MEASUREMENT PROCEDURE AND 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-603A).

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.

UHF1

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
10.	Frequency Stability (Volt/Temp)	x

UHF2

1.	Test Equipment List	X
2.	RF Power Output	X
3.	Audio Frequency Response	X
4.	Post Limiter Filter Frequency Response	X
5.	Modulation Limiting	X
6.	Occupied Bandwidth	X
7.	Conducted Spurious Emissions	X
8.	Radiated Spurious Emissions	X
9.	Frequency Stability	X
10.	Transient Frequency Behavior	X

TEST EQUIPMENT LIST

Pursuant To FCC Rules 2.947 (d)

UHF1

1. HP 8566A Spectrum Analyzer.
2. Rohde & Schwarz ESMI Test Receiver.
3. HP 4436B RF Signal Generator.
4. HP 6033A Power Supply
5. HP 8903B Audio Analyzer.
6. HP 34401A Digital Multimeter
7. HP 8901B Modulation Analyzer
8. Weinschel Model WA53 30 dB attenuator (DC - 1.5 GHz)
9. HP 437B Power Meter with 8482H Power Sensor
10. Agilent Technologies MXA Signal Analyzer N9020A (20 Hz – 3.6 GHz)
11. Agilent E4440A PSA Spectrum Analyzer (3 Hz – 26.5 GHz)
12. A.H. Systems Inc. DRG Horn Antenna (700 MHz – 18 GHz)
13. Schaffner-Chase EMC Ltd. Bilog Antenna (30 MHz – 2 GHz)
14. RAD4010ARB, 3dB, Roof Mount Antenna, 136-174 MHZ
15. Mini-Circuits, VHF High Pass Filter, NHP 300
16. ESPEC Temperature Chamber
17. Agilent infiniium 54832B Oscilloscope
18. Weinschel Model1440-4 RF Terminating Load
19. Agilent 778D, Bi directional coupler

UHF2

1. HP 8901B Modulation Analyzer
2. HP 5334B Universal Counter
3. Thermotron 2800 Temperature Chamber
4. HP 6652A Power Supply
5. HP 6032A Power Supply
6. HP 8903B Audio Analyzer.
7. HP 34401A Digital Multimeter
8. Keithley 2001 Multimeter with 2001 Scanner Card
9. Rohde and Schwarz Model FSEA Spectrum Analyzer
10. Rohde and Schwarz Model UPD Audio Analyzer
11. Weinschel Model WA1426-4 RF Terminating Load
12. Weinschel Model WA53 30 dB attenuator (DC - 1.5 GHz)
13. Rohde and Schwarz Model SMP22 Signal Generator
14. Rohde and Schwarz Model ESI26 Spectrum Analyzer/ ESI Test Receiver
15. HP 437B Power Meter with 8482H Power Sensor
16. Agilent Technologies MXA Signal Analyzer N9020A (20 Hz - 3.6 GHz)
17. Narda Bi-Directional Coaxial Coupler Model 3020A (50-1000 MC)
18. Narda High Power Attenuator Model 26298
19. Agilent E4440A PSA Spectrum Analyzer (3 Hz - 26.5 GHz)
20. Schaffner-Chase EMC Ltd. Bilog Antenna (30 MHz - 2 GHz)

RF POWER OUTPUT

Pursuant to FCC Rules 2.1046 (a)

Method of Measurement

The RF power output is measured with the transmitter adjusted in accordance with the tune-up procedure outlined in Exhibit 7 to give the value of voltage and current as specified in Exhibit 4 as required by 2.1033(c)(8). A 50-ohm RF attenuator of proper power rating was used as a load for making these measurements.

The power measurements were made using an HP 437B RF power meter with 8482H power sensor and 30 dB attenuator.

