Exhibit F – Test Report

The data required by 47 CFR Sections 2.1046 through 2.1057 inclusive, measured in accordance with the procedures set out in Section 2.1041. (2.1033 (c) (14))

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F.1 Test Procedure and Compliance Matrix

This section documents the test procedures and results of tests to demonstrate compliance with the applicable requirements of Parts 2 and 87 of the FCC Rules and Regulations, Code of Federal Regulations (CFR) Title 47.

Tests were conducted on engineering “Red Label” units under configuration management. “Red Label” units are considered to be identical to production “Black Label” units in terms of the performance criteria specified in this section. “Red Label” units are converted to “Black Label” units once FAA Technical Standard Order (TS0) and FCC approval are obtained.

The Table F- below identifies the applicable sections of this document and its relationship between the Parts 2 and 87 requirements. The test results are included within each individual test section.

Table F-1 – Test Requirements Matrix

47 CFR Part 2 Section	47 CFR Part 87 Section	Test Description Summary	Section
2.1047	87.141	Modulation Characteristics	F.2
2.1046	87.131	RF Power Output	F.4
2.1055	87.133	Frequency Stability	F.5
2.1049	87.135	Occupied Bandwidth	F.6
2.1051	87.139	Spurious Emissions at Antenna Terminals	F.7
2.1053	87.139	Field Strength of Spurious Radiation	F.8

F.2 RTA-41XX Modulation Characteristics (2.1047)

Requirement:

47 CFR Section 2.201 – Emission, Modulation, and Transmission Characteristics

47 CFR Section 2.1047(d) states: "A curve or equivalent data which shows that the equipment will meet the modulation requirements of the rules under which the equipment is to be licensed."

Weather/Turbulence/Map Operation:

The RTA-41XX utilizes rectangular pulses modulated with Binary Phase-Shift Keying (BPSK).

Under the guidelines of Section 2.201 of the CFR the Emissions Designation of the RTA-41XX is as follows:

23M60M1X

Where:

"23M60" - The necessary bandwidth is calculated in two parts. The necessary bandwidth for a single frequency channel is calculated as $B_n = 2R / \log_2(S) = 7.6$ MHz. R is the maximum symbol rate for the Ultra Short pulse as described below. S is the number of modulation states (S = 2 for BPSK). In addition there is a 16 MHz frequency separation between the lowest frequency and highest frequency channel as described below. This separation is added to the single channel necessary bandwidth as the lowest frequency lower spectrum and the highest frequency upper spectrum dictate the overall necessary bandwidth.

"M" – A sequence of pulses modulated in position/phase.

"1" – A single channel containing quantized or digital information without the use of a modulating sub-carrier, excluding time-division multiplex.

"X" – Type of information to be transmitted – Cases not otherwise covered.

The following paragraphs describe the transmitted output waveform and frequency utilization.

The RTA-41XX Weather Radar System utilizes a single fixed pulse pattern for all Weather, Turbulence, and Map modes of operation. This same pattern is utilized regardless of whether the system is in Manual operation or Automatic MultiScan™ operation.

The transmitter pulse pattern consists of a sequence of seven pulses. This includes a series of two 3.4 µs transmitter pulses for short-range weather detection, one 55 µs pulse for long-range weather detection, and a series of four 20 µs pulses for measuring weather and turbulence out to 40 nm. Figure F-1 below shows this pattern. The time period for this group of 7 pulses is called an Epoch. A small variable delay is inserted between epochs to reduce mutual interference between radar systems by dithering the pulse timing.

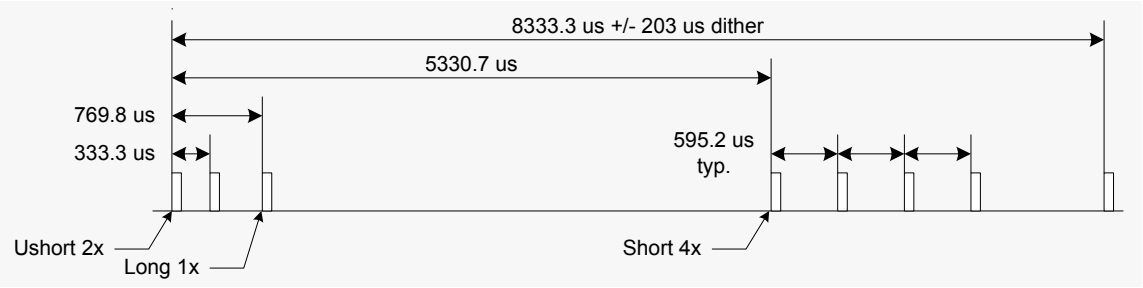

Figure F-1 – Transmit Pulse Pattern

In addition, BPSK modulation is utilized. Since the 13 to 1 ratio is maintained regardless of the pulse width, the chip widths become narrower as the pulse width decreases. The maximum chip rate (smallest chip width) is associated with the Ultra Short pulse and is utilized in calculating the necessary bandwidth of the transmitted pulse pattern. The following equation calculates the chip rate.

