18.39	100.0	H	0.0	-3.5
10459.366667	---	40.89	54.00	13.11	100.0	V	333.0	-1.0
10539.266667	50.75	---	74.00	23.25	100.0	V	0.0	-0.8

ESP32-PICO-MINI-02U

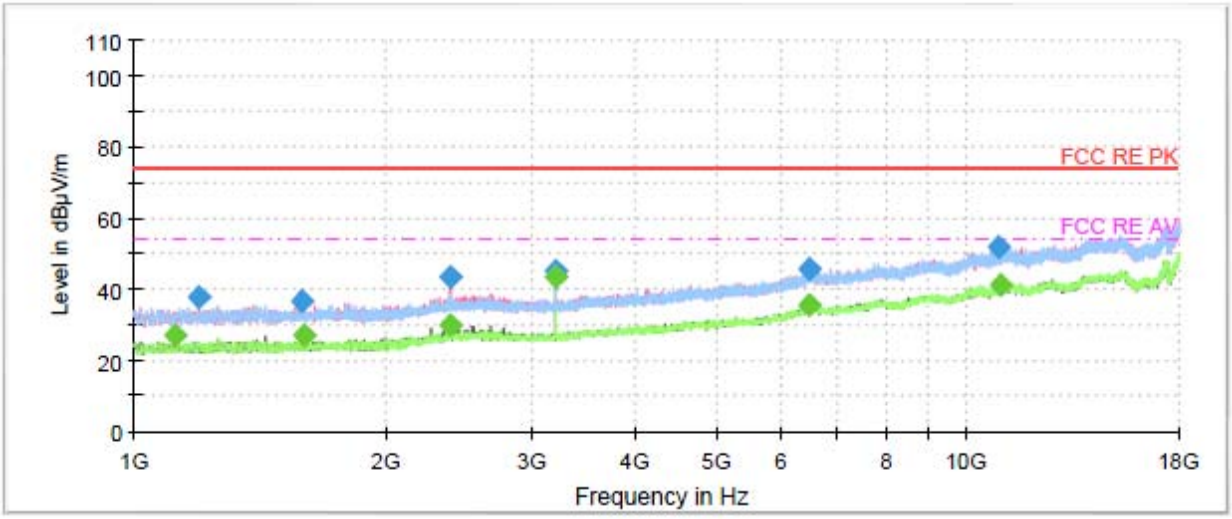


Radiated Emission from 30MHz to 1GHz

Frequency (MHz)	Quasi-Peak (dBuV/m)	Height (cm)	Polarization	Azimuth (deg)	Correct Factor (dB)	Margin (dB)	Limit (dBuV/m)
30.000000	19.66	180.0	V	13.0	12.2	20.34	40.00
61.206250	19.56	105.0	V	310.0	13.2	20.44	40.00
143.972500	31.27	112.0	V	68.0	9.0	12.23	43.50
167.698750	32.60	100.0	V	144.0	10.0	10.90	43.50
191.911250	24.79	125.0	H	200.0	12.4	18.71	43.50
359.883750	24.37	105.0	H	56.0	16.4	21.63	46.00

Remark: 1. Correction Factor = Antenna factor + Insertion loss(cable loss+amplifier gain)

2. Margin = Limit – Quasi-Peak



Radiated Emission from 1GHz to 18GHz

Frequency (MHz)	Peak (dBuV/m)	Average (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Height (cm)	Polarization	Azimuth (deg)	Correct Factor (dB)
1119.566667	---	27.29	54.00	26.71	200.0	V	357.0	-20.6
1195.500000	37.73	---	74.00	36.27	100.0	V	34.0	-20.3
1592.733333	36.93	---	74.00	37.07	100.0	H	58.0	-18.9
1599.533333	---	26.92	54.00	27.08	100.0	V	160.0	-18.9
2394.566667	43.30	---	74.00	30.70	200.0	V	143.0	-16.5
2396.833333	---	30.01	54.00	23.99	100.0	V	216.0	-16.5
3215.666667	---	43.19	54.00	10.81	100.0	V	216.0	-15.1
3215.666667	44.90	---	74.00	29.10	100.0	V	216.0	-15.1
6476.266667	45.69	---	74.00	28.31	200.0	H	2.0	-3.9
6487.600000	---	35.61	54.00	18.39	100.0	V	216.0	-3.8
10897.400000	51.89	---	74.00	22.11	200.0	V	186.0	-0.4
10960.300000	---	41.44	54.00	12.56	200.0	V	0.0	-0.2

