Appendix Measurement of low power radio frequency devices

Appendix I Measurement of international radiators

I. Note:
The following procedure may be used as a guide for determining compliance of international radiators operation on frequencies above 30 MHz that can be tested on an open site with certain regulatory requirements.

II. Test items:

(I) AC power line conducted emission measurements setup: applies only to EUTs that operate from public utility powerlines.

1. The AC power line conducted emission test site shall conform to the requirements of CNS13306-1; The measuring instruments, containing the LISN, shall conform to the requirements of CNS13306-1.
2. The EUT shall be configured in accordance with CNS13438. If the EUT uses a detachable antenna, these measurements shall be made with a suitable dummy load connected to the antenna output terminals; otherwise, the tests shall be made with the antenna connected and, if adjustable, fully extended.
3. Use the type and length of interface cables specified in 5.6 and connect them to the interface ports on the EUT. In accordance with 5.6.1, the bundle shall be secured with masking tape or any other nonconducting material that will not affect the measurements.
4. Connect the EUT power cord to one LISN and connect the peripheral or support equipment power cords to a separate LISN. AC power for all LISNs is to be obtained from the same one power source. If the EUT power cord is long enough to be bundled, the bundle should be secured with masking tape or any other nonconducting material that will not affect the measurements. Power cords of non-EUT equipment do not require bundling. Drape AC power cords of non-EUT equipment over the rear edge of the table, and route them down onto the floor of the AC powerline conducted emission test site to the second LISN. Power cords of floor-standing accessory equipment may be routed in any convenient fashion atop the reference groundplane or insulating material specified in 5.6.2. Power cords of peripheral equipment should not be draped over the top of an LISN.
5. The EUT shall be supplied with the appropriate modulation. If the EUT transmit only pulse modulation and has coding switches, these shall be set to the position that produces the maximum duty cycle during measurements.

(II) AC power line conducted emission measurements:

1. Check the calibration of measuring instrument using either an internal calibrator or a known signal level from an external signal generator.
2. A spectrum analyzer or other instrument providing spectral display is recommended for exploratory AC powerline conducted emission measurements. Connect the measuring instrument to the RF port of a section of the LISN supplying current to the EUT using a suitable length of coaxial cable. Terminate all other RF ports of the LISN in 50-ohm resistive. Set the 6dB bandwidth of the measuring instrument to not less than 10 kHz and the detector function to the peak mode. Set the controls on the measuring instrument to enable viewing the entire frequency range for which limits are specified.
3. Activate the EUT and the measuring instrument. The EUT should be set to transmit on any one convenient frequency in its rated range.
4. Exercise the EUT in all modes of operation as specified in 5.4. Accessory equipment connected to the EUT shall be exercised individually.
5. Use the procedure in 5.8 to determine the arrangement of the EUT system that produces the emission with the highest amplitude relative to the limit. The EUT may be turned off and on to determine which emissions emanate from it.

6. Repeat step 5 with the measuring instrument connected to the RF port of the other LISN section supplying the EUT with AC power.

   Note: Measurement are to be made only on emanations at the RF ports of the LISNs connected to the EUT.

7. Select the EUT arrangement and mode of operation that produced the highest emission relative to the limit for final AC powerline conducted emission measurements. If the EUT is moved to a final AC powerline conducted emission test site from an exploratory conducted emission test site, be sure to re-maximize the highest emission according to 5.8. Set the bandwidth and the detector function of the instrument to measure the final AC powerline conducted emission from the EUT.
8. Repeat step 7 with the measuring equipment connected to the RF port of the other LISN section supplying the EUT with AC power.
9. Record the EUT arrangement, mode of operation, and interconnect cable or wire positions used for final AC powerline conducted emission measurements. This can be done with either diagrams or photographs.

