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Federal Communications Commission
Office of Engineering and Technology
Laboratory Division

<u>Draft Laboratory Division Publications Report</u>

Title: Wideband Consumer Signal Booster Measurement Guidance

Short Title: Consumer Signal Booster Procedure

Reason: Draft measurement procedure to address rulemaking on Consumer Signal Boosters

Publication: 935210 D03

Keyword/Subject: Signal Booster

First Category: Radio Service Rules

Second Category: Certification

Question: What is the Commission guidance for the evaluation of Signal Boosters?

Answer: A recent FCC Report and Order (FCC 13-21) introduces a new regulatory framework for signal boosters, including the introduction of a Network Protection Standard (NPS) that specifies the technical and operational requirements necessary to minimize the potential for interference from signal boosters to wireless networks. These requirements are codified in 47 C.F.R. Part 20.21.

<u>935210 D01 Booster Definitions v01</u>, provides guidance for classifying types of devices and applicable rules for performing compliance measurements on signal boosters operating under 47 CFR §§ 20.21, 90.219, and Parts 22, 24, 27, 90; considerations for some provisions and devices under other rules is also given, *e.g.,* parts 2, 25, 97, and 101.

<u>935210 D02 Certification Requirements v01</u>, provides certification requirements for signal boosters that operate under parts 20, 22, 24, 27 and 90.

<u>935210 DR03 Consumer Signal Booster Procedure v01</u> provides preliminary guidance for demonstrating compliance to the various requirements for Wideband Consumer Signal Boosters as specified in part 20.21(e), *Consumer Signal Booster Network Protection Standard*. This document represents the current version of an ongoing effort by the C63 Wireless Working Group, RF Booster Task Group to develop applicable measurement guidance. The task group includes representatives from the signal booster manufacturing industry, the compliance testing industry and the FCC. The procedures described here represent draft guidance and as such are still subject to further review, evaluation and update. This draft guidance is being offered now as a draft KDB so as to provide the opportunity for review and comment. The measurement procedures will be further refined as necessary based on comments received from the public and the C63 working group. Alternative measurement procedures acceptable to the Commission may also be used to prepare data demonstrating compliance to the applicable technical and operational requirements as per Section 2.947(a)(3) of the FCC rules.

This measurement procedure may be used to demonstrate compliance with the technical requirements. We encourage the use of this procedure on actual devices to determine where changes should be made and encourage all parties to provide comments based on experience with applying the test procedures.

Note:

This Draft publication is out for a comment a second time for a proposed third attachment to Knowledge Data Base (KDB) publication 935210 as DR03 Consumer Signal Booster Procedure*.The first draft publication posted Jun 14 2013(935210 D03 Wideband Consumer Signal Booster Measurement Guidance DR03-41439) is superseded by this Draft publication.

The current KDB publication 935210, updated on 06/14/2013, includes attachments D01 Booster Definitions** and D02 Certification Requirements**. These ** attachments are final and are not open for comment.

Attachment List:

935210 D01 Booster Definitions v01**
935210 D02 Certification Requirements v01**
935210 D03 Consumer Signal Booster Procedure v01*

935210 D03 Consumer Signal Booster Procedure v01

1.0 Introduction

1.1 Background

The FCC recently 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.[1]

The signal booster R&O creates two classes of signal boosters – Consumer and Industrial – with distinct regulatory requirements.

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. Both Wideband and Provider-Specific Consumer Signal Boosters can be either fixed (intended for operation at a fixed location within a building) or mobile (intended for operation while moving, *e.g.*, in a vehicle or boat).

The signal booster R&O introduces a Network Protection Standard (NPS) that specifies new technical, operational, and registration requirements applicable to Consumer Signal Boosters in order 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 Network Protection Standard and is FCC certificated; and operate the booster on a secondary, non-interference basis and shut it down if it causes harmful interference.

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[1] 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.

The new signal booster rules are codified §20.21. The NPS requirements are specified in §20.21(e)(8) for Wideband Consumer Signal Boosters and §20.21(e)(9) for provider-specific (frequency-selective) consumer signal boosters.

Industrial Signal Boosters include all signal boosters other than Consumer Signal Boosters. The Industrial Signal Booster classification thus covers a wide variety of devices that are designed for installation by licensees or qualified installers. The Industrial Signal Booster classification also includes signal boosters deployed in the Private Land Mobile Radio bands (PLMR) by licensees or those with the consent of PLMR licensees.

This KDB provides guidance with respect to acceptable measurement procedures for demonstrating Consumer Signal Booster compliance to the applicable requirements imposed by the NPS. At this time, this guidance is limited to Wideband Consumer Signal Boosters. Efforts are continuing to develop and document similar guidance for Provider-Specific Consumer Signal Boosters. 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 see the second attachment (D02) of this KDB publication (935210).

For additional information regarding Signal Booster definitions and certification requirements, see the other attachments (D01 and D02) included as a part of this KDB publication.[2]

1.2 Objective

The objective of this effort is to establish and document standardized measurement procedures that will produce the data required to demonstrate that a Consumer Signal Booster is compliant with the technical requirements specified by the NPS.

1.3 Approach

The measurement procedures provided in this document represent the current status of ongoing efforts by the RF Booster Task Group of the C63 Wireless Working Group to develop standardized measurement methodologies that can be applied to Consumer Signal Boosters in order 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.

