Federal Communications Commission
Office of Engineering and Technology
Laboratory Division

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Draft Laboratory Division Publications Report

Title: Signal Boosters

Reason: This draft updates two attachments to the publication: (1) 935210 D02 Signal Booster Certification v02r01 , (2) 935210 D03 Signal Booster Measurements v02r01 and adds a new attachment 935210 D05 Indus Booster Basic Meas v01 to replace annex D in the current 935210 D02 Signal Booster Certification v02r01.

Publication: 935210

Keyword/Subject: 20.21; 90.219; 22; 24; 27; 90; signal booster; amplifier

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Question: What are the Commission guidance documents for the evaluation of Signal Boosters?
Answer:

This review draft package contains draft subdocuments that are proposed updates to KDB 935210 attachments and are available for comment:

- 935210 D02 Signal Booster Certification v03 DR07-42107 **
- 935210 D03 Signal Booster Measurements v03 DR07-42107 **
- 935210 D05 Indus Booster Basic Meas v01 DR07-42107 **

The existing publication 935210 currently contains the following 4 attachments:

- 935210 D01 Signal Booster Definitions v02 *
- 935210 D02 Signal Booster Certification v02r01 **
- 935210 D03 Signal Booster Measurements v02r01**
- 935210 D04 Signal Booster Provider Specific v01*

Until the final versions of the attachments are published the following guidance can be used:

- 935210 D01 Signal Booster Definitions v02 *
- Either draft 935210 D02 Signal Booster Certification v03 DR07-42107 ** or current attachment 935210 D02 Signal Booster Certification v02r01 *.
- Either 935210 D03 Signal Booster Measurements v03 DR07-42107 ** or current attachment 935210 D03 Signal Booster Measurements v02r01* can be used.
- Either 935210 D05 Indus Booster Basic Meas v01 DR07-42107 ** or 935210 D02 Signal Booster Certification v02r01 Appendix D * can be used.

Attachment List:
935210 D01 Signal Booster Definitions v02 *
935210 D02 Signal Booster Certification v03 DR07-42107 **
935210 D03 Signal Booster Measurements v03 DR07-42107 **
935210 D04 Signal Booster Provider Specific v01*
935210 D05 Indus Booster Basic Meas v01 DR07-42107 **

* Document not for comment and is currently published in KDB935210
** Subdocument open for comment contained in this document (DR07-42107).

935210 D02 Signal Boosters Certification v03 DR07-42107

The following subdocument D02 within this review draft package DR07-42107 is an update to the existing 935210 D02 v02r01.

This subdocument D02 also incorporates, updates, and supersedes the preceding 935210 D01 v02.
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Federal Communications Commission
Office of Engineering and Technology
Laboratory Division

April 13, 2015

SIGNAL BOOSTERS BASIC CERTIFICATION REQUIREMENTS

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I. INTRODUCTION

In Report and Order FCC 13-21 (WT Docket No. 10-4, referred to as "the *Order*"), the Commission outlines equipment authorization and operational requirements for signal boosters that operate under Parts 20, 22, 24, 27 and 90 of the FCC rules.[R3]-[R7][1] The *Order* created two classes of signal boosters, Consumer and Industrial, with specific regulatory requirements for each class. Part 90 PLMR signal boosters, a special type of Industrial Boosters, have additional unique requirements. Certain consumer booster rules were also updated by an *Order on Reconsideration* FCC 14-138.[R19]

This document provides a summary of the rules related to equipment authorization, as well as additional policies and guidance for certification applications. Due to the significant changes from the preceding rules and with the intended new framework, manufacturers, test labs, and TCBs are encouraged to submit KDB inquiries to request clarification and guidance before starting compliance testing or submitting an

[1] Numbers in brackets [Rxx] refer to documents listed in APPENDIX G.

equipment authorization application where the available policies and test procedures do not readily support review and approval of a specific booster device.

For equipment operation, boosters must also comply with applicable service rules that apply to the bands of operation, in addition to those specified in the *Order*. For equipment authorization, booster test reports must address all applicable requirements in Part 2 and the respective rule parts for the band of operations, in addition to the requirements listed in sections II to V of this document.
Compliance testing uniform procedures are given in KDB Publication 935210 Attachment D03 for Wideband Consumer Signal Boosters, in KDB Publication 935210 Attachment D04 for Provider-Specific Consumer Signal Boosters, and in KDB Publication 935210 Attachment D05 for Industrial Signal Boosters (CMRS and PLMRS) and non-consumer repeater and amplifier devices.

II. GENERAL CERTIFICATION RULES AND POLICIES

The following lists general rules and policies applicable to signal booster device certifications.

(a) All boosters within the scope of the *Order* certified after 2/20/2013 must comply with new rules.

(b) The rules apply for the frequency bands listed in APPENDIX B [*cf*. §§ 20.21(a)(4), 20.21(e)(3), 90.219(b)].

(c) The rules established by FCC 13-21 became effective May 13, 2013, except those rules containing new or modified information collection requirements, which were subject to OMB PRA review; the OMB PRA portion was completed and with all rules being effective from September 11, 2013.

(d) At the time of publication of this version of KDB Publication 935210 D02, some types of signal boosters remain subject to PBA for TCB processing per KDB Publication 388624.[R12]

(e) Until all final procedures are published and associated notice is given to TCBs, certification applications are reviewed on a case-by-case basis; in addition, FCC may request device samples to be tested at the FCC Lab.

(f) 800 MHz ESMR Part 90 consumer boosters will be allowed only when the nationwide band reconfiguration is substantially completed; applications are not accepted until further notice [*cf*. § 20.21(a)(4)].

(g) Consumer signal boosters are not allowed for 2.6 GHz Part 27 BRS/EBS band [*cf*. *Order* ¶ 41, and § 20.21(a)(4)]. (See also Appendix D about frequency bands.)

(h) Modular approval is not allowed for boosters.[2]

(i) Extended frequency listing (KDB Publication 634817 [R16]) on the grant, or the EF grant note, is not allowed for boosters, rather applications must meet all necessary requirements; if test reports present test data outside the scope of authorization application, such results must be individually marked “Not applicable for FCC certification.”

(j) The operational description exhibit must describe how unauthorized/out-of-scope parameters (frequency bands, power levels, gains, antennas, operation modes, etc.) are selected and how different versions are managed and controlled.

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[2] Policies, procedures, and rules for modular approval equipment authorizations are described in KDB Publication 996369.[R15]

(k) Third-party or field configuration of frequency, power, or other parameters that affect regulatory compliance:

(1) Consumer boosters: not allowed unless under direct control of grantee; the operational description exhibit must describe how control is achieved.

(2) Industrial boosters: allowed within operation bands and other conditions specified during certification; the operational description exhibit must explain what can be modified/configured by any third-party (anyone other than the grantee), the associated procedure, and how control is achieved to prevent installers from accidentally configuring or modifying the device resulting in unauthorized operation.

(l) All boosters, consumer and industrial, must comply with general population RF exposure limits, including labeling for fixed antennas where § 1.1307(b)(1) requirements apply [*cf*. *Order* ¶¶ 125-126, 181].

(m) Test reporting and application contents.

(1) Identify specific rule paragraph(s) relevant for compliance demonstration of each set of test results, and for each test-setup and test-procedure description section of a report.

EXAMPLE: Because § 20.21(e)(8)(i)(C)(2) has two separate sets of limits
[i.e., § 20.21(e)(8)(i)(C)(2)(i) for Fixed Boosters and § 20.21(e)(8)(i)(C)(2)(iii) for Mobile Boosters], a test report listing only "20.21(e)(8)(i)(C)(2)" is ambiguous and not appropriate.
For this example, the specific applicable limits of § (i) or § (iii) must be listed for each data set.

(2) With each test results set, provide text explaining where and how the specific numeric, graphic, and/or tabular results demonstrate compliance for the associated rule paragraph(s).

(3) Where a Form 731 application is intended to cover multiple model number versions (e.g., with corresponding multiple separate user manual exhibits in a filing), please include a cover letter exhibit in the filing listing the intended versions and brief description of the differences.

(4) Show and explain compliance explicitly for § 90.219(e)(1) to (e)(4) (*Device Specifications*) in test reports for devices subject to § 90.219. Note that in equipment authorization applications, § 90.219(d) (*Deployment Rules*) is relevant primarily for installation/operating instructions and operational description exhibits, and generally is not applicable for § 90.219(e) compliance demonstrations.

(n) System operation – When transmitter requires other devices in a system, select Form 731 "Part of system…" checkbox. List FCC IDs of other components. Test with system components if needed. Usually applies for fiber-optic systems. Control of power level is one implication.

Filings for DAS devices need to clearly describe and show whether test setup is end-to-end (input to host through to output from remote), or which partial paths only relative to the described full transmit paths are tested, etc. (see also related provisions in A.5.3 and B.1 of this document).

(o) Devices supporting MIMO transmissions in end-use booster system configurations.

(1) Based on various application filings since February 2013, some DAS remote unit devices are also optionally intended for operation along with same-band/same-frequency integral or connectable (add-on or expansion) remote unit(s), and along with host unit(s) and transport links that support MIMO streams. See Appendix A of this document for an example system diagram.

(2) Equipment authorization applications for such intended operations need to address KDB Publication 662911 multi-port testing [R20], and include associated technical information describing the end-to-end booster system configurations and associated devices.

(3) Filings for remote unit devices capable of MIMO transmissions but without MIMO testing.

(i) If compliance for MIMO operations is not addressed in a filing for a remote unit device that is intended for use as part of an end-use MIMO booster system, the following grant condition should be used:

"This filing has compliance demonstration information and test data only for SISO (single-input single-output) booster system configurations; additional equipment authorization is required to allow this device to be used in MIMO (multiple-input multiple-output) industrial booster systems."

(ii) To permit subsequent end-use MIMO operations, a permissive change filing is appropriate including compliance information for end-use MIMO operations where the device optionally can be used as part of a booster system along with same-band/same-frequency integral or connectable (add-on) remote unit(s), and along with host unit(s) and system transport links that support MIMO streams.

(p) Miscellaneous items for which compliance supporting information may be appropriate [continued from existing booster authorization framework (*Order* ¶¶ 110-116, 185-186), not elsewhere covered in 935210].

(1) Affirm that device cannot operate in saturation. Means to control maximum power and to assure linear operation (use in system configuration may be necessary) should be described, as well as means to prevent saturation or over-modulation prevented for pulsed signal inputs where applicable.

(2) Out-of-band rejection–testing for rejection of out-of-band signals may be appropriate. Alternatively, filter frequency response plots are acceptable.

(3) Worst case results should be reported for occupied bandwidth comparison and intermodulation tests done with and without any AGC circuitry activated, for devices so equipped.

(4) Devices using automatic gain control (AGC) as a means for complying with service rule power limits should provide test results showing maximum output with and without AGC activated. Rated power listed on grant should not exceed the applicable service rule limit (see, e.g., V j 1).

EXAMPLE: Consider a rule output power limit of 1 W EIRP (30 dBm). Compliance testing was done based on AGC designed or set to 32 dBm, and with professional-installation instructions to use an antenna with maximum gain of −2 dBi. The grant should not list the higher maximum power as measured with AGC off (32 dBm), because that would construe non-compliance with the 30 dBm ERP rule limit.

III. CONSUMER SIGNAL BOOSTER SPECIFICS

(a) Consumer Signal Booster Network Protection Standard (NPS) requirements – see summary listing in APPENDIX D, and test procedures in KDB Publication 935210 D03 (Wideband) and KDB Publication 935210 D04 (Provider-Specific).

(b) Warning label requirements:

(1) Example label [R11] – see also III (b) (9)

> **This is a CONSUMER device.**
>
> **BEFORE USE**, you **MUST REGISTER THIS DEVICE** with your wireless provider and have your provider's consent. Most wireless providers consent to the use of signal boosters. Some providers may not consent to the use of this device on their network. If you are unsure, contact your provider.
>
> You **MUST** operate this device with approved antennas and cables as specified by the manufacturer. Antennas **MUST** be installed at least 20 cm (8 inches) from any person.
>
> You **MUST** cease operating this device immediately if requested by the FCC or a licensed wireless service provider.
>
> **WARNING**. E911 location information may not be provided or may be inaccurate for calls served by using this device.

(2) Must include required information on registration, antenna/cable restriction, cease operation, and E911.

(3) Can be combined with the FCC ID label

(4) The content and location of the label should be presented in the ID Label exhibit

(5) Permanently affixed to a permanently attached part of the equipment enclosure, and readily visible

(6) Alternative label text and/or layout requires advance FCC approval

(7) Stating that the booster is approved by all providers for use is prohibited on the label or elsewhere

(8) The label may contain acknowledgement that particular providers have given consent to this device; such statement would be inserted before "Some wireless providers may not consent to the use of this device on their network. If you are unsure, contact your provider."

(9) After the OMB PRA process gets completed for the rules established by FCC-14-138 [R19], the label for consumer signal boosters certified for fixed indoor operation must also include the following language: This device may be operated ONLY in a fixed location for in-building use.

(c) Attestation (must be non-confidential exhibits, signed by the applicant; signature by test lab, agent, or TCB is not acceptable) should include:

(1) Licensee consent for provider-specific booster has been obtained (consent be made available upon FCC/TCB request)

(2) NPS and other compliance/safeguard features have been implemented

(3) NPS and other compliance/safeguard features are defaulted to "ON" configuration (in operation)

(4) NPS and other compliance/safeguard features cannot be field reconfigured, disabled or removed

(5) Consumer booster is not user programmable, does not need fine tuning or adjustment, does not require professional installation

(6) Future software upgrade will not cause non-compliance

(d) User's Manual (non-confidential or short-term confidential) should include:

(1) Warning label message

(2) Warning message for use of unauthorized antennas, cables, and/or coupling devices

(3) Provide a complete list of authorized antennas, cables, and/or coupling devices

(4) List the default antenna, cable, and/or coupling device that are shipped with the booster

(5) Describe installation accessory, procedure, and any required fine tuning or adjustment

(6) Contact information for providers (support for end-user registrations; see also APPENDIX F)

(7) High level summary and/or description of safeguard features (if operational description is confidential)

(e) Operational Description (can request confidentiality) should include:

(1) Provide a list of all operation bands

(2) If device is capable of operating outside the current band plan through software configuration, describe how software is managed and controlled

(3) Describe the self-monitoring mechanism (HW and SW)

(4) Describe the anti-oscillation mechanism

(5) Describe the automatic power-down and shut-down mechanism when the booster is not in need

(6) Detection scheme for own network

(7) Detection scheme for other networks, like and unlike

(8) Power down triggering criteria and adjustable range

(9) Shut down triggering criteria and resume/recovery algorithm

(10) Describe how "operate only for the duration of a call" is achieved

(11) Describe any interference avoidance scheme

(f) Fixed Consumer Signal Boosters specific considerations

(1) § 20.3 specifies that Fixed Consumer Signal Boosters are devices designed to be operated in a fixed location in a building. More specifically the server / coverage / downlink transmit antenna must be operated at a fixed location in a building; the donor-side antenna may optionally be installed outdoors.

(2) The 10 meter height limit of § 27.50(d)(4) applies for Fixed Consumer Signal Boosters transmitting in 1710-1755 MHz. The 10 meter antenna height limitation can be addressed in install/operate instructions in one of two ways:

(i) Specify that the antenna for the device must be installed to comply with the 10 meter above ground maximum antenna height limitation OR

(ii) Specify that the antenna for the device has a 10 meter above ground maximum antenna height limitation when the device is used with a handset that covers the 1710-1755 MHz band and that owners could be subject to potential FCC enforcement action for noncompliance.

(g) Contact coupling accessories capable of operating with handsets or modems in § 2.1093 portable device RF exposure conditions.

(1) Contact coupling accessories capable of operating while nearby or attached to a handset in held-to-ear voice mode renders the combination to be a portable device. The NPRM and *Order* in WT Docket No. 10-4 precludes the operation of signal boosters in § 2.1093 portable device RF exposure conditions. (*cf*. [R2] ¶¶ 40-41, and *Order* ¶¶ 125-126, 181)

(2) Part 2 subpart J certification in general is valid for representations and test data shown in each equipment authorization record. Handset FCC ID records typically do not include compliance demonstrations when operated with attached coupling accessories.

(3) In general a coupling accessory capable of operating while nearby or attached to a handset is expected to effect the local RF current distributions and thus SAR FCC compliance results for each head and body transmitting configuration as originally reported.[3]

(h) Single device authorized for marketing and operation as both an Industrial Booster (multi-user, e.g., small office) only or a 20.21 Consumer Booster (personal use) only

(1) Two different FCC IDs can be used for the single device – one for consumer use and the other for industrial use (NOTE: here “industrial use” is a broad term and applies for any multi-user environment).

(2) Approval as both a Consumer Booster and Industrial Booster under a single FCC ID.

(i) A composite-Form 731 application is needed, i.e., B2I along with B2W or B2P.

(ii) Each part of the composite-Form 731 application must be stand-alone/self-contained and clearly identified as for a Consumer Booster only or Industrial Booster only; exhibits covering both equipment classes are not allowed in either portion of the composite-Form 731.

(iii) The Industrial Booster only and Consumer Booster only versions must each be marketed and sold separately and must each have unique user’s manual, labels, etc., meeting the respective consumer or industrial rule requirements.
Packaging, user’s manuals, labels, etc., cannot be assembled such as to market and sell a “dual use” device.
This means for example for the Consumer Booster version, references in any filing exhibits to office, commercial, or industrial use must be omitted.

(iv) Each application must include an attestation that the manufacturer understands and agrees to comply with the prior restriction on selling and marketing the device as either industrial use only or consumer use only, but not dual use.

(i) Example grant conditions and grant comments.

(1) This device is a Wideband Fixed Consumer Signal Booster approved for operating with the coverage/server antenna installed at a fixed location inside a building.

(2) The installation height of the antenna for AWS band (1700/2100 MHz) operations is limited to 10 meters above ground for compliance with Section 27.50.

(3) This Consumer Signal Booster is authorized only for operation by and marketing to members of the general public for their personal use in accordance with the requirements of Sections 20.21(a) and 20.21(g).

(4) This device is part of a booster system operated with FCC ID *XXX-YYYYYY*.

(5) Users and installers must be provided with the antenna kitting and installation and operating instructions and conditions for satisfying RF exposure and Section 20.21(a) compliance.

[3] See for example KDB Publication 447498 “After-market accessories.” [R17]

IV. INDUSTRIAL (PART 20) SIGNAL BOOSTER SPECIFICS

(a) Industrial boosters may only be used by FCC licensees or those given express (individualized) consent of a licensee

(b) Consent can be in the form of a letter, e-mail or other record sent from a licensee or an agent of a licensee to an operator, owner, or installer of an industrial signal booster with specified frequency bands for retransmission

(c) Industrial booster warning label

  (1) Example label [R11]

> **WARNING**. This is **NOT** a **CONSUMER** device. It is designed for installation by **FCC LICENSEES** and **QUALIFIED INSTALLERS**. You **MUST** have an **FCC LICENSE** or express consent of an FCC Licensee to operate this device. Unauthorized use may result in significant forfeiture penalties, including penalties in excess of $100,000 for each continuing violation.

  (2) Can be combined with the FCC ID label

  (3) The content and location of the label should be presented in the ID Label exhibit

  (4) Permanently affixed to a permanently attached part of the equipment enclosure, readily visible

  (5) Alternative label text and/or layout requires advance FCC approval

(d) Attestation (must be non-confidential exhibit, signed by the applicant; signature by test lab, agent, or TCB is not acceptable) should include:

  (1) Warning label messages will be also shown in online and point-of-sale marketing materials and on outside packaging of device

(e) Operational Description (can request confidentiality) should include:

  (1) Provide a list of all operation bands and the scope of the license or the licensee consent

  (2) If HW or SW platform permits other frequency bands, describe how are they selected and managed

  (3) Describe the automatic power down mechanism and its adjustable range to ensure that the booster operates only with the power necessary to achieve the intended communications

(f) User's Manual (non-confidential or short-term confidential) should include:

  (1) Signal booster warning label message

  (2) Warning message for use of unauthorized antennas, cables, and/or coupling devices

  (3) Provide a complete list of authorized antennas, cables, and/or coupling devices

  (4) List default antenna, cable, and/or coupling device that are shipped with the booster

  (5) Describe installation procedure and any power, RF cable, and antenna adjustment guidelines

  (6) Licensee contact information (if available)

(g) Example grant conditions and grant comments.

(1) This transmitter operates as a remote unit as part of a system along with master unit components as described in this filing, and excluding any other devices connected to the (downlink) output terminal of the master unit.

(2) This application covers only the system configuration with master unit connected to a base station in the downlink path; operations if any with master unit connected to antenna or amplifier in the downlink require separate equipment authorization.

(3) This device is part of a booster system operated with FCC ID *XXX-YYYYYY*.

(4) The installation height of the antenna for AWS band (1700/2100 MHz) operations is limited to 10 meters above ground for compliance with Section 27.50.

V. PART 90 SIGNAL BOOSTER SPECIFICS

(a) § 90.219 allows booster operation above 150 MHz, but not used to extend the boundary of the normal service area of a specific license

(b) Mobile Class B boosters certifications are not permitted

(c) Both Class A and Class B can be used outdoors

(d) May not amplify service bands where the operator does not have license or licensee consent

(e) Class B cannot amplify both commercial (including CMRS and ESMR) and PLMR bands (except in-building DAS)

(f) Part 90 Booster warning label

(1) Example label (after [R11])

Part 90 Signal Boosters **THIS IS A 90.219 CLASS A DEVICE**

WARNING. This is **NOT** a **CONSUMER** device. It is designed for installation by **FCC LICENSEES** and **QUALIFIED INSTALLERS**. You **MUST** have an **FCC LICENSE** or express consent of an FCC Licensee to operate this device. You **MUST** register Class B signal boosters (as defined in 47 CFR 90.219) online at **www.fcc.gov/signal-boosters/registration**. Unauthorized use may result in significant forfeiture penalties, including penalties in excess of $100,000 for each continuing violation.

(2) Specify booster is Class A or Class B device

(3) Can be combined with the FCC ID label

(4) The content and location of the label should be presented in the ID Label exhibit

(5) Permanently affixed to a permanently attached part of the equipment enclosure, readily visible

(6) Alternative label text and/or layout requires advance FCC approval

(g) Attestation (must be non-confidential exhibit, signed by the applicant; signature by test lab, agent, or TCB is not acceptable) should include:

(1) Warning label messages and Class A/B disclosure will be also shown in online and point-of-sale marketing materials and on outside packaging of device

(h) Operational Description (can request confidentiality) should include:

(1) Provide a list of all operation bands and the scope of the license or the licensee consent

(2) If HW or SW platform permits other frequency bands, describe how are they selected and managed

(3) Describe the automatic power down mechanism and its adjustable range to ensure that the booster operates only with the power necessary to achieve the intended communications

(i) User's Manual (non-confidential or short-term confidential is acceptable) should include:

(1) Specify booster is Class A or Class B device

(2) Signal booster warning label message

(3) Warning message for use of unauthorized antennas, cables, and/or coupling devices

(4) Provide a complete list of authorized antennas, cables, and/or coupling devices

(5) List default antenna, cable, and/or coupling device that are shipped with the booster

(6) Describe installation procedure and any power, RF cable, and antenna adjustment guidelines

(7) Contact information, i.e., licensee for Class A/B devices, if available;
and the FCC at (https://signalboosters.fcc.gov/signal-boosters/) for Class B devices.

