中认信通
CHINA CERTIFICATION ICT CO., LTD (DONGGUAN)

ACCREDITED
TESTING LABORATORY
CERTIFICATE # 6356.01

TEST REPORT

Applicant: **SHENZHEN HUAPTEC CO., LTD**

Address: 3rd FL, E BLDG, Sogood Science Park, SanWei community, Hangcheng Street, Bao'an District, Shenzhen, China

FCC ID: **OWWF115715S**

Product Name: **Wideband Consumer Signal Booster**

Standard(s): **47 CFR Part 20.21**
ANSI C63.26-2015
KDB 935210 D03 Signal Booster Measurements v04r04

The above device has been tested and found compliant with the requirement of the relative standards by China Certification ICT Co., Ltd (Dongguan)

Report Number: **CR230954301-00A1**

Date Of Issue: **2023/12/28**

Reviewed By: **Calvin Chen**

Title: RF Engineer

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Test Facility

The Test site used by China Certification ICT Co., Ltd (Dongguan) to collect test data is located on the No. 113, Pingkang Road, Dalang Town, Dongguan, Guangdong, China.

The lab has been recognized as the FCC accredited lab under the KDB 974614 D01 and is listed in the FCC Public Access Link (PAL) database, FCC Registration No. : 442868, the FCC Designation No. : CN1314.

Declarations

China Certification ICT Co., Ltd (Dongguan) is not responsible for the authenticity of any test data provided by the applicant. Data included from the applicant that may affect test results are marked with a triangle symbol "▲". Customer model name, addresses, names, trademarks etc. are not considered data.

Unless otherwise stated the results shown in this test report refer only to the sample(s) tested.

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DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
1.0	CR230954301-00A1	Original Report	2023/12/28

1. GENERAL INFORMATION

1.1 Product Description for Equipment under Test (EUT)

1.1.1 General:

EUT Name:	Wideband Consumer Signal Booster
EUT Model:	F20GTI-5S-IOT.PRO
Multiple Model(s):	F10GTI-5S-IOT, F10GTI-5S-IOT.PRO, F15GTI-5S-IOT, F15GTI-5S-IOT.PRO, F20GTI-5S-IOT
Trade Mark:	HiBoost
Rated Input Voltage:	DC 12V from adapter
Serial Number:	2BHQ-1
EUT Received Date:	2023/9/20
EUT Received Status:	Good
Note: The Multiple models are electrically identical with the test model. Please refer to the declaration letter for more detail, which was provided by manufacturer.	

1.1.2 Operation Frequency:

Bands	Uplink Frequency (MHz)	Downlink Frequency (MHz)
Lower 700	698-716	728-746
Upper 700	776-787	746-757
Cellular	824-849	869-894
PCS	1850-1915	1930-1995
AWS-1	1710-1755	2110-2155

1.1.3 Antenna kitting Information▲:

EUT has multiple sets antenna kitting for marketing, the antenna gain for varied band were listed in user manual, fulfill the requirement of FCC Part 20.21(e)(8)(i)(G), more detail information please refer to the user manuals.

Outdoor Antenna:

Bands	Frequency (MHz)	Yagi antenna (model: HODL698-2700V8i60A) (dBi)	Cable Loss (dB)
Lower 700	698-716	7.5	4.97
Upper 700	776-787	7.5	4.97
Cellular	824-849	8	5.17
PCS	1850-1915	9	7.51
AWS-1	1710-1755	9	7.51

Indoor Antenna:

Bands	Frequency (MHz)	Panel antenna (model: AI698-2700V09iB) (dBi)	Internal antenna (dBi)	Cable Loss (dB)
Lower 700	728-746	6.5	0	4.97
Upper 700	746-757	6.5	0	4.97
Cellular	869-894	6.5	0	5.17
PCS	1930-1995	8.5	0	7.51
AWS-1	2110-2155	8.5	0	7.51
Note: the antenna gain of the two antenna including the cable loss				

Note: Antenna port of indoor 1 connects to the internal antenna, this port is only used for internal antenna port conducted test, indoor 1 port cannot connect to any external indoor antenna, the cable loss is 0 dB.

The antenna port of indoor 1 and indoor 2 has the same circuit path, there is a switch between these ports.

There are two testing configurations:
Configuration 1:EUT will be connected to internal antenna, testing was conducted at port of indoor l
Configuration 2: EUT will be connected to external indoor antenna, testing was conducted at port of indoor 2

1.1.4 Accessory Information:

Accessory Description	Manufacturer	Model	Parameters
Adapter	Shenzhen Jiuzhou Power Technology Co., Ltd.	GM50-120300-F	Input: AC 100-240V, 50/60Hz, 1.5A Output: DC 12V, 3.0A

1.2 Description of Test Configuration

1.2.1 EUT Operation Condition:

EUT Operation Mode:	The system was configured for testing in a test mode which has been done in the factory.
Equipment Modifications:	No
EUT Exercise Software:	No

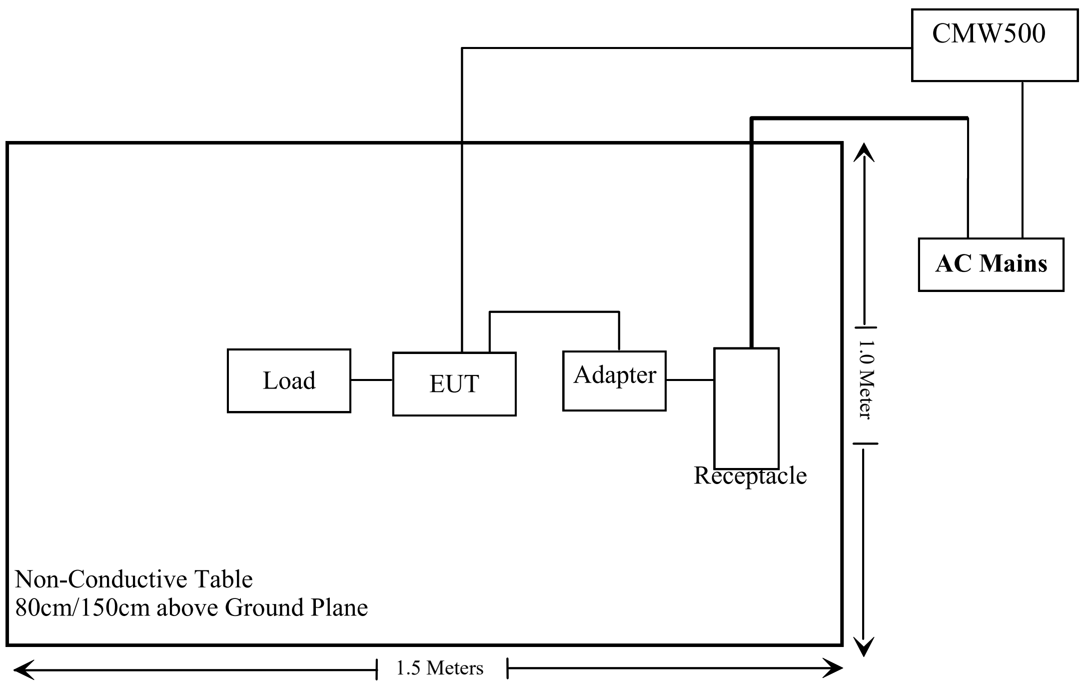
1.2.2 Support Equipment List and Details

Manufacturer	Description	Model	Serial Number
Unknown	50ΩLoad	Unknown	BACLload002
Rohde & Schwarz	Wideband Radio Communication Tester	CMW500	154606

1.2.3 Support Cable List and Details

Cable Description	Length (m)	From Port	To
Un-shielded Un-Detachable DC cable	1.2	Adapter	EUT
Shielded Detachable RF cable	5.0	CMW500	EUT

1.2.4 Radiated Spurious Emissions Block Diagram of Test Setup



1.3 Measurement Uncertainty

Otherwise required by the applicant or Product Regulations, Decision Rule in this report did not consider the uncertainty. The extended uncertainty given in this report is obtained by combining the standard uncertainty times the coverage factor K with the 95% confidence interval.

Parameter	Measurement Uncertainty
Occupied Channel Bandwidth	±5 %
RF output power, conducted	±0.61dB
Unwanted Emissions, radiated	30M~200MHz: 4.15 dB,200M~1GHz: 5.61 dB,1G~6GHz: 5.14 dB, 6G~18GHz: 5.93 dB,18G~26.5G:5.47 dB,26.5G~40G:5.63 dB
Unwanted Emissions, conducted	±1.26 dB
Temperature	±1℃
Humidity	±5%
DC and low frequency voltages	±0.4%
Duty Cycle	1%
RF Frequency	$\pm 0.082\times10^{-6}$

2. SUMMARY OF TEST RESULTS

S/N	FCC Rules	Description of Test	Results	Remark
1	§20.21(e)(3)	3.1 Authorized Frequency Band Verification	-	See Note
2	§ 20.21(e)(8)(i)(D) § 20.21(e)(8)(i)(B) §20.21(e)(4)	3.2 Maximum Power Measurement	Report only	-
3	§ 20.21(e)(8)(i)(C)(2)(i) § 20.21(e)(8)(i)(B) §20.21(e)(4)	3.3 Maximum Booster Gain Computation	-	See Note
4	§ 20.21(e)(8)(i)(F)	3.4 Intermodulation Product	-	See Note
5	§ 20.21(e)(8)(i)(E)	3.5 Out Of Band Emissions	-	See Note
6	§2.1051	3.6 Spurious Emissions At Antenna Terminals	-	See Note
7	§ 20.21(e)(8)(i)(A)(1)(i) § 20.21(e)(8)(i)(H) §20.21(e)(4)	3.7 Noise Limits	-	See Note
8	§ 20.21(e)(8)(i)(I) §20.21(e)(4)	3.8 Uplink Inactivity	-	See Note
9	§ 20.21(e)(8)(i)(C)(1) § 20.21(e)(8)(i)(H)	3.9 Variable Booster Gain	-	See Note
10	§ 2.1049	3.10 Occupied Bandwidth	-	See Note
11	§ 20.21(e)(8)(ii)(A) §20.21(e)(5)	3.11 Oscillation Detection	-	See Note
12	§2.1053	3.12 Radiated Spurious Emissions	Compliant	-
13	§ 20.21(e)(8)(i)(B) § 20.21(e)(3)	3.13 Spectrum block filtering test procedure	Not applicable	-
14	§ 1.1307	RF Exposure Evaluation	Compliant	-

Not applicable: This item only for wideband consumer boosters using spectrum block filtering.