AUDIO FREQUENCY RESPONSE

Pursuant FCC Rules 2.1047 (a)

Method of Measurement

Operate the transmitter under standard test conditions and monitor the output with a frequency deviation meter or calibrated test receiver. With 1000 Hz sine wave audio input applied through a dummy microphone circuit, adjust the audio input to give 20% of full rated system deviation maintaining a constant input voltage, vary the input frequency from 300 to 3000 Hz, and observe the deviation.

Minimum Standard

The audio frequency response shall not vary more than +1 or -3 dB from 300 to 3000 Hz from a true 6 dB per octave pre-emphasis characteristic as referenced to 1000 Hz level, with the exception of a permissible 6 dB/octave roll off below 500 Hz. Equivalent to TIA/EIA 603A Section 5.2.6.2 mask.

POST LIMITER FILTER FREQUENCY RESPONSE

Pursuant FCC Rules 2.1047 (a)

Method of Measurement

Operate the transmitter under standard test conditions and monitor the output of the post limiter low-pass filter with an audio spectrum analyzer or AC voltmeter. Adjust the audio input frequency to 1000 Hz and the input level to 20 dB greater than that required to produce standard test modulation. Note the output level on the audio spectrum analyzer or AC voltmeter. User this output dB level as reference (LEVREF), vary the modulating frequency from 3000 Hz to the upper low pass filter limit and record the dB level on the audio spectrum analyzer or AC voltmeter as LEVFRE while maintaining a constant input level. The audio frequency response of the low-pass filter in accordance with the following formula:

Low-Pass Filter Response = LEVFREQ-LEVREF

FCC Limits -- Per EIA/TIA 603 3.2.15.

b) For equipment operating with 25 KHz spacing channels between 406 MHz and 512 MHz through 896 MHz, and between 929 MHz through 930 MHz:
At frequencies from 3000 Hz through 20,000 Hz the attenuation shall be greater than the attenuation at 1000 Hz by at least: 60 log10 (f / 3000) dB, where: f is the audio frequency in Hz.
At frequencies above 20,000 Hz, the attenuation shall be greater than the attenuation at 1000 Hz, by at least: 50 dB.

c) For equipment operating on channels between 896 MHz through 901 MHz, between 935 MHz through 940 MHz, and 12.5 or 15 kHz spaced channels in the frequency range 138-174 MHz and 406-512 MHz:
At frequencies from 3000 Hz through 20,000 Hz the attenuation shall be greater than the attenuation at 1000 Hz by at least: 100 log10 (f / 3000) dB, where: f is the audio frequency in Hz.

MODULATION LIMITING

Pursuant FCC Rules 2.1047 (b)

Method of Measurement

The transmitter shall be adjusted for full rated system deviation. Adjust the audio input for 60% of rated system deviation at 1000 Hz. Using this level as a reference (0 dB) vary the audio input level from the reference to a level 20 dB above it for modulation frequencies of 300, 1000 and 3000 Hz. Record the system deviation obtained as a function of the input level.

FCC Limits

Minimum Standard - The transmitter modulation must not exceed rated system deviation at any audio frequency input or reasonable change in input level.

OCCUPIED BANDWIDTH

Pursuant to FCC Rules 2.1049

Method of Measurement

Data on occupied bandwidth is presented in the form of a spectrum analyzer photograph, which illustrates the transmitter sidebands. For analog signals, the reference line for the data plot is taken of the unmodulated carrier, to which is superimposed the sideband display generated by modulating the carrier with a 2500 Hz tone at a level 16 dB greater than that required to produce 50 percent modulation. For digital voice and data, the reference line for the data plot is that of the peak value of the modulated carrier. For digital voice, the carrier with a 2500 Hz tone at a level 16 dB greater than that required to produce 50 percent modulation. For digital data, the carrier is modulated with a Standard Transmitter Test Pattern, which is a continuously repeating 511 bit pseudo-random bit sequence based on ITU-T 0.153. If tone or digital coded squelch is indicated, photographs using both the 2500 Hz tone and the indicated squelch signal are used to modulate the transmitter. During these measurements, the instantaneous Deviation Control is set for a maximum of +5 kHz.