(j) Other provisions for part 90 boosters in specific bands and/or for specific conditions.

(1) Equipment authorizations to support both § 90.219 and higher power operations.

For devices that support output power higher than the 5 W ERP limit of § 90.219, and are intended for marketing and subsequent US non-federal (FCC) station operations both within and outside the scope of the § 90.219 authorization and deployment framework,[4] for equipment authorization purposes the following provisions apply.

(i) For equipment to be certified as acceptable for § 90.219(b) operations, B9A and B9B Form 731 applications must contain test data, install/operating instructions, etc., specifically for the § 90.219(e) requirements, along with the usual §§ 2.911(b), 2.1033(c), 90.203, and associated contents requirements. In addition, the B9A or B9B application must contain test data, install/operating instructions, etc., for other intended and supported maximum output powers and maximum emissions end-use configurations.

(ii) Per the usual OET practice, the highest output powers for each emission mode are listed on Form 731 line entries. It is preferred, however not required, that the § 90.219 associated

[4] "[I]f licensees need more than 5 watts ERP per channel for a particular deployment, they can use other allowances in Part 90, including obtaining an additional [station] authorization for a repeater or base station" [*Order*, ¶ 180].
FCC Form 601 (ULS) station class codes used at the time of licensing may include FB (Base), FB2 (Mobile Relay), FB4 (Community Repeater) (http://www.fcc.gov/forms).
For equipment authorizations, OET generally has not established other hardware parameters or requirements to distinguish among the FCC Form 601 station classes established by FCC WTB.

emission modes (reflecting maximum 5 W ERP) are also separately listed on the Form 731 line entries. While policies and procedures for part 90 boosters pursuant to the *Order* are still developing, during FCC review of a TCB PBA [e.g., KDB Publication 388624 D02 v15r01 item II C 2 h], a grant condition could be applied about specific station authorizations are required for equipment operations exceeding § 90.219 conditions.

(2) 800 MHz Band operations.

(i) Per § 90.219(d)(7), the passband of a Class B booster (except for DAS boosters installed in buildings) should not encompass CMRS [e.g., 800 MHz Band ESMR, Cellular Radiotelephone (22H)] along with part 90 PLMRS and/or PSRS (e.g., 800 MHz Band NPSPAC Public Safety, 800 MHz Band Interleaved-PS-B/ILT-SMR).

(ii) Further to 90.219(d)(7) and *Order* ¶¶ 190-193, etc., new equipment applications for 800 MHz SMR need to reflect the post-rebanding channel plan.
This generally means § 90.614(a) channels are subject to § 90.219 (B9A or B9B), and § 90.614(b) channels are subject to § 20.21 (B2I).

(iii) For devices that support the 90.613 full 800 MHz Band, in general two separate FCC IDs with separate Form-731 filings and device-specific contents and test data in each can be appropriate.
Alternatively applicants may submit for FCC consideration other proposed means to ensure § 90.217(d)(7) compliance.

(3) 800 MHz NPSPAC Public Safety Band operations.

(i) To maintain a stable environment during the pendency of the rulemaking under proceeding docket no. 13-209 (NPRM FCC-13-117), DA-13-1803 stipulates the following. [R12],[R13]
Applications for equipment capable of operating on the NPSPAC public safety channels [806-809/851-854 MHz, § 90.617(a)(1)] must demonstrate that:
• the equipment conforms to Emission Mask H [§ 90.210(h)] when operating on the NPSPAC public safety channels; and
• the equipment is capable of operating with analog FM modulation on the NPSPAC mutual aid channels.

(ii) Compliance for the preceding first bullet item can be addressed relative to §§ 90.219(e)(4)(ii) and 90.219(e)(4)(iii) using an appropriate input signal.

(4) 900 MHz Band operations.

(i) For 935-940 MHz part 90, both §§ 20.21 [*cf*. cross-reference in § 90.219 ¶ 1] and 90.219 apply because those bands include interleaved commercial and private services.
Filings generally need to include compliance test data for § 90.219(e) items; booster label and install/operating instructions need to address § 90.219(e)(5) requirements; install/operating instructions need to explicitly describe how to comply with the § 90.219 5 W ERP limit.

(ii) For 940-941 MHz, for US that is allocated and licensable only for part 24 subpart D. Further to the preceding 935-940 MHz provisions, filings need to address part 24 subpart D compliance.

(5) For the remote unit of a conventional fiber-connected host/remote DAS booster system, it is acceptable to submit compliance information and test data consistent with 90.219(d)(6)(ii) (i.e., ERP of noise ≤ −43 dBm in 10 kHz RBW) for the downlink path only, in place of 90.219(e)(2) noise figure test data (i.e., NF ≤ 9 dB for both UL and DL). Test reports must provide explicit details about instrumentation and procedure used for 90.219(d)(6)(ii) testing.

APPENDIX A

BASIC DEFINITIONS AND CONCEPTS
FOR EQUIPMENT AUTHORIZATION PURPOSES

A.1 Booster device terms and definitions

This appendix provides additional guidance about basic definitions and various known types of signal booster devices that are subject to the rules and requirements described in the *Order*, to facilitate equipment authorization application filings under part 2 subpart J of the Commission's rules. Booster, amplifier, and repeater devices operating under other rule parts and/or sections may use basic and specific FCC and OET rules, policies, and procedures for equipment authorization–see A.4, and APPENDIX D in KDB Publication 935210 D05.

A.2 through A.4 summarize basic device-related terms and definitions established by the *Order*, as well as lists a few existing terms and definitions from other FCC rules and documents. A.5 provides supplemental information to assist classifying devices using block diagrams for two basic booster system configurations. In cases where the guidance herein is not clearly applicable, an applicant or agent or test lab should submit a KDB inquiry including device details to obtain guidance from FCC. Other background about terms and concepts is available for example in APPENDIX B "Signal Boosters Terminology and Concepts" of the *Order*.

A.2 Signal boosters in subscriber-based services

The term "signal booster" as used in the *Order* and the associated rule sections includes all manner of
- amplifiers,
- repeaters,
- boosters,
- distributed antenna systems, and
- in-building radiation systems

that serve to amplify signals ***<u>between a device and a wireless network</u>***. [*Order*, ¶ 3, fn 1]

A.2.1 Consumer signal booster (Part 20)

A **Consumer Signal Booster (Part 20)** is a device that automatically receives, amplifies, and retransmits *<u>on a bi-directional basis</u>* the signals received from base, fixed, mobile, or portable stations, with no change in frequency or authorized bandwidth, and that is marketed and sold to the general public for use without modification. [§ 20.3]

Consumer Signal Boosters allow an individual [and occasional third-party *de minimis* use; *Order*, ¶ 48; § 20.21(b)] to improve wireless coverage within a limited area such as a home, car, boat, or RV.[5] Consumer Signal Boosters are designed to be installed without third-party professional assistance and used "out-of-the-box" without fine tuning or other technical adjustments. [*Order*, ¶ 13]

[5] See also considerations about Consumer Boosters marketed also for Industrial Booster operations in III h) of this document.

Consumer Signal Boosters can be operated only with approved antennas, cables, and/or coupling devices as specified by the manufacturer of the Consumer Signal Booster. [§ 20.21(a)(3)]

Consumer boosters are further distinguished in terms of the intended operating frequency ranges relative to wireless services providers' frequency bands, as follows.

> **a) Provider-Specific (Frequency Selective, Carrier Specific) Consumer Signal Booster:** A Provider-Specific Consumer Signal Booster may only operate on the frequencies and in the market areas of the specified licensee(s). A Provider-Specific Consumer Signal Booster may only be certificated and operated with the consent of the licensee(s) whose frequencies are being amplified by the device. [§ 20.3]
>
> **b) Wideband Consumer Signal Booster:** A Wideband Consumer Signal Booster may operate on the frequencies and in the market areas of multiple licensees. [§ 20.3]

Besides delineation by congruence of device and service provider frequency ranges [A.2.1 a), b)], all **Consumer Boosters** are also distinguished by station equipment type and RF exposure device type, as follows.

> **c) Fixed Consumer Signal Booster:** A Consumer Signal Booster designed to be operated in a fixed location in a building (i.e. indoors). [§ 20.3] The downlink transmitting antenna at minimum must be installed at a fixed location in a building.
>
> **d) Mobile Consumer Signal Booster:** A Consumer Signal Booster designed to operate in a moving vehicle where both uplink and downlink transmitting antennas are at least 20 cm from the user or any other person. [§ 20.3]

A.2.2 Industrial signal booster (Part 20)

An **Industrial Signal Booster (Part 20)** is any signal booster that is not a Consumer Signal Booster (Part 20) [i.e., CMRS parts 22, 24, 27, 90 (ESMR)].[6] [§ 20.3]

Industrial Signal Boosters are designed to serve multiple users simultaneously. [*Order*, ¶ 16 and fn 31]

Industrial Signal Boosters may be fixed-station equipment or mobile-station equipment, and are designed for installation by licensees or qualified installers. Unlike Consumer Signal Boosters, industrial signal boosters used in the CMRS bands are not distinguished as wideband or provider-specific. Part 90 Signal Boosters, other than Consumer Signal Boosters, are a type of Industrial Signal Booster—see also other specific part 90 terms and definitions below. [*Order*, ¶ 15]

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[6] Industrial Signal Boosters include large, high powered devices intended for professional or enterprise use. These devices tend to have more expansive functionality than Consumer Signal Boosters. For example, unlike Consumer Signal Boosters, many Industrial Signal Boosters incorporate remote monitoring capability to allow the operator to use a graphical user interface to control the device's functions, including remote power control, turn-on, and turn-off. The output power and gain for Industrial Signal Boosters are typically multiple times the power and gain of Consumer Signal Boosters. These devices are designed to serve multiple users simultaneously and cover larger areas such as stadiums, shopping malls, office buildings, tunnels, and campuses. An Industrial Signal Booster installation may support a single wireless provider or multiple wireless providers. In addition, such an installation may utilize a greater number of antennas, amplifiers, and other components, compared to Consumer Signal Boosters. [*Order*, ¶ 16]

A.3 Signal boosters for PSRS and PLMRS operations under Part 90 (§ 90.219)

Per the first unnumbered paragraph of § 90.219, signal boosters operating under part 90 radio service rules and in the Commercial Mobile Radio Services (CMRS) are subject to § 20.21 rather than § 90.219.

The following specific terms and definitions apply only for devices subject to § 90.219.

A.3.1 Signal Booster (§ 90.219)

A **Signal Booster (§ 90.219)** is a device or system that automatically receives, amplifies, and retransmits signals from wireless stations into and out of building interiors, tunnels, shielded outdoor areas and other locations where these signals would otherwise be too weak for reliable communications. Signal booster systems may contain both Class A and Class B signal boosters as components. [§ 90.219(a)]

All **§ 90.219 boosters** are a type of Industrial Signal Booster, and are classified as either **Class A boosters** (narrowband) or **Class B boosters** (wideband).[R11] [*Order*, ¶ 15]

Note also that Consumer Signal Boosters are not defined for PLMRS or PSRS because licensees are considered to operate private services. Part 90 PLMR licensees typically obtain authorizations for individual narrowband channels or groups of channels to satisfy their own communication needs. Moreover, many Part 90 channels are interleaved and a licensee's channels may not be adjacent to one another, which presents unique considerations for signal boosters used with Part 90 PLMR services. [*Order*, ¶ 144]

> **a) Class A signal booster:** A signal booster designed to retransmit signals on one or more specific channels. A signal booster is deemed to be a Class A signal booster if none of its passbands exceed 75 kHz. [§ 90.219(a)]
>
> **b) Class B signal booster:** A signal booster designed to retransmit any signals within a wide frequency band. A signal booster is deemed to be a Class B signal booster if it has a passband that exceeds 75 kHz. [§ 90.219(a)]
>
> Class B signal boosters may be deployed only at fixed locations; mobile operation of Class B signal boosters is prohibited (after November 1, 2014). [§ 90.219(d)(4)]
>
> Except for signal boosters incorporating distributed antenna systems (DAS) and installed in buildings, the passband of a Class B booster shall not encompass both commercial services (such as ESMR and Cellular Radiotelephone) and Part 90 Land Mobile and Public Safety Services. [§ 90.219(d)(7)]

A.3.2 Distributed Antenna System (DAS) (§ 90.219)

A **Distributed Antenna System (DAS) (§ 90.219)** is a network of spatially separated antenna nodes connected to a common source via a transport medium that provides wireless service within a geographic area or structure. [§ 90.219(a)]

Other considerations on DAS are given in APPENDIX B of this document. A parallel definition for DAS operating under part 20 was not established by the *Order*.

A.4 Booster, amplifier, and repeater devices under other licensed rules

The following terms and definitions are listed for equipment authorization general reference purposes, and are not applicable for §§ 20.21 or 90.219 booster device purposes. [§ 20.21(e)(2)(ii); § 90.219(a)]

- **a) Signal amplifier (Part 90):** A device that amplifies radio frequency signals and is connected to a mobile radio transceiver, portable or handset, typically to the antenna connector. Note that a signal amplifier is not the same thing as a signal booster. [§ 90.7]
- **b) External radio frequency (RF) power amplifier (Part 97):** A device capable of increasing power output when used in conjunction with, but not an integral part of, a transmitter. [97.3; see also 2.815] *Syn.:* ERFPA.
- **c) In-building radiation systems (Part 22):** Supplementary systems comprising low power transmitters, receivers, indoor antennas and/or leaky coaxial cable radiators, designed to improve service reliability inside buildings or structures located within the service areas of stations in the Public Mobile Services. [§ 22.99]
- **d) Repeater:** A device that retransmits the signals of other stations. Generally repeaters are different from boosters in that they can include frequency translation and can extend coverage beyond the design of the original base station. A repeater is typically single channel, but can also be multiple channels.
- **e) Mobile repeater station (Part 90 PLMRS):** A mobile station authorized to retransmit automatically on a mobile service frequency, communications to or from hand-carried transmitters; used to extend the communications range of hand-carried units. [§ 90.7, § 90.247]
- **f) Mobile relay station (Part 90 PLMRS):** A base station in the mobile service authorized to retransmit automatically on a mobile service frequency communications which originate on the transmitting frequency of the mobile station. [§ 90.7, § 90.243]

A.5 Block diagrams for classifying and describing booster system basic configurations

A.5.1 Signal amplifier devices

Figure A.1 a) shows a simplified schematic of a (single-enclosure) amplifier device. FCC OET policy for equipment application processing has conventionally reserved use of the Form-731 equipment class AMP only for an external radio frequency power amplifier (ERFPA), i.e., a device inserted between a transmitter (i.e., equipment class TNB/PCB; see APPENDIX C) and an antenna.[7] An ERFPA is defined as having only a single (i.e., uni-directional) antenna transmit port.

A.5.2 Single-enclosure booster devices

Figure A.1 b) shows a simplified schematic of an example single-enclosure consumer booster (Form-731 equipment class B2W or B2P), connecting to a device using either contact/proximity coupling or connection via an RF port/connector. Figure A.2 shows a simplified diagram of a basic single-enclosure booster system and the associated basic parameters.

[7] See also footnote 6 concerning amplifier other example use.

A.5.3 Multiple-enclosure booster systems

Figure A.3 shows a simplified diagram of a basic two-enclosure booster system and the associated basic parameters. Example device types include indoor-DAS and outdoor-DAS (see also A.3.2 and APPENDIX B in this document). Another example is a donor/server Consumer Booster system with two non-identical component enclosures, using 802.11 for the system-internal transport link between the donor unit placed near a window and the server unit placed elsewhere in a building for coverage enhancement.

Where donor-side and server-side components (components B, C of Figure A.3) are not electrically identical, each component generally is subject to separate / individual equipment authorization. For example, where a donor-side device never connects to an antenna for transmitting over-the-air, then only part 15 subpart B digital device authorization can apply.

Donor-side and server-side components generally need to be tested together as a system, and equipment applications need to describe and address compliance for the supported signal and modulation types for each transmission path. The Form-731 provision for "part of a system that operates with, or is marketed with, another device that requires an equipment authorization" needs to be completed as applicable, e.g., when the transport link uses proprietary signaling such that each donor or server component operates only with specific associated booster system devices.

A.5.4 Figures for A.5

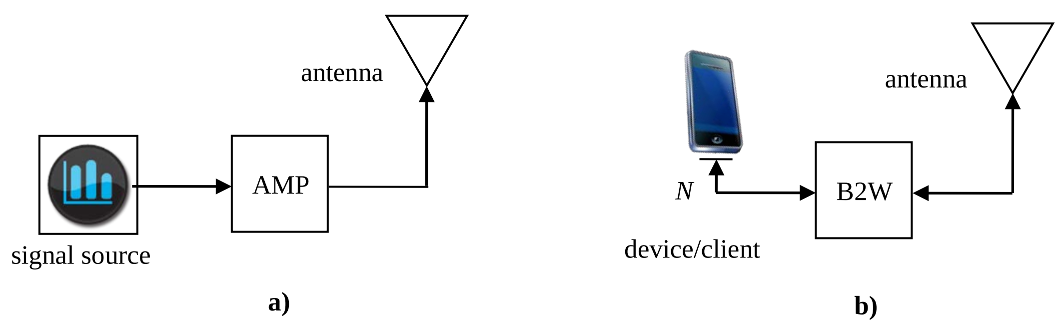
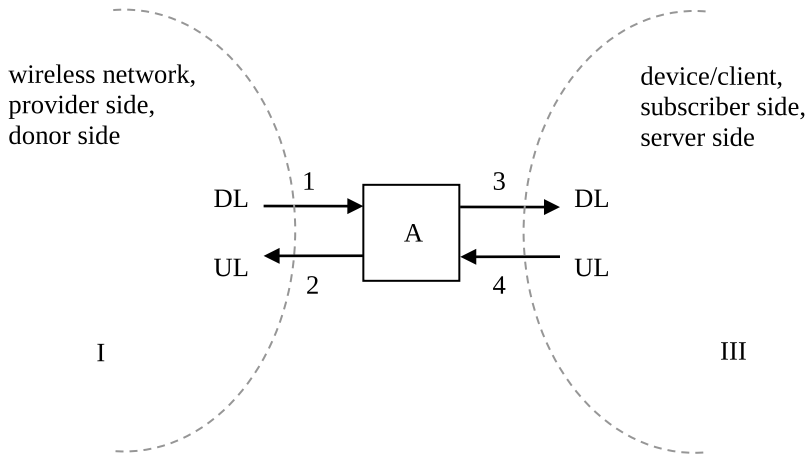


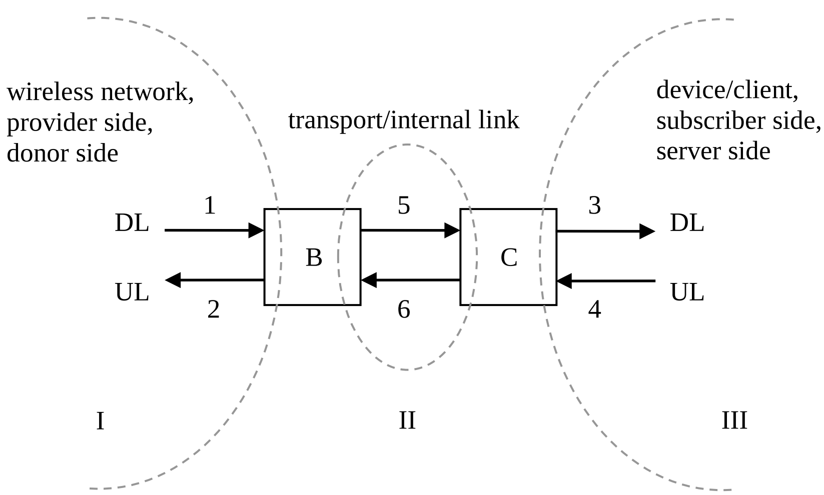
Figure A.1 – Simplified schematics of:
a) single-enclosure amplifier device – Form-731 equipment class AMP;
b) single-enclosure consumer booster – Form-731 equipment class B2W or B2P, connecting to a device at node *N* using either contact/proximity coupling or RF-port connection.



KEY:

- A: Single enclosure booster device, with donor-side and server-side ports.
- UL, DL: Uplink (subscriber / mobile station to provider / base station); downlink (provider / base station to subscriber / mobile station).
  Each of donor-side and server-side may or may not connect to over-the-air antenna(s).
- 1…4: Signal paths 1,2,3,4 typically are parts 22, 24, 27, 90 paired-band frequencies.
- I, III: Region I: provider / base-station coverage;
  Region II: booster internal operations;
  Region III: subscriber / mobile-station coverage, e.g., indoors, dead spot (§ 22.99).

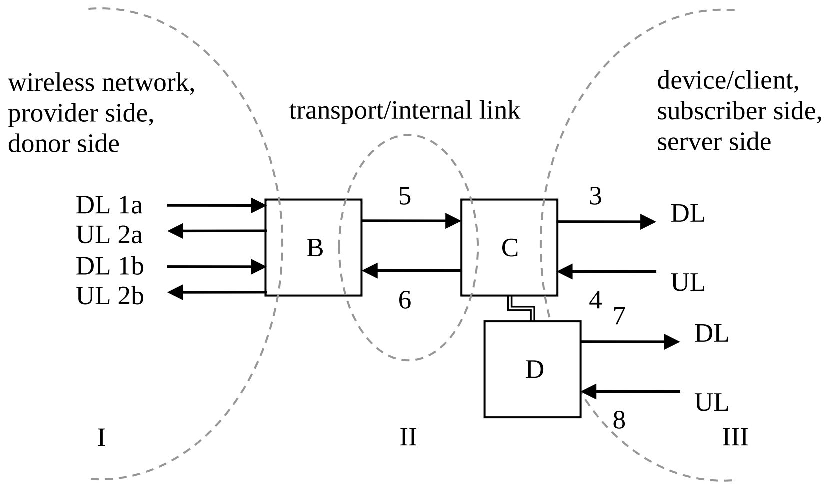
Figure A.2 – Simplified schematic of single-enclosure booster device, and signal path and coverage/operations regions geometries



KEY:

- B, C: Donor-side and server-side system components.
  For this basic configuration, components B,C may or may not be (RF) electrically identical.
  B,C typically are tested together as a system, however generally each may be subject to separate / individual equipment authorization (e.g., separate FCC IDs).
- UL, DL: Same as in Figure A.2.
- Signal paths 1,2,3,4 frequencies are as in Figure 2.
- Signal paths 5,6 are system internal “transport” paths, typically RF-on-fiber-optic or coax cable or over-the-air locally; for the latter two, either on-channel or frequency-shifted.
- I, II, III: Same as in Figure A.2.

