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Title: Guidelines for Compliance Testing of Unlicensed National Information Infrastructure (U-NII) Devices - Part 15, Subpart E

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First Category: Administrative Procedures

Second Category: Measurement Procedures

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Question: What are the general test procedures for measuring compliance of U-NII devices to Section 15.407 Requirements?

Answer: The Attachment below - 789033 D01 UNII General Test Procedures v01- provides test procedure guidance for measuring compliance to the general technical requirements of Section 15.407.

This test procedure replaces and supersedes guidance contained in Public Notice DA 02-2138 of August 30, 2002.[1] Procedures for evaluating Dynamic Frequency Selection (DFS) functionality are not covered in this document (see FCC Order, ET Docket No.03-122 (FCC 06-96)). For EUTs that can transmit on multiple outputs simultaneously (e.g., MIMO or beamforming devices), please refer to FCC KDB Publication Number 662911 for additional guidance.

Attachment List:

789033 D01 General UNII Test Procedures v01

[1] Public Notice DA 02-2138 is currently posted on http://transition.fcc.gov/oet/ea/eameasurements.html and is scheduled to be removed at the end of the draft publication comment period, if or when 789033 D01 General UNII Test Procedures v01 is published and becomes effective.

Guidelines for Compliance Testing of Unlicensed National Information Infrastructure (U-NII) Devices - Part 15, Subpart E

This document provides guidance for determining compliance of U-NII devices under Part 15, Subpart E of the FCC rules. It replaces and supersedes guidance contained in Public Notice DA 02-2138 of August 30, 2002 with changes as follows:

- The document interprets and clarifies the language of 15.407(a)(4) (maximum conducted output power);
- Revises the spectrum analyzer-based methodologies for measuring maximum conducted power and provides an option to use an RF power meter;
- Revises the methodologies for measuring Peak Power Spectral Density (PPSD) to match those used to measure maximum conducted output power;
- Specifies the use of max hold when measuring Emission Bandwidth (EBW);
- Defines compliance with 15.407(a)(6) (peak excursion) in terms of the ratio of maximum of the peak-hold spectrum to the maximum of the average spectrum—eliminating the need to compute the ratio at each frequency (a process that had resulted in unintended failures near band edges);
- Adds guidance for measuring unwanted emissions. The guidance interprets the non-restricted band limit as a peak limit and restricted band limits as including both average and peak limits. Both restricted and non-restricted band limits are based on continuous transmission with no subsequent reduction for operational duty cycle. The guidelines permit both restricted and non-restricted band compliance be demonstrated by radiated measurements or by antenna-port conducted measurements combined with radiated cabinet emission measurements.

The document includes acceptable procedures for measuring maximum conducted transmit power, peak power spectral density, emission bandwidth, peak excursion measurement, and unwanted emissions both in and out of the restricted bands. Procedures for evaluating Dynamic Frequency Selection (DFS) functionality are not covered in this document. For EUTs that can transmit on multiple outputs simultaneously (e.g., MIMO or beamforming devices), please refer to FCC KDB Publication Number 662911 for additional guidance.

All operating modes and data rates of the equipment under test (EUT) must satisfy all requirements.

<u>ACCEPTABLE MEASUREMENT PROCEDURES</u>

A) Antenna-port conducted versus radiated testing. All in-band measurements (sections B) through F), below) are based on antenna-port conducted measurements. However, if antenna-port conducted tests cannot be performed on the EUT, radiated tests are acceptable to show compliance with the various conducted emission requirements. See KDB Publication 412172 for converting field strength measurements to EIRP. Subtract the antenna gain of the EUT (in dBi) from the EIRP associated with a given in-band measurement to compute transmit power in the measurement bandwidth.