Note:
1: This is Class II permissive change application for FCC ID: OWWF115715S, the below changes was made based on the device granted on 09/12/2022, which was provided by the manufacturer▲:

a. Changing product name.
b. Changing product appearance.
c. Changing the combiner.

2: The output power was checked and consist with original device.

3: The test data refers to the report SZNS220622-27964E-RF-00.

4: The China Certification ICT Co., Ltd (Dongguan) is responsible for all the information provided in this report, except when information is provided by the customer as identified in this report.

3. REQUIREMENTS AND TEST PROCEDURES

3.1 Authorized Frequency Band Verification

3.1.1 Applicable Standard

According to§ 20.21(e)(3) *Frequency Bands*.

This test is intended to confirm that the signal booster only operates on the CMRS frequency bands authorized for use by the NPS. In other words, the signal booster shall reject amplification of other signals outside of its passband. In addition, this test will identify the frequency at which the maximum gain is realized within each CMRS operational band, which then serves as a basis for subsequent tests.

3.1.2 Test Procedure

a) Connect the EUT to the test equipment as shown in **Figure 1**. Begin with the uplink output (donor) port connected to the spectrum analyzer.
b) Set the spectrum analyzer resolution bandwidth (RBW) for 100 kHz with the video bandwidth (VBW) ≥ 3 the RBW, using a PEAK detector with the MAX HOLD function.
c) Set the center frequency of the spectrum analyzer to the center of the operational band under test with a span of 1 MHz.
d) Set the signal generator for CW mode and tune to the center frequency of the operational band under test.
e) Set the initial signal generator power to a level that is at least 6 dB below the AGC level specified by the manufacturer.
f) Slowly increase the signal generator power level until the output signal reaches the AGC operational level.
g) Reduce the signal generator power to a level that is 3 dB below the level noted above, then manually reset the EUT (e.g., cycle ac/dc power).
h) Reset the spectrum analyzer span to 2 the width of the CMRS band under test. Adjust the tuned frequency of the signal generator to sweep 2 the width of the CMRS band using the sweep function. The AGC must be deactivated throughout the entire sweep.
i) Using three markers, identify the CMRS band edges and the frequency with the highest power. Affirm that the values of all markers are visible on the display of the spectrum analyzer (e.g., marker table set to on).
j) Capture the spectrum analyzer trace for inclusion in the test report.
k) Repeat 7.1c) to 7.1j) for all operational uplink and downlink bands.

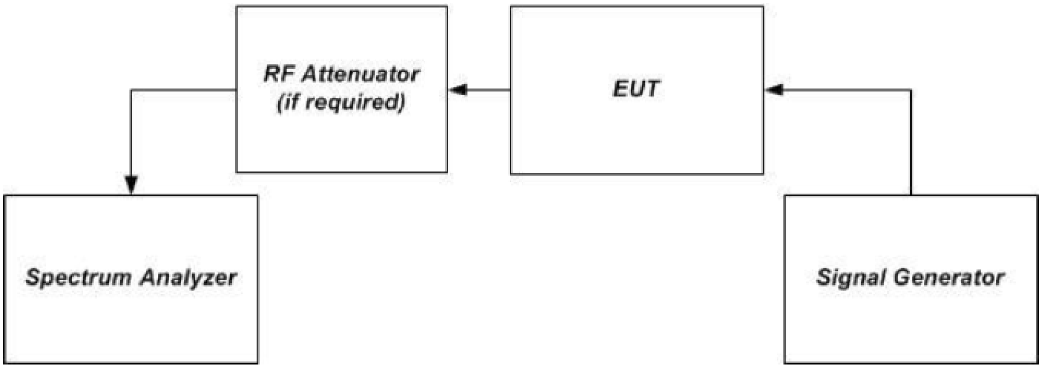


Figure 1 – Band verification test instrumentation setup

3.2 Maximum Power Measurement

3.2.1 Applicable Standard

According to§ 20.21(e)(8)(i)(D) *Power Limits*; § 20.21(e)(8)(i)(B) *Bidirectional Capability* (uplink minimum conducted power output); §20.21(e)(4) *Self-monitoring*.

This procedure shall be used to demonstrate compliance to the signal booster power limits and requirements as specified in Sections 20.21(e)(8)(i)(D) and 20.21(e)(8)(i)(B) for wideband consumer signal boosters.

a) Compliance to applicable EIRP limits must be shown using the highest gains from the list of antennas, cabling, and coupling devices declared by the manufacturer for use with the consumer booster.
b) In addition, the maximum power levels measured in this procedure will be used in calculating the maximum gain as described in the next subclause.
c) The frequency with the highest power level in each operational band as determined in 7.1 is to be measured discretely by applying the following procedure using the stated emission and power detector types independently.
d) Use a signal generator to create a pulsed CW or GSM signal with a pulse width of 570 μs and a duty cycle of 12.5% (i.e., one GSM timeslot), then measure using the burst power function of the measuring instrument.
e) Use a signal generator to create an AWGN signal with a 99% occupied bandwidth (OBW) of 4.1 MHz, then measure using the channel power or band power function of the measuring instrumentation.
f) All modes of operation must be verified to maintain operation within applicable limits at the maximum uplink and downlink test levels per device type as defined in 5.5, by increasing the power level in 2 dB steps from the AGC level to the maximum input level specified in 5.5.

3.2.2 Test Procedure

a) Connect the EUT to the test equipment as shown in **Figure 1**. Begin with the uplink output (donor) port connected to the spectrum analyzer.
b) Configure the signal generator and spectrum analyzer for operation on the frequency determined in 7.1 with the highest power level, but with the center frequency of the signal no closer than 2.5 MHz from the band edge. The spectrum analyzer span shall be set to at least 10 MHz.
c) Set the initial signal generator power to a level well below that which causes AGC activation.
d) Slowly increase the signal generator power level until the output signal reaches the AGC operational limit (from observation of signal behavior on the spectrum analyzer; i.e., no further increase in output power as input power is increased).
e) Reduce power sufficiently on the signal generator to ensure that the AGC is not controlling the power output.
f) Slowly increase the signal generator power to a level just below (and within 0.5 dB of) the AGC limit without triggering the AGC. Note the signal generator power level as Pin.
g) Measure the output power, Pout, with the spectrum analyzer as follows.
  1) Set RBW = 100 kHz for AWGN signal type, or 300 kHz for CW or GSM signal type.
  2) Set VBW ≥ 3*RBW.
  3) Select either the BURST POWER or CHANNEL POWER measurement mode, as required for each signal type. For AWGN, the channel power integration bandwidth shall be the 99% OBW of the 4.1 MHz signal.
  4) Select the power averaging (rms) detector.
  5) Affirm that the number of measurement points per sweep ≥ (2*span)/RBW.
  NOTE–This requirement does not apply for BURST power measurement mode.
  6) Set sweep time = auto couple, or as necessary (but no less than auto couple value).
  7) Trace average at least 100 traces in power averaging (i.e., rms) mode.
  8) Record the measured power level Pout, with one set of results for the GSM or CW input stimulus, and another set of results for the AWGN input stimulus.
h) Repeat step g) while increasing the signal generator amplitude in 2 dB steps until the maximum input level indicated in 5.5 is reached. If the booster has shut down at any point during the input power steps, it should be noted and step g) shall be repeated at an input level 1 dB less than that found to cause the shutdown. The test report shall include either a statement describing that the device complies at 10 dB above AGC or at the 5.5 power levels, or a table showing compliance at the additional input power(s) required.
i) Repeat the entire procedure for each operational uplink and downlink frequency band supported by the booster.
j) Provide tabulated results in the test report.

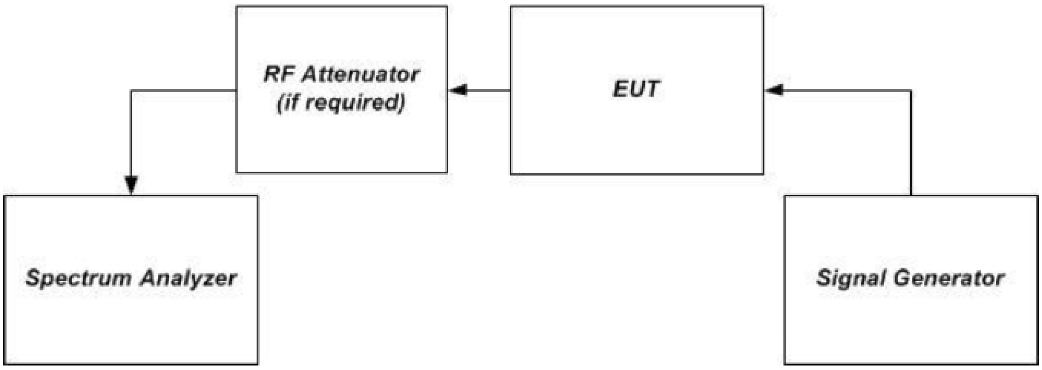


Figure 1 – Band verification test instrumentation setup

3.3 Maximum Booster Gain Computation

3.3.1 Applicable Standard

According to§ 20.21(e)(8)(i)(C)(2) *Booster Gain Limits* (maximum gain); § 20.21(e)(8)(i)(B) *Bidirectional Capability* (equivalent uplink and downlink gain); §20.21(e)(4) *Self-monitoring*.

This subclause provides guidance for the calculation of the maximum gain, based on the results obtained from the 7.1 and 7.2 measurements. The NPS limits on maximum gain for fixed and mobile wideband consumer signal boosters are provided in Section 20.21(e)(8)(i)(C)(2). Additionally, Section 20.21(e)(8)(i)(B) requires that wideband consumer signal boosters be able to provide equivalent uplink and downlink gain, i.e., within 9 dB.

3.3.2 Test Procedure

a) Calculate the maximum gain of the booster as follows to demonstrate compliance to the applicable gain limits as specified.
b) For both the uplink and downlink in each supported frequency band, use each of the P_{OUT} and P_{IN} result pairs for all signal types used in 7.2 in the following equation to obtain the maximum gain, G:
$G\ (dB) = P_{OUT}(dBm) - P_{IN}(dBm)$.
c) Record the maximum gain of the uplink and downlink paths for each supported frequency band, and verify that the each gain value complies with the applicable limit.
d) Provide tabulated results in the test report.

3.4 Intermodulation Product

3.4.1 Applicable Standard

According to§ 20.21(e)(8)(i)(F) *Intermodulation Limits*.