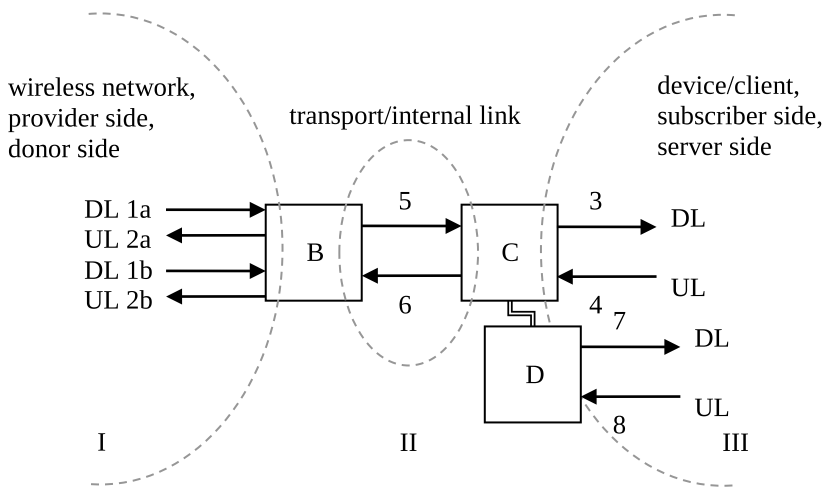
Figure A.3 – Simplified schematic of two-enclosure booster system, and signal path and coverage/operations regions geometries



KEY:

- B, C: Same as in Figure A.3.
  D: RF expansion unit or additional remote unit; may be installed internal or connected external to remote unit C.
- UL, DL: Same as in Figure A.2.
- Signal paths 1a,2a,3,4 frequencies are as in Figure 2 (1,2,3,4 therein).
- Signal paths 1b,2b,7,8 typically are parts 22, 24, 27, 90 paired-band frequencies, and are different frequencies from 1a,2a,3,4 (aka single-input single-output, SISO).
- Signal paths 5,6 typically are same as in Figure A.3.
- I, II, III: Same as in Figure A.2.

Figure A.4 – Simplified schematic of multiple-enclosure booster system (SISO), and signal path and coverage/operations regions geometries



KEY:

- B, C, D: Same as in Figure A.4.
- UL, DL: Same as in Figure A.2.
- Signal paths 1a,2a,3,4 frequencies are as in Figure 2 (1,2,3,4 therein).
- For MIMO (multiple-input multiple-output) operations, signal paths 1b,2b,7,8 are same frequencies as 1a,2a,3,4.
- Signal paths 5,6 typically are same as in Figure A.3; however, some designs may use two separate transport paths for the two MIMO streams.
- I, II, III: Same as in Figure A.2.

Figure A.5 – Simplified schematic of multiple-enclosure booster system for MIMO operations, and signal path and coverage/operations regions geometries

APPENDIX B

CONSIDERATIONS ON DISTRIBUTED ANTENNA SYSTEMS AND DISTRIBUTED RADIO SYSTEMS FOR EQUIPMENT AUTHORIZATIONS

B.1 Basic fiber-optic RF distribution systems

One example conventional booster device type has been a fiber-optic distribution system that receives RF signals from an antenna, distributes the signal over fiber-optic cable, and then retransmits at another location, for example within a building or tunnel. Most fiber-optic systems have been considered to be signal boosters; however, some may meet the definition of repeaters (i.e., frequency translation; see also B.2, *Order* ¶ 3 fn 1, and APPENDIX A).

These systems generally have two or more enclosures typically called host (or local or donor unit) and remote (or coverage or server unit). Some systems may also have an optional "expansion" component for fan-out to multiple remotes. Generally fiber-optic systems transmit downlink signals from the remote unit to handsets, portables, or clients, and transmit uplink signals via the host unit.

Usually but not always the uplink of a fiber-optic booster system goes through an intermediate amplifier to a "donor" antenna. Therefore both uplink and downlink paths must be tested, unless an equipment application filing effectively documents how connection of the uplink path to a donor antenna with or without an intermediate amplifier will be prevented; for example use with only a cabled direct connection to a base station is ensured.

Fiber-optic booster systems are typically comprised of two or more of the following components, each described further below: host unit (might be digital device only); remote unit; expansion unit; passive interface unit; active interface unit.

1) ***host unit***
   a) transmits uplink to base station via antenna thru coaxial cable, typically either a ***passive interface unit***, or an ***active interface unit*** (amplifier)
   b) sends base-station downlink via fiber-optic or coaxial cable to ***remote***
   c) receives handset uplink via fiber-optic or coaxial cable from ***remote***
   d) optional connection to ***expansion unit*** via fiber-optic
   e) separate FCC ID from ***remote***, unless electrically identical
   f) ***non-transmitting host unit***
      i) connects directly to a base station via coaxial cable but cannot connect to antenna and/or amplifier
      ii) Part 15 digital device subject to Verification, no FCC ID
2) ***remote unit***
   a) receives base-station downlink via fiber-optic or coaxial cable from ***host***, transmits via antenna to handsets
   b) returns handset uplink via fiber-optic or coaxial cable to ***host***
   c) separate FCC ID from ***remote***, unless electrically identical

3) ***fiber-optic expansion unit***
   a) fiber-optic or coaxial cable from ***host***
   b) fiber-optic or coaxial cable fan-out to ***remote(s)***
   c) Part 15 digital device subject to Verification, no FCC ID
4) ***RF expansion unit***
   a) internal or external device used to add band(s) and/or transmit mode(s) to a ***remote***
   b) operates only when connected to a ***remote unit*** as part of a booster system
   c) contains signal-processing functions to convert baseband signal into modulated RF signal
   d) use equipment class PCB or TNB for an ***RF expansion unit*** (the associated ***remote*** uses an equipment class Bxx per **Table C.1** of this document, e.g., B2I)
5) ***passive interface unit***
   a) contains attenuators, splitters, combiners
   b) coaxial cable RF connection between ***host*** and base-station
   c) passive device, no FCC ID
6) ***active interface unit***
   a) amplifies uplink signal from ***host unit*** for transmit by donor antenna
   b) attenuates downlink from donor antenna
   c) coaxial cable RF connection between ***host*** and ***active interface unit***
   d) usually has separate FCC ID; in some cases could be combined/included with ***host*** as one enclosure

B.2 Distributed antenna systems

The term “signal booster” as used in the *Order* and the associated rule sections includes all manner of distributed antenna systems and in-building radiation systems that serve to amplify signals between a device and a wireless network. [*Order*, ¶ 3, fn 1] A distributed antenna system (DAS) is a system of spatially separated antennas connected via cables (i.e., coaxial or fiber optic cable) to a signal source, such as a base station or an external antenna capable of communicating with a base station wirelessly. DAS are used to distribute wireless signals through large structures such as skyscrapers, hospitals, hotels, arenas and tunnels where the signal coverage may be lacking or to increase the capacity of the wireless system by achieving channel reuse on a smaller scale. Some DAS configurations may be considered signal boosters when the network of internal antennas achieves communication through the use of an amplifier that is connected to an external antenna that communicates with a base station wirelessly. [*Order*, APPENDIX B ¶ 3]

Distributed antenna systems (“DAS”) are one alternative to the use of macrocells mounted on tall antenna structures for wireless coverage. A DAS network is used to distribute RF signals from a central hub to a specific area with poor coverage or inadequate capacity. Because the facilities deployed at each node of a DAS are physically much smaller than for example macrocell base station and antenna equipment, they can be placed on a variety of short structures or on rooftops. Macrocells and small cells are usually operator-managed and support use by a single wireless service provider, whereas DAS networks can often accommodate multiple wireless providers using different frequencies and/or wireless air interfaces. ([R24], ¶ 16)

A DAS network consists of: (i) a number of remote communications nodes deployed throughout the desired coverage area, each including at least one antenna for the transmission and reception of a wireless service provider’s RF signals, (ii) a high capacity signal transport medium (typically fiber optic cable) connecting each node to a central communications hub site, and (iii) radio transceivers located at the hub site (rather than at each individual node as is the case for small cells) to process or control the communications signals transmitted and received through the antennas. [R24]

Some industry literature further distinguishes between active DAS and passive DAS, the main difference being whether a remote communications node has only an antenna or also has RF hardware. Some industry literature has also referred to active DAS as distributed radio systems. In general, for equipment authorization purposes compliance demonstration of the antenna system portion of a passive DAS for operation under FCC licensed radio service rules is addressed by appropriate § 2.1033(c) installation and operating instructions.

B.3 Distributed base station systems

In general mobile radio base stations consist of a baseband unit (BBU) and a radio frequency unit (RFU), which in a distributed base station architecture usually is a remote radio head (RRH).[R25],[R26] CPRI (Common Public Radio Interface) is one example protocol that allows the use of a distributed architecture where base stations, containing the radio equipment control, are connected to remote radio heads via lossless fiber-optic links that carry the CPRI data.[R24]

RRH devices used for distributed base station (DBS) systems as described here generally are not subject to §§ 20.21 and 90.219 booster rules. Similarly as for multiple-enclosure booster systems described in B.1 and APPENDIX A, where the BBU and RRH components for a DBS system are not electrically identical, each component generally is subject to separate / individual equipment authorization. For example, only part 15 subpart B digital device authorization might apply for a (non-transmitting) BBU.

BBU and RRH components generally need to be tested together as a system, and equipment applications need to describe and address compliance for the supported signal and modulation types for each transmission path. The Form-731 provision for “part of a system that operates with, or is marketed with, another device that requires an equipment authorization” needs to be completed as applicable, e.g., when the transport link uses proprietary signaling such that each BBU or RRH component operates only with specific associated DBS system devices.

APPENDIX C

EQUIPMENT AUTHORIZATION SYSTEM (EAS)
FORM-731 EQUIPMENT CLASS DESIGNATORS

C.1 Applicable equipment classes

Equipment classes to be used for signal booster device applications are shown in Table C.1.[8] An applicant or agent or test lab should submit a KDB inquiry providing device details to get FCC guidance in case equipment class and/or allowed composite-application conditions are unclear for any specific device.

Table C.1 – Form-731 Equipment Classes for Licensed-Service Signal Booster and Related Equipment Types

B2W	Part 20 Wideband Consumer Booster (CMRS 22/24/27/90-S)
B2P	Part 20 Provider-Specific Consumer Booster (CMRS 22/24/27/90-S)
B2I	Part 20 Industrial Booster (CMRS 22/24/27/90-S)
B9A	Part 90 Class A Industrial Booster (PLMRS, PSRS, non-cellular SMR)
B9B	Part 90 Class B Industrial Booster (PLMRS, PSRS, non-cellular SMR)
BOS	Other signal boosters (not subject to §§ 20.21, 90.219; also for some frequencies not listed in Table D.1 and Table D.2 of this document)
AMP	Amplifier (i.e., ERFPA)
PCB	PCS Licensed Transmitter (new grants for booster devices use Bxx equipment classes)
TNB	Licensed Non-Broadcast Station Transmitter (new grants for booster devices use Bxx equipment classes)
NOTE 1–For background, since the early 2000s FCC OET policy was that the equipment class AMP is used for basic unidirectional-path signal amplifier devices, and equipment classes PCB or TNB for all other signal booster and related device types. NOTE 2–In the above, 90-S refers to part 90 subpart S, i.e., ESMR per §§ 90.209(b)(7), 90.614(b),(c).	

C.2 Form 731 entries

a) For ERFPA
   1) In one enclosure
      i) Equipment Class – AMP
      ii) List AMP in frequency tolerance field of Form 731
      iii) List emission designators without necessary bandwidth (e.g., F3E, F1D)
   2) In two enclosures – Does not exist (if it does, use same entries as for one enclosure)

[8] The EAS Form-731 equipment class is a three character code which is used by FCC to define a type of equipment and the radio service in which it is used; (https://apps.fcc.gov/oetcf/eas/reports/EquipmentRulesList.cfm).
In many cases the rule part and type of operation intended (i.e. portable, mobile, base station, handheld, etc) can be determined from the equipment class.
The equipment class also generally determines the required exhibit types in a Form-731 application [§§ 2.1033(c), 2.911(b)] (https://apps.fcc.gov/oetcf/eas/misc/EasFaq.cfm).

b) For Booster
    1) In one enclosure
        i) Equipment Class –BOS, B2I, B9A, B9B
        ii) List AMP in frequency tolerance field of Form 731
        iii) List emission designators without necessary bandwidth (e.g., F3E, F1D)
        iv) List in Form-731 description or comments field the word "booster"
    2) In two enclosures (host/remote)
        i) Two separate FCC IDs/applications
        ii) Equipment Class –BOS, B2I, B9A, B9B
        iii) List AMP in frequency tolerance field of Form 731
        iv) List emission designators without necessary bandwidth (e.g., F3E, F1D)
        v) List in comments field the words "Part of booster system used with FCC ID: xxxyyy." (Where xxxyyy is FCC ID of other device(s) in system).

c) For Repeater
    1) In one enclosure
        i) Equipment Class – BOS, B2I, B9A, B9B
        ii) List AMP in frequency tolerance field of Form 731 if device contains no frequency translation; otherwise, measure frequency tolerance and list.
        iii) List in comments field the word "repeater"
    2) In two enclosures (host/remote)
        i) Two separate FCC IDs/applications
        ii) Equipment Class – BOS, B2I, B9A, B9B
        iii) List AMP in frequency tolerance field of Form 731 if device contains no frequency translation; otherwise, measure frequency tolerance and list.
        iv) List in comments field the words "Part of repeater system used with FCC ID: xxxyyy." (Where xxxyyy is FCC ID of other device(s) in system).

C.3 Devices with multiple equipment classes under a single FCC ID – composite applications

a) FCC OET application filing procedures require more than one Form-731 per FCC ID whenever a device has operations subject to multiple rule parts or rule sections each with different equipment classes; such a multiple-Form-731 FCC ID is known as a composite-system application [§ 2.1033(e)]. For signal booster devices, composite applications (i.e., single FCC ID) with more than one of the equipment classes listed in Table A.1 (e.g., B2W and B2P, B9A and B9B[9]) are not permitted.

b) For booster system devices using a wireless link for system-internal operations (see discussion in APPENDIX A of this document), composite applications are permitted; e.g., 802.11 under part 15 (equipment class DTS and/or NII) along with B2P.

c) Booster devices that include signal paths for transmitting on part 15 frequencies from the donor port and/or server port (not including booster systems using part 15 on system-internal transport links) generally are considered to be part 15 amplifiers subject to § 15.204 requirements and the policies and procedures of KDB Publication 602159.[R27]

[9] §§ 90.219(a), 90.219(e)(5); Order ¶ 15 n.28, ¶ 156, ¶ 186, ¶ 189; 2.925(b)(1).

C.4 Permissive change for consumer devices granted before February 20, 2013

The following applies for booster devices with grants issued before February 20, 2013 (i.e., typically equipment class AMP or TNB or PCB), and that have been previously marketed and operated as what would now be considered a Consumer Booster under the FCC 13-21 new framework.

a) Permissive change applications can be processed by TCBs to update representations and/or test data (install/operate instructions, labeling, etc.) under the FCC ID for subsequent marketing and operation only as an Industrial Booster under the FCC 13-21 new framework.

b) Section III h of this document describes conditions for single-FCC ID composite-Form 731 Industrial Booster (B2I) and § 20.21 Consumer Booster (B2W or B2P) devices. For consumer devices with pre-existing FCC ID similarly intended for subsequent marketing and operation both as Industrial Booster only or § 20.21 Consumer Booster only, a new FCC ID composite-Form 731 is required (i.e., rather than a permissive change to the pre-existing FCC ID).

C.5 Permissive changes for non-consumer devices granted before February 20, 2013

The following applies for booster devices with grants issued before February 20, 2013 (i.e., typically equipment class AMP or TNB or PCB), and that have been previously marketed and operated as what would now be considered as an Industrial Booster under the FCC 13-21 new framework.

a) PLMRS and PSRS part 90 devices
    1) PLMRS and PSRS part 90 boosters are industrial boosters, and are subject to the new rules and KDB Publication 935210 D02 policies and procedures.

    2) For PLMRS/PSRS bands (e.g, see Table D.3), since March 1, 2014 all industrial boosters sold and marketed in US have been required to comply with § 90.219(e); i.e., explicit compliance information and test data must be on file under the FCC ID, along with explicit labelling identifying a device as § 90.219(a) Class A or Class B, and with associated installation/operation instructions.

    3) Booster device/system subsequent operations must comply with §§ 90.219(a) to 90.219(d). [FCC 13-21 ¶¶ 187, 194-195, etc.]

    4) Depending on details of specific existing FCC IDs and operating frequencies, a new FCC ID rather than a permissive change might need to be considered; applicants or agents should submit a KDB inquiry to request guidance.

b) CMRS parts 22, 24, 27, 90 devices
    1) For the CMRS bands listed in Table D.2, non-consumer boosters are industrial boosters, subject to §§ 20.21(c) and 20.21(f)(1).

    2) Equipment authorization permissive change for legacy non-consumer industrial boosters to update labelling and install instructions per § 20.21(f) is allowed but is not required.

    3) Permissive change filings shall retain the existing/legacy equipment class (i.e., AMP or TNB or PCB), without change to B2I.

4) For CMRS bands (see Table D.2), since March 1, 2014 all industrial boosters sold and marketed in US have been required to comply with § 20.21(f), regardless whether a permissive change is filed or not.

5) Booster device/system subsequent operations must comply with §§ 20.21(c), 20.21(d).
[FCC 13-21 ¶¶ 6, 110-116]

APPENDIX D

FREQUENCY BANDS FOR SIGNAL BOOSTERS UNDER §§ 20.21 AND 90.219

Consumer Signal Boosters must be designed and manufactured such that they operate only on the frequencies and rule parts used for the provision of subscriber-based services [§ 20.21(e)(3)], i.e., as listed in the following Table D.1.

Form-731 extended frequency listings per the provisions of KDB Publication 634817 [R16] are not permitted for Consumer Signal Booster equipment grants.

Industrial Signal Boosters that are to be professionally installed and operated in close coordination with affected licensees are not limited to specific spectrum bands. [*Order*, ¶ 36] Nonetheless, Table D.2 lists bands generally available for CMRS Industrial Signal Boosters.

Table D.3 lists the basic Part 90 PLMRS bands, for reference.[10]

Table D.1 – Frequency Bands (in MHz) and Rule Parts for Consumer Signal Booster Equipment Grants

22 (Cellular)	824-849 UL 869-894 DL
24 (Broadband PCS)	1850-1915 UL 1930-1995 DL
27-L (AWS-1)	1710-1755 UL 2110-2155 DL
27 (Lower A-E Blocks)	A 698-704 / 728-734 B 704-710 / 734-740 C 710-716 / 740-746 D 716-722 E 722-728
27 (700 MHz Upper C Block)	746-757 DL 776-787 UL
90 (Specialized Mobile Radio) [a] [§§ 90.614(b), 90.614(c) [b]]	813.5/817-824 UL 858.5/862-869 DL
[a] Consumer Signal Boosters for operation on Part 90 (Specialized Mobile Radio) frequencies will not be certificated until the FCC releases a Public Notice announcing the date that Consumer Signal Boosters may be used in the band [*cf.* § 20.21(e)(3)]. [b] For devices that cover 813.5-817/858.5-862 MHz bands, applicants must specify whether the device is for CMRS or private use so that the appropriate rules can be applied.	
NOTE—Equipment authorization for Consumer Signal Boosters is permitted only for the frequency bands and service rules listed, but is NOT available for various bands recently established, e.g., AWS-4, AWS-3.	

[10] FCC WTB Wireless Services – Industrial/Business, (http://wireless.fcc.gov/services/index.htm?job=service_bandplan&id=industrial_business).

Table D.2 – Industrial Signal Booster Authorized Frequency Bands for § 20.21(c)

FCC Band Name	†UL (MHz): UE tx; BS rx	†DL (MHz): BS tx; UE rx	Channel Block Assignments	Selected FCC Rule §§
Lower 700 MHz	698-716	716-746	**A Block:** 698-704 MHz (UL) paired 728-734 (DL); **B Block:** 704-710 MHz (UL) paired 734-740 MHz (DL); **C Block:** 710-716 MHz (UL) paired 740-746 MHz (DL); **D Block:** 716-722 MHz (DL), unpaired; **E Block:** 722-728 MHz (DL), unpaired	§§ 27.5(c), 27.50(c), 27.53(g)
Upper 700 MHz	776-787	746-757	**A Block:** 757-758 MHz paired 787-788 MHz **B Block:** 775-776 MHz paired 805-806 MHz **C Block:** 776-787 MHz (UL) paired 746-757 MHz (DL)	§§ 27.5(b), 27.50(b), 27.53(c), 27.53(f)
ESMR	817-824	862-869	N/A	§§ 90.614, 90.635, 90.691
Cellular	824-849	869-894	**A Block:** 824-835 MHz (UL) paired 869-880 MHz (DL), and 845-846.5 MHz (UL) paired 890-891.5 MHz (DL); **B Block:** 835-845 MHz (UL) paired 880-890 MHz (DL), and 846.5-849 MHz (UL) paired 891.5-894 MHz (DL)	§§ 22.905, 22.913, 22.917
AWS-1	1710-1755	2110-2155	**A Block:** 1710-1720 MHz (UL) paired 2110-2120 MHz (DL); **B Block:** 1720-1730 MHz (UL) paired 2120-2130 MHz (DL); **C Block:** 1730-1735 MHz (UL) paired 2130-2135 MHz (DL); **D Block:** 1735-1740 MHz (UL) paired 2135-2140 MHz (DL); **E Block:** 1740-1745 MHz (UL) paired 2140-2145 MHz (DL); **F Block:** 1745-1755 MHz (UL) paired 2145-2155 MHz (DL)	§§ 27.5(h), 27.50(d), 27.53(h) 27.50(d)(4) "Fixed ... stations operating in the 1710-1755 MHz band ... are limited to 1 watt EIRP. Fixed stations operating in the 1710-1755 MHz band are limited to a maximum antenna height of 10 meters above ground. ..."
AWS-3	1695-1710 1755-1780	2155-2180	Block A1: 1695-1700 MHz (UL), unpaired Block B1: 1700-1710 MHz (UL), unpaired Block G: 1755-1760 MHz (UL) paired 2155-2160 MHz (DL); Block H: 1760-1765 MHz (UL) paired 2160-2165 MHz (DL); Block I: 1765-1770 MHz (UL) paired 2165-2170 MHz (DL); Block J: 1770-1780 MHz (UL) paired 2170-2180 MHz (DL)	§§ ... 27.77, 27.1134, 27.5(h) 2175-2180 MHz fka AWS-2 J block. Fixed stations prohibited from operating in the 1695-1710 MHz and 1755-1780 MHz bands.
Broadband PCS	1850-1915	1930-1995	**A Block:** 1850-1865 MHz (UL) paired 1930-1945 MHz (DL); **B Block:** 1870-1885 MHz (UL) paired 1950-1965 MHz (DL); **C Block:** 1895-1910 MHz (UL) paired 1975-1990 MHz (DL); **D Block:** 1865-1870 MHz (UL) paired 1945-1950 MHz (DL); **E Block:** 1885-1890 MHz (UL) paired 1965-1970 MHz (DL); **F Block:** 1890-1895 MHz (UL) paired 1970-1975 MHz (DL); **G Block:** 1910-1915 MHz (UL) paired 1990-1995 MHz (DL)	§§ 24.229, 24.232, 24.238
AWS-2	1915-1920	1995-2000	1915-1920 MHz (UL) paired 1995-2000 MHz (DL)	§§ ... 27.5(k), aka AWS-2 H block. 27.50(d)(9) Fixed ... stations operating in the 1915-1920 MHz band are limited to 300 mW EIRP.
AWS-4	2000-2020	2180-2200	Block A: 2000-2010 MHz (UL) paired 2180-2190 MHz (DL) Block B: 2010-2020 MHz (UL) paired 2190-2200 MHz (DL)	... 27.5(j) ...
WCS	2305-2320	2345-2360	Block A: 2305-2310 MHz paired 2350-2355 MHz Block B: 2310-2315 MHz paired 2355-2360 MHz Block C: 2315-2320 MHz (UL), unpaired; Block D: 2345-2350 MHz (DL), unpaired	27.50(a)(1)(i), 27.50(a)(1)(ii), As an industrial (licensee authorized/operated) not consumer booster, 27.50(a)(2) "customer premise" station provisions generally should not apply.
BRS/EBS	2496-2690	2496-2690		2495-2496 MHz is guardband (reserved; not available). See also KDB pub 634817 D02.