R = Chip Rate = 13 * 1 / PW_{US} = 13 * 1 / 3.439 µs = 3.78 MHz

Frequency Selection:

The RTA-41XX is capable of tuning to 5 different frequencies which are listed in Table F-2 below. Use of multiple frequencies significantly improves the accuracy of weather and ground target amplitude estimations. Transmit Channel 3 is reserved for built-in test (BIT)/future growth and is not used in normal operation of the RTA-41XX. This channel will not be included in testing.

Table F-2 – RTA-41XX Channel Frequencies

TX CH	X Band TX (MHz)
1	9460.9
2	9464.9
3	9468.9 (BIT Only)
4	9472.9
5	9476.9

Weather Operation:

Four frequencies from Table F-2 are allocated for Weather, Turbulence and Mapping. These are:

F1 – 9460.9 MHz (Channel 1)
F2 – 9464.9 MHz (Channel 2)
F4 – 9472.9 MHz (Channel 4)
F5 – 9476.9 MHz (Channel 5)

The radar randomly selects one of the four frequencies for each of the three pulse widths within the epoch. The epoch pulse set consists of two 3.4 µs pulses, one 55 µs pulse, and four 20 µs pulses on the same frequency. After transmission on one frequency, the next pulse width transmitted (consisting of either two 3.4 µs pulses, one 55 µs pulse, or four 20 µs pulses) occurs on one of the three remaining frequencies. This pattern is repeated until all four frequencies are used. The software ensures that the same frequency is not repeated between adjacent pulse widths.

Internal Test Operation:

At the end of each antenna sweep six test functions are performed using Channel 3 (9468.9 MHz). The power amplifier is disabled during these tests and the unit is not transmitting.

1. Receiver Noise Figure
2. Receiver Spectrum Monitor
3. Receiver VGA Gain Monitor
4. Receiver Loop Gain Monitor
5. Receiver AGC Limit Monitor
6. BPSK Mod/Demod Accuracy

F.3 Special FCC Test Conditions

To demonstrate compliance of the RTA-41XX over the full range of frequencies listed in Table F-2, it is necessary to configure the R/T unit in a special test condition. This test mode is described below.

Fixed Frequency Operation

The RTA-41XX can be locked onto a single fixed frequency by commands through the factory port input. The radar operates identically in all respects to normal operation including transmitter pulse patterns with the exception that the transmit frequency is locked to a single channel. Five conditions were defined; four fixed frequency channels and one normal operating condition with the normal channel selections. These special test conditions were used during subsequent testing described in this exhibit.

Table F-3 lists the Special FCC Test Conditions described above and lists which FCC test paragraphs utilized these conditions.

Table F-3 – Special FCC Test Conditions

Test Condition	Frequency (MHz)	2.1046 RF Pwr Out	2.1049 Occ BW	2.1051 Spur Emiss	2.1053 Spur Radiat	2.1055 Freq Stab
Normal	Switching		X	X	X	
Fixed Channel 1	9460.9	X				X
Fixed Channel 2	9464.9	X				X
Fixed Channel 4	9472.9	X				X
Fixed Channel 5	9476.9	X				X

F.4 RF Power Output (2.1046)

Requirement:

47 CFR Section 2.1046(a) "For transmitters other than single sideband, independent sideband and controlled carrier radiotelephone, power output shall be measured at the RF output terminals when the transmitter is adjusted in accordance with the tune-up procedure to give the value of current and voltage on circuit elements specified in 2.1033 (c)(8). The electrical characteristics of the radio frequency load attached to the output terminals when this test is made shall be stated."

47 CFR Section 2.1033(c)(8) "The dc voltages applied to and dc currents into the several elements of the final radio frequency amplifying device for normal operation over the power range."

47 CFR Section 87.131, Note 7 "Frequency, emission, and maximum power will be determined by appropriate standards during the certification process".

Test Equipment and Setup:

The RTA-41XX unit utilizes a +28 VDC power supply. The power amplifier components utilize a +10 VDC supply at an average current of 800 mA as well as a +6 VDC supply at an average current of 1.1 A. This voltage is derived from the main +28 VDC input supply by on-board power supplies. Transmitter tuning is not required. The test shall be completed by varying the input +28 VDC power input ±15%.

The equipment used for the RF Power Output Test is shown in Table F-4.

Table F-4 – Test Equipment Used for RF Power Output Test

Equipment	Manufacturer/Model Number	Specific Identification
Receiver/Transmitter Module	Rockwell Collins RTA-4112 (822-2254-949, Rev E)	S/N 3CNFT
Test Harness	Rockwell Collins RTA-41XX Breakout Panel	653-4444-200
DC Power Supply	HP E3634A	460-0142-806
Waveguide to Coax Adapter	HP X281A	469-0073-438
Attenuator (30 dB)	Weinschel Model 2	469-0074-560
Attenuator (10 dB)	Weinschel Model 1	469-0063-633
Peak Power Meter	Giga-tronics 8542C	469-0074-355
Peak Power Sensor	Giga-tronics 80350A	469-0074-356
Personal Computer	Dell Precision 380	MBL00270
ARINC 429 PCI Card	Condor Engineering CEI-520-4	N/A
Ethernet Switch	D-Link DSS-16+	N/A

A functional block diagram of the equipment setup for the RF Power Output Test is shown in Figure F-2.