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

The guidance provided herein is currently in draft form and as such is still subject to further review, evaluation and update. Thus, the measurement procedures provided in this KDB may be further refined as necessary based on comments received from the public and from the C63 working group as practical experience is gained. 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.

2.0 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, is defined as a bi-directional signal booster that is marketed and sold to the general public for use without modification.

The bi-directional 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 both an RF input and output port (*e.g.*, a downlink signal input and an uplink signal output). Thus, the RF ports of these bi-directional signal boosters are often referred to as the *donor* and *server* ports. The term "donor port" of a bi-directional 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 as 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.

3.0 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.[3]

[3] §20.21(e)(3)

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

4.0 Other Applicable Rule Parts

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

In addition, because signal boosters will require certification by the FCC, 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).

5.0 Measurement Equipment Requirements

The following paragraphs provide a list of requisite test equipment and relevant minimum capabilities necessary to perform the measurements specified within this KDB. It is assumed that all equipment used is appropriately calibrated prior in accordance to laboratory accreditation requirements.

5.1 Measurement Instrumentation

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

- 5.1.1 A tuning range that will permit measurements over the frequency ranges under investigation (including unwanted emissions),
- 5.1.2 A power averaging (RMS) detector,
- 5.1.3 A trace averaging capability (*i.e.*, the ability to average over multiple measurement traces)
- 5.1.4 An integrated power function (*e.g.*, band or channel power),
- 5.1.5 A burst power measurement capability,
- 5.1.6 A peak power detector,
- 5.1.7 A maximum hold function.

5.2 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 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.

5.3 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:

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

5.4 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 (referenced to the booster's input port). This may require the use of an external linear amplifier.

- 5.4.1 Direct Connect: 27 dBm,
- 5.4.2 Direct Contact Coupling (*e.g.*, cradle-type): 23 dBm,
- 5.4.3 Mobile using inside antenna(s): 10 dBm,
- 5.4.4 Fixed using inside antenna(s): 0 dBm.

The maximum downlink input level for all device types is -20 dBm.

5.5 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 0-70 dB of attenuation in 10 dB steps, 0-10 dB of attenuation in 1 dB steps, and 0-1 dB in 0.1 dB steps.

5.6 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 Watt of input power.

5.7 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 Watt of input power.

5.8 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 of 1.5:1) with respect to the booster under test.

6.0 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 C63.4 and C63.10 standards. When performing radiated tests, special care should be taken to ensure isolation of the EUT from any ambient CSMR signals.

7.0 Compliance Measurement Procedures (Wideband Consumer Signal Boosters)

The following sections 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

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 with each CMRS operational band, which then serves as a basis for subsequent tests.

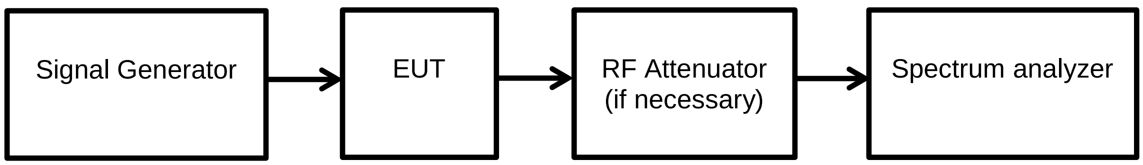


Figure 1 – Band verification test instrumentation setup

7.1.1 Connect the EUT to the test equipment as shown in **Figure 1**. Begin with the uplink output connected to the spectrum analyzer.

7.1.2 Set the spectrum analyzer RBW for 100 kHz with the VBW ≥3X the RBW using a PEAK detector with the MAX HOLD function.

7.1.3 Set the center frequency of the spectrum analyzer to the center of the operational band under test with a span of 1 MHz.

7.1.4 Set the signal generator for CW mode and tune to the center frequency of the operational band under test.

7.1.5 Set the initial signal generator power to a level that is at least 6 dB below the AGC level specified by the manufacturer.

7.1.6 Slowly increase the signal generator power level until the output signal reaches the AGC operational level.

7.1.7 Reduce the signal generator power to a level that is 3 dB below the level noted above and manually reset the EUT.

7.1.8 Slowly increase the signal generator power to a level just below (within 0.5 dB of) the AGC level without triggering the AGC.

7.1.9 Reset the spectrum analyzer span to 2 X the CMRS band under test. Adjust the tuned frequency of the signal generator to sweep 2 times the CMRS band using the sweep function. Note: The AGC must not be activated throughout entire sweep.

7.1.10 Using three markers identify the CMRS band edges and the frequency with the highest power. Ensure that the values of all markers are visible on the display of the spectrum analyzer (*e.g.*, marker table set to on).

7.1.11 Capture the spectrum analyzer trace for inclusion in the test report.

7.1.12 Repeat steps 7.1.3 to 7.1.11 for all operational uplink and downlink bands.

7.2 Maximum power measurement test procedure

The following procedures 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 (*i.e.*, a maximum uplink composite power level of 1 watt (30 dBm) conducted power and EIRP, a maximum downlink power level of 0.05 watt (17 dBm) conducted power and EIRP, and a conducted uplink power output that is at least 0.05 watt (17 dBm) for each band of operation).

Compliance to authorized EIRP limits must be shown using the highest gains from the list of antennas, cabling and coupling devices authorized by the manufacturer for use with the consumer booster.