† UE = user equipment (donor-port transmit); BS = base station (server-port transmit); UL = uplink (donor-port transmit); DL = downlink (server-port transmit)

Table D.3 – Various Part 90 PLMRS band allocations, rule parts/sections, and service types for 90.219 purposes (for info only – see rules for details, also KDB Publication 634817 [R16])

F_L (MHz)	–	F_L (MHz)	Rule(s)	
150	–	150.05	Federal (non-FCC)	
150.05	–	150.8	§ 90.265	
150.8	–	162.0125	90	
162.0125	–	173.2	§ 90.265	
173.2	–	173.4	90	
173.4	–	174	Federal (non-FCC)	
406.1	–	420	§ 90.265	
420	–	421	ULS presently shows no licensees for 420-420.9 MHz	
421	–	430	90	
430	–	450	Not available under 90 subparts B, C land mobile service	
450	–	470	90 (selected bands)	
470	–	512	90	
746	–	757	27.5(b)(3) Block C; 90 not available	
757	–	758	27.5(b)(1) Block A; 90 not available	
758	–	768	90-R, Public Safety (PS) Broadband (FirstNet)	LTE
768	–	769	PS Guardband	
769	–	775	PS Narrowband	
775	–	776	27.5(b)(2) Block B; 90 not available	
776	–	787	27.5(b)(3) Block C; 90 not available	
787	–	788	27.5(b)(1) Block A; 90 not available	
788	–	798	90-R, Public Safety (PS) Broadband (FirstNet)	LTE
798	–	799	PS Guardband	
799	–	805	PS Narrowband	
805	–	806	27.5(b)(2) Block B; 90 not available	
806	–	809	90 NPSPAC (PS)	B9B/B9A
809	–	815	90 Interleaved PS; B/ILT; SMR [§ 90.614(a); § 90.613 ch. nos. 1-470]	
815	–	816	90 Expansion B/ILT; SMR [§ 90.614(a); § 90.613 ch. nos. 470-550]	
816	–	817	90 Guardband	
817	–	824	CMRS 90 ESMR [§ 90.614(b); § 90.613 ch. nos. 551-830]	B2I
824	–	849	22 H; 90 not available	
849	–	851	22 G; 90 not available	
851	–	854	90 NPSPAC (PS)	
854	–	860	90 Interleaved PS; B/ILT; SMR [§ 90.614(a); § 90.613 ch. nos. 1-470]	
860	–	861	90 Expansion B/ILT; SMR [§ 90.614(a); § 90.613 ch. nos. 470-550]	
861	–	862	90 Guardband	
862	–	869	CMRS 90 ESMR [§ 90.614(b); § 90.613 ch. nos. 551-830]	B2I
869	–	894	22-H; 90 not available	
894	–	896	22-G; 90 not available	
896	–	901	90 Interleaved B/ILT [§ 90.617(c)] and SMR [§ 90.617(f)]; UL (donor)	
901	–	902	24-D; 90 not available	
928	–	929	101; 90 not available	
929	–	930	22-E; § 90.493(c) allows part 90 for eqpt. auth., in lieu of part 22[11]	B9B/B9A
930	–	931	24-D; 90 not available	
931	–	932	22-E; 90 not available[1]	
932	–	935	101; 90 not available	
935	–	940	90 Interleaved B/ILT [§ 90.617(c)] and SMR [§ 90.617(f)]; DL (server)	
940	–	941	24-D; 90 not available	B2I

[11] FCC Spectrum Dashboard, Browse Spectrum Bands (225 MHz - 3700 MHz) (http://reboot.fcc.gov/spectrumdashboard/searchSpectrum.seam): 928-929 MHz, 101; 929-930 MHz, 22 [see also (http://wireless.fcc.gov/services/index.htm?job=service_home&id=private_land_paging), (http://wireless.fcc.gov/services/index.htm?job=service_bandplan&id=paging)].

APPENDIX E

NETWORK PROTECTION STANDARD (NPS) – PARAPHRASED SUMMARY OF RULE PARAGRAPHS, MEASUREMENT QUANTITIES, AND REQUIREMENTS[12]

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).

§ 20.21(e)(8) ***Wideband Consumer Signal Boosters.***	§ 20.21(e)(9) ***Provider-Specific Consumer Signal Boosters.***
§ 20.21(e)(8)(i) *Technical Requirements*	§ 20.21(e)(9)(*i*) *Technical Requirements*
§ 20.21(e)(8)(i)(A) *Noise Limits.*	§ 20.21(e)(9)(*i*)(A) *Noise Limits.*
§ 20.21(e)(8)(i)(A)(*1*) UL ~~and DL~~ ports transmitted noise power [dBm/MHz]: $P_{TN} \le -(103+RSSI)$.	UL and DL ports transmitted noise power [dBm/MHz] outside licensee's blocks, § 20.21(e)(9)(*i*)(A)(*1*): $P_{TN} \le -(103+RSSI)$
RSSI is DL composite received signal power P_{RS} [dBm] at donor port for all operating-band BS.	§ 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)(8)(i)(A)(*2*) UL and DL ports maximum transmitted noise power [dBm/MHz]:	§ 20.21(e)(9)(*i*)(A)(*2*)
§ 20.21(e)(8)(i)(A)(*2*)(*i*) Fixed booster: $P_{TN,max} \le (-102.5+20\lg f_{MHz})$.	§ 20.21(e)(9)(*i*)(A)(*2*)(*i*) Fixed booster DL maximum: $P_{TN,max} \le (-102.5+20\lg f_{MHz})$.
§ 20.21(e)(8)(i)(A)(*2*)(*ii*) Mobile booster: $P_{TN,max} \le -59$.	§ 20.21(e)(9)(i)(A)(2)(ii) Mobile booster: $P_{TN,max} \le -59$.
§ 20.21(e)(8)(i)(A)(*2*)(*iii*): Instrumentation, etc. (see rule).	§ 20.21(e)(9)(*i*)(A)(*2*)~~(*ii*)~~(*iii*): Instrumentation, etc. (see rule).
§ 20.21(e)(8)(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*)(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)(8)(i)(C) *Booster Gain Limits.*	§ 20.21(e)(9)(*i*)(C) *Booster Gain Limits.*
§ 20.21(e)(8)(i)(C)(*1*) "variable gain" $G_{UL} \le (-34-RSSI-MSCL)$ [dB]	§ 20.21(e)(9)(*i*)(C)(*1*) "variable gain" G_{UL}, G_{DL} $\le [BSCL-28-(40-MSCL)]$ [dB]
§ 20.21(e)(8)(i)(C)(*1*)(*i*): RSSI is DL composite received signal power P_{RS} [dBm] at donor port for all operating-band BS.	§ 20.21(e)(9)(*i*)(C)(*1*)(i): BSCL, MSCL definitions (see rule).
§ 20.21(e)(8)(i)(C)(*1*)(*ii*): MSCL definition (see rule).	§ 20.21(e)(9)(*i*)(C)(*1*)(*ii*): BSCL derivation (see rule).

[12] This summary table is for information and quick reference purposes only; parties must use the most recent complete versions of §§ 20.21(e)(8) and 20.21(e)(9) for compliance testing purposes.

§ 20.21(e)(8) ***Wideband Consumer Signal Boosters.***	§ 20.21(e)(9) ***Provider-Specific Consumer Signal Boosters.***
§ 20.21(e)(8)(i)(C)(*2*) maximum gain [dB]	§ 20.21(e)(9)(*i*)(C)(*2*) maximum gain [dB] § 20.21(e)(9)(i)(C)(*2*)(*i*) Fixed booster $G_{UL,max}$, $G_{DL,max}$ ≤ 19.5+20lg f_{MHz}, or $G_{UL,max}$, $G_{DL,max}$ ≤ 100, for systems with donor/server isolation-measurement based automatic gain adjustment.
§ 20.21(e)(8)(i)(C)(*2*)(*i*) Fixed Booster: $G_{UL,max}$, $G_{DL,max}$ ≤ 60+20lg f_{MHz}	
§ 20.21(e)(8)(i)(C)(*2*)(*ii*) f_{MHz} is UL midband frequency.	§ 20.21(e)(9)(i)(C)(*2*)(*ii*) f_{MHz} is UL midband frequency.
§ 20.21(e)(8)(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)(i)(C)(*2*)(*iii*) Mobile Booster: $G_{UL,max}$, $G_{DL,max}$ ≤ 50 dB, inside antenna; ≤ 23 dB, contact coupling; ≤ 15 dB, direct connect.
	$G_{UL,max}$, $G_{DL,max}$ ≤ 58 below 1 GHz, $G_{UL,max}$, $G_{DL,max}$ ≤ 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)(8)(i)(D) *Power Limits.* UL P_{cond} ≤ 1 W, and UL EIRP ≤ 1 W. DL P_{cond} ≤ 0.05 W, and DL EIRP ≤ 0.05 W.	§ 20.21(e)(9)(*i*)(D) *Power Limits.* UL P_{cond} ≤ 1 W, and UL EIRP ≤ 1 W. DL P_{cond} ≤ 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)(8)(i)(E) *Out of Band Emission Limits.* OOBE ≤ 6 dB below service rule mobile limit; OOBE compliance tested using high PAR signals.	§ 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)(8)(i)(F) *Intermodulation Limits.* UL and DL IM products ≤ −19 dBm. IM testing per description in rule.	§ 20.21(e)(9)(*i*)(G) *Intermodulation Limits.* UL and DL IM products ≤ −19 dBm. IM testing per description in rule.
§ 20.21(e)(8)(i)(G) *Booster Antenna Kitting.*	§ 20.21(e)(9)(*i*)(H) *Booster Antenna Kitting.*
§ 20.21(e)(8)(i)(H) *Transmit Power Off Mode.* Power-off mode required for devices not meeting noise and gain limits [§ 20.21(e)(8)]. The power-off mode for such devices requires: UL and DL P_{TN} ≤ −70 [dBm/MHz], and G_{UL} and G_{DL} ≤ min{23 dB; MSCL}.	§ 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} ≤ −70 [dBm/MHz], and G_{UL} ≤ min{23 dB; MSCL}.

§ 20.21(e)(8) ***Wideband Consumer Signal Boosters.***	§ 20.21(e)(9) ***Provider-Specific Consumer Signal Boosters.***
§ 20.21(e)(8)(i)(I) *Uplink Inactivity*. ...	§ 20.21(e)(9)(*i*)(J) *Uplink Inactivity*.
§ 20.21(e)(8)(ii) *Interference Safeguards.*	§ 20.21(e)(9)(ii) *Interference Safeguards.*
§ 20.21(e)(8)(ii)(A) *Anti-Oscillation.*	§ 20.21(e)(9)(ii)(A) *Anti-Oscillation.*
§ 20.21(e)(8)(ii)(B) *Gain Control.*	§ 20.21(e)(9)(ii)(B) *Gain Control.*
§ 20.21(e)(8)(ii)(C) *Interference Avoidance for Wireless Subsystems.*	§ 20.21(e)(9)(ii)(C) *Interference Avoidance for Wireless Subsystems.*

APPENDIX F

FURTHER INFORMATION ON SIGNAL BOOSTER END-USE REGISTRATION

F.1 CONSUMER BOOSTERS

A subscriber must have the consent of a wireless provider to operate a Consumer Signal Booster. Subscribers may obtain provider consent in a variety of ways. For example, AT&T, Sprint, T–Mobile, and Verizon Wireless have voluntarily committed to allow their subscribers to use properly certificated Consumer Signal Boosters (i.e., boosters that meet the new rules) on their networks. Also, a signal booster manufacturer could seek authorization for use of a particular booster model on behalf of all subscribers of individual providers. Alternatively, a provider may specify a testing protocol that if satisfied would result in licensee consent to specific booster models. A subscriber may also seek a licensee's express consent to operate a signal booster, e.g., by phone call or e-mail.[R11]

Public Notices DA 15-61 [R21] and DA 15-138 [R22] give listings of Consumer Boosters that have received FCC certification as of March 2, 2015.

The following selected information about wireless providers' Consumer Booster registration mechanisms supplements the requirements and information given in §§ 20.21, 22.9, 24.9, 27.9, and the FCC Signal Boosters website (http://wireless.fcc.gov/signal-boosters/).

- Sprint Nextel will allow consumers to register their signal boosters by calling their toll-free number. They have already trained their calling center and have designated an engineer to handle inquiries. They may eventually allow consumers to register on their website but they want to gauge how the process works via phone first.

- T-Mobile online registration link: (www.T-Mobile.com/BoosterRegistration); (https://saqat.t-mobile.com/sites/SignalBooster#).

- Verizon's online registration link: (http://www.verizonwireless.com/wcms/consumer/register-signal-booster.html).

- AT&T will allow online registration and will inform OET Lab with the weblink when it is ready.

- U.S.Cellular (http://www.uscellular.com/uscellular/support/fcc-booster-registration.jsp).

F.2 PART 90 CLASS B SIGNAL BOOSTERS

Licensees and signal booster operators are required to register existing Class B signal booster installations with the FCC by November 1, 2014. After November 1, 2014, operation of an existing, unregistered Class B signal booster will be unauthorized and subject to enforcement action. Any new Class B signal booster installed after November 1, 2014 must be registered prior to operation. To encourage compliance with this new requirement, registration will be free of cost to the operator and/or licensee.[R11], [R9]

FCC Part 90 Class B Signal Booster Registration & Discovery website: (https://signalboosters.fcc.gov/signal-boosters/).

APPENDIX G

SELECTED FCC DOCUMENTS AND REFERENCES FOR OTHER BACKGROUND

For KDB publications, the most recent version as published at the time of application submission should be used.

[R1] DA 10-14; Wireless Telecommunications Bureau Seeks Comment On Petitions Regarding The Use Of Signal Boosters And Other Signal Amplification Techniques Used With Wireless Services; WT Docket No. 10-4; Released: January 6, 2010.

[R2] FCC 11-53; 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; Notice Of Proposed Rulemaking; Adopted: April 5, 2011; Released: April 6, 2011.

[R3] 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; Adopted: February 20, 2013; Released: February 20, 2013.

[R4] Signal Booster Rules, 78 Federal Register 21555-21565, April 11, 2013.

[R5] Signal Booster Rules, Correcting amendment, 78 Federal Register 29062, May 17, 2013.

[R6] Signal Booster Rules, Announcement of effective date, 78 Federal Register 55648-55649, September 11, 2013.

[R7] An associated FCC Small Entity Compliance Guide about the signal booster rules is available:
DA 13-1143, WT Docket No. 10-4, May 17, 2013;
(http://www.fcc.gov/encyclopedia/compliance-guides-small-businesses),
(http://www.fcc.gov/document/commissions-rules-improve-wireless-coverage).

[R8] DA 13-2389; Wireless Telecommunications Bureau Reminds Signal Booster Manufacturers of March 1, 2014 Equipment Compliance Date; December 13, 2013.

[R9] DA 14-15; Wireless Telecommunications Bureau Announces Availability of Part 90 Class B Signal Booster Registration Tool; January 7, 2014;
(https://signalboosters.fcc.gov/signal-boosters/).

[R10] DA 14-177; WT Docket No. 10-4; Order, responding to “Wireless Telecommunications Bureau Seeks Comment on ClearRF Request for Waiver of March 1, 2014 Signal Booster Compliance Deadline,” DA 13-2465; Adopted: February 11, 2014; Released: February 11, 2014. [Waives the March 1, 2014, sale and marketing deadline in § 20.21(g), and extends for 60 days (until April 30, 2014) the deadline by which all Consumer Signal Boosters marketed, distributed, or sold in the United States must comply with § 20.21.]

[R11] FCC Signal Boosters (http://wireless.fcc.gov/signal-boosters/);
Consumer Signal Boosters (http://wireless.fcc.gov/signal-boosters/consumer-boosters/);
Industrial Signal Boosters (http://wireless.fcc.gov/signal-boosters/industrial-boosters/);
Part 90 Signal Boosters (http://wireless.fcc.gov/signal-boosters/part-90-boosters/);
FAQ & Resources (http://wireless.fcc.gov/signal-boosters/faq.html).

[R12] FCC 13-117; Emission Mask Requirements for Digital Technologies on 800 MHz NPSPAC Channels; Analog FM Capability on Mutual Aid and Interoperability Channels; PS Docket No. 13-209; Notice Of Proposed Rulemaking; Adopted: August 23, 2013; Released: August 27, 2013.

[R13] DA 13-1803; PUBLIC SAFETY AND HOMELAND SECURITY BUREAU AND OFFICE OF ENGINEERING AND TECHNOLOGY FREEZE CERTAIN APPLICATIONS IN THE 800 MHz NPSPAC PUBLIC SAFETY BAND; PS Docket No. 13-209; August 27, 2013; ERRATUM, August 29, 2013.

[R14] KDB Publication 388624 D01 PERMIT BUT ASK PROCEDURE; KDB Publication 388624 D02 PERMIT BUT ASK LIST; (https://apps.fcc.gov/oetcf/kdb/reports/GuidedPublicationList.cfm).

[R15] KDB Publication 996369 D01 Transmitter Module Equipment Authorization Guide; (https://apps.fcc.gov/oetcf/kdb/reports/GuidedPublicationList.cfm).

[R16] KDB Publication 634817 D01 Frequency Range Listings for Certification Grants;
KDB Publication 634817 D02 Frequency Range Listings Background;
(https://apps.fcc.gov/oetcf/kdb/reports/GuidedPublicationList.cfm).

[R17] KDB Publication 447498 D01 Mobile and Portable Devices RF Exposure Procedures and Equipment Authorization Policies; (https://apps.fcc.gov/oetcf/kdb/rseports/GuidedPublicationList.cfm).

[R18] KDB Publication 670583 Intermodulation Testing General Guidance; (http://appsint.fcc.gov/oetcf/kdb/forms/FTSSearchResultPage.cfm?id=20395&switch=P).

[R19] 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 And Further Notice Of Proposed Rulemaking; Adopted: September 19, 2014; Released: September 23, 2014; final rule, petition for reconsideration, 79 FR 70790-70796, Nov. 28, 2014; further notice of proposed rulemaking, 79 FR 70837-70838, Nov. 28, 2014; information collection review, 80 FR 5748-5749, Feb. 3, 2015.

[R20] KDB Publication 662911 D01 Emissions Testing of Transmitters with Multiple Outputs in the Same Band; (https://apps.fcc.gov/oetcf/kdb/reports/GuidedPublicationList.cfm).

[R21] DA 15-61; WIRELESS TELECOMMUNICATIONS BUREAU REMINDS NATIONWIDE WIRELESS SERVICE PROVIDERS OF OBLIGATION TO RELEASE INFORMATION REGARDING CONSUMER SIGNAL BOOSTERS BY MARCH 2, 2015; January 15, 2015.

[R22] DA 15-138; WIRELESS TELECOMMUNICATIONS BUREAU UPDATES LIST OF CONSUMER SIGNAL BOOSTERS; January 30, 2015.

[R23] FCC 13-122; Acceleration of Broadband Deployment by Improving Wireless Facilities Siting Policies; WT Docket No. 13-238; Notice Of Proposed Rulemaking; Adopted: September 26, 2013; Released: September 26, 2013.

[R24] CPRI Specification V5.0 (2011-09-21), Common Public Radio Interface (CPRI); Interface Specification; (http://www.cpri.info/spec.html), also e.g., (http://www.altera.com/technology/high_speed/protocols/cpri/pro-cpri.html).

[R25] ETSI GS ORI 001 V1.1.1 (2011-10), Open Radio equipment Interface (ORI); Requirements for Open Radio equipment Interface (ORI) (Release 1).

[R26] ETSI TR 102 681 V1.1.1 (2009-06), Reconfigurable Radio Systems (RRS); Radio Base Station (RBS) Software Defined Radio (SDR) status, implementations and costs aspects, including future possibilities.

[R27] KDB Publication 602159 Part 15 Repeaters; (http://appsint.fcc.gov/oetcf/kdb/forms/FTSSearchResultPage.cfm?id=28433&switch=P).

CHANGE NOTICE:

07/24/2014: 935210 D02 Signal Boosters Certification v02r01 has replaced 935210 D02 Signal Boosters Certification v02. Various minor editorial changes are made, and cross-references to draft procedures for provider-specific consumer boosters are updated to cite 935210 D04. Consistent with consumer boosters, example grant conditions for industrial boosters amended for AWS 1700-band compliance. Text updated to reflect 90.219(e) priority over 90.219(d) for equipment authorization filings. Cross-reference to 670583 added in APPENDIX D.

04/xx/2015: 935210 D02 Signal Boosters Certification v03 replaces 935210 D02 Signal Boosters Certification v02r01.
The previous 935210 D01 v02 is incorporated herein and superseded (removed),
Appendix D of 935210 D02 v02r01 is removed; portions are replaced by new 935210 D05 or incorporated in this 935210 D02.
II(n) is added using 935210 D02 v02r01 D.3 (f) and Oct. 2014 FCC-TCB notes.
II(o) is added pursuant to Oct. 2014 FCC-TCB notes.
II(p) is added pursuant to FCC-13-21 and 935210 D02 v02r01 Appendix D items not incorporated in DR01 935210 D05.
III(b)(9) indicates CSB label change forthcoming per Feb. 2015 OMB PRA and FCC-14-138.
V(j)(5) is added per application reviews since Sep. 2014.
Figs. A.4 & A.5 are amended pursuant to Oct. 2014 FCC-TCB notes.
C.2 is transposed from Appendix D of 935210 D02 v02r01.
C.3 c) is added per application reviews since Dec. 2014.
C.5 is amended pursuant to Oct. 2014 FCC-TCB notes.
Table D.2 is added.
Table D.3 is updated from Table B.2 of 935210 D02 v02r01, and considering 2014 updates to KDB 634817.
Appendix E table is updated from the Appendix C table of 935210 D02 v02r01 to indicate rules changes per FCC-14-138.
Appendix F is updated to cite the 2015 public notice listing approved CSB device.
Miscellaneous editorial changes are done due to merging 935210 D01 v02 and 935210 D02 v02r01.

935210 D03 Signal Booster Measurements v03 DR07-42107

The following subdocument D03 within this review draft package DR07-42107 is an update to the existing 935210 D03 v02r01.

Pages 40 -74

Federal Communications Commission
Office of Engineering and Technology
Laboratory Division

April XX, 2015

WIDEBAND CONSUMER SIGNAL BOOSTER COMPLIANCE MEASUREMENT GUIDANCE

1. Introduction

1.1 Background

In February 2013 the FCC released a Report and Order (FCC 13-21) that establishes new rules for the operation of signal boosters that will 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.[13]

The signal booster R&O creates 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 D01 and D02 for policies and procedures.