FCC Limits - Per 90.210 (b), (d).

Emission Mask B. For transmitters that are equipped with an audio low-pass filter pursuant to Sec. 90.211(a), the power of any emission must be below the unmodulated carrier power (P) as follows:

(1) On any frequency removed from the assigned frequency by more than 50 percent, but not more than 100 percent of the authorized bandwidth: At least 25 dB.
(2) On any frequency removed from the assigned frequency by more than 100 percent, but not more than 250 percent of the authorized bandwidth: At least 35 dB.
(3) On any frequency removed from the assigned frequency by more than 250 percent of the authorized bandwidth: At least 43 + 10 log (P) dB, where P is the mean output power in watts.

Emission Mask D. 12.5 kHz channel bandwidth equipment. 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 f0 to 5.625 kHz removed from f0: Zero dB.
(2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 5.625 kHz but no more than 12.5 kHz: At least 7.27(fd - 2.88 kHz) dB.

(3) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 12.5 kHz: At least 50 + 10 log (P) dB or 70 dB, whichever is the lesser attenuation.

(4) The reference level for showing compliance with the emission mask shall be established using a resolution bandwidth sufficiently wide (We used 30 KHz, which is more than two times the channel bandwidth) to capture the true peak emission of the equipment under test. In order to show compliance with the emissions 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 emissions beyond 50 kHz from the edge of the authorized bandwidth, see paragraph **(m)** of this section. If it can be shown that use of the above instrumentation settings do not accurately represent the true interference potential of the equipment under test, then an alternate procedure may be used provided prior Commission approval is obtained.

(m) Instrumentation. The reference level for showing compliance with the emission mask shall be established, except as indicated in Secs. 90.210 (d), (e), and (k), using standard engineering practices for the modulation characteristic used by the equipment under test. When measuring emissions in the 150-174 MHz and 421-512 MHz the following procedures will apply. 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 10 kHz must be used for frequencies below 1000 MHz. Above 1000 MHz the resolution bandwidth of the instrumentation must be at least 1 MHz. If it can be shown that use of the above instrumentation settings do not accurately represent the true interference potential of the equipment under test, then an alternate procedure may be used provided prior Commission approval is obtained.

ADJACENT CHANNEL COUPLED POWER RATIO

Pursuant to FCC Rules 90.543

Method of Measurement

A reference level of the Unit Under Test was obtained by setting the measurement bandwidth of the spectrum analyzer to the channel size and measuring the power in the channel. Measurements were then taken at specified offsets and measurement bandwidths as specified in 90.543(a). For the far-out offsets, the dynamic range of the spectrum analyzer had to be extended. This was accomplished by connecting the output of the Unit Under Test to Port 1 of a circulator, connecting a tunable bandpass filter with a terminating load to Port 2 and connecting Port 3 of the circulator to the spectrum analyzer. With the spectrum analyzer swept over the desired measurement offset, the bandpass filter was slowly tuned from a higher frequency setting toward the current transmitter frequency. As the bandpass filter is tuned, frequencies outside of the filter's bandpass response are reflected back to the circulator where they are then passed to the spectrum analyzer. Frequencies inside the filter's response are passed to the terminating load and thus eliminated from the input of the spectrum analyzer. As the bandpass filter is tuned, the display of the spectrum analyzer is observed. As the center frequency of the filter approaches the current transmitter frequency, the level of the transmitter signal on the display of the spectrum analyzer will drop. The bandpass filter was tuned to the point where sufficient dynamic range of the spectrum analyzer was obtained. Actual measurements are recorded in the attached table.

FCC Limits - Per Rule 90.543(a).