(III) Radiated emission measurements setup:

1. The measuring instruments shall conform to the requirements in CNS13306-1.
2. The EUT shall be positioned on a turntable as specified in 5.6 and configured as “AC power line conducted emission measurements setup”.
3. If operated from AC power, connect the power cord of the EUT and any accessory equipment to the AC power source receptacle located on the turntable. If the battery operated, begin the tests with a new or a fully charged battery installed in the EUT. The AC power cords of the EUT and accessories do not require bundling. Drape all AC power cords of equipment tested on a tabletop over the rear edge of the table and route them down onto the turntable surface to the AC receptacle. AC power cords of floor-standing equipment may be routed in any convenient fashion.
4. If the EUT is provided only with an adjustable permanently attached antenna, it shall be tested with this antenna extended to its maximum length. If the EUT is provided with terminals for connection of an external antenna, connect the antenna normally used with the EUT to these terminals, and position it in a typical location or orientation.
5. The EUT shall be supplied with modulation as specified in Section 5.16. If the EUT transmits only pulsed modulation and has coding switches, these shall be set to the position that produces the maximum duty cycle during measurements.

(IV) Radiated emission measurement:

1. Check the calibration of measuring instrument using either an internal calibrator or a known signal level from an external signal generator.
2. A spectrum analyzer or other instrument providing a spectral display is recommended for exploratory radiated measurements. The frequency range may be scanned in segments or in its entirely depending on the rated frequency range of the measurement antenna [see NOTE under step 5], and the resolution and noise floor of the measuring instrument. Set the 3 dB bandwidth of the measuring instrument to 100 kHz or greater and the detector function to the peak mode. Set the display on the measuring instrument to enable viewing of emissions. Adjust the sweep speed control so the analyzer display is calibrated. Video filter is not used for measurement.

   Note: I. If ambient radio or TV signals are of such magnitude or spacing that emission from the EUT may be hidden, the scan width control may be set to 10 MHz per division or less to identify EUT emission. Use of a bandwidth less than 100 kHz might be helpful.

   II. The bandwidth of the measuring instrument shall be wider than the pulse repetition frequency of the transmitted signal to measure its maximum peak level.

3. Activate the EUT and the measuring instrument. If the EUT operates over a range of frequencies, set it to one of the number of frequencies specified in 5.12.

Note: These exploratory tests shall be run with the EUT powered in turn from both AC and DC (battery) power, if the device has these capabilities, to determine which power source produces the highest emission relative to the limit.

4. Exercise the EUT as specified in 5.4. Accessories connected to the EUT shall be exercised independently.

5. Use the procedure stipulated in 5.8 to maximize emission from the EUT and note the EUT latitude, arrangement, operating mode, and interconnect cable or wire positions that produce the highest emission relative to the limit. In addition, exploratory radiated emission testing of hand-held or body-worn devices shall include rotation of the EUT through three orthogonal axes to determine the latitude that produces the highest emission relative to the limit.

   Note: Exploratory scanning of radiated emission. A broadband antenna is recommended for exploratory scanning of radiated emission. It shall be necessary to change to other measurement antennas during this process to cover the complete frequency range of the test.

6. Tune the spectrum analyzer to the next segment of the frequency spectrum to be scanned, and repeat step 3 through 5 until the frequency range of interest has been investigated. When radiation measurements are required on an EUT on more than one operating frequency, repeat setp 3 through 5 for each additional frequency.

7. Select the EUT arrangement, operating mode, and interconnecting cable or wire positions from step 5 that produced the highest emission relative to the limit to use for final radiated measurements. Set the bandwidth and the detector function as specified in appropriated section.

8. It is recommended that highest emission relative to the limit be remaximized per Section 5.8 before performing final measurements, even if the EUT is not moved from a exploratory to a final radiated emission test site, as slight variations in cable or wire positions can cause large variations in signal amplitude. Only slight variation in cable movements should be needed to remaximize the highest emission again.
   Note: The same measurement antenna and distance should be used for remaximizing the highest emission relative to the limit at the final radiated emission test site.

9. Place the measurement antenna the distance from the EUT specified in the appropriate regulations.

10. Follow the procedure to measure final radiated emission from the EUT on the number of frequencies specified. When average detector function limits are specified for a pulse-modulated transmitter, the average level of emission shall be determined by measuring the peak level of the emissions and correcting them with the duty cycle detailed as follows:

    Note: It may be necessary to use multiple measurement antennas during this process to cover the complete frequency range of the test.