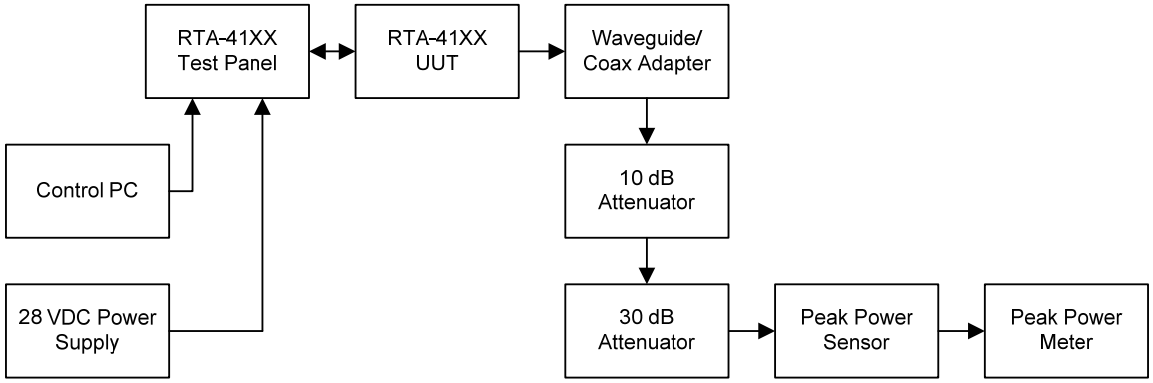

Figure F-2 – RF Power Output Test Equipment Setup Diagram

Test Procedure:

This test shall measure the RF output power while the primary power input varies up to ±15%. The power output shall be measured during the Weather plus Turbulence operating mode with the transmitter locked to one of four possible channels.

For each voltage specified in Table F-5, set the radar to each of the four fixed frequencies of operation and measure the peak RF output power. The power shall be measured through 40 dB of attenuation to avoid damage to the test equipment.

Test Results:

The measured transmitter power output for each operating frequency versus power supply voltage is contained in Table F-5.

Table F-5 – RF Power Output

Line Voltage (VDC)	Peak Transmitter Power Output (Watts)			
	Channel 1	Channel 2	Channel 4	Channel 5
23.8 (28 – 15%)	50.6	50.7	50.7	50.8
25.2 (28 – 10%)	50.6	50.6	50.7	50.8
26.6 (28 – 5%)	50.6	50.7	50.7	50.6
28.0	50.6	50.7	50.5	50.6
29.4 (28 + 5%)	50.6	50.7	50.5	50.7
30.8 (28 + 10%)	50.6	50.7	50.5	50.5
32.2 (28 + 15%)	50.6	50.7	50.5	50.5

F.5 Frequency Stability (2.1055)

Requirement:

47 CFR Section 2.1055(a)(2) The frequency shall be measured with variation of ambient temperature from -20° to +50° centigrade for equipment licensed for use aboard aircraft in the Aviation Services under part 87 of FCC Code of Federal Regulations Title 47.

47 CFR Section 2.1055(b) The frequency measurement shall be made at the extremes and at intervals of not more than 10° centigrade through the range. A period of time sufficient to stabilize all of the components of the oscillator circuit at each temperature level shall be allowed prior to frequency measurement.

47 CFR Section 2.1055(d)(1)(3) The frequency stability shall be measured with variation of primary supply voltage from 85 to 115 percent of the nominal value. The supply voltage shall be measured at the input to the cable normally provided with the equipment, or at the power supply terminals if cables are not normally provided.

47 CFR Section 87.133 (a) Frequency tolerance for Frequency band (8) 2450 to 10500 MHz – Note 9,

"Where specific frequencies are not assigned to radar stations, the bandwidth occupied by the emissions of such stations must be maintained within the band allocated to the service and the indicated tolerance (1250 ppm) does not apply."

Test Equipment and Setup:

The equipment used for the Frequency Stability tests is shown in Table F-6.

Table F-6 – Equipment Used for Frequency Stability Test

Equipment	Manufacturer/Model Number	Specific Identification
Receiver/Transmitter Module	Rockwell Collins RTA-4112 (822-2254-949, Rev E)	S/N 3CNFT
Test Harness	Rockwell Collins RTA-41XX Breakout Panel	653-4444-200
Temperature Chamber	Thermotron SM-5.5C	S/N 18118
DC Power Supply	HP E3634A	460-0142-806
Waveguide to Coax Adapter	HP X281A	469-0073-438
Attenuator (30 dB)	Weinschel Model 2	469-0074-560
Attenuator (10 dB)	Weinschel Model 1	469-0063-633
Spectrum Analyzer	Rohde & Schwarz FSP40	460-0154-656
Personal Computer	Dell Precision 380	MBL00270
ARINC 429 PCI Card	Condor Engineering CEI-520-4	N/A
Ethernet Switch	D-Link DSS-16+	N/A

The test setup for the Frequency Stability test is shown in Figure F-3.