B) Duty Cycle (x), Transmission Duration (*T*), and Maximum Power Control Level

1) All measurements are to be performed with the EUT transmitting at 100 percent duty cycle at its maximum power control level; however, if 100 percent duty cycle cannot be achieved, measurements of duty cycle, x, and maximum-power transmission duration, *T*, are required for each tested mode of operation.
   a) ***T* refers to the transmission duration over which the transmitter is on and is transmitting at its maximum power control level.**
   b) **Duty cycle (x), as used in this document, refers to the fraction of time over which the transmitter is on and is transmitting at its maximum power control level.**
   c) The term "maximum power control level" is intended to distinguish between operating power levels of the EUT and differences in power levels of individual symbols that occur with some modulation types such as quadrature amplitude modulation (QAM). During testing, the EUT is not required to transmit continuously its highest possible symbol power level. Rather, it should transmit all of the symbols and should do so at the highest power control level (i.e., highest operating power level) of the EUT.
2) Measurements of duty cycle and transmission duration shall be performed using one of the following techniques:
   a) A diode detector and an oscilloscope that together have sufficiently short response time to permit accurate measurements of the on and off times of the transmitted signal.
   b) The zero-span mode on a spectrum analyzer if the response time and spacing between bins on the sweep are sufficient to permit accurate measurements of the on and off times of the transmitted signal. Set center frequency of the spectrum analyzer to the center frequency of the transmission. Set RBW ≥ EBW if possible; otherwise, set RBW to the largest available value. Set VBW ≥ RBW. Set detector = peak. The zero-span measurement method shall not be used unless both RBW and VBW are > 50/*T*, where *T* is defined in section B)1)a), and the number of sweep points across duration *T* exceeds 100. (For example, if VBW and/or RBW are limited to 3 MHz, then the zero-span method of measuring duty cycle shall not be used if *T* ≤ 16.7 microseconds.)

C) Maximum conducted output power

1) Clarification. The following language from 15.407(a)(4) is not applicable to maximum conducted output power measurements and should be ignored:

   > *"The measurement results shall be properly adjusted for any instrument limitations, such as detector response times, limited resolution bandwidth capability when compared to the emission bandwidth, sensitivity, etc, so as to obtain a true peak measurement conforming to the above definition for the emission in question."*

2) If possible, configure or modify the operation of the EUT so that it transmits continuously at its maximum power control level (see section B)).
   a) The intent is to test at 100 percent duty cycle; however a small reduction in duty cycle (to no lower than 98 percent) is permitted if required by the EUT for amplitude control purposes. Manufacturers are expected to provide software to the test lab to permit such continuous operation.
   b) If continuous transmission (or at least 98 percent duty cycle) cannot be achieved due to hardware limitations (e.g., overheating), the EUT shall be operated with the transmit duration as long as possible and the duty cycle as high as possible.
3) Maximum conducted output power may be measured using a spectrum analyzer or an RF power meter.

4) Measurement using a spectrum analyzer (SA)
   a) The test method shall be selected as follows:
      (i) Method SA-1 or SA-1 Alternative (averaging with the EUT transmitting at full power throughout each sweep) shall be applied if either of the following conditions can be satisfied.
         - The EUT transmits continuously (or with a duty cycle ≥ 98 percent).
         - Sweep triggering can be implemented in a way that ensures that the device transmits at the maximum power control level throughout the duration of each of the spectrum analyzer sweeps to be averaged. This condition can generally be achieved by triggering the spectrum analyzer's sweep if the duration of the sweep (with the analyzer configured as in Method SA-1, below) is longer than the duration *T* of each transmission from the EUT and if those transmissions exhibit full power throughout their durations.
      (ii) Method SA-2 or SA-2 Alternative (averaging across on and off times of the EUT transmissions, followed by duty cycle correction) shall be applied if the conditions of (i) cannot be achieved and the transmissions exhibit a consistent duty cycle during the measurement duration.
      (iii) Method SA-3 (RMS detection with max hold) or SA-3 Alternative (reduced VBW with max hold) shall be applied if the conditions of (i) and (ii) cannot be achieved.
   b) **Method SA-1** (trace averaging with the EUT transmitting at full power throughout each sweep):
      (i) Set span to encompass the entire emission bandwidth (EBW) of the signal.
      (ii) Set RBW = 1 MHz.
      (iii) Set VBW ≥ 3 MHz.
      (iv) Number of points in sweep ≥ 2 Span / RBW. (This ensures that bin-to-bin spacing is ≤ RBW/2, so that narrowband signals are not lost between frequency bins.)
      (v) Sweep time = auto.
      (vi) Detector = RMS (i.e., power averaging), if available. Otherwise, use sample detector mode.
      (vii) If transmit duty cycle < 98 percent, use a video trigger with the trigger level set to enable triggering only on full power pulses. Transmitter must operate at maximum power control level for the entire duration of every sweep. If the EUT transmits continuously (i.e., with no off intervals) or at duty cycle ≥ 98 percent and if the each transmission is entirely at the maximum power control level, then the trigger shall be set to "free run".
      (viii) Trace average at least 100 traces in power averaging (i.e., RMS) mode.
      (ix) Compute power by integrating the spectrum across the 26 dB EBW of the signal using the spectrum analyzer's band power measurement function with band limits set equal to the EBW band edges. If the spectrum analyzer does not have a band power function, sum the spectrum levels (in linear power units) at 1 MHz intervals extending across the 26 dB EBW of the spectrum.
      (x) **Method SA-1 Alternative**: If the EUT is configured to transmit at full power continuously (100 percent duty cycle) and the spectrum analyzer has an RMS detector, RMS averaging with a slow sweep may be used instead of trace averaging. Replace steps (v) through (viii) with the following:

- Manually set sweep time ≥ 10 * (number of points in sweep) * (symbol period of the transmitted signal);
- Set detector = RMS;
- 100 percent duty cycle is required;
- Perform a single sweep.

c) **Method SA-2** (trace averaging across on and off times of the EUT transmissions, followed by duty cycle correction). Perform steps (i) through (iii), below.

(i) Measure the duty cycle, x, of the transmitter output signal as described in section B).

(ii) Follow the procedure for Method SA-1, except for the following changes:

- In step (vii) the trigger shall be set to "free run". Sweep triggering shall not be used.
- In step (viii) a minimum of 100 traces shall be averaged; however, the number of traces to be averaged shall be increased above 100 as needed to ensure that the average accurately represents the true average over the on and off periods of the transmitter.
- **Method SA-2 Alternative**: As an alternative, RMS averaging with a slow sweep may be used instead of trace averaging. Replace steps C)4)b)(v) through C)4)b)(viii) with the following: manually set sweep time ≥ 10 * (number of points in sweep) * (total on/off period of the transmitted signal); set detector = RMS; perform a single sweep.

(iii) Add 10 log(1/x), where x is the duty cycle, to the measured power in order to compute the average power during the actual transmission times (because the measurement represents an average over both the on and off times of the transmission). For example, add 10 log(1/0.25) = 6 dB if the duty cycle is 25 percent.

d) **Method SA-3** (RMS detection with max hold):

(i) Set span to encompass the entire emission bandwidth (EBW) of the signal.

(ii) Set sweep trigger to "free run".

(iii) Set RBW = 1 MHz.

(iv) Set VBW ≥ 3 MHz

(v) Number of points in sweep ≥ 2 Span / RBW.

(vi) Sweep time ≤ (number of points in sweep) * *T*, where *T* is defined in section B)1)a). Note: if this results in a sweep time less than the auto sweep time of the analyzer, Method SA-3 Alternative shall not be used.

(vii) Detector = RMS.

(viii) Trace mode = max hold.

(ix) Allow max hold to run for at least 60 seconds, or longer as needed to allow the trace to stabilize.

(x) Compute power by integrating the spectrum across the 26 dB EBW of the signal using the spectrum analyzer's band power measurement function with band limits set equal to the EBW band edges. If the spectrum analyzer does not have a band power function, sum the spectrum levels (in linear power units) at 1 MHz intervals extending across the 26 dB EBW of the spectrum.

e) **Method SA-3 Alternative** (Reduced VBW with max hold):

(i) Set span to encompass the entire emission bandwidth (EBW) of the signal.

(ii) Set sweep trigger to "free run".

(iii) Set RBW = 1 MHz.