Consumer signal boosters are defined as devices that are marketed to and sold for personal use by individuals and are designed to be used "out of the box" by individuals to improve their wireless coverage within a limited area such as a home, car, boat, or recreational vehicle. Individuals 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. Wideband and provider-specific consumer signal boosters can be either fixed (intended for operation at a fixed location with the server antenna inside a building) or mobile (intended for operation while moving, e.g., in a vehicle or boat). [14]

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[13] FCC 13-21, *Report and Order In the Matter of 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, February 20, 2013.

[14] KDB Publication 935210 D01 Annex A provides other information about typical configurations.

The signal booster R&O introduces a network protection standard (NPS) that specifies 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 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 new 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 § 20.21. The NPS common requirements are specified in § 20.21(e)(1) to (e)(7), in § 20.21(e)(8) for wideband consumer signal boosters, and in § 20.21(e)(9) for provider-specific (frequency-selective) consumer signal boosters.

This KDB publication provides guidance with respect to acceptable measurement procedures for demonstrating wideband consumer signal booster compliance to the applicable requirements imposed by the NPS. Note that the guidance offered herein is not directly applicable to industrial signal boosters, including distributed antenna system (DAS) boosters. For similar compliance measurement guidance applicable to industrial signal boosters and provider-specific consumer signal boosters, see Attachments D02 and D04 of KDB Publication 935210, respectively.

For additional information regarding signal booster definitions and certification requirements, see also Attachments D01 and D02 included as a part of KDB Publication 935210.[15]

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 wideband consumer signal booster is compliant with the technical requirements specified by the NPS.

1.3 Approach

The measurement procedures provided in this document represent efforts by the RF Booster Task Group of the ANSI ASC C63® SC1 Wireless Working Group[16] to develop standardized measurement methodologies that can be applied to wideband 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 § 2.947(a)(3) of the FCC rules, but such alternative procedures must be approved by the FCC prior to use.

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[15] KDB Publication 935210, Attachments D01 Booster Definitions and D02 Certification Requirements.

[16] ANSI ASC C63® SC1 is abbreviation for American National Standards Institute Accredited Standards Committee C63®—Electromagnetic Compatibility, Subcommittee 1—Techniques and Development;

cf. (http://c63.org/index.htm).

1.4 Cross-references from KDB Publication 935210 D03 procedures to rule paragraphs

§ 20.21(e)(3) *Frequency Bands* § 20.21(a)(4) *Self-monitoring*	7.1 Authorized frequency band verification test
§ 20.21(e)(8)(i)(A) *Noise Limits* § 20.21(e)(8)(i)(H) *Transmit Power Off Mode*	7.7 Noise limits test procedure
§ 20.21(e)(8)(i)(B) *Bidirectional Capability* § 20.21(e)(3) *Frequency Bands*	7.13 Spectrum block filtering test procedure
§ 20.21(e)(8)(i)(C)(1) *Booster Gain Limits* § 20.21(e)(8)(i)(H) *Transmit Power Off Mode*	7.9 Variable booster gain test procedure
§ 20.21(e)(8)(i)(C)(2) *Booster Gain Limits* § 20.21(e)(8)(i)(B) *Bidirectional Capability*	7.3 Maximum booster gain computation
§ 20.21(e)(8)(i)(D) *Power Limits* § 20.21(e)(8)(i)(B) *Bidirectional Capability*	7.2 Maximum power measurement test procedure
§ 20.21(e)(8)(i)(E) *Out of Band Emission Limits*	7.5 Out-of-band emissions test procedure
§ 20.21(e)(8)(i)(F) *Intermodulation Limits*	7.4 Intermodulation product test procedure
§ 20.21(e)(8)(i)(G) *Booster Antenna Kitting*	[17]
§ 20.21(e)(8)(i)(H) *Transmit Power Off Mode*	[18]
§ 20.21(e)(8)(i)(I) *Uplink Inactivity*	7.8 Uplink inactivity test procedure
§ 20.21(e)(8)(ii)(A) *Anti-Oscillation*	7.11 Oscillation detection test procedure
§ 20.21(e)(8)(ii)(B) *Gain Control*	[19]
§ 20.21(e)(8)(ii)(C) *Interference Avoidance for Wireless Subsystems*	†
§ 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. Signal booster description

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 to the general public for use without modification.

The bidirectional operation of consumer signal boosters can introduce ambiguities with the use of traditional references to the RF input and output ports of the device since a single RF port can represent

[17] 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.

[18] 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.

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

both an RF input and output port (e.g., a downlink signal input and an uplink signal output). Thus, the RF ports of these bidirectional signal boosters are often referred to as the *donor* and *server* ports. 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 also 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 also transmits the amplified downlink signal received from a base station. For the case of 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 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.[20]

Annex A of this KDB publication provides a detailed summary of the frequency bands associated with each of the wireless services itemized above.

4. Other applicable rule parts

Most of the technical limits and requirements applicable to consumer signal boosters are specified within § 20.21. 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. Annex A provides a cross-reference to the applicable rule sections 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 § 2.911(b) the requirements specified in § 2.1033 are also applicable. Therefore, the measurement guidance provided herein also includes procedures for obtaining the data required per § 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

[20] *cf.* § 20.21(e)(3)

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,
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 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; and are referenced to the booster’s input port). This may require the use of an external linear amplifier.

a) Direct connect: 27 dBm,
b) Direct contact coupling (e.g., cradle-type): 23 dBm,
c) Mobile using inside antenna(s): 10 dBm,
d) Fixed using inside antenna(s): 0 dBm.

The maximum downlink input 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 utilizing 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 Annex A). All RF filters shall be rated for at least 1 W of input power.

5.9 RF cables and adapters

All RF cables and adapters used in the measurements described herein shall be rated for the appropriate frequency and power ranges and must be impedance-matched (VSWR ≤ 1.5:1) with respect to the booster under test.

6. Measurement configurations

6.1 Conducted measurements

The procedures provided in this KDB guidance document typically utilize 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 the ANSI C63.4 standard. When performing radiated tests, special care should be taken to ensure isolation of the EUT from any ambient CMRS signals.

7. Compliance measurement procedures (wideband 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 wideband 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

Rule paragraph(s): § 20.21(e)(3) *Frequency Bands*; § 20.21(a)(4) *Self-monitoring* (self-correct of shut down automatically for signals outside of subscriber-based services blocks).

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

a) Connect the EUT to the test equipment as shown in **Figure 1**. Begin with the uplink output connected to the spectrum analyzer.
b) Set the spectrum analyzer RBW for 100 kHz with the VBW ≥ 3 × the RBW using a PEAK detector with the MAX HOLD function.
c) Set the center frequency of the spectrum analyzer to the center of the operational band under test with a span of 1 MHz.
d) Set the signal generator for CW mode and tune to the center frequency of the operational band under test.
e) Set the initial signal generator power to a level that is at least 6 dB below the AGC level specified by the manufacturer.
f) Slowly increase the signal generator power level until the output signal reaches the AGC operational level.
g) Reduce the signal generator power to a level that is 3 dB below the level noted above and manually reset the EUT.
h) Reset the spectrum analyzer span to 2 × the CMRS band under test. Adjust the tuned frequency of the signal generator to sweep 2 × the CMRS band using the sweep function. The AGC must not be activated throughout the entire sweep.
i) Using three markers, identify the CMRS band edges and the frequency with the highest power. Affirm that the values of all markers are visible on the display of the spectrum analyzer (e.g., marker table set to on).
j) Capture the spectrum analyzer trace for inclusion in the test report.
k) Repeat 7.1c) to 7.1j) for all operational uplink and downlink bands.

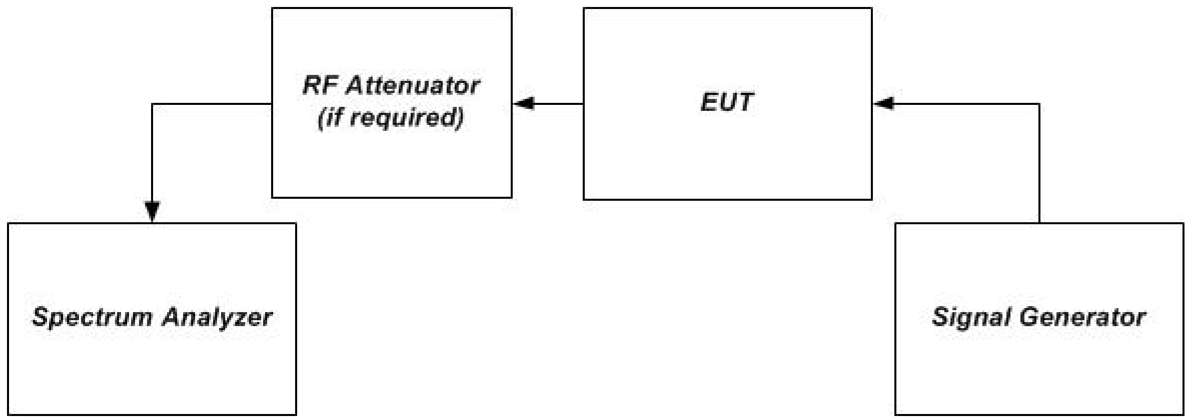

Figure 1 – Band verification test instrumentation setup

7.2 Maximum power measurement test procedure

7.2.1 General

Rule paragraph(s): § 20.21(e)(8)(i)(D) *Power Limits*; § 20.21(e)(8)(i)(B) *Bidirectional Capability* (uplink minimum conducted power output).

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

a) Compliance to authorized EIRP limits must be shown using the highest gains from the list of antennas, cabling, and coupling devices declared by the manufacturer for use with the consumer booster.
b) In addition, the maximum power levels measured in this procedure will be utilized in calculating the maximum gain as described in the next section.
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 utilizing the stated emission and power detector types independently.
d) Use a signal generator to create a pulsed CW or GSM signal with a pulse width of 570 μs and a duty cycle of 12.5% (i.e., one GSM timeslot), then measure utilizing the burst power function of the measuring instrument.
e) Use a signal generator to create an AWGN signal with a 99% occupied bandwidth of 4.1 MHz, then measure utilizing the channel power or band power function of the measuring instrumentation.
f) All modes of operation must be verified to maintain operation within authorized limits at the maximum uplink and downlink test levels per device type as defined in 5.4, by increasing the power level in 2 dB steps from the AGC level to the maximum input level specified in 5.4.

7.2.2 Procedure

a) Connect the EUT to the test equipment as shown in Figure 1. Begin with the uplink output (donor port) connected to the spectrum analyzer.
b) Configure the signal generator and spectrum analyzer for operation on the frequency determined in 7.1 with the highest power level, but with the center frequency of the signal no closer than 2.5 MHz from the band edge. The spectrum analyzer span shall be set to at least 10 MHz.

c) Set the initial signal generator power to a level well below that which causes AGC control.
d) Slowly increase the signal generator power level until the output signal reaches the AGC operational limit (from observation of signal behavior on the spectrum analyzer; i.e., no further increase in output power as input power is increased).
e) Reduce power sufficiently on the signal generator to ensure that the AGC is not controlling the power output.
f) Slowly increase the signal generator power to a level just below (within 0.5 dB of) the AGC limit 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 and 300 kHz for CW or GSM signal type.
    2) Set VBW ≥ 3 × RBW.
    3) Select either the BURST POWER or CHANNEL POWER measurement tool, as required for each signal type. The channel power integration bandwidth shall be 99% occupied bandwidth (4.1 MHz).
    4) Select the RMS (power averaging) detector.
    5) Ensure that the number of measurement points per sweep ≥ (2 × span)/RBW.
    Note: *This requirement does not apply for BURST power measurement mode.*
    6) Set sweep time = auto couple, or as necessary (but no less than auto couple value).
    7) Trace average at least 100 traces in power averaging (i.e., RMS) mode.
h) Record the measured power level as $P_{\mathbf{OUT}}$ with one set of results for the GSM or CW input stimulus and another set of results for the AWGN input stimulus.
i) Repeat step h) while increasing the signal generator amplitude in 2 dB steps until the maximum input level indicated in 5.4 is reached. If the booster has shut down at any point during the input power steps it should be noted and step h) shall be repeated at an input level 1 dB less than that found to cause the shutdown.
j) Repeat the entire procedure for each operational uplink and downlink frequency band supported by the booster.
k) Provide tabulated results in the test report.

7.3 Maximum booster gain computation

Rule paragraph(s): § 20.21(e)(8)(i)(C)(2) *Booster Gain Limits* (maximum gain); § 20.21(e)(8)(i)(B) *Bidirectional Capability* (equivalent uplink and downlink gain).

This subclause provides guidance on the computation of the maximum gain based on the results obtained from previous measurements. The NPS limits on maximum gain for fixed and mobile wideband consumer signal boosters are provided in § 20.21(e)(8)(i)(C)(*2*). Additionally, § 20.21(e)(8)(i)(B) requires that wideband consumer signal boosters be able to provide equivalent uplink and downlink gain (within 9 dB).[21]

a) Calculate the maximum gain of the booster as follows to demonstrate compliance to the applicable gain limits as specified.

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

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

7.4 Intermodulation product test procedure

Rule paragraph(s): § 20.21(e)(8)(i)(F) *Intermodulation Limits.*

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

a) Connect the signal booster to the test equipment as shown in Figure 2. Begin with the uplink output connected to the spectrum analyzer.
b) Set the spectrum analyzer RBW = 3 kHz.
c) Set the VBW ≥ 3 × RBW.
d) Select the RMS detector.
e) Set the spectrum analyzer center frequency to the center of the supported operational band under test.
f) Set the span to 5 MHz. Affirm that the number of measurement points per sweep ≥ (2 × span)/RBW.
g) Configure the two signal generators for CW operation with generator 1 tuned 300 kHz below the operational band center frequency and generator 2 tuned 300 kHz above the operational band center frequency.
h) Set the signal generator amplitudes so that the power from each into the RF combiner is equivalent, then turn on the RF output.
i) Increase the signal generators' amplitudes equally until just before the EUT begins AGC and affirm that all intermodulation products (if any exist) are below the specified limit of −19 dBm.
j) Utilize the trace averaging 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) Repeat 7.4e) to 7.4l) for all uplink and downlink operational bands.
   Note: *If using a single signal generator with dual outputs, affirm that intermodulation products are not the result of the generator.*
n) Increase the signal generator amplitude in 2 dB steps to 10 dB above the AGC threshold determined in 7.4i), but to not to exceed the maximum input level in 5.4, to affirm that the EUT maintains compliance with the intermodulation limit.

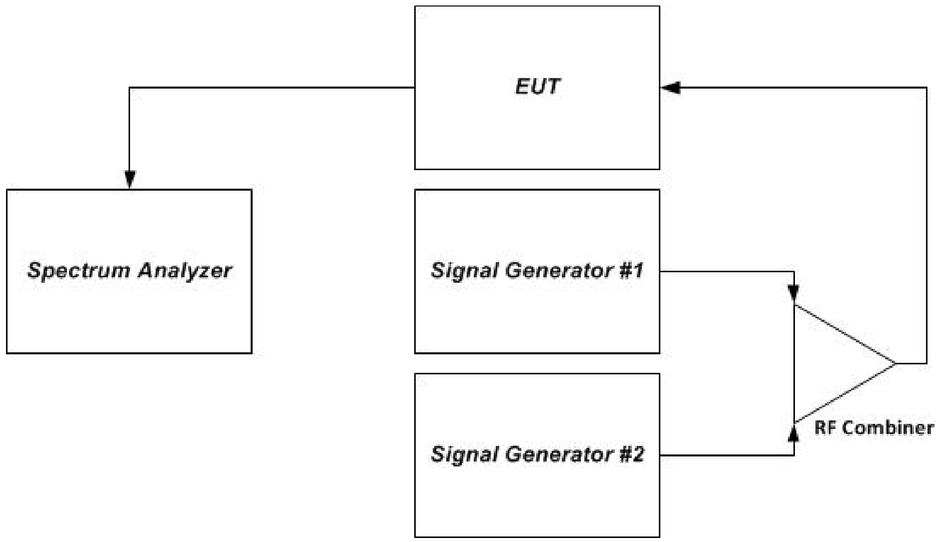

Figure 2 – Intermodulation product instrumentation test setup

7.5 Out-of-band emissions test procedure

Rule paragraph(s): § 20.21(e)(8)(i)(E) *Out of Band Emission Limits.*

This measurement is intended to demonstrate compliance to the limit specified in § 20.21(e)(8)(i)(E). The mobile emission limit applicable to the supported band of operation can be determined from the applicable rule part as listed in Annex A for each authorized operating band.

a) Connect the EUT to the test equipment as shown in **Figure 1**. Begin with the uplink output connected to the spectrum analyzer.
b) Configure the signal generator for the appropriate operation for all uplink and downlink bands:
   i) GSM: 0.2 MHz from upper and lower band edges.
   ii) LTE (5 MHz): 2.5 MHz from upper and lower band edges.
   iii) CDMA: 1.25 MHz from upper and lower band edges, except for cellular band as follows (only the upper and lower frequencies need to be tested):
   824.88 MHz, 845.73 MHz, 836.52 MHz, 848.10 MHz, 869.88 MHz, 890.73 MHz, 881.52 MHz, 893.10 MHz.

   Note 1: *Alternative test modulation types:*
   - CDMA (alternative 1.25 MHz AWGN)
   - LTE 5 MHz (alternative W-CDMA or 4.1 MHz AWGN)

   Note 2: *For LTE, the signal generator should utilize the uplink and downlink signal types for these modulations in uplink and downlink tests, respectively. LTE shall use 5 MHz signal, 25 resource blocks transmitting.*

   Note 3: *When using an AWGN test signal, the bandwidth shall be the measured 99% occupied bandwidth.*
   c) Set the signal generator amplitude to the maximum power level prior to AGC similar to the procedures in 7.2.2e) to 7.2.2f) of power measurement procedure for appropriate modulations.
d) Set RBW = measurement bandwidth specified in the applicable rule section for the supported frequency band (*see Annex A for cross-reference to applicable rule section*).

e) Set VBW = 3 × RBW.
f) Select the RMS (power averaging) detector.
g) Sweep time = auto-couple.
h) Set the analyzer start frequency to the upper band/block edge frequency and the stop frequency to the upper band/block edge frequency plus 300 kHz (when operational frequency is < 1 GHz) or 3 MHz (when operational frequency is ≥ 1 GHz).
i) Trace average at least 100 traces in power averaging (i.e., RMS) mode.
j) Use peak marker function to find the maximum power level.
k) Capture the spectrum analyzer trace of the power level for inclusion in the test report.
l) Increase the signal generator amplitude in 2 dB steps until the maximum input level indicated in 5.4 is reached. Affirm that the EUT maintains compliance with the OOBE limits.
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 and repeat 7.5j) 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): § 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 § 2.1051.

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

a) Connect the EUT to the test equipment as shown in **Figure 1**. Begin with the uplink output connected to the spectrum analyzer.
b) Configure the signal generator for AWGN with a 99% occupied bandwidth of 4.1 MHz with a center frequency corresponding to the center of the CMRS band under test.
c) Set the signal generator amplitude to the level determined in the power measurement procedure in 7.2.
d) Turn on the signal generator RF output and measure the spurious emission power levels with an appropriate measurement instrument as follows.
    1) Set RBW = measurement bandwidth specified in the applicable rule section for the operational frequency band under consideration (see Annex 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) 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 start and stop frequencies above be subdivided, depending on the available number of measurement points provided by the spectrum analyzer. Trace average at least 10 traces in power averaging (i.e., 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 × the highest frequency of the fundamental emission. Note that the number of measurement points in each sweep must be ≥ (2 × span/RBW) which may require that the measurement range defined by the start and stop frequencies above be subdivided, depending on the available number of measurement points provided by the spectrum analyzer.
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): § 20.21(e)(8)(i)(A) *Noise Limits*; § 20.21(e)(8)(i)(H) *Transmit Power Off Mode* (uplink and downlink noise power).

7.7.1 Maximum transmitter noise power level

a) Connect the EUT to the test equipment as shown in **Figure 3**. Begin with the uplink output connected to the spectrum analyzer. When measuring downlink noise, connect the downlink output to the spectrum analyzer.
b) Set the spectrum analyzer RBW to 1 MHz with the VBW ≥ 3 × RBW.
c) Select the power averaging (RMS) detector and trace average over at least 100 traces.
d) Set the center frequency of the spectrum analyzer to the center of the CMRS band under test with the span ≥ 2 × the CMRS band.
e) Measure the maximum transmitter noise power level.
f) Save the spectrum analyzer plot as necessary for inclusion in the final test report.
g) Repeat 7.7b) to 7.7f) for all operational uplink and downlink bands.
h) Connect the EUT to the test equipment as shown in **Figure 4** for uplink and **Figure 5** for downlink. Affirm the coupled path of the RF coupler is connected to the spectrum analyzer.
i) Configure the signal generator for 4.1 MHz AWGN operation.
j) Set the spectrum analyzer RBW for 1 MHz with the VBW ≥ 3 × RBW with a power averaging (rms) detector with at least 100 trace averages.

k) Set the center frequency of the spectrum analyzer to the center of the CMRS band under test with the span ≥ 2 × the CMRS band. This shall include all spectrum blocks in the particular CMRS band under test (see Annex A).
    i) 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.
    ii) For downlink noise measurements, set the spectrum analyzer center frequency 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.
l) Measure the maximum transmitter noise power level when varying the downlink signal generator output level from −90 dBm to −20 dBm, as measured at the input port, in 1 dB steps inside the RSSI-dependent region and in 10 dB steps outside the RSSI-dependent region. Report the six values closest to the limit with at least two points within the RSSI-dependent region of the limit. See noise limit in Annex D.
m) Repeat 7.7.1h) through 7.7.1l) for all operational uplink and downlink bands.

7.7.2 Variable uplink noise timing

Variable uplink noise timing is to 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 power level of signal generator 1 to the lowest level of the RSSI-dependent noise.
d) Select MAX HOLD and increase the power level of signal generator 1 by 10 dB for mobile boosters and 20 dB for fixed boosters.
e) Confirm that the uplink noise decreases to the specified level within 1 second for mobile devices and 3 seconds for fixed devices.[22]
f) Repeat 7.7.2a) to 7.7.2e) for all operational uplink and downlink bands.
g) Include plots and summary table in test report.