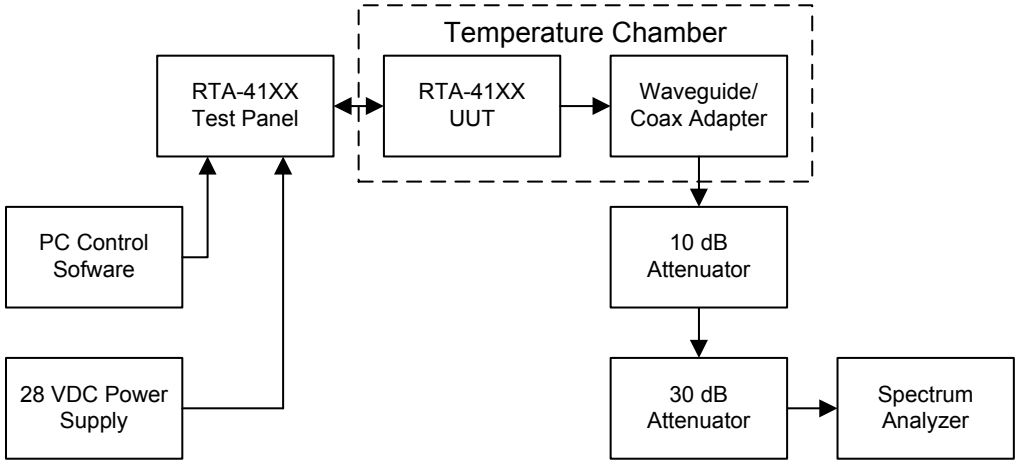

Figure F-3 – Frequency Stability Test Setup Diagram

Test Procedure – Primary Supply Variation:

This test shall measure the RF output frequency while the primary power input varies up to ±15%. The test shall be completed at ambient room temperature. The output frequency shall be measured during the Weather plus Turbulence operating mode with the transmitter locked to one of four possible channels.

For each voltage specified in Table F-7, set the radar to each of the four fixed frequencies of operation and measure the RF output frequency. The frequency shall be measured through 40 dB of attenuation to avoid damage to the test equipment. The frequency shall be within ±470 kHz of the center frequencies specified in Table F-2.

Test Results - Primary Supply Variation:

Frequency Stability vs Line Voltage test results are shown in Table F-7. There were no out of tolerance frequency variations as a result of line voltage variations from 23.8 VDC to 32.2 VDC.

Table F-7 – Transmitted Frequency vs. Input Voltage

Line Voltage (VDC)	Frequency (Spectrum Analyzer) (MHz)			
	Channel 1	Channel 2	Channel 4	Channel 5
23.8 (28 – 15%)	9460.8272	9464.8272	9472.8288	9476.8284
25.2 (28 – 10%)	9460.8272	9464.8284	9472.8288	9476.8288
26.6 (28 – 5%)	9460.8272	9464.8280	9472.8288	9476.8288
28.0	9460.8272	9464.8288	9472.8292	9476.8288
29.4 (28 + 5%)	9460.8272	9464.8284	9472.8296	9476.8280
30.8 (28 + 10%)	9460.8272	9464.8284	9472.8284	9476.8280
32.2 (28 + 15%)	9460.8268	9464.8292	9472.8288	9476.8288

Test Procedure – Temperature Variation:

This test shall measure the RF output frequency while the ambient temperature is varied from -55 °C to +70 °C in 10 °C increments. The test shall be completed at with a nominal input voltage level of +28 VDC. The output frequency shall be measured during the Weather plus Turbulence operating mode with the transmitter locked to one of four possible channels.

For each temperature step specified in Table F-8, set the radar to each of the four fixed frequencies of operation and measure the RF output frequency. The frequency shall be measured through 40 dB of attenuation to avoid damage to the test equipment. The frequency shall be within ±470 kHz of the center frequencies specified in Table F-2.

Test Results – Temperature Variation:

Temperature Test results are shown in Table F-8 and Figure F-4. There were no out of tolerance frequency variations as a result of temperature extremes from -55 ºC to +70 ºC.

Table F-8 – Transmitted Frequency vs. Temperature

Temp. (ºC)	Frequency (Spectrum Analyzer) (MHz)			
	Channel 1	Channel 2	Channel 4	Channel 5
-55	9460.971	9464.969	9472.968	9476.967
-50	9461.001	9464.999	9472.999	9476.996
-40	9461.040	9465.041	9473.038	9477.040
-30	9461.054	9465.054	9473.054	9477.054
-20	9461.045	9465.047	9473.047	9477.048
-10	9461.016	9465.017	9473.018	9477.019
0	9460.966	9464.968	9472.971	9476.972
10	9460.936	9464.938	9472.939	9476.941
20	9460.912	9464.912	9472.912	9476.912
30	9460.881	9464.881	9472.879	9476.879
40	9460.845	9464.844	9472.843	9476.843
50	9460.816	9464.816	9472.816	9476.815
60	9460.816	9464.816	9472.817	9476.817
70	9460.851	9464.852	9472.852	9476.852

