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September 9, 2013

Federal Communications Commission
Office of Engineering and Technology
Laboratory Division
445 12th Street SW
Washington, DC 20554

Re: Publication 935210 D03 - Consumer Signal Booster Procedure

Dear Sir or Madam:

AT&T Services, Inc., on behalf of its affiliates ("AT&T"), submits these comments on the Office of Engineering and Technology's ("OET") document #KDB935210D03 ("OET Report" or the "Document") entitled "Signal Boosters Certification Requirements."

AT&T appreciates the opportunity to comment on the proposed testing procedures. Overall, AT&T finds the OET's proposed testing protocol a useful and important beginning to the process of certifying signal boosters. In the attachment to this letter, AT&T offers some suggestions that it believes will improve the certification procedure for these devices.

In February of 2013, the FCC released an order[1] that codified the performance and basic test requirements associated with signal boosters intended for operation in the CMRS bands. Those requirements for signal booster certification are contained in section 20.21 of the Commission's rules.[2] The OET Report describes the proposed test procedures by which the FCC would certify signal boosters for use on wireless networks.

Attached[3] to these comments is an analysis by AT&T that compares the rules in §20.21 with the test procedures described in the OET Report.

In performing this analysis, AT&T identified some overall concerns in the testing methodology that can be cured relatively easily through minor changes to the Document.

1. Many of the tests include vague descriptions of the initial test equipment setup. We recommend a more detailed description of the initial test equipment setup.
2. Very few of the tests described in KDB93510D03 include any explicit pass/fail criteria, and most of the tests are extremely vague concerning the data which must be collected and included in the test report. We recommend explicit pass/fail criteria for

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[1] *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,* Report and Order, FCC 13-21 (February 20, 2013) ("Signal Booster Order").
[2] 47 C.F.R. § 20.21.
[3] Attachment 1, "Evaluation of the FCC OET Test Methodology for Cellular Boosters" ("Evaluation").

> all tests and a more detailed description of the data to be collected and included in the test report.
> 3. At least two tests include references to booster operating points which are undefined

AT&T identified some specific concerns with the testing procedures. One of the key protections that wireless providers sought in the signal booster proceeding was an automatic gain control ("AGC") to

> [P]rotect against excessive input signals that would cause output power and emissions in excess of that authorized by the Commission".[4]

Despite the importance of this rule, all of the tests described in the Document specifically call for the booster to be tested with a downlink signal level that's below the AGC threshold. As a result, there is no verification that the booster's AGC actually works. In addition, there is no verification that the booster's AGC will maintain the booster's output power and/or emissions levels within the limits stipulated by §20.21.

Another important protection from interference by malfunctioning boosters is the requirement for a booster to shut down when it cannot meet noise and gain limits.

> When the consumer booster cannot otherwise meet the noise and gain limits defined herein it must operate in "Transmit Power OFF Mode'. In this mode, the uplink and downlink noise power shall not exceed -70 dBm/MHz and uplink gain shall not exceed the lesser of 23 dB or MSCL.[5]

There is no test in the document to verify that this requirement is met.

Another test that the Document is missing is one to verify that boosters using unlicensed bands (e.g. Part 15, such as 802.11(x)) as a link between the "donor" and "server" booster subsystem employ avoidance technology to prevent interference with CMRS networks.

> Interference Avoidance for Wireless Subsystems. Consumer boosters using unlicensed (part 15) or other frequency bands for wireless transmissions between donor and server subsystems for its internal operations must employ interference avoidance methods to prevent interference transmitted into authorized CMRS spectrum bands.[6]

Because of the lack of a test procedure for this requirement, the OET test methodology cannot verify that the unlicensed link between the donor and server portions of the booster (if used) will not cause interference to CMRS operations.

AT&T offers some recommendations to correct these and other problems in the Document. The recommendations, which can found at pages 31 to 32 of Attachment 1, are:

[4] 47 C.F.R. §20.21(e)(8)(ii)(B).
[5] 47 C.F.R. §20.21(e)(8)(i)(H)
[6] 47 C.F.R. §20.21(e)(8)(ii)(C)

1. Modify Sections 7.2, 7.4, 7.5, 7.9 and 7.13 so that these tests include a supplementary test process which evaluates the parameter(s) under test using uplink and/or downlink input power levels which will cause the booster's output power to exceed its AGC threshold by at least 6 dB.
2. Add a test to validate the "transmit off" function called for by §20.21(e)(8)(i)(H).
3. Add a test to validate co-existence between an unlicensed donor/server link and the CMRS bands supported by the booster in compliance with §20.21(e)(8)(ii)(C).
4. The intermodulation distortion test in Section 7.4 is inadequate for boosters operating in today's complex RF environment. While the two-tone test currently specified must be retained to comply with §20.21(e)(8)(i)(F), a second, more strenuous wideband IMD test should be added to ensure that the Commission's IMD requirements are met when presented with an input signal with a wide bandwidth and high peak-to-average ratio.
5. Add very specific pass/fail criteria to all tests to avoid inconsistent device evaluation due to differences in FCC rule interpretations.
6. Define ambiguous terms such as "RSSI-dependent", "points above the limit", etc..
7. Add missing test setup or execution details.
8. Eliminate Section 7.10. Move the signal generator characterization previously included in 7.10 to the document's test prerequisites and expand test 7.1 to collect the booster's occupied bandwidth data for all applicable airlinks.

AT&T is grateful for this opportunity to comment on the OET's proposed testing methodology. The company believes that the analysis and recommendations contained in the attachment hereto offer some sensible and helpful improvements to the process OET has described in its draft publication.

Respectfully submitted,

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Evaluation of the FCC OET Test Methodology for Cellular Boosters

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1 Introduction

In February of 2013 the FCC released a Report & Order (FCC 13-21) which codifies the performance and basic test requirements associated with signal boosters intended for operation in the CMRS bands.

The purpose of this document is to compare the rules in §20.21 with the test procedures described by the FCC OET in their document #KDB935210D03.

The subsections in the "Test Case Description and Analysis" portion of this document are divided into two parts. The first part paraphrases the OET's current test methodology as described by KDB935210D03 in an attempt to make the OET's language easier to understand. The second part provides an analysis of each step of the OET's test methodology, including information concerning errors, omissions and discrepancies. The paraphrased text and associated analysis in this document only applies to wideband consumer boosters intended for installation in a fixed environment. Any unique test aspects pertaining to mobile boosters were not analyzed.

2 Test Case Description and Analysis

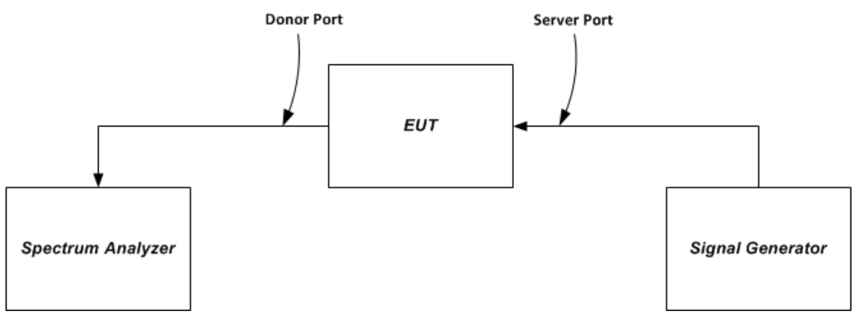
2.1 Authorized Frequency Band

2.1.1 Authorized Frequency Band Verification Methodology

According to KDB935210D03, the purpose of the test described in Section 7.1 is to confirm that the signal booster operates only in its authorized CMRS band(s). The test in Section 7.1 also determines what frequency corresponds to the maximum gain of the booster in each supported CMRS band and in each direction of operation.

