# TEST SET-UP PROCEDURES AND TEST EQUIPMENT USED

Pursuant to 47 CFR 2.1041

Except where otherwise stated, all measurements are made following the Telecommunications Industries Association/Electronic Industries Association (TIA/EIA) "Land Mobile FM or PM Communications Equipment Measurement and Performance Standards" (TIA/EIA-603-A).

This exhibit presents a brief summary of how the measurements were made, the required limits, and the test equipment used.

The following procedures are presented with this application:

1) Test Equipment List
2) RF Power Output
3) Transmit Audio Frequency Response
4) Post Limiter Lowpass Filter Response
5) Modulation Limiting Characteristic
6) Occupied Bandwidth
7) Conducted Spurious Emissions
8) Radiated Spurious Emissions
9) Frequency Stability vs. Temperature and Voltage
10) Transient Frequency Behavior

## Test Equipment List

Pursuant to 47 CFR 2.1033(c)

The following test equipment was used to perform the measurements of the submitted data. The calibration of this equipment is performed at regular intervals.

| Device | Model | S/N | Due Date |
|---|---|---|---|
| RF Signal Generator | Agilent E4432B | GB38320171 | 8-Dec-2013 |
| Modulation Analyzer | HP 8901B | 2920A02186 | 8-Dec-2012 |
| Audio Analyzer | HP 8903B | 3729A17909 | 8-Dec-2012 |
| Audio Analyzer | Agilent U8903A | MY49420007 | 23-Sep-2012 |
| UPV Audio analyzer | Rhode & Schwarz UPV Audio Analyzer | 100068 | 17-Sep-2014 |
| Spectrum Analyzer | Agilent E4443A | MY48240080 | 8-Dec-2013 |
| Spectrum Analyzer | Agilent N9020A | MY49060057 | 8-Dec-2012 |
| Power Meter | Agilent E4416A | GB41293783 | 2-Nov-2012 |
| Power Sensor | Agilent E9323A | MY44420279 | 13-Dec-2012 |
| DC Power Supply | HP 6033A | MY41000948 | 12-Dec-2012 |
| Vector Signal Analyzer | Agilent 89600S | US43490737 | 15-Dec-2012 |
| Multimeter | HP 3458A | MY45044025 | 2-Nov-2012 |

## Measurement Procedures Used for Submitted Data

### EXHIBIT 6A - RF Power Output vs. DC Power Input – Pursuant to 47 CFR 2.1046

Conducted power is measured in accordance with TIA/EIA-603-A section 2.2.1.2. The transmitter under test is connected to an HP 438A Power Meter using the forward port of a directional coupler and a 20 dB pad. Appropriate calibration offsets, derived from a traceable RF attenuator, which has been precision characterized by an outside testing laboratory, are entered into the wattmeter to calibrate for the use of the coupler.

The transmitter is operated under normal conditions at the specified nominal dc input voltage. The DC supply path to the final stage only (or to the RF power amplifier module, if the final stage only is not accessible) is interrupted to allow insertion of a DC ammeter in series with the DC supply. The DC voltage drop of the ammeter is negligible. A DC voltmeter is used to measure the DC voltage applied to the final stage. The DC input power to the final stage (in watts) is computed as the product of the DC current (in amperes) times the DC voltage (in volts). This measurement is performed at the lowest, the middle, and the highest operating frequencies of the operating bandwidth of the equipment.

The calibration of the power meter, detector, and attenuator pads is verified on an annual basis. Other power measurement systems that may be used are correlated with this calibrated reference system before measurements are performed, and calibration factors are adjusted as necessary to obtain precise correlation.

**EXHIBIT 6B - Transmitter Audio Frequency Response** – Pursuant to 47 CFR 2.1047(a)

The transmitter output is monitored with an HP 8901B Modulation Analyzer, whose FM demodulator output is fed to an HP 8903B Audio Analyzer. De-emphasis is disabled and filtering above 15 kHz, internal to the test equipment, is used. An audio oscillator signal, derived from the HP 8903B Audio Analyzer, is connected to the microphone audio input of the transmitter. At a frequency of 1 kHz, the level is adjusted to obtain 20% of full system deviation to ensure that limiting does not occur at any frequency in the range of 300 Hz - 3000 Hz. A constant input level is then maintained and the oscillator frequency is varied between the range of 100 Hz to 5000 Hz. The frequency response is plotted, using a reference of 0 dB at 1 kHz.

**EXHIBIT 6C - Transmitter Audio Post Limiter Lowpass Filter Response** – Pursuant to 47 CFR 2.1047(a)

The audio oscillator portion of an HP 8903B Audio Analyzer is connected to the input of the post limiter lowpass filter. The output of the lowpass filter (OMAP TX SSI) is measured with the Rohde & Schwarz UPV Audio Analyzer. The response is swept between the limits of 100 Hz and 30 kHz. Oscillator level is chosen to be the as high as possible that will not cause limiting at any frequency, and is maintained constant vs. frequency.