3.2 Conducted Emission

Ambient condition

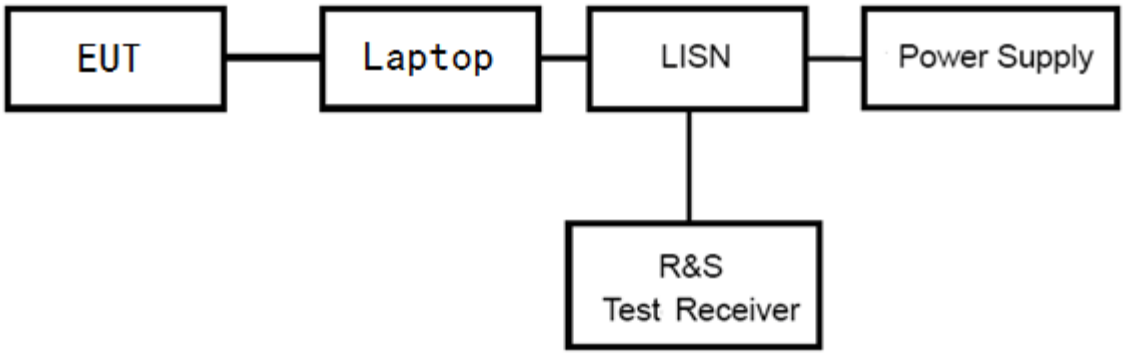
Temperature	Relative humidity	Pressure
15°C~35°C	30%~60%	101.5kPa

Methods of Measurement

The EUT is placed on a non-metallic table of 80cm height above the horizontal metal reference ground plane. During the test, the EUT was operating in its typical mode. The test method is according to ANSI C63.4-2014. Connect the AC power line of the EUT to the L.I.S.N. Use EMI receiver to detect the average and Quasi-peak value. RBW is set to 9 kHz, VBW is set to 30kHz. The measurement result should include both L line and N line.

During the test, EUT is connected to a laptop via a USB cable in the case of power supply.

Test Setup



Note: Power Supply is AC Power source and it is used to change the voltage 120V/60Hz.

Limits

Frequency (MHz)	Conducted Limits(dBμV)	
	Quasi-peak	Average
0.15 - 0.5	66 to 56 *	56 to 46*
0.5 - 5	56	46
5 - 30	60	50
*: Decreases with the logarithm of the frequency.		

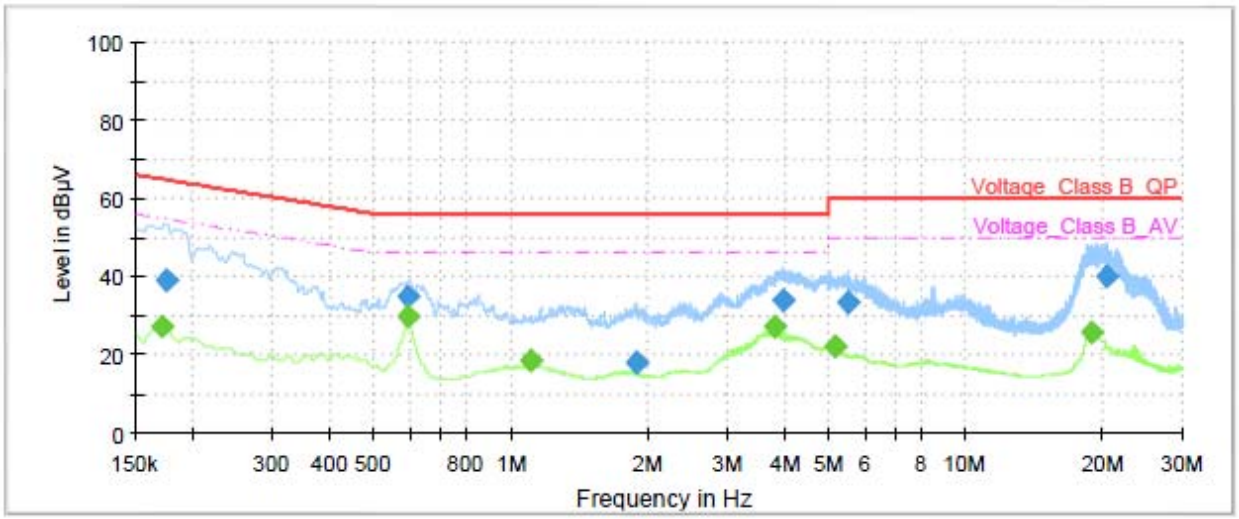
Measurement Uncertainty

The assessed measurement uncertainty to ensure 95% confidence level for the normal distribution is with the coverage factor k = 1.96. U= 2.57 dB.