Note: *Some signal boosters will require a signal generator input because they will not operate unless a signal is received at the input terminals. If this is the case, connect a second signal generator and cycle the RF output to simulate this function.*

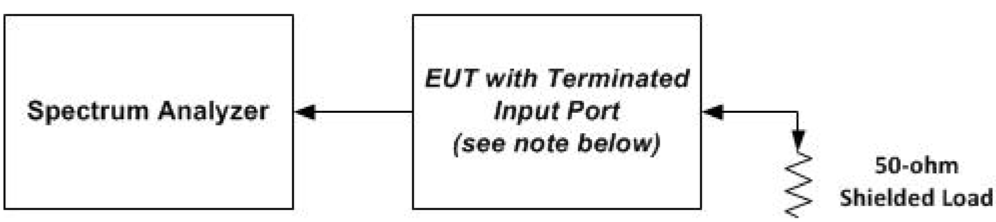

Figure 3 – Noise limit instrumentation test setup

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

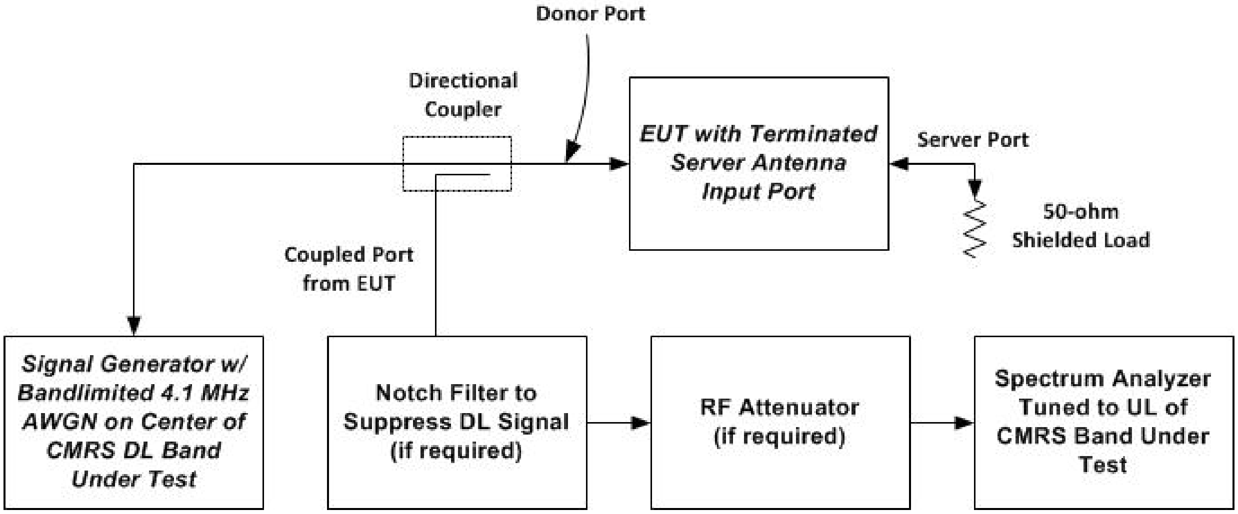

Figure 4 – Test setup for uplink noise power measurement in the presence of a downlink signal

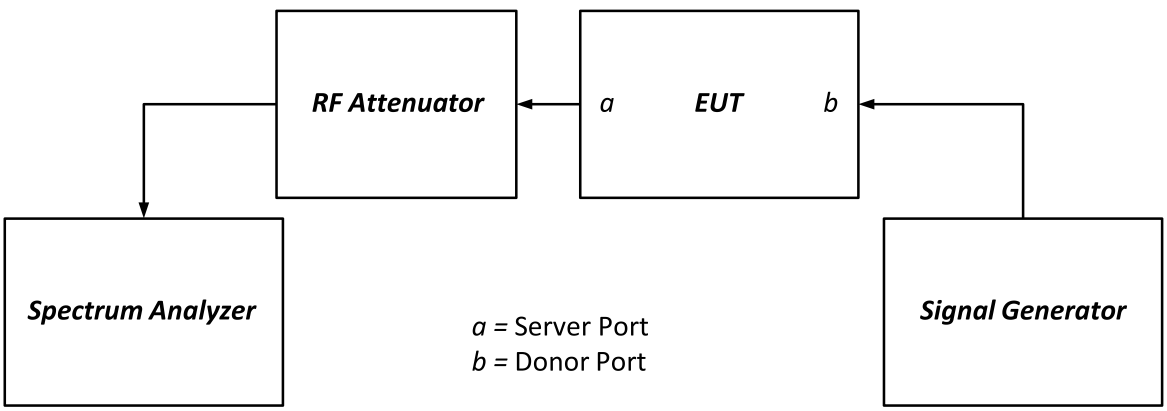

Figure 5 – Test setup for downlink noise power measurement in the presence of a downlink signal

7.8 Uplink inactivity test procedure

Rule paragraph(s): § 20.21(e)(8)(i)(I) *Uplink Inactivity*.

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

a) Connect the EUT to the test equipment as shown in **Figure 3** with the uplink output connected to the spectrum analyzer.
b) Select the RMS power averaging detector.
c) Set the spectrum analyzer RBW for 1 MHz with the VBW ≥ 3 × RBW.
d) Set the center frequency of the spectrum analyzer to the center of the uplink operational band.

e) Set the span for 0 Hz with a single sweep time for a minimum of 330 seconds.
f) Start to capture a new trace using MAX HOLD.
g) After approximately 15 seconds turn on the EUT power.
h) Once the full spectrum analyzer trace is complete place a MARKER on the leading edge of the pulse and use the DELTA MARKER METHOD to measure the time until the uplink becomes inactive.
i) Affirm that the noise level for the squelched signal is below the uplink inactivity noise power limit, as specified by the rules.
j) Capture the plot for inclusion in the test report.
k) Measure noise using procedures in 7.7.1a) to 7.7.1e).
l) Repeat 7.8d) through 7.8k) for all operational uplink bands.

Note: *Some signal boosters will require a signal generator input because they will not operate unless a signal is received at the input terminals. If this is the case, connect a signal generator and cycle the RF output to simulate this function.*

7.9 Variable booster gain test procedure

Rule paragraph(s): § 20.21(e)(8)(i)(C)(1) *Booster Gain Limits* (variable gain); § 20.21(e)(8)(i)(H) *Transmit Power Off Mode* (uplink gain).

7.9.1 Maximum gain

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

a) Connect the EUT to the test equipment as shown in **Figure 6** with the uplink output connected to signal generator 1, and in Figure 18 for downlink gain measurements. Confirm that the coupled path of the RF coupler is connected to the spectrum analyzer.
b) Configure downlink signal generator 1 for AWGN operation with a 99% occupied bandwidth of 4.1 MHz tuned to the center of the operational band.
c) Set the power level and frequency of signal generator 2 to a value 5 dB below the AGC level determined from 7.2. The signal type is AWGN with a 99% OBW of 4.1 MHz.
d) Set RBW = 100 kHz.
e) Set VBW ≥ 300 kHz.
f) Select the CHANNEL POWER measurement mode.
g) Select the RMS (power averaging) detector.
h) Ensure that the number of measurement points per sweep ≥ (2 × span)/RBW.
i) Sweep time = auto couple or as necessary (but no less than auto couple value).
j) Trace average at least 10 traces in power averaging (i.e., RMS) mode.
k) Measure the maximum channel power and compute maximum gain when varying the signal generator 1 output to a level from −90 dBm to −20 dBm as measured at the input port in 1 dB steps inside the RSSI-dependent region and 10 dB steps outside the RSSI-dependent region and report the six values closest to the limit, including at least two points from within the RSSI-dependent region of operation. See gain limit in charts in Annex D for uplink gain requirements. Additionally, document

that the EUT provides equivalent uplink and downlink gain, and when operating in shutoff mode the uplink and downlink gain is within the transmit power off mode gain limits.

l) Repeat 7.9.1c) to 7.9.1k) for all operational uplink bands.

7.9.2 Variable uplink gain timing

Variable uplink gain timing is to 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 power level of signal generator 1 to the lowest level of the RSSI-dependent gain.
d) Select MAX HOLD and increase the power level of signal generator 1 by 10 dB for mobile boosters and 20 dB for fixed indoor boosters. Signal generator 2 remains same, as described in 7.9.1c).
e) Confirm that the uplink gain decreases to the specified levels within 1 second for mobile devices and 3 seconds for fixed devices.[23]
f) Repeat 7.9.2a) to 7.9.2e) for all operational uplink bands.

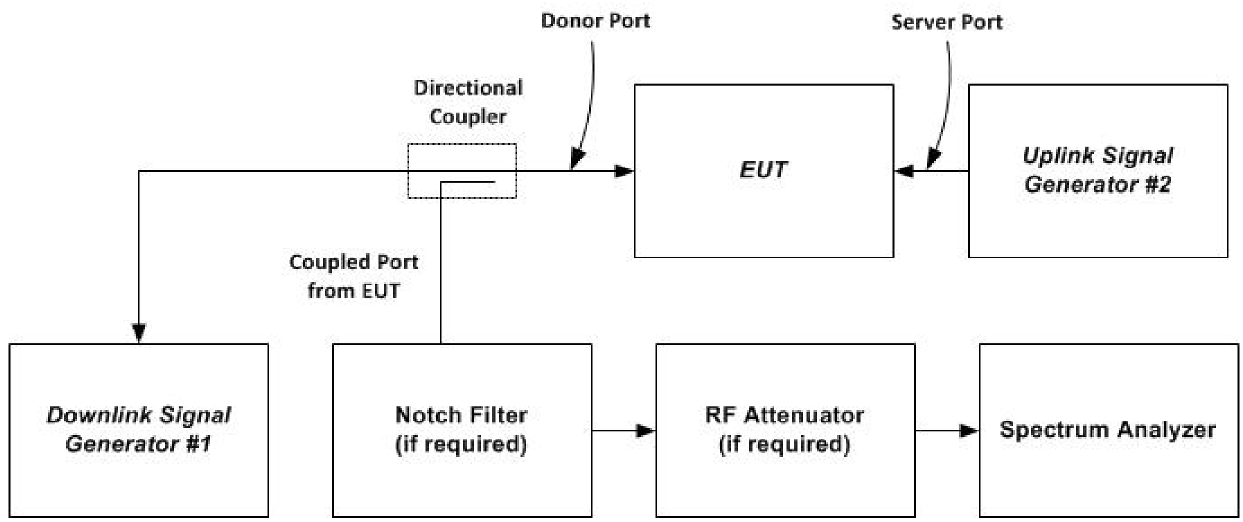

Figure 6 – Variable gain instrumentation test setup

7.10 Occupied bandwidth test procedure

Rule paragraph(s): § 2.1049 *Measurements required: Occupied bandwidth.*

This measurement is required to compare the uniformity of the output signal relative to the input signal and to satisfy the requirements of § 2.1049.

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

a) Connect the test equipment as shown in **Figure 7** to measure the characteristics of the test signals produced by the signal generator.
b) Set VBW to ≥ 3 × RBW.
c) Set the center frequency of the spectrum analyzer to the center of the operational band. The span will be adjusted for each modulation type and occupied bandwidth as necessary for accurately viewing the signals.
d) Set the signal generator for power level to match the values obtained in 7.2.
e) Set the signal generator modulation type for GSM with a PRBS pattern and allow the trace on the signal generator to stabilize adjusting the span as necessary.
f) Set the spectrum analyzer RBW for 1% to 5% of the emissions bandwidth.
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**. Begin with the uplink output connected to the spectrum analyzer.
j) Repeat 7.10c) to 7.10h) in this new configuration.

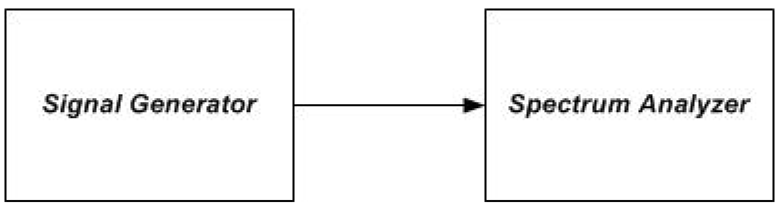

Figure 7 – Occupied bandwidth instrumentation test setup

7.11 Oscillation testing procedures

Rule paragraph(s): § 20.21(e)(8)(ii)(A) *Anti-Oscillation.*

7.11.1 General

For this measurement two EUTs will be permitted, one operating in a normal mode and the second operating in a test mode that is capable of disabling the uplink inactivity squelching and or a reduction of the time between restarts to 5 seconds. This will greatly decrease the test time required.

NOTE — Consumer boosters certified as direct connection mobile boosters having less than or equal to 15 dB are exempt from compliance to testing procedures in sections 7.11.2 and 7.11.3.

7.11.2 Oscillation restart tests

a) Connect the EUT set for normal operation to the test equipment as shown in **Figure 8** beginning with the spectrum analyzer on the uplink output side of the RF path. Confirm that the RF coupled path is connected to the spectrum analyzer.
Note: *The band pass filter shall provide sufficient out-of-band rejection to prevent oscillations from occurring in bands not under test.*

b) Set the spectrum analyzer’s center frequency to the center of the band under test. Set the spectrum analyzer’s span to equal or slightly exceed the width of the band under test. Set the spectrum analyzer for a continuous sweep, max-hold. Set the spectrum analyzer’s RBW ≥ 1 MHz and the VBW > 3 × RBW.
c) Decrease the variable attenuator until the spectrum analyzer displays a signal within the band under test. Using a marker, identify the approximate center frequency of this signal on the max-hold display, then increase the attenuation by 10 dB. Reset the EUT.
d) Repeat 7.11.2c) twice to ensure that the center of the signal created by the booster remains within 250 kHz of the spectrum analyzer’s center frequency. If the frequency of the signal is unstable, confirm that the spectrum analyzer display is centered between the frequency extremes observed. If the signal is wider than 1 MHz, ensure that the spectrum analyzer display is centered on the signal by increasing the resolution bandwidth. Reset the EUT after each oscillation event if necessary. Set the spectrum analyzer’s sweep trigger level such that it’s just below the peak amplitude of the displayed oscillation signal from the EUT.
e) Set the spectrum analyzer to zero-span with a sweep time of 5 seconds, single-sweep with max-hold. The spectrum analyzer’s sweep trigger level in this and subsequent steps shall be the level identified in 7.11.2d).
f) Decrease the variable attenuator until the spectrum analyzer’s sweep is triggered, then increase the attenuation 10 dB. Reset the EUT.
g) Reset the zero-span trigger of the spectrum analyzer and repeat 7.11.2f) twice to ensure that the spectrum analyzer is reliably triggered, resetting the EUT after each oscillation event if necessary.
h) Reset the zero-span sweep trigger of the spectrum analyzer and reset the EUT with a power cycle.
i) Force the EUT to oscillate by reducing the attenuation.
j) Use the marker function of the spectrum analyzer to measure the time from the on-set of oscillation until the EUT turns off by setting Marker 1 on the leading edge of the oscillation signal and Marker 2 on the trailing edge. The spectrum analyzer’s sweep time may be altered to improve the time resolution of these cursors.
k) Capture the spectrum analyzer’s zero-span trace for inclusion in the test report. Report the power level associated with the oscillation (separately if it can’t be displayed on the trace).
l) Repeat 7.11.2b) to 7.11.2k) for all operational uplink and downlink bands.
m) Set the spectrum analyzer’s zero-span sweep time for longer than 60 seconds and measure the restart time for each operational uplink and downlink band.
n) Replace the normal operating EUT for the EUT set-up to support an anti-oscillation test mode.
o) Set the spectrum analyzer’s zero-span time for a minimum of 120 seconds and a single sweep.
p) Manually trigger the spectrum analyzer’s zero-span sweep and manually force the booster into oscillation as described in 7.11.2i).
q) When the sweep is complete place cursors between the first two oscillation detections and save the plot for inclusion in the test report. The time between restarts must match the manufacturer’s timing for the test mode and there can be no more than 5 restarts.
r) Repeat 7.11.2m) to 7.11,2q) for all operational uplink and downlink bands.

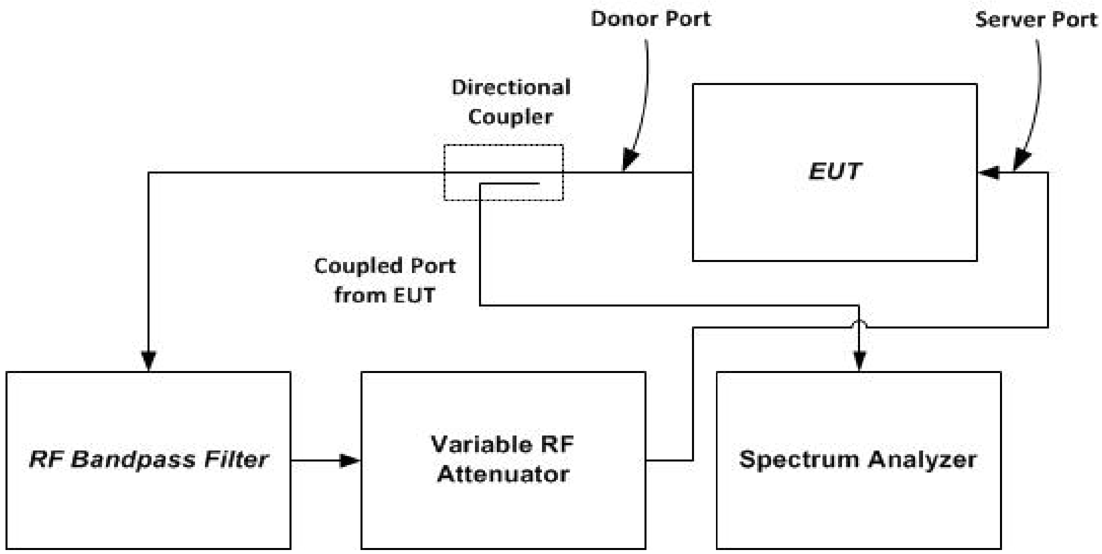

Figure 8 – Oscillation detection instrumentation test setup

7.11.3 Test procedure for measuring oscillation mitigation or shutdown

a) Connect the EUT set for normal operation to the test equipment as shown in **Figure 9**.

b) Set the spectrum analyzer center frequency to the center of band under test, and use the following settings: Set RBW=30 kHz, VBW ≥ 3 × RBW, rms detector, trace averages ≥ 100, span ≥ 120% of operational band under test, number of sweep points ≥ 2 × Span/RBW.

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

c) Configure signal generator for AWGN operation with 99 % occupied bandwidth of 4.1 MHz tuned to the frequency of 2.5 MHz above the lower edge or below the upper edge of the operating band under test. Adjust the RF output level of the signal generator; such that the measured power level of the AWGN signals at the output port of the booster is 30 dB less than the maximum power of the booster for the band under test. 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 in the measurement.

NOTE—Boosters with spectrum bandwidths of 10 MHz or less may use a CW signal source at the band edge instead of AWGN. Standard CMRS signal sources (i.e., CDMA, WCDMA, LTE) may be used instead of AWGN at the band edge.

d) Set the variable attenuator with a high attenuation setting such that the booster will operate at maximum gain when powered on. Reset the power on the EUT. Allow the EUT to complete its booting process, reach full operational gain, and stabilize its operation.

e) Set the variable attenuator such that the insertion loss for center of band under test (isolation) between the booster's donor and server ports is 5 dB greater than the maximum gain, as recorded in the maximum gain test procedure, for the band under test.
f) Verify the EUT shuts down, to mitigate the oscillations. For boosters that do 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's center frequency to the frequency of the highest oscillation level, and reduce the span such that the upper and lower adjacent oscillation peaks are within the span.
   4) Use the Minimum Search Marker function to find the lowest output level that is within the span, and within the operational band under test, and record its output level and frequency.
   5) Affirm that the peak oscillation level, as measured in step 2) above, does not exceed the minimal output level, as measured in step 7.11.3f)4), by 12.0 dB. Record measurement results of step 7.11.3f)2) and step 7.11.3f)4) in tabular format for inclusion in the test report.

g) Decrease the variable attenuator in 1 dB steps, and repeat step 7.11.3f) for each 1 dB step. Continue testing to the level when the insertion loss for center of band under test (isolation) between the booster's donor and server ports is 5 dB lower than the maximum gain.
h) Repeat 7.11.3a) to 7.11.3g) for all operational uplink and downlink bands.

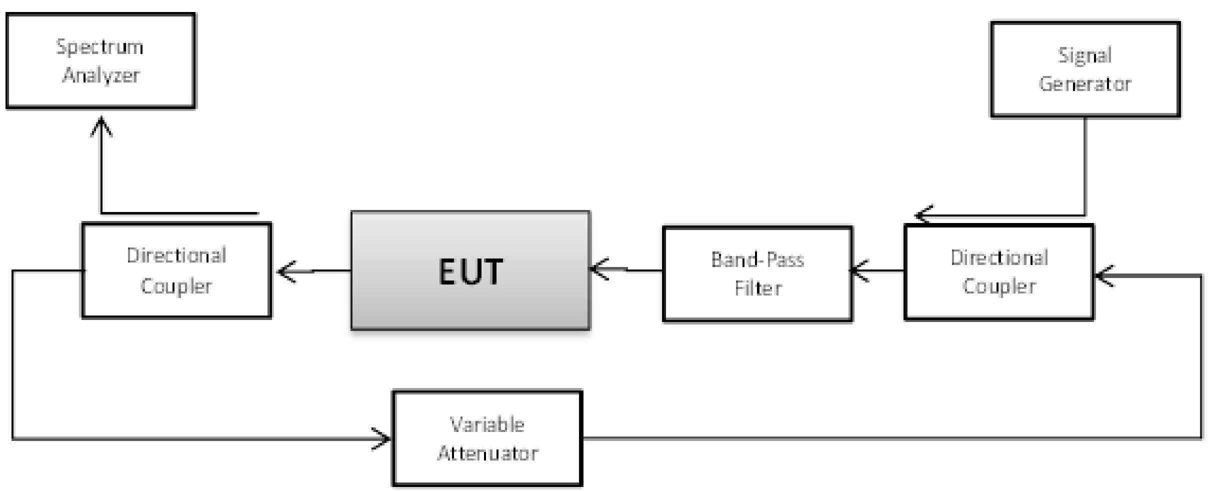

Figure 9 – Oscillation mitigation/shutdown test setup.

7.11.4 Alternate test procedure for measuring oscillation mitigation or shutdown

NOTE — This is an alternate procedure for measuring oscillation mitigation or shutdown, and may be used in lieu of the procedure provided in section 7.11.3.

a) Connect the EUT set for normal operation to the test equipment as shown in **Figure 10**, using a band pass filter for the downlink band under test.
b) Set spectrum analyzer #1 to the center frequency of the CMRS downlink band under test, and use the following settings: Set RBW=1 MHz, VBW ≥ 3 × RBW, rms detector, trace averages ≥ 100,

span ≥ 120% of operational band under test, number of sweep points ≥ 2 × Span/RBW. Set spectrum analyzer #2 to the center frequency of the CMRS uplink band under test, and use the following settings: Set RBW=1 MHz, VBW ≥ 3 × RBW, rms detector, trace averages ≥ 100, span ≥ 120% of operational band under test, number of sweep points ≥ 2 × Span/RBW.

c) Configure signal generator for AWGN operation with 99 % occupied bandwidth of 4.1 MHz tuned to the frequency of 2.5 MHz above the lower edge or below the upper edge of the CMRS downlink band under test. Adjust the RF output level of the signal generator such that the measured power level of the AWGN signal at the output port of the booster is 30 dB less than the maximum power of the booster for the downlink band under test. Confirm that the input signal is not obstructing the measurement of the maximum noise power level in the downlink band under test.