In addition, the maximum power levels measured in this procedure will be utilized in calculating the maximum gain as described in the next section.

The frequency with the highest power level in each operational band as determined in section 7.1 is to be measured discretely by applying the following procedure utilizing the stated emission and power detector types independently.

Use a signal generator to create a pulsed CW signal with a pulse width of 570 μsec and a duty cycle of 12.5% and measure utilizing the burst power function of the measuring instrument.

Use a signal generator to create an AWGN signal with a 99% Occupied Bandwidth of 4.1 MHz and measure utilizing the channel or band power function of the measurring instrumentation.

All modes of operation must be verified to maintain operation at the maximum uplink and downlink test levels per device type as defined in section 5.4.

7.2.1 Connect the EUT to the test equipment as shown in figure 1. Begin with the uplink output (donor port) connected to the spectrum analyzer.

7.2.2 Configure the signal generator and spectrum analyzer for operation on the frequency determined in section 7.1 of 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.

7.2.3 Set the initial signal generator power to a level well below that which causes AGC control.

7.2.4 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; *e.g.*, no further increase in output power as input power is increased).

7.2.5 Reduce power sufficiently on the signal generator to ensure that the AGC is not controlling the power output.

7.2.6 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}).

7.2.7 Measure the output power (P_{out}) with the spectrum analyzer as follows.

7.2.8 Set RBW = 100 kHz.

7.2.9 Set VBW ≥ 300 kHz.

7.2.10 Select either the BURST POWER or CHANNEL POWER measurement tool, as required for each signal type.

7.2.11 Select the RMS (power averaging) detector.

7.2.12 Ensure that the number of measurement points per sweep ≥ (2 x span)/RBW (Note: This requirement does not apply for BURST power measurement mode).

7.2.13 Set sweep time = auto couple, or as necessary.

7.2.14 Trace average at least 100 traces in power averaging (i.e., RMS) mode.

7.2.15 Record the measured power level as $P_{\mathbf{OUT}}$.

7.2.16 Repeat the procedure for each operational uplink and downlink frequency band supported by the booster.

7.3 Maximum Booster Gain Computation

This section 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).

7.3.1 Compute the maximum gain of the booster as follows to demonstrate compliance to the applicable gain limits as specified.

7.3.2 For both the uplink and downlink in each supported frequency band, use each of the P_{OUT} and P_{IN} value pairs determined in 7.2 in the following equation to determine the maximum gain (G) of the booster:

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

7.3.3 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.

7.4 Intermodulation product test procedure

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 (*i.e.*, -19 dBm).

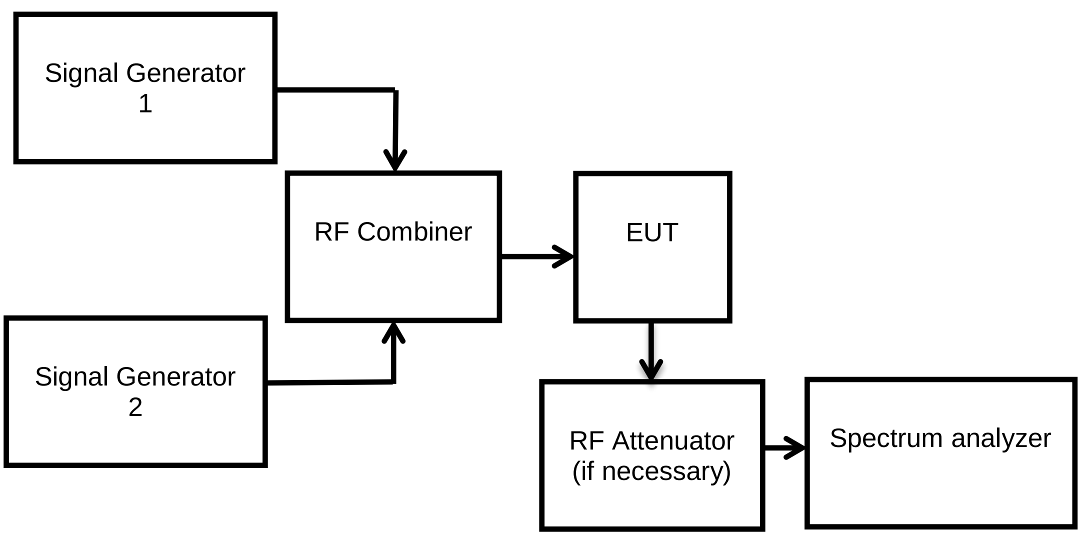


Figure 2 – Intermodulation product instrumentation test setup

7.4.1 Connect the signal booster to the test equipment as shown in Figure 2. Begin with the uplink output connected to the spectrum analyzer.

7.4.2 Set the spectrum analyzer RBW = 3 kHz.

7.4.3 Set the VBW ≥ 3 X the RBW.

7.4.4 Select the RMS detector.

7.4.5 Set the spectrum analyzer center frequency to the center of the supported operational band under test.

7.4.6 Set the span to 5 MHz.

7.4.7 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.

7.4.8 Set the signal generator amplitudes so that the power from each into the RF combiner is equivalent and turn on the RF output.

7.4.9 Increase the signal generators' amplitudes equally until just before the EUT begins AGC and ensure that all intermodulation products (if any exist), are below the specified limit of -19 dBm.

7.4.10 Utilize the MAX HOLD function of the spectrum analyzer and wait for the trace to stabilize. Place a marker at the highest amplitude intermodulation product.

