Federal Communications Commission
Office of Engineering and Technology
Laboratory Division

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PROVIDER-SPECIFIC CONSUMER SIGNAL BOOSTERS COMPLIANCE MEASUREMENTS GUIDANCE

1 INTRODUCTION

1.1 Background

In February 2013 the FCC released a Report and Order (R&O, FCC 13-21) that established new rules for the operation of signal boosters to enhance the wireless coverage of commercial mobile voice and broadband radio services, particularly in rural, underserved, and difficult-to-serve areas, while ensuring that the boosters do not adversely affect wireless networks.[1] In 2014 and 2015, various consumer booster rules were also updated by the *Order on Reconsideration* FCC 14-138.[2] The *Second Report and Order* FCC 18-35 modified personal-use conditions for Provider-Specific Consumer Signal Boosters.[3]

The signal booster R&O created two classes of signal boosters – consumer and industrial – with distinct regulatory requirements. Industrial boosters are not discussed further in this document; instead see KDB Publication 935210 Attachments D02 and D05 for policies and procedures.

Consumer signal boosters are defined as devices that are marketed to and sold for use by subscribers and are designed to be used "out of the box" to improve wireless coverage within a limited area such as a home, car, boat, or recreational vehicle. Subscribers should be able to install a consumer signal booster without third-party professional assistance.

Consumer signal boosters include those designed to amplify over-the-air transmissions from multiple wireless providers (wideband consumer signal boosters) and those dedicated to amplifying the signals transmitted by a single provider (provider-specific consumer signal booster). Wideband signal boosters may operate on the frequencies and in the market areas of multiple licensees (service providers). Provider-specific (frequency-selective) signal boosters may operate only on the frequencies and in the market area of specific licensees. Consumer signal boosters can be either fixed (intended for operation at

[1] FCC 13-21, *Amendment of Parts 1, 2, 22, 24, 27, 90 and 95 of the Commission's Rules to Improve Wireless Coverage Through the Use of Signal Boosters*, WT Docket No. 10-4, Report and Order, February 20, 2013.

[2] FCC 14-138, *Amendment of Parts 1, 2, 22, 24, 27, 90 and 95 of the Commission's Rules to Improve Wireless Coverage Through the Use of Signal Boosters*, WT Docket No. 10-4, Order On Reconsideration, Adopted: September 19, 2014, Released: September 23, 2014.

[3] FCC 18-35, *Amendment of Parts 1, 2, 22, 24, 27, 90 and 95 of the Commission's Rules to Improve Wireless Coverage Through the Use of Signal Boosters*, WT Docket No. 10-4; Second Report and Order, Adopted: March 22, 2018, Released: March 23, 2018.

a fixed location with the server antenna[4] inside a building) or mobile (intended for operation while moving, e.g., in a vehicle or boat).

The signal booster R&O introduced a network protection standard (NPS) that specified new technical, operational, and registration requirements applicable to consumer signal boosters to minimize the potential for interference to wireless networks. Consumer signal boosters will be authorized for use under provider licenses subject to certain requirements. Specifically, subscribers must obtain some form of licensee consent to operate the booster; register the booster with their provider; use a booster that meets the NPS and is FCC certificated; and operate the booster on a secondary, non-interference basis and shut it down if it causes harmful interference.

The signal booster rules are codified Section 20.21. The common requirements of the NPS are specified in Sections 20.21(e)(1) to (e)(7), in Section 20.21(e)(8) for wideband consumer signal boosters, and in Section 20.21(e)(9) for provider-specific (frequency-selective) consumer signal boosters.

This KDB Publication provides guidance on acceptable measurement procedures for demonstrating compliance of provider-specific consumer signal boosters to the applicable requirements imposed by the NPS. The guidance proffered herein is not directly applicable to industrial signal boosters, including distributed antenna system (DAS) boosters, nor for wideband consumer signal boosters. For similar compliance measurement guidance applicable to industrial signal boosters and wideband consumer signal boosters, see Attachments D02 and D05, and D03, respectively, of KDB Publication 935210.

For additional information regarding signal booster definitions and basic certification requirements, see also Attachment D02 included as a part of KDB Publication 935210.[5]

Procedures for compliance measurements on consumer signal boosters operating under Section 20.21 are also provided in Clause 7 of ANSI C63.26-2015.[6] As part of the rule changes adopted by the *First Report and Order* FCC 17-93 (docket no. 15-170),[7] Sections 2.910(c) and 2.1041 were amended to include ANSI C63.26-2015 as an acceptable measurement procedures standard for equipment that operates in authorized radio services covered by its scope, where compliance measurements are required per Sections 2.1046, 2.1047, 2.1049, 2.1051, 2.1053, 2.1055, 2.1057, also 2.911(c).[8] KDB Publication 935210 D03 served as a basis for and was developed concurrently with the ANSI C63.26 measurement procedures, and as such each provides pertinent guidance for performing compliance measurements for signal boosters operating under Section 20.21.[9] As a companion document for use along with ANSI C63.26-

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[4] KDB Publication 935210 D02 provides other information about typical equipment configurations and related concepts.

[5] KDB Publication 935210 Attachment D02 Certification Requirements.

[6] ANSI C63.26-2015, *American National Standard for Compliance Testing of Transmitters*.

[7] FCC 17-93; Amendment of Parts 0, 1, 2, 15 and 18 of the Commission's Rules regarding Authorization of Radiofrequency Equipment; ET Docket No. 15-170; First Report and Order; Adopted: July 13, 2017; Released: July 14, 2017.

[8] ANSI C63.26-2015 was developed by ANSI-Accredited Standards Committee (ASC) C63® to provide equipment authorization applicants, manufacturers, and test laboratories with uniform, reliable, and consistent measurement procedures necessary to demonstrate that transmitters used in licensed radio services comply with FCC's technical requirements. ASC C63® is a standards development organization that includes participants from the wireless industry, test laboratories, and regulators. At present ASC C63® has an open project for developing various updates of ANSI C63.26; information is available at: (http://www.c63.org/documents/misc/matrix/c63_standards.htm).

[9] Applicants, test labs, and TCBs are requested to submit a KDB inquiry requesting guidance in case unclear or inconsistent provisions are found between ANSI C63.26-2015 and KDB Publication 935210.

2015, KDB Publication 935210 D03 provides rule section numbers and other information about FCC rules, policies, and procedures that is otherwise generally not part of the normative text in documents developed by the Accredited Standards Committee (ASC) C63®—Electromagnetic Compatibility (EMC).

1.2 Objective

The objective of this KDB Publication is to establish and document standardized measurement procedures that will produce the data required to demonstrate that a provider-specific consumer signal booster is compliant with the technical requirements specified by the NPS.

1.3 Approach

The measurement procedures provided in this document reflect efforts by the RF Booster Task Group of the ANSI ASC C63® SC4 C63.26 (Licensed Wireless) Working Group[10] to develop standardized measurement methodologies that can be applied to provider-specific consumer signal boosters to obtain the data necessary to demonstrate compliance to the NPS requirements. This RF Booster Task Group includes representatives from signal booster manufacturers, commercial wireless service providers, compliance test laboratories, and the FCC.

Alternative measurement procedures acceptable to the Commission may also be used to provide the requisite data to demonstrate compliance to the NPS technical requirements, as per Section 2.947(a)(3) of the FCC rules, but such alternative procedures must be approved by the FCC prior to use.

1.4 Cross-references from KDB Publication 935210 D04 procedures to rule paragraphs

Table 1 provides a summary listing of the technical requirements in Sections 20.21(e)(9) and other FCC rules, and the subclause numbers of the associated test procedures in this document. Appendix E provides a summary listing of Section 20.21(e) (NPS) rule paragraphs, measurement quantities, and requirements. Additional requirements for specific booster device types is given in 7.17 (single-donor-port multiple-server-port).

Table 1 – Cross-references between FCC rules technical requirements and KDB Publication 935210 D04 procedures

FCC Rule 47 CFR	KDB Publication 935210 D04 Subclause
§ 20.21(e)(3) *Frequency Bands*	7.1 Authorized frequency band verification test and authorized CMRS provider test
§ 20.21(e)(4) *Self-monitoring*	[11]
§ 20.21(e)(9)(i)(A) *Noise Limits* § 20.21(e)(9)(i)(I) *Transmit Power Off Mode*	7.7 Noise limits test procedure
§ 20.21(e)(9)(i)(B) *Bidirectional Capability* § 20.21(e)(3) *Frequency Band*	7.13 Spectrum block filtering test procedure

[10] ANSI ASC C63® SC4 is abbreviation for American National Standards Institute Accredited Standards Committee C63®—Electromagnetic Compatibility, Subcommittee 4—Wireless and ISM Equipment Measurements; *see* (http://c63.org/index.htm). When originally formed in 2013, the RF Booster Task Group was part of the ASC C63® SC1 Wireless Working Group (Subcommittee 1—Techniques and Development).

[11] There is no specific test for this functionality but it is instead indirectly addressed by the noise and gain limits tests.

FCC Rule 47 CFR	KDB Publication 935210 D04 Subclause
§ 20.21(e)(9)(i)(C)(1) *Booster Gain Limits* § 20.21(e)(9)(i)(I) *Transmit Power Off Mode*	7.9 Variable booster gain test procedure
§ 20.21(e)(9)(i)(C)(2) *Booster Gain Limits* § 20.21(e)(9)(i)(B) *Bidirectional Capability*	7.3 Maximum booster gain computation
§ 20.21(e)(9)(i)(D) *Power Limits* § 20.21(e)(9)(i)(B) *Bidirectional Capability*	7.2 Maximum power measurement test procedure
§ 20.21(e)(9)(i)(E) *Out of Band Gain Limits*	7.14 Out of band gain limits test procedure
§ 20.21(e)(9)(i)(F) *Out of Band Emission Limits*	7.5 Out-of-band emissions test procedure
§ 20.21(e)(9)(i)(G) *Intermodulation Limits*	7.4 Intermodulation product test procedure
§ 20.21(e)(9)(i)(H) *Booster Antenna Kitting*	[12]
§ 20.21(e)(9)(i)(I) *Transmit Power Off Mode*	[13]
§ 20.21(e)(9)(i)(J) *Uplink Inactivity*	7.8 Uplink inactivity test procedure
§ 20.21(e)(9)(ii)(A) *Anti-Oscillation* § 20.21(e)(5) *Anti-Oscillation*	7.11 Oscillation detection test procedure
§ 20.21(e)(9)(ii)(B) *Gain Control*	[14]
§ 20.21(e)(9)(ii)(C) *Interference Avoidance for Wireless Subsystems*	[15]
§ 2.1049 *Measurements required: Occupied bandwidth*	7.10 Occupied bandwidth test procedure
§ 2.1051 *Measurements required: Spurious emissions at antenna terminals*	7.6 Conducted spurious emissions test procedure
§ 2.1053 *Measurements required: Field strength of spurious radiation*	7.12 Radiated spurious emissions test procedure
§ 2.1055 *Measurements required: Frequency stability*	7.15 Frequency stability test procedure

2 SIGNAL BOOSTER DESCRIPTIONS

A signal booster is defined as a device that automatically receives, amplifies, and retransmits, on a bidirectional or unidirectional basis, the signals received from base, fixed, mobile, or portable stations, with no change in frequency or authorized bandwidth. A consumer signal booster, the subject of this KDB publication, is defined as a bidirectional signal booster that is marketed and sold for use without modification.

The bidirectional operation of consumer signal boosters can introduce ambiguities when using conventional RF input and RF output port descriptions, because a single RF port can represent both an RF input and RF output port (e.g., a downlink signal input and an uplink signal output). Thus, the terms *donor* port and *server* port are often used for bidirectional signal boosters. The term "donor port" of a bidirectional signal booster refers to the RF port that receives the downlink signal from a base station transmitter, and which also re-transmits an amplified uplink signal received from a mobile user. The term "server port" refers to the RF port that receives the uplink signal from a mobile user, and which also transmits the amplified downlink signal received from a base station transmitter. For a wideband consumer signal booster, multiple uplink and downlink bands can be used.

Consumer signal boosters can also be operated on either a fixed or mobile platform. Fixed consumer signal boosters are designed to be operated in a fixed location within a building, whereas a mobile

[12] Generic testing requirements are not established; rather technical documentation is used describing all antennas, cables, and/or coupling devices that may be used with a consumer booster and how those meet the requirements.

[13] There is no specific test for this functionality but it is instead addressed through a combination of the variable noise, variable gain, and oscillation detection tests.

[14] Conformance to the requirement to include AGC circuitry is verified in 7.1 and 7.2.

[15] Before testing please submit a proposed test plan in a KDB inquiry for FCC review and acceptance.

consumer signal booster is intended to operate in a moving vehicle where both the uplink and downlink transmitting antennas are at least 20 cm from the user or any other person.

3 APPLICABLE FREQUENCY BANDS

The NPS specifies that consumer signal boosters must be designed and manufactured such that they only operate on the frequencies used for the provision of subscriber-based services under parts 22 (Cellular), 24 (Broadband PCS), 27 (AWS-1, 700 MHz Lower A-E Blocks, and 700 MHz Upper C Block), and 90 (Specialized Mobile Radio). The Commission will not certificate any consumer signal boosters for operation on Part 90 (Specialized Mobile Radio) frequencies until the Commission releases a Public Notice announcing the date consumer signal boosters may be used in the band.[16]

Appendix A of this KDB Publication provides a detailed summary of the frequency bands associated with each of the services itemized above.

4 OTHER APPLICABLE RULE PARTS

Most of the technical limits and requirements applicable to consumer signal boosters are specified within the Section 20.21 rules for signal boosters. However, in some cases the technical limits are specified as relative to the limit applicable for each particular operational frequency band (e.g., unwanted emission limits) and as such, the applicable radio service rule part must be consulted. Appendix A provides a cross-reference to the applicable rule parts for each frequency band in which consumer signal boosters are authorized to operate.

In addition, because signal boosters require part 2 subpart J certification, further to Section 2.911(c) the requirements specified in Section 2.1033 are also applicable. Therefore, the measurement guidance provided herein also includes procedures for obtaining the data required per Section 2.1033(c)(14).

5 MEASUREMENT EQUIPMENT REQUIREMENTS

5.1 General

The following paragraphs provide a list of requisite test equipment and relevant minimum capabilities necessary to perform the measurements specified within this KDB publication. All equipment used shall be appropriately calibrated prior to use in accordance with laboratory accreditation requirements.

5.2 Measurement instrumentation

Most of the measurement procedures provided herein are based on the use of a spectrum/signal analyzer or an EMI receiver with similar capabilities. The measurement instrumentation must provide the following minimum capabilities:

a) A tuning range that will permit measurements over the frequency ranges under investigation (including unwanted emissions),
b) A power averaging (rms) detector,
c) A trace averaging capability (i.e., the ability to average over multiple measurement traces)
d) An integrated power function (e.g., band or channel power),
e) A burst power measurement capability,
f) A peak power detector,

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[16] *See* § 20.21(e)(3).

g) A maximum hold function.

5.3 Digital storage oscilloscope

Some of the technical requirements specified by the NPS are time-based (e.g., uplink inactivity and anti-oscillation tests). In most cases a spectrum/signal analyzer or EMI receiver operated in zero-span mode can be used to make such time domain measurements; however, a digital oscilloscope with an appropriate RF (diode) detector may also be used. Note that there may be cases where an oscilloscope with an RF detector may not provide sufficient dynamic range for performing some tests.