Test Results

Following plots, Blue trace uses the peak detection; Green trace uses the average detection.

ESP32-PICO-MINI-02

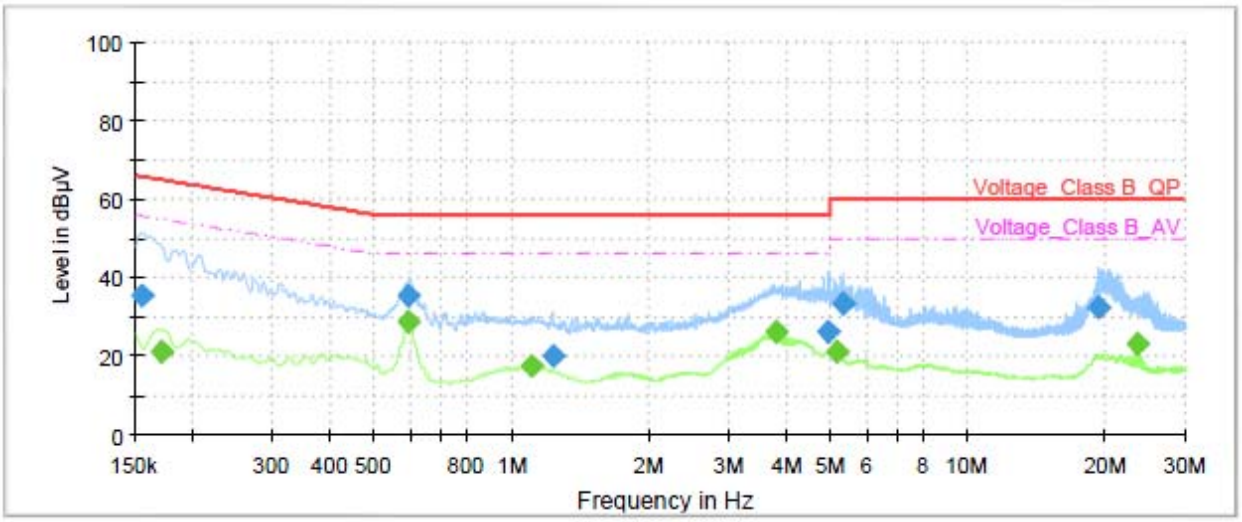


Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.17	---	27.19	54.95	27.76	70.0	9.000	L1	ON	21
0.17	39.03	---	64.73	25.70	70.0	9.000	L1	ON	21
0.59	34.76	---	56.00	21.24	70.0	9.000	L1	ON	20
0.60	---	29.64	46.00	16.36	70.0	9.000	L1	ON	20
1.11	---	18.37	46.00	27.63	70.0	9.000	L1	ON	20
1.90	18.20	---	56.00	37.80	70.0	9.000	L1	ON	20
3.82	---	26.97	46.00	19.03	70.0	9.000	L1	ON	19
3.96	33.74	---	56.00	22.26	70.0	9.000	L1	ON	19
5.16	---	21.87	50.00	28.13	70.0	9.000	L1	ON	19
5.49	33.09	---	60.00	26.91	70.0	9.000	L1	ON	19
19.03	---	25.68	50.00	24.32	70.0	9.000	L1	ON	20
20.37	40.20	---	60.00	19.80	70.0	9.000	L1	ON	20