**EXHIBIT 6D - Modulation Limiting Characteristic** – Pursuant to 47 CFR 2.1047(b)

An audio oscillator is connected to the microphone audio input. The transmitter output is monitored with an HP 8901B Modulation Analyzer. The flat frequency response FM demodulator output of the HP 8901B is fed to an HP 8903B Audio Analyzer. The 20 kHz lowpass filter of the modulation analyzer is used to reduce the level of residual high frequency noise. The oscillator level is adjusted at 1 kHz to obtain 60% of full-system deviation. The oscillator level is then varied over a range of ±20 dB in 5 dB increments, and the resulting deviation is plotted. This measurement is repeated at 300 Hz and 3 kHz. The above procedure is performed four times, for conditions with Tone Private Line, Digital Private Line, Trunking (these are continuous subaudible signaling formats), and without subaudible signalling (referred to as “carrier squelch mode”).

**EXHIBIT 6E - Occupied Bandwidth** – Pursuant to 47 CFR 2.1049(c)(1)

**Procedure for Occupied Bandwidth Measurement for Voice Transmission**

The transmitter is connected, via a suitable attenuator, to the Agilent N9020A Spectrum Analyzer. The spectrum analyzer settings for the reference calibration are in accordance with 47 CFR 90.210(d)(4). The unmodulated carrier’s emission spectrum is captured on the spectrum analyzer and then used to establish a 0 dB reference plot for exhibits.

The HP 8903B audio source is connected to the microphone audio input of the transmitter. The audio source frequency is set to 2500 Hz and the amplitude is adjusted to a level 16 dB above that required to produce 50% of full system deviation at the frequency of maximum response of the audio modulation circuit, in accordance with 47

CFR Part 2.1049(c)(1). The spectrum analyzer settings are adjusted in accordance with 47 CFR 90.210(d)(4) and the analyzer is swept to record the resultant emission levels using the appropriate emission mask.

This measurement is repeated with Tone Private Line (TPL) sub-audible signaling and audio by adding a 250.3 Hz TPL tone at 15% full system deviation with the previously defined 2500 Hz tone. The amplitude of the modulating signal is adjusted so that the total deviation, which includes the TPL deviation, is the full system deviation. An additional measurement is made with Digital Private Line (DPL) sub-audible signaling and audio by adding a DPL code 131 at 15% full system deviation with the previously defined 2500 Hz tone. The amplitude of the modulating signal is adjusted so that the total deviation, which includes the DPL deviation, is the full system deviation.

## Procedure for Occupied Bandwidth Measurement for 2000/3000 Hz FSK Data

The transmitter is connected, via a suitable attenuator, to the Agilent N9020A Spectrum Analyzer. The spectrum analyzer settings for the reference calibration are in accordance with 47 CFR 90.210(d)(4). The unmodulated carrier's emission spectrum is captured on the spectrum analyzer and then used to establish a 0 dB reference plot for exhibits.

The audio function generator is connected to the flat (non-pre-emphasized) transmit audio input of the radio under test. A second function generator producing a square wave output at a frequency of 1200 Hz is connected to the voltage control input of the first generator. The first generator is set to produce a sine wave signal at a center frequency of 2500 Hz and the amplitude of the square wave from the second generator is adjusted so that the frequency of the first generator is varied ± 500 Hz. The resulting output of the first generator is an AFSK sine wave signal that shifts between two discrete frequencies, 2000 Hz and 3000 Hz, at a rate of 1200 Hz. The amplitude of the first generator, which modulates the transmitter, is adjusted for full system deviation. The spectrum analyzer settings are adjusted in accordance with 47 CFR 90.210(d)(4) and the analyzer is swept to record the resultant emission levels using the appropriate emission mask.

This measurement is repeated with Tone Private Line (TPL) sub-audible signaling and 2000/3000 Hz FSK data by adding a 250.3 Hz TPL tone at 15% full system deviation with the previously defined data signal. The amplitude of the modulating signal is adjusted so that the total deviation, which includes the TPL deviation, is the full system deviation. An additional measurement is made with Digital Private Line (DPL) sub-audible signaling and 2000/300 Hz FSK data by adding a DPL code 131 at 15% full system deviation with the previously defined 2500 Hz tone. The amplitude of the modulating signal is adjusted so that the total deviation, which includes the DPL deviation, is the full system deviation.

## Procedure for Occupied Bandwidth Measurement for DTMF

The transmitter is connected, via a suitable attenuator, to the Agilent N9020A Spectrum Analyzer. The spectrum analyzer settings for the reference calibration are in accordance with 47 CFR 90.210(d)(4). The unmodulated carrier's emission spectrum is captured on the spectrum analyzer and then used to establish a 0 dB reference plot for exhibits.

The transmitter is keyed up and the "#" key pressed to generate the worst-case DTMF tones (941 Hz and 1633 Hz). The spectrum analyzer settings are adjusted in accordance with 47 CFR 90.210(d)(4) and the analyzer is swept to record the resultant emission levels using the appropriate emission mask.

