

# ANNEX M

## Measurement Methods

### M.1 GENERAL

#### M.1.1 Introduction

Chapter 5 of this Manual contains Radio Frequency Spectrum Standards applicable to federal radio stations and systems. This Annex supplements Chapter 5 with the measurement methods appropriately referenced from the various sections of Chapter 5. A measurement method, in turn, is referenced back to Chapter 5. Cross-references to the FCC 47 CFR and/or other measurement method procedures are also provided in this annex.

#### M.1.2 Measurement Methods

1. Measurement methods included or referenced in this annex are provided only for clarification and uniform interpretation of the standards. In cases of harmful interference, the agencies involved are expected to utilize these or equivalent, mutually agreed upon, methods of measurement for resolution of any disagreement concerning compliance with the standards. Agencies may, at their discretion, use these measurement methods as minimum qualification test procedures, e.g., as part of factory test procedures.

2. NTIA standards are available for purchase from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. Electronic Industries Association and Telecommunications Industry Association (EIA/TIA) standards may be obtained by calling Global Engineering Documents (1-800-854-7179).

#### M.1.3 Resolution Bandwidth

Resolution bandwidth is the 3 dB bandwidth of the measurement system used, e.g., in power spectral density measurements. The appropriate resolution bandwidth of the measurement system varies depending on the modulation type and frequency band but should not be greater than the necessary bandwidth of the transmitter being measured.

### M.2 MEASUREMENT METHODS

#### M.2.1 Fixed and Mobile Services

##### M.2.1.1 Fixed and Mobile Single Sideband and Independent Sideband Equipment (2-29.7 MHz)

This measurement method is referenced from Section 5.3.1. For HF single sideband transmitters, the transmitter without a device to limit modulation or peak envelope power shall be modulated as follows. The input level of the modulating signal shall be that necessary to produce rated peak envelope power. HF single sideband transmitters in J3E, H3E, or R3E emission modes shall be modulated by two tones at frequencies of 400 Hz and 1800 Hz (for 3.0 kHz authorized bandwidth), applied simultaneously. The input levels of the tones shall be so adjusted that the two principal frequency components of the radio frequency signal produced are equal in magnitude and 3 dB below the maximum received signal level (RSL) as indicated in Figure 5.3.1 of Chapter 5. The plot of the spectrum shall have a span of 21.1 kHz or that necessary to identify intermodulation products up through the 13th and a resolution bandwidth of 100 Hz. This measurement method is also contained in Title 47 CFR Section 2.989 (d)(2).

##### M.2.1.2 Maritime Mobile, FM Operation (150.8 - 162.0125 MHz)

This measurement method is referenced from Section 5.2.1, see Note (q). The measurement method for frequency tolerances to be used is as given in the Electronic Industries Association (EIA) Standard TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards (ANSI/TIA/EIA-603-92), Chapters 2, 3, and 4, or equivalent.

### **M.2.1.3 Fixed Services (406.1-420 MHz, 932-935/941-944 MHz, and 1.71-15.35 GHz)**

#### **1. Transmitter Standards**

a. Measurement Method for Frequency Tolerance of Transmitter (referenced from Section 5.2.1, see Note (u)): A sample of the unmodulated carrier at the center frequency should be measured with equipment having an accuracy of at least five times that of the minimum to be measured.

b. Measurement Method for Unwanted Emissions of Transmitters Employing Digital Modulation Techniques (referenced from Section 5.5.3): A sample of the transmitter output at the interface point with the antenna transmission line shall be measured using a measurement system with 4 kHz resolution bandwidth. The full unmodulated carrier power output is used as the transmitter average output reference.

c. Measurement of the unwanted emissions shall be made from the lowest radio frequency generated by the equipment to the third harmonic of the carrier with the transmitter modulated as follows:

(1) Analog-white noise generator in accordance with EIA RS-252A recommended loading levels.

(2) Digital-pseudorandom code generator with appropriate loading levels and format.

#### **2. Receiver Standards**

a. Receiver Intermediate Frequency (IF) Measurement Method, (referenced from Section 5.3.3): The IF shall be measured with equipment having an accuracy of at least five times greater than the frequency tolerance to be measured. The measurement shall be made with an unmodulated input signal on the assigned frequency coupled to the input of the receiver at a level greater than 20 dB above the receiver ambient noise.

b. Receiver Unwanted Signals Measurement Method, (referenced from Section 5.3.3): Couple two signal generators to the input of the receiver and connect a spectrum analyzer to the baseband output. The unmodulated output of one signal generator (desired signal) on the assigned frequency shall be adjusted to reduce the baseband noise by 3 dB as observed on the spectrum analyzer. The unmodulated output of the second signal generator (unwanted signals) shall be adjusted to 70 dB above that of the desired signal. The output frequency of the unwanted signals shall be varied over a range of  $\pm 1$  percent of the assigned frequency excluding frequencies within the receiver 60 dB selectivity bandwidth.

c. At each receiver response of the unwanted frequency, adjust the output of the unwanted signal generator for a 3 dB reduction in baseband noise. The difference, expressed in dB, in the output levels of the two signal generators is the unwanted signal attenuation.