5.4 Test signal generators

Several of the technical requirements specified by the NPS are expressed such that one or more input signals are required when collecting the data necessary to demonstrate compliance. Thus, the capability to generate a minimum of two separate signal paths is required (two independent signal generators or one signal generator with separately-controlled dual outputs). The signal generator(s) must have the following minimum capabilities:

a) a tuning range that completely encompasses the operational frequency ranges of the booster (e.g., 100 kHz to 3 GHz),
b) a minimum output power range of −103 dBm to +20 dBm,
c) the ability to replicate CMRS signal types GSM, CDMA, W-CDMA (LTE is optional) with a pseudo-random symbol pattern,
d) the ability to generate non-pulsed and pulsed CW tones and band-limited AWGN.

5.5 Maximum transmitter test input levels

Several of the measurements will require that the booster be driven into saturation while observing the spectrum for undesired changes in the spectral envelope or unwanted emission levels (e.g., spectral regrowth). The following are the maximum uplink transmitter test levels for various signal booster configurations. Note that these levels may exceed the signal generator output power capabilities, as referenced to the booster's input port, and may require the use of an external linear amplifier.

a) The following are the maximum uplink transmitter test levels for various signal booster configurations, as referenced to the booster's uplink input (server) port. External linear amplifier(s) shall be used if these levels exceed the output power capabilities of the signal generator(s) available for these tests.

    1) Direct connect: 27 dBm,
    2) Direct contact coupling (e.g., cradle-type): 23 dBm,
    3) Mobile using inside antenna(s): 10 dBm,
    4) Fixed using inside antenna(s): 0 dBm.

b) The maximum downlink input (donor) port test level for all device types is −20 dBm.

5.6 RF step attenuators

Some measurement procedures will require that the requisite input signal power be stepped over a specified range of values. This is typically accomplished by using external RF step attenuators inserted into the input signal path. The granularity of the measurement steps will require the use of a combination of linear step attenuators to provide at least 0 dB to 70 dB of attenuation in 10 dB steps, 0 dB to 10 dB of attenuation in 1 dB steps, and 0 dB to 1 dB in 0.1 dB steps.

5.7 RF combiner and directional coupler

Several of the measurement procedures require that input signals be combined (e.g., intermodulation test) or that output signals be differentiated at a common port (e.g., noise and variable gain tests). The RF combiners and directional couplers used to accomplish this shall be frequency matched to the operational band under test and rated for at least 1 W of input power. RF directional couplers must provide a minimum of 10 dB of coupling loss.

5.8 RF filters

Some of the measurement procedures may require that RF filtering (band pass and/or band notch) be applied to enable measuring a desired signal level in the presence of an undesired signal. Tunable filters are recommended and the specific tuning ranges should be commensurate with the operational frequency range capabilities of the signal booster under test (see Appendix A). All RF filters shall be rated for at least 1 W of input power.

5.9 Impedance matching

When connected to test equipment in this specification, the EUT must be terminated in the characteristic impedance of its input port and output port. All test equipment interconnection figures included in this specification are based on test equipment whose characteristic impedance matches that of the EUT. If the EUT presents a source and/or load impedance which differs from the characteristic impedance of the test equipment, minimum-loss impedance matching pads shall be employed, and the losses associated with these pads shall be factored into all subsequent measurements.

5.10 Base station simulator

Base station simulator with support for all standards the EUT supports.

6 MEASUREMENT CONFIGURATIONS

6.1 Conducted measurements

The procedures provided in this KDB guidance document typically use a conducted test configuration (i.e., the RF interface between the signal booster and the measurement instrumentation is established via coaxial cable and RF connectors). While coaxial cables typically provide some level of shielding from ambient signals, care should still be taken to ensure that the measurements are not influenced by strong ambient signals in the CMRS frequency ranges under test.

6.2 Radiated measurements

The measurement procedures provided for demonstrating compliance to the radiated spurious emission limits will require the use of a radiated test configuration. These measurements may be performed with the transmit antenna port(s) terminated. The test site requirements, EUT arrangement and signal maximization procedures shall be consistent with those described in ANSI C63.26. When performing radiated tests, special care should be taken to ensure isolation of the EUT from any ambient CMRS signals.

6.3 Test configurations for provider-specific consumer signal boosters

6.3.1 General

Provider-specific consumer boosters are capable of decoding the received CMRS signal from the base station and identifying the CMRS licensee to whom the signal transmission belongs. Only on positively confirming that the signal belongs to the CMRS operator that has provided consent for the operation of the provider-specific signal booster (as defined in Section 20.3) can the booster start to operate on the authorized licensee's spectrum block(s). During operation, the operating conditions must be monitored and adjusted to meet the FCC Rules and Regulations.

To accurately and efficiently evaluate the performance of a provider-specific consumer booster, two modes of EUT operation, i.e., EUT normal operational mode and EUT test mode, are described in the following subclauses.

6.3.2 EUT normal operational mode

In this mode, a base station simulator is employed to send a modulated signal, including valid control channel information containing the authorized licensee's unique identification code, to the EUT. A step attenuator is used to simulate the BSCL while the booster's internal control circuit adjusts its operational gain accordingly. Uplink RF characteristics are to be evaluated via the coupled port of an RF coupler, using the donor port spectrum analyzer as is shown in Figure 1. Downlink RF characteristics are to be evaluated via the coupled port of an RF coupler, using the server port spectrum analyzer as is shown in Figure 1.

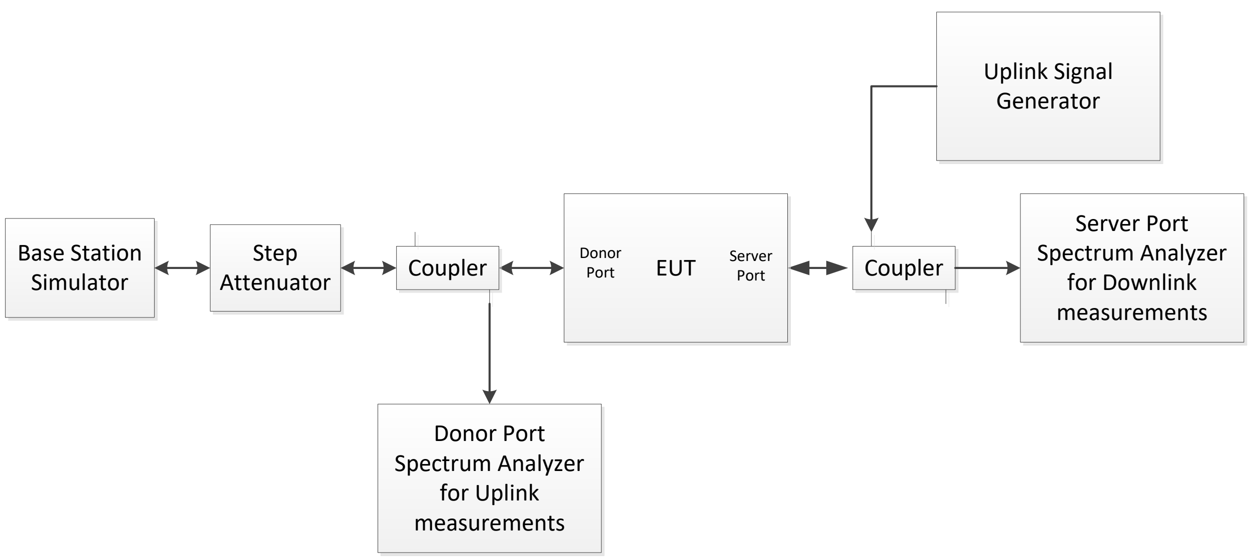

Figure 1 – Test configuration in EUT normal operational mode

6.3.3 EUT test mode

In this mode, to ease the measurement of parameters independent of gain and BSCL, a supporting controller/computer and test software is used to set the booster in test mode, where the gain, spectrum block, and other operating parameters can be manually set. For all tests performed in test mode, the booster shall be set to operate at maximum gain. All changes from normal operation shall be documented in the test report. In test mode, uplink RF characteristics are evaluated at the donor port as shown in Figure 2, and downlink RF characteristics are evaluated at the server port as shown in Figure 3.

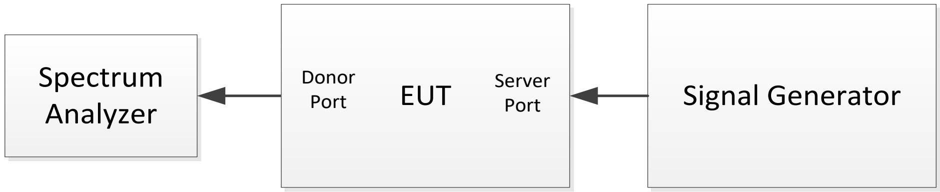

Figure 2 – Uplink test configuration in EUT test mode

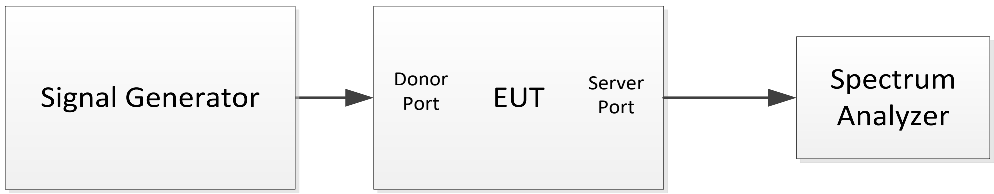

Figure 3 – Downlink test configuration in EUT test mode

7 COMPLIANCE MEASUREMENT PROCEDURES (PROVIDER-SPECIFIC CONSUMER SIGNAL BOOSTERS)

The following subclauses provide recommended measurement procedures for collecting the data necessary to demonstrate compliance to each of the technical regulations applicable to provider-specific consumer signal boosters. The user is encouraged to read completely through each procedure prior to initiating the tests.

7.1 Authorized frequency band verification test and authorized CMRS provider test

Two independent tests shall be performed to:

- verify the frequency band of operation, and
- verify that only the authorized CMRS licensee's spectrum block(s) is boosted.

7.1.1 Authorized frequency band verification test

Rule paragraph(s): Section 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 with each CMRS operational band, which then serves as a basis for subsequent tests.

EUT operating mode: normal mode (Figure 1) or test mode (Figure 2 and Figure 3), with the gain manually set to the maximum gain and a minimum bandwidth setting (e.g., 5 MHz) in the CMRS band under test.

a) Connect the EUT to the test equipment either in test mode or normal mode and set the passband of the EUT to the lowest passband frequency of the booster in the CMRS band.
b) Set the spectrum analyzer resolution bandwidth (RBW) for 100 kHz with the video bandwidth (VBW) $\geq 3 \times$ 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 5 MHz.
d) Set the signal generator for CW mode and tune to the center frequency of the operational band under test. Alternatively, for signal boosters that implement narrowband rejection protection capability, a 200 kHz or an AWGN signal with a 99% occupied bandwidth (OBW) of 4.1 MHz can be used, as appropriate.
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. Ensure 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 with the passband of the booster set to the center of the CMRS band and the highest and lowest passband frequencies of the booster in the CMRS band.

7.1.2 Authorized CMRS provider spectrum blocks

The following procedure shall be used to ensure the booster restricts its operation only to the spectrum assigned to the CMRS provider supporting the equipment certification request.

a) Set up the booster in normal mode as shown in Figure 1, with the base station simulator transmitting an authorized CMRS provider signal to the booster.
b) Set the level of the base station simulator such that the booster reaches maximum output power in the downlink direction.
c) Set the level of the uplink signal generator such that the booster reaches maximum output power in the uplink direction.
d) Set the center frequency of the donor port spectrum analyzer to the one of the authorized uplink spectrum blocks, and server port spectrum analyzer to the one of the authorized downlink spectrum blocks
e) Set the spectrum analyzer RBW to 1 MHz with the VBW ≥ 3 × RBW.
f) Select the power averaging (rms) detector and trace average over at least 100 traces.
g) Measure the transmit power levels in both the uplink and downlink directions.
h) Change the base station simulator signal to a non-authorized CMRS provider signal at the same center frequency.
i) Reset the EUT (e.g., cycle ac/dc power).
j) Measure the maximum transmitter noise power level in both the uplink and downlink directions.
k) Calculate the booster gain level in the uplink direction.
l) Save the spectrum analyzer plot as necessary for inclusion in the final test report.

m) Check compliance from reset condition (which includes the manufacturer's declared boot-up time) or change in provider code set [see 7.1.2h)] by verifying that the booster is inactive for at least 30 seconds after reset and is in compliance with the noise power and gain limits as specified in Section 20.21(e)(9)(i)(I) for all non-authorized spectrum block(s) within the CMRS band under test.
n) Repeat 7.1.2h) through 7.1.2m) for two additional non-authorized CMRS provider Signals.
o) Repeat 7.1.2a) through 7.1.2n) for all CMRS bands.

7.1.3 Authorized CMRS provider spectrum for mobile devices

The following procedure shall be used to verify that a mobile booster restricts its operation only to the spectrum assigned to the CMRS provider supporting the device certification request.

a) Set up the booster in normal mode as shown in Figure 4, with base station simulator #1 transmitting a fully loaded, authorized CMRS provider signal (see definition in Appendix C) to the booster, and base station simulator #2 transmitting a fully loaded, non-authorized co-channel CMRS provider signal of the same technology type (e.g., UMTS) to the booster.
b) Set the level of base station simulator #1 such that level at the donor port is equal to −85 dBm in the downlink direction.
c) Set the level of the base station simulator #2 to a level that is 0 dB lower than that of base station simulator #1, as measured at the booster donor port with the step attenuator set to 0 dB.
d) Set the step attenuator to 20 dB or greater.
e) Set the level of the uplink signal generator such that the booster reaches maximum output power in the uplink direction.
f) Set the center frequency of the donor port spectrum analyzer to the one of the authorized uplink spectrum blocks, and server port spectrum analyzer to the one of the authorized downlink spectrum blocks.
g) Select the power averaging (rms) detector.
h) Set the spectrum analyzer RBW for 1 MHz with the VBW ≥ 3 MHz.
i) Set the span for 0 Hz, then initiate a single sweep with a sweep time of at least 10 seconds.
j) Measure the transmit power levels in both the uplink and downlink directions.
k) Change the step attenuator to 0 dB in a single step.
l) Verify that the booster output drops below the transmit power off mode limit within 5 seconds in both the uplink and downlink directions. The spectrum analyzer settings may need to be adjusted to measure the noise power level to comply with the transmit power off mode limit.
m) Save the spectrum analyzer plot as necessary for inclusion in the final test report.
n) Repeat 7.1.3a) to 7.1.3m) with base station simulator #2 set to a technology type that is different from that of base station simulator #1. An AWGN signal with equivalent OBW as the CMRS signal generated by base station simulator #1 may also be used.
o) Repeat 7.1.3a) to 7.1.3n) for all CMRS bands supported by the booster.