This measurement is repeated with Tone Private Line (TPL) sub-audible signaling and DTMF by adding a 250.3 Hz TPL tone at 15% full system deviation with the previously defined DTMF signal. An additional measurement is made with Digital Private Line (DPL) sub-audible signaling and DTMF by adding a DPL code 131 at 15% full system deviation with the previously defined DTMF signal.

### Procedure for Occupied Bandwidth Measurement for 4-Level FSK Data

The transmitter is connected, via a suitable attenuator, to the Agilent N9020A Spectrum Analyzer. The spectrum analyzer settings for the reference calibration are in accordance with 47 CFR 90.210(d)(4). The unmodulated carrier's emission spectrum is captured on the spectrum analyzer and then used to establish a 0 dB reference plot for exhibits.

The radio is placed in test mode such that it transmits a 511-bit pseudo-random bit sequence based on ITU-T O.153 in the 2:1 TDMA protocol's payload, which is in accordance to 47 CFR 2.1049(h). The spectrum analyzer settings are adjusted in accordance with 47 CFR 90.210(d)(4) and the analyzer is swept to record the resultant emission levels using the appropriate emission mask.

FCC Limits for 12.5 kHz Channel: 47 CFR 90.210(d)

For transmitters designed to operate with a 12.5 kHz channel bandwidth, any emission must be attenuated below the power (P) of the highest emission contained within the authorized bandwidth as follows:

1) On any frequency from the center of the authorized bandwidth $f_o$ to 5.625 kHz removed from $f_o$: 0 dB.
2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency ($f_d$ in kHz) of more than 5.625 kHz but no more than 12.5 kHz: at least 7.27*($f_d$ – 2.88 kHz) dB.
3) On any frequency removed from the center of the authorized bandwidth by a displacement frequency ($f_d$ in kHz) of more than 12.5 kHz: at least 50 + 10*log(P) dB or 70 dB (whichever is the lesser attenuation).

   Note: The occupied bandwidth plot exhibits cover a ± 100 kHz frequency range that is centered on the assigned frequency. The radiated and conducted spurious emissions exhibits cover emissions at frequency offsets greater than ± 100 kHz.

## EXHIBIT 6F - Conducted Spurious Emissions – Pursuant to 47 CFR 2.1051

The output of the transmitter is connected, via a suitable attenuator, to the input of an HP 85685A RF Pre-selector and HP 8566B Spectrum Analyzer. After a carrier reference level has been established, a tunable notch-filter is inserted between the attenuator and the spectrum analyzer to allow suppression of the carrier level. The effects of the notch filter on other frequencies, if any, is taken into account. The level of spurious emissions, in dB relative to the carrier, is plotted. This data is measured at the upper and lower frequency limits of the frequency range. If transmit power is adjustable, the measurement is repeated at various power levels including minimum and maximum.

## EXHIBIT 6G - Radiated Spurious Emissions – Pursuant to 47 CFR 2.1053

Transmitter radiated spurious emissions were measured by the Motorola Plantation OATS (Open Area Test Site) Lab, located at 8000 West Sunrise Blvd, Plantation, Florida 33322. Measurements were made at an approved open field test site constructed in accordance with Appendix B, FCC/OST 55 (1982), and were performed in accordance with the Code of Federal Regulations, Title 47, Part 2, paragraph 2.1053. The data is plotted as "Radiated Spurious and Harmonic Emissions (Horizontal and Vertical)" on the graphs comprising EXHIBIT 6G. The specification limit corresponding to a level of 43 dB + 10 log (Pout) below the fundamental carrier power of the transmitter is indicated on each graph for reference.

The following additional instruments are used in performing the radiated field strength measurements:

- Hewlett Packard model 8566A Spectrum Analyzer
- Hewlett Packard model 8350B Sweep Oscillator
- Empire Devices DM-105/T3 tuned dipole antenna (400-1000 MHz)
- EMCO 3121C-DB4 tuned dipole antenna (400-1000 MHz)
- EMCO 3105 ridged W.G. antennas (1-12.4 GHz)
- Bird model 8130 50 Ω, 50 Watt load

**EXHIBIT 6H-1 and 7H-2 - Frequency Stability vs. Temperature and vs. Voltage** – Pursuant to 47 CFR 2.1055(a)(b) and (d)

Frequency Stability vs. Temperature data is measured in accordance with FCC Rules Part 2.1055(a)(1). An HP 5061A Cesium Beam Frequency Standard is used as a reference for frequency measurements. The calibration of the temperature measurements of the environmental chamber is referenced to an HP 2804A Quartz Thermometer.

Frequency Stability vs. Voltage data is measured in accordance with FCC Rules Part 2.1055(d). An HP 5061A Cesium Beam Frequency Standard is used as a reference for frequency measurements.

**EXHIBIT 6I - Transient Frequency Behavior** – Pursuant to 47 CFR 90.214

The trigger level on the Agilent 89600S Vector Signal Analyzer is set at 40 dB below rated power and the trigger sense is set to capture either the key-up or de-key event as appropriate. The center frequency and span are set to the appropriate levels. The Vector Signal Analyzer is then placed into the single-trigger mode. The radio is keyed up or dekeyed as appropriate, and the resultant captured waveform is plotted.