## Measurement Procedure & Test Equipment Used

Except where otherwise stated, all measurements are made following the Electronic Industries Association (EIA) Minimum Standard for Portable/Personal Land Mobile Communications FM or PM Equipment 25-1000 MHz (EIA/TIA-603-D).

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.

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| 1. Test Equipment List | x |
| 2. RF Power Output Data | x |
| 3. Audio Frequency Response | x |
| 4. Audio Low Pass Filter Response | x |
| 5. Modulation Limiting | x |
| 6. Occupied Bandwidth | x |
| 7. Radiated Spurious Emissions | x |
| 8. Conducted Spurious Emissions | x |
| 9. Frequency Stability (Volt/Temp) | x |
| 10. Transient Frequency Behavior | x |

**Test Equipment List**

**Measurement Equipment List-** Pursuant To FCC Rules 2.947 (d)

| Device | Model | S/N | Due Date |
|---|---|---|---|
| Computer | HP EliteBook 8570w | 5CB238199F | Cal Not Required |
| RF Signal Generator | Agilent E4420B | MY43350119 | 25-Nov-14 |
| Modulation Analyzer | HP 8901B | 2914A02068 | 30-Nov-14 |
| Audio Analyzer | HP 8903B | 3729A17572 | 14-Apr-14 |
| Dynamic Signal Analyzer | Agilent 35670A | MY42507095 | 05-Oct-14 |
| PSA Series Spectrum Analyzer | Agilent E4445A | MY45300745 | 28-Aug-14 |
| Power Supply | HP 6623A | 3448A04981 | 11-Oct-14 |
| Power Meter | Agilent E4416A | MY52080011 | 12-Apr-14 |
| Power Sensor (with 30DB Pad) | Agilent E9301B | MY51420004 | 1-Feb-14 |
| Infiniium Oscilloscope | Agilent MSO8104A | MY45001030 | 10-Oct-14 |
| Spectrum Analyzer | HP 8594E | 3624A03051 | 19-Sep-14 |
| 15MHz Functional Generator | HP 33120A | US36005090 | 1-Jun-14 |
| Espec Chamber | Espec SH-241 | 92012360 | 28-Sep-14 |
| Dual Directional Coupler | HP 778D | 14163 | Cal Not Required |
| NHP-88 + High Pass Filter 50 ohm (780-3000) | Mini Circuits | 15542 | Cal Not Required |
| 4-Way Pad | Measurement DIV M530 | NA | Cal Not Required |
| 30-dB attenuator | Weischel Engineering 9305 30 | NA | Cal Not Required |
| USB Programming Cable | GPIB-USB-HS | 152C7D | Cal Not Required |
| Aeroflex Weinshel (50ohm terminated) | 1424-4 | 22769 | Cal Not Required |
| Antennas | Chase CBL6111 | 1138 | 7-Jan-15 |
| Antennas | EMCO 3115 | 2419 | 18-Jan-14 |
| Amplifiers | HP 8447D | 2443A03952 | 31-Dec-13 |
| Cable set | ACS Boca-Chamber EMI Cable set | 2037 | 1-Jan-14 |
| Spectrum Analyzers | Agilent 8573A | 2407A03233 | 12-Dec-13 |
| Amplifiers | Agilent 83017A | 3123A00214 | 20-Dec-13 |
| Software | ETS Lidgren Tile4!-Version 4.2.A | 85242 | Cal Not Required |

Table 1: List of Equipment

| Test Name | FCC Rules Part (47 CFR) | IC Rules |
|---|---|---|
| RF Power Output Data | 2.1046(a), 2.1033(c)(6), 2.1033(c)(7) and 2.1033(c)(8)<br>* 90.545(b)(4) (700MHz)<br>22.565(f) (VHF & UHF),<br>* 24D (900MHz) | RSS-Gen Sec 4.8,<br>RSS-119 Sec 5.4.1,<br>* RSS 134 (900MHz) |
| TX Audio Frequency Response | 2.1047 and 2.1033(c)(13)<br>22.355 | - |
| TX Audio Low Pass Filter Response | 2.1047 | - |
| Modulation Limiting | 2.1047 | - |
| Occupied Bandwidth | 2.1049, 90.210,<br>* 90.691 (800MHz),<br>22.359 (b) (VHF & UHF),<br>* 24D (900MHz) | RSS GEN Sec 4.6,<br>RSS 119 Sec 5.5,<br>* RSS 134 (900MHz) |
| TX Conducted Spurious Emissions | 2.1051, 90.210,<br>22.359(a) (VHF & UHF),<br>* 24D (900MHz)<br>* 80 (VHF) | RSS GEN Sec 6.2,<br>RSS 119,<br>* RSS 134 (900MHz)<br>* RSS 182 (VHF) |
| TX Radiated Spurious Emissions | 2.1053, 90.210,<br>22.359(a) (VHF & UHF),<br>* 24D (900MHz) | RSS GEN Sec 4.9,<br>RSS 119 Sec 4.2, 5.8,<br>* RSS 134 (900MHz) |
| Frequency Stability (Temp / Supply Voltage) | 2.1055, 90.213,<br>22.355<br>* 90.539 (700MHz) | RSS GEN Sec 4.7,<br>RSS 119 Sec 5.3 |

Table 2: List of FCC and IC reference

** Note: Not Applicable for this filing*

## EXHIBIT 7A - RF Output Power

The transmitter under test is connected to Power Meter using the forward port of 30dB attenuator and power sensor 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, power sensor 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 7B - Transmit Audio Frequency Response

The transmitter output is monitored with modulation analyzer, whose FM demodulator output is fed to an audio analyzer. De-emphasis or filtering within the test equipment is not used. An audio oscillator signal, derived from the Audio Analyzer, is connected to the microphone audio input of the transmitter. At a frequency of 1kHz, 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 300Hz – 3000Hz. A constant input level is then maintained and the oscillator frequency is varied between the ranges of 100Hz to 5000Hz. The frequency response is plotted, using a reference of 0 dB at 1kHz.