Remark: Correct factor=cable loss + LISN factor

L line

Conducted Emission from 150 KHz to 30 MHz



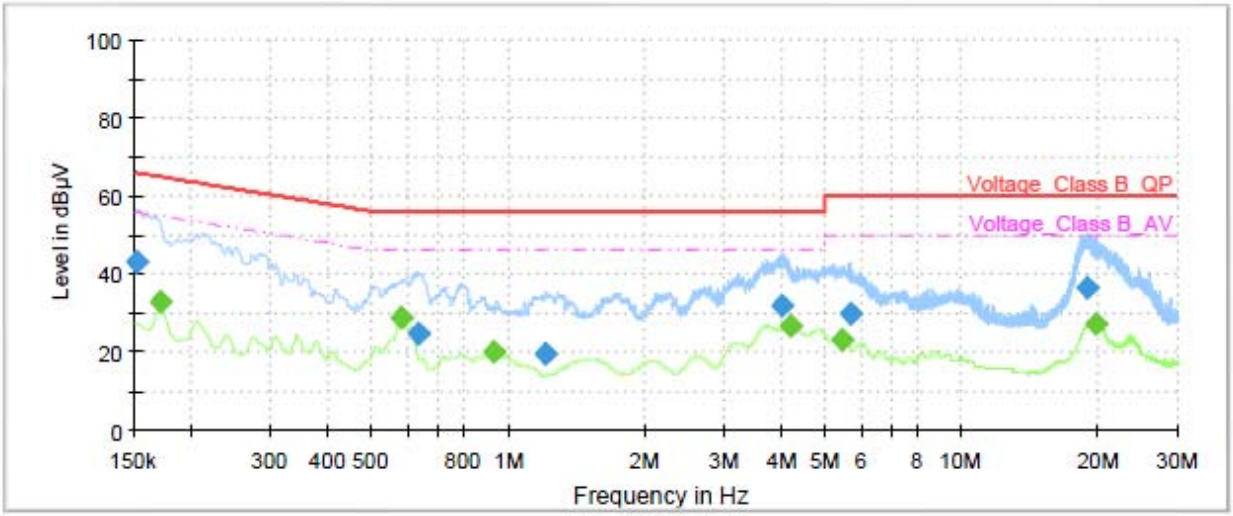
Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.15	35.59	---	65.75	30.16	70.0	9.000	N	ON	21
0.17	---	21.20	54.95	33.75	70.0	9.000	N	ON	21
0.60	---	28.56	46.00	17.44	70.0	9.000	N	ON	20
0.60	35.13	---	56.00	20.87	70.0	9.000	N	ON	20
1.11	---	17.38	46.00	28.62	70.0	9.000	N	ON	20
1.23	20.13	---	56.00	35.87	70.0	9.000	N	ON	20
3.80	---	26.37	46.00	19.63	70.0	9.000	N	ON	19
4.94	26.08	---	56.00	29.92	70.0	9.000	N	ON	19
5.16	---	21.26	50.00	28.74	70.0	9.000	N	ON	19
5.35	33.26	---	60.00	26.74	70.0	9.000	N	ON	19
19.47	32.12	---	60.00	27.88	70.0	9.000	N	ON	20
23.71	---	23.13	50.00	26.87	70.0	9.000	N	ON	20