3.4.2 Test Procedure

The following procedures shall be used to demonstrate compliance to the intermodulation limit specified in Section 20.21(e)(8)(i)(F) for wideband consumer signal boosters.

a) Connect the signal booster to the test equipment as shown in **Figure 2**. Begin with the uplink output (donor) port connected to the spectrum analyzer.
b) Set the spectrum analyzer RBW = 3 kHz.
c) Set the VBW ≥ 3*RBW.
d) Select the rms detector.
e) Set the spectrum analyzer center frequency to the center of the supported operational band under test.
f) Set the span to 5 MHz. Affirm that the number of measurement points per sweep ≥ (2 × span)/RBW.

g) Configure the two signal generators for CW operation with generator #1 tuned 300 kHz below the operational band center frequency and generator #2 tuned 300 kHz above the operational band center frequency. If the maximum output power is not at the operational-band (booster pass band) center frequency, configure the test signal pair around the frequency with maximum output power as determined per 7.2.
h) Set the signal generator amplitudes so that the power from each into the EUT is equivalent, then turn on the RF output.
i) Simultaneously increase each signal generators' amplitude equally until just before the EUT begins AGC, then affirm that all intermodulation-product emissions (if any occur) are below the specified limit of −19 dBm.
j) Use the trace averaging function of the spectrum analyzer, and wait for the trace to stabilize. Place a marker at the highest amplitude intermodulation-product emission.
k) Record the maximum intermodulation product amplitude level that is observed.
l) Capture the spectrum analyzer trace for inclusion in the test report.
m) Repeat 7.4e) to 7.4l) for all uplink and downlink operational bands.
NOTE–If using a single signal generator with dual outputs, affirm that intermodulation products are not the result of the generator.
n) Increase the signal generator amplitude in 2 dB steps to 10 dB above the AGC threshold determined in 7.4i), but not exceeding the maximum input level of 5.5, to affirm that the EUT maintains compliance with the intermodulation limit. The test report shall include either a statement describing that the device complies at 10 dB above AGC or at the 5.5 power levels, or a table showing compliance at the additional input power(s) required.

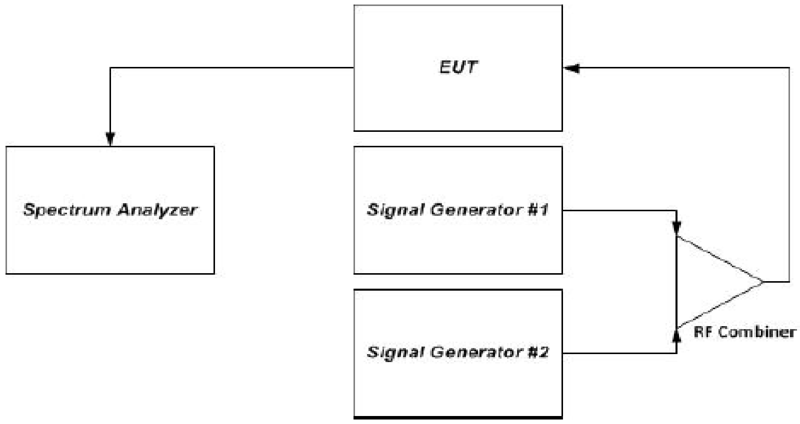


Figure 2 – Intermodulation product instrumentation test setup

3.5 Out Of Band Emissions

3.5.1 Applicable Standard

According to§ 20.21(e)(8)(i)(E) *Out of Band Emission Limits*.

3.5.2 Test Procedure

This measurement is intended to demonstrate compliance to the limit specified in Section 20.21(e)(8)(i)(E). The mobile-station emission limit is listed in Appendix A for each applicable operating band and rule part.

a) Connect the EUT to the test equipment as shown in **Figure 1**. Begin with the uplink output (donor) port connected to the spectrum analyzer.
b) Configure the signal generator for the appropriate operation for all uplink and downlink bands:

1) GSM: 0.2 MHz from upper and lower band edges.
2) LTE (5 MHz): 2.5 MHz from upper and lower band edges.
3) CDMA: 1.25 MHz from upper and lower band edges, except for cellular band as follows (only the upper and lower frequencies need to be tested):
824.88 MHz, 845.73 MHz, 836.52 MHz, 848.10 MHz,
869.88 MHz, 890.73 MHz, 881.52 MHz, 893.10 MHz.

NOTE 1–Alternative test modulation types:
• CDMA (alternative 1.25 MHz AWGN)
• LTE 5 MHz (alternative W-CDMA or 4.1 MHz AWGN)
NOTE 2–For LTE, the signal generator should use the uplink and downlink signal types for these modulations in uplink and downlink tests, respectively. LTE shall use 5 MHz signal, 25 resource blocks transmitting.
NOTE 3–When using an AWGN test signal, the bandwidth shall be the measured 99% OBW.

c) Set the signal generator amplitude to the maximum power level prior to AGC similar to 7.2.2e) to 7.2.2f) of the power measurement procedures for the appropriate modulations.
d) Set RBW = measurement bandwidth specified in the applicable rule section for the supported frequency band (see Appendix A for cross-reference to applicable rule section).
NOTE 3–Within 300 kHz and 3 MHz away from band edge, if smaller RBW is used (i.e., RBW < 100 kHz or 1 MHz, for above and below 1 GHz, respectively), per Parts 24 and 27 the smaller RBW is applicable only for frequencies within 100 kHz or 1 MHz (for above and below 1 GHz, respectively) away from the band edge.
e) Set VBW = 3* RBW.
f) Select the power averaging (rms) detector.
g) Sweep time = auto-couple.
h) Set the analyzer start frequency to the upper band/block edge frequency and the stop frequency to the upper band/block edge frequency plus: 300 kHz (when operational frequency is < 1 GHz), or 3 MHz (when operational frequency is ≥ 1 GHz).
i) Trace average at least 100 traces in power averaging (i.e., rms) mode.
j) Use peak marker function to find the maximum power level.
k) Capture the spectrum analyzer trace of the power level for inclusion in the test report.
l) Increase the signal generator amplitude in 2 dB steps until the maximum input level per 5.5 is reached. Affirm that the EUT maintains compliance with the OOBE limits. The test report shall include either a statement describing that the device complies at 10 dB above AGC or at the 5.5 power levels, or a table showing compliance at the additional input power(s) required.
m) Reset the analyzer start frequency to the lower band/block edge frequency minus: 300 kHz (when operational frequency is < 1 GHz), or 3 MHz (when operational frequency is ≥ 1 GHz), and the stop frequency to the lower band/block edge frequency, then repeat 7.5i) to 7.5l).
n) Repeat 7.5b) through 7.5m) for each uplink and downlink operational band.

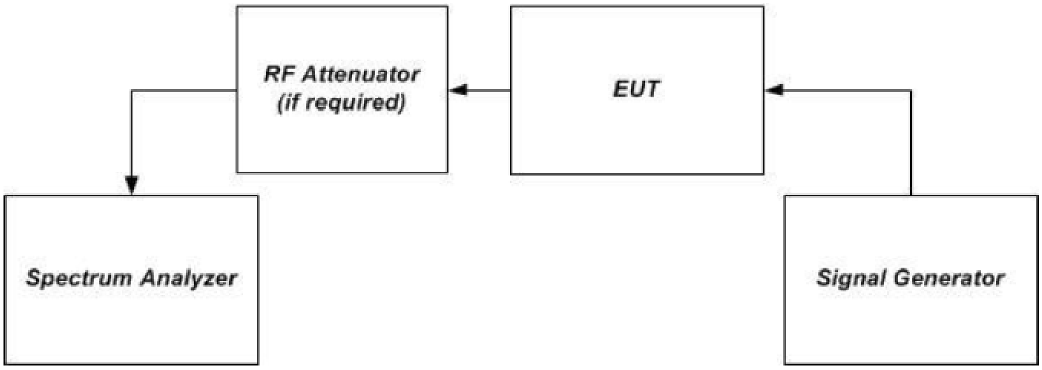


Figure 1 – Band verification test instrumentation setup

3.6 Spurious Emissions at Antenna Terminals

3.6.1 Applicable Standard

According to §2.1051 *Measurements required: Spurious emissions at antenna terminals.*

§20.21(e)(8)(i)(E): Booster out of band emissions (OOBE) shall be at least 6 dB below the FCC's mobile emission limits for the supported bands of operation. Compliance to OOBE limits will utilize high peak-to-average CMRS signal types.

§22.917 (a) Out of band emissions. The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least 43 + 10 log(P) dB.

§24.238 (a) Out of band emissions. The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least 43 + 10 log(P) dB.

§27.53: the power of any emission shall be attenuated outside the band below the transmitter power (P) by at least 43 + 10 log (P) dB;

3.6.2 Test Procedure

The following procedures shall be used to demonstrate compliance to the applicable conducted spurious emissions limits as per Section 2.1051.

NOTE–For frequencies below 1 GHz, an RBW of 1 MHz may be used in a preliminary measurement. If non-compliant emissions are detected, a final measurement shall be made with a 100 kHz RBW. Additionally, a peak detector may also be used for the preliminary measurement. If non-compliant emissions are detected then a final measurement of these emissions shall be made with the power averaging (rms) detector.

a) Connect the EUT to the test equipment as shown in **Figure 1**. Begin with the uplink output (donor) port connected to the spectrum analyzer.
b) Configure the signal generator for AWGN with a 99% OBW of 4.1 MHz, with a center frequency corresponding to the center of the CMRS band under test.
c) Set the signal generator amplitude to the level determined in the power measurement procedure in 7.2.
d) Turn on the signal generator RF output and measure the spurious emission power levels with an appropriate measuring instrument as follows.
   1) Set RBW = measurement bandwidth specified in the applicable rule section for the operational frequency band under consideration (see Appendix A for relevant cross-references). Note that many of the individual rule sections permit the use of a narrower RBW [typically ≥ 1% of the emission bandwidth (EBW)] to enhance measurement accuracy, but the result must then be integrated over the specified measurement bandwidth.
   2) Set VBW = 3* RBW.
   3) Select the power averaging (rms) detector. (See above note regarding the use of a peak detector for preliminary measurements.)
   4) Sweep time = auto-couple.
   5) Set the analyzer start frequency to the lowest radio frequency signal generated in the equipment, without going below 9 kHz, and the stop frequency to the lower band/block edge frequency minus 100 kHz or 1 MHz, as specified in the applicable rule part. Note that the number of measurement points in each sweep must be ≥ (2 span/RBW), which may require that the measurement range defined by the preceding start and stop frequencies be subdivided, depending on the available number of measurement points of the spectrum analyzer. Trace average at least 10 traces in power averaging (i.e., rms) mode.
   6) Sweep time = auto-couple.
   7) Use the peak marker function to identify the highest amplitude level over each measured frequency range. Record the frequency and amplitude and capture a plot for inclusion in the test report.

