Appendix III Measurement Guidelines for Frequency Hopping Spread Spectrum Systems

I. Carrier frequency separation:
   (I) The EUT must have its hopping function enabled.
   (II) Use the following spectrum analyzer settings:
      1. Span = wide enough to capture the peaks of two adjacent channels.
      2. Resolution (or IF) Bandwidth (RBW) >= 1 % of the span; Video (or Average) Bandwidth (VBW) >= RBW.
      3. Sweep = auto; Detector function = peak; Trace = max hold
      4. Use the marker-delta function to determine the separation between the peaks of the adjacent channels.

II. Number of hopping frequencies:
   (I) The EUT must have its hopping function enabled.
   (II) Use the following spectrum analyzer settings:
      1. Span = the frequency band of operation.
      2. Resolution (or IF) Bandwidth (RBW) >= 1 % of the span; Video (or Average) Bandwidth (VBW) >= RBW.
      3. Sweep = auto; Detector function = peak; Trace = max hold

III. Time of occupancy (Dwell Time):
   (I) The EUT must have its hopping function enabled.
   (II) Use the following spectrum analyzer settings:
      1. Span = zero span, centered on a hopping channel; RBW = 1 MHz; VBW >= RBW
      2. Sweep = as necessary to capture the entire dwell time per hopping channel.
      3. Detector function = peak; Trace = max hold
      4. If possible, use the marker-delta function to determine the dwell time. If this value varies with different modes of operation (e.g., data rate, modulation format, etc.), repeat this test for each variation.

IV. 20 dB bandwidth:
   (I) Use the following spectrum analyzer settings:
      1. Span = approximately 2 to 3 times the 20 dB bandwidth, centered on a hopping channel.
      2. RBW >= 1% of the 20 dB bandwidth; VBW >= RBW
      3. Sweep = auto; Detector function = peak; Trace = max hold
      4. The EUT should be transmitting at its maximum data rate. Allow the trace to stabilize. Use the marker-to-peak function to set the marker to the peak of the emission.
      5. Use the marker-delta function to measure 20 dB down bandwidth of the emission. If this value varies with different modes of operation (e.g., data rate, modulation format, etc.), repeat this test for each variation.

V. The peak output power:

(I) Use the following spectrum analyzer settings:

1. Span = approximately 5 times the 20 dB bandwidth, centered on a hopping channel.
2. RBW > 1 % of the 20 dB bandwidth of the emission being measured; VBW >= RBW
3. Sweep = auto; Detector function = peak; Trace = max hold
4. Use the marker-to-peak function to set the marker to the peak of the emission. The indicated level is the peak output power.
5. Please note above regarding external attenuation and cable loss.

VI. Band-edge compliance of RF conducted emissions:

(I) Use the following spectrum analyzer settings:

1. Span = wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation signal which fall outside of the authorized band of operation
2. RBW = 1 % of the span; VBW >= RBW.
3. Sweep = auto; Detector function = peak; Trace = max hold
4. Set the marker on the emission at the band edge, or on the highest modulation product outside of the band, if this level is greater than that at the band edge.
5. Enable the marker-delta function, then use the marker-to-peak function to move the marker to the peak of the in-band emission. The marker-delta value now displayed must comply with the limit specified in this Section.
6. Using the same instrument settings, enable the hopping function of the EUT.
7. Follow the same procedure listed above to determine if any spurious emissions caused by the hopping function also comply with the specified limit.

VII. Spurious RF conducted emissions

(I) Use the following spectrum analyzer settings:

1. Span = wide enough to capture the peak level of the in-band emission and all spurious emissions (e.g., harmonics) from the lowest frequency generated in the EUT up through the 10th harmonic. Typically, several plots are required to cover this entire span.
2. RBW = 100 kHz; VBW >= RBW.
3. Sweep = auto; Detector function = peak; Trace = max hold
4. Set the marker on the peak of any spurious emission recorded. The level displayed must comply with the specified limit.