The test setup is very simple, requiring a signal generator connected to one input of the booster (referred to in the procedure as the Equipment Under Test or EUT) and a spectrum analyzer connected to the output of the EUT as shown in Figure 2.1.2 below.

Figure 2.1.2 Authorized Frequency Band Test Equipment Configuration



The test equipment is configured as shown in Table 2.1.2:

Table 2.1.2 Equipment Configuration for Authorized Frequency Band Verification Test

Test Equipment	Parameter	Parameter Setting
Spectrum Analyzer	Center Frequency	Center of the CMRS band under test
Spectrum Analyzer	Resolution Bandwidth	100 kHz
Spectrum Analyzer	Video Bandwidth	300 kHz
Spectrum Analyzer	Span	1 MHz
Signal Generator	Modulation Mode	CW
Signal Generator	Frequency	Center of the CMRS band under test

The test begins by setting the test equipment according to Table 2.1.2 above:

2.1.2.1 Begin with the signal generator power level at least 6 dB below the EUT's AGC threshold. Increase the output power of the signal generator to the input level specified by the manufacturer as representing the AGC onset point.

2.1.2.2 Reduce the signal generator output power by 3 dB.

2.1.2.3 Increase the signal generator output power to a level within 0.5 dB of the onset of AGC (***Note:*** The procedure calls for the lab to ensure that the AGC threshold has not been reached, but provides no guidance as to how this can be determined.)

2.1.2.4 Set the span of the spectrum analyzer to twice the bandwidth of the CMRS band under test (e.g. span=120 MHz if testing an EUT intended for Band 2, 50 MHz for an EUT intended for Band 5, etc.).

2.1.2.5 Enable the signal generator's sweep function and set up the sweep to include the same frequency range as that employed by the spectrum analyzer in Step 2.1.2.4.

2.1.2.6 Set markers on the spectrum analyzer at the lower and upper CMRS band edge and a third marker at the frequency displaying the highest output power. Ensure that the EUT's AGC threshold has not been reached anywhere within the sweep range.

2.1.2.7 Capture the spectrum analyzer trace and repeat Steps 2.1.2.1 through 2.1.2.6 for both directions of the EUT in all bands supported by the EUT.

2.1.3 Authorized Frequency Band Verification Analysis

It appears that this test doesn't directly validate conformance to any §20.21 rule part. Instead, the information collected during this test is used in subsequent tests as part of their initial conditions. Also note that this test, in spite of its title, does not verify that the booster operates only within the frequency bands for which it's designed, as the lab must only save the data showing the amplifier's frequency response as a function of frequency. There is no guidance concerning the amplifier's gain outside each CMRS frequency band, so the data from this test appears to be entirely informative.

2.2 Maximum Power Measurement

2.2.1 Maximum Power Measurement Methodology

According to KDB935210D03, the purpose of the test described in Section 7.2 is to demonstrate compliance to the booster uplink and downlink power limits called for in §20.21(e)(8)(i)(D) as well as the uplink minimum power requirement called for in §20.21(e)(8)(i)(B).

The initial test setup is very simple, requiring a signal generator connected to the server input of the booster while the donor output of the booster (uplink) is connected to a spectrum analyzer[1]. This is the same test setup as that shown in Figure 2.1.2.

The test equipment is configured as follows:

Table 2.2.1 Equipment Configuration for Maximum Power Measurement Test

Test Equipment	Parameter	Parameter Setting
Spectrum Analyzer	Center Frequency	Frequency of highest gain from previous test
Spectrum Analyzer	Resolution Bandwidth	100 kHz
Spectrum Analyzer	Video Bandwidth	300 kHz
Spectrum Analyzer	Span	10 MHz
Spectrum Analyzer	Peak Detector	Max Hold
Signal Generator	Modulation Mode	CW
Signal Generator	Duty Cycle	12.5%
Signal Generator	Pulse Duration	570 μsec
Signal Generator	Frequency	Frequency of highest gain from previous test 7.1
Signal Generator	Output Power	At least 6 dB below the input power associated with onset of AGC action in EUT

1. For “server” and “donor” definitions, see FCC KDB935210D01, Page 12, Figures 2 and 3.

The test begins by setting the test equipment according to Table 2.2.1 above.

2.2.1.1 Increase the output power of the signal generator to the input level representing the EUT's AGC onset point (e.g. further increase in input power does not cause a corresponding linear increase in output power). ***Note:*** This step differs from Step 2.1.2.1 where the *manufacturer* is expected to provide the lab with information concerning the AGC threshold.

2.2.1.2 Reduce the signal generator output power to a level just below the AGC threshold.

2.2.1.3 Increase the signal generator output power until the EUT output power is within 0.5 dB of the AGC threshold. Document this power level as $P_{In\ Burst}$.

2.2.1.4 Using the $P_{In\ Burst}$ power from Step 2.2.1.2, measure the EUT output power using a spectrum analyzer mode appropriate for accurate measurement of pulsed signals and record the EUT's output power as $P_{Out\ Burst}$

2.2.1.5 Set the signal generator to create a bandlimited AWGN signal with a 99% occupied bandwidth of 4.1 MHz centered on the frequency which corresponds to maximum gain from Step 2.1.2.6. The AWGN signal must remain inside the CMRS band. If the frequency corresponding to maximum gain is less than 2.5 MHz from either CMRS band edge, the center of the AWGN signal must be moved so that it is 2.5 MHz away from the band edge.

2.2.1.6 Increase the signal generator output power until the power of the EUT's output signal is within 0.5 dB of the onset of AGC. Document this level as $P_{In\ AWGN}$.

2.2.1.7 Set the spectrum analyzer for RMS power measurement with sufficient measurement points to equal or exceed 2 x (span kHz/ RBW kHz).

2.2.1.8 Using the $P_{In\ AWGN}$ from Step 2.2.1.6, measure the EUT's average output power of the AWGN input signal over a total of 100 traces. The absolute power level from this measurement shall be documented as $P_{Out\ AWGN}$

2.2.1.9 Repeat Steps 2.2.1.1-2.2.1.8 for each band and each input/output port combination supported by the EUT.

2.2.2 Maximum Power Measurement Analysis

This test does not include any pass/fail criteria, even though the introduction states that the purpose of the test is to validate compliance to the booster power limits called for in §20.21(e)(8)(i)(D) and §20.21(e)(8)(i)(B).

This test will provide the following information:

- Input power corresponding to maximum booster output power when using a pulsed (GSM-like) CW input signal. This measurement is made in each direction and in every supported CMRS band. This data can be used to calculate the booster's gain when amplifying a pulsed CW signal whose output power is just below the booster's AGC threshold.
- Input power corresponding to maximum booster output power using an AWGN stimulus with a high peak-to-average ratio. This measurement is made in each direction and in every supported CMRS band. This data can be used to calculate the booster's gain when amplifying a signal that's similar to a 5 MHz LTE carrier with a high peak-to-average ratio and whose output power is just below the booster's AGC threshold.