   NOTE—Boosters with spectrum bandwidths of 10 MHz or less may use a CW signal source at band edge instead of AWGN.

d) Set the variable attenuator with a high attenuation setting such that the booster will operate at maximum gain when powered on. Reset the power on the EUT. Allow the EUT to complete its booting process, reach full operational gain, and stabilize its operation.

e) Set the variable attenuator such that the total insertion loss (e.g. the total feedback loop loss introduced by the variable attenuator and all associated cables, connectors, etc.) at the center of the downlink band under test is 5 dB greater than the booster's maximum downlink gain, as recorded in the maximum gain test procedure, for the downlink band under test. Reset the power on the EUT.

f) Verify the EUT shuts down on the downlink and uplink bands under test on spectrum analyzer #1 and #2, respectively. Measure the maximum transmitter noise power level and verify it meets the transmit power off mode limits for uplink and downlink bands. Save the spectrum analyzer traces for inclusion in the report.

   NOTE—EUT may use a test mode that is capable of disabling the uplink inactivity squelching, or the test operator must verify the uplink measurements are not impacted by uplink inactivity squelching.

g) Confirm the EUT's uplink gain is 4 to 9 dB less than the downlink gain for each operational band supported by the booster. Compliance to this requirement must be demonstrated using test procedures in section 7.3.5 and 7.3.11.1, for the maximum gain and variable gain measurements including results measured in 1 dB steps within the RSSI-dependent region, respectively.

h) Repeat a) to g) for all operational bands.

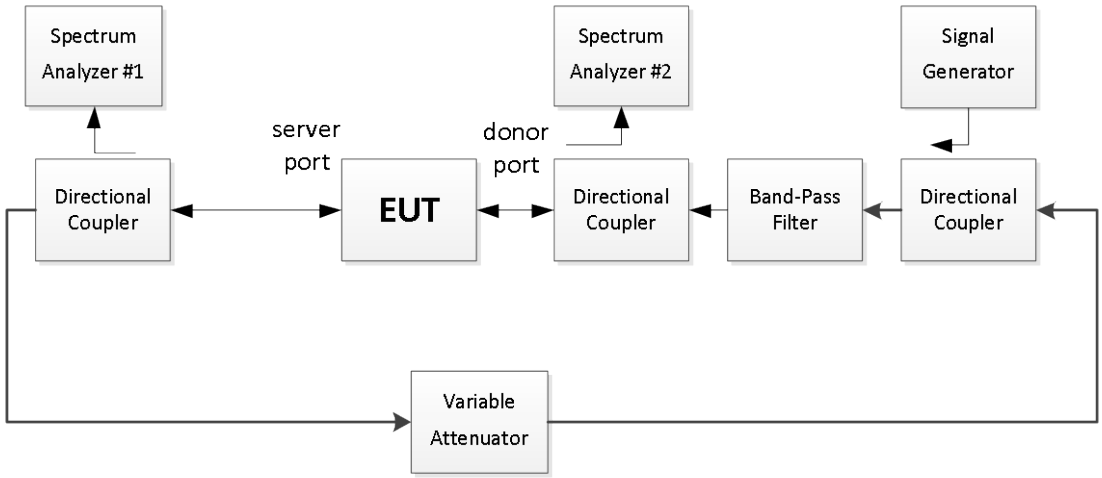

Figure 10 – Alternative oscillation mitigation/shutdown test setup.

7.12 Radiated spurious emissions test procedure

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

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

a) Place the EUT on an OATS or semi-anechoic chamber turntable 3 m from the receiving antenna. [24]
b) Connect the EUT to the test equipment as shown in **Figure 11** beginning with the uplink output.
c) Set the signal generator to produce a CW signal with the frequency set to the center of the operational band under test and the power level set at P_{IN} as determined from 7.2.
d) Measure the radiated spurious emissions from the EUT from lowest to the highest frequencies as specified in § 2.1057. Maximize the radiated emissions by utilizing the procedures described in Clause 8 of ANSI C63.4-2009.
e) Capture the peak emissions plots using a peak detector with Max-Hold for inclusion in the test report. Tabular data is acceptable in lieu of spectrum analyzer plots.
f) Repeat 7.12c) through 7.12e) for all operational bands.

[24] Radiated emissions tests shall performed in accordance with the procedure in ANSI C63.4-2014. See for example 5.6 of KDB Publication 971168 about conversion of field strength to ERP and EIRP, or KDB Publication 412172.

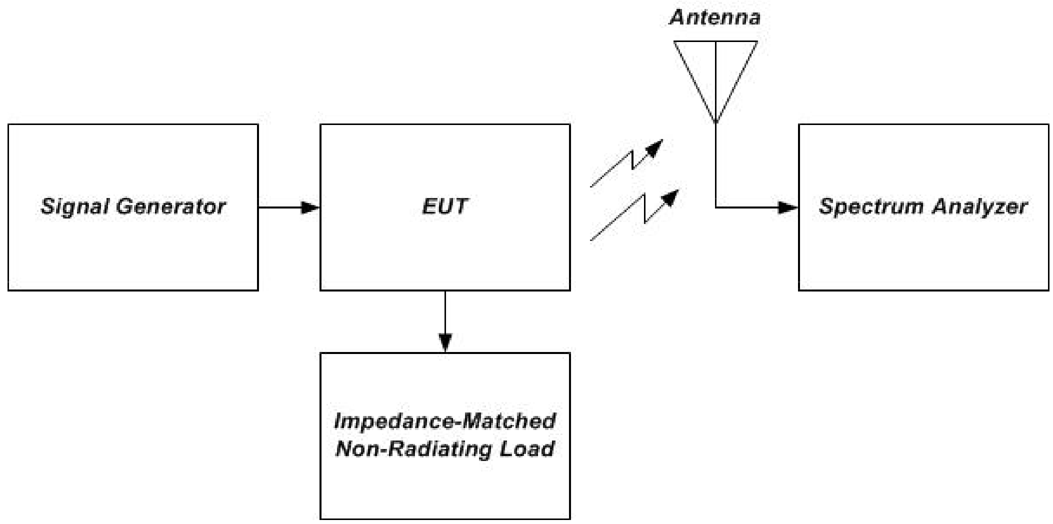

Figure 11 – Radiated spurious emissions test instrumentation setup

7.13 Spectrum block filtering test procedure

Rule paragraph(s): § 20.21(e)(8)(i)(B); § 20.21(e)(3).

The following procedures are required only for wideband consumer boosters utilizing spectrum block filtering.[25]

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. Use procedures in 7.1 for this comparison, with the trace data measurement points normalized for the uplink and downlink frequency bands.[26] If there are non-compliant measurement points for specific frequencies, use procedures in 7.13b) and 7.13c) for determining compliance.
b) For any non-compliant frequencies within filtered spectrum blocks within the CMRS band under test, verify the uplink transmitted noise power level within the filtered spectrum blocks does not exceed authorized limits. Use procedures in 7.7.1h) to 7.7.1l) to measure the uplink noise power level within each 5 MHz of paired spectrum that are within the filtered spectrum blocks that are not-compliant with 7.13a). Set the signal generator and spectrum analyzer to the center of each 5 MHz of paired

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[25] 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).

[26] 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).

spectrum within the filtered spectrum blocks that are not-compliant with 7.13a). Repeat test for all 5 MHz of paired spectrum within the filtered spectrum blocks that are not-compliant with 7.13a).[27]

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 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 levels, as measured in 7.7.1 to 7.7.6, that do not exceed the uplink noise power limit specified for Transmitter Power Off Mode, will satisfy the requirements of 7.13b).*

c) For any non-compliant frequencies within filtered spectrum blocks within the CMRS band under test, verify the uplink gain within the filtered spectrum blocks does not exceed authorized limits. Use procedures in 7.9.1a) to 7.9.1l) to measure the uplink gain within the filtered spectrum blocks, using signal generator 1 and signal generator 2 set to the center of each 5 MHz of paired spectrum within the filtered spectrum blocks that are not-compliant with 7.13a). Repeat test for all 5 MHz of paired spectrum within the filtered spectrum blocks that are not-compliant with 7.13a).

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 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 7.13c).*

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[27] For example, a wideband consumer booster with spectrum block filtering for the AWS-1 F Block showing non-compliance in 7.13a) 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 7.13.1). 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.

ANNEX A

Consumer Signal Booster Authorized Frequency Bands per § 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.

ANNEX 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.[28] MSCL must be calculated or measured for each band of operation and provided in compliance test reports.[29] 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 authorized 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 § 20.21(e)(8)(i)(G).

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)[30] 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[31] as follows:

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

where:

L_P = basic free space path loss,
f = frequency in MHz,

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[28] § 20.21(e)(8)(i)(C)(*1*)(*ii*).

[29] *Id*.

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

[31] See for example KDB Publication 412172.

d = separation distance in meters.

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., 3 feet to 5 feet 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, or mobile with inside antenna, consumer booster applications. For example, the following antenna types and minimum separation distances are considered for fixed indoor server antenna types:

B5.1 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).

B5.2 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.

B5.3 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 utilize 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 (i.e., cup holders) within the vehicle.

ANNEX 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) **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.

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

4) **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.

5) **Consumer signal booster:** a bidirectional signal booster that is marketed and sold to the general public 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.

6) **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.

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

8) **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.

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

10) **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.

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

12) **Mobile consumer signal booster:** A consumer signal booster designed to operate in a moving vehicle where both uplink and downlink transmitting antennas are at least 20 cm from the user or any other person.

13) **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.

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

15) **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).

16) **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.

17) **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.

18) **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.

19) 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.

20) **Received signal strength indication (RSSI) for wideband consumer boosters:** The downlink composite received signal power in dBm, 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 § 20.21(e)(8)(i)(A)(*1*) and gain limits in § 20.21(e)(8)(i)(C)(*1*).

21) **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.

22) **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.

23) **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).

24) **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.

25) **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).

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

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

ANNEX D
Wideband Consumer Booster Noise and Gain Limits Charts

These charts illustrate the wideband consumer booster noise, gain and transmit power off mode limits pursuant to §§ 20.21(e)(8)(i)(A), 20.21(e)(8)(i)(C), and 20.21(e)(8)(i)(H), respectively. The noise limits chart show the consumer booster transmitted noise power limits at various RSSI levels, and gain limits charts show the fixed and mobile consumer booster gain limits at various RSSI levels for sample MSCL values.

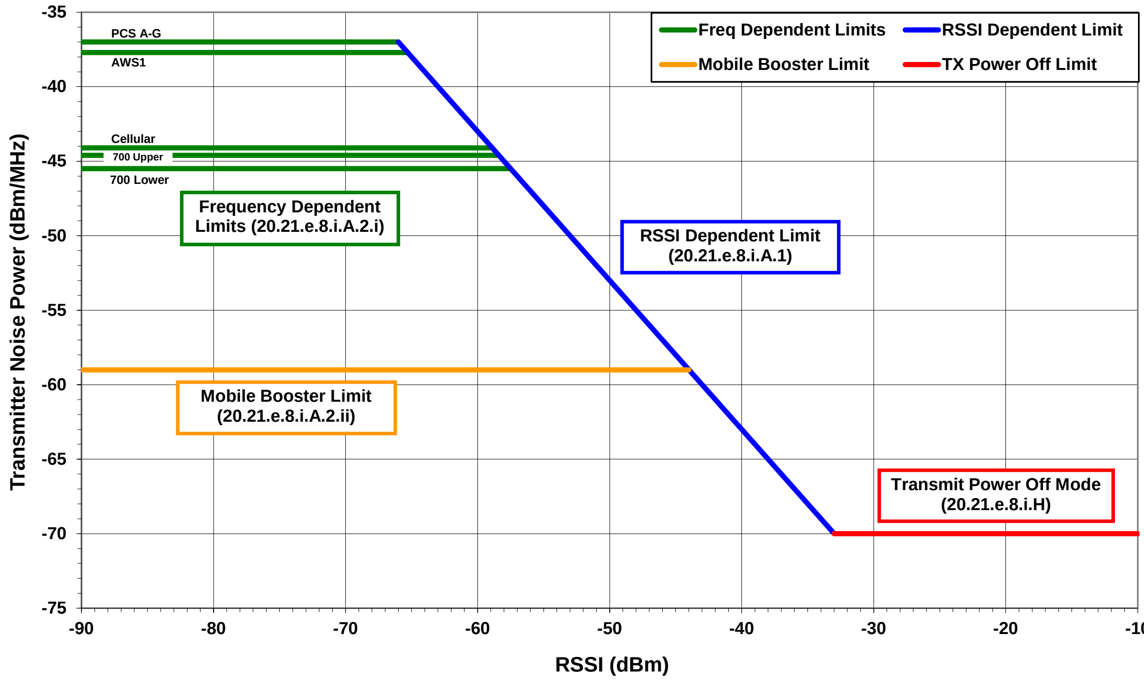

Figure D1. Wideband consumer signal booster variable noise limits.

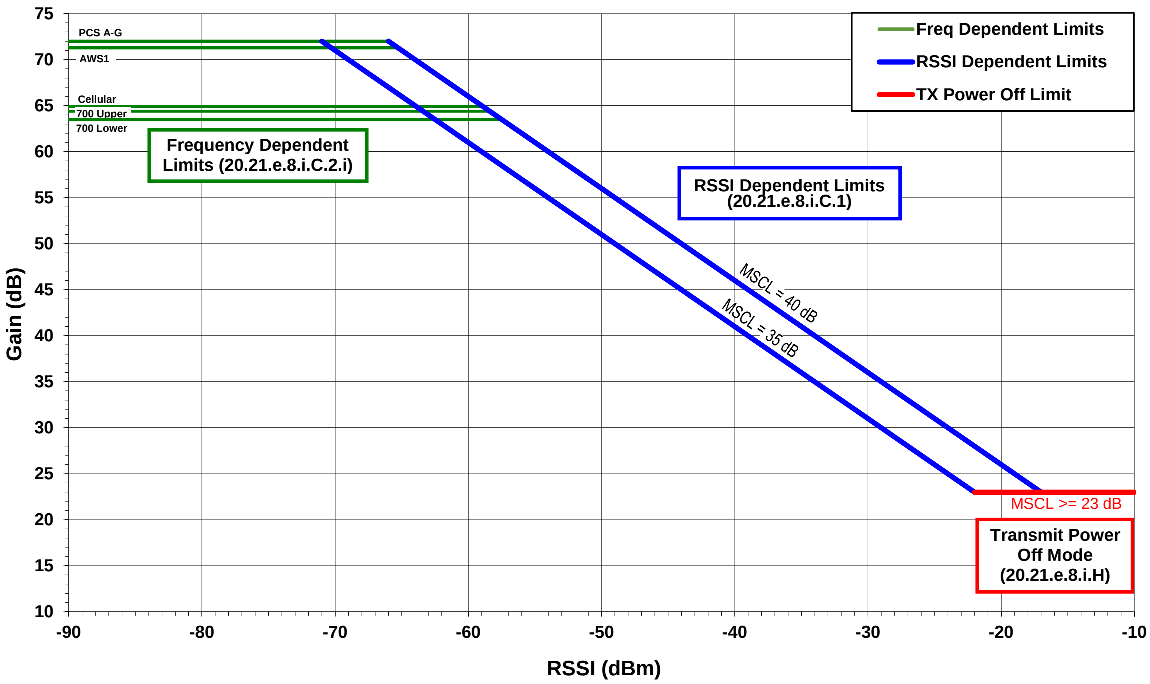

Figure D2. Fixed wideband consumer signal booster variable gain limits.

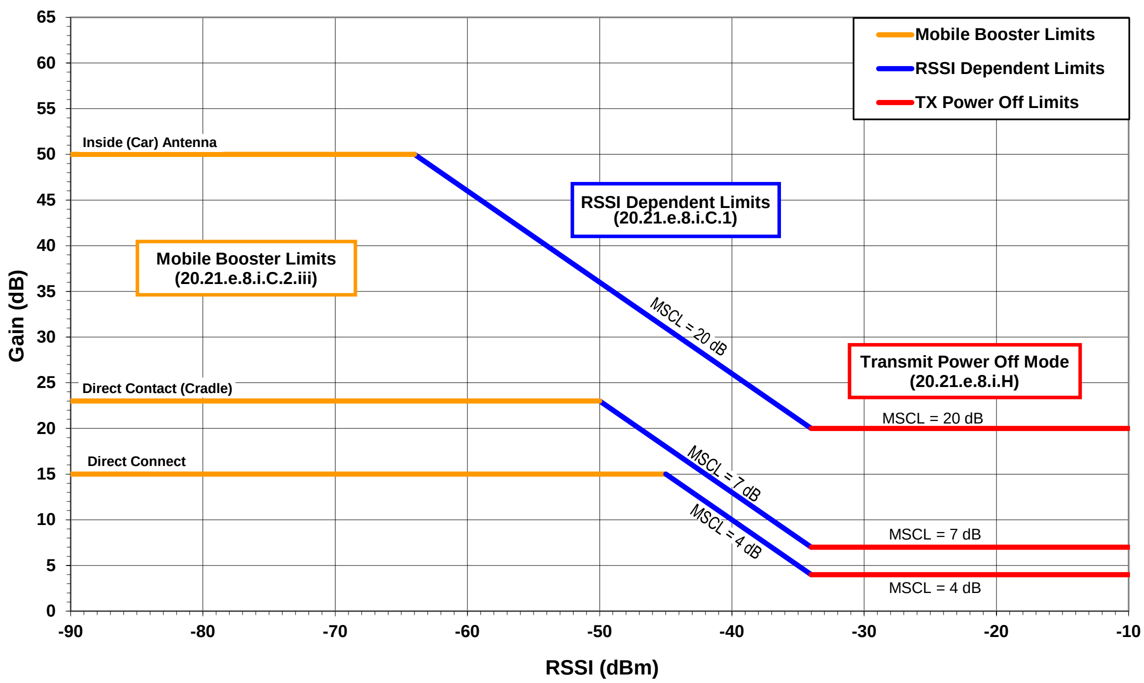

Figure D3. Mobile wideband consumer signal booster variable gain limits.

Change Notices:

03/06/2014: 935210 D03 Signal Booster Measurements v01r01 is replaced by 935210 D03 Signal Booster Measurements v02. Substantive changes are as follows.

- Subclause 1.4 inserted, giving cross-reference listing between rules and 935210 D03 procedures; similarly a rule listing statement was inserted at most Clause 7 subclauses.
- Test report guidance was amended in 7.2.2, 7.3.
- Figure 5 in 7.7 was replaced, per consultation with ANSI ASC C63® task group member(s).
- Footnotes about parameters established by ANSI ASC C63® task group added at 7.3, 7.7, and 7.9.
- Annex A was amended concerning recent rulemaking numbering change for 27.53.
- The existing definition in a 7.13 footnote for spectrum block filtering was added also in Annex C.

07/24/2014: 935210 D03 Signal Booster Measurements v02 is replaced by 935210 D03 Signal Booster Measurements v02r01. Changes summary is as follows.

- Annex A was amended concerning recent rulemaking numbering change for 27.53, per the following. For 935210 D03 v02, effective January 6, 2014, section 27.53 was amended by removing the paragraph (d) text, then redesignating paragraphs (e) through (n) as paragraphs (d) through (m) (79 FR 598; FCC-13-137, docket no. 12-94).
  For 935210 D03 v02r01, effective July 7, 2014, section 27.53 was amended by redesignating paragraphs (d) through (m) as parasgraphs (e) through (n), and adding and reserving new paragraph (d) (79 FR 32413; FCC-14-31, docket no. 12-94).
- Various minor editorial adjustments.

04/xx/2015: 935210 D03 Signal Booster Measurements v02r01 is replaced by 935210 D03 Signal Booster Measurements v03. Changes summary is as follows.

- Added Subclause 7.11.4, entitled "Alternate test procedure for measuring oscillation mitigation or shutdown" as an alternative procedure.
- Performed various minor editorial adjustments.

935210 D05 Indus Booster Basic Meas v03 DR07-42107

The following subdocument D05 within this review draft package DR07-42107 is a new attachment for the existing 935210.

Pages 76 -88

Federal Communications Commission
Office of Engineering and Technology
Laboratory Division

April 13, 2015

MEASUREMENTS GUIDANCE FOR INDUSTRIAL AND NON-CONSUMER SIGNAL BOOSTER, REPEATER, AND AMPLIFIER DEVICES

1.0 INTRODUCTION

In Report and Order FCC 13-21 (WT Docket No. 10-4, referred to as "the *Order*"), the Commission outlines equipment authorization and operational requirements for signal boosters that operate under Parts 20, 22, 24, 27 and 90 of the FCC rules. The *Order* created two classes of signal boosters, Consumer and Industrial, with specific regulatory requirements for each class. Part 90 PLMR signal boosters, a special type of Industrial Boosters, have additional unique requirements as specified in §90.219. This document provides a summary of the equipment authorization requirements for industrial and non-consumer amplifiers, boosters, and repeaters as well as acceptable procedures for performing the necessary compliance measurements.

This guidance must be used in conjunction with the most recent version of KDB Publication 935210 D02 Certification Requirements, which describes basic administrative and other application content requirements and guidance for these devices (e.g., reporting and labeling requirements). Due to some significant changes relative to the preceding rules, manufacturers, test labs, and TCBs are encouraged to submit KDB inquiries to request clarification and guidance before initiating compliance testing or submitting an application for equipment authorization for devices where the existing policies and test procedures may not be applicable.

2.0 MEASUREMENT EQUIPMENT REQUIREMENTS FOR AMPLIFIER/BOOSTER TESTING

2.1 General

Most of the measurement procedures provided in this document presume the use of a spectrum/signal analyzer or an EMI receiver with similar capabilities. Such measurement instrumentation must provide the following minimum capabilities:

a) a tuning range that will permit measurements over the frequency ranges to be investigated (including unwanted emissions),
b) a power averaging (rms) detector,
c) a positive peak power detector,
d) a trace averaging mode (i.e., capability to average over multiple measurement traces),
e) a maximum hold (max hold) mode,
f) an integrated power function (e.g., band or channel power),
g) a burst power measurement capability.

2.3 Signal generator

Several of the technical requirements are expressed such that one or more input signals are required when collecting the data necessary to demonstrate compliance (e.g., intermodulation tests). Thus, the capability to generate a minimum of two separate signal paths may be 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) Tuning range that completely encompasses the operational frequency ranges of the amplifier/booster (e.g., 100 kHz to 3 GHz),
b) Nominal output power range of −103 dBm to +20 dBm,
c) Ability to replicate CMRS signal types GSM, CDMA, W-CDMA (LTE is optional) with a pseudo-random symbol pattern,
d) Ability to generate non-pulsed and pulsed CW tones and band-limited AWGN.

2.4 RF step attenuators

Some tests will require that the requisite input signal power be stepped over a specified range of values. This is typically accomplished by utilizing external RF step attenuators inserted into the input signal path. The resolution of the measurement steps may 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.

2.5 RF combiner and directional coupler

Several of the measurement procedures presented herein will 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 necessary to accomplish this shall be rated to cover the frequency 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.

2.6 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 introduced 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. All RF filters shall be rated for at least 1 W of input power.

2.7 RF cables and adapters

All RF cables and adapters used in the measurements described herein shall be rated for the appropriate frequency and power ranges and must be impedance-matched (VSWR ≤ 1.5:1) with respect to the booster under test.