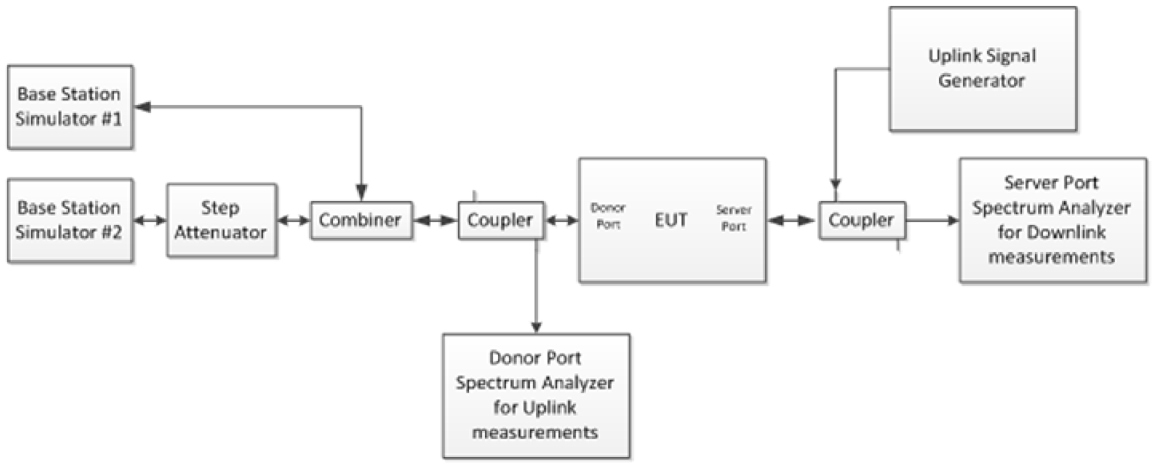

Figure 4 – Test set-up for authorized CMRS provider spectrum for mobile devices

7.2 Maximum power measurement test procedure

7.2.1 General

Rule paragraph(s): Section 20.21(e)(9)(i)(D) *Power Limits*; Section 20.21(e)(9)(i)(B) *Bidirectional Capability* (uplink minimum conducted power output).

The procedure of this subclause shall be used to demonstrate compliance to the signal booster power limits and requirements as specified in Sections 20.21(e)(9)(i)(D) and 20.21(e)(9)(i)(B) for provider-specific 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) The maximum power levels to be measured using this procedure will also 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) This test can be performed in either normal mode (see Figure 1) or test mode (see Figure 2 and Figure 3).
e) For an uplink test signal, in either normal mode or test mode, an AWGN signal with occupied bandwidth equal to that of the technology deployed in the band can be used (e.g., 4.1 MHz 99% OBW, to represent a UMTS signal or 5 MHz LTE signal).
f) For a downlink test signal:
   - in test mode, an AWGN signal with occupied bandwidth equal to that of the technology deployed in the band can be used (e.g., 4.1 MHz 99% OBW, to represent a UMTS signal or 5 MHz LTE signal).
   - in normal mode, a simulated base station signal with technology type the same as exists in the CMRS band.
g) All operating modes 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.

7.2.2 Procedure

a) Connect the EUT in either normal mode or test mode.
b) Configure the signal generator and spectrum analyzer for operation on the frequency with the highest power level as determined in 7.1. Set for appropriate signal type as specified in 7.2.1e) and 7.2.1f).
c) Set the initial signal generator power to a level far below the AGC threshold level.
d) Slowly increase the signal generator power level until the output signal reaches the AGC threshold level as determined from observation of the 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 limiting the output power.
f) Slowly increase the signal generator power to a level just below (and within 0.5 dB of) the AGC threshold without triggering the AGC. Note the signal generator power level as (P_{in}).
g) Measure the output power (P_{out}) 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 $\geq 3 \times$ RBW.
    3) Select either the BURST POWER or CHANNEL POWER measurement mode, as appropriate 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 $\geq$ (2 $\times$ 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 P_{out}, 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 7.2.2g) while increasing the signal generator amplitude in 2 dB steps until the maximum input level indicated in 5.5 is reached. Ensure that the EUT maintains compliance with applicable power 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.
i) Repeat the procedure for each operational uplink and downlink frequency band supported by the booster.
j) Provide tabulated results in the test report.

7.3 Maximum booster gain computation

Rule paragraph(s): Section 20.21(e)(9)(i)(C)(2) *Booster Gain Limits* (maximum gain);
Section 20.21(e)(9)(i)(B) *Bidirectional Capability* (equivalent uplink and downlink gain).

This subclause provides guidance for the calculation of the maximum gain, based on the data obtained from the 7.1 and 7.2 measurements. The NPS limits on maximum gain for provider-specific consumer signal boosters are provided in Section 20.21(e)(9)(i)(C)(*2*). Additionally, Section 20.21(e)(9)(i)(B) requires that provider-specific consumer signal boosters be able to provide equivalent (within 9 dB) uplink and downlink gain.[17]

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} value pairs for all input signal types used in 7.2 in the following equation to determine the maximum gain, G:

$$G\ (\text{dB}) = P_{OUT}(\text{dBm}) - P_{IN}(\text{dBm}).$$

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 test report.

7.4 Intermodulation-product test procedure

Rule paragraph(s): Section 20.21(e)(9)(i)(G) *Intermodulation Limits*.

The following procedures shall be used to demonstrate compliance to the intermodulation limit specified in Section 20.21(e)(9)(i)(G) for provider-specific consumer signal boosters.

a) Connect the signal booster to the test equipment as shown in Figure 5 and configure it for operation in either normal mode or test mode.
b) Set the spectrum analyzer RBW = 3 kHz.
c) Set the VBW ≥ 3 × the RBW.
d) Select the power averaging (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.
g) Configure the two signal generators for CW operation, with signal generator #1 tuned 300 kHz below the operational band center frequency, and signal generator #2 tuned 300 kHz above the operational band center frequency.
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 the signal generators' amplitudes equally until just before the EUT begins AGC, then affirm that all intermodulation products (if any occur), are below the specified limit of −19 dBm.
j) Utilize the MAX HOLD function of the spectrum analyzer and wait for the trace to stabilize. Place a marker at the highest amplitude intermodulation product.
k) Record the maximum intermodulation product amplitude level that is observed.
l) Capture the spectrum analyzer trace for inclusion in the test report.
m) Increase the signal generator amplitude in 2 dB steps to 10 dB above the AGC threshold determined in 7.4i), but to not to exceed the maximum input level specified in 5.5, to ensure that the EUT maintains compliance with the intermodulation limit. The test report shall include either a statement

[17] The margin for equivalent gain is a provisional specification determined by the ANSI ASC C63® task group working in collaboration and consultation with FCC OET Laboratory Division staff.

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.

n) Repeat 7.4e) to 7.4m) for all uplink and downlink operational bands.

NOTE–If using a single signal generator with dual outputs, ensure that intermodulation products are not the result of the generator.

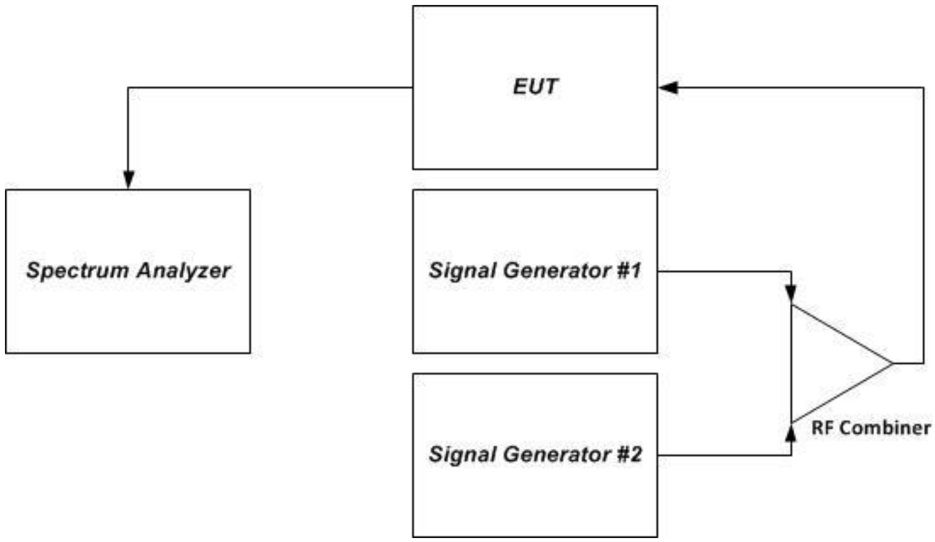

Figure 5 – Intermodulation product instrumentation test setup

7.5 Out-of-band emissions test procedure

Rule paragraph(s): Section 20.21(e)(9)(i)(F) *Out of Band Emission Limits*.

The booster will be configured to operate on frequencies associated with the highest and lowest spectrum blocks within the CMRS band under test. The out-of-band emissions are referenced to the licensee spectrum block. This measurement is intended to demonstrate compliance to the limit specified in Section 20.21(e)(9)(i)(F), which specifies that out-of-band emissions generated by a provider-specific signal booster shall meet the mobile station emission limit applicable to the supported band of operation. The mobile-station emission limit is listed in Appendix A for each applicable operating band and rule part.

a) Connect the EUT in normal mode or test mode as shown in Figures 1 to 3. The EUT passband shall be configured for the highest and lowest authorized spectrum blocks within the CMRS band under test.
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 edge.
    2) LTE (5 MHz): 2.5 MHz from upper and lower band edge.
    3) CDMA: 1.25 MHz from upper and lower band edge, except for cellular 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–The LTE simulator must utilize the uplink and downlink signal formats in the uplink and downlink tests, respectively. LTE signals shall use a 5 MHz signal with 25 active resource blocks.

NOTE 3–The AWGN bandwidth shall be the measured 99% occupied bandwidth.

c) Set the signal generator amplitude to the maximum power level prior to the AGC threshold as determined from 7.2.2d) to 7.2.2f) of the power measurement procedure for the appropriate modulations.

d) Set RBW = reference 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 (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.

7.6 Conducted spurious emissions test procedure

Rule paragraph(s): Section 2.1051 *Measurements required: Spurious emissions at antenna terminals*.

The following procedures shall be used to demonstrate compliance to the applicable conducted spurious emissions limits as per Section 2.1051. This test may be performed in normal or test mode.

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 in normal or test mode as shown in Figures 1 to 3.
b) Configure the signal generator for AWGN with a 99% OBW of 4.1 MHz operation with a center frequency corresponding to the center of the CMRS band under test.
c) Set the signal generator amplitude to the pre-AGC threshold level as determined in 7.2.2.
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 (rms) mode.
    6) 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.
    7) 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 be subdivided, depending on the available number of measurement points provided by the spectrum analyzer.
    8) 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.

7.7 Noise limits test procedure

Rule paragraph(s): Section 20.21(e)(9)(i)(A) *Noise Limits*; Section 20.21(e)(9)(i)(I) *Transmit Power Off Mode* (uplink and downlink noise power).

This procedure provides a measurement methodology for demonstrating compliance to the noise limits specified in Section 20.21(e)(9)(i)(A) and Section 20.21(e)(9)(i)(I) for provider-specific consumer signal boosters. This test may be performed using either normal mode or test mode of the EUT.

7.7.1 Maximum transmitter noise power level

a) Connect the EUT to the test equipment as shown in Figure 6, and use the test mode to set to maximum gain and minimum passband bandwidth.
b) Set the spectrum analyzer RBW to 1 MHz with the VBW ≥ 3 MHz.
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 transmitter noise power spectral density over the CMRS band and use a marker to identify the maximum noise power within the CMRS band but outside of the authorized licensee spectrum block(s).
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 downlink bands.
h) Connect the EUT to the test equipment as shown in Figure 7 or Figure 8 as appropriate for uplink or downlink directions.
i) Configure the signal generator for AWGN with a 99% OBW of 4.1 MHz.
j) Set the spectrum analyzer RBW to 1 MHz with the VBW ≥ 3 MHz. Select the power averaging (rms) detector and average over at least 100 traces.
k) Set the center frequency of the spectrum analyzer to the center of the CMRS band under test with a span setting ≥ 2 × the CMRS band. The span 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) For downlink noise measurements, set the spectrum analyzer to the center of the downlink band and tune the signal generator to the upper or lower band-edge of the same band, ensuring that the maximum noise power is being measured.
n) Set the passband of the EUT and the RF filter frequencies to the other edge of the CMRS band. Ensure that the signal generator does not contribute to the in-band noise level of the booster.
    1) Filter 1 in Figure 8 should be configured as needed to ensure that no additional noise is present within or outside the passband of the booster at its donor port. Filter 2 should be configured such that an accurate measurement of the noise power outside of the CMRS licensee's block can be made on the spectrum analyzer.
    2) Any filter effects that may reduce the measured transmit noise level outside of the CMRS licensee's band of the EUT must be accounted for, to ensure that an accurate noise measurement is taken. The test report shall indicate the type and characteristics of the filters used.
o) Measure the maximum transmitter noise power level while varying the downlink signal generator output level from −90 dBm to −20 dBm in 1 dB steps within 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 included from within the RSSI-dependent region of the limit. See Appendix D for noise limits graphs. The EUT response time shall be less than 3 seconds.
p) Repeat 7.7h) through 7.7o) for all operational uplink and downlink bands.

NOTE–Some signal boosters will require a signal generator input as they will not operate unless a signal is received at the input terminals. If this is the case, for the setups shown in Figures 6 to 8 connect a second signal generator in place of the matched load, then cycle the RF output of the second signal generator to simulate this function.

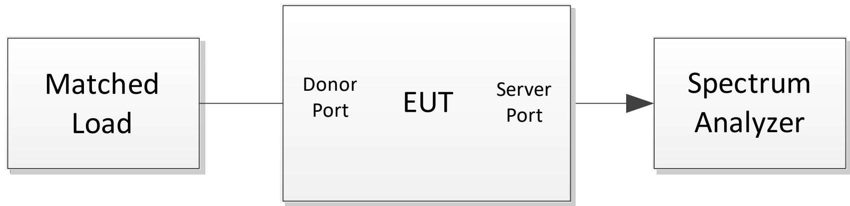

Figure 6 – Maximum downlink noise limit test configuration

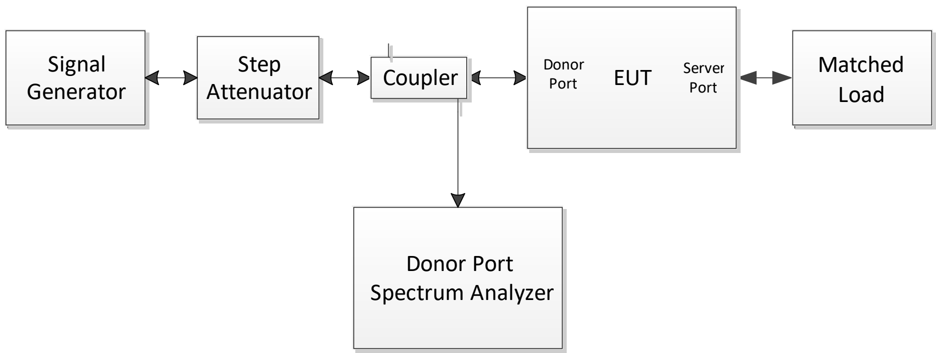

Figure 7 – Uplink RSSI-dependent noise limit test configuration

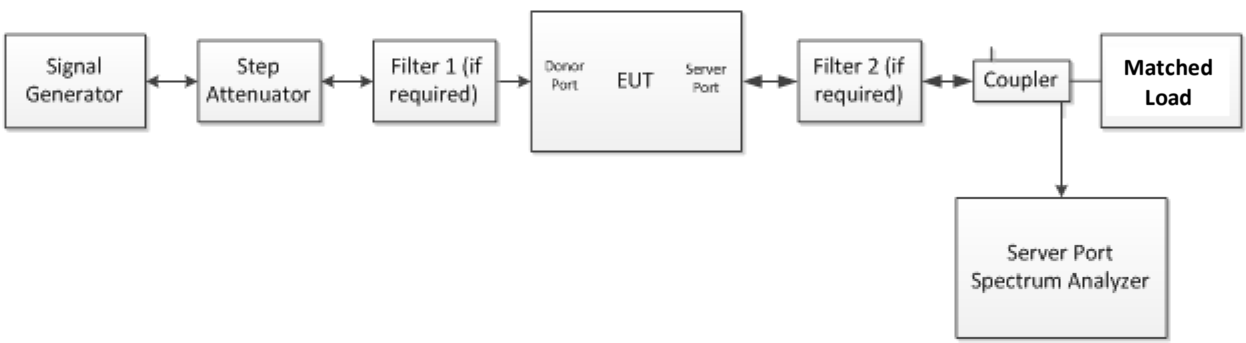

Figure 8 – Downlink RSSI-dependent noise limit test configuration

7.7.2 Variable noise response time

The variable noise response time shall be measured as follows, using the test set-up of Figure 7 or Figure 8 as appropriate for uplink or downlink directions.