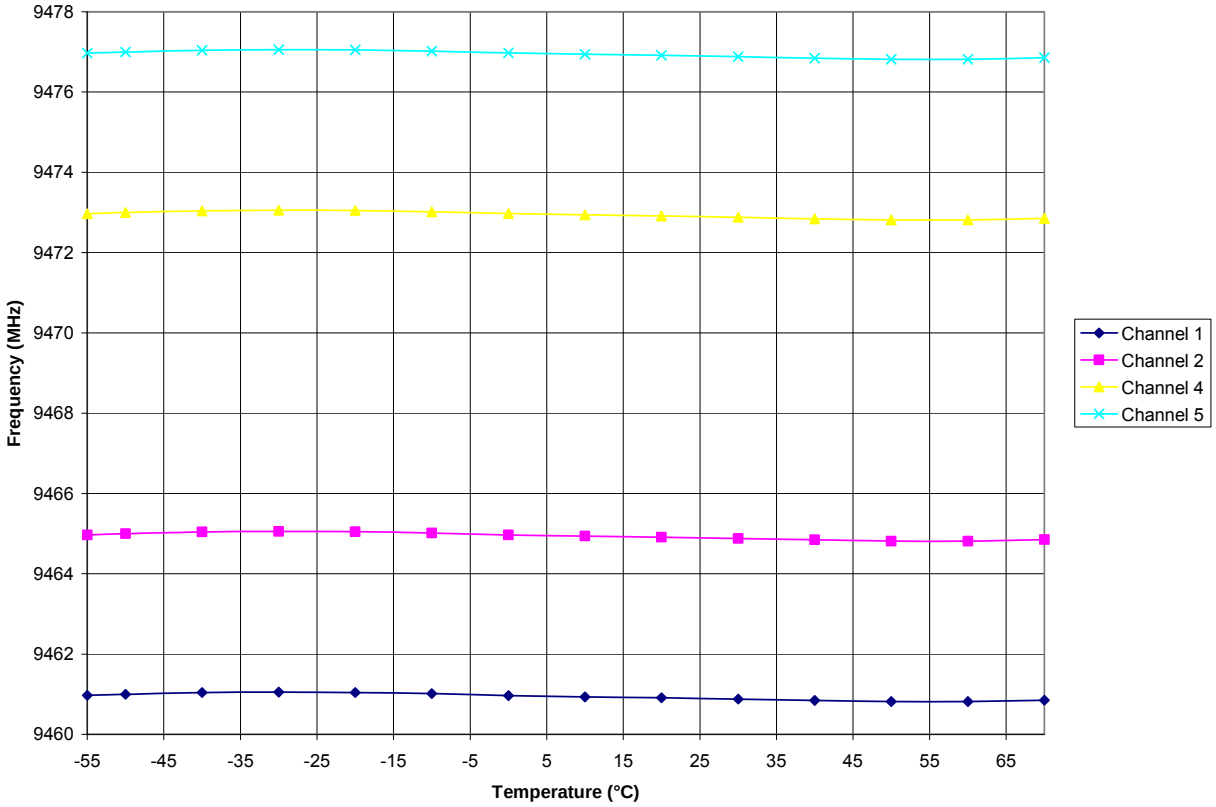

Figure F-4 – Transmitter Frequency Stability vs. Temperature

F.6 Occupied Bandwidth (2.1049)

Requirement:

47 CFR Section 2.1049 “The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission shall be measured under the following conditions as applicable.”

47 CFR Section 2.1049(i) “Transmitters designed for other types of modulation – when modulated by an appropriate signal of sufficient amplitude to be representative of the type of service in which used. A description of the input signal should be supplied.”

47 CFR Section 87.133 (a) Frequency tolerance for Frequency band (8) 2450 to 10500 MHz – Note 9,

“Where specific frequencies are not assigned to radar stations, the bandwidth occupied by the emissions of such stations must be maintained within the band allocated to the service and the indicated tolerance (1250 ppm) does not apply.”

47 CFR Section 87.135

(a) Occupied bandwidth is the width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to 0.5 percent of the total mean power of a given emission.

(b) The authorized bandwidth is the maximum occupied bandwidth authorized to be used by a station.

(c) The necessary bandwidth for a given class of emission is the width of the frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions.

Test Equipment and Setup:

The equipment used for the Occupied Bandwidth Test is shown in Table F-9.

Table F-9 – Equipment Used for Occupied Bandwidth Tests

Equipment	Manufacturer/Model Number	Specific Identification
Receiver/Transmitter Module	Rockwell Collins RTA-4112 (822-2254-949, Rev E)	S/N 3CNFT
Test Harness	Rockwell Collins RTA-41XX Breakout Panel	653-4444-200
DC Power Supply	HP E3634A	460-0142-806
Waveguide to Coax Adapter	HP X281A	469-0073-438
Attenuator (30 dB)	Weinschel Model 2	469-0074-560
Attenuator (10 dB)	Weinschel Model 1	469-0063-633
Spectrum Analyzer	Rohde & Schwarz FSP40	460-0154-656
Personal Computer	Dell Precision 380	MBL00270
ARINC 429 PCI Card	Condor Engineering CEI-520-4	N/A
Ethernet Switch	D-Link	DSS-16+

A functional block diagram of the equipment setup for the Occupied Bandwidth Test is shown in Figure F-5.