CONDUCTED SPURIOUS EMISSIONS

Pursuant to FCC Rule 2.1051

Method of Measurement:

The transmitter is terminated into a 50 ohm load and interfaced with a spectrum analyzer which allows the spurious emission level relative to the carrier level to be measured directly. Modulate the transmitter with a 2500 Hz sine wave at an input level 16 dB greater than that required to produce 50% of rated system deviation at 1000 Hz. Measurements shall be made from the lowest radio frequency generated in the equipment to the tenth harmonic of the carrier or as high as the state of the art permits except for that region close to the carrier equal to ± 250% of the authorized bandwidth.

FCC Limits - Per Applicable Rule Parts.

Conducted spurious emissions shall be attenuated below the maximum level of emission of the carrier frequency in accordance with the following formula:

Spurious attenuation in dB = 43 + 10 $\log_{10}$ (Power output in watts) for 25 kHz Channelization.

Spurious attenuation in dB = 50 + 10 $\log_{10}$ (Power output in watts) for 12.5 kHz Channelization.

RADIATED SPURIOUS EMISSIONS

Pursuant to FCC Rules 2.1053

Test Site:

The site, located at Plantation, Florida, is in a region, which is reasonably free from RF interference and has been approved by the Commission for Spurious Measurements.

The equipment is placed on the turntable, connected to a dummy RF load and then placed in normal operation using the intended power source. A broadband receiving antenna, located 10 meters from the transmitter-under-test (TUT), picks up any signals radiated from the transmitter and its operation accessories. The antenna is adjustable in height and can be horizontally and vertically polarized. A spectrum analyzer covering the necessary frequency range is used to detect and measure any radiation picked up by the above mentioned receiving antenna.

Method of Measurement:

The equipment is adjusted to obtain peak reading of received signals wherever they occur in the spectrum by:

1. Rotating the transmitter under test.
2. Adjusting the antenna height.

The testing procedure is repeated for both horizontal and vertical polarization of the receiving antenna. Relative signal strength is indicated on the spectrum analyzer connected to the receiving antenna. To obtain actual radiated signal strength for each spurious and harmonic frequency observed, a standard signal generator with calibrated output is connected to a dipole antenna adjusted to that particular frequency. This dipole antenna is substituted for the transmitter under test. The signal generator is adjusted in output level until a reading identical to that obtained with the actual transmitter is observed on the spectrum analyzer. Signal strength is then read directly from the generator. Actual measurements are recorded on the attached graphs.

FCC Limits -- Per Applicable Rule Parts.

Radiated spurious emissions shall be attenuated below the maximum level of emission of the carrier frequency in accordance with the following formula:
Spurious attenuation in dB = 43 + 10 $\log_{10}$ (Power output in watts) for 25 kHz Channelization.

Spurious attenuation in dB = 50 + 10 $\log_{10}$ (Power output in watts) for 12.5 kHz Channelization.

1559-1610 MHz RADIATED EMISSIONS

Pursuant to FCC Rules 2.1053 & 90.543 (e)

Method of Measurement:

Measurements were conducted per TIA-102.CAAA-B Section 2.2.6.4. The transmitter is terminated into a 50 ohm load and interfaced through a suitable high pass filter to a spectrum analyzer. This allows for the measurement of spurious emission levels in the GNSS band. The transmitter is replaced with a signal generator to determine the loss of the setup at the measurement frequencies. And, the radiated emissions in the GNSS band are calculated as follows:

EIRP (dBm) = Level (dBm) - Loss (dB) + Antenna Gain (dBi)

FCC Limits -- Per 47 CFR 90.543(e).

All emissions including harmonics in the band 1559-1610 MHz shall be limited to -70 dBW/MHz equivalent isotropically radiated power (EIRP) for wideband signals, and -80 dBW EIRP for discrete emissions of less than 700 Hz bandwidth.

FREQUENCY STABILITY

Pursuant to FCC Rule 2.1055

Method of Measurement:

A. Temperature (Non-heated type crystal oscillators):
Frequency measurements are made at the extremes of the temperature range -30 to +60 degrees centigrade and at intervals of not more than 10 degrees centigrade throughout the range. Sufficient time is allowed prior to each measurement for the circuit components to stabilize.