8) Reset the analyzer start frequency to the upper band/block edge frequency plus 100 kHz or 1 MHz, as specified in the applicable rule part, and the analyzer stop frequency to 10 times the highest frequency of the fundamental emission. Note that the number of measurement points in each sweep must be ≥ (2*span/RBW) which may require that the measurement range defined by the start and stop frequencies above be subdivided, depending on the available number of measurement points provided by the spectrum analyzer.

9) Use the peak marker function to identify the highest amplitude level over each of the measured frequency ranges. Record the frequency and amplitude and capture a plot for inclusion in the test report.

e) Repeat 7.6b) through 7.6d) for each supported frequency band of operation.

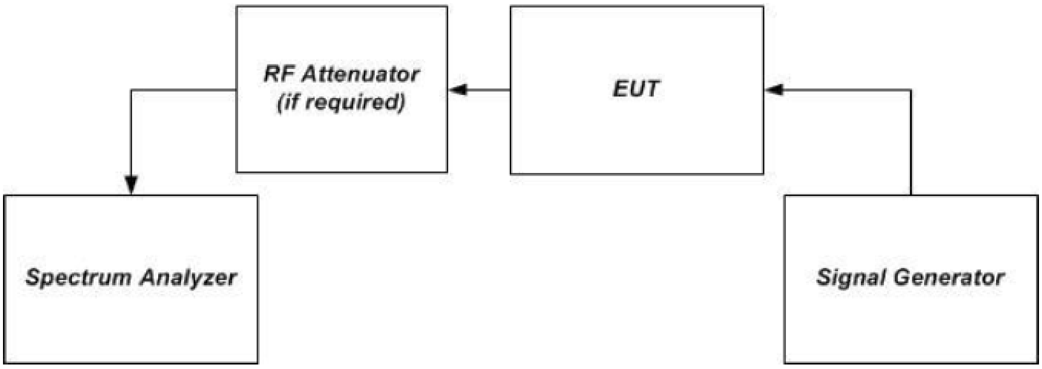


Figure 1 – Band verification test instrumentation setup

3.7 Noise Limits

3.7.1 Applicable Standard

According to§ 20.21(e)(8)(i)(A) *Noise Limits*; § 20.21(e)(8)(i)(H) *Transmit Power Off Mode* (uplink and downlink noise power); §20.21(e)(4) *Self-monitoring*.

3.7.2 Test Procedure

Maximum transmitter noise power level

a) Connect the EUT to the test equipment as shown in **Figure 3**. Begin with the uplink output (donor) port connected to the spectrum analyzer. When measuring downlink noise, connect the downlink output (server) port to the spectrum analyzer.
b) Set the spectrum analyzer RBW to 1 MHz with the VBW ≥ 3 *RBW.
c) Select the power averaging (rms) detector and trace average over at least 100 traces.
d) Set the center frequency of the spectrum analyzer to the center of the CMRS band under test with the span ≥ 2 the CMRS band.
e) Measure the maximum transmitter noise power level.
f) Save the spectrum analyzer plot as necessary for inclusion in the final test report.
g) Repeat 7.7b) to 7.7f) for all operational uplink and downlink bands.
h) Connect the EUT to the test equipment as shown in Figure 4 for uplink noise power measurement in the presence a downlink signal. Affirm the coupled path of the RF coupler is connected to the spectrum analyzer.
i) Configure the signal generator for AWGN operation with a 99% OBW of 4.1 MHz.
j) Set the spectrum analyzer RBW for 1 MHz, VBW ≥ 3*RBW, with a power averaging (rms) detector with at least 100 trace averages.
k) Set the center frequency of the spectrum analyzer to the center of the CMRS band under test, with the span ≥ 2*the CMRS band. This shall include all spectrum blocks in the particular CMRS band under test (see Appendix A).
l) For uplink noise measurements, set the spectrum analyzer center frequency for the uplink band under test, and tune the signal generator to the center of the paired downlink band.
m) Measure the maximum transmitter noise power level while varying the downlink signal generator output level from −90 dBm to −20 dBm, as measured at the input port (i.e., downlink signal level at the booster donor port node of Figure 4), in 1 dB steps inside the RSSI-dependent region, and in 10 dB steps outside the RSSI-dependent region. Report the six values closest to the limit, with at least two points within the RSSI-dependent region of the limit. See Appendix D for noise limits graphs.
n) Repeat 7.7.1h) through 7.7.1m) for all operational uplink bands.
NOTE–Some signal boosters will require a signal generator input because they will not operate unless a signal is received at the input terminals. If this is the case, for the setups shown in Figure 3 and Figure 4 connect a second signal generator at the server port, then cycle the RF output of the second signal generator to simulate this function.

NOTE-Some signal boosters have a maximum transmitter noise power level that is less than the Transmit Power Off Mode of -70 dBm. For these boosters it is still necessary to confirm that the uplink noise power limits are met in the presence of a downlink signal. Test reports should show measurement data demonstrating compliance. Alternatively the applicant may provide attestation with detailed design information and explanation justifying the omission of the variable uplink testing.

Variable uplink noise timing

Variable uplink noise timing is to be measured as follows, using the test setup shown in **Figure 4**.

a) Set the spectrum analyzer to the uplink frequency to be measured.
b) Set the span to 0 Hz, with a sweep time of 10 seconds.
c) Set the power level of signal generator to the lowest level of the RSSI-dependent noise [see 7.7.1m)].
d) Select MAX HOLD and increase the power level of signal generator by 10 dB for mobile boosters, and 20 dB for fixed boosters.
e) Confirm that the uplink noise decreases to the specified level within 1 second for mobile devices, and within 3 seconds for fixed devices.18
f) Repeat 7.7.2a) to 7.7.2e) for all operational uplink bands.
g) Include plots and summary table in test report.

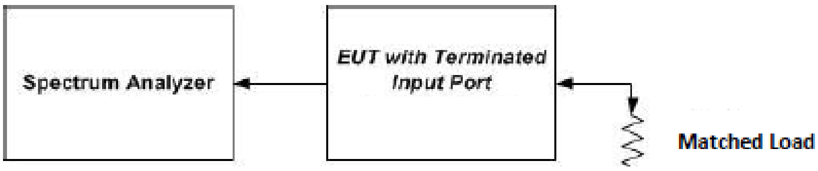


Figure 3 – Noise limit test setup (also used for 7.8)

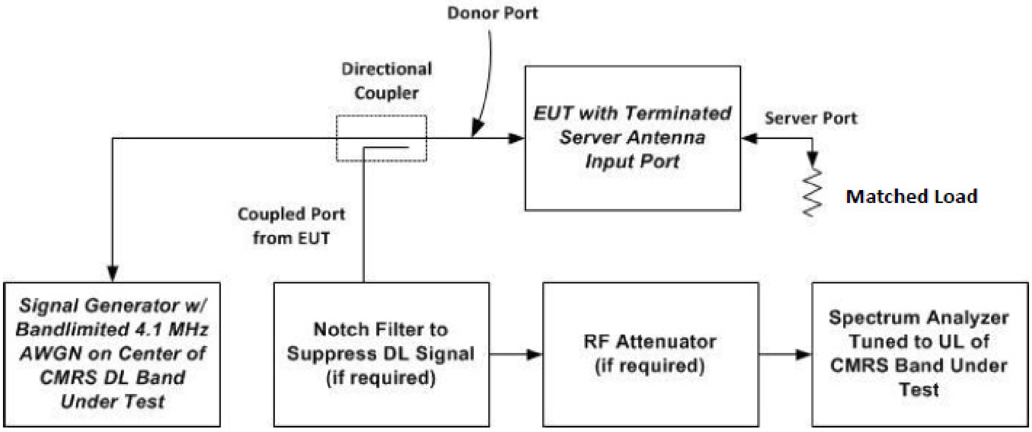


Figure 4 – Test setup for uplink noise power measurement in the presence of a downlink signal

3.8 Uplink Inactivity

3.8.1 Applicable Standard

According to§ 20.21(e)(8)(i)(I) *Uplink Inactivity*&§20.21(e)(4); §20.21(e)(4) *Self-monitoring*.

3.8.2 Test Procedure

This measurement procedure is intended to demonstrate compliance to the uplink inactivity requirements specified for wideband consumer signal boosters in Section 20.21(e)(8)(i)(I).

a) Connect the EUT to the test equipment as shown in **Figure 3** with the uplink output (donor) port connected to the spectrum analyzer.
NOTE–Some signal boosters will require a signal generator input because they will not operate unless a signal is received at the input terminals. If this is the case for the setup shown in Figure 3 connect a signal generator at the server port, then cycle the RF output of the signal generator to simulate this function.
b) Select the power averaging (rms) detector.
c) Set the spectrum analyzer RBW for 1 MHz with the VBW ≥ 3* RBW.
d) Set the center frequency of the spectrum analyzer to the center of the uplink operational band.
e) Set the span for 0 Hz with a single sweep time for a minimum of 330 seconds.
f) Start to capture a new trace using MAX HOLD.
g) After approximately 15 seconds, turn on the EUT power.
h) After the full spectrum analyzer trace is complete, place a MARKER on the leading edge of the pulse, then use the DELTA MARKER METHOD to measure the time until the uplink becomes inactive.
i) Affirm that the noise level is below the uplink inactivity noise power limit, as specified by the rules.
j) Capture the plot for inclusion in the test report.
k) Measure noise using procedures in 7.7.1a) to 7.7.1f).
l) Repeat 7.8d) through 7.8k) for all operational uplink bands.

NOTE-Some signal boosters have a maximum transmitter noise power level that is less than the uplink inactivity limit. For these boosters it is still necessary to confirm the uplink activity timing requirement. Test reports should show measurement data demonstrating compliance. Alternatively the applicant may provide attestation with detailed design information and explanation justifying the omission of the uplink inactivity test procedure.

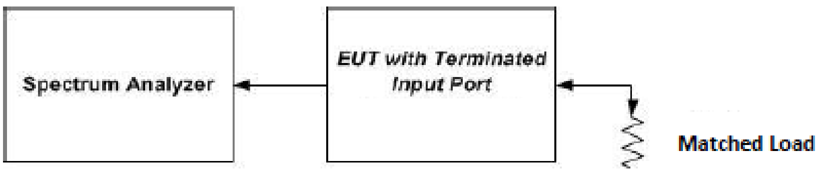


Figure 3 – Noise limit test setup (also used for 7.8)

3.9 Variable Booster Gain

3.9.1 Applicable Standard

According to § 20.21(e)(8)(i)(C)(1) *Booster Gain Limits* (variable gain); § 20.21(e)(8)(i)(H) *Transmit Power Off Mode* (uplink gain).