VIII. Spurious radiated emissions

(I) This test is required for any spurious emission or modulation product that falls in a Restricted Band, as defined in Section 2.7.

(II) It must be performed with the highest gain of each type of antenna proposed for use with the EUT. Use the following spectrum analyzer settings:

1. Span = wide enough to fully capture the emission being measured
2. RBW = 1 MHz for f >= 1 GHz, 100 kHz for f < 1 GHz; VBW >= RBW.
3. Sweep = auto; Detector function = peak; Trace = max hold
4. Follow the guidelines in Appendix 1 with respect to maximizing the emission. A pre-amp and a high pass filter may be required for this test, in order to provide the measuring system with sufficient sensitivity. The peak reading of the emission, after being corrected by the antenna factor, cable loss, pre-amp gain, etc., is the peak field strength, which must comply with the limit specified in Section 5.15.2.
5. Now set the VBW to 10 Hz, while maintaining all of the other instrument settings. This peak level, once corrected, must comply with the limit specified in Section 2.8.
6. If the dwell time per channel of the hopping signal is less than 100 ms, then the reading obtained with the 10 Hz VBW may be further adjusted by a “duty cycle correction factor” in an effort to demonstrate compliance with the Section 2.8 limit.

IX. Alternative test procedures:
If antenna conducted tests cannot be performed on this device, radiated tests to show compliance with the peak output power limit specified in Section 3.10.1.2 and the spurious RF conducted emission limit specified in Section 3.10.1.5 are acceptable. As stated previously, a pre-amp, and, probably, a high pass filter, are required for the following measurements.

(I) Calculate the transmitter's peak power using the following equation:

$$E = \frac{\sqrt{30PG}}{d}$$

E is the measured maximum fundamental field strength in V/m.
G is the numeric gain of the transmitting antenna with reference to an isotropic radiator.
d is the distance in meters from which the field strength was measured.
P is the power in W.

$$P = \frac{(Ed)^2}{30G}$$

(II) The spurious RF conducted emission
Use the following spectrum analyzer settings:

1. Span = wide enough to fully capture the emission being measured
2. RBW = 100 kHz; VBW >= RBW.
3. Sweep = auto; Detector function = peak; Trace = max hold
4. Measure the field strength of both the fundamental emission and all spurious emissions with these settings. The measured field strength of all spurious emissions must be below the measured field strength of the fundamental emission by the amount specified in 3.10.1.5. This is only applied on spurious emissions that do not fall in restricted band.

(III) Marker-delta method:

While undertaking radiated band-edge measurements according to Chapter 5, the following techniques are for determining band-edge compliance.

1. Perform an in-band field strength measurement of the fundamental emission using the RBW and detector function required by Section 5.15.2 for the frequency being measured. For transmitters operating above 1 GHz, use a 1 MHz RBW, a 1 MHz VBW, and a peak detector. Repeat the measurement with an average detector (i.e., 1 MHz RBW with 10 Hz VBW).
   Note: For pulsed emissions, corrector factors must be included. Also, please note that radiated measurements of the fundamental emission of a transmitter operating under 3.10.1 are not normally required, but they are necessary in connection with this procedure.
2. Choose a spectrum analyzer span that encompasses both the peaks of the fundamental emission and the band-edge emission under investigation. Set the analyzer RBW to 1 % of the total span (but never less than 30 kHz) with a video bandwidth equal to or greater than the RBW. Record the peak levels of the fundamental emission and the relevant band-edge emission. Observe the stored trace and measure the amplitude delta between the peak of the fundamental and the peak of the band-edge emission. This is only a relative measurement to determine the amount by which the emission drops at the band-edge relative to the highest fundamental emission level.
3. Subtract the delta measured in step (2) from the field strengths measured in step 1. The resultant field strengths are then used to determine band-edge compliance as required by Section 2.7.
4. The above "delta" measurement technique may be used for measuring emissions that are up to two "standard" bandwidths away from the band-edge, where a "standard" bandwidth is the bandwidth specified by Section 5.15.2 for the frequency being measured.