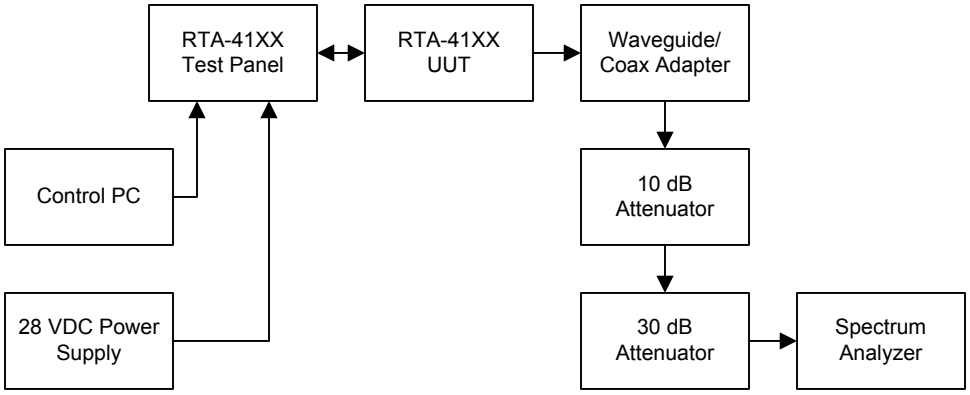

Figure F-5 – Occupied Bandwidth Test Equipment Setup

Test Procedure:

The RTA-41XX radar system is designed to operate on 4 separate frequencies in the band from 9460.9 MHz to 9476.9 MHz. During normal operation, each selected mode utilizes multiple transmitter frequencies. Utilization of multiple frequencies enables the radar system to obtain significantly greater accuracy in estimation of echo signal strength from both ground targets and weather targets. A complete description of the frequency selection, pulse repetition frequencies, and pulse width selection is provided in Section F.2, Modulation Characteristics.

This test shall measure the occupied bandwidth during the Weather plus Turbulence operating mode. The test shall be completed at with a nominal input voltage level of +28 VDC. The occupied bandwidth shall be measured through 40 dB of attenuation to avoid damage to the test equipment.

Test Results:

The Rohde & Schwarz FSP40 spectrum analyzer was set up to automatically measure 99% occupied bandwidth. Table F-10 contains the test result for the Weather plus Turbulence operating mode.

Table F-10 – RTA-41XX Occupied Bandwidth Measurement Results

Operational Mode	99% Occupied Bandwidth	Reference Figure
Weather plus Turbulence Detection	21.7 MHz	Figure F-6

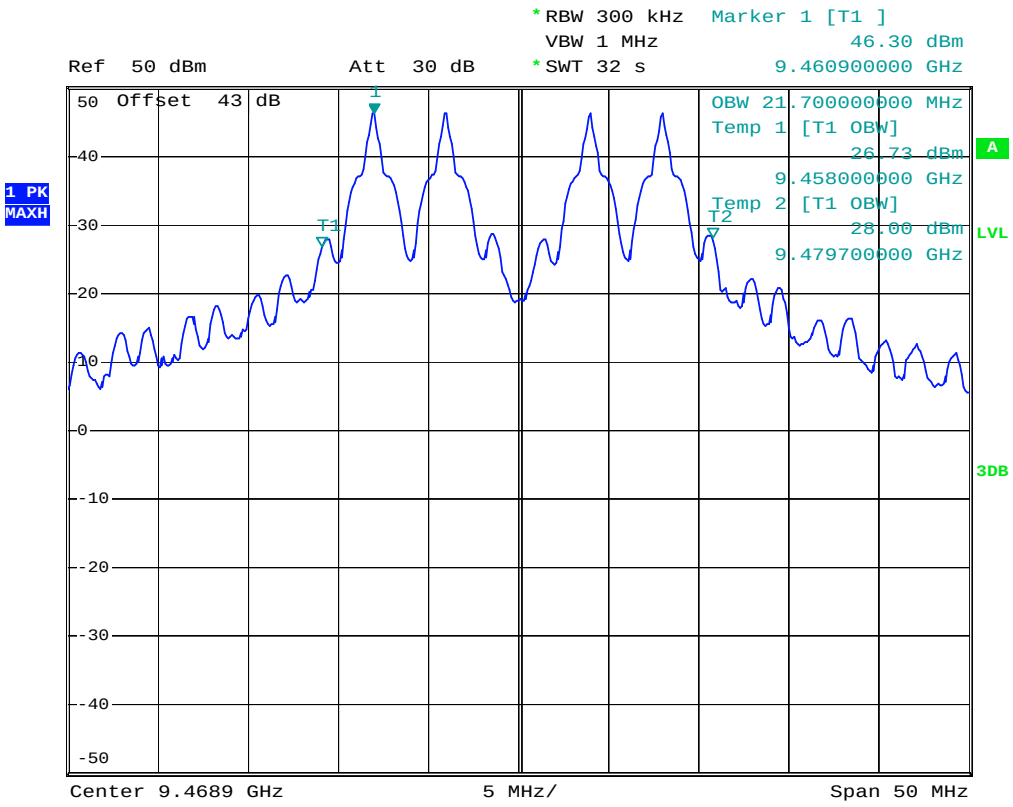

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Figure F-6 – Occupied Bandwidth Measurement