3.0 TEST METHODS FOR CMRS NON-CONSUMER REPEATER/AMPLIFIER AND INDUSTRIAL BOOSTER DEVICES

3.1 General

Commercial Mobile Radio Service (CMRS) non-consumer RF repeaters, amplifiers, and industrial boosters shall be tested for compliance with the applicable regulatory technical requirements. Input and output power and emissions measurements must be performed using test signals that are intended to bind the typical signal space encountered within the CMRS bands. Broadband amplifiers/boosters shall be tested using a representative band-limited AWGN signal. The AWGN test signal must have a 4.1 MHz 99 % occupied bandwidth (representative of a 5 MHz LTE channel). Narrowband test signals shall use a representative MSK modulated signal, with a Gaussian Filter of 0.3 and a data rate of 270 kbps (representative of a GSM-TDMA signal).

3.2 Measuring the EUT AGC threshold

The AGC threshold is to be determined as follows.

a) Connect a signal generator to the input of the EUT.
b) Connect a spectrum analyzer or power meter to the output of the EUT using appropriate attenuation as necessary.
c) The signal generator should initially be configured to produce either of the required test signals (i.e., broadband or narrowband).
d) Set the signal generator frequency to the center frequency of the EUT operating band.
e) While monitoring the output power of the EUT, measured using the methods of 3.5.3 or 3.5.4, increase the input level until a 1 dB increase in the input signal power no longer causes a 1 dB increase in the output signal power.
f) Record this level as the AGC threshold level.
g) Repeat the procedure with the remaining test signal.

In the case of fiber-optic distribution systems, the RF input port of the equipment under test refers to the RF input of the supporting equipment RF to optical convertor.

Devices intended to be directly connected to an RF source only need to be evaluated for any over-the-air transmit paths.

3.3 EUT out-of-band rejection

Adjust the internal gain control of the equipment under test to the maximum gain for which equipment certification is sought.

a) Connect a signal generator to the input of the EUT.
b) Configure a swept CW signal with the following parameters:
    1) Frequency range = ± 250 % of the passband from the center of the passband.
    2) Level = a sufficient level to affirm that the out-of-band rejection is > 20 dB above the noise floor and will not engage the AGC during the entire sweep.
    3) Dwell time = approx. 10 ms.
    4) Number of points = SPAN/(RBW/2).
c) Connect a spectrum analyzer to the output of the EUT using appropriate attenuation.

d) Set the span of the spectrum analyzer to the same as the frequency range of the signal generator.
e) Set the resolution bandwidth of the spectrum analyzer to be 1 % to 5 % of the passband and the video bandwidth shall be set to ≥ 3 × RBW.
f) Set the detector to Peak Max-Hold and wait for the spectrum analyzer's spectral display to fill.
g) Place a marker to the peak of the frequency response and record this frequency as f_0.
h) Place two markers, one at the lowest and the other at the highest frequency of the envelope of the spectral display such that each marker is at or slightly below the −20 dB down amplitude to determine the 20 dB bandwidth. Capture the frequency response of the EUT.

3.4 EUT input-versus-output signal comparison

A 26 dB bandwidth measurement shall be performed on the input signal and the output signal (alternatively, the 99% OBW can be measured and used) to demonstrate compliance to the technical requirements specified in §90.219(e)(4)(i) and (ii). See KDB Publication 971168 for more information regarding measuring the OBW.

a) Connect a signal generator to the input of the EUT.
b) Configure the signal generator to transmit the AWGN signal.
c) Configure the signal amplitude to be just below the AGC threshold level (see 3.2), but not more than 0.5 dB below.
d) Connect a spectrum analyzer to the output of the EUT using appropriate attenuation.
e) Set the spectrum analyzer center frequency to the nominal EUT channel center frequency. The span range of the spectrum analyzer shall be between 2 times to 5 times the EBW or alternatively, the OBW.
f) The nominal resolution bandwidth (RBW) shall be in the range of 1 % to 5 % of the anticipated OBW, and the VBW shall be ≥ 3 × RBW.
g) Set the reference level of the instrument as required to preclude the signal from exceeding the maximum spectrum analyzer input mixer level for linear operation. In general, the peak of the spectral envelope must be more than [10 log (OBW / RBW)] below the reference level.
NOTE—Steps f) and g) may require iteration to enable adjustments within the specified tolerances.
h) The noise floor of the spectrum analyzer at the selected RBW shall be at least 36 dB below the reference level.
i) Set spectrum analyzer detection function to positive peak.
j) Set the trace mode to max hold.
k) Determine the reference value: Allow the trace to stabilize. Set the spectrum analyzer marker to the highest amplitude level of the displayed trace (this is the reference value) and record the associated frequency as f_0.
l) Place two markers, one at the lowest and the other at the highest frequency of the envelope of the spectral display, such that each marker is at or slightly below the −26 dB down amplitude. The 2 dB emission bandwidth is the positive frequency difference between the two markers.
NOTE—The spectral envelope may cross the −26 dB down amplitude at multiple points. If so, the lowest or highest frequency shall be selected as the frequencies the furthest removed from the center frequency at which the spectral envelope crosses the −26 dB down amplitude point.
m) Repeat steps e) to l) with the input signal connected directly to the spectrum analyzer (i.e., input signal measurement).
n) Compare the spectral plot of the input signal (determined from step m), to the output signal (determined from step l) to affirm that they are similar and provide in test report.
o) Repeat steps a) to n) with the signal generator set to the narrowband signal.
p) Repeat the procedure for both test signals with the input signal amplitude set 3 dB above the AGC threshold.

q) Repeat for all frequency bands authorized for use by the EUT.

3.5 EUT mean output power and amplifier gain

3.5.1 General

The following guidance is provided for performing the measurement of mean input and output power of a CMRS amplifier, booster or repeater, in order to compute the gain of the device.

Adjust the internal gain control of the equipment under test to the maximum gain for which the equipment certification is being sought. Any attenuation settings shall be set to their minimum setting. Input power levels (uplink and downlink) should be set to maximum input ratings while confirming that the device is not capable of operating in saturation (non-linear mode) at the rated input levels, including during the performance of the input/output power measurements.

3.5.2 Measuring the EUT mean input and output power

a) Connect a signal generator to the input of the EUT.
b) Configure to generate the AWGN (broadband) test signal.
c) The frequency of the signal generator shall be set to the frequency of (f0) as determined from 3.4.
d) Connect a spectrum analyzer or power meter to the output of the EUT using appropriate attenuation as necessary.
e) Set the signal generator output power to a level that produces an EUT output level that is just below the AGC threshold (see 3.2), but not more than 0.5 dB below.
f) Measure the output power of the EUT and record (see 3.5.3 or 3.5.4 for power measurement guidance).
g) Remove the EUT from the measurement setup and using the same signal generator settings, repeat the power measurement on the input signal to the EUT and record as input power.
h) Repeat the procedure with the narrowband test signal.
i) Repeat the procedure for both test signals with input signal amplitude set to 3 dB above the AGC threshold level.
j) Repeat for all frequency bands authorized for use by the EUT.

3.5.3 Method 1: Power measurement with a spectrum or signal analyzer

Guidance for performing input/output power measurements using a spectrum or signal analyzer is provided in 5.2 of KDB Publication 971168.

3.5.4 Method 2: Power measurement with a power meter

As an alternative to measuring input and output power levels with a spectrum or signal analyzer, a broadband RF power meter may be used with appropriate detector, as specified in 5.2.3 of KDB Publication 971168.

3.5.5 Calculating the mean amplifier, booster, or repeater gain

After the mean input and output power levels have been measured as described above, the mean gain of the EUT can be determined from:

Gain (dB) = output power (dBm) − input power (dBm).

Report the mean gain for each authorized operating frequency band and each test signal stimulus.

3.6 Measuring the EUT out-of-band/block (including intermodulation) emissions and spurious emissions

3.6.1 General

Refer to the applicable rule part(s) for specified limits on unwanted (out-of-band/block and spurious) emissions.

Spurious emissions shall be measured using a single test signal sequentially tuned to the low, middle and high channels or frequencies within each authorized frequency band of operation.

Out-of-band/block emissions (including intermodulation products) shall be measured under each of the following two stimulus conditions:

a) two adjacent test signals sequentially tuned to the lower and upper frequency band/block edges;
b) a single test signal, sequentially tuned to the lowest and highest frequencies or channels within the frequency band/block under examination.
   NOTE—Single channel boosters that cannot accommodate two simultaneous signals within the passband, can be excluded from the test stipulated in step a).

3.6.2 EUT out-of-band/block emissions conducted measurement

a) Connect a signal generator to the input of the EUT.
   NOTE—If the signal generator is not capable of generating two modulated carriers simultaneously, then two discrete signal generators can be connected with an appropriate combining network to support the two-tone test.
b) Set the signal generator to produce two AWGN signals as previously described (e.g., 4.1 MHz OBW).
c) Set the center frequencies such that the AWGN signals occupy adjacent channels, as defined by industry standards such as 3GPP or 3GPP2, at the upper edge of the frequency band or block of interest.
d) Set the composite power levels such that the input signal is just below the AGC threshold (see 3.2), but not more than 0.5 dB below. The composite power can be measured using the procedures provided in KDB Publication 971168, but it will be necessary to expand the power integration bandwidth so as to include both of the transmit channels. Alternatively, the composite power can be measured using an average power meter as described in KDB Publication 971168.
e) Connect a spectrum analyzer to the output of the EUT using appropriate attenuation as necessary.
f) Set the RBW = reference bandwidth in the applicable rule section for the supported frequency band (typically 1 % of the emission bandwidth, 100 kHz, or 1 MHz)
g) Set the VBW = 3 × RBW.
h) Set the detector to power averaging (rms) detector.
i) Set the Sweep time = auto-couple.
j) Set the analyzer start frequency to the upper block edge frequency and the stop frequency to the upper block edge frequency plus 300 kHz or 3 MHz for frequencies below and above 1 GHz, respectively.
k) Trace average at least 100 traces in power averaging (i.e., rms) mode.

l) Use the marker function to find the maximum power level.
m) Capture the spectrum analyzer trace of the power level for inclusion in the test report.
n) Repeat the procedure with the composite input power level set to 3 dB above the AGC threshold.
o) Reset the input signals frequencies to the lower edge of the frequency block or band under examination.
p) Reset the spectrum analyzer start frequency to the lower block edge frequency minus 300 kHz, or 3 MHz (for frequencies below and above 1 GHz, respectively), and the stop frequency to the lower band or block edge frequency.
q) Repeat steps k) to n).
r) Repeat steps a) to q) with the signal generator configured for a single test signal tuned as close as possible to the block edges.
s) Repeat steps a) to r) with the narrowband test signal.
t) Repeat steps a) to s) for all authorized frequency bands or blocks used by the EUT.

3.6.3 EUT spurious emissions conducted measurement

a) Connect a signal generator to the input of the EUT.
b) Set the signal generator to produce the broadband test signal as previously described (e.g., 4.1 MHz OBW AWGN).
c) Set the center frequency of the test signal to the lowest available channel within the frequency band or block.
d) Set the EUT input power to a level that is just below the AGC threshold (see 3.2), but not more than 0.5 dB below.
e) Connect a spectrum analyzer to the output of the EUT using appropriate attenuation as necessary.
f) Set the RBW = reference bandwidth in the applicable rule section for the supported frequency band of operation (e.g., reference bandwidth is typically 100 kHz or 1 MHz).
g) Set the VBW ≥ 3 × RBW.
h) Set the Sweep time = auto-couple.
i) 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—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.
j) Select the power averaging (rms) detector function.
k) Trace average at least 10 traces in power averaging (i.e., rms) mode.
l) 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.
m) 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 (see §2.1057). 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.
n) Trace average at least 10 traces in power averaging (i.e., rms) mode.

o) 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 and provide tabular data, if required.
p) Repeat the procedure with the input test signals tuned to a middle band/block frequency/channel and then a high band/block frequency/channel.
q) Repeat entire procedure with the narrowband test signal.
r) Repeat for all authorized frequency bands/blocks used by the EUT.

3.7 EUT frequency stability measurements

Frequency stability measurements are required by §2.1055 of the FCC rules. However, this requirement presumes that the EUT processes an input signal in a manner that can influence the output signal frequency/frequencies (i.e., most signal boosters do not incorporate an oscillator). If this is not the case (i.e., the amplifier, booster, or repeater does not alter the input signal in any way), then a frequency stability test may not be required.

When performing frequency stability measurements on these types of devices, the instability associated with the EUT must be isolated from any frequency instability associated with the measurement instrumentation. One method for realizing this isolation is to connect the reference clock input of the signal generator to the reference output of the frequency counter to confirm that any frequency instability is associated with the EUT and not due to differences between the reference oscillators internal to the measurement instrument.

3.8 EUT spurious emissions radiated measurements

This measurement is intended to produce the data necessary to demonstrate compliance to the radiated spurious emission requirements specified in §2.1053 of the FCC rules. This test is intended to capture any emissions that radiate directly from the case, cabinet, control circuits, etc., instead of via the antenna output port, and thus would not be captured in conducted measurements. See KDB Publication 971168 for additional guidance.

4.0 TEST METHODS FOR PLMRS/PSRS REPEATER/AMPLIFIER AND INDUSTRIAL BOOSTER DEVICES

4.1 General

The procedures offered herein are specific to operations in the Private Land Mobile Radio Service (PLMRS) and Public Safety Radio Service (PSRS) that are governed under the provisions and requirements of the Part 90 rules (i.e., §90.219).

Table 1 depicts signal types associated with PLMRS operations, and as such are to be considered as test signals to be used in performing the requisite compliance testing on PLMRS amplifiers, boosters, and repeaters. Not all of the procedures offered herein will require the use of each of the signals specified in the table, because for many EUTs a CW tone will adequately model the narrow band signals typically encountered within these services. For EUTs intending to accommodate digitally modulated signals, any signal supported by the device under test may be assumed to be representative (i.e., P25 Phase 1 and Phase 2, TETRA, etc.).

Table 1—Test signals for PLMRS devices

Emission Designator	Modulation	Occupied Bandwidth	Channel Bandwidth	Audio Frequency
16K0F3E	FM	16 kHz	25 kHz	1 kHz
11K3F3E	FM	11.3 kHz	12.5 kHz	1 kHz
4K00F1E	FM	4 kHz	6.25 kHz	1 kHz
N/A	CW	N/A	N/A	N/A

4.2 Measuring the EUT AGC threshold

Testing at and above the AGC threshold will be required. The AGC threshold shall be determined by applying the procedure defined in 3.2 with the signal generator configured to produce either a test signal defined in Table 1 or a CW input signal, as appropriate.

4.3 PLMRS device out-of-band rejection

Adjust the internal gain control of the equipment under test to the maximum gain for which equipment certification is sought.

a) Connect a signal generator to the input of the EUT.
b) Configure a swept CW signal with the following parameters:
c) Frequency range = ± 250 % of the manufacturer’s pass band.
d) The CW amplitude will be 3 dB below the AGC threshold (see 4.2) and but not activate the AGC threshold throughout the test.
e) Dwell time = approx. 10 ms.
f) Frequency step = 50 kHz.
g) Connect a spectrum analyzer to the output of the EUT using appropriate attenuation.
h) Set the resolution bandwidth of the spectrum analyzer between 1 % and 5 % of the manufacturer’s pass band with the video bandwidth set to 3 × RBW.
i) Set the detector to Peak and the trace to Max-Hold.
j) After the trace is completely filled, place a marker at the peak amplitude, which is designated as f_0, and with two additional markers (use the marker-delta method) at the 20 dB bandwidth (i.e., at the points where the gain has fallen by 20 dB).
k) Capture the frequency response plot and for inclusion in the test report.

4.4 EUT input-versus-output signal comparison

The emissions mask of the EUT output shall be measured for the following public safety signal types (see Table 1 for associated test signal modulation specifications).

- 16K0F3E,
- 11K3F3E,
- 4K00F1E.

Refer to the applicable regulatory requirements (e.g., §90.210) for emission mask specifications.

a) Connect a signal generator to the input of the EUT.
b) Configure the signal generator to transmit the appropriate test signal associated with the public safety emission designation (see Table 1).
c) Configure the signal level to be just below the AGC threshold (see results from 4.2).
d) Connect a spectrum analyzer to the output of the EUT using appropriate attenuation as necessary.
e) Set the spectrum analyzer center frequency to the nominal EUT channel center frequency. The span range for the spectrum analyzer shall be between 2 times to 5 times the EBW (or OBW).
f) The nominal resolution bandwidth (RBW) shall 300 Hz for 16K0F3E and 100 Hz for all other emissions types.
g) Set the reference level of the spectrum analyzer to accommodate the maximum input amplitude level.
h) Set spectrum analyzer detection mode to peak, and trace mode to max hold.
i) Allow the trace to fully stabilize.
j) Confirm that the signal is contained within the appropriate emissions mask.
k) Use the marker function to determine the maximum emission level and record the associated frequency as f_0.
l) Capture the emissions mask plot for inclusion in the test report (output signal spectra).
m) Measure the EUT input signal power (signal generator output signal) directly from the signal generator using power measurement guidance provided in KDB Publication 971168 (input signal spectra).
n) Compare the spectral plot of the output signal (determined in step k), to the input signal (determined in step l) to affirm they are similar.
o) Repeat steps b) to n) for all authorized operational bands and emissions types (see applicable regulatory specifications, e.g., §90.210).
p) Include all accumulated spectral plots depicting EUT input signal and EUT output signal in the test report and note any observed dissimilarities.

4.5 EUT input/output power and amplifier gain

4.5.1 General

The following guidance is provided for performing the measurement of mean input and output power of a PLMRS and/or PSRS amplifier, booster, or repeater, to compute the gain of the device.

Adjust the internal gain control of the equipment under test to the maximum gain for which the equipment certification is being sought. Any attenuation settings shall be set to their minimum setting. Input power levels (uplink and downlink) should be set to maximum input ratings while confirming that the device is not capable of operating in saturation (non-linear mode) at the rated input levels, including during the performance of the input/output power measurements.

4.5.2 Measuring the EUT input and output power levels for determining amplifier/booster gain

Apply the guidance provided in 3.5.2 to measure the maximum input and output power levels necessary for computing the mean EUT gain, with the following modifications:

a) Configure the signal generator for CW operation instead of AWGN,

b) Select the analyzer positive peak detector instead of the power averaging (rms) detector,
c) Activate the max hold function instead of the trace average function,
d) Use in conjunction with guidance provided in 4.5.3.

4.5.3 Method 1: Power measurement with a spectrum or signal analyzer

a) Set the frequency span to at least 1 MHz.
b) Set the resolution bandwidth to 100 kHz.
c) Set the video bandwidth to $\geq 3 \times$ RBW.
d) Set the detector to PEAK and trace mode to MAX HOLD.
e) Place a marker on the peak of the signal and record the value as the maximum power.

4.5.4 Method 2: Measuring input/output power with a power meter

As an alternative to measuring the input and output power levels with a spectrum or signal analyzer, a broadband RF power meter may be used with an appropriate detector.

4.5.5 Calculating the amplifier, booster, or repeater gain

After the input and output power levels have been measured as described above, the gain of the EUT can be determined from:

Gain (dB) = output power (dBm) − input power (dBm).

Report the gain for each authorized operating frequency band and each test signal stimulus.

4.6 EUT noise figure measurement

90.219(e)(2) limits the noise figure of a signal booster to ≤ 9 dB in either direction. The following guidance is offered with regards to measuring the noise figure to demonstrate compliance to this limitation.

There are several widely recognized methods for performing noise figure measurements. Some require the use of specialized equipment such as a noise figure analyzer and/or an excess noise ratio (ENR) calibrated noise source, while others involve the use of conventional measurement instrumentation such as a spectrum analyzer. The methodology that requires the use of a noise figure analyzer is generally accepted as producing the most accurate results, and thus is considered to be the primary method within this document, while other methods are considered to be acceptable alternatives. Consult the relevant instrumentation application notes for detailed guidance regarding the selection and application of an appropriate methodology for performing noise figure measurements. It should also be noted that noise figure measurements will require that any AGC circuitry be disabled over the duration of the measurement.

4.7 Measuring the EUT out-of-band/block (including intermodulation) and spurious emissions

4.7.1 General

Refer to the applicable rule part(s) for specified limits on unwanted (out-of-band/block and spurious) emissions (e.g., §90.210).

Spurious emissions shall be measured using a single test signal sequentially tuned to the low, middle and high channels or frequencies within each authorized frequency band of operation.

4.7.2 EUT out-of-band/block emissions conducted measurement

Intermodulation products shall be measured while applying two CW tones spaced in frequency ±12.5 kHz relative to the center frequency (f_0) as determined from 4.4.

a) Connect a signal generator to the input of the EUT.
   NOTE—If the signal generator is not capable of producing two independent modulated carriers simultaneously, then two discrete signal generators can be connected with an appropriate combining network to support the two-tone test.
b) Configure the two signal generators to produce CW tones on frequencies spaced at ± 12.5 kHz relative to f0 with amplitude levels set just below the AGC threshold (see 4.2).
c) Connect a spectrum analyzer to the EUT output.
d) Set the span to 100 kHz.
e) Set the resolution bandwidth to 300 Hz with a video bandwidth ≥ 3 × RBW.
f) Set the detector to power average (rms).
g) Place a marker on highest intermodulation product amplitude.
h) Capture the plot for inclusion in the test report.
i) Repeat steps b) to h) for all operational bands.

4.7.3 EUT spurious emissions conducted measurement

a) Connect a signal generator to the input of the EUT.
b) Configure the signal generator to produce a CW signal.
c) Set the frequency of the CW signal to the center channel of the pass band.
d) Set the output power level so that the resultant signal is just below the AGC threshold (see 4.2).
e) Connect a spectrum analyzer to the output of the EUT using appropriate attenuation as necessary.
f) Set the RBW to 100 kHz.
g) Set the VBW = 3 × RBW.
h) Set the Sweep time = auto-couple.
i) Set the detector to PEAK.
j) Set the analyzer start frequency to 30 MHz (or the lowest radio frequency signal generated in the equipment, without going below 9 kHz if the EUT has internal clock frequencies) and the stop frequency to 10 × the highest allowable frequency of the pass band.
k) Select MAX HOLD and use the marker peak function to find the highest emission(s) outside the pass band. (This could be either at a frequency lesser or greater than the pass band.)
l) Capture a plot for inclusion in the test report.
m) Repeat steps c) to l) for each authorized frequency band/block of operation.

4.8 EUT frequency stability measurements

90.219(e)(4)(i) requires that a signal being retransmitted by an amplifier, booster, or repeater meet the frequency stability requirements of 90.213. However, this requirement presumes that the EUT processes an input signal in a manner that can influence the output signal frequency/frequencies (i.e., most signal boosters do not incorporate an oscillator). If this is not the case (i.e., the amplifier, booster, or repeater does not alter the input signal in any way), then a frequency stability test may not be required.

When performing frequency stability measurements on these types of devices, the instability associated with the EUT must be isolated from any frequency instability associated with the measurement instrumentation. One method for realizing this isolation is to connect the reference clock input of the signal generator to the reference output of the frequency counter to confirm that any frequency instability is associated with the EUT and not due to differences between the reference oscillators internal to the measurement instrument.

4.9 EUT spurious emissions radiated measurements

This measurement is intended to produce the data necessary to demonstrate compliance to the radiated spurious emission requirements specified in §2.1053 of the FCC rules. This test is intended to capture any emissions that radiate directly from the case, cabinet, control circuits, etc., instead of via the antenna output port, and thus would not be captured in conducted measurements. See KDB Publication 971168 for additional guidance.