7.4.11 Record the maximum intermodulation product amplitude level that is observed.

7.4.12 Capture the spectrum analyzer trace for inclusion in the test report.

7.4.13 Repeat steps 7.4.5 to 7.4.12 for all uplink and downlink operational bands. *Note: If using a single signal generator with dual outputs, ensure that intermodulation products are not the result of the generator.*

7.5 Out-of-band emissions test procedure

This measurement is intended to demonstrate compliance to the limit specified in §20.21(e)(8)(i)(E), which specifies that out-of-band emissions generated by a Wideband Signal Booster shall be at least 6 dB below the mobile emission limit applicable to the supported band of operation. The mobile emission limit applicable to the supported band of operation can be determined from the applicable rule part which is referenced in Annex A for each authorized operating band.

7.5.1 Connect the EUT to the test equipment as shown in figure 1. Begin with the uplink output connected to the spectrum analyzer.

7.5.2 Configure the signal generator for the appropriate operation for all uplink and downlink bands:

7.5.2.1 GSM: 0.2 MHz from upper and lower band edge

7.5.2.2 LTE: 2.5 MHz from upper and lower band edge

7.5.2.3 CDMA: 1.25 MHz from upper and lower band edge, except for cellular as follows (only the upper and lower frequencies need to be tested):

7.5.2.3.1 824.88 MHz

7.5.2.3.2 845.73 MHz

7.5.2.3.3 836.52 MHz

7.5.2.3.4 848.10 MHz

7.5.2.3.5 869.88 MHz

7.5.2.3.6 890.73 MHz

7.5.2.3.7 881.52 MHz

7.5.2.3.8 893.10 MHz

7.5.3 Set the signal generator amplitude to the maximum power level prior to AGC similar to the procedures in 7.2.4 to 7.2.6 of power measurement procedure for appropriate modulations.

7.5.4 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*).

7.5.5 Set VBW = 3 X RBW.

7.5.6 Select the RMS (power averaging) detector.

7.5.7 Sweep time = auto-couple.

7.5.8 Set the analyzer start frequency to the upper band/block edge frequency and the stop frequency to the upper band/block edge frequency plus 100 kHz or 1 MHz, per applicable rule part.

7.5.9 Trace average at least 100 traces in power averaging (i.e., RMS) mode.

7.5.10 Use peak marker function to find the maximum power level.

7.5.11 Capture the Spectrum Analyzer trace of the power level for inclusion in the test report.

7.5.12 Increase the signal generator amplitude to the saturation level indicated in 5.4. Ensure that the EUT maintains compliance with the OOBE limits.

7.5.13 Reset the analyzer start frequency to the lower band/block edge frequency minus 100 kHz or 1 MHz, as per applicable rule part, and the stop frequency to the lower band/block edge frequency and repeat steps 7.5.10-7.5.12.

7.5.14 Repeat steps 7.5.2 through 7.5.14 for each uplink and downlink operational band.

7.6 Conducted spurious emissions test procedure

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.

7.6.1 Connect the EUT to the test equipment as shown in Figure 1. Begin with the uplink output connected to the spectrum analyzer.

7.6.2 Configure the signal generator for AWGN with an emissions bandwidth of 4.1 MHz operation with a center frequency corresponding to the center of the operational band under test and with a bandwidth representative of the bandwidth of the uplink or downlink signal.

7.6.3 Set the signal generator amplitude to the level determined in the power measurement procedure in 7.2.

7.6.4 Turn on the signal generator RF output and measure the spurious emission power levels with an appropriate measurement instrument as follows.

7.6.5 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) in order to enhance measurement accuracy, but the result must then be integrated over the specified measurement bandwidth.

7.6.6 Set VBW = 3 X RBW.

7.6.7 Select the power averaging (RMS) detector. (See above note regarding the use of a peak detector for preliminary measurements.)

7.6.8 Sweep time = auto-couple.

7.6.9 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 x 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.

7.6.10 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.

7.6.11 Reset the analyzer start frequency to the upper band/block edge frequency plus 100 kHz or 1 MHz, as specified in the applicable rule part, and the analyzer stop frequency to 10 times the highest frequency of the fundamental emission. Note that the number of measurement points in each sweep must be ≥ (2 x 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.

7.6.12 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.

7.6.13 Repeat steps 7.6.2 through 7.6.12 for each supported frequency band of operation.

7.7 **Noise limits test procedure**

This procedure provides a measurement methodology for demonstrating compliance to the noise limits specified in §20.21(e)(8)(i)(A) for Wideband Consumer Signal Boosters.

7.7.1 Connect the EUT to the test equipment as shown in **Figure 3**. Begin with the uplink output connected to the spectrum analyzer.

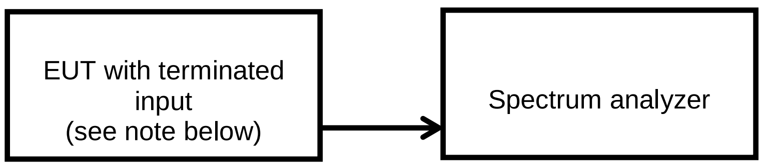


Figure 3 – Noise limit instrumentation test setup

7.7.2 Set the spectrum analyzer RBW to 1 MHz with the VBW ≥ 3X RBW

7.7.3 Select the power averaging (RMS) detector and trace average over at least 100 traces.

7.7.4 Set the center frequency of the spectrum analyzer to the center of the CMRS band under test with the span ≥ 2X the CMRS band.