3.9.2 Test Procedure

Maximum gain

This procedure shall be used to demonstrate compliance to the booster gain limits specified for wideband consumer signal boosters in Section 20.21(e)(8)(i)(C) or Section 20.21(e)(8)(i)(H). The variable booster gain limits are expressed as a function of RSSI and MSCL, and are shown graphically in Appendix D. The RSSI is varied over a range of values as specified within the procedure. Refer to Appendix B of this document for guidance on determining the applicable MSCL value.

a) Connect the EUT to the test equipment as shown in **Figure 5** with the uplink output (donor) port connected to signal generator #1. Affirm that the coupled path of the RF coupler is connected to the spectrum analyzer.
b) Configure downlink signal generator #1 for AWGN operation with a 99% OBW of 4.1 MHz, tuned to the center of the operational band.
c) Set the power level and frequency of signal generator #2 to a value that is 5 dB below the AGC level determined from 7.2. The signal type is AWGN with a 99% OBW of 4.1 MHz.
d) Set RBW = 100 kHz.
e) Set VBW ≥ 300 kHz.
f) Select the CHANNEL POWER measurement mode.
g) Select the power averaging (rms) detector.
h) Affirm that the number of measurement points per sweep ≥ (2*span)/RBW.
i) Sweep time = auto couple or as necessary (but no less than auto couple value).
j) Trace average at least 10 traces in power averaging (i.e., rms) mode.
k) Measure the maximum channel power and compute maximum gain when varying the signal generator #1 output to a level from −90 dBm to −20 dBm, as measured at the input port (i.e., downlink signal level at the booster donor port node of Figure 5), in 1 dB steps inside the RSSI-dependent region, and 10 dB steps outside the RSSI-dependent region. Report the six values closest to the limit, including at least two points from within the RSSI-dependent region of operation. See gain limit in charts in Appendix D for uplink gain requirements. Additionally, document that the EUT provides equivalent uplink and downlink gain, and when operating in shutoff mode that the uplink and downlink gain is within the transmit power off mode gain limits.
l) Repeat 7.9.1b) to 7.9.1k) for all operational uplink bands.

Variable uplink gain timing

Variable uplink gain timing is to be measured as follows, using the test setup shown in **Figure 5**.

a) Set the spectrum analyzer to the uplink frequency to be measured.
b) Set the span to 0 Hz with a sweep time of 10 seconds.
c) Set the power level of signal generator #1 to the lowest level of the RSSI-dependent gain [see 7.9.1k)].
d) Select MAX HOLD and increase the power level of signal generator #1 by 10 dB for mobile boosters, and by 20 dB for fixed indoor boosters. Signal generator #2 remains same, as described in 7.9.1c).
e) Confirm that the uplink gain decreases to the specified levels, within 1 second for mobile devices, and within 3 seconds for fixed devices.19
f) Repeat 7.9.2a) to 7.9.2e) for all operational uplink bands.

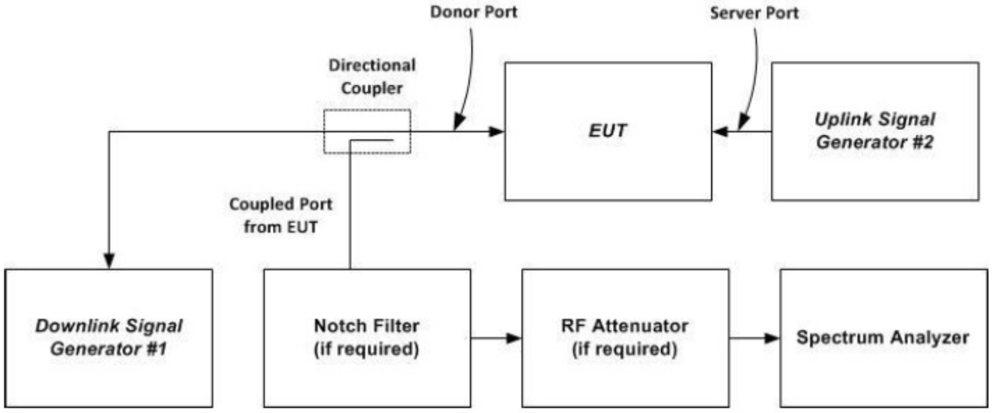


Figure 5 – Variable gain instrumentation test setup

3.10 Occupied Bandwidth

3.10.1 Applicable Standard

According to§ 2.1049 *Measurements required: Occupied bandwidth*.

3.10.2 Test Procedure

This measurement is required to compare the consistency of the output signal relative to the input signal, and to satisfy the requirements of Section 2.1049.

a) Connect the test equipment as shown in **Figure 6** to firstly measure the characteristics of the test signals produced by the signal generator.
b) Set VBW ≥ 3*RBW.
c) Set the center frequency of the spectrum analyzer to the center of the operational band. The span will be adjusted for each modulation type and OBW as necessary for accurately viewing the signals.
d) Set the signal generator for power level to match the values obtained from the tests of 7.2.
e) Set the signal generator modulation type for GSM with a PRBS pattern and allow the trace on the signal generator to stabilize adjusting the span as necessary.
f) Set the spectrum analyzer RBW for 1% to 5% of the EBW.
g) Capture the spectrum analyzer trace for inclusion in the test report.
h) Repeat 7.10c) to 7.10g) for CDMA and W-CDMA modulation, adjusting the span as necessary. AWGN or LTE may be used in place of W-CDMA, as an option.
i) Repeat 7.10c) to 7.10h) for all uplink and downlink operational bands.
j) Connect the test equipment as shown in Figure 1, with the uplink output (donor) port connected to the spectrum analyzer, and the server port connected to the signal generator.
k) Repeat 7.10c) to 7.10i) with this EUT uplink path test setup.
l) Connect the test equipment as shown in Figure 1, with the downlink output (server) port connected to the spectrum analyzer, and the donor port connected to the signal generator.
m) Repeat 7.10c) to 7.10i) with this EUT downlink path test setup.

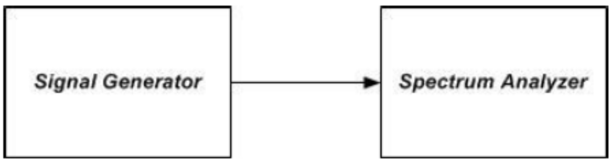


Figure 6 – Test setup for measuring characteristics of test signals used for subsequent EUT occupied bandwidth testing

3.11 Oscillation Detection

3.11.1 Applicable Standard

According to § 20.21(e)(8)(ii)(A) *Anti-Oscillation*, §20.21(e)(4) *Self-monitoring*.

Use of two EUTs is permitted for this measurement, which can greatly reduce the test time required. One EUT shall operate in a normal mode, and the second EUT shall operate in a test mode that is capable of disabling the uplink inactivity function and/or allows a reduction to 5 seconds of the time between restarts.

The procedures in 7.11.3 and 7.11.4 do not apply for devices that operate only as direct-connection mobile boosters having gain of less than or equal to 15 dB.

3.11.2 Test Procedure

Oscillation restart tests

a) Connect the normal-operating mode EUT to the test equipment as shown in **Figure 7** beginning with the spectrum analyzer on the uplink output (donor) port. Confirm that the RF coupled path is connected to the spectrum analyzer.

NOTE–The band-pass filter shall provide sufficient out-of-band rejection to prevent oscillations from occurring in bands not under test.

b) Spectrum analyzer settings:
1) Center frequency at the center of the band under test
2) Span equal or slightly exceeding the width of the band under test
3) Continuous sweep, max-hold
4) RBW≥ 1 MHz, VBW > 3* RBW

c) Decrease the variable attenuator until the spectrum analyzer displays a signal within the band under test. Using a marker, identify the approximate center frequency of this signal on the max-hold display, increase the attenuation by 10 dB, then reset the EUT (e.g., cycle ac/dc power).

d) Repeat 7.11.2c) twice to ensure that the center of the signal created by the booster remains within 250 kHz of the spectrum analyzer display center frequency. If the frequency of the signal is unstable, confirm that the spectrum analyzer display is centered between the frequency extremes observed. If the signal is wider than 1 MHz, ensure that the spectrum analyzer display is centered on the signal by increasing the RBW. Reset the EUT (e.g., cycle ac/dc power) after each oscillation event, if necessary. Set the spectrum analyzer sweep trigger level to just below the peak amplitude of the displayed EUT oscillation signal.

e) Set the spectrum analyzer to zero-span, with a sweep time of 5 seconds, and single-sweep with max-hold. The spectrum analyzer sweep trigger level in this and the subsequent steps shall be the level identified in 7.11.2d).

f) Decrease the variable attenuator until the spectrum analyzer sweep is triggered, increase the attenuation by 10 dB, then reset the EUT (e.g., cycle ac/dc power).

g) Reset the zero-span trigger of the spectrum analyzer, then repeat 7.11.2f) twice to ensure that the spectrum analyzer is reliably triggered, resetting the EUT (e.g., cycle ac/dc power) after each oscillation event if necessary.

h) Reset the zero-span sweep trigger of the spectrum analyzer, and reset the EUT (e.g., cycle ac/dc power).

i) Force the EUT into oscillation by reducing the attenuation.

j) Use the marker function of the spectrum analyzer to measure the time from the onset of oscillation until the EUT turns off, by setting Marker 1 on the leading edge of the oscillation signal and Marker 2 on the trailing edge. The spectrum analyzer sweep time may be adjusted to improve the time resolution of these cursors.

k) Capture the spectrum analyzer zero-span trace for inclusion in the test report. Report the power level associated with the oscillation separately if it can't be displayed on the trace.

l) Repeat 7.11.2b) to 7.11.2k) for all operational uplink and downlink bands.