One of the biggest problems in this test is that the wording is difficult to follow, and while the procedure above differentiates between $P_{In}/P_{out\ Burst}$ and $P_{In}/P_{out\ AWGN}$, the OET's procedure does not make this very important distinction.

The OET's procedure does not contain any information concerning the documentation of results to confirm EUT compliance. A table should be added to record $P_{In\ Burst}$, $P_{Out\ Burst}$, $P_{In\ AWGN}$ and $P_{Out\ AWGN}$ in each direction and in each supported CMRS band, with limits from the rules:

- Minimum uplink conducted power of 50 mW (+17 dBm)
- Maximum uplink conducted power of 1 W (+30 dBm)
- Maximum downlink conducted power of 50 mW (+17 dBm).

Lastly, this test is executed at an output power level below the AGC threshold, so any non-linearities due to AGC are not captured.

2.3 Maximum Booster Gain Computation

2.3.1 Maximum Booster Gain Computation Methodology

According to KDB935210D03, the purpose of the test described in Section 7.3 is to demonstrate compliance to the booster gain limits called for in §20.21(e)(8)(i)(C)(2) and the bidirectional gain requirements called for in §20.21(e)(8)(i)(B). According to the OET, bidirectional gain equivalence is defined as a gain imbalance between uplink and downlink of ≤ 9 dB.

For gain calculation, the OET uses the following formula:

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

The methodology simply calls for the lab to calculate the gain for each direction in each supported band based on the absolute measurements made during execution of test 7.2.

2.3.2 Maximum Booster Gain Computation Analysis

There are several aspects in which this calculation requires refinement. The first is that the previous test (7.2) included measurement of P_{In} and P_{Out} in terms of a pulsed input stimulus and in terms of an AWGN input stimulus, respectively. As a result, the gain expression above must be changed as follows:

$$\text{Gain}_{Pulse}\ \text{(dB)}=P_{Out\ Pulse}\ \text{(dBm)} - P_{In\ pulse}\ \text{(dBm)}$$

$$\text{Gain}_{AWGN}\ \text{(dB)}=P_{Out\ AWGN}\ \text{(dBm)} - P_{In\ AWGN}\ \text{(dBm)}$$

This change is necessary because the first test in 7.2 utilizes a pulsed CW input stimulus with a peak-to-average ratio of 0 dB (PEP). Therefore, the power measured at the input and output ports using a CW burst signal may not be the same as that measured when using a high peak-to-average AWGN input stimulus.

Lastly, §20.21(e)(8)(i)(C)(2) includes a formula which limits the booster's maximum uplink gain as a function of downlink RSSI and coupling loss between the booster's server antenna and the UE. The maximum uplink gain formula is:

$$-34\ \text{dB} - (\text{RSSI}) + \text{MSCL}$$

where RSSI = total integrated power in dBm at the booster's donor antenna terminal and MSCL = propagation loss between the UE and the booster's server antenna terminal in dB. According to

§20.21(e)(8)(i)(C)(2), the MSCL term assumed by the manufacturer must be included in the compliance report, but MSCL is not taken into consideration as part of this test.

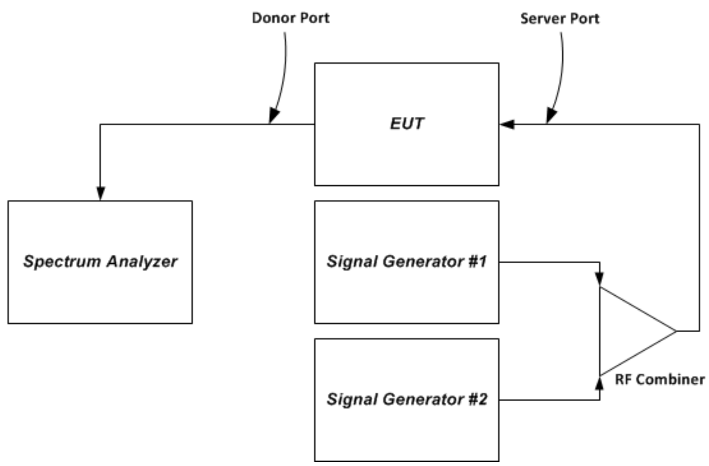
2.4 Intermodulation Product Measurement

2.4.1 Intermodulation Measurement Test Methodology

According to KDB935210D03, the purpose of the test described in Section 7.4 is to demonstrate compliance to the intermodulation limit called for in §20.21(e)(8)(i)(F). According to this rule part, IMD products shall not exceed -19 dBm.

The initial test setup is relatively simple, requiring two signal generators connected through an RF combiner to the server input of the EUT while the donor output of the EUT (uplink) is connected to a spectrum analyzer as shown in Figure 2.4.2 below.

Figure 2.4.2 Intermodulation Distortion Test Configuration



The test equipment is configured as follows:

Table 2.4.2 Equipment Configuration for Intermodulation Power Measurement Test

Test Equipment	Parameter	Parameter Setting
Spectrum Analyzer	Center Frequency	Center of the supported CMRS band under test
Spectrum Analyzer	Resolution Bandwidth	3 kHz
Spectrum Analyzer	Video Bandwidth	10 kHz
Spectrum Analyzer	Span	5 MHz
Spectrum Analyzer	Detector Type	RMS Detector
Signal Generator #1	Modulation Mode	CW
Signal Generator #2	Modulation Mode	CW

Test Equipment	Parameter	Parameter Setting
Signal Generator #1	Frequency	(Center of supported CMRS band)-300 kHz
Signal Generator	Frequency	(Center of supported CMRS band)+300 kHz

The test begins by setting the test equipment according to Table 2.4.2 above.

2.4.2.1 Enable the two signal generators at the same power and synchronously increase their power while monitoring the EUT's output power. The combined signal generator power shall be increased to a level just below that required for the EUT's output power to reach the EUT AGC threshold.

2.4.2.2 Using the combined signal generator input signal power described in Step 2.4.2.1, measure the EUT's output signal with a spectrum analyzer and confirm that no IMD products above -19 dBm are observed.

2.4.2.3 With the spectrum analyzer's Max Hold function enabled, place markers on any visible intermodulation products.

2.4.2.4 Save the spectrum analyzer trace as a record of the EUT's two-tone IMD performance.

2.4.2.5 Repeat Steps 2.4.2.1-2.4.2.4 for each band and each input/output port combination supported by the EUT.

2.4.3 Intermodulation Distortion Measurement Analysis

The most significant problem in this test methodology is that it utilizes a two-tone CW stimulus. A two-tone stimulus has a peak-to-average ratio (PAR) of 0 dB (PEP) per tone, and is not necessarily representative of the of signals the booster will be exposed to in the real world. When deployed, most boosters will see a number of input signals, almost all of which have a much higher PAR than CW. Thus, this test falls short of confirming that the booster can co-exist in a complex RF environment, and could easily result in the production of boosters that can cause interference in the field.

Another problem with this test methodology is that the procedure specifically calls for the use of input signal levels below the booster's AGC threshold. Such a test is appropriate for determining IMD levels when the booster is operating in its linear range, however, once the booster's AGC threshold is exceeded (which is likely to occur in real-world deployments), IMD levels could be significant depending upon the booster's design. At the very least, a second step should be included which measures the booster's 2-tone IMD performance at, say, 6 dB above the AGC threshold.