F.7 Spurious Emissions at Antenna Terminal (2.1051)

Requirement:

47 CFR Section 2.1051 The radio frequency voltage or powers generated within the equipment and appearing on a spurious frequency shall be checked at the equipment output terminals when properly loaded with a suitable artificial antenna. Curves or equivalent data shall show the magnitude of each harmonic and other spurious emissions that can be detected when the equipment is operated under the conditions specified in Section 2.1049 as appropriate. The magnitude of spurious emissions attenuated more than 20 dB below the permissible values need not be specified.

47 CFR Section 87.139(a) "… the mean power of any emission must be attenuated below the mean power of the transmitter (pY) as follows:

(1) When the frequency is removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth the attenuation must be at least 25 dB.

(2) When the frequency is removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth the attenuation must be at least 35 dB.

(3) When the frequency is removed from the assigned frequency by more than 250 percent of the authorized bandwidth the attenuation for aircraft station transmitters must be at least 40 dB; and the attenuation for aeronautical station transmitters must be at least 43+log10(pY) dB.

Since the RTA-41XX clearly falls under the definition of an aircraft station transmitter defined in Section 87.139(a)(3), the worst case limit is 40 dBc. The Authorized Bandwidth is assumed to be 9.3 – 9.5 GHz which is the frequency range allocated for radar.

The RTA-41XX has a nominal peak power output of 50 watts. Based on this power level, the absolute limits are calculated as follows using 40 dBc as an example.

P_{TX_peak} = 50 Watts = 47 dBm

FCC Limit = 40 dBc

Absolute Limit = P_{TX_peak} (dBm) – FCC Limit (dBc) = +7 dBm

Note: The FCC limit is specified in terms of mean power (pY). However, the test equipment utilized for these tests provides peak measurements. Calculation of the FCC limits based on mean power, then converting to peak readings will yield the same limits.

The requirements for the Spurious Emissions Test are contained in Table F-11.

Table F-11 – Spurious Emission Test Requirements (87.139(a)(3))

Frequency Band	Emission Level	Absolute FCC Limit (Peak)
Below 8800 MHz	-40 dBc	+7.00 dBm
From 8800 MHz to 9100 MHz	-35 dBc	+12.0 dBm
From 9100 MHz to 9200 MHz	-25 dBc	+22.0 dBm
From 9600 MHz to 9700 MHz	-25 dBc	+22.0 dBm
From 9700 MHz to 10000 MHz	-35 dBc	+12.0 dBm
Over 10000 MHz	-40 dBc	+7.00 dBm

Test Equipment and Setup:

The equipment used for all Spurious Emissions test is shown in Table F-12. In addition specialized waveguide connections are required for higher frequency measurements. The equipment lists for each of these frequency bands are shown in Table F-13 through Table F-16.

Table F-12 – Equipment Used for Spurious Emissions Tests – All Frequencies

Equipment	Manufacturer/Model Number	Specific Identification
Receiver/Transmitter Module	Rockwell Collins RTA-4112 (822-2254-949, Rev E)	S/N 3CNFT
Test Harness	Rockwell Collins RTA-41XX Breakout Panel	653-4444-200
DC Power Supply	HP E3634A	460-0142-806
Waveguide to Coax Adapter	HP X281A	469-0073-438
Attenuator (30 dB)	Weinschel Model 2	469-0074-560
Attenuator (10 dB)	Weinschel Model 1	469-0063-633
Spectrum Analyzer	Rohde & Schwarz FSP40	460-0154-656
Personal Computer	Dell Precision 380	MBL00270
ARINC 429 PCI Card	Condor Engineering CEI-520-4	N/A
Ethernet Switch	D-Link	DSS-16+

Table F-13 – Equipment Used for Spurious Emissions Tests – X Band (8.2 – 12.4 GHz)

Equipment	Manufacturer/Model Number	Specific Identification
Directional Coupler (20dB)	HP X752D	SN 622 460-0132-809
Waveguide Termination	CMT LPT90-1B	SN 970005-001 460-0133-413 Component of 460-0132-809
Waveguide to Coax Adapter	HP X281C	SN 3032A-06660 460-0210-312 Component of 460-0132-809
Attenuator (20 dB)	Weinschel WA1-20	460-0203-439 Component of 460-0132-809

Table F-14 – Equipment Used for Spurious Emissions Tests – P band (Ku) (12.4 – 18.0 GHz)

Equipment	Manufacturer/Model Number	Specific Identification
Directional Coupler (20dB)	HP P752D	SN 359 460-0132-825
Waveguide Taper (X to P Band)	Space Machine & Engineering	460-0133-402 Component of 460-0132-825
Waveguide Termination	CMT LPT62-1B	SN 970005-002 460-0133-414 Component of 460-0132-825
Waveguide to Coax Adapter	HP P281B	460-0133-418 Component of 460-0132-825