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.
d) Select MAX HOLD and increase the power level of signal generator by 20 dB for fixed boosters, and by 10 dB for mobile boosters.

e) Affirm that the uplink noise decreases to the specified level within 3 seconds for fixed boosters, and within 1 second for mobile boosters.[18]
f) Repeat 7.7.a) through 7.7e) for all operational uplink and downlink bands.
g) Include plots and summary table in test report.

7.8 Uplink inactivity test procedure

Rule paragraph(s): Section 20.21(e)(9)(i)(J) *Uplink Inactivity*.

This measurement procedure is intended to demonstrate compliance to the uplink inactivity requirements specified for provider-specific consumer signal boosters in Section 20.21(e)(9)(i)(J).

a) Connect the EUT to the test equipment as shown in Figure 1 (normal operational mode).
b) Select the power averaging (rms) detector.
c) Set the spectrum analyzer RBW for 1 MHz with the VBW ≥ 3 MHz.
d) Set the center frequency of the spectrum analyzer to the center of the uplink operational band.
e) Set the span for 0 Hz, then initiate a single sweep with a sweep time of at least 30 seconds.
f) Start to capture a new trace using MAX HOLD.
g) After approximately 15 seconds, turn on the Signal Generator Output.
h) After approximately 5 seconds, turn off the Signal Generator Output.
i) After the full-sweep time-domain trace is complete, place a MARKER on the leading edge of the pulse then use the DELTA MARKER function to determine the elapsed time until the uplink becomes inactive.
j) Measure the noise power level using the procedures of 7.7.1a) to 7.7.1e), then demonstrate that the results are below the applicable uplink inactivity noise power limit.
k) Capture the plot for inclusion in the test report.
l) Repeat 7.8d) to 7.8k) for all operational uplink bands.

NOTE–Some signal boosters will require a signal generator input as they will not operate unless a signal is received at the input terminals. If this is the case connect a signal generator and cycle the RF output of the signal generator to simulate this function.

7.9 Variable booster gain test procedure

Rule paragraph(s): Section 20.21(e)(9)(i)(C)(1) *Booster Gain Limits* (variable gain);
Section 20.21(e)(9)(i)(I) *Transmit Power Off Mode* (uplink gain).

7.9.1 Variable gain

This procedure shall be used to demonstrate compliance to the variable gain limits specified for provider-specific consumer signal boosters in Section 20.21(e)(9)(i)(C)(1) or Section 20.21(e)(9)(i)(I). The variable gain limits are expressed as a function of BSCL and MSCL, and are shown graphically in Appendix D. The BSCL is varied over a range of values by adjusting the variable attenuator between the base station simulator and the booster, as specified within the procedure. See Section 20.21(e)(9)(i)(C)(1) for guidance on determining the BSCL value. Refer to Appendix B of this document for guidance on determining the applicable MSCL value.

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[18] The time response requirements are provisional and are as determined by the ANSI ASC C63® task group working in collaboration and consultation with FCC OET Laboratory Division staff.

a) Connect the EUT to the test equipment as shown in Figure 1 (normal operational mode).
b) Configure the base station simulator for the transmission of a valid base station signal for the standard being tested (e.g., W-CDMA or LTE), and set the base station forward pilot/control channel TX power to a fixed value that is able to achieve the dynamic range indicated in the following procedure.
c) Set the power level and frequency of the signal generator to a value 5 dB below the AGC threshold level as determined in 7.2.2 with the booster operating at maximum gain. The uplink signal type is AWGN with a 99% OBW of 4.1 MHz.
d) Set RBW = 100 kHz on the donor and server port spectrum analyzers.
e) Set VBW ≥ 300 kHz on the donor and server port spectrum analyzers.
f) Select the CHANNEL POWER measurement mode on the donor and server port spectrum analyzers.
g) Select the power averaging (rms) detector on the donor and server port spectrum analyzers.
h) Set 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 (rms) mode.
k) Measure the maximum channel power in the uplink and downlink directions, and compute maximum gain, when varying the variable attenuator to achieve a received signal channel power level (RPCH) at the booster port of from −90 dBm to −20 dBm, in 1 dB steps inside the RPCH dependent region, and in 10 dB steps outside the RPCH dependent region. Report the six values closest to the limit, including at least two points from within the RPCH dependent region of operation. See gain limit charts in Appendix D.

   NOTE 1–The RPCH is the total signal power level in the downlink channel in dBm, referenced to the booster donor port (i.e., downlink signal level at the booster donor port), which is greater than the received pilot power level.

   NOTE 2–For provider-specific boosters with maximum gain greater than 85 dB, which have automatic gain adjustment based on antenna isolation per the gain limits requirements, the starting value for RPCH shall be −100 dBm, rather than −90 dBm as specified in the preceding procedure.

l) Repeat 7.9.1a) to 7.9.1k) for all uplink and downlink bands.

7.9.2 Variable gain timing

Variable uplink gain timing shall be measured as follows.

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 BSCL to obtain the maximum booster gain within the BSCL dependent gain region.
d) Select MAX HOLD and decrease the BSCL by decreasing the variable attenuator in 20 dB steps for fixed boosters, and in 10 dB steps for mobile boosters. The signal generator output power remains fixed at the level determined in 7.9.1c).

e) Ensure that the uplink gain decreases to the specified levels within 3 seconds for fixed boosters, and within 1 second for mobile boosters.[19]

f) Repeat 7.9.2a) to 7.9.2e) for all operational uplink bands.

7.10 Occupied bandwidth test procedure

Rule paragraph(s): Section 2.1049.

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 9** to firstly measure the characteristics of the test signals produced by the signal generator.

b) 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.

c) Set the signal generator for power level to match the values obtained from the tests of 7.2.

d) 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.

e) Set the spectrum analyzer RBW for 1% to 5% of the EBW.

f) Set VBW $\geq 3 \times$ RBW.

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, for all uplink and downlink operational bands. AWGN or LTE may be used in place of W-CDMA, as an option.

i) Connect the test equipment as shown in **Figure 1** (normal operational mode).

j) Repeat 7.10c) to 7.10h) in this new configuration using signal types as appropriate for the signal type being transmitted in a specific CMRS band.

NOTE–Some signal boosters will require a signal generator input as they will not operate unless a signal is received at the input terminals. If this is the case connect a signal generator and cycle the RF output of the signal generator to simulate this function.

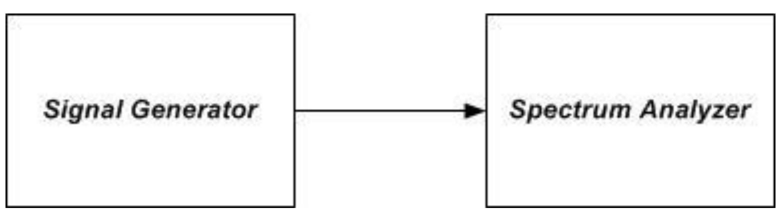

Figure 9 – Test setup for measuring characteristics of test signals used for subsequent EUT occupied bandwidth testing

[19] The time response requirements are provisional and are as determined by the ANSI ASC C63® working group in collaboration and consultation with FCC OET Laboratory Division staff.

7.11 Oscillation testing procedures

7.11.1 General

Rule paragraph(s): Section 20.21(e)(9)(ii)(A) *Anti-Oscillation*.

This measurement is required to demonstrate compliance to the anti-oscillation specification for provider-specific consumer signal boosters provided in Section 20.21(e)(9)(ii)(A).

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.

7.11.2 Oscillation detection tests

a) Connect the normal-operating mode EUT to the test equipment as shown in Figure 10 (uplink) or Figure 11 (downlink).
b) Set the feedback step attenuator to 110 dB, and set the BSCL step attenuator such that the booster is operating at maximum gain and the minimum input level required for normal operation.
c) Spectrum analyzer settings:
    1) Set the spectrum analyzer center frequency to the center of the passband of the booster.
    2) Set the spectrum analyzer RBW to at least 1 MHz and the VBW $\geq$ 3 MHz.
    3) Set the spectrum analyzer to zero-span, with a sweep time of 5 seconds, single-sweep, max-hold.
d) Set the spectrum analyzer sweep trigger level in this and the subsequent steps to 3 dB above the output power level of the booster that was found in 7.11.2b).
e) Reduce the feedback step attenuator setting from 110 dB until the sweep is triggered at oscillation onset, which may require an iterative process to find the precise setting where oscillation occurs, or up to a level equal to the booster maximum gain – 20 dB.
f) Use the CURSOR function of the spectrum analyzer to measure the time from the onset of oscillation until the EUT turns off, by setting CURSOR 1 on the leading edge of the oscillation signal, and CURSOR 2 on the trailing edge. The spectrum analyzer sweep time may be adjusted to improve the time resolution of these cursors.
g) Capture the spectrum analyzer trace for inclusion in the test report, and with the oscillation power level being discernible.
h) Repeat 7.11.2b) to 7.11.2g) for all operational uplink and downlink bands.
i) Replace the normal-operating mode EUT with the EUT that supports a test mode.
j) Set the spectrum analyzer time base (zero-span time) for a minimum 120 seconds, with the same trigger as in the preceding steps, and a single sweep.
k) Start the spectrum analyzer sweep, and manually force the booster into oscillation by changing the feedback step attenuator, as described in 7.11.2e).
l) When the sweep is complete, place cursors between the first two oscillation detections, and save the plot for inclusion in the test report; report the power level associated with the oscillation separately if it can't be displayed on the trace. The time between restarts must match the manufacturer's timing for the test mode, and there shall be no more than five restarts.
m) Repeat 7.11.2j) through 7.11.2l) for all operational uplink and downlink bands.
n) If no oscillations are detected with the preceding procedure, a pre-test shall be performed with a wider spectrum span to ensure that the frequency of oscillation is within the RBW of the spectrum analyzer.

7.11.3 Test procedure for measuring oscillation mitigation or shutdown

a) Connect the normal-operating mode EUT to the test equipment as shown in Figure 12. Alternatively, the test mode EUT as described in 6.3.3 may be used.
b) Spectrum analyzer settings:
    1) Set the spectrum analyzer's center frequency to the center of band under test,
    2) RBW = 30 kHz, VBW $\geq$ 3 × RBW,
    3) power averaging (rms) detector,
    4) trace averages $\geq$ 100,
    5) span $\geq$ 120 % of operational band under test,
    6) number of sweep points $\geq$ 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: i) Perform pre-tests with span equal to smaller band segments, such that 120 % of the operational band is captured in multiple tests, using the setup parameters specified; ii) record the center frequency of the strongest oscillation level occurring, and iii) confirm 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.
d) 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. The input signal shall not obstruct the measurement of the strongest oscillation peak in the band, and shall not be included within the span of the measurement.

    NOTE–Boosters with operating spectrum passbands of 10 MHz or less may use a CW signal source at band edge rather than AWGN. 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.
e) 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.
f) 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.
g) 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) The peak oscillation level, as measured in 7.11.3g2), shall not exceed by 12.0 dB the minimal output level measured in 7.11.3g4). Record the measurement results of 7.11.3g2) and 7.11.3g4) in tabular format for inclusion in the report.
    6) The procedure of 7.11.3g1) to 7.11.3.g5) allows the spectrum analyzer trace to stabilize, and verification of shutdown or oscillation level measurement shall occur within 300 seconds.[20]

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[20] The time response requirements are provisional and are as determined by the ANSI ASC C63® task group in collaboration and consultation with FCC OET Laboratory Division staff.

h) Decrease the variable attenuator in 1 dB steps, and repeat 7.11.3g) 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).
NOTE–Provider-specific boosters with gain greater than 75 dB and 85 dB must continue testing to the levels 15 dB and 25 dB lower than maximum gain, respectively.

i) Repeat 7.11.3b) to 7.11.3h) for all operational uplink and downlink bands.

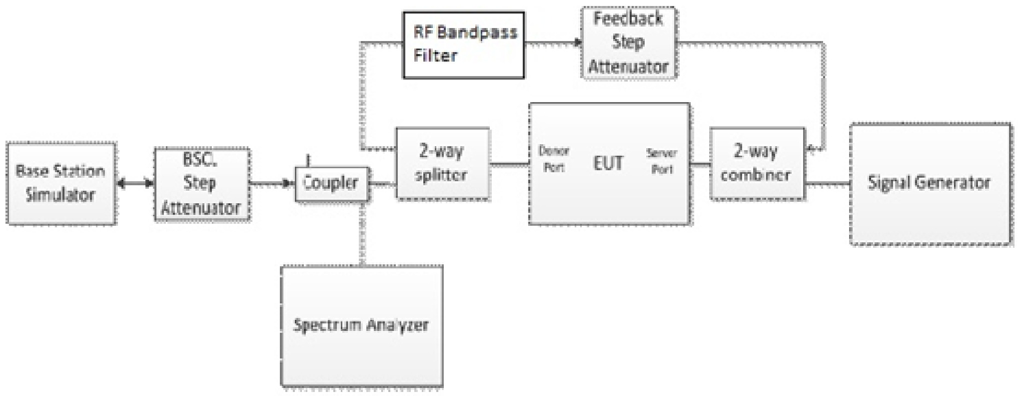

Figure 10 – Uplink oscillation detection test setup

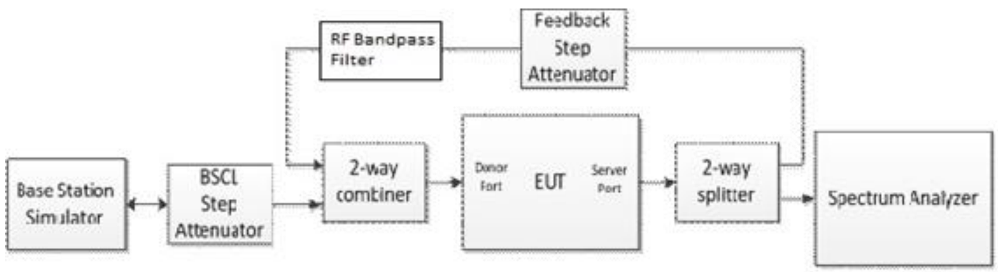

Figure 11 – Downlink oscillation detection test setup

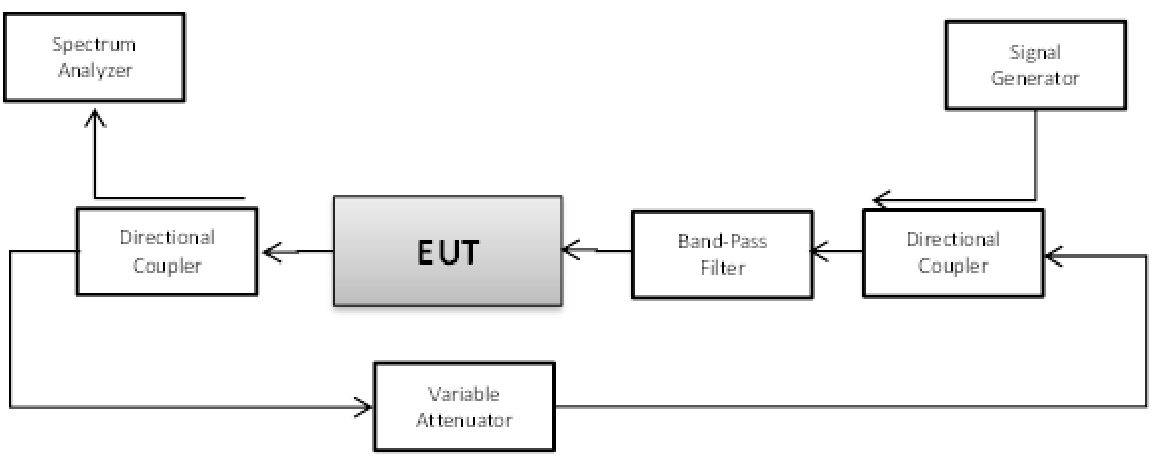

Figure 12 – Downlink oscillation mitigation test setup

7.12 Mobile booster automatic feedback cancellation test procedure

The following procedure is required to show compliance to the automatic gain adjustment and automatic feedback cancellation requirements for mobile provider-specific consumer boosters having gain greater than 50 dB. [Section 20.21(e)(9)(i)(C)(2)(iii)]