    10.1 Turn on the transmitter, and set it to transmit the pulse train continuously.

    10.2 Tune a spectrum analyzer to the transmitter, carrier frequency, and set the spectrum analyzer resolution bandwidth wide enough to encompass all significant spectral components. The video bandwidth should be at least as wide as the resolution bandwidth.

    10.3 Set the spectrum analyzer vertical scale (amplitude) to the linear mode and the analyzer frequency scan to 0 Hz. If necessary, move the receiving antenna closer to the device to obtain a signal level.

    10.4 Connect a storage oscilloscope to the video output of the spectrum analyzer that is used to demodulate and detect the pulse train.

    10.5 Adjust the oscilloscope settings(or use a spectrum analyzer set to zero span) to observe the pulse train, and determine the number and width of the pulses, as well as the period of the train.

    10.6 Measure the pulsewidth by determining the time difference between the two half-voltage points on the pulse.

    10.7 When the pulse train is less than 100 ms (including blanking intervals), calculate the duty cycle by averaging the sum of the pulswidths over one complete pulse train. Alternatively, when the pulse train is not periodic or the period exceeds 100 ms, calculate the duty cycle by averaging the sum of the pulsewidths over the 100 ms width with highest average value, which the work period is the total pulse width is divided by 100 ms.

10.8 Multiply the peak-detector field strength (expressed in uV/m) of an emission from a transmitter using pulsed modulation by the duty cycle just measured to determine the average detector field strength of that emission for comparison to the average detector limit.

10.9 If regulations do not require radiated measurements above 1 GHz, proceed to step 13. If radiated measurements above 1 GHz are required, an instrument capable of measuring both peak and average detector function signals shall be used. Set the bandwidth of this instrument to 1 MHz and the detector function to the peak mode.

11. Should all of the emission levels above 1 GHz as measured with the peak detector function comply with the average limit specified by the appropriate regulations, proceed to step 13. Should any of thess emission levels exceed the average lkimit but comply with the peak limit, proceed to step 12.

12. Set the detector function of the measuring instrument to the average mode and according to step 11 remeasure only those emissions form step 11 that complied with the peak limits but exceed the average limits.

13. Record the EUT arrangement, operating mode, and cable or wire positions used for final radiated emission measurements. This can be done with either diagrams or photographs.

14. Where radiated measurements are required on an EUT on more than one operating frequency, the report shall list the field strength measured at the fundamental frequency, the field strength of the three highest harmonic or spurious emissions relative to the limit, and the field strength of the three highest restricted band emissions relative to the limit and the frequencies on which these were observed, for each operating frequency measured.

    Note: For the purposes of this standard, spurious emissions shall include out-of-band emissions typically associated with or generated by the modulating signal.

(V) Operating frequency measurement

1. Operating frequency measurements may be made at ambient room temperature if it is within the range of +15 °C~+25 °C; otherwise, an environmental temperature test chamber set for a temperature of +20 °C shall be used. If possible, an antenna should be connected to the EUT, as the use of dummy load could affect the output frequency of the EUT. If the EUT is equipped with or uses an adjustable length antenna, it should be fully extended.

2. Supply the EUT with nominal AC voltage, or install a new or fully charged battery in the EUT. Turn the EUT on, and couple its output to the frequency counter or precision frequency measurement instrument which is capable of measuring the required frequency tolerance of the EUT.

    Note: For purposes of measurement, place the measurement antenna at a distance (15 cm, for example) close to the EUT by connecting to the measurement instrument with a suitable length of coaxial cable.

3. Tune it to one of the number of frequencies required in Section 5.12. Adjust the location of the measurement antenna and the controls on the measuring instrument to obtain a suitable signal level, a level will not overload the measuring instrument, but is strong enough to allow the measurement or the fundamental frequency of the EUT.Turn the EUT on and record the operating frequency at startup and two, five, and ten minutes after the EUT is energized. Four measurements in total are made.Turn the EUT off, and place it inside an environmental chamber if appropriate. Allow about 30 minutes for the chamber to stabilize at +20 °C before proceeding.

4. If there is more than one frequency for measurement, turn the EUT off to allow enough time to stablize to environmental temperature. Set the EUT to a new operating frequency, and repeat step 3 until the number of frequencies specified in 5.12 are measured.