B. Power Supply Voltage:
The primary voltage was varied from 85% to 115% of the nominal supply voltage. Voltage is measured at the input to the cable normally provided with the equipment, or at the power supply terminals if cables are not normally provided. In addition, the primary voltage will be reduced to the point where the radio performs a reset (battery operating end point).

FCC Limits -- Per FCC Rule 90.213

Temperature - Frequency Stability of ± 1.5 ppm from -30 to +60 degrees centigrade.
Power Supply Voltage - Frequency Stability of ± 1.5 ppm from 85% to 115% of nominal voltage.

Transient Frequency Behavior

Pursuant to FCC Rule 90.214

Transient frequency behavior is a measure of the difference, as a function in time, of the actual transmitter frequency to the assigned transmitter frequency when the transmitted RF output power is switched on or off.

Setup -- Per TIA/EIA 603, Section 2.2.19

Connect the output port of the transmitter under test (TUT) to an attenuator and this to a directional coupler. Connect an RF peak detector to the coupled output of the directional coupler, and connect the output of the RF peak detector to the external trigger on a storage oscilloscope. The output of the directional coupler is mixed, via an RF combining network, with the output of a signal generator. Verify that the TUT signal level present at the combining network output is approximately 40 dB below the maximum input level of the test receiver as per step (f). Set the signal generator at the same frequency as the TUT, modulated with a 1 kHz tone, with an FM deviation equal to the assigned channel spacing (+25 kHz).

Following step (h), adjust the signal generator to provide 20 dB less power at the combiner output than the level set in step (f). Connect the output of the RF combiner to a test receiver, and the test receiver's output port to a vertical input channel of the storage scope. Adjust the horizontal sweep rate on the oscilloscope to 10msec/div, and the vertical amplitude to display the 1 kHz tone over +/- 4 divisions centered on the display. Reduce the transmit attenuation by 30 dB as per step (l) so that the difference in the power between the reference signal and the TUT signal at the combiner is 50 dB when the TUT is turned on. Following step (k), adjust the oscilloscope to trigger on an increasing signal from the RF detector at one division from the left side of the display when the TUT is turned on. Switch on the TUT and record the display (for RF Output Power ON). Following step (q), adjust the oscilloscope trigger controls to trigger on a decreasing signal from the RF peak detector, at 1 division from the right side of the display when the TUT is turned off. Switch off the transmitter and record the display (for RF Output Power OFF).

* Steps (f), (h), (k), (l), and (q) - section 2.2.19 of the TIA/EIA 603 were followed.

Method of Measurement -- Per TIA/EIA-603-2.2 19.

For RF Output Power ON: Turn the transmitter ON. Once the demodulator output has been captured by the transmitter power, the 1 kHz test signal will be completely suppressed. This point in time is named T-on. The display will then show the frequency difference from the assigned frequency to the actual transmitter frequency versus time. Two time intervals will be measured following T-on: T-1 and T-2.
So, the RF ON time intervals are as follows: T-on --------> T-1 -----------> T-2

For RF Output Power OFF: Turn the transmitter OFF. The display will show the transmitter frequency difference versus time, and when the 1 kHz test signal starts to rise, it indicates total absence of the transmitter output at the specified frequency. This point is named T-off. Time interval T-3 precedes T-off. So, the RF OFF time intervals are as follows: T-3 --------> T-off.

FCC Limits -- Per 90.214.

	Frequency Range (MHz)		
Time Interval	30 to 300	300 to 500	500 to 1000
T-1	5.0 ms	10.0 ms	20.0 ms
T-2	20.0 ms	25.0 ms	50.0 ms
T-3	5.0 ms	10.0 ms	10.0 ms

*Per Applicable Rule Parts.