Remark: Correct factor=cable loss + LISN factor

N line

Conducted Emission from 150 KHz to 30 MHz

ESP32-PICO-MINI-02U

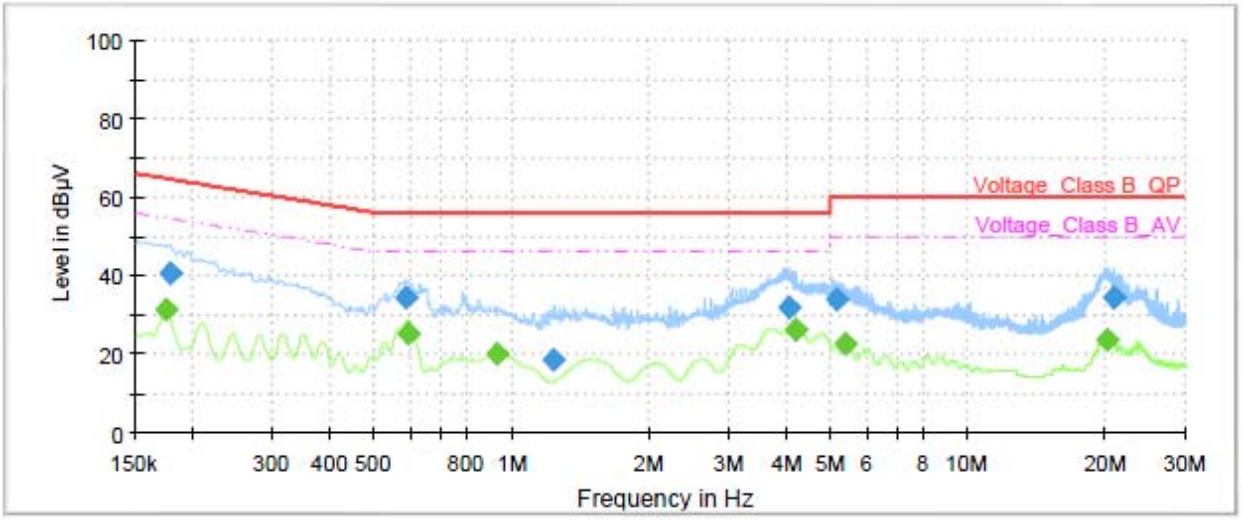


Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.15	43.31	---	65.88	22.57	70.0	9.000	L1	ON	21
0.17	---	32.90	54.95	22.05	70.0	9.000	L1	ON	21
0.58	---	28.56	46.00	17.44	70.0	9.000	L1	ON	20
0.63	24.84	---	56.00	31.16	70.0	9.000	L1	ON	20
0.93	---	19.82	46.00	26.18	70.0	9.000	L1	ON	20
1.21	19.53	---	56.00	36.47	70.0	9.000	L1	ON	20
4.01	31.90	---	56.00	24.10	70.0	9.000	L1	ON	19
4.21	---	26.70	46.00	19.30	70.0	9.000	L1	ON	19
5.44	---	22.83	50.00	27.17	70.0	9.000	L1	ON	19
5.71	29.86	---	60.00	30.14	70.0	9.000	L1	ON	19
19.03	36.42	---	60.00	23.58	70.0	9.000	L1	ON	20
19.83	---	27.23	50.00	22.77	70.0	9.000	L1	ON	20

Remark: Correct factor=cable loss + LISN factor

L line

Conducted Emission from 150 KHz to 30 MHz



Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.17	---	31.46	54.73	23.27	70.0	9.000	N	ON	21
0.18	40.55	---	64.52	23.97	70.0	9.000	N	ON	21
0.59	34.59	---	56.00	21.41	70.0	9.000	N	ON	20
0.59	---	25.12	46.00	20.88	70.0	9.000	N	ON	20
0.93	---	19.99	46.00	26.01	70.0	9.000	N	ON	20
1.24	18.65	---	56.00	37.35	70.0	9.000	N	ON	20
4.08	31.80	---	56.00	24.20	70.0	9.000	N	ON	19
4.19	---	26.38	46.00	19.62	70.0	9.000	N	ON	19
5.18	33.81	---	60.00	26.19	70.0	9.000	N	ON	19
5.40	---	22.55	50.00	27.45	70.0	9.000	N	ON	19
20.17	---	23.82	50.00	26.18	70.0	9.000	N	ON	20
20.89	34.18	---	60.00	25.82	70.0	9.000	N	ON	20

Remark: Correct factor=cable loss + LISN factor

N line

Conducted Emission from 150 KHz to 30 MHz

4 Main Test Instruments

Name	Manufacturer	Type	Serial Number	Calibration Date	Expiration Time
Spectrum Analyzer	R&S	FSV40	15195-01-00	2021-05-15	2022-05-14
EMI Test Receiver	R&S	ESCI	100948	2021-05-15	2022-05-14
Trilog Antenna	SCHWARZBECK	VULB 9163	391	2019-12-16	2022-12-15
Horn Antenna	R&S	HF907	102723	2020-08-11	2023-08-10
Horn Antenna	ETS-Lindgren	3160-09	00102643	2018-06-20	2023-06-19
EMI Test Receiver	R&S	ESR	101667	2021-05-16	2022-05-15
LISN	R&S	ENV216	101171	2018-12-15	2021-12-14
Bore Sight Antenna mast	ETS	2171B	00058752	/	/
Test software	EMC32	R&S	9.26.0	/	/

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

ANNEX A: The EUT Appearance

The EUT Appearance are submitted separately.

ANNEX B: Test Setup Photos

The Test Setup Photos are submitted separately.