(iv) Set VBW ≥ $1/T$, where T is defined in section B)1)a).
(v) Number of points in sweep ≥ 2 Span / RBW.
(vi) Sweep time = auto.
(vii) Detector = peak.
(viii) Video filtering shall be applied to a voltage-squared or power signal (i.e., RMS mode), if possible. Otherwise, it shall be set to operate on a linear voltage signal (which may require use of linear display mode). Log mode must not be used.
   - The preferred voltage-squared (i.e., power or RMS) mode is selected on some analyzers by setting the "Average-VBW Type" to power or RMS.
   - If RMS mode is not available, linear voltage mode is selected on some analyzers by setting the display mode to linear. Other analyzers have a setting for "Average-VBW Type" that can be set to "Voltage" regardless of the display mode.
(ix) Trace mode = max hold.
(x) Allow max hold to run for at least 60 seconds, or longer as needed to allow the trace to stabilize.
(xi) Compute power by integrating the spectrum across the 26 dB EBW of the signal using the spectrum analyzer's band power measurement function with band limits set equal to the EBW band edges. If the spectrum analyzer does not have a band power function, sum the spectrum levels (in linear power units) at 1 MHz intervals extending across the 26 dB EBW of the spectrum.
(xii) If linear mode was used in step (viii), add 1 dB to the final result to compensate for the difference between linear averaging and power averaging.

5) **Method PM** (Measurement using an RF average power meter):
   a) As an alternative to spectrum analyzer measurements, measurements may be performed using a wideband RF power meter with a thermocouple detector or equivalent if all of the conditions listed below are satisfied.
      (i) The EUT is configured to transmit continuously or to transmit with a consistent duty factor.
      (ii) At all times when the EUT is transmitting, it must be transmitting at its maximum power control level.
      (iii) The integration period of the power meter exceeds the repetition period of the transmitted signal by at least a factor of five.
   b) If the transmitter does not transmit continuously, measure the duty cycle, x, of the transmitter output signal as described in section B).
   c) Measure the average power of the transmitter. This measurement is an average over both the on and off periods of the transmitter.
   d) Adjust the measurement in dBm by adding 10 log(1/x) where x is the duty cycle (e.g., 10 log(1/0.25) if the duty cycle is 25 percent).

D) Emission bandwidth

1) Set RBW = approximately 1% of the emission bandwidth.
2) Set the VBW > RBW.
3) Detector = Peak.
4) Trace mode = max hold.

5) Measure the maximum width of the emission that is 26 dB down from the peak of the emission. Compare this with the RBW setting of the analyzer. Readjust RBW and repeat measurement as needed until the RBW/EBW ratio is approximately 1%.

Note: The automatic bandwidth measurement capability of a spectrum analyzer may be employed if it implements the functionality described above.

E) Peak power spectral density (PPSD)

1) Follow the instructions for measuring maximum conducted output power using a spectrum analyzer, selecting and applying the appropriate test method (SA-1, SA-2, SA-3, or alternatives to each) as described in section C). (The step labeled, "Compute power…" in the selected method can be omitted for the PPSD test.)
2) Use the peak search function on the spectrum analyzer to find the peak of the spectrum.
   a) If Method SA-1 or SA-3 (or the corresponding alternative) was used, the peak of the spectrum is the PPSD.
   b) If Method SA-2 or SA-2 Alternative was used, add 10 log(1/x), where x is the duty cycle, to the peak of the spectrum. If linear mode was used in step C)4)e)(viii), add an additional 1 dB to the final result to compensate for the difference between linear averaging and power averaging. The result is the PPSD.

F) Peak excursion measurement

1) Compliance with the peak excursion requirement of 15.407(a)(6) shall be demonstrated by computing the ratio of the maximum of the peak-max-hold spectrum to the maximum of the average spectrum for continuous transmission. (Earlier procedures that required computing the ratio of the two spectra at each frequency can lead to unintended failures at band edges and will no longer be required.)
2) Set the spectrum analyzer span to view the entire emission bandwidth.
3) Find the maximum of the peak-max-hold spectrum.
   a) Set RBW = 1 MHz.
   b) VBW ≤ 3 MHz.
   c) Detector = peak.
   d) Trace mode = max-hold.
   e) Allow the sweeps to continue until the trace stabilizes.
   f) Use the peak search function to find the peak of the spectrum.
4) Use the procedure found under E) to measure the PPSD.
5) Compute the ratio of the maximum of the peak-max-hold spectrum to the PPSD.