§20.21(e)(8)(i)(F) explicitly states that the IMD test must be executed using a two-tone stimulus. However, §20.21(e)(8)(i)(F) also states that the IMD test shall be executed with the EUT *"operating at maximum gain and maximized rated output power..."*. The OET's procedure seems to assume that the AGC threshold represents the maximum gain/ maximum power condition, but depending upon the EUT's AGC characteristics, this may or may not be entirely true.

It should be possible to modify this very important test so that it more accurately assesses the booster's performance under conditions emulating that of the real-world while still remaining within the rules defined by §20.21(e)(8)(i)(F). For example, the inclusion of a wideband IMD test stimulus in addition to the two-tone test described here would be appropriate. There is precedent in KDB935210D03 for the inclusion of a more stringent test methodology than that explicitly called for in the rules (see Section 2.7 of this document).

2.5 Out of Band Emissions Measurement

2.5.1 Out of Band Emissions Measurement Methodology

According to KDB935210D03, the purpose of the test described in Section 7.5 is to demonstrate the booster's compliance to the out-of-band emissions (OOBE) requirements called for in §20.21(e)(8)(i)(E). According to this rule part, OOBE shall not exceed a power level 6 dB below the associated mobile station OOBE limit. Since most CMRS bands below 1 GHz call for a mobile station OOBE limit of -13 dBm/100 kHz and most CMRS bands above 1 GHz call for a -13 dBm/1 MHz limit, the OOBE limit for a booster shall be either -19 dBm/100 kHz or -19 dBm/1 MHz, as applicable.

§20.21(e)(8)(i)(E) also states that *"..Compliance to OOBE limits will utilize high peak-to-average CMRS signal types"*.

The OOBE methodology calls for the use of GSM, LTE and CDMA as the input stimulus in order to meet the high peak-to-average requirements of §20.21(e)(8)(i)(E). The OOBE test utilizes standard industry procedures which will not be summarized in this paper.

2.5.2 Out of Band Emissions Measurement Analysis

Like all other tests in this document, the OOBE test is executed just below the EUT's AGC threshold, so any excessive emissions related to non-linearity once the booster's AGC threshold is exceeded are not captured. This is a very significant problem, and must be addressed since there is no guarantee that all input signals will remain below the EUT's AGC threshold. If all signals could be maintained below the AGC threshold, the AGC would be unnecessary.

2.6 Conducted Spurious Emissions Measurement

2.6.1 Conducted Spurious Emissions Measurement Methodology

According to KDB935210D03, the purpose of the test described in Section 7.6 is to demonstrate compliance to the conducted spurious emissions limits called for in §2.1051. This rule part applies to almost all devices going through FCC Type Acceptance.

The conducted spurious emissions test utilizes standard industry procedures which will not be summarized in this paper.

2.6.2 Conducted Spurious Emissions Measurement Analysis

Because this test uses standard conducted emissions test procedures and none of the procedures are specific to booster operation, no analysis of this test is required.

2.7 Noise Limit Measurement

2.7.1 Noise Limit Measurement Test Methodology

According to KDB935210D03, the purpose of the test described in Section 7.7 is to demonstrate compliance to the noise limits called for in §20.21(e)(8)(i)(A).

The initial test setup is very simple, requiring nothing more than a spectrum analyzer connected to the donor output of the booster (uplink) while the booster's server input is terminated in a 50-ohm load. This test verifies that the booster will meet the noise floor called for in the formulas included in §20.21(e)(8)(i)(A)(1)

Initially, the test equipment is configured as follows:

Table 2.7.1 Equipment Configuration for Terminated-Input EUT Noise Floor Test

Test Equipment	Parameter	Parameter Setting
Spectrum Analyzer	Center Frequency	Center of the supported CMRS band under test
Spectrum Analyzer	Resolution Bandwidth	1 MHz
Spectrum Analyzer	Video Bandwidth	3 MHz
Spectrum Analyzer	Span	Twice the width of the CMRS band under test (e.g. 120 MHz for Band 2)
Spectrum Analyzer	Detector Type	RMS Detector, Averaging over 100 traces

The test begins by setting the test equipment according to Table 2.7.1 above.

2.7.1.1 Terminate the EUT's server antenna port in a 50-ohm shielded load.

2.7.1.2 Using the spectrum analyzer's averaging function, measure the EUT's noise power at the donor port in a 1 MHz bandwidth

2.7.1.3 Save the spectrum analyzer trace as a record of the EUT's noise floor performance.

2.7.1.4 Repeat Steps 1-4 for each band and each input/output port combination supported by the EUT.

Once the noise floor of the booster has been measured with its input ports terminated in a shielded load, the test setup becomes much more complicated.

The first supplementary test utilizes a bandlimited AWGN signal on the downlink while measuring the EUT's noise floor on the uplink. See Figure 2.7.2 below. The associated test equipment settings are documented in Table 2.7.2 below.

Figure 2.7.2 .Uplink Noise Test Configuration

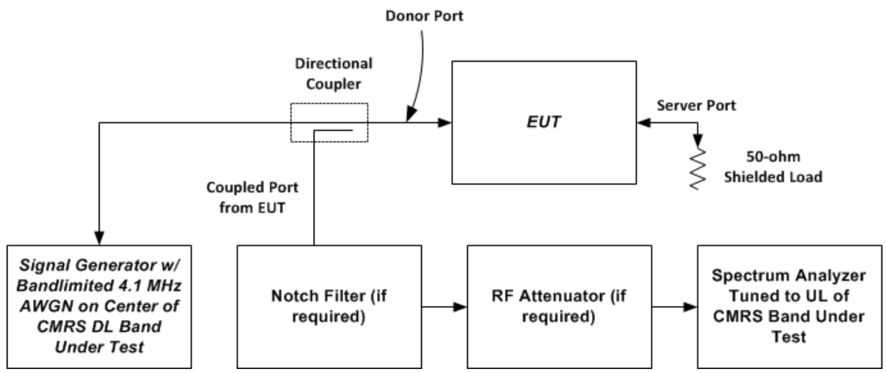


Table 2.7.2 Equipment Configuration for EUT Uplink Noise Floor Test

Test Equipment	Parameter	Parameter Setting
Spectrum Analyzer	Center Frequency	Center of the supported CMRS uplink band under test
Spectrum Analyzer	Resolution Bandwidth	1 MHz
Spectrum Analyzer	Video Bandwidth	3 MHz
Spectrum Analyzer	Span	Twice the width of the CMRS uplink band under test (e.g. 120 MHz for Band 2)
Spectrum Analyzer	Detector Type	RMS Detector, Averaging over 100 traces
Signal Generator	Modulation Type	Bandlimited AWGN, 4.1 MHz 99% occupied BW
Signal Generator	Center Frequency	Center of CMRS downlink band under test

The supplementary test methodology is described below:

2.7.2.1 With the signal generator connected as shown in Figure 2.7.2, measure the maximum uplink noise power as the downlink signal generator output power is varied from -90 dBm to -10 dBm in 1 dB steps inside the "RSSI dependent region" and in 10 dB steps "outside the RSSI-dependent region".