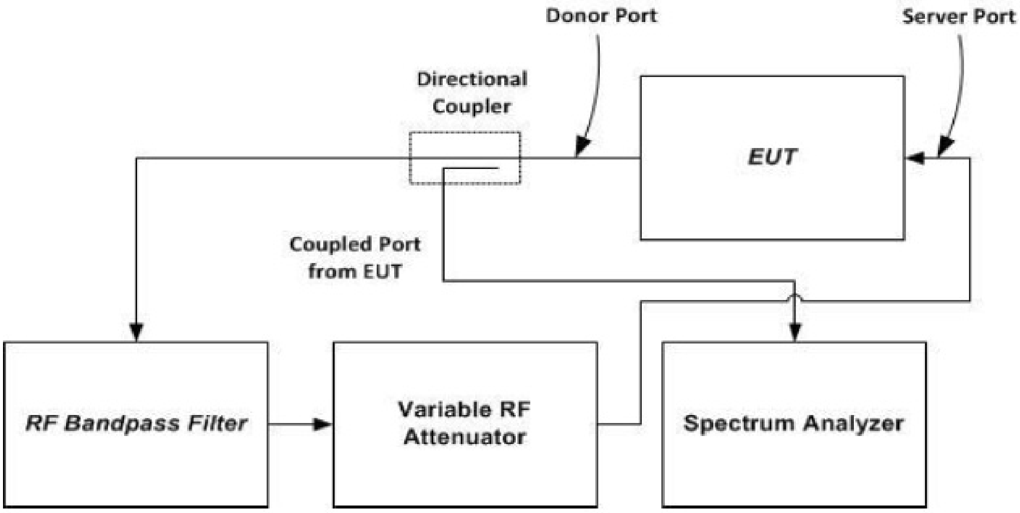
m) Set the spectrum analyzer zero-span sweep time for longer than 60 seconds, then measure the restart time for each operational uplink and downlink band.

n) Replace the normal-operating mode EUT with the EUT that supports an anti-oscillation test mode.

o) Set the spectrum analyzer zero-span time for a minimum of 120 seconds, and a single sweep.

p) Manually trigger the spectrum analyzer zero-span sweep, and manually force the booster into oscillation as described in 7.11.2i).

q) When the sweep is complete, place cursors between the first two oscillation detections, and save the plot for inclusion in the test report. The time between restarts must match the manufacturer's timing for the test mode, and there shall be no more than 5 restarts.
r) Repeat 7.11.2m) to 7.11.2q) for all operational uplink and downlink bands.



NOTE—This figure shows the test setup for uplink bands transmission path tests; i.e., signal flow is out from the donor port into the directional coupler. For downlink bands transmission path tests, the feedback signal flow path direction and equipment connections shall be reversed, i.e., signal flow is out from the server port into the directional coupler, and signal flow is into the donor port from the variable RF attenuator.

Figure 7 – Oscillation detection (7.11.2) test setup

Test procedure for measuring oscillation mitigation or shutdown

a) Connect the normal-operating mode EUT to the test equipment as shown in **Figure 8**.
b) Set the spectrum analyzer center frequency to the center of band under test, and use the following settings:
   1) RBW=30 kHz, VBW ≥ 3 × RBW,
   2) power averaging (rms) detector,
   3) trace averages ≥ 100,
   4) span ≥ 120% of operational band under test,
   5) number of sweep points ≥ 2 × Span/RBW.

NOTE—To measure 120% of the band under test in one span with spectrum analyzers having less than the required number of sweep points: Perform pretests with span equal to smaller band segments, such that 120% of the operational band is captured in multiple tests, using the setup parameters specified; record the center frequency of the strongest oscillation level occurring, and affirm this frequency is within the span and band segment used in this test.

c) Configure the signal generator for AWGN operation with a 99% OBW of 4.1 MHz, tuned to the frequency of 2.5 MHz above the lower edge or below the upper edge of the operating band under test. Adjust the RF output level of the signal generator such that the measured power level of the AWGN signal at the output port of the booster is 30 dB less than the maximum power of the booster for the band under test. Affirm that the input signal is not obstructing the measurement of the strongest oscillation peak in the band, and is not included within the span in the measurement.
   1) Boosters with operating spectrum passbands of 10 MHz or less may use a CW signal source at the band edge rather than AWGN.
   2) For device passbands greater than 10 MHz, standard CMRS signal sources (i.e., CDMA, W-CDMA, LTE) may be used instead of AWGN at the band edge.
d) Set the variable attenuator to a high attenuation setting such that the booster will operate at maximum gain when powered on. Reset the EUT (e.g., cycle ac/dc power). Allow the EUT to complete its boot-up process, to reach full operational gain, and to stabilize its operation.

e) Set the variable attenuator such that the insertion loss for the center of the band under test (isolation) between the booster donor port and server port is 5 dB greater than the maximum gain, as recorded in the maximum gain test procedure (see 7.3), for the band under test.

f) Verify the EUT shuts down, i.e., to mitigate the oscillations. If the booster does not shut down, measure and verify the peak oscillation level as follows.

1) Allow the spectrum analyzer trace to stabilize.
2) Place the marker at the highest oscillation level occurring within the span, and record its output level and frequency.
3) Set the spectrum analyzer center frequency to the frequency with the highest oscillation signal level, and reduce the span such that the upper and lower adjacent oscillation peaks are within the span.
4) Use the Minimum Search Marker function to find the lowest output level that is within the span, and within the operational band under test, and record its output level and frequency.
5) Affirm that the peak oscillation level measured in 7.11.3f2), does not exceed by 12.0 dB the minimal output level measured in 7.11.3f)4). Record the measurement results of 7.11.3f2) and 7.11.3f4) in tabular format for inclusion in the test report.
6) The procedure of 7.11.3f1) to 7.11.3.f5) allows the spectrum analyzer trace to stabilize, and verification of shutdown or oscillation level measurement must occur within 300 seconds.20

g) Decrease the variable attenuator in 1 dB steps, and repeat step 7.11.3f) for each 1 dB step. Continue testing to the level when the insertion loss for the center of band under test (isolation) between the booster donor port and server port is 5 dB lower than the maximum gain (see 7.3).

h) Repeat 7.11.3a) to 7.11.3g) for all operational uplink and downlink bands.

3.12 Radiated Spurious Emissions

3.12.1 Applicable Standard

According to § 2.1053 *Measurements required: Field strength of spurious radiation.*

3.12.2 Test Procedure

This procedure is intended to satisfy the requirements specified in Section 2.1053. The applicable limits are those specified for mobile station emissions in the rule part appropriate to the band of operation (see Appendix A).

Separate compliance requirements are applicable for any digital device circuitry that controls additional functions or capabilities and that is not used only to enable operation of the transmitter in a booster device [i.e., Section 15.3(k) digital device definition]. Separate compliance requirements are applicable for any receiver components/functions that tune within 30 MHz to 960 MHz contained in booster devices [Section 15.101(b)].

a) Place the EUT on an OATS or semi-anechoic chamber turntable 3 m from the receiving antenna.
b) Connect the EUT to the test equipment as shown in **Figure 10** beginning with the uplink output (donor) port.
c) Set the signal generator to produce a CW signal with the frequency set to the center of the operational band under test, and the power level set at PIN as determined from measurement results per 7.2.
d) Measure the radiated spurious emissions from the EUT from the lowest to the highest frequencies as specified in Section 2.1057. Maximize the radiated emissions by using the procedures described in ANSI C63.26.
e) Capture the peak emissions plots using a peak detector with Max-Hold for inclusion in the test report. Tabular data is acceptable in lieu of spectrum analyzer plots.
f) Repeat 7.12c) through 7.12e) for all uplink and downlink operational bands.

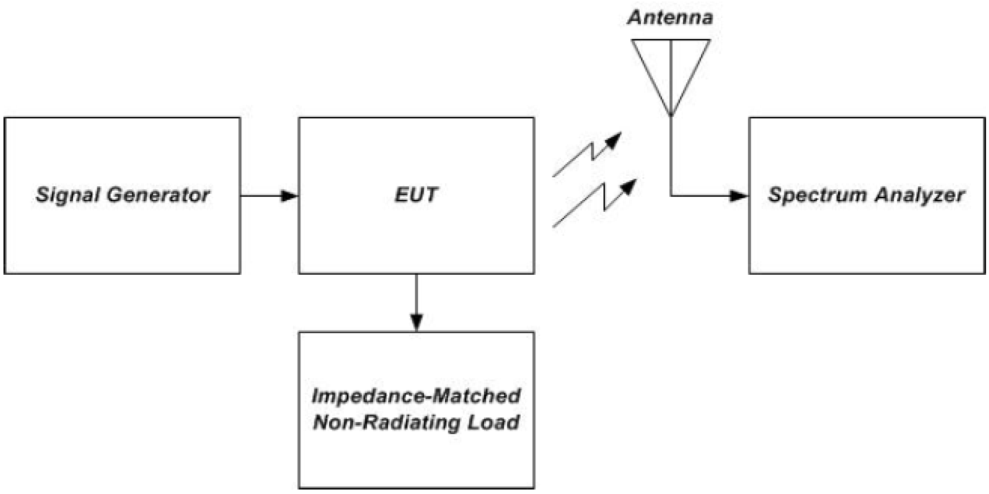


Figure 10 – Radiated spurious emissions test instrumentation setup

4. ANTENNA PORT TEST DATA AND RESULTS

Serial Number:	2BHQ-1	Test Date:	2023/12/07
Test Site:	RF	Test Mode:	Transmitting
Tester:	Ken Tang	Test Result:	Pass

Environmental Conditions:

Temperature: (℃)	25.6	Relative Humidity: (%)	56	ATM Pressure: (kPa)	101

Test Equipment List and Details:

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
R&S	Spectrum Analyzer	FSV40	101474	2023/3/31	2024/3/30
YINSAIGE	Coaxial Cable	SS402	SJ0100001	Each time	N/A
YINSAIGE	Coaxial Cable	SS402	SJ0100002	Each time	N/A
Agilent	MXG Vector Signal Generator	N5182B	MY51350144	2023/3/31	2024/3/30

** Statement of Traceability: China Certification ICT Co., Ltd (Dongguan) attests that all calibrations have been performed, traceable to National Primary Standards and International System of Units (SI).*

Test Data:

4.1 Maximum Power Measurement:

AGC Input Level:

Mode	Operation Band	Signal Type	AGC Input Level dBm
Uplink	Lower 700MHz	AWGN	-41.01
		GSM	-40.75
	Upper 700MHz	AWGN	-40.62
		GSM	-40.04
	Cellular	AWGN	-40.95
		GSM	-41.64
	AWS-1	AWGN	-47.98
		GSM	-48.19
	PCS	AWGN	-48.62
		GSM	-48.95
Downlink1	Lower 700MHz	AWGN	-50.06
		GSM	-49.48
	Upper 700MHz	AWGN	-51.26
		GSM	-51.03
	Cellular	AWGN	-49.62
		GSM	-49.48
	AWS-1	AWGN	-57.19
		GSM	-56.73
	PCS	AWGN	-57.93
		GSM	-56.34

Mode	Operation Band	Signal Type	AGC Input Level dBm
Uplink	Lower 700MHz	AWGN	-41.62
		GSM	-41.68
	Upper 700MHz	AWGN	-41.65
		GSM	-42.06
	Cellular	AWGN	-42.13
		GSM	-42.48
	AWS-1	AWGN	-49.71
		GSM	-49.91
	PCS	AWGN	-47.39
		GSM	-47.39
Downlink2	Lower 700MHz	AWGN	-49.62
		GSM	-49.66
	Upper 700MHz	AWGN	-50.75
		GSM	-50.52
	Cellular	AWGN	-51.13
		GSM	-51.44
	AWS-1	AWGN	-57.13
		GSM	-56.76
	PCS	AWGN	-56.15
		GSM	-56.12

Note: Downlink1 means indoor 1, Downlink2 means indoor 2.