G) Unwanted emissions measurement

Note. Sections 1) and 2), below, cover measurements in the restricted and non-restricted bands, respectively. However, those sections are not self contained. Rather, they reference the general unwanted emissions measurement requirements in section 3) and the specific measurement procedures in sections 4), 5), and 6).

1) <u>Unwanted emissions in the restricted bands</u>
   a) For all measurements, follow the requirements in section G)3), *"General Requirements for Unwanted Emissions Measurements"*.
   b) At frequencies below 1000 MHz, use the procedure described in section G)4), *"Procedure for Unwanted Emissions Measurements Below 1000 MHz"*.
   c) At frequencies above 1000 MHz, measurements performed using the peak and average measurement procedures described in sections G)5) and G)6), respectively, must satisfy the

respective peak and average limits. If all peak measurements satisfy the average limit, then average measurements are not required.

d) For *conducted* measurements above 1000 MHz, EIRP shall be computed as specified in section G)3)b) and then field strength shall be computed as follows (see KDB Publication Number 412172):
   (i) E[dBuV/m] = EIRP[dBm] - 20 log(d[meters]) + 104.77, where E = field strength and d = distance at which field strength limit is specified in the rules;
   (ii) E[dBuV/m] = EIRP[dBm] + 95.2, for d = 3 meters.

e) For *conducted* measurements below 1000 MHz, the field strength shall be computed as specified in d), above, and then an additional 4.7 dB shall be added as an upper bound on the field strength that would be observed on a test range with a ground plane for frequencies between 30 MHz and 1000 MHz, or an additional 6 dB shall be added for frequencies below 30 MHz.[2]

2) <u>Unwanted emissions that fall outside of the restricted bands</u>
   a) For all measurements, follow the requirements in section G)3), *"General Requirements for Unwanted Emissions Measurements"*.
   b) At frequencies below 1000 MHz, use the procedure described in section G)4), *"Procedure for Unwanted Emissions Measurements Below 1000 MHz"*.
   c) At frequencies above 1000 MHz, use the procedure for peak emissions described in section G)5), *"Procedure for Peak Unwanted Emissions Measurements Above 1000 MHz"*.
   d) If *radiated* measurements are performed, field strength is then converted to EIRP as follows:
      (i) EIRP = ((E*d)^2) / 30
      where:
      - E is the field strength in V/m;
      - d is the measurement distance in meters;
      - EIRP is the equivalent isotropically radiated power in watts.

      (ii) Working in dB units, the above equation is equivalent to:
      EIRP[dBm] = E[dBuV/m] + 20 log(d[meters]) - 104.77

      (iii) Or, if d is 3 meters:
      EIRP[dBm] = E[dBuV/m] - 95.2

3) <u>General Requirements for Unwanted Emissions Measurements</u>. The following requirements apply to all unwanted emissions measurements, both in and outside of the restricted bands:
   a) EUT Duty Cycle
      (i) The EUT shall be configured or modified to transmit continuously except as stated in (ii), below. The intent is to test at 100 percent duty cycle; however a small reduction in duty cycle (to no lower than 98 percent) is permitted if required by the EUT for amplitude control purposes. Manufacturers are expected to provide software to the test lab to permit such continuous operation.

[2] At frequencies above 30 MHz, 47 CFR 15.209 specifies the limit on emissions at a distance of 3 meters. Below 30 MHz, the emission limit is specified at 30 or 300 meters. At the 30 and 300 meter distances, the contribution of the ground bounce can approach 6 dB, whereas at 3 meters it is limited to 4.8 dB [for example, FCC Report and Order FCC 82-359 of August 1982, Appendix B (Bulletin OST-55, "Characteristics of Open Field Test Sites"), paragraph 7.4.2]. A value of 4.7 dB has commonly been used as representative of the ground-reflection addition for 3-meter measurements (for example, FCC Bulletin OCE 44, "Calibration of a Radiation Measurement Site—Site Attenuation", Figure 2; and, FCC First Report and Order FCC 02-48, released April 22, 2002, paragraph 245).