7.7.5 Measure the maximum Transmitter Noise Power Level.

7.7.6 Save the spectrum analyzer plot as necessary for inclusion in the final test report.

7.7.7 Repeat steps 7.7.2 to 7.7.6 for all operational uplink and downlink bands.

7.7.8 Connect the EUT to the test equipment as shown in **Figure 4** for uplink and **Figure 5** for downlink. Ensure the coupled path of the RF coupler is connected to the spectrum analyzer.

7.7.9 Configure the signal generator for 4.1 MHz AWGN operation for uplink test and 200 kHz 99% OBW AWGN for downlink test.

7.7.10 Set the spectrum analyzer RBW for 1 MHz with the VBW ≥3X the RBW with an RMS AVERAGE detector with at least 100 trace averages.

7.7.11 Set the center frequency of the spectrum analyzer to the center of the CMRS band under test with the span ≥ 2X the CMRS band. This shall include all spectrum blocks in the particular CMRS band under test (see Annex A). 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. For downlink noise measurements, set the spectrum analyzer to the center of the downlink band and tune the signal generator to the upper or lower band-edge of the same band, ensuring that the maximum noise power is being measured.

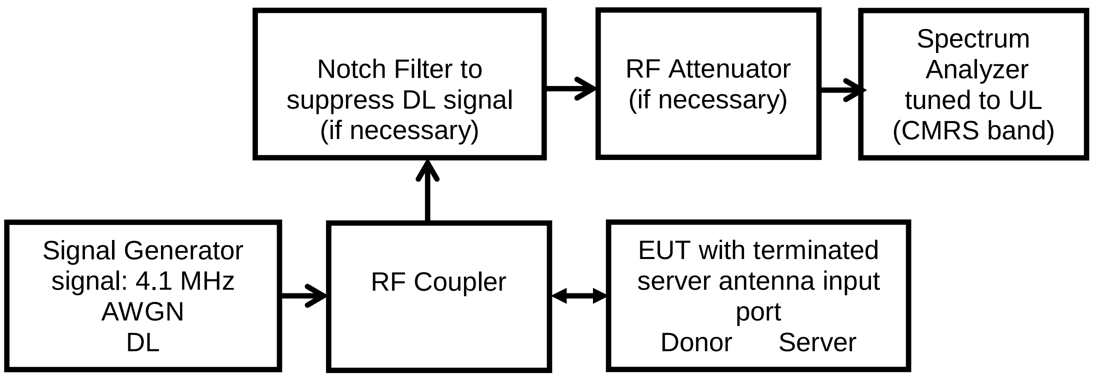


Figure 4 – Test setup for uplink noise power measurement in the presence of a downlink signal

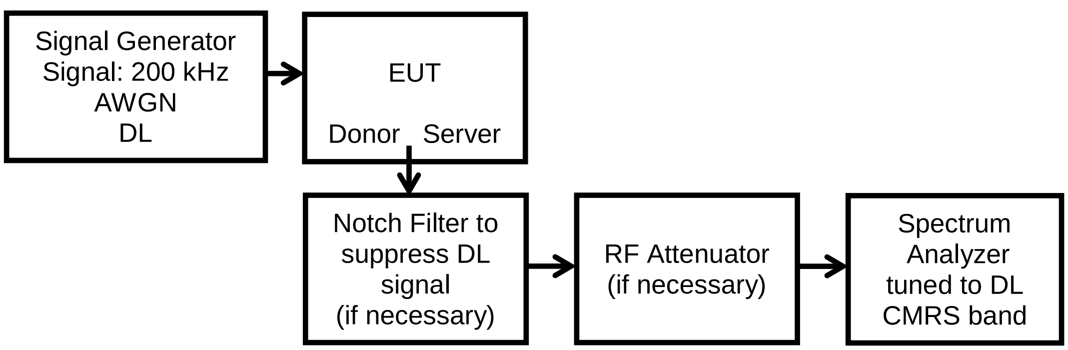


Figure 5 – Test setup downlink noise power measurement in the presence of a downlink signal

7.7.12 Measure the maximum Transmitter Noise Power Level when varying the downlink signal generator level from -90 to -10 dBm in 1 dB steps inside the RSSI dependent region and 10 dB steps outside the RSSI dependent region, report the six values closest to the limit with at least 2 points within the RSSI dependent region of the limit.

7.7.13 Repeat 7.7.7 through 7.7.11 for all operational uplink and downlink bands.

7.7.14 Variable Uplink noise timing is to be measured as follows.

7.7.15 Set the spectrum analyzer to the uplink frequency to be measured.

7.7.16 Set the span to 0 Hz with a sweep time of 10 seconds.

7.7.17 Set the power level of signal generator 1 to the lowest level of the RSSI dependent noise.

7.7.18 Select MAX HOLD and increase the power level of signal generator 1 by 10 dB for mobile boosters and 20 dB for fixed boosters.

7.7.19 Ensure that the Uplink noise decrease to the specified levels within 1 second for mobile devices and 3 seconds for fixed devices.

7.7.20 Repeat 7.7.14 – 7.7.19 for all operational uplink bands

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

7.8 Uplink inactivity test procedure

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).