2.7.2.2 Report the six downlink power values and frequencies closest to the limit with at least two of these six points obtained within the "RSSI-dependent" region

2.7.2.3 Repeat steps 2.7.2.1 and 2.7.2.2 for each supported CMRS band

The supplementary test continues with the configuration shown in Figure 2.7.3 below and equipment settings as shown in Table 2.7.3 below

Figure 2.7.3 Downlink Noise Test Configuration

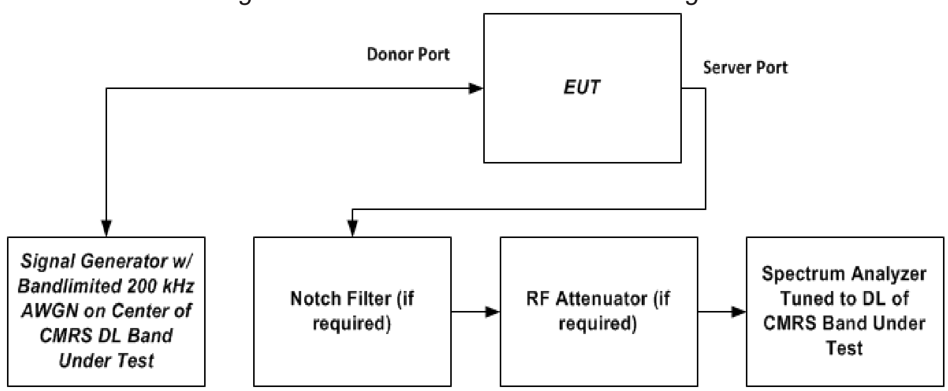


Table 2.7.3 Equipment Configuration for EUT Uplink Noise Floor Test

Test Equipment	Parameter	Parameter Setting
Spectrum Analyzer	Center Frequency	Center of the supported CMRS downlink band under test
Spectrum Analyzer	Resolution Bandwidth	1 MHz
Spectrum Analyzer	Video Bandwidth	3 MHz
Spectrum Analyzer	Span	Twice the width of the CMRS uplink band under test (e.g. 120 MHz for Band 2)
Spectrum Analyzer	Detector Type	RMS Detector, Averaging over 100 traces
Signal Generator	Modulation Type	Bandlimited AWGN, 200 kHz 99% occupied BW
Signal Generator	Center Frequency	Center of CMRS downlink band under test

2.7.3.1 With the signal generator connected as shown, measure the maximum downlink noise power as the downlink signal generator output power is varied from -90 dBm to -10 dBm in 1 dB steps inside the “RSSI dependent regain” and in 10 dB steps “outside the RSSI-dependent region”.

2.7.3.2 Tune the downlink signal generator from the low end of the CMRS band under test to the high end of the CMRS band under test, looking for downlink frequencies that create the most downlink noise.

2.7.3.3 Report the six downlink power values and frequencies closest to the limit with at least two of these six points obtained within the “RSSI-dependent” region of the limit.

2.7.3.4 Repeat steps 2.7.3.1 through 2.7.3.3 for each supported downlink CMRS band

The supplementary methodology continues still further with an “Uplink Noise Timing” test.

Table 2.7.3 Equipment Configuration for EUT Uplink Noise Timing Test

Test Equipment	Parameter	Parameter Setting
Spectrum Analyzer	Center Frequency	Center of the supported CMRS uplink band under test
Spectrum Analyzer	Resolution Bandwidth	1 MHz
Spectrum Analyzer	Video Bandwidth	3 MHz
Spectrum Analyzer	Span	Zero span
Spectrum Analyzer	Detector Type	RMS detection
Spectrum Analyzer	Sweep Time	1 second
Signal Generator	Modulation Type	Bandlimited AWGN, 4.1 MHz BW
Signal Generator	Center Frequency	Center of CMRS DL band under test

2.7.3.1 Using the configuration shown in Figure 2.7.3, configure the test equipment settings to those described in Table 2.7.3.

2.7.3.2 Set the downlink signal generator to the lowest level which will generate “RSSI dependent” noise.

2.7.3.3 Change the spectrum analyzer to Max Hold and increase the downlink signal generator power by 20 dB.

2.7.3.4 Measure the amount of time required to observe a decrease in uplink noise, which must occur within 3 seconds.

2.7.3.5 Repeat steps 2.7.3.1 through 2.7.3.4 above for all uplink CMRS bands supported by the EUT.

2.7.4 Noise Limit Measurement Analysis

Without question, this is the most complicated test described in KDB935210D03. It's also interesting to note that the test methodology goes well beyond what's required by the rules in §20.21(e)(8)(i)(A).

There are two noise limits defined by §20.21(e)(8)(i)(A). The first is defined in §20.21(e)(8)(i)(A)(*1*), and the OET refers to it as "transmitted noise power", specified in dBm/MHz. This noise term pertains to both the uplink and the downlink, and the formula for transmitted noise power is:

$$(-103\ \text{dBm/MHz}) - (\text{RSSI})$$

where RSSI = total integrated power in the *downlink* from all donor cells within a CMRS band, expressed in dBm and measured at the booster's donor antenna port. An interesting aspect of this formula is that the RSSI term has no bandwidth associated with it, so it simply represents a measurement of total power in the CMRS downlink band as seen by the booster. If there is no input signal (only thermal noise), the rules aren't clear as to how a lab shall calculate the noise power to be used with this formula. If we assume that the OET intended to use a noise bandwidth equal to the width of the CMRS band, and if we assume that the EUT being tested is operating in 3GPP Band 2 (PCS Band), the thermal noise power would be -96.2 dBm/60 MHz, resulting in a "transmitted noise power" of -6.8 dBm, which is very high when you consider that the maximum allowable downlink power from the booster is +17 dBm (the maximum uplink power from a booster is +30 dBm).

The second noise aspect is defined in §20.21(e)(8)(i)(A)(2)(*i*) and is referred to as "transmitted maximum noise power" in dBm/MHz. This noise term also applies to the uplink and the downlink, and the formula is:

$$(-102.5\ \text{dBm/MHz}) + (20(\log_{10}F_C))$$

where F_C is the center frequency of the uplink CMRS band under test.

Under this rule, if we assume a shielded load connected to the booster's server port and the booster operating in 3GPP Band 2, the transmitted maximum noise power on the booster's donor port must not exceed -37.0 dBm according to the formula above. The same would be true if we reversed the port connections to calculate the maximum noise power on the downlink.

We now have two definitions for noise power. The first definition is dependent on total downlink power in an undefined bandwidth (where the total power can include both desired and undesired downlink CMRS signals). The second definition is dependent on operating frequency. With no CMRS signal input (thermal noise only), the first formula allows the booster's noise power to be 30.2 dB higher than the noise power calculated by the second formula.

It would help considerably to obtain some information from the OET as to the need for both noise formulas. Since the formula in §20.21(e)(8)(i)(A)(2)(*i*) is the most stringent, it appears to be the only one required and the one upon which all booster noise compliance is assessed.

If we turn to the test methodology, we find that the first portion does verify that the booster's noise limits are met with the booster's input terminated (which is required by §20.21(e)(8)(iii)), but this is only a small part of the test process. The remainder of the test process involves measurement of noise with a signal present, which seems to be the portion of the methodology that the OET is most interested in[2].

At no point does the methodology state what the noise limits are. Instead, it appears to be the responsibility of the lab to determine them. In addition, the methodology calls out "RSSI-dependent" and "non RSSI-dependent" regions of operation. These terms are not defined anywhere. Likewise, the methodology in Section 7.7 calls for the lab to report the "six downlink power values and frequencies closest to the limit with at least two of these six points obtained within the RSSI-dependent region". There are no limits called out in this methodology, so it isn't clear how a lab would identify these six points.