(VI)Frequency stability with respect to temperature

1. Place the EUT in an environmental temperature test chamber, and supply the EUT with nominal AC voltage, or install a new fully charged battery in the EUT. If possible, an antenna should be connected to the EUT, because use of dummy load could affect the output frequency of the EUT. If the EUT is equipped with or uses an adjustable length antenna, it should be fully extended.

2. Supply the EUT with nominal AC voltage, or install a new or fully charged battery in the EUT. Turn the EUT on, and couple its output to the frequency counter or precision frequency measurement instrument which is capable of measuring the required frequency tolerance of the EUT.

   Note: For purposes of measurement, place the measurement antenna at a distance (15 cm, for example) close to the EUT by connecting to the measurement instrument with a suitable length of coaxial cable.

3. Tune it to one of the number of frequencies required in Section 5.12. Adjust the location of the measurement antenna and the controls on the measuring instrument to obtain a suitable signal level, a level that will not overload the measuring instrument, but is strong enough to allow the measurement or the fundamental frequency of the EUT.Turn the EUT off, and place it inside an environmental temperature chamber at the highest specified temperature. For devices that are normally operated continuously, the EUT may be energized while inside the test chamber. For devices that have oscillator heaters, energize only the heater circuit while the EUT is inside the chamber.

4. While maintaining a constant temperature inside the environmental chamber, turn the EUT on and record the operating frequency at startup and two, five, and ten minutes after the EUT is energized. Four measurements in total are made.

5. If there is just one frequency for measurement, skip to step 6; otherwise, turn the EUT off to allow enough time to stablize to environmental temperature. Set the EUT to a new operating frequency, and repeat step 4 until the number of frequencies specified in 5.12 are measured.

6. Repeat step 4 and 5 for the EUT with the test chamber set at the lowest temperature. Before proceeding measurement, make sure the test chamber is stablized.

(VII) Frequency stability with respect to input voltage

1. Operating frequency measurements may be made at ambient room temperature if it is within the range of +15°C~+25 °C; otherwise, an environmental temperature test chamber set for a temperature of +20 °C shall be used. If possible, an antenna should be connected to the EUT, as use of the dummy load could affect the output frequency of the EUT. If the EUT is equipped with or uses an adjustable length antenna, it should be fully extended.

2. Supply the EUT with nominal AC voltage, or install a new or fully charged battery in the EUT. Turn the EUT on, and couple its output to the frequency counter or precision frequency measurement instrument which is capable of measuring the required frequency tolerance of the EUT.

   Note: For purposes of measurement, place the measurement antenna at a distance (15 cm, for example) close to the EUT by connecting to the measurement instrument with a suitable length of coaxial cable.

3. Tune it to one of the number of frequencies required in Section 5.12. Adjust the location of the measurement antenna and the controls on the measuring instrument to obtain a suitable signal level. A level will not overload the measuring instrument, but is strong enough to allow the measurement or the fundamental frequency of the EUT.Turn the EUT off, and place it in an environmental chamber. Allow about 30 minutes for the chamber to stabilize at +20 °C before proceeding, a level that will not overload the measuring instrument, but is strong enough to allow measurement of the fundamental frequency of the EUT. Turn the EUT on and record the operating frequency at startup and two, five, and ten minutes after the EUT is energized. Four measurements in total are made.

4. If there is just one frequency for measurement, skip to step 5; otherwise, turn the EUT off to allow enough time to stablize to environmental temperature. Set the EUT to a new operating frequency, and repeat step 3 until the number of frequencies specified in 5.12 are measured.
5. If the EUT is powered from the AC power line, supply it with 85% of the nominal AC voltage and repeat step 3 and step 4. If the EUT is battery-operated supply it with the lowest working voltage.
6. If the EUT is powered from the AC power line, supply it with 115% of the nominal AC voltage and repeat step 3 and step 4.

(VIII) Occupied bandwidth measurements

1. Check the calibration of measuring instrument using either an internal calibrator or a known signal level from an external signal generator.
2. A spectrum analyzer or other instrument providing spectral display is recommended for. Video filter is not used for measurement.