Maximum power measurement

Mode	Operation Band	Signal type	Pre AGC Input leve dBm	Conducted Output level dBm	Limit dBm	Antenna Gain dBi	Cable loss dB	EIRP dBm	Limit dBm
Uplink	Lower 700MHz	AWGN	-41.51	19.98	17~30	7.5	4.97	22.51	≤30
		GSM	-41.25	19.89				22.42	
	Upper 700MHz	AWGN	-41.12	20.74		7.5	4.97	23.27	
		GSM	-40.54	20.69				23.22	
	Cellular	AWGN	-41.45	19.45		8	5.17	22.28	
		GSM	-42.14	19.01				21.84	
	AWS	AWGN	-48.48	20.54		9	7.51	22.03	
		GSM	-48.69	20.78				22.27	
	PCS	AWGN	-49.12	20.25		9	7.51	21.74	
		GSM	-49.45	20.04				21.53	
Downlink1	Lower 700MHz	AWGN	-50.56	12.35	≤17	6.5	4.97	13.88	≤17
		GSM	-49.98	12.78				14.31	
	Upper 700MHz	AWGN	-51.76	11.25		6.5	4.97	12.78	
		GSM	-51.53	11.94				13.47	
	Cellular	AWGN	-50.12	12.04		6.5	5.17	13.37	
		GSM	-49.98	12.29				13.62	
	AWS	AWGN	-57.69	12.46		8.5	7.51	13.45	
		GSM	-57.23	13.34				14.33	
	PCS	AWGN	-58.43	12.48		8.5	7.51	13.47	
		GSM	-56.84	13.82				14.81	

Mode	Operation Band	Signal type	Pre AGC Input leve dBm	Conducted Output level dBm	Limit dBm	Antenna Gain dBi	Cable loss dB	EIRP dBm	Limit dBm
Uplink	Lower 700MHz	AWGN	-42.12	19.78	17~30	7.5	4.97	22.31	≤30
		GSM	-42.18	20.13				22.66	
	Upper 700MHz	AWGN	-42.15	20.36		7.5	4.97	22.89	
		GSM	-42.56	21.2				23.73	
	Cellular	AWGN	-42.63	19.42		8	5.17	22.25	
		GSM	-42.98	19				21.83	
	AWS	AWGN	-50.21	20.87		9	7.51	22.36	
		GSM	-50.41	20.63				22.12	
	PCS	AWGN	-47.89	20.76		9	7.51	22.25	
		GSM	-47.89	21.35				22.84	
Downlink2	Lower 700MHz	AWGN	-50.12	11.92	≤17	6.5	4.97	13.45	≤17
		GSM	-50.16	12.53				14.06	
	Upper 700MHz	AWGN	-51.25	11.68		6.5	4.97	13.21	
		GSM	-51.02	11.45				12.98	
	Cellular	AWGN	-51.63	11.69		6.5	5.17	13.02	
		GSM	-51.94	12.85				14.18	
	AWS	AWGN	-57.63	11.5		8.5	7.51	12.49	
		GSM	-57.26	12.76				13.75	
	PCS	AWGN	-56.65	12.71		8.5	7.51	13.7	
		GSM	-56.62	13.28				14.27	

Maximum Input level

Mode	Operation Band	Signal type	Maximum Input level dBm	Limit dBm	Conducted Output level dBm
Uplink	Lower 700MHz	AWGN	-28.69	27	19.18
		GSM	-29.87		19.36
	Upper 700MHz	AWGN	-29.46		20.68
		GSM	-29.46		20.3
	Cellular	AWGN	-29.68		18.79
		GSM	-29.41		18.5
	AWS	AWGN	-36.98		19.95
		GSM	-36.98		20.07
	PCS	AWGN	-37.05		19.48
		GSM	-37.26		19.11
Downlink1	Lower 700MHz	AWGN	-37.18	-20	12.01
		GSM	-37.56		12.51
	Upper 700MHz	AWGN	-38.15		10.67
		GSM	-38.15		11.55
	Cellular	AWGN	-38.79		11.37
		GSM	-38.62		11.68
	AWS	AWGN	-49.63		11.92
		GSM	-45.82		12.95
	PCS	AWGN	-50.42		12.36
		GSM	-43.05		12.94

Mode	Operation Band	Signal type	Maximum Input level dBm	Limit dBm	Conducted Output level dBm
Uplink	Lower 700MHz	AWGN	-30.21	27	19.09
		GSM	-30.21		20.13
	Upper 700MHz	AWGN	-29.12		20.15
		GSM	-29.28		21.32
	Cellular	AWGN	-28.52		19.15
		GSM	-29.45		18.3
	AWS	AWGN	-35.28		20.65
		GSM	-34.82		20.26
	PCS	AWGN	-36.84		20.56
		GSM	-37.42		21.34
Downlink2	Lower 700MHz	AWGN	-37.52	-20	11.19
		GSM	-37.12		12.1
	Upper 700MHz	AWGN	-37.86		10.9
		GSM	-39.45		11.17
	Cellular	AWGN	-37.12		11.33
		GSM	-37.24		12.19
	AWS	AWGN	-43.06		11.09
		GSM	-43.05		12.06
	PCS	AWGN	-43.51		12.68
		GSM	-42.95		12.47

4.2 Radiated Spurious Emissions:

Serial Number:	2BHQ-1	Test Date:	2023/10/09~2023/10/16
Test Site:	966-1, 966-2	Test Mode:	Transmitting
Tester:	Carl Xue, coco Tian	Test Result:	Pass

Environmental Conditions:

Temperature: (℃)	25.5~26.3	Relative Humidity: (%)	62~65	ATM Pressure: (kPa)	100.7~101

Test Equipment List and Details:

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
Sunol Sciences	Antenna	JB6	A082520-5	2020/10/19	2023/10/18
R&S	EMI Test Receiver	ESR3	102724	2023/3/31	2024/3/30
TIMES MICROWAVE	Coaxial Cable	LMR-600-UltraFlex	C-0470-02	2023/7/16	2024/7/15
TIMES MICROWAVE	Coaxial Cable	LMR-600-UltraFlex	C-0780-01	2023/7/16	2024/7/15
Sonoma	Amplifier	310N	186165	2023/7/16	2024/7/15
EMCO	Adjustable Dipole Antenna	3121C	9109-756	N/A	N/A
MICRO-COAX	Coaxial Cable	UFA210B-0-0720-300300	99G1448	2022/7/16	2024/7/15
Agilent	Signal Generator	E8247C	MY43321352	2022/11/18	2023/11/17
AH	Double Ridge Guide Horn Antenna	SAS-571	1394	2023/2/22	2025/2/23
R&S	Spectrum Analyzer	FSV40	101591	2023/3/31	2024/3/30
MICRO-COAX	Coaxial Cable	UFA210A-1-1200-70U300	217423-008	2023/8/6	2024/8/5
MICRO-COAX	Coaxial Cable	UFA210A-1-2362-300300	235780-001	2023/8/6	2024/8/5
Mini	Pre-amplifier	ZVA-183-S+	5969001149	2022/11/9	2023/11/8
AH	Double Ridge Guide Horn Antenna	SAS-571	1396	2021/10/18	2024/10/17
MICRO-COAX	Coaxial Cable	UFA210B-0-0720-300300	99G1448	2022/7/16	2024/7/15
Agilent	Signal Generator	E8247C	MY43321352	2022/11/18	2023/11/17
PASTERNACK	Horn Antenna	PE9852/2F-20	112002	2021/2/5	2024/2/4
PASTERNACK	Horn Antenna	PE9852/2F-20	112001	2021/2/5	2024/2/4
Quinstar	Preamplifier	QLW-18405536-JO	15964001005	2023/9/15	2024/9/14
PASTERNACK	Horn Antenna	PE9850/2F-20	072001	2021/2/5	2024/2/4
PASTERNACK	Horn Antenna	PE9850/2F-20	072002	2021/2/5	2024/2/4
MICRO-COAX	Coaxial Cable	UFB142A-1-2362-200200	235772-001	2023/8/6	2024/8/5

** Statement of Traceability: China Certification ICT Co., Ltd (Dongguan) attests that all calibrations have been performed, traceable to National Primary Standards and International System of Units (SI).*

Test Data:

Uplink:

Frequency (MHz)	Polar (H / V)	Receiver Reading (dBµV)	Substituted Method			Absolute Level (dBm)	Limit (dBm)	Margin (dB)
			Substituted Level (dBm)	Antenna Gain (dBd/dBi)	Cable Loss (dB)			
Lower 700MHz, Test Frequency: 707MHz								
108.64	H	40.15	-72.10	0.00	0.19	-72.29	-19.00	53.29
106.38	V	46.17	-60.45	0.00	0.19	-60.64	-19.00	41.64
1414.000	H	34.25	-69.42	8.26	0.72	-61.88	-19.00	42.88
1414.000	V	34.17	-69.55	8.26	0.72	-62.01	-19.00	43.01
2121.000	H	34.38	-67.60	9.17	0.92	-59.35	-19.00	40.35
2121.000	V	34.62	-67.34	9.17	0.92	-59.09	-19.00	40.09
2828.000	H	34.58	-65.22	9.92	1.06	-56.36	-19.00	37.36
2828.000	V	34.79	-64.95	9.92	1.06	-56.09	-19.00	37.09
Upper 700MHz, Test Frequency: 781.5MHz								
109.41	H	40.21	-72.03	0.00	0.19	-72.22	-19.00	53.22
105.64	V	46.54	-60.12	0.00	0.19	-60.31	-19.00	41.31
1563.000	H	35.12	-68.91	8.58	0.80	-61.13	-46.00	15.13
1563.000	V	34.67	-69.41	8.58	0.80	-61.63	-46.00	15.63
2344.500	H	35.24	-66.29	9.31	0.97	-57.95	-19.00	38.95
2344.500	V	34.88	-66.42	9.31	0.97	-58.08	-19.00	39.08
3126.000	H	34.67	-62.78	10.25	1.13	-53.66	-19.00	34.66
3126.000	V	34.79	-62.51	10.25	1.13	-53.39	-19.00	34.39
Cellular Band, Test Frequency: 836.5MHz								
110.56	H	40.08	-72.14	0.00	0.20	-72.34	-19.00	53.34
105.27	V	46.24	-60.45	0.00	0.19	-60.64	-19.00	41.64
1673.000	H	34.61	-69.70	8.71	0.85	-61.84	-19.00	42.84
1673.000	V	34.72	-69.69	8.71	0.85	-61.83	-19.00	42.83
2509.500	H	35.03	-65.58	9.42	1.01	-57.17	-19.00	38.17
2509.500	V	34.78	-65.84	9.42	1.01	-57.43	-19.00	38.43
3346.000	H	34.97	-62.19	10.34	1.16	-53.01	-19.00	34.01
3346.000	V	35.17	-61.85	10.34	1.16	-52.67	-19.00	33.67
AWS-1 Band, Test Frequency: 1732.5MHz								
111.34	H	40.04	-72.17	0.00	0.20	-72.37	-19.00	53.37
107.13	V	46.20	-60.37	0.00	0.19	-60.56	-19.00	41.56
3465.000	H	35.23	-62.58	10.39	1.15	-53.34	-19.00	34.34
3465.000	V	34.79	-62.98	10.39	1.15	-53.74	-19.00	34.74
5197.500	H	34.65	-59.48	11.32	1.44	-49.60	-19.00	30.60
5197.500	V	35.47	-58.51	11.32	1.44	-48.63	-19.00	29.63
PCS Band, Test Frequency: 1882.5MHz								
109.41	H	40.01	-72.23	0.00	0.19	-72.42	-19.00	53.42
105.64	V	45.32	-61.34	0.00	0.19	-61.53	-19.00	42.53
3765.000	H	34.62	-61.71	10.67	1.25	-52.29	-19.00	33.29
3765.000	V	34.52	-61.69	10.67	1.25	-52.27	-19.00	33.27
5647.500	H	34.28	-59.17	11.32	1.55	-49.40	-19.00	30.40
5647.500	V	35.17	-58.16	11.32	1.55	-48.39	-19.00	29.39