Overall, the OET's noise test is very complicated and includes terms that are not defined, so it's unlikely that the FCC would see consistent lab results from the TCBs.

2. FCC OET KDB935210D01 or FCC-13-21, Annex B, (5) and (6)

2.8 Uplink Inactivity Measurement

2.8.1 Uplink Inactivity Test Methodology

According to KDB935210D03, the purpose of the test described in Section 7.8 is to demonstrate compliance with the uplink inactivity limit called for in §20.21(e)(8)(i)(I).

The test setup is very simple, with the donor output of the EUT (uplink) connected to a spectrum analyzer and the server input terminated with a shielded load.

The test equipment is configured as follows:

Table 2.8.1 Equipment Configuration for Uplink Inactivity Measurement Test

Test Equipment	Parameter	Parameter Setting
Spectrum Analyzer	Center Frequency	Center of the supported uplink CMRS band under test
Spectrum Analyzer	Resolution Bandwidth	1 MHz
Spectrum Analyzer	Video Bandwidth	3 MHz
Spectrum Analyzer	Span	Zero span
Spectrum Analyzer	Sweep Time	330 seconds
Spectrum Analyzer	Detector Type	RMS

The test begins by setting the test equipment according to Table 2.8.1 above.

2.8.1.1 With the EUT turned off, select the RMS detection mode on the spectrum analyzer.

2.8.1.2 Initiate a single 330 second sweep with Max Hold enabled on the spectrum analyzer.

2.8.1.3 Apply power to the EUT approximately 15 seconds after the sweep in Step 2.8.1.2 was initiated. Wait for the sweep to complete.

2.8.1.4 Place a marker at the leading edge of the amplifier's noise pulse and a second marker a the trailing edge of the noise pulse (this measures the amount of time that the EUT was un-squelched)

2.8.1.5 Verify that the measured noise level (when the EUT is squelched) is below the -70 dBm/MHz uplink inactivity noise power limit specified in §20.21(e)(8)(i)(I).

2.8.1.6 Repeat Steps 2.8.1.1 through 2.8.1.5 for each CMRS uplink band supported by the EUT.

2.8.2 Uplink Inactivity Measurement Analysis

This test is very straightforward in that it simply measures the uplink noise power without any downlink or uplink signal present while the booster is operating in a squelched mode and an unsquelched mode. The rules in §20.21(e)(8)(i)(I) state that the idle noise power (when the booster is squelched) shall be limited to no more than -70 dBm/MHz. This test also measures the amount of time that the booster is unsquelched in between uplink transmissions. §20.21(e)(8)(i)(I) states that the EUT may remain in an unsquelched state for no more than five minutes, at which point the EUT must squelch itself and limit its noise power to the -70 dBm/MHz level mentioned previously. This test verifies both aspects of this rule part using a straightforward approach. As with other tests in this document, the test methodology lacks pass/fail criteria, even though the criteria is clearly stated in the associated rule part.

2.9 Variable Booster Gain Measurement

2.9.1 Variable Booster Gain Test Methodology

According to KDB935210D03, the purpose of the test described in Section 7.9 is to demonstrate compliance to the variable booster gain limits called for in §20.21(e)(8)(i)(C). This rule part includes rules concerning booster gain limits based on RSSI and/or operating frequency. Compliance to §20.21(e)(8)(i)(C) was also validated in Test 7.3 (Section 2.3 of this document). However, this test focuses on the variable-gain aspect of a booster, and references the fact that the booster's gain is limited as a function of downlink RSSI and uplink MSCL. The test in Section 7.3 was simply a calculation of booster gain without regard to the RSSI and MSCL dependencies.

The test setup requires two signal generators, a notch filter, and a spectrum analyzer connected as shown in Figure 2.9.2 below:

Figure 2.9.2 Variable Booster Gain Test Configuration

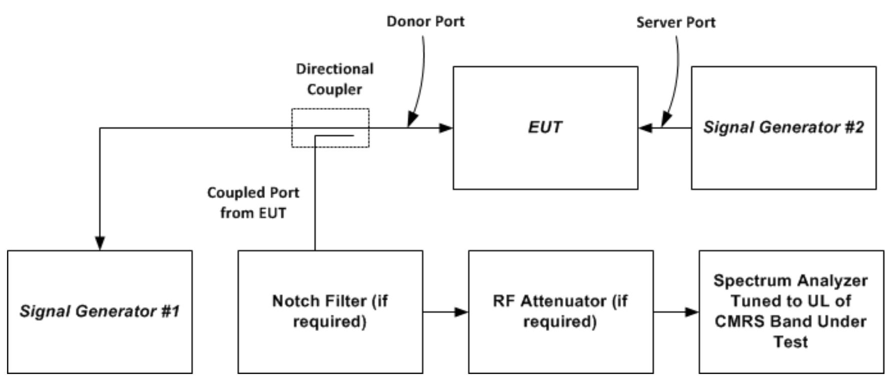


Table 2.9.2 Equipment Configuration for Variable Booster Gain Test

Test Equipment	Parameter	Parameter Setting
Spectrum Analyzer	Center Frequency	Center of the supported CMRS uplink band under test
Spectrum Analyzer	Resolution Bandwidth	1 MHz
Spectrum Analyzer	Video Bandwidth	3 MHz
Spectrum Analyzer	Span	Twice the width of the CMRS band under test (e.g. 120 MHz for Band 2)
Signal Generator #1	Center Frequency	Center of the supported CMRS downlink band under test
Signal Generator #1	Modulation Type	Bandlimited AWGN, 4.1 MHz 99% OBW

Test Equipment	Parameter	Parameter Setting
Signal Generator #2	Center Frequency	Frequency associated with greatest gain in the CMRS band under test (from Section 7.1)
Signal Generator #2	Modulation Type	Bandlimited AWGN, 4.1 MHz 99% OBW

The test begins by setting the test equipment according to Table 2.9.2 above.

2.9.2.1 Ensure that Signal Generator #2 is set to a power level 5 dB below the AGC threshold described in Test 7.2 of the OET's procedure (Section 2.2 of this document). Also ensure that Signal Generator #2 is set to the uplink frequency corresponding to maximum gain as determined by the test described in Section 7.1.

2.9.2.2 Setup the spectrum analyzer to make a channel power measurement using an RMS detector. Ensure that the number of measurement points per sweep is ≥ twice the span (kHz)/RBW (kHz). All measurements shall average at least 10 traces

2.9.2.3 Measure the channel power of the 4.1 MHz AWGN input stimulus while varying the output level of Signal Generator #1 from -90 dBm to -10 dBm in 1 dB steps inside the RSSI-dependent region of operation and in 10 dB steps outside the RSSI-dependent region of operation, reporting the six values closest to the limit, which must include at least two points from within the RSSI-dependent region of operation.

2.9.2.4 Repeat Steps 2.9.2.1-2.9.2.3 for each band and direction supported by the EUT.

The OET's procedure continues with a series of steps which measure the EUT's AGC attack time:

2.9.2.5 With the test equipment connected as shown in Figure 2.10.2, disable the output from Signal Generator #1 but leave Signal Generator #2 as configured in Step 2.9.2.1.

2.9.2.6 Set the spectrum analyzer to zero span centered on the uplink frequency to be measured. Set the spectrum analyzer to single sweep with a sweep time of 10 seconds and display set to Max Hold.