(ii) If continuous transmission (or at least 98 percent duty cycle) cannot be achieved due to hardware limitations of the EUT (e.g., overheating), the following additions to the measurement and reporting procedures are required:
- The EUT shall be configured to operate at the maximum achievable duty cycle.
- Measure the duty cycle, x, of the transmitter output signal as described in section B).
- Adjustments to measurement procedures (e.g., increasing test time and number of traces averaged) shall be performed as described in the procedures below.
- The test report shall include the following additional information:
  - The reason for the duty cycle limitation.
  - The duty cycle achieved for testing and the associated transmit duration and interval between transmissions.
  - The sweep time and the amount of time used for trace stabilization during max-hold measurements for peak emission measurements.

(iii) **Reduction of the measured emission amplitude levels to account for operational duty factor is not permitted. Compliance is based on emission levels occurring during transmission - <u>not</u> on an average across on and off times of the transmitter.**

b) Radiated versus Conducted Measurements.
The unwanted emission limits in both the restricted and non-restricted bands are based on radiated measurements; however, as an alternative, antenna-port conducted measurements in conjunction with cabinet emissions tests will be permitted to demonstrate compliance provided that the following steps are performed:

(i) Cabinet emissions measurements. A radiated test shall be performed to ensure that cabinet emissions are below the emission limits. For the cabinet-emission measurements the antenna may be replaced by a termination matching the nominal impedance of the antenna.

(ii) Impedance matching. Conducted tests shall be performed using equipment that matches the nominal impedance of the antenna assembly used with the EUT.

(iii) EIRP calculation. A value representative of an upper bound on out-of-band antenna gain (in dBi) shall be added to the measured antenna-port conducted emission power to compute EIRP within the specified measurement bandwidth. (For emissions in the restricted bands, additional calculations are required to convert EIRP to field strength at the specified distance.) The upper bound on antenna gain for a device with a single RF output shall be selected as the maximum in-band gain of the antenna across all operating bands or 2 dBi, whichever is greater.[3] However, for devices that operate in multiple bands using the same transmit antenna, the highest gain of the antenna within the operating band nearest to the out-of-band frequency being measured may be used in lieu of the overall highest gain when measuring emissions at frequencies within 20 percent of the absolute frequency at the nearest edge of that band, but in no case shall a value less than 2 dBi be selected.

[3] If an EUT uses an "electrically short antenna" (i.e., an antenna shorter than its resonant length of 1/4th or 1/2 wavelength), the in-band antenna gain may be low—perhaps even less than 0 dBi—but the gain may be higher at an out-of-band frequency where the antenna is resonant. In such a case, the gain is not expected to exceed that of a resonant ½-wavelength dipole, which is 2.15 dBi—rounded, here, to 2 dBi.

(iv) EIRP adjustments for multiple outputs. For devices with multiple outputs occupying the same or overlapping frequency ranges in the same band (e.g., MIMO or beamforming devices), compute the total EIRP as follows:
- Compute EIRP for each output, as described in (iii), above.
- Follow the procedures specified in FCC KDB Publication Number 662911 for summing emissions across the outputs or adjusting emission levels measured on individual outputs by 10 log(N), where N is the number of outputs.
- Add an array gain term of 10 log(N) [in addition to the 10 log(N) term mentioned above] if the in-band transmitted signals are classified as correlated according to FCC KDB Publication Number 662911 or if the unwanted emission is a narrowband line such as might originate from a clock or local-oscillator frequency (including harmonics thereof) in the device.[4]

c) For all radiated emissions tests, measurements must correspond to the direction of maximum emission level for each measured emission (see ANSI C63.10 for guidance).