a) Connect the normal-operating mode EUT to the test equipment as shown in Figure 13. Alternatively, the test mode EUT as described in 6.3.3 may be used.
b) Set the spectrum analyzer center frequency to the center of the pass band of the booster 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 the pass band of the booster 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: i) Perform pre-tests with span equal to smaller band segments, such that 120 % of the operational band is captured in multiple tests, using the setup parameters specified; ii) record the center frequency of the strongest oscillation level occurring, and iii) confirm that this frequency is within the span and band segment used in this test.
c) Configure the signal generator for AWGN operation with 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.
d) Set the signal generator amplitude such that it is 20 dB less than the level required for maximum power of the booster. Confirm that the input signal is not obstructing the measurement of the strongest oscillation peak in the band, and is not included within the span of the measurement.
   NOTE—Boosters with operating spectrum passbands of 10 MHz or less may use a CW signal source at the band edge rather than AWGN. For devices with 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.
e) 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.
f) Set the variable attenuator such that the insertion loss for center of band under test (isolation) between the booster donor port and server port is 10 dB less than the maximum gain, as recorded in the maximum gain test procedure (see 7.3), for the band under test.
g) Set the spectrum analyzer for max-hold capture, and capture the booster output signal on the spectrum analyzer for inclusion in the test report.
h) Increase the attenuation of the continuously variable attenuator by 10 dB within a 1 second period, such that the insertion loss between the booster donor port and server port is equal to the maximum gain, as recorded in the maximum gain test procedure (see 7.3), for the band under test.
i) Capture the booster output signal on the spectrum analyzer for inclusion in the test report.
j) 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) Place a marker at the highest oscillation level occurring within the span, and record its output level and frequency.
   2) 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.
   3) 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.
   4) Confirm that the peak oscillation level measured in 7.12j2), does not exceed by 12.0 dB the minimal output level measured in 7.12j3).
   5) Record the measurement results of 7.12j2) and 7.12j3) in tabular format for inclusion in the report.

k) On the spectrum analyzer, reset the max hold capture. Decrease the setting of the continuously variable attenuator by 10 dB within a 1 second, period such that the insertion loss between the booster donor port and server port is 10 dB less than the maximum gain, as recorded in the maximum gain test procedure (see 7.3), for the band under test.
l) Capture the booster output signal on the spectrum analyzer for inclusion in the test report.
m) Repeat 7.12j).
n) Repeat 7.12b) through 7.12m) for all operational uplink and downlink bands.

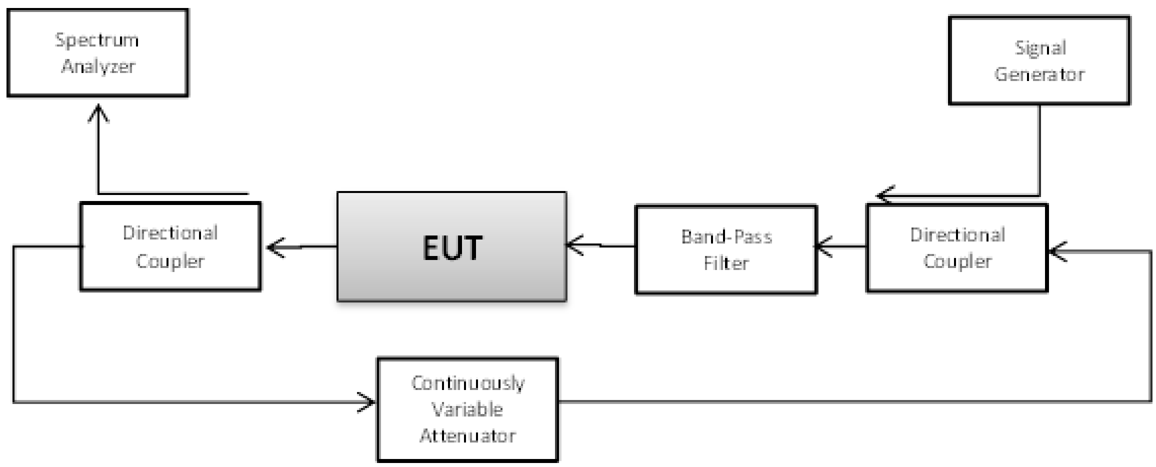

Figure 13 – Mobile booster automatic feedback cancellation test procedure

7.13 Radiated spurious emissions test procedure

Rule paragraph(s): Section 2.1053 *Measurements required: Field strength of spurious radiation.*

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 applicable 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.[21]
b) Connect the EUT to the test equipment as shown in **Figure 13** beginning with the uplink output (donor port).
c) Set the signal generator for the center frequency of the operational band under test with the power level set at P_{IN} from measurement results per 7.2 with CW or other narrowband signal.

[21] Radiated emissions tests shall performed in accordance with the procedures in ANSI C63.26-2015. See also for example 5.6 of KDB Publication 971168 about conversion of field strength to ERP and EIRP, or KDB Publication 412172.

d) Measure the radiated spurious emissions from the EUT from lowest to the highest frequencies as specified in Section 2.1057. Maximize the radiated emissions 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 7.13c) to 7.13e) for all uplink and downlink operational bands.

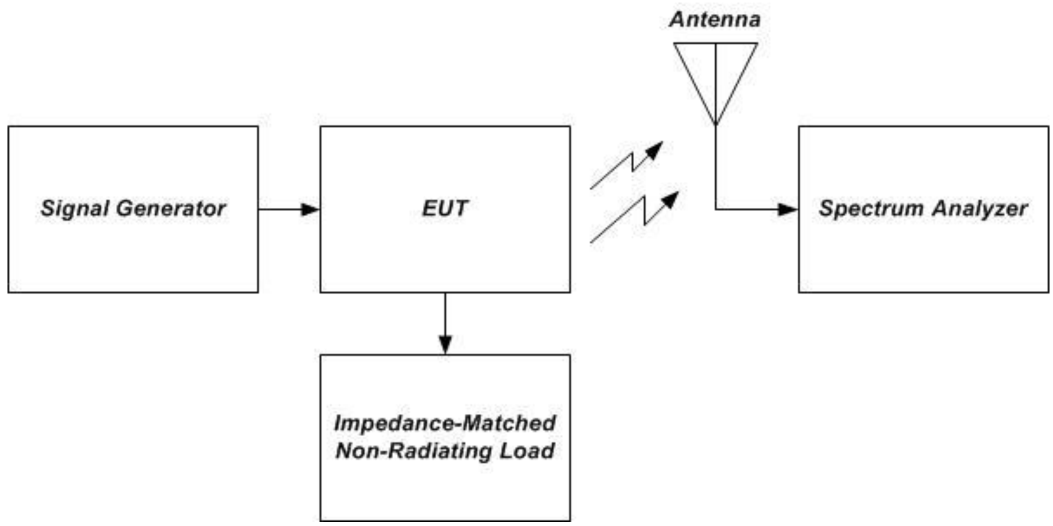

Figure 14 – Radiated spurious emissions test instrumentation setup

7.14 Spectrum block filtering test procedure

Rule paragraph(s): Section 20.21(e)(9)(i)(B); Section 20.21(e)(3).

The following procedures shall be used for provider-specific consumer boosters using spectrum block filtering.[22]

a) For all frequency ranges within the filtered spectrum blocks within the CMRS band under test, verify the uplink filter attenuation is not less than the downlink filter attenuation, for all paired frequency bands, as follows.
   1) Use procedures in 7.1 for this comparison, with the trace data measurement points normalized for the uplink and downlink frequency bands.[23]
   2) If there are non-compliant measurement points for specific frequencies, use procedures in 7.14b) and 7.14c) for compliance.

[22] Spectrum block filtering for a wideband consumer booster is defined as providing filtering, rejection, or attenuation to one or more spectrum blocks within a CMRS band (e.g., a consumer booster supporting the Cellular A band, with filtering that attenuates or blocks the Cellular B band spectrum).

[23] Normalize the uplink and downlink measurements such that the filter attenuation for the paired uplink and downlink frequency bands can be compared. Compare the trace measurement points for the paired frequency bands (i.e., referenced to the frequency offset from the lower band edges for the uplink and downlink paired frequency bands). The uplink and downlink filter attenuation is referenced to maximum gain for the respective uplink and downlink bands (i.e., the attenuation at a specific frequency is equal to the maximum gain in the CMRS band under test, minus the gain at the specific frequency).

b) For any non-compliant frequencies within filtered spectrum blocks within the CMRS band under test found per 7.14a), verify the uplink transmitted noise power level within the filtered spectrum blocks does not exceed applicable limits, as follows.
   1) Use the procedures in 7.7h) to 7.7l) to measure the uplink noise power level within each 5 MHz of paired spectrum that are within the filtered spectrum.
   2) Set the signal generator and spectrum analyzer to the center of each 5 MHz of paired spectrum within the filtered spectrum.
   3) Repeat test for all 5 MHz of paired spectrum within the filtered spectrum.[24]

   NOTE 1–For boosters with filtered spectrum blocks less than 5 MHz wide, use the signal generator with a narrower AWGN signal bandwidth (e.g., with a 99% OBW of 1.25 MHz or 200 kHz) that does not extend outside the filtered spectrum block under test.

   NOTE 2–Boosters with uplink maximum noise power as measured in 7.7a) to 7.7g), that do not exceed the uplink noise power limit specified for Transmitter Power Off Mode, meets the requirements of7.14b).

c) For any non-compliant frequencies within filtered spectrum blocks within the CMRS band under test found per 7.14a), verify the uplink gain within the filtered spectrum blocks does not exceed the applicable limits, as follows.
   1) Use procedures in 7.9a) to 7.9k) to measure the uplink gain within the filtered spectrum blocks, using base station simulator and downlink signal generator set to the center of each 5 MHz of paired spectrum within the filtered spectrum.
   2) Repeat test for all 5 MHz of paired spectrum within the filtered spectrum.

   NOTE 3–For boosters with filtered spectrum blocks less than 5 MHz wide, use both signal generators with narrower AWGN signal bandwidths (e.g., with a 99% OBW of 1.25 MHz or 200 kHz) that does not extend outside the filtered spectrum block under test.

   NOTE 4–Boosters with MSCL greater than or equal to 40 dB for the CMRS band under test are excluded from the requirements of 7.14c).

7.15 Out-of-band gain limits test procedure

The following procedures shall be used to demonstrate compliance to the out-of-band gain limit specified in Section 20.21(e)(9)(i)(E). This test uses the test mode of the signal booster.

7.15.1 Procedure

a) Connect the EUT to the test equipment as shown in Figure 2 or Figure 3, as appropriate.
b) Set the signal generator to transmit a CW signal at the center of the authorized licensee’s spectrum block(s), with output power level set to that as determined in 7.1.2.
c) Set the spectrum analyzer RBW = 100 kHz, VBW ≥ 300 kHz, set the center frequency to the center of the authorized spectrum block, then measure the output power of the generated signal.
d) With the power setting of the signal generator remaining unchanged, measure the output power level of the generated signal at a frequency offset in accordance with Section 20.21(e)(9)(i)(E).

[24] For example, a provider-specific consumer booster with spectrum block filtering for the AWS-1 F Block showing non-compliance in 7.14a) on frequencies within the 10 MHz AWS-1 F block, shall test with a 4.1 MHz 99% OBW AWGN signal centered on 2147.5 MHz, and subsequently on 2152.5 MHz [i.e., test each 5 MHz of filtered spectrum that is non-compliant with 7.14a)]. In each test, measure and verify the uplink noise power level (in dBm per MHz) within the 5 MHz of spectrum under test does not exceed authorized limits.

e) Connect the RF signal output of the signal generator to the booster, then measure the output signal at the center of the authorized spectrum block and at the frequency offset as determined in 7.15.1d).
f) Compute out-of-band gain by subtracting the power measured in 7.15.1e) from the power measured in 7.15.1d). The computed out-of-band gain must be below the reference gain in the center of the band, as specified in Section 20.21(e)(9)(i)(E).
g) Repeat 7.15.1a) through 7.15.1f) for all uplink and down link operational bands.

7.15.2 Alternative procedure for boosters employing narrowband signal protection

This procedure is for use with high-gain boosters that incorporate narrowband protection circuitry rendering the use of an input CW signal impractical. Additionally, the necessity for providing a separate input signal to maintain system gain can result in measurement inaccuracies. For these cases, two band-limited AWGN signals of different bandwidths can be used, as described below.

a) Connect the EUT to the test equipment as shown in Figure 4.
b) Set one of the signal generators to produce a band-limited AWGN signal with an OBW (99%) of 4.1 MHz, with the output power level set to the level determined from 7.1.2.
c) Set the second signal generator to produce a band-limited AWGN signal with an OBW (99%) of 200 kHz, with the output power level set to a level that is 20 dB higher than the level determined from 7.1.2, while centered on a frequency that corresponds to the applicable frequency offset relative to the band edge, as specified by Section 20.21(e)(9)(i)(E).
d) Set the spectrum analyzer RBW = 10 kHz, VBW ≥ 10 kHz, with the center frequency set to the center of the authorized spectrum block, and span from a start frequency set to the lowest offset frequency less 1 MHz up to a stop frequency that is set to the highest frequency offset plus 1 MHz. Set the trace function of the analyzer in continuous sweep mode with maximum hold activated, then capture a plot of the combined signals.
e) With the power setting of the signal generator remaining unchanged, set the 200 kHz AWGN signal to the remaining frequency offsets relative to the band edge, as specified by Section 20.21(e)(9)(i)(E). Place markers and record the RF amplitude level at each frequency offset.
f) Remove the booster from the setup, then measure the reference signal level by repeating 7.15.2d) and 7.15.2e) with the output of the RF combiner connected directly to the spectrum analyzer. Note that some adjustment to the spectrum analyzer internal attenuation and amplitude offset may be necessary, to ensure an accurate measurement.
g) Compute the out-of-band gain at each frequency offset relative to the band edge by subtracting the signal amplitude level measured in 7.15.2e) from the reference signal amplitude level measured in 7.15.2f). Ensure that the computed out-of-band gain levels comply with the limits specified in Section 20.21(e)(9)(i)(E).
h) Repeat 7.15.2a) to 7.15.2f) for all uplink and downlink operational bands.