### **M.2.1.4 Land Mobile, Single Channel Narrowband Operations (220 - 222 MHz)**

1. This measurement method is referenced from 5.3.4. A sample of the unmodulated carrier at the center frequency should be measured with equipment having an accuracy of at least five times that of the minimum to be measured.

2. Measurement Method for Resolution Bandwidth. The resolution bandwidth of the instrumentation used to measure the emission power shall be 100 Hz for measuring emissions up to and including 250 kHz from the edge of the authorized bandwidth, and 10 kHz for measuring emissions more than 250 kHz from the edge of the authorized bandwidth. If a video filter is used, its bandwidth shall not be less than the resolution bandwidth. The power level of the highest emission within the channel to which the attenuation is referenced shall be remeasured for each change in resolution bandwidth.

3. Additional guidelines may be obtained from the latest revision of Electronic Industries Association (EIA) TSB-57, Sideband Spectrum Measurement Procedure for Transmitters Intended for Use in the 220-222 MHz Band. Modulation is referenced to FCC regulations (CFR 47 2.989).

### **M.2.1.5 Analog or Digital FM/PM Operations**

#### **1. Wideband (29.7-50, 162-174, and 406.1-420 MHz)**

a. Measurement Methods for Transmitter Frequency Deviation and Receiver Conducted Spurious Emissions, All Station Classes and Bands, (referenced from Section 5.3.6): The prescribed measurement methods to be used are given in the latest revision of Electronic Industries Association (EIA) Standard TIA/EIA-603, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards (ANSI/TIA/EIA-603-92), Chapters 2, 3, and 4.

The present EIA measurement methods were written for analog systems. Some of these methods are not appropriate for digital systems. Appropriate analog to digital or digital to analog test sets will have to be used.

b. Measurement Method for Frequency Tolerance, (referenced from Section 5.2.1, see Note (i)): An unmodulated standard input signal source, adjusted to the standard input frequency as specified in the latest revision of Electronic Industries Association (EIA) Standard RS-204, Minimum Standards for Land Mobile Communications FM or PM Transmitter, 25-866 MHz shall be connected to the receiver under test and adjusted for an output of 20 dB above the receiver sensitivity. The center frequency of the IF passband shall be measured with equipment having a degree of accuracy of at least five times the minimum tolerance to be measured.

2. Narrowband (138-150.8, 162-174, and 406.1-420 MHz Bands)

a. Transmitter and Receiver Measurement Methods (referenced from Section 5.3.7): The measurement methods to be used are as given in the Telecommunications Industries Association standard TIA/EIA-603-C for narrowband analog equipment, and TIA-102.CAAA-B for narrowband digital equipment. Where these methods are not specified for a particular system type, appropriate test procedures should be applied.

3. Digital 6.25 kHz Channel Equipment in the 406.1-420 MHz band.

a. Transmitter and Receiver Measurement Methods (referenced from Section 5.3.11): The reference level for showing compliance with the equipment emission mask shall be established using a resolution bandwidth sufficiently wide (usually two or three times the channel bandwidth) to capture the true peak emission of the equipment under test. In order to show compliance with the emission mask up to and including 50 kHz removed from the edge of the authorized bandwidth, adjust the resolution bandwidth to 100 Hz with the measuring instrument in a peak hold mode. A sufficient number of sweeps must be measured to insure that the emission profile is developed. If video filtering is used, its bandwidth must not be less than the instrument resolution bandwidth. For frequencies more than 50 kHz removed from the edge of the authorized bandwidth a resolution of at least 100 kHz must be used for frequencies below 1000 MHz. Above 1000 MHz the resolution bandwidth of the instrumentation must be at least 1 MHz.

b. The measurement method to be used for the receiver standards are as given in the Telecommunications Industry Association standard TIA-102.CAAA-B for narrowband digital equipment.

c. Where these methods are not specified for a particular system type, appropriate test procedures should be applied.