## EXHIBIT 7C - Transmit Audio Post Limiter Low Pass Filter Response

The audio oscillator portion of an audio analyzer is connected to the input of the post limiter low pass filter. The oscillator is adjusted, at 1000Hz and level 16 dB greater than that required to produce standard test modulation. The output of the low pass filter is measured with dynamic signal analyzer. The response is swept between the limits of 1000Hz - 30000Hz. Oscillator level is chosen to be as high as possible and that will not cause limiting at any frequency, and maintaining a constant input level versus frequency.

## EXHIBIT 7D – Modulation Limiting Characteristic

An audio oscillator is connected to the microphone audio input. The transmitter output is monitored with modulation analyzer. The flat frequency response FM demodulator output of the modulation analyzer is fed to an audio analyzer. The 20kHz low pass filter of the modulation analyzer is used to reduce the level of residual high frequency noise. The oscillator level is adjusted, at 1kHz, to obtain 60% of full system deviation. The oscillator level is then varied over a range of +/-20dB in 5 dB increments, and the resulting deviation is plotted. This measurement is repeated at 300 Hz and 3kHz. The above procedure is performed three times, for conditions with Tone Private Line, Digital Private Line, and Carrier Squelch Mode (without sub-audible signaling).

**EXHIBIT 7E - Occupied Bandwidth**

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

The transmitter is connected, via a suitable attenuator, to the Series 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.

Audio source from audio analyzer is connected to the microphone audio input of the transmitter. The audio source frequency is set to 2500Hz 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 250.3Hz TPL tone at 15% full system deviation with the previously defined 2500Hz 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 2500Hz 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 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 1200Hz 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 2500Hz and the amplitude of the square wave from the second generator is adjusted so that the frequency of the first generator is varied ± 500Hz. The resulting output of the first generator is an AFSK sine wave signal that shifts between two discrete frequencies, 2000Hz and 3000Hz, at a rate of 1200Hz. 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 2000/3000Hz FSK data by adding a 250.3Hz 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 2000/300Hz FSK data by adding a DPL code 131 at 15% full system deviation with the previously defined 2500Hz 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 4-Level FSK Data**

The transmitter is connected, via a suitable attenuator, to the 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.

Note: The occupied bandwidth plot exhibits cover a ± 50kHz frequency range that is centered on the assigned frequency.

**EXHIBIT 7F - Radiated Spurious Emissions**

Radiated spurious emissions were measured by Advanced Compliance Solutions Lab. 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 Emissions" on the graphs. The specification limit corresponding to a level of 43 dB + 10log (Pout) for 25kHz Channel Spacing and 50 dB + 10log (Pout) for 12.5kHz Channel Spacing below the fundamental carrier power of the transmitter as indicated on each graph for reference.

**EXHIBIT 7G - Conducted Spurious Emissions**

The output of the transmitter is connected, via a suitable attenuator, to the input of an Spectrum Analyzer. This data is measured at the upper and lower frequency limits of the frequency range. If transmit power is adjusted, the measurement is repeated at various power levels including minimum and maximum.

Note:
For part 90, RBW setting is adjusted to 10kHz for spurious emissions below 1GHz and 1MHz for spurious emissions above 1GHz.
For part 22, RBW setting is adjusted to >30kHz.

**EXHIBIT 7H – Frequency Stability vs. Temperature and vs. Voltage**

Frequency Stability vs. Temperature data is measured in accordance with FCC Rules Part 2.1055 (a) (1). A modulation analyzer is used to measure the frequency of the signal transmitted by the radio by way of a 20dB attenuator. The radio is placed in a SH 241 Temperature and Humidity Chamber, and the frequency is measured as the temperature is incremented from –30 to +60 degrees C in 10 degrees increments.

Frequency Stability vs. Voltage data is measured in accordance with FCC Rules Part 2.1055 (d). A modulation analyzer is used to measure the frequency of the signal transmitted by the radio by way of a 20dB attenuator. The supply voltage of the radio is swept +30% and –23% of 7.5Vdc.

**EXHIBIT 7I - Transient Frequency Behavior**

The output of the radio is connected to an modulation analyzer by way of a directional coupler, 30dB attenuator, and 2:1 combining network. This output is first measured with an power meter and then the power meter is replaced by the modulation analyzer, and the RF output of an signal generator is connected to the second port of the combining network at a level of 30dB less than the output level of the radio measured after the attenuator. The RF output of the signal generator is modulated with a 1kHz tone and deviation of 12.5kHz or 25kHz depending on the channel spacing. The modulation output of the modulation analyzer is connected to a digital storage oscilloscope. The signal generator is turned on first, and then the radio keyed or de-keyed depending on the particular test. The oscilloscope is triggered by way of a RF peak detector that detects the RF output of the radio by way of the directional coupler.

The picture of the oscilloscope display is stored on a floppy disk and transferred to a computer. The key up attack time plot shows the 1kHz from the RF signal generator signal from the modulation output of the modulation analyzer, and when the radio is keyed, the output signal from the radio captures the receiver of the modulation analyzer, resulting in the carrier only signal. The de-key decay time plots show the unmodulated signal from the radio and when the radio is de-keyed, the 1kHz from the RF signal generator signal captures the receiver of the modulation analyzer, resulting in the 1kHz signal shown in the plots.