7.16 Frequency stability test procedure

The following procedure shall be used to determine the frequency stability of the EUT, as required by Section 2.1055 as well as the applicable radio service rule parts (e.g., Sections 22.355, 24.235, 27.54). If the frequency stability requirements are not applicable due to specifics associated with the booster design (e.g., the booster does not contain an oscillator), then a detailed explanation shall be provided in the operational description in lieu of measurement data.

a) Configure the booster to operate in normal mode as shown in Figure 1, with nominal supply voltage and at room temperature.
b) Set the EUT center frequency to the center of the CMRS band under test, and set the applicable spectrum analyzer to the same frequency, with RBW = 100 Hz, and VBW = RBW.
c) Configure the base station simulator or signal generator (as appropriate) to inject a CW tone, centered within the CMRS band under test, into the booster port. The booster does not need to be at maximum gain for this test.
d) Measure the frequency of the CW tone at the output port of the booster.
e) Document the frequency deviation at the output relative to the input of the booster.
f) Repeat 7.16a) to 7.16e) for primary supply variations of 85% of nominal supply voltage, as well as for 115% of nominal supply voltage.
g) Repeat 7.16a) to 7.16f) for all uplink and downlink CMRS bands.
h) Set the primary supply voltage to its nominal level.
i) Place the EUT in an environmental chamber with the temperature set to 50 ºC, then allow the temperature of the EUT to stabilize.
j) Measure the frequency of the CW tone at the output port of the booster.
k) Document the frequency deviation at the output relative to the input of the booster.
l) Reduce the environmental chamber temperature in steps of 10 ºC down to −30 ºC, while repeating 7.16j) and 7.16k) at each temperature step.
m) Repeat 7.16i) through 7.16l) for all uplink and downlink CMRS bands.

7.17 Additional requirements for single-donor-port multiple-server-port consumer signal boosters

The following requirements apply for fixed provider-specific consumer boosters with a single donor port and multiple server ports.

a) The following tests per this document apply for all RF paths in the EUT.

    1) 7.1 Authorized frequency band verification and authorized CMRS provider tests
    2) 7.11.2 Oscillation detection; steps a) through n)
    3) 7.11.3 Oscillation mitigation and shutdown; steps a) through i)

b) The tests in 7.17) b) 1) apply for the EUT DL path(s), along with the requirements of KDB Publication 662911 D01 (linear sum of power from all server ports) where applicable per 7.17) b) 2).

    1) Required tests per this document

        i) 7.2 Maximum power measurement test procedure
        ii) 7.6 Conducted spurious emissions test procedure
        iii) 7.7.1 Maximum transmitter noise power test procedure; steps a) through g)

    2) Applicability of summing test data across multiple ports per KDB Publication 662911 D01 procedures

        i) For boosters that allow installation with multiple server-port antennas providing coverage to the same area within a building, linear summation of downlink power, noise, and spurious emission test data across all server ports per KDB Publication 662911 D01 procedures is required.

ii) For boosters that ONLY allow installation with multiple server-port antennas providing coverage to different areas within a building (see NOTE), each server port is tested independently, and the summation of downlink power, noise, and spurious emission test data across all server ports is not required.

NOTE–For example, appropriate and prominent instructions are needed in filings to ensure that the multiple server-port antennas will be installed at least 10 m apart and provide coverage to different areas of the building, and with minimal or no overlap of coverage areas.

c) The tests of 7.3 (maximum booster gain) and 7.9.1 (variable gain) shall be performed per the following steps.

1) UL and DL gain of each RF path shall be measured, and the worst-case UL and DL gain measurement results of each RF path shall comply with the 7.3 requirement.

2) The test of 7.9.1 shall be performed with only one worst-case UL gain path, as determined per the tests of 7.3.

d) The tests of all other subclauses in this document shall be performed with one worst-case DL path as determined per the tests of 7.2.2 (maximum power), while the DL path(s) not under test shall be terminated with an impedance-matched load.

APPENDIX A
CONSUMER SIGNAL BOOSTER AUTHORIZED FREQUENCY BANDS PER SECTION 20.21(e)(3)†

FCC Band Name	Uplink Band (MHz): UE transmit; BS receive	Downlink Band (MHz): BS transmit; UE receive	Channel Block Assignments	Applicable FCC Rule Part(s)
Broadband PCS	1850-1915	1930-1995	**A Block:** 1850-1865 MHz (UL) paired with 1930-1945 MHz (DL); **B Block:** 1870-1885 MHz (UL) paired with 1950-1965 MHz (DL); **C Block:** 1895-1910 MHz (UL) paired with 1975-1990 MHz (DL); **D Block:** 1865-1870 MHz (UL) paired with 1945-1950 MHz (DL); **E Block:** 1885-1890 MHz (UL) paired with 1965-1970 MHz (DL); **F Block:** 1890-1895 MHz (UL) paired with 1970-1975 MHz (DL); **G Block:** 1910-1915 MHz (UL) paired with 1990-1995 MHz (DL)	24E: § 24.229, § 24.232, § 24.238
AWS-1	1710-1755	2110-2155	**A Block:** 1710-1720 MHz (UL) paired with 2110-2120 MHz (DL); **B Block:** 1720-1730 MHz (UL) paired with 2120-2130 MHz (DL); **C Block:** 1730-1735 MHz (UL) paired with 2130-2135 MHz (DL); **D Block:** 1735-1740 MHz (UL) paired with 2135-2140 MHz (DL); **E Block:** 1740-1745 MHz (UL) paired with 2140-2145 MHz (DL); **F Block:** 1745-1755 MHz (UL) paired with 2145-2155 MHz (DL)	27: § 27.5(h), § 27.50(d), § 27.53(h)
ESMR††	817-824	862-869	N/A	90: § 90.614, § 90.635, § 90.691
Cellular	824-849	869-894	**A Block:** 824-835 MHz (UL) paired with 869-880 MHz (DL), and 845-846.5 MHz (UL) paired with 890-891.5 MHz (DL) **B Block:** 835-845 MHz (UL) paired with 880-890 MHz (DL), and 846.5-849 MHz (UL) paired with 891.5-894 MHz (DL)	22H: § 22.905, § 22.913, § 22.917
Lower 700 MHz	698-716	716-746	**A Block:** 698-704 MHz (UL) paired with 728-734 (DL); **B Block:** 704-710 MHz (UL) paired with 734-740 MHz (DL); **C Block:** 710-716 MHz (UL) paired with 740-746 MHz (DL); **D Block:** 716-722 MHz, unpaired **E Block:** 722-728 MHz, unpaired	27: § 27.5(c), § 27.50(c), § 27.53(g)
Upper 700 MHz	776-787	746-757	**C Block:** 776-787 MHz (UL) paired with 746-757 MHz (DL)	27: § 27.5(b), § 27.50(b), § 27.53(c) & § 27.53(f)

† UE = user equipment; BS = base station; UL = uplink; DL = downlink
†† Consumer signal boosters for operation on Part 90 (Specialized Mobile Radio) frequencies will not be certificated until the Commission releases a Public Notice announcing the date consumer signal boosters may be used in the band.

APPENDIX B
GUIDELINES FOR DETERMINING THE MOBILE STATION COUPLING LOSS (MSCL)

The following guidelines should be used for determining the mobile station coupling loss (MSCL) factor for consumer signal booster equipment applying for certification under the FCC network protection standard (NPS) presented in the Part 20 rules.

B1. MSCL definition

Mobile Station Coupling Loss (MSCL) is the minimum coupling loss (in dB) between the wireless device and the input (server) port of the Consumer Booster.[25] MSCL must be calculated or measured for each band of operation and provided in compliance test reports.[26] MSCL includes the path loss from the wireless device, and the booster's server antenna gain and cable loss. The wireless device is assumed to be an isotropic (0 dBi) antenna reference. Minimum separation distances assumed between indoor consumer wireless devices and the signal booster's server antenna must be reasonable and must be specified by the manufacturer in customer provided installation manuals.

The MSCL is specified as a positive loss value for use with appropriate limits in the NPS (i.e., in gain limits formula).

B2. MSCL requirements

Compliance test reports must provide the calculation or measurement for each antenna type (includes booster server antenna, cabling and coupling devices) authorized by the manufacturer for use with the consumer booster submitted for certification, and MSCL must be provided for each uplink frequency band supported by the consumer booster.

Compliance must be shown to the applicable limits (i.e., gain limits) using the ***lowest*** MSCL value from the list of authorized antennas. Compliance must also be demonstrated to the booster antenna kitting requirements provided in Section 20.21(e)(9)(i)(H).

B3. MSCL calculations and measurements

Calculations should use the basic free-space propagation path loss equation with an appropriate minimum separation distance (i.e., 1 m to 2 m depending on the antenna type)[27] between the mobile device and booster server antenna for each uplink frequency band supported by the booster. The free space path loss can be calculated[28] as follows:

$$L_P = 20\log f + 20\log d - 27.5$$

where:

L_P = basic free space path loss,
f = frequency in MHz,
d = separation distance in meters.

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[25] § 20.21(e)(9)(i)(C)(*1*)(*i*).

[26] Id.

[27] For more information on appropriate separation distances see B5.

[28] See for example KDB Publication 412172.

Measurements to determine free space propagation path loss and server antenna gain should be made on an OATS or anechoic chamber. For MSCL measurements and calculations, the mobile device must be referenced to a 0 dBi antenna gain. The results from tests using other low gain antennas (i.e., half-wave dipole with a gain of 2.1 dBi) must be adjusted accordingly, such that the results reference MSCL with a 0 dBi mobile antenna gain reference. Justification must be provided for any and all assumptions made in either calculating or measuring the MSCL value used.

MSCL measurements performed on fixed indoor boosters should include various mobile station antenna orientations (i.e., vertical, horizontal, slant 45 degrees) at appropriate heights above the floor (i.e., 0.91 m to 1.52 m, depending on the antenna type) to determine the minimum coupling loss to the booster's server antenna.

Measurements for mobile cradle type boosters should include various mobile station antenna locations within the cradle to determine the minimum coupling loss to the booster's server antenna. The placement of actual radiating antennas within CMRS mobiles varies, so various locations within the cradle (which is designed for minimum coupling loss) should be measured.

B4. CMRS mobile device antenna gain (0 dBi)

CMRS device antenna gain is assumed to be 0 dBi per industry standards. This is the assumed antenna gain for the mobile device for reference with the MSCL calculation.

B5. Minimum separation distances for MSCL calculation or measurements

Minimum separation distances from inside wireless devices to the booster's server antenna must be reasonable and specified by the manufacturer in customer provided installation manuals. The minimum separation distance will depend on the particular server antenna type used for fixed indoor consumer booster applications. For example, the following antenna types and minimum separation distances are considered for fixed indoor server antenna types:

a) **Ceiling mounted (e.g., dome-type) antennas**: These antennas are mounted at the ceiling (i.e., ~2.4 m high) and typically have lower gain directly below the antenna, with minimum coupling loss (higher gain) at elevation angles at a distance from the antenna (i.e., up to 2 m distant). Thus, the minimum separation distance for this antenna type can be up to 2 m horizontally removed from the antenna (i.e., not directly below the antenna).

b) **Wall mounted (i.e., panel or other type) antennas:** These antennas are mounted on the wall (i.e., 1.2 m to 1.8 m high) and typically have the highest gain (lowest coupling loss) at a close distance relative to the antenna. For this type of antenna, a reasonable minimum separation distance is up to 1 m horizontally removed from the antenna.

Alternatively, if a manufacturer clearly specifies a minimum separation distance to consumer devices in the installation manual or other user documentation provided with the booster, a reasonable minimum separation distance could be up to 2 m horizontally removed from the antenna. In this case, the user would be required to ensure this minimum separation distance for all CMRS devices authorized for use with this booster.

c) **Table top antennas:** These antennas are intended to be placed or mounted on top of a table (i.e., 0.6 m to 0.9 m high) and will typically have the highest gain (lowest coupling loss) at separation distances close to the antenna. For this type of antenna, a reasonable minimum separation distance is up to 1 m horizontally from the antenna.

> Due to the sizes of typical tables in residences and reasonable separation distances from CMRS user devices to the booster server antennas on these tables, i.e., from CMRS devices such as a USB modem, personal-router/hotspot, or other mobile wireless device(s) sitting on the table adjacent to such antennas, an assumed minimum separation distance for determining MSCL shall not exceed 1 m.

In addition, the manufacturer must clearly specify this minimum separation distance to consumer devices in installation manuals or other user documentation provided with the booster. The user will be required to maintain this separation distance for all CMRS devices authorized for use with this booster.

MSCL measurement results submitted with the application for certification must be reasonable, and shall be equivalent or comparable to calculations assuming unobstructed free-space propagation path losses using appropriate server antenna gains and cable losses as authorized by the manufacturer and provided for use with the booster. Compliance test reports must use the lowest MSCL value associated with all antennas authorized for use by the manufacturer for the consumer signal booster.

For inside antennas that are used in mobile booster applications, the minimum separation distance must be specified by the manufacturer and must be reasonable when considering the location and placement of CMRS devices held by users in the vehicle (at the hand or head of the user), or placed in typical locations (e.g., cup holders) within the vehicle.

APPENDIX C
TERMS, DEFINITIONS, AND ACRONYMS

1) **Additive white gaussian noise (AWGN):** The statistically random radio noise having a frequency spectrum that is continuous and uniform over a specified frequency band. White noise has equal power per hertz over the specified frequency band.

2) **Authorized CMRS provider signal (CPS):** This is the CMRS Provider's downlink signal that is generated by the base station simulator that represents the authorized licensee's base station signal for Provider-Specific boosters to determine the appropriately licensed spectrum blocks of operation. For example, a 3GPP UMTS base station signal will contain the licensee's unique PLMN identification code.

3) **Automatic gain control (AGC):** A circuit that automatically controls the gain of a signal by applying more gain to weaker received signals and less (or no) gain to stronger received signals.

4) **Base Station Coupling Loss (BSCL):** The coupling loss (in dB) between the donor port of the Consumer Booster and the input port of the Base Station. BSCL can be determined in three ways as specified in Section 20.21(e)(9)(i)(C)(1)(ii). During testing, BSCL is composed of two elements. The first is a fixed part which is equal to the difference between the forward pilot level signaled by the base station simulator and the actual transmitted level of the pilot channel. The second is a variable portion that is implemented by using a variable attenuator between the base station simulator output port and the Consumer Booster Donor Input Port. For example, if the signaled forward pilot signal level is 30 dBm and the actual transmitted pilot level is −20 dBm, the fixed portion of the BSCL is 50 dB. Added to this is the variable portion which is the variable attenuator setting. For example, if this was set to 70 dB to yield a −90 dBm input pilot level at the Consumer Booster donor port, the total BSCL would be equal to 50 dB + 70 dB = 120 dB.