7.8.1 Connect the EUT to the test equipment as shown in **Figure 3** with the uplink output connected to the spectrum analyzer.

7.8.2 Select the RMS power averaging detector.

7.8.3 Set the spectrum analyzer RBW for 1 MHz with the VBW ≥ 3X RBW.

7.8.4 Set the center frequency of the spectrum analyzer to the center of the uplink operational band.

7.8.5 Set the span for 0 Hz with a single sweep time for a minimum of 330 seconds.

7.8.6 Start to capture a new trace using MAX HOLD.

7.8.7 After approximately 15 seconds turn on the EUT power.

7.8.8 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 was squelched.

7.8.9 Ensure the noise level for the squelched signal is below the uplink inactivity noise power limit, as specified by the rules.

7.8.10 Capture the plot for inclusion in the test report.

7.8.11 Measure noise using procedures in sections 7.7.1- 7.7.5.

7.8.12 Repeat steps 7.8.3 to 7.8.10 for all operational uplink bands.

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

7.9 Variable booster gain test procedure

This procedure shall be used to demonstrate compliance to the Booster Gain Limits specified for Wideband Consumer Signal Boosters in §21(e)(8)(i)(C). 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 with respect to determining the applicable MSCL value.

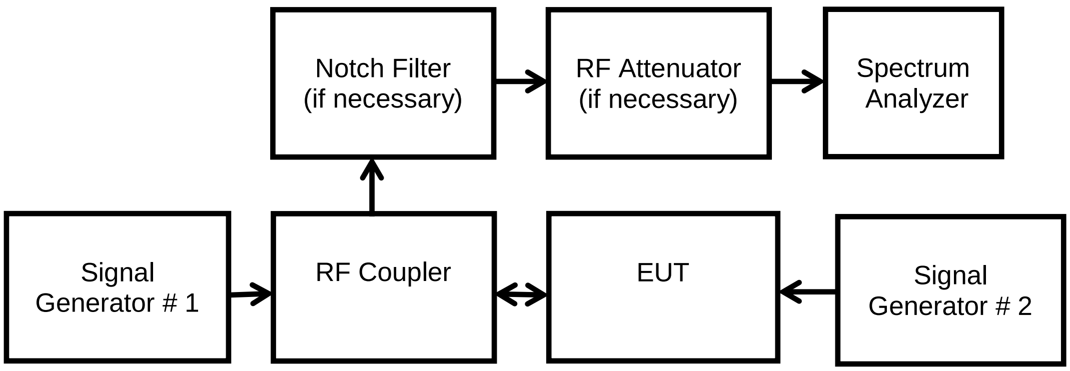


Figure 6 – Variable gain instrumentation test setup

7.9.1 Connect the EUT to the test equipment as shown in **Figure 6** with the uplink output connected to signal generator 1. Ensure the coupled path of the RF coupler is connected to the spectrum analyzer.

7.9.2 Configure downlink signal generator #1 for AWGN operation with an 99% occupied bandwidth of 4.1 MHz tuned to the center of the operational band.

7.9.3 Set the power level and frequency of signal generator # 2 to a value 5 dB below the AGC level from section 7.2. The signal type is AWGN with a 99% OBW of 4.1 MHz.

7.9.4 Set RBW = 100 kHz.

7.9.5 Set VBW ≥ 300 kHz.

7.9.6 Select the CHANNEL POWER measurement tool.

7.9.7 Select the RMS (power averaging) detector.

7.9.8 Ensure that the number of measurement points per sweep ≥ (2 x span)/RBW.

7.9.9 Sweep time = auto couple or as necessary.

7.9.10 Trace average at least 10 traces in power averaging (i.e., RMS) mode.

7.9.11 Measure the maximum channel power and compute maximum gain when varying the signal generator 1 to a level from -90 to -10 dBm 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.

7.9.12 Repeat 7.9.3 – 7.9.11 for all operational uplink bands.

7.9.13 Variable Uplink gain timing is to be measured as follows.

7.9.14 Set the spectrum analyzer to the uplink frequency to be measured.

7.9.15 Set the span to 0 Hz with a sweep time of 10 seconds.

7.9.16 Set the power level of signal generator 1 to the lowest level of the RSSI dependent gain.

7.9.17 Select MAX HOLD and increase the power level of signal generator 1 by 10 dB for mobile booster and 20 dB for fixed indoor boosters.

7.9.18 Ensure that the Uplink gain decrease to the specified levels within 1 second for mobile devices and 3 seconds for fixed devices.

7.9.19 Repeat 7.9.13 – 7.9.18 for all operational uplink bands.

7.10 Occupied bandwidth test procedure

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.

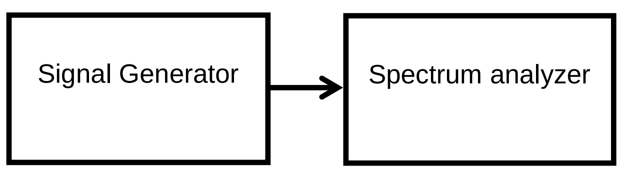


Figure 7 – Occupied bandwidth instrumentation test setup

7.10.1 Connect the test equipment as shown in **Figure 7** to measure the characteristics of the test signals produced by the signal generator.

7.10.2 Set VBW to ≥ 3X RBW

7.10.3 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.

