

**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 25-1000MHz-(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.

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

**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	HP 8657A	3217A04516	31-Jan-14
Modulation Analyzer	HP 8901B	3122A03671	11-Oct-13
Audio Analyzer	HP 8903B	2614A01379	25-Aug-14
Dynamic Signal Analyzer	Agilent 35670A	MY42507095	05-Oct-14
PSA Series Spectrum Analyzer	Agilent E4443A	MY46181975	16-Mar-14
Power Supply	HP 6623A	3351A03372	28-Feb-14
Power Meter	Agilent E4416A	MY45101016	03-Oct-14
Power Sensor (with 30DB Pad)	Agilent E9301B	MY41495551	01-Oct-14
Infiniium Oscilloscope	Agilent DSO 54833A	MY43000201	13-Nov-14
Spectrum Analyzer	HP 8594E	3911A08915	14-Nov-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-300 + High Pass Filter 50 ohm	Mini Circuits	8724 14	Cal Not Required
Dual Directional Coupler	HP 778D	MY52180211	Cal Not Required
30 dB attenuator	Aeroflex/Weinschel, model 23-30-34, 10W	N/A	Cal Not Required
50 Ohms terminating load	MCE/Weinschel 1429-4	N/A	Cal Not Required
Measurements DIV. 2:1 Combiner	M501	N/A	Cal Not Required
Spectrum Analyzers	Agilent	MY45103293	08-Jan-15
Antennas	Chase CBL6111	1138	07-Jan-15
Antennas	Electro Metrics RGA-180	2121	11-Apr-13
Antennas	EMCO 3146	1385	30-Nov-13
Antennas	EMCO 3115	2419	18-Jan-14
Amplifier	HP 8447D	2443A03952	31-Dec-13
Cable Set	ACS Boca Chamber EMI Cable Set	2037	01-Jan-14
Cable Set	ACS Boca Substitution Cable Set	2078	01-Jan-14
Cables	QMI	2044	31-Dec-13
Cables	HP5061-5458	2076	29-Dec-13
Amplifiers	Agilent 83017A	3123A00214	20-Dec-13
Spectrum Analyzers	Agilent 8573A	2407A03233	12-Dec-13
Software	ETS Lindgren TILE4! – Version 4.2A	85242	Cal Not Required
Signal Generators	HP 8673D	3034A01078	21-May-13

Table 1: List of equipment used

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) * 90.545(b)(4) (700MHz) 22.565(f) (VHF & UHF), * 24D (900MHz)	RSS-Gen Sec 4.8, RSS-119 Sec 5.4.1,  * RSS 134 (900MHz)
TX Audio Frequency Response	2.1047 and 2.1033(c)(13)	-
TX Audio Low Pass Filter Response	2.1047	-
Modulation Limiting	2.1047	-
Occupied Bandwidth	2.1049, 90.210, * 90.691 (800MHz), 22.359 (b) (VHF & UHF), * 24D (900MHz)	RSS GEN Sec 4.6, RSS 119 Sec 5.5,  * RSS 134 (900MHz)
TX Conducted Spurious Emissions	2.1051, 90.210, 22.359(a) (VHF & UHF), * 24D (900MHz) * 80 (VHF)	RSS GEN Sec 6.2, RSS 119, * RSS 134 (900MHz) * RSS 182 (VHF)
TX Radiated Spurious Emissions	2.1053, 90.210, 22.359(a) (VHF & UHF), * 24D (900MHz)	RSS GEN Sec 4.9, RSS 119 Sec 4.2, 5.8, * RSS 134 (900MHz)
Frequency Stability (Temp / Supply Voltage)	2.1055, 90.213, 22.355 * 90.539 (700MHz)	RSS GEN Sec 4.7, 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  $\pm$  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  $\pm 50\text{kHz}$  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  $43\text{ dB} + 10\log(\text{Pout})$  for 25kHz Channel Spacing and  $50\text{ dB} + 10\log(\text{Pout})$  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 a 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 a modulation analyzer by way of a directional coupler, 30dB attenuator, and 2:1 combining network. This output is first measured with a power meter and then the power meter is replaced by the modulation analyzer, and the RF output of a 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.