5) **Base Station Coupling Loss (BSCL) Dependent Region:** The region within Gain Limits where the permitted Gain varies with and is dependent on the BSCL parameter. For example, see BSCL Dependent Limit (blue line segment) on Provider-specific consumer booster Gain Limits chart in Annex D, which is between the maximum permitted levels (e.g., Frequency Dependent Limits) and the Transmit Power Off Mode Limit.

6) **Code division multiple access (CDMA):** A method for transmitting multiple digital signals simultaneously over the same carrier frequency or channel.

7) **Commercial Mobile Radio Service (CMRS)**: A mobile service that is: (1) provided for profit, i.e., with the intent of receiving compensation or monetary gain; (2) an interconnected service; and (3) available to the public, or to such classes of eligible users as to be effectively available to a substantial portion of the public; or the functional equivalent of such a mobile service described above.

8) **Consumer signal booster:** a bidirectional signal booster that is marketed and sold for use without modification, installed without third-party assistance and operated only with approved antennas, cables, and/or coupling devices as specified by the booster manufacturer.

9) **Continuous wave (CW):** An electromagnetic wave of constant amplitude and frequency; and in mathematical analysis, of infinite duration. Can also refer to a data modulation scheme in which the data is represented by a carrier signal being switched on and off.

10) **Equipment under test (EUT):** A device or system being evaluated for compliance that is representative of a product to be marketed.

11) **Equivalent isotropic radiated power (EIRP):** The sum of the power supplied to the antenna (in dBm) and the antenna gain (in dBi) in a given direction relative to an isotropic antenna.

12) **Fixed consumer signal booster:** A consumer signal booster designed to be operated in a fixed location in a building.

13) **Global System for Mobile Communication (GSM):** A standard developed by the European Telecommunications Standards Institute (ETSI) to describe protocols for second generation (2G) digital cellular networks used by mobile phones.

14) **Long Term Evolution (LTE):** A standard for wireless communication of high-speed data for mobile phones and data terminals.

15) **Mobile station coupling loss (MSCL):** the minimum coupling loss (in dB) between the wireless device and the input (server) port of the consumer booster. MSCL must be calculated or measured for each band of operation and provided in compliance test reports. MSCL includes the path loss from the wireless device, and the booster's server antenna gain and cable loss. The wireless device is assumed to be an isotropic (0 dBi) antenna reference. Minimum standoff distances from inside wireless devices to the booster's server antenna must be reasonable and specified by the manufacturer in customer provided installation manuals.

16) **Network protection standard (NPS)**: Specifies technical, operational, and registration requirements applicable to consumer signal boosters to minimize the potential for interference to wireless networks.

17) **Non-authorized CMRS provider signal:** This is for a non-authorized CMRS Provider's downlink signal that is generated by the base station simulator that represents a non-authorized licensee's base station signal. For example, a 3GPP UMTS base station signal will contain another licensee's unique PLMN identification code.

18) **Occupied bandwidth (OBW):** the occupied bandwidth is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean power levels are each equal to 0.5% of the total mean power contained within the fundamental emission (also known as the 99% bandwidth).

19) **Open area test site (OATS):** An open, flat, level area where the ground is covered with conductive material and that is clear of overhead wires and reflecting structures.

20) **Out-of-band emission (OOBE):** An emission on a frequency or frequencies immediately outside the necessary bandwidth which results from the modulation process, but excluding spurious emissions.

21) **Provider-specific consumer signal booster:** A consumer signal booster that may only operate on the frequencies and in the market areas of the specified licensee(s). Provider-specific consumer signal boosters may only be certificated and operated with the consent of the licensee(s) whose frequencies are being amplified by the device.

22) **Pseudorandom binary sequence (PRBS):** A fixed-length, mathematically-randomized sequence of bits that satisfies many of the criteria for a true random sequence and thus is frequently used in digital functionality testing.

23) **Received Signal Power Level within Channel (RPCH) Dependent Region:** The region within Gain Limits where the permitted Gain varies with and is dependent on the downlink RPCH parameter. For example, see RPCH Dependent Limit (blue line segment) on Provider-specific

consumer booster Gain Limits chart in Annex D, which is between the maximum permitted levels (e.g., Frequency Dependent Limits) and the Transmit Power Off Mode Limit.

24) **Received Signal Power Level within Channel (RPCH) for provider-specific consumer boosters:** The total received signal power level within the authorized downlink channel in dBm referenced to the consumer booster's donor port. This parameter is applicable to Gain limits in Section 20.21(e)(9)(i)(C)(1)(ii).

25) **Received signal strength indication (RSSI) for provider-specific consumer boosters:** The downlink composite received signal power in dBm for frequencies outside the authorized licensee's spectrum block(s), referenced to the consumer booster's donor antenna port, for all CMRS base stations' signals received within the band of operation. This parameter is applicable to noise limits in Section 20.21(e)(9)(i)(A)(*1*).

26) **Received signal strength indication (RSSI) dependent region:** The region within applicable noise and gain limits where the permitted noise and gain varies with and is dependent on the downlink RSSI parameter. For example, see RSSI dependent limit (blue line segment) in the figures provided in Annex D, which is between the maximum permitted levels (e.g., frequency dependent limits) and the transmit power off mode limit.

27) **Signal booster:** A device that automatically receives, amplifies, and retransmits on a bidirectional or unidirectional basis, the signals received from base, fixed, mobile, or portable stations, with no change in frequency or authorized bandwidth.

28) **Spectrum block filtering:** for a wideband consumer booster, spectrum block filtering is defined as providing filtering, rejection, or attenuation to one or more spectrum blocks within a CMRS band (e.g., a consumer booster supporting the Cellular A band, with filtering that attenuates or blocks the Cellular B band spectrum).

29) **Spurious emission:** An emission on a frequency or frequencies which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out-of-band emissions.

30) **Transmitted noise power level:** The noise power level measured at the signal booster output that is represented by the sum of the thermal noise power, the booster noise figure and the booster gain, and expressed in dBm within a 1 MHz bandwidth (dBm/MHz).

31) **Wideband code division multiple access (W-CDMA):** An air interface standard found in 3G mobile telecommunications networks.

32) **Wideband consumer signal booster:** A consumer signal booster that may operate on the frequencies and in the market areas of multiple licensees.

APPENDIX D
PROVIDER-SPECIFIC CONSUMER BOOSTER NOISE AND GAIN LIMITS CHARTS

These charts illustrate the provider-specific consumer booster noise, gain and transmit power off mode limits pursuant to Sections 20.21(e)(9)(i)(A), 20.21(e)(9)(i)(C), and 20.21(e)(9)(i)(I), respectively. The noise limits chart show the consumer booster transmitted noise power limits at various RSSI levels, and gain limits charts show the consumer booster gain limits at various RPCH and BSCL levels for sample MSCL values.

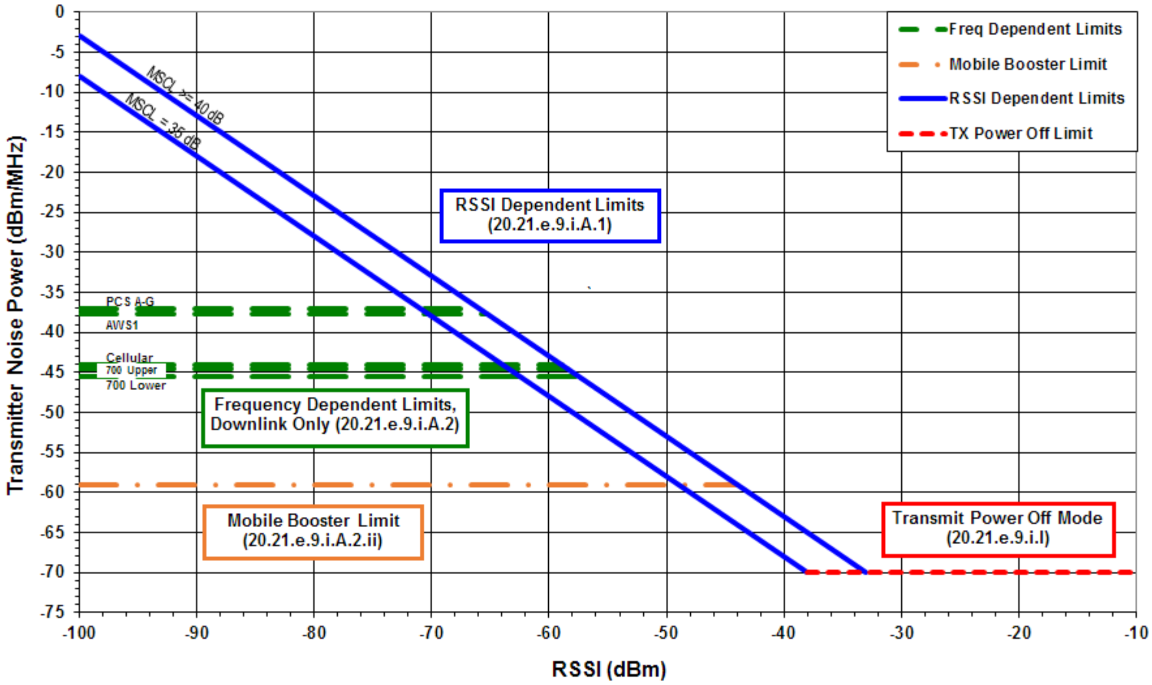

Figure D1 – Provider-specific consumer signal booster variable noise limits

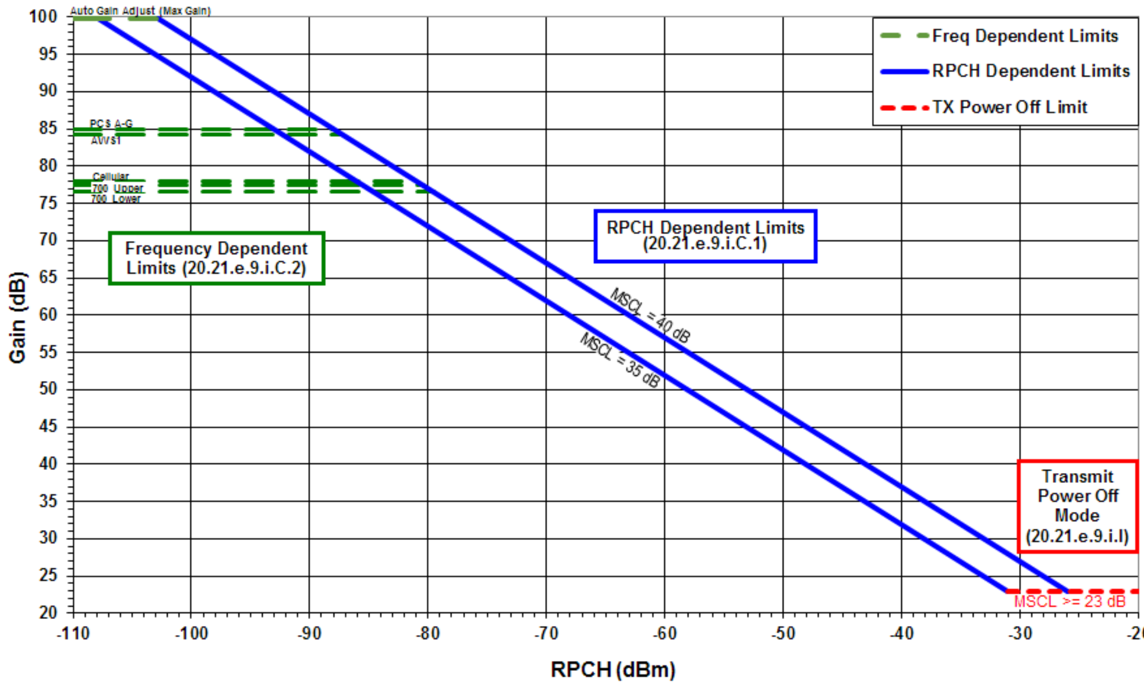

Figure D2 – Provider-specific consumer signal booster variable gain limits

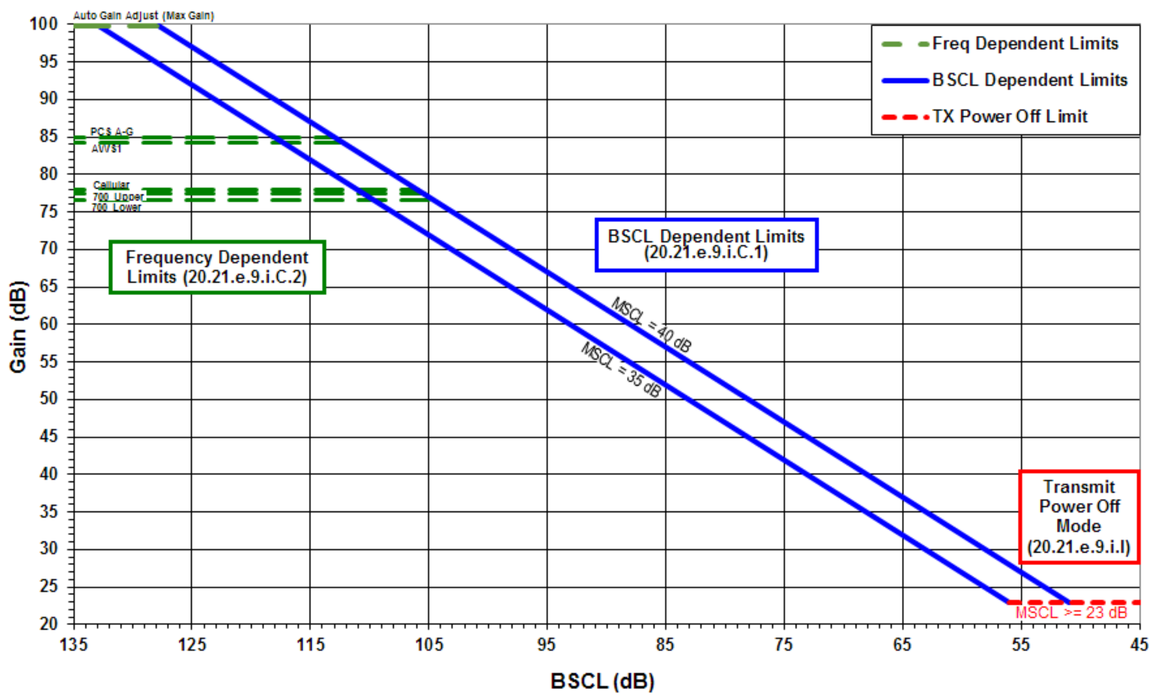

Figure D3 – Provider-specific consumer signal booster variable gain limits

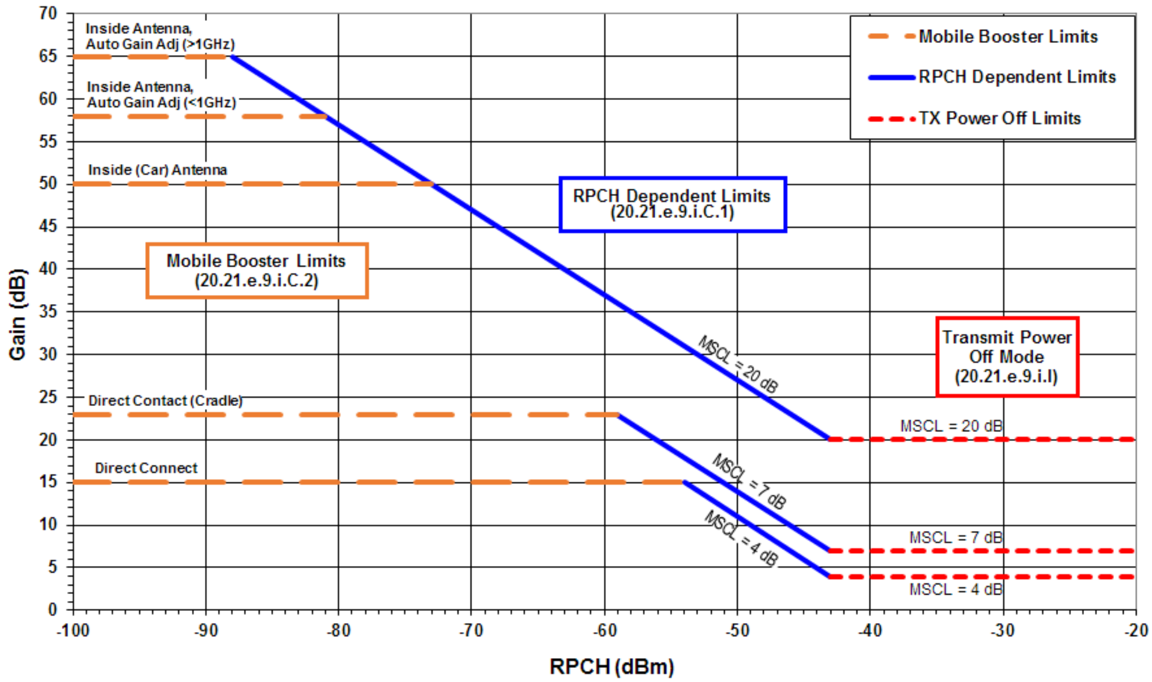

Figure D4 – Mobile provider-specific consumer signal booster variable gain limits