2.9.2.7 Enable the output from Signal Generator #1 at a low level (approx -100 dBm) and increase it to the lowest level which results in RSSI-dependent gain.

2.9.2.8 Start the spectrum analyzer sweep and within 2 seconds increase the level from Signal Generator #1 by 20 dB. Allow the spectrum analyzer's sweep to complete.

2.9.2.9 Review the spectrum analyzer trace, verifying that the uplink gain decreases within 3 seconds of the time at which the level from Signal Generator #1 was increased by 20 dB.

2.9.2.10 Repeat steps 2.9.2.5 through 2.9.2.9 for all uplink bands supported by the EUT

2.9.3 Variable Booster Gain Test Analysis

In many respects, the variable gain test described in Section 7.9 of KDB935210D03 is very similar to the noise limit tests described in Section 7.7. It's not clear why the first portion of this test was broken out into a separate section, and like Section 7.7, the test purpose explicitly references the booster's gain dependency on downlink RSSI and declared uplink MSCL, but neither of these two terms are taken into consideration in the test procedure.

Like the procedure in Section 7.7, the OET relies on terms that are undefined, such as the "RSSI-dependent" and "points above the limit". These two terms must be defined, as it's unlikely that any two labs would return the same results for a given device when these operating points are vague.

This test methodology also includes a procedure to verify the attack time of the booster's AGC, confirming that it responds to large signal increases within 3 seconds. I don't see this 3-second requirement anywhere in the rules. Also, this portion of the test procedure is extremely vague, since it does not call out the initial power setting for Signal Generator #2 and it does not call for the use of a single sweep of the spectrum analyzer (these two details were added in my paraphrased procedure). Both of these omissions must be addressed in order to ensure consistent results between labs.

2.10 Occupied Bandwidth Measurement

2.10.1 Occupied Bandwidth Measurement Methodology

The first portion of this test calls for the lab to characterize GSM, CDMA and W-CDMA test signals provided by the signal generators. Specifically, the OET is expecting the lab to capture traces which show the signal generator's occupied bandwidth and related characteristics. The procedure also allows the lab to substitute AWGN or LTE for W-CDMA. Once the occupied bandwidth characteristics of the test equipment has been documented, the same test is repeated with the EUT in line, and the process at this point appears to be a repeat of the procedure from Section 7.1. This is one of the few tests in this document which does not explicitly require avoidance of AGC action.

2.10.2 Occupied Bandwidth Measurement Analysis

This test contains the least information of any test in this document. It's not clear why test equipment characterization was even included as a separate test, since such a characterization really should be a prerequisite to the execution of the overall test suite described in KDB935210D03. If the OET had taken this approach, then there would be no need for this test, as Section 7.1 could be used to obtain the occupied bandwidth information called for in Section 7.10.

2.11 Oscillation Detection Testing

2.11.1 Oscillation Detection Test Methodology

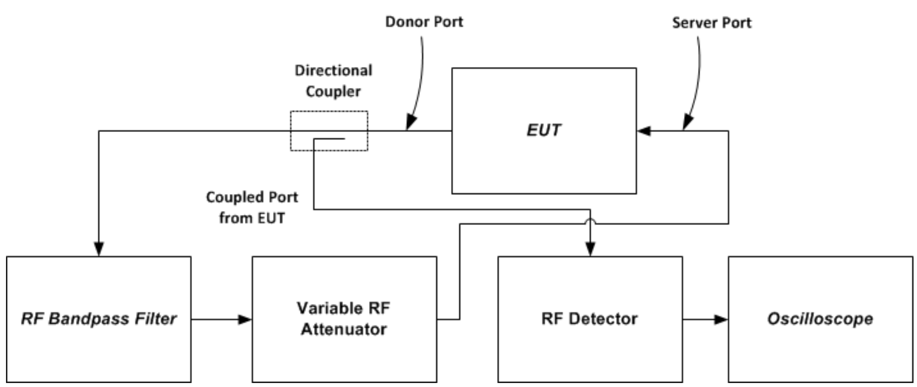
According to KDB935210D03, the purpose of the test described in Section 7.11 is to demonstrate compliance to the to the anti-oscillation requirements called for in §20.21(e)(8)(ii)(A).

This test is unique in that it allows the use of two EUTs. The first EUT must be a production unit configured as it will be sold to consumers.

The second EUT, if used, must include a "test mode". The test mode enables an anti-oscillation timer value that's significantly shorter than that used in a production booster. While the timeout value is not specified in this procedure, it should probably be set to no more than 10 seconds in order to ensure that the lab will detect any anomalous operation.

The test setup is shown in Figure 2.11.2 below:

Figure 2.11.2 Oscillation Test Equipment Configuration



The test procedure follows:

2.11.2.1 Connect the EUT to the test equipment as shown in Figure 2.11.2. Ensure that the RF bandpass filter displays minimal attenuation in the CMRS band under test but displays sufficient attenuation to prevent oscillation due to feedback in the other CMRS bands supported by EUT. Ensure that the variable attenuator is set such that the EUT will not oscillate.

2.11.2.2 Set the oscilloscope for DC input coupling, a single sweep of 10 seconds, and automatic, positive-edge triggering. Confirm that the oscilloscope will trigger on the presence of a low-level signal (e.g. -50 dBm) from the EUT.

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

2.11.2.4 Slowly reduce the setting of the variable attenuator until the EUT begins to oscillate, which will create a DC output from the RF detector feeding the oscilloscope (which will trigger the sweep). Allow the oscilloscope trace to complete.

2.11.2.5 Place a time marker at the beginning of the oscilloscope trace and a time marker on the trailing edge of the trace. The trailing edge corresponds to the point at which the oscillation was disabled by the EUT.

2.11.2.6 Capture the trace from Step 2.11.2.5 and include this information in the test report.

2.11.2.7 Repeat Steps 2.11.2.1 through 2.11.2.6 for all uplink and downlink CMRS bands supported by the EUT.

2.11.2.8 After returning to the initial conditions called for in Steps 2.11.2.1 through 2.11.2.3, change the oscilloscope sweep time to 120 seconds and change the EUT to a device which includes a “test mode”.

2.11.2.9 Slowly decrease the setting of the variable attenuator until the EUT begins to oscillate, which will trigger the oscilloscope sweep.

2.11.2.10 Once the sweep has completed, place a time marker at the first trailing edge observed in the trace and place a second time marker at the rising edge of the next output burst from the EUT. Validate that the amount of time between shutdown events due to oscillation conforms to the manufacturer’s anti-oscillation timing value for this “test mode” EUT. Also validate that the EUT does not “restart” (cycle between RF disabled and RF enabled) more than 5 times, but instead shuts down completely.

2.11.2.11 Repeat steps 2.11.2.8 through 2.11.2.10 for all uplink and downlink CMRS bands supported by the EUT.

2.11.3 Oscillation Detection Test Analysis

Like the test described in Section 7.9 of KDB935210D03, this test is lacking several important details concerning the test equipment configuration. For example, the procedure fails to note that the oscilloscope must be configured to trigger on what may be a relatively low-level DC signal from the RF detector when EUT oscillation begins. There is no guidance concerning the minimum power level which must trigger the oscilloscope. In addition, the oscilloscope must be set up for DC coupling to trigger properly based on the DC signal from an RF detector.