Note 1:The unit of antenna gain is dBd for frequency below 1GHz and is dBi for frequency above 1GHz.
Note 2:
Absolute Level = Substituted Level - Cable loss + Antenna Gain
Margin = Limit- Absolute Level

Downlink:

Frequency (MHz)	Polar (H / V)	Receiver Reading (dBμV)	Substituted Method			Absolute Level (dBm)	Limit (dBm)	Margin (dB)
			Substituted Level (dBm)	Antenna Gain (dBd/dBi)	Cable Loss (dB)			
Lower 700MHz, Test Frequency: 737MHz								
106.38	H	41.69	-70.59	0.00	0.19	-70.78	-19.00	51.78
104.90	V	45.18	-61.53	0.00	0.19	-61.72	-19.00	42.72
1474.000	H	34.37	-69.14	8.43	0.75	-61.46	-19.00	42.46
1474.000	V	34.59	-69.00	8.43	0.75	-61.32	-19.00	42.32
2211.000	H	35.11	-67.19	9.23	0.94	-58.90	-19.00	39.90
2211.000	V	35.26	-67.10	9.23	0.94	-58.81	-19.00	39.81
2948.000	H	34.95	-64.15	10.12	1.12	-55.15	-19.00	36.15
2948.000	V	34.88	-64.32	10.12	1.12	-55.32	-19.00	36.32
Upper 700MHz , Test Frequency:751.5MHz								
113.31	H	41.65	-70.53	0.00	0.20	-70.73	-19.00	51.73
105.27	V	44.95	-61.74	0.00	0.19	-61.93	-19.00	42.93
1503.000	H	34.77	-68.70	8.50	0.76	-60.96	-19.00	41.96
1503.000	V	35.02	-68.55	8.50	0.76	-60.81	-19.00	41.81
2254.500	H	34.64	-67.48	9.25	0.93	-59.16	-19.00	40.16
2254.500	V	34.73	-67.31	9.25	0.93	-58.99	-19.00	39.99
3006.000	H	34.58	-64.03	10.20	1.10	-54.93	-19.00	35.93
3006.000	V	34.63	-64.08	10.20	1.10	-54.98	-19.00	35.98
Cellular Band, Test Frequency:881.5MHz								
113.71	H	41.61	-70.57	0.00	0.19	-70.76	-19.00	51.76
105.27	V	44.85	-61.84	0.00	0.19	-62.03	-19.00	43.03
1763.000	H	34.67	-69.12	8.82	0.86	-61.16	-19.00	42.16
1763.000	V	34.49	-69.47	8.82	0.86	-61.51	-19.00	42.51
2644.500	H	35.43	-64.53	9.63	1.06	-55.96	-19.00	36.96
2644.500	V	35.37	-64.49	9.63	1.06	-55.92	-19.00	36.92
3526.000	H	35.49	-62.28	10.43	1.20	-53.05	-19.00	34.05
3526.000	V	36.28	-61.41	10.43	1.20	-52.18	-19.00	33.18
AWS-1 Band, Test Frequency:2132.5MHz								
106.76	H	42.13	-70.15	0.00	0.19	-70.34	-19.00	51.34
105.64	V	45.48	-61.18	0.00	0.19	-61.37	-19.00	42.37
4265.000	H	35.02	-61.15	10.74	1.31	-51.72	-19.00	32.72
4265.000	V	34.96	-61.11	10.74	1.31	-51.68	-19.00	32.68
6397.500	H	35.03	-57.01	11.22	1.89	-47.68	-19.00	28.68
6397.500	V	34.96	-57.12	11.22	1.89	-47.79	-19.00	28.79
PCS Band, Test Frequency:1962.5MHz								
114.11	H	42.39	-69.78	0.00	0.19	-69.97	-19.00	50.97
105.27	V	45.40	-61.29	0.00	0.19	-61.48	-19.00	42.48
3925.000	H	34.67	-61.40	10.83	1.28	-51.85	-19.00	32.85
3925.000	V	34.82	-61.19	10.83	1.28	-51.64	-19.00	32.64
5887.500	H	34.41	-59.19	11.04	1.66	-49.81	-19.00	30.81
5887.500	V	34.97	-58.68	11.04	1.66	-49.30	-19.00	30.30

Note 1:The unit of antenna gain is dBd for frequency below 1GHz and is dBi for frequency above 1GHz.
Note 2:
Absolute Level = Substituted Level - Cable loss + Antenna Gain
Margin = Limit- Absolute Level

5. RF EXPOSURE EVALUATION

5.1 FCC MAXIMUM PERMISSIBLE EXPOSURE (MPE)

5.1.1 Applicable Standard

According to subpart 2.1091 systems operating under the provisions of this section shall be operated in a manner that ensures the public is not exposed to RF energy level in excess of the communication guidelines.

According to KDB 447498 D04 Interim General RF Exposure Guidance

MPE-Based Exemption:

General frequency and separation-distance dependent MPE-based effective radiated power(ERP) thresholds are in Table B.1 [Table 1 of § 1.1307(b)(1)(i)(C)] to support an exemptionfrom further evaluation from 300 kHz through 100 GHz.

Table 1 to § 1.1307(b)(3)(i)(C) - Single RF Sources Subject to Routine Environmental Evaluation

RF Source frequency (MHz)	Threshold ERP (watts)
0.3-1.34	1,920 R^2.
1.34-30	3,450 R^2/f^2.
30-300	3.83 R^2.
300-1,500	0.0128 R^2f.
1,500-100,000	19.2R^2.

Ris the minimum separation distance in meters
f = frequency in MHz

For multiple RF sources: Multiple RF sources are exempt if:

in the case of fixed RF sources operating in the same time-averaging period, or of multiple mobile or portable RF sources within a device operating in the same time averaging period, if the sum of the fractional contributions to the applicable thresholds is less than or equal to 1 as indicated in the following equation:

$$\sum_{i=1}^{a} \frac{P_i}{P_{th,i}} + \sum_{j=1}^{b} \frac{ERP_j}{ERP_{th,j}} + \sum_{k=1}^{c} \frac{Evaluated_k}{Exposure\ Limit_k} \leq 1$$

5.1.2 MPE Results

Tune-Up Power Including Tolerance:

Mode	Frequency (MHz)	Tune up conducted power	Cable Loss (dB)	Antenna Gain		ERP		Evaluation Distance (m)	ERP Limit (W)
		(dBm)		(dBi)	(dBd)	(dBm)	(W)		
UL	698-716	21.0	4.97	7.5	5.35	21.38	0.137	0.2	0.357
	776-787	21.5	4.97	7.5	5.35	21.88	0.154	0.2	0.397
	824-849	20.0	5.17	8	5.85	20.68	0.117	0.2	0.422
	1710-1755	21.0	7.51	9	6.85	20.34	0.108	0.2	0.768
	1850-1915	21.5	7.51	9	6.85	20.84	0.121	0.2	0.768
DL	728-746	13.0	4.97	6.5	4.35	12.38	0.017	0.2	0.373
	746-757	12.0	4.97	6.5	4.35	11.38	0.014	0.2	0.382
	869-894	14.0	5.17	6.5	4.35	13.18	0.021	0.2	0.445
	2110-2155	13.5	7.51	8.5	6.35	12.34	0.017	0.2	0.768
	1930-1995	14.0	7.51	8.5	6.35	12.84	0.019	0.2	0.768
BT	2402-2480	5.5	0	3.74	1.59	7.09	0.005	0.2	0.768
BLE	2402-2480	2	0	3.74	1.59	3.59	0.002	0.2	0.768
Wi-Fi	2412-2462	24	0	3.74	1.59	25.59	0.362	0.2	0.768

Note:

*The EUT contains a certified module (FCC ID: 2AC7Z-ESP32WROVERB)
According to the MPE reports of FCC ID: 2AC7Z-ESP32WROVERB, Wi-Fi and Bluetooth can’t transmit simultaneously, so consider the Booster and Wi-Fi transmitting simultaneously is the worst case:
The ratio= $ERP/Limit_{Booster}$+ $ERP/Limit_{Wi\text{-}Fi}$ =0.154/0.397+0.362/0.768=0.859<1.0

The ERP was calculated base on the maximum value of antenna gain and cable loss combination.

To maintain compliance with the FCC’s RF exposure guidelines, place the equipment at least 20cm from nearby persons.

Result: Pass

6. EUT PHOTOGRAPHS

Please refer to the attachment CR230954301-EXP EUT EXTERNAL PHOTOGRAPHS and CR230954301-INP EUT INTERNAL PHOTOGRAPHS

7. TEST SETUP PHOTOGRAPHS

Please refer to the attachment CR230954301-00A1-TSP TEST SETUP PHOTOGRAPHS.

=====END OF REPORT=====