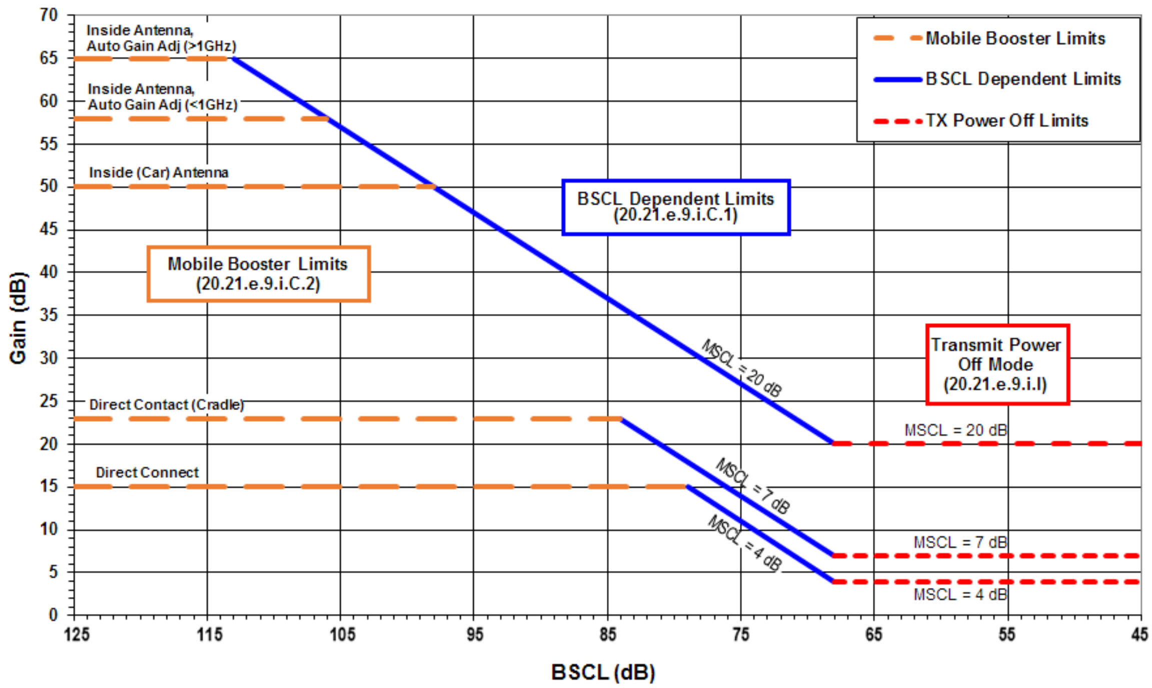

Figure D5 – Mobile provider-specific consumer signal booster variable gain limits

APPENDIX E
NETWORK PROTECTION STANDARD (NPS) –SUMMARY OF RULE PARAGRAPHS, MEASUREMENT QUANTITIES, AND REQUIREMENTS

The following table includes blue font strikethrough (deleted) and underline (new) text applicable since the Dec. 29, 2014 effective date listed in the Federal Register for rules established under FCC-14-138 (79 FR 70790-70796). This summary table is for information and quick reference purposes only; applicants and laboratories must use the most recent complete version of Section 20.21(e)(9) for compliance testing purposes.

§ 20.21(e)(9) ***Provider-Specific Consumer Signal Boosters.***
§ 20.21(e)(9)(*i*) *Technical Requirements*
§ 20.21(e)(9)(*i*)(A) *Noise Limits.*
UL and DL ports transmitted noise power [dBm/MHz] outside licensee's blocks, § 20.21(e)(9)(*i*)(A)(*1*): $P_{TN} \le -(103+RSSI)$
§ 20.21(e)(9)(*i*)(A)(*1*)(*i*): RSSI is DL composite received signal power P_{RS} [dBm] at donor port for all outside licensee's blocks operating-band BS.
§ 20.21(e)(9)(*i*)(A)(*1*)(*ii*) Device MSCL < 40 dB requires: $P_{TN} \le -(103+RSSI) - (40-MSCL)$.
§ 20.21(e)(9)(*i*)(A)(*2*)
§ 20.21(e)(9)(*i*)(A)(*2*)(*i*) Fixed booster DL maximum: $P_{TN,max} \le (-102.5+20\lg f_{MHz})$. f_{MHz} is UL midband frequency.
§ 20.21(e)(9)(i)(A)(*2*)(*ii*) Mobile booster: $P_{TN,max} \le -59$.
§ 20.21(e)(9)(*i*)(A)(*2*)~~(*ii*)~~(*iii*): Instrumentation, etc. (see rule).
§ 20.21(e)(9)(*i*)(B) *Bidirectional Capability.* UL and DL gain shall be equivalent; UL $P_{cond} \ge 0.05$ W; One-way boosters prohibited; Block filtering (see rule).
§ 20.21(e)(9)(*i*)(C) *Booster Gain Limits.*
§ 20.21(e)(9)(*i*)(C)(*1*) UL and DL "variable gain" $G_{UL}, G_{DL} \le [BSCL-28-(40-MSCL)]$ [dB]
§ 20.21(e)(9)(*i*)(C)(*1*)(i): BSCL, MSCL definitions (see rule).
§ 20.21(e)(9)(*i*)(C)(*1*)(*ii*): BSCL derivation (see rule).
§ 20.21(e)(9)(*i*)(C)(*2*) UL and DL maximum gain [dB] § 20.21(e)(9)(i)(C)(*2*)(*i*) Fixed booster $G_{UL,max}, G_{DL,max} \le 19.5+20\lg f_{MHz}$, or $G_{UL,max}, G_{DL,max} \le 100$, for systems with donor/server isolation-measurement based automatic gain adjustment.
§ 20.21(e)(9)(i)(C)(*2*)(*ii*) f_{MHz} is UL midband frequency.
§ 20.21(e)(9)(i)(C)(*2*)(*iii*) Mobile Booster: $G_{UL,max}, G_{DL,max}$ ≤ 50 dB, inside antenna; ≤ 23 dB, contact coupling; ≤ 15 dB, direct connect.

§ 20.21(e)(9) ***Provider-Specific Consumer Signal Boosters.***
$G_{UL,max}, G_{DL,max} \le 58$ below 1 GHz, $G_{UL,max}, G_{DL,max} \le 65$ above 1 GHz, for systems with inside antenna and donor/server isolation-measurement based automatic gain adjustment and auto feedback cancellation.
§ 20.21(e)(9)(*i*)(D) *Power Limits.* UL $P_{cond} \le 1$ W, and UL EIRP ≤ 1 W. DL $P_{cond} \le 0.05$ W, and DL EIRP ≤ 0.05 W.
§ 20.21(e)(9)(*i*)(E) *Out of Band Gain Limits.*
§ 20.21(e)(9)(*i*)(E)(*1*) Ratio(s) of OOB to in-band gains from edge(s) of licensee's blocks shall be:
§ 20.21(e)(9)(*i*)(E)(*1*)(*i*) −20 dB at band edge(s), § 20.21(e)(9)(*i*)(E)(*1*)(*ii*) −30 dB at 1 MHz offset, § 20.21(e)(9)(*i*)(E)(*1*)(*iii*) −40 dB at 5 MHz offset.
§ 20.21(e)(9)(*i*)(E)(*2*) OOB gain for devices with licensee's blocks passband midband maximum gain ≥ 80 dB shall be: 60 dB at 0.2 MHz offset, and 45 dB at 1 MHz offset.
§ 20.21(e)(9)(*i*)(F) *Out of Band Emission Limits.* OOBE ≤ service rule mobile limit; OOBE compliance tested using high PAR signals.
§ 20.21(e)(9)(*i*)(G) *Intermodulation Limits.* UL and DL IM products ≤ −19 dBm. IM testing per description in rule.
§ 20.21(e)(9)(*i*)(H) *Booster Antenna Kitting.*
§ 20.21(e)(9)(*i*)(I) *Transmit Power Off Mode.* Power-off mode required for devices not meeting noise and gain limits [§ 20.21(e)(9)]. The power-off mode for such devices requires: UL and DL $P_{TN} \le -70$ [dBm/MHz], and $G_{UL} \le \min\{23 \text{ dB}; MSCL\}$.
§ 20.21(e)(9)(*i*)(J) *Uplink Inactivity.* UL $P_{TN} \le -70$ [dBm/MHz] after 5 min. without active device connection.
§ 20.21(e)(9)(ii) *Interference Safeguards.*
§ 20.21(e)(9)(ii)(A) *Anti-Oscillation.* Detect and mitigate within: 0.3 sec. for UL, 1.0 sec. for DL.
§ 20.21(e)(9)(ii)(B) *Gain Control.*
§ 20.21(e)(9)(ii)(C) *Interference Avoidance for Wireless Subsystems.*

Change Notice

02/12/2016: 935210 D04 Provider Specific Booster Measurements v01r01 is replaced by 935210 D04 Provider Specific Booster Measurements v02. Changes summary is as follows.

- Updates per FCC-14-138 adding mobile under 20.21(e)(9).
- Updates for consistency where appropriate with the most recent version of test procedures from the ASC C63® Wireless Working Group (September 2015).
- Omitted reference to 20.21(a)(4) at the first row of the table in 1.4. 20.21(a)(4) originally was listed in that row because it basically has the same frequency and rule part requirements as does 20.21(e)(3); the difference being 20.21(a) provisions are for end-use operating conditions, and 20.21(e) provision are for NPS compliance demonstrations in equipment authorizations. Further, the listing of "20.21(a)(4) Self-monitoring" was incorrect; self-monitoring is 20.21(e)(4), but was not intended to explicitly apply for the 7.1 test conditions.
- Omitted reference to 20.21(a)(4) in 7.1.1, same reasons as described above.
- 5.9 updated to clarify impedance matching requirements.
- 7.1.1i) changed from "a marker" to "three markers."
- 7.1.3 with Fig 4 added.
- 7.4i) added "simultaneously."
- 7.5m change from 7.5j) to 7.5i).
- 7.7 former a) to u) split into 7.7.1 Maximum transmitter noise power level and 7.7.2 Variable noise response time.
- 7.7 former k) v) omitted "See Annex C."
- 7.7 former l) [now 7.7.1o)] added "See Appendix D for noise limits graphs."
- 7.7.2 Fig 6, Fig 7, Fig 8 changed "50-ohm Termination" to "Matched Load."
- 7.9 former a) to n) split into 7.9.1 Variable gain and 7.9.2 Variable gain timing.
- 7.9.2d) added 10 dB steps for mobile boosters.
- 7.9.2ed) added 1 second for mobile boosters.
- 7.11 renumbered to be 7.11.2.
- 7.11 former note converted to be 7.11.2n).
- 7.11.3 and Fig 12 added.
- 7.11.3 former Fig 9 and Fig 10 are renumbered as Fig 10 and Fig 11, and modified to add bandpass filter block.
- 7.12 and Fig 13 added.
- 7.12 added para. on part 15 emissions basic requirements.
- Former 7.13 renumbered to 7.14.
- Former 7.13c) was duplicate of former 7.13a) and is omitted, along with the former footnote 16.
- 7.14 renumbered from former 7.13.
- 7.14b3) footnote 17 (former footnote 15) changed from wideband to provider-specific.
- B.3 changed from "3 feet to 5 feet" to "0.91 m to 1.52 m."
- Appendix E portion repeated from 935210 D02, for convenience.

10/27/2017: 935210 D04 Provider Specific Booster Measurements v02 is replaced by 935210 D04 Provider Specific Booster Measurements v02r01. Changes summary is as follows.

- Citations added for FCC 17-93 and ANSI C63.26.
- Miscellaneous format/style editorial changes (change from "§" to "Section," etc.).
- Cross-references to ANSI C63.4 for radiated emission measurements basic guidance are replaced using ANSI C63.26.
- Use of test-mode EUT added in 7.11.3 and 7.12; 300 s timing added in 7.11.3 (March 2017 ASC C63® Booster WG members and OET Lab staff consultations).

06/19/2018: 935210 D04 Provider Specific Booster Measurements v02r01 is replaced by 935210 D04 Provider Specific Booster Measurements v02r02. Changes summary is as follows.

- Updates in 1.1), 2) ¶1, and C8) for removing provider-specific consumer boosters personal-use requirement per Order FCC 18-35.
- Add footnote citation to FCC 14-138.
- Last sentence added in 7.2.2h), 7.4m), 7.5l) per ASC C63® SC-4 Wireless WG input.
- Note 3 added in per 7.5) ASC C63® SC-4 Wireless WG input.

04/12/2019: 935210 D04 Signal Booster Measurements v02r02 is replaced by 935210 D04 Signal Booster Measurements v02r03. Changes summary is as follows.

- Reference ASC C63® SC4 rather than SC1
- Subclause heading 1.4 and caption Table 1 added
- 7.17 added per ASC C63® SC-4 Wireless WG input

04/03/2020: 935210 D04 Signal Booster Measurements v02r03 is replaced by 935210 D04 Signal Booster Measurements v02r04. Changes summary is as follows.

- Clarification on frequencies of operation added in 7.1.1 introductory paragraph
- Changed from “combiner” to EUT in 7.4 h) (per ASC C63® SC-4 Wireless WG input)
- Cross-reference errors corrected in 7.17 b) and 7.17 b) 1) iii)