It's important to point out that the directional coupler, while necessary to isolate the RF detector from the DUT, introduces a unique measurement uncertainty aspect. Specifically, the direction coupler in Figure 2.11.2 above is connected such that RF from the EUT's donor port will be coupled to the RF detector. This allows the oscilloscope to be triggered when a feedback loop is established from the EUT's donor port to its server port. However, since the EUT is bidirectional, there could be some cases where the EUT oscillates due to feedback from the server port to the donor port. Because of the relatively high coupling loss in the reverse direction, the oscilloscope will not be triggered. and this behavior will not be observed. This problem can be remedied by inserting an RF isolator between the directional coupler and the RF bandpass filter, thus ensuring that feedback can only take place in one direction. The test methodology should be modified so that the configuration in Figure 2.11.2 above is required specifically for donor-server port feedback tests. A new figure, which reverses the EUT ports, should be included for server-donor port feedback tests. The latter feedback mode is not described in the present document.

In this procedure, the OET does not include any specifications for the anti-oscillation timer used for the "test mode" EUT. This is very important, because the OET's procedure looks for oscillation/shutdown/restart to occur within a 2-minute period. In addition to verifying that the booster complies with the EUT's inter-event timer (the value of which is chosen by the manufacturer), the procedure also verifies that the EUT will only try to restart a total of five times, at which point it's supposed to shutdown entirely. If the inter-event timer is too long, the lab may see five restarts but they may not have been aware that the EUT was ready to begin a sixth restart just after the oscilloscope concluded its 2-minute sweep. This "test mode" timer value and its tolerance should be specified by the OET.

2.12 Radiated Spurious Emissions Measurement

2.12.1 Radiated Spurious Emissions Measurement Methodology

According to KDB935210D03, the purpose of the test described in Section 7.12 is to demonstrate compliance to the radiated spurious emissions limits called for in §2.10513.This rule part applies to almost all devices going through FCC Type Acceptance.

The radiated spurious emissions test utilizes standard industry procedures which will not be summarized in this paper.

2.12.2 Radiated Spurious Emissions Measurement Analysis

Because this test uses standard radiated emissions test procedures and none of the procedures are specific to booster operation, no analysis of this test is required.

2.13 Spectrum Block Filtering

2.13.1 Spectrum Block Filtering Measurement Methodology

This portion of the document does not cite any particular sections on the rules, nor does it indicate why the test is required. The tests in this section appear to have been added to better understand the characteristics of boosters which utilize filters to limit their operational bandwidth to some pre-defined portion of a CMRS band. For example, a carrier whose spectrum holdings are primarily in 3GPP Band 2 (PCS), Block B, might deploy boosters which attenuate all Band 2 signals except those in Block B.

2.13.2 Radiated Spurious Emissions Measurement Analysis

Because this test is intended for special cases where the amplifier only supports a selected portion of any given CMRS band, an analysis is unnecessary because this test repeats KDB935210D03 Section 7.1 and portions of Section 7.7, both of which have been reviewed earlier in this document.

3 Conclusion

This paper provides a detailed analysis of each test proposed for Type Acceptance of cellular boosters. From this analysis, the following concerns have been identified:

1. Many of the tests include vague descriptions of the initial test equipment setup.
2. Several tests skip important steps, apparently assuming that the lab knows that these unwritten steps are required as part of normal lab procedures.
3. Very few of the tests described in KDB93510D03 include any explicit pass/fail criteria, and most of the tests are vague concerning the data which must be collected and included in the test report.
4. At least two tests include references to booster operating points which are undefined.
5. Because pass/fail criteria is lacking in almost all tests, it's the lab's responsibility to determine whether a device has met the conformance criteria. In several cases the FCC rules in §20.21 are not clear, so pass/fail decisions could vary by lab just on the basis of each lab's interpretation of the rules.

The concerns listed above are reasonably simple to resolve through relatively minor changes to the document. However, there are several problems which can only be resolved by re-writing a portion of the test plan:

a. **Emissions and Power Levels with Gain Limiting:** FCC §20.21(e)(8)(ii)(B) states that boosters must have "automatic limiting control "(e.g. AGC) to *"...protect against excessive input signals that would cause output power and emissions in excess of that authorized by the Commission"*. This is a very important rule part, however, all of the tests described in this document where AGC may be invoked specifically call for the booster to be tested with a downlink signal level that's below the AGC threshold. As a result, there is no verification that the booster's AGC actually works. In addition, there's no verification that the booster's AGC implementation does not create an output power or level of emissions in excess of that allowed by the rules. Since interference caused by overloaded boosters with insufficient linearity is one of our primary concerns, several tests must be modified to include evaluation of performance with AGC.

b. **Transmitter Off Mode:** §20.21(e)(8)(i)(H) states that *"When the consumer booster cannot otherwise meet the noise and gain limits defined herein it must operate in "Transmit Power OFF Mode" In this mode, the uplink and downlink noise power shall not exceed -70 dBm/MHz and uplink gain shall not exceed the lesser of 23 dB or MSCL."*. This is another important rule that's closely associated with (a) above. However, there is no test in this document to verify that this rule has been met. Instead, there is a test (7.8) which simply verifies that the booster's noise power does not exceed -70 dBm/MHz when in the squelched state. The test does not verify that the booster will enter the squelched state if it cannot meet the noise and gain limits specified in §20.21.

c. **Interference to CMRS Bands from Unlicensed Bands:** Another oversight in the OET's test methodology pertains to §20.21(e)(8)(ii)(C). This rule states that boosters using unlicensed bands (e.g. Part 15, such as 802.11(x)) as a link between the "donor" and "server" booster subsystem must *"employ interference avoidance methods to prevent interference transmitted into authorized CMRS spectrum...."*. KDB935210 does not contain any tests which verify that the unlicensed link between the donor and server portions of the booster (if used) will not cause interference to CMRS operations.

Recommendations:

Based on the inconsistencies noted above, the following changes are recommended:

1. Modify Sections 7.2, 7.4, 7.5, 7.9 and 7.13 so that these tests include a supplementary test process which evaluates the parameter(s) under test using uplink and/or downlink input power levels which will cause the booster's output power to exceed its AGC threshold by at least 6 dB.
2. Add a test to validate the "transmit off" function due to excess noise and/or gain called for by §20.21(e)(8)(i)(H).
3. Add a test to validate co-existence between an unlicensed donor/ server link and the CMRS bands supported by the booster in compliance with §20.21(e)(8)(ii)(C).

4. The intermodulation distortion test in Section 7.4 is inadequate for boosters operating in today's complex RF environment. While the two-tone test currently specified must be retained to comply with §20.21(e)(8)(i)(F), a second, more strenuous wideband IMD test should be added to ensure that the Commission's IMD requirements are met when the booster is presented with an input signal displaying a high peak-to-average ratio.
5. Add very specific pass/fail criteria to all tests to avoid inconsistent device evaluation due to differences in FCC rule interpretations.
6. Define ambiguous terms such as "RSSI-dependent", "points above the limit", etc. noted in the "Analysis" portion of the preceding sections.
7. Add missing test setup or execution details, such as those documented in the "Analysis" portion of the preceding sections.
8. Eliminate Section 7.10. Move the signal generator characterization previously included in 7.10 to the document's test prerequisites and expand test 7.1 to collect the booster's occupied bandwidth data for all applicable airlinks.