7.10.4 Set the signal generator for power level to match the values obtained in section 7.2.

7.10.5 Set the signal generator modulation type for GSM with a PBRS pattern and allow the trace on the signal generator to stabilize adjusting the span as necessary.

7.10.6 Set the spectrum analyzer RBW for 1% to 5% of the emissions bandwidth.

7.10.7 Capture the spectrum analyzer trace for inclusion in the test report.

7.10.8 Repeat steps 7.10.3 – 7.10.7 for CDMA and WCDMA modulation adjusting the span as necessary for all uplink and downlink operational bands. [AWGN or LTE may be used in place of WCDMA, as an option]

7.10.9 Connect the test equipment as shown in **Figure 1**. Begin with the uplink output connected to the spectrum analyzer

7.10.10 Repeat steps 7.10.3 – 7.10.8 in this new configuration.

7.11 Oscillation detection test procedure

This measurement is required to demonstrate compliance to the Anti-Oscillation specification for Wideband Consumer Signal Boosters provided in §20.21(e)(8)(ii)(A).

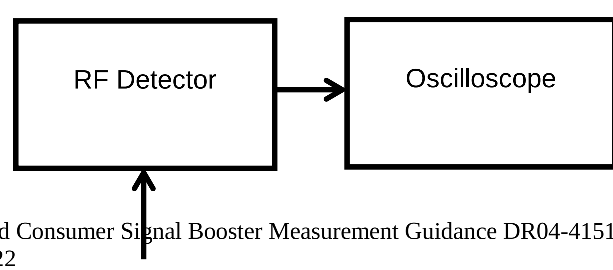
For this measurement two EUTs will be permitted, one operating in a normal mode and the second operating in a test mode that is capable of disabling the uplink inactivity squelching and or a reduction of the time between restarts to 5 seconds. This will greatly decrease the test time required.

7.11.1 Connect the EUT set for normal operation to the test equipment as shown in **Figure 8** beginning with the RF detector on the uplink output side of the RF path. Ensure that the RF coupled path is connected to the RF detector.

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

7.11.2 Set the oscilloscope for a positive edge trigger and single trigger operation.

7.11.3 Set the attenuation as necessary until the oscilloscope triggers and increase the attenuation level to a point 10 dB above that point.



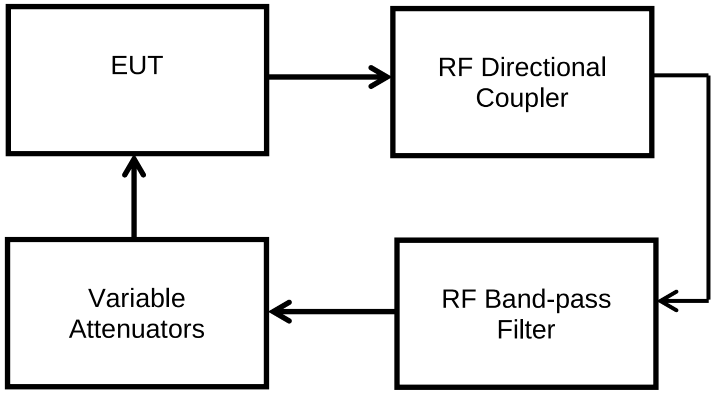


Figure 8 – Oscillation detection instrumentation test setup

7.11.4 Reset the trigger of the oscilloscope and reset the EUT with a power cycle.

7.11.5 Force the EUT to oscillate this will trigger the oscilloscope.

7.11.6 Use the CURSOR function of the oscilloscope to measure the time from the detection of oscillation until the EUT turns off by setting CURSOR 1 on the leading edge of the signal and CURSOR 2 on the trailing edge.

7.11.7 Capture the oscilloscope trace for inclusion in the test report.

7.11.8 Repeat steps 7.11.2 to 7.11.7 for all operational uplink and downlink bands.

7.11.9 Set the oscilloscope time base for longer than 1 minute and measure the restart time for each operational uplink and downlink band.

7.11.10 Replace the normal operating EUT for the EUT with the test mode.

7.11.11 Set the oscilloscope time base for a minimum 120 seconds with an AUTO Trigger and a single sweep.

7.11.12 Start the Oscilloscope and a manually force the booster into oscillation.

7.11.13 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.

7.11.14 Repeat steps 7.11.12 to 7.11.13 for all operational uplink and downlink bands.

Note: In lieu of an oscilloscope and RF detector, a spectrum analyzer set for 0 span, can be used to enhance sensitivity, with a center frequency set equal to the center of the operational band for broadband oscillation or a discrete frequency of oscillation. RBW shall be at least 1 MHz with VBW ≥ 3 times RBW using a peak detector.

7.12 Radiated spurious emissions test procedure

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 applicable to the band of operation (see Annex A).

7.12.1 Place the EUT on an OATS or Anechoic chamber turntable 3m from the receiving antenna. [4])

7.12.2 Connect the EUT to the test equipment as shown in **Figure 9** beginning with the uplink output

7.12.3 Set the signal generator for the center frequency of the operational band under test with the power level set at P_{IN} from section 7.2 with CW signal.

7.12.4 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 C63.4.

7.12.5 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.

7.12.6 Repeat steps 7.12.3 to 7.12.5 for all operational bands.

[4] Radiated emissions tests shall performed in accordance with the procedure in C63.10-2009. See KDB 971168 for conversion of field strength to ERP and EIRP.