### **M.2.1.6 Wideband and Narrowband Emission Level and Temporal Measurements in the Navstar Global Positioning System Bands**

1. The wideband and narrowband radiated equivalent isotropically radiated power (EIRP) levels in the 1164-1240 MHz and 1559-1610 MHz frequency bands are to be measured for systems operating in the frequency bands: 390-413 MHz, and 960-1710 MHz. The following guidelines are to be used in measuring the wideband and narrowband EIRP levels:

a. The radiated EIRP levels in these frequency bands are to be measured using a root mean square (RMS) spectrum analyzer detector function.

b. The wideband emission levels are to be measured using a 1 MHz resolution bandwidth.

c. The narrowband emission levels are to be measured using a 1 kHz resolution bandwidth.

d. For the wideband emission measurement, the RMS levels are to be measured using a 2 millisecond averaging time over each 1 MHz segment.

e. The video bandwidth of the spectrum analyzer should not be less than the resolution bandwidth.

f. The measurement system must have a noise floor of approximately -141 dBW as measured in a 1 MHz resolution bandwidth.

2. The following guidelines are to be used in measuring the temporal characteristics of the emissions in the 1164.45-1188.45 MHz, 1215.6-1239.6 MHz, and 1563.42-1587.42 MHz bands:

a. The system under test should be tuned to its assignable channel that is closest to the GPS frequency band under consideration.

b. A time-domain measurement of the waveform envelope in a 20 MHz bandwidth can be measured using an antenna with appropriate gain and frequency response characteristics connected to either a notch filter or a bandstop filter. The filter is connected to a low noise amplifier (LNA) that operates across the frequency range of at least 1100-1600 MHz. The LNA is connected to a vector signal analyzer (VSA).

c. Tune the VSA sequentially to the 1164.45-1188.45 MHz, 1215.6-1239.6 MHz, and 1563.42-1587.42 MHz bands and perform time-domain measurements using the full VSA bandwidth of 36 MHz.

d. Subsequent to the data capture, the time-domain waveform envelopes are processed in a 20 MHz bandwidth.

e. Alternative techniques to perform these measurements should be provided to NTIA for review.

## **M.2.2 Radar Spectrum Engineering Criteria (RSEC)**

### **M.2.2.1 General including RSEC-A**

This measurement method is referenced from Section 5.5.1. NTIA Technical Report TR-05-420 titled “*Measurement procedures for the radar spectrum engineering criteria (RSEC)*” should be used for radar emission measurements by federal agencies or other parties seeking system certification by NTIA. It describes techniques for measuring radar spectrum-related parameters and characteristics for compliance with the RSEC. Measurements for both conventional and advanced radar types are addressed. The report can be downloaded at: <http://www.its.bldrdoc.gov/publications/2450.aspx>.

### **M.2.2.2 RSEC B**

This measurement method is referenced from Section 5.5.2. In order to coordinate radar operations in the field, an accurate measurement of the operating frequency is necessary. An accuracy of 1 ppm is desirable, although, for most radars 100 ppm is adequate. Of comparable importance is the capability to measure pulse rise time and spectrum occupancy. Accordingly, each federal agency shall have access to the instrumentation necessary to make a frequency measurement to at least 100 ppm and suitable oscilloscopes and spectrum analyzers to measure time and frequency parameters necessary to determine conformance with these criteria. For fast rise devices, such as magnetrons, oscilloscopes with bandwidths of at least 50 MHz should be used.

### **M.2.2.3 RSEC C and RSEC D**

This measurement method is referenced from Sections 5.5.3 and 5.5.4. In order to coordinate radar operations in the field, an accurate measurement of the operating frequency is necessary. An accuracy of 100 ppm is adequate. Of comparable importance is the capability to measure pulse rise time and spectrum occupancy. Accordingly, each federal agency shall have access to the instrumentation necessary to make a frequency measurement to at least 100 ppm and suitable oscilloscopes and spectrum analyzers to measure time and frequency parameters necessary to determine conformance with these criteria. For fast rise devices, such as magnetrons, oscilloscopes with bandwidths of at least 50 MHz should be used.

### **M.2.2.4 RSEC E**

This measurement method is referenced from Section 5.5.5. In order to coordinate radar operations in the field, an accurate measurement of the operating frequency is necessary. An accuracy of 1 ppm is adequate. Of comparable importance is the capability to measure pulse rise time and spectrum occupancy. Accordingly, each federal agency shall have access to the instrumentation necessary to make a frequency measurement to at least 1 ppm and suitable oscilloscopes and spectrum analyzers to measure time and frequency parameters necessary to determine conformance with these criteria. Measurement instruments shall have resolution bandwidths of at least 10 kHz to measure close in bandwidth limits, and otherwise 100 kHz bandwidth below 1 GHz and 1 MHz bandwidth at and above 1 GHz should be used.

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