   Note: In order to measure the modulated signal properly, a resolution bandwidth that is small compared with the bandwidth required. Under some circumstance, the improper measurement will be made due to too small bandwidth. Thus, the resolution bandwidth of the measuring instrument shall be set to a value greater than 5 % of the bandwidth requirements. When no bandwidth requirements are specified, the resolution bandwidth of the measuring instrument is given in the following table:

Fundamental frequency (MHz)	Minimum resolution bandwidth (kHz)
0.009 to 30	1
30 to 1000	10
1000 to 4000	100

3. Supply the EUT with nominal AC voltage, or install a new or fully charged battery in the EUT. Turn the EUT on, and set it to any convenient frequency within its operating range. Set a reference level on the measuring instrument at –26 dB below the unmodulated carrier. Take modulated frequency into consideration, adjust resolution bandwidth, sweep speed, and sweep range and display calibrated.
4. Apply modulation signal(s) as specified in 5.16 and measure the frequencies of the modulated signal from the EUT where it is the specified number of dB below the reference level set in step 3. This is the occupied bandwidth. The measured result may be undertaken with plotted graphs or photographs of the measuring instrument display.

(IX) Input power measurements

1. If possible, an antenna should be connected to the EUT, as use of a dummy load could affect the output frequency of the EUT. If the EUT is equipped with or uses an adjustable length antenna, it should be fully extended.
2. Supply the EUT with nominal AC voltage, or install a new or fully charged battery in the EUT. Typical modulation shall be applied to the EUT during these tests.
3. Turn the EUT on and tune it to any one convenient frequency specified in Section 5.12. For measurement of the input power to the final RF stage, while varying the input modulation sources, measure the voltage at the supply to the final RF stage of the EUT, and the current in to that stage, using a DC voltmeter and ammeter of appropriate ranges respectively. The input power to the final RF stage is the product of these values. For input power measurements on an intentional radiator, use a voltmeter and ammeter and measure, as appropriate, either the AC or DC voltage and current at the AC power cord or battery input terminals of the intentional radiator. Again, the input power is the product of these values.Turn the EUT on and tune it to any one convenient frequency specified in Section 5.12. For measurement of the input power to the final RF stage, while varying the input modulation sources,

measure the voltage at the supply to the final RF stage of the EUT, and the current in to that stage, using a DC voltmeter and ammeter of appropriate ranges respectively. The input power to the final RF stage is the product of these values. For input power measurements on an intentional radiator, use a voltmeter and ammeter and measure, as appropriate, either the AC or DC voltage and current at the AC power cord or battery input terminals of the intentional radiator. Again, the input power is the product of these values.

(X) Effective radiated power measurements

1. Test arrangement is as field strength radiation measurement
2. Set the resolution bandwidth of measuring instrument per 5.15.2. The video bandwidth is not less than resolution bandwidth. In order to enable viewing of emissions, set the sweep speed, and sweep range on the measuring instrument enough to cover all tested frequencies.
3. The receiving horizontal polarization antenna shall be raised or lowered through 1 meter~ 4 meter height range until a maximum reading is obtained on the measuring instrument, the EUT shall be rotated through 360° around a horizontal axis until a higher maximum signal is received. This level shall be recorded as reference level.
4. Repeat step 3 until all frequencies that need to be measured are complete.
5. Repeat step 4 with search antenna in vertical polarized orientations.
6. Replace the EUT with a transmitting antenna (tuned dipole antenna for frequency no more than 1 GHz and horn antenna for frequency above 1 GHz) in horizontally polarized orientation and as the same polarized orientation with search antenna. Connect the tuned dipole antenna to a standard signal generator (SG). Tune SG to the frequency obtained from above steps as well as set SG at an appropriate output level. Rise and lower the search antenna to get the highest value on the measurement instrument, and then hold this position. Adjust the SG output to get an identical value derived from step 3 on measurement instrument. Record this value for result calculated.
7. Repeat step 6 until all frequencies that need to be measured are complete.
8. Repeat step 7 with both transmitting antenna and search antenna in vertical polarized orientations.
9. If the antenna gain of EUT relative to dipole antenna (or isotropic antenna) is known, then the ERP (or EIRP) can be derived from the product of conducted output power at antenna terminal and the antenna gain.