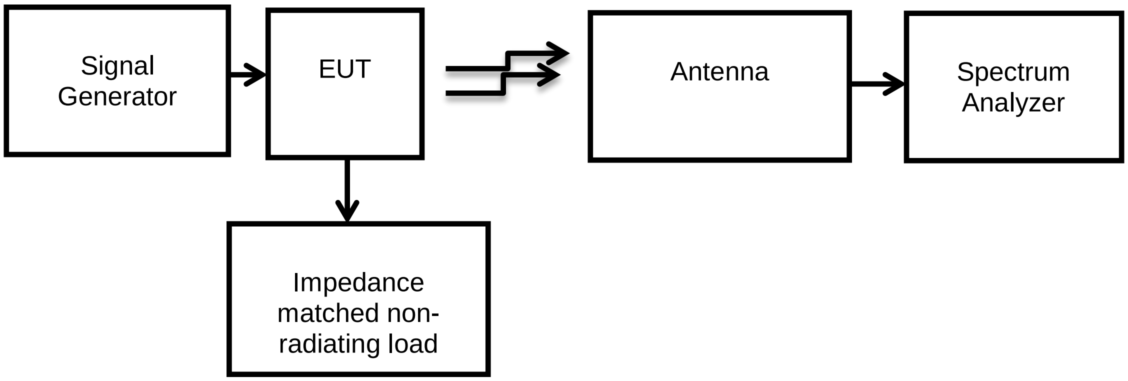


Figure 9 – Radiated spurious emissions instrumentation test setup

7.13 Spectrum block filtering test procedure

The following procedures are required only for wideband consumer boosters utilizing spectrum block filtering.[5]

7.13.1 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 section 7.1 for this comparison, with the trace data measurement points normalized for the uplink and downlink frequency bands.[6] If there are non-compliant measurement points for specific frequencies, use procedures in sections 7.13.2 and 7.13.3 for compliance.

7.13.2 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 sections 7.7.7 to 7.7.12 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 section 7.13.1. Set the signal generator and spectrum analyzer to the center of each 5 MHz of paired spectrum within the filtered spectrum blocks

[5] 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).

[6] 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).

that are not-compliant with section 7.13.1. Repeat test for all 5 MHz of paired spectrum within the filtered spectrum blocks that are not-compliant with section 7.13.1.[7]

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 as measured in sections 7.7.1 to 7.7.6, that do not exceed the uplink noise power limit specified in Transmitter Power Off Mode of FCC rules, meets the requirements of section 7.13.2.

7.13.3 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 sections 7.9.1 to 7.9.12 to measure the uplink gain within the filtered spectrum blocks, using Signal Generator #1 and #2 set to the center of each 5 MHz of paired spectrum within the filtered spectrum blocks that are not-compliant with section 7.13.1. Repeat test for all 5 MHz of paired spectrum within the filtered spectrum blocks that are not-compliant with section 7.13.1.

Note 3: For boosters with filtered spectrum blocks less than 5 MHz wide, use both signal generator 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 section 7.13.3.

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[7] For example, a wideband consumer booster with spectrum block filtering for the AWS-1 F Block showing non-compliance in section 7.13.1 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 section 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)	24(E): 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[1]	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)	22(H): 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(f)

[1] 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.

UE = user equipment; BS = base station; UL = uplink; DL = downlink

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 mobile Consumer Signal Booster Equipment applying for Certification under the FCC National Protection Standard (NPS) presented in the Part 20 rules.

B1. MSCL Definition

Mobile Station Coupling Loss (MSCL) is the minimum inside 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.[8] 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 indoors 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 Part 20.21(e)(8)(i)(G).

B3. MSCL Calculations & Measurements

Calculations should use the basic free-space propagation loss equation with an appropriate minimum separation distance (*i.e.*, 1 to 2 meters depending on the antenna type) [9] between the mobile device and booster server antenna for each uplink frequency band supported by the booster. 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.

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[8] §20.21(e)(8)(C)(1).

[9] For more information on appropriate separation distances see Section 6 below.

MSCL Measurements performed on fixed indoor boosters should include various mobile antenna orientations (*i.e.*, vertical, horizontal, slant 45 degrees) at appropriate heights above the floor (*i.e.*, 3 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 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 (*i.e.*, Dome-type) Antennas: These antennas are mounted at the ceiling (*i.e.*, ~8 feet 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 6 feet, or 2 meters distant). Thus, the minimum separation distance for this antenna type can be up to 6 feet (or 2 meters) 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.*, 4 to 6 feet 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 3 feet (or 1 meter) 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 6 feet (or 2 meters) 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.*, 2 to 3 feet 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 3 feet (or 1 meter) 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 USB modems, Jetpacks, MiFi, or other mobile devices sitting on the table adjacent to such antennas, an assumed minimum separation distance for determining MSCL shall not exceed 3 feet (or 1 meter).

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

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.

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.

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.

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.

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.

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.

Equipment Under Test (EUT): A device or system being evaluated for compliance that is representative of a product to be marketed.

Mobile Station Coupling Loss (MSCL): the minimum inside 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.

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.

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

percent of the total mean power contained within the fundamental emission (also known as the 99% bandwidth).

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.

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.

Received Signal Strength Indication (RSSI): 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.

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.

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.

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).

Wideband Consumer Signal Booster: A consumer signal booster that may operate on the frequencies and in the market areas of multiple licensees.