4) Procedure for Unwanted Emissions Measurements Below 1000 MHz.
   a) Follow the requirements in section G)3), *"General Requirements for Unwanted Emissions Measurements"*.
   b) Compliance shall be demonstrated using CISPR quasi-peak detection; however, peak detection is permitted as an alternative to quasi-peak detection.
5) Procedure for Peak Unwanted Emissions Measurements Above 1000 MHz.
   a) Follow the requirements in section G)3), *"General Requirements for Unwanted Emissions Measurements"*.
   b) Peak emission levels are measured by setting the analyzer as follows:
      (i) RBW = 1 MHz.
      (ii) VBW ≥ 3 MHz.
      (iii) Detector = Peak.
      (iv) Sweep time = auto.
      (v) Trace mode = max hold.
      (vi) Allow sweeps to continue until the trace stabilizes. Note that if the transmission is not continuous, the time required for the trace to stabilize will increase by a factor of approximately 1/x, where x is the duty cycle. For example, at 50 percent duty cycle, the measurement time will increase by a factor of two relative to measurement time for continuous transmission.
6) Procedures for Average Unwanted Emissions Measurements above 1000 MHz.
   a) Follow the requirements in section G)3), *"General Requirements for Unwanted Emissions Measurements"*.
   b) Average emission levels shall be measured using one of the following two methods.
   c) **Method AD** (Average Detection): Primary method
      (i) RBW = 1 MHz.
      (ii) VBW ≥ 3 MHz.

[4] Though out-of-band signals are not intentionally correlated between outputs and are not intended to exhibit array gain, we note the following: (1) if the in-band signals on two outputs are correlated, out-of-band intermodulation products and harmonics are also expected to be correlated; (2) narrowband signals originating from the same source are also expected to exhibit correlation between channels.

(iii) Detector = Average, if span/(# of points in sweep) ≤ RBW/2. Satisfying this condition may require increasing the number of points in the sweep or reducing the span. If the condition is not satisfied, the detector mode shall be set to peak.

(iv) Averaging type.

- Averaging type shall be set for linear voltage mode to ensure that trace averaging is applied to a linear voltage signal rather than to a log (dB) signal. Some analyzers require linear display mode in order to accomplish this. Others have a setting for Average Type, which can be set to "Voltage" or "Linear" regardless of the display mode.
- As an alternative to linear voltage averaging, power averaging (using the RMS detector) may be used.

(v) Sweep time = auto.

(vi) Perform a trace average of at least 100 traces if the transmission is continuous. If the transmission is not continuous, the number of traces shall be increased by a factor of 1/x, where x is the duty cycle. For example, with 50 percent duty cycle, at least 200 traces should be averaged.

(vii) If tests are performed with the EUT transmitting at a duty cycle less than 98 percent, a correction factor shall be added to the measurement results prior to comparing to the emission limit in order to compute the emission level that would have been measured had the test been conducted at 100 percent duty cycle. The correction factor is computed as follows:

- If linear voltage averaging mode was used in step (iv) above, the correction factor is 20 log(1/x), where x is the duty cycle. For example, if the transmit duty cycle was 50 percent, then 6 dB must be added to the measured emission levels.
- If power averaging (RMS) mode was used in step (iv) above, the correction factor is 10 log(1/x), where x is the duty cycle. For example, if the transmit duty cycle was 50 percent, then 3 dB must be added to the measured emission levels.

d) **Method VB** (Averaging using reduced video bandwidth): Alternative method.

(i) RBW = 1 MHz.

(ii) Video bandwidth.

- If the EUT is configured to transmit with duty cycle ≥ 98 percent, set VBW ≤ RBW/100 (i.e., 10 kHz) but not less than 10 Hz.
- If the EUT duty cycle is < 98 percent, set VBW ≥ 1/T, where T is defined in section B)1)a).

(iii) Video bandwidth mode or display mode

- The analyzer shall be set for linear detector mode to ensure that video filtering is applied to a linear voltage output rather than to a log (dB) output. Some analyzers require linear display mode in order to accomplish this. Others have a setting for Average-VBW Type, which can be set to "Voltage" regardless of the display mode.
- As an alternative to linear voltage mode, the video bandwidth may be applied in the power domain (i.e., voltage squared, or RMS) by setting the Average-VBW Type to Power (RMS).

(iv) Detector = Peak.

(v) Sweep time = auto.

(vi) Trace mode = max hold.

(vii) Allow max hold to run for at least 50 traces if the transmitted signal is continuous or has at least 98 percent duty cycle. For lower duty cycles, increase the minimum number of traces by a factor of 1/x, where x is the duty cycle. For example, use at least 200 traces if the duty cycle is 25 percent.