Table F-15 – Equipment Used for Spurious Emissions Tests – K Band (18.0 – 26.5 GHz)

Equipment	Manufacturer/Model Number	Specific Identification
Directional Coupler (20dB)	HP K752D	SN 177 460-0132-826
Waveguide Taper (X to K Band)	Space Machine & Engineering	460-0133-404 Component of 460-0132-826
Waveguide Termination	CMT LPT42-1B	SN 970005-003 460-0133-416 Component of 460-0132-826
Waveguide to Coax Adapter	HP K281C	SN3032A-09068 460-0133-412 Component of 460-0132-826

Table F-16 – Equipment Used for Spurious Emissions Tests – R Band (Ka) (26.5 – 40.0 GHz)

Equipment	Manufacturer/Model Number	Specific Identification
Directional Coupler (20dB)	HP R752D	SN 463 460-0132-827
Waveguide Taper (X to R Band)	Space Machine & Engineering	460-0133-406 Component of 460-0132-827
Waveguide Termination	CMT LPT28-1B	SN 970005-004 460-0133-415 Component of 460-0132-827
Waveguide to Coax Adapter	HP R281A	SN 02136 460-0133-417 Component of 460-0132-827
Waveguide 90° E-Bend	CMT REB28-1A-1A-1.50-1.50-A	SN 961963-002 Component of 460-0132-827

A functional block diagram of the equipment setup for the X Band (8.2 to 12.4 GHz) Spurious Emissions at Antenna Terminal test is shown in Figure F-7.

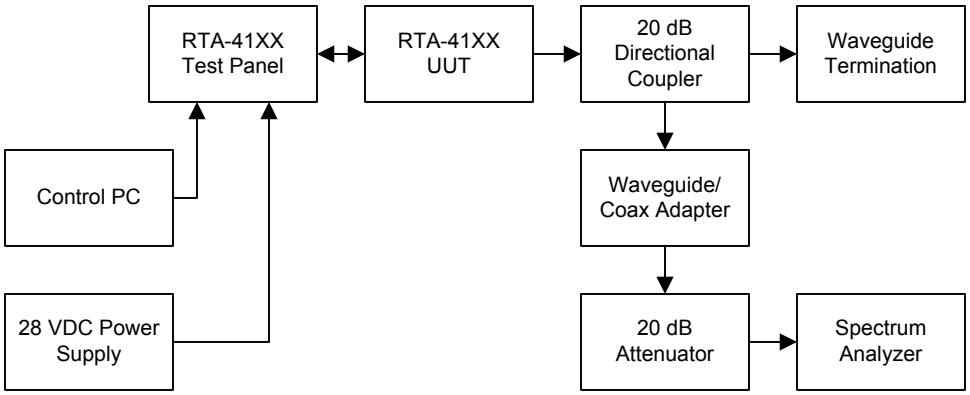


Figure F-7 – Spurious Emissions of Antenna Terminal Test Setup Diagram (8.2 – 12.4 GHz)

A functional block diagram of the equipment setup for the P Band (Ku) (12.4 to 18.0 GHz), K Band (18.0 to 26.5 GHz), and R Band (Ka) (26.5 to 40.0 GHz) Spurious Emissions at Antenna Terminal Tests is shown in Figure F-8.

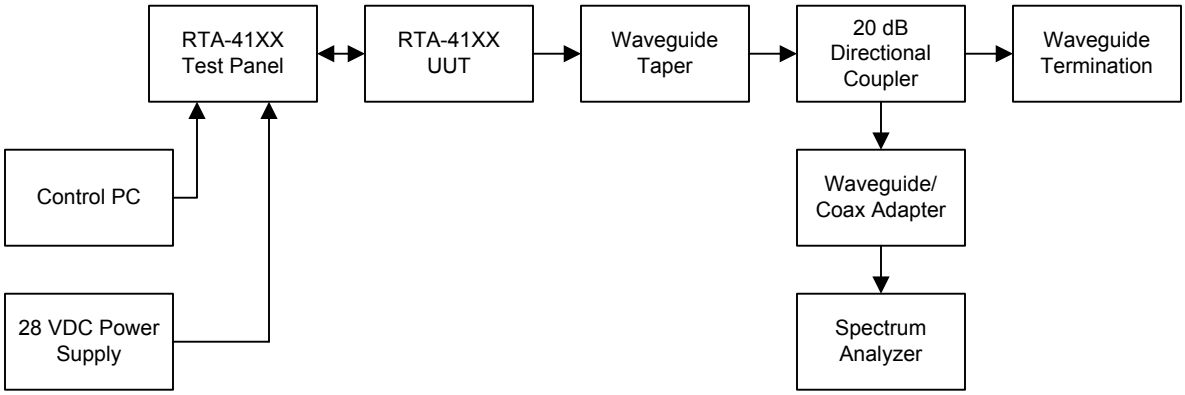


Figure F-8 – Spurious Emissions at Antenna Terminal Test Setup Diagram (12.4 – 40 GHz)

Test Procedure:

This test shall measure spurious emissions at the antenna terminal during the Weather plus Turbulence operating mode. The test shall be completed at with a nominal input voltage level of +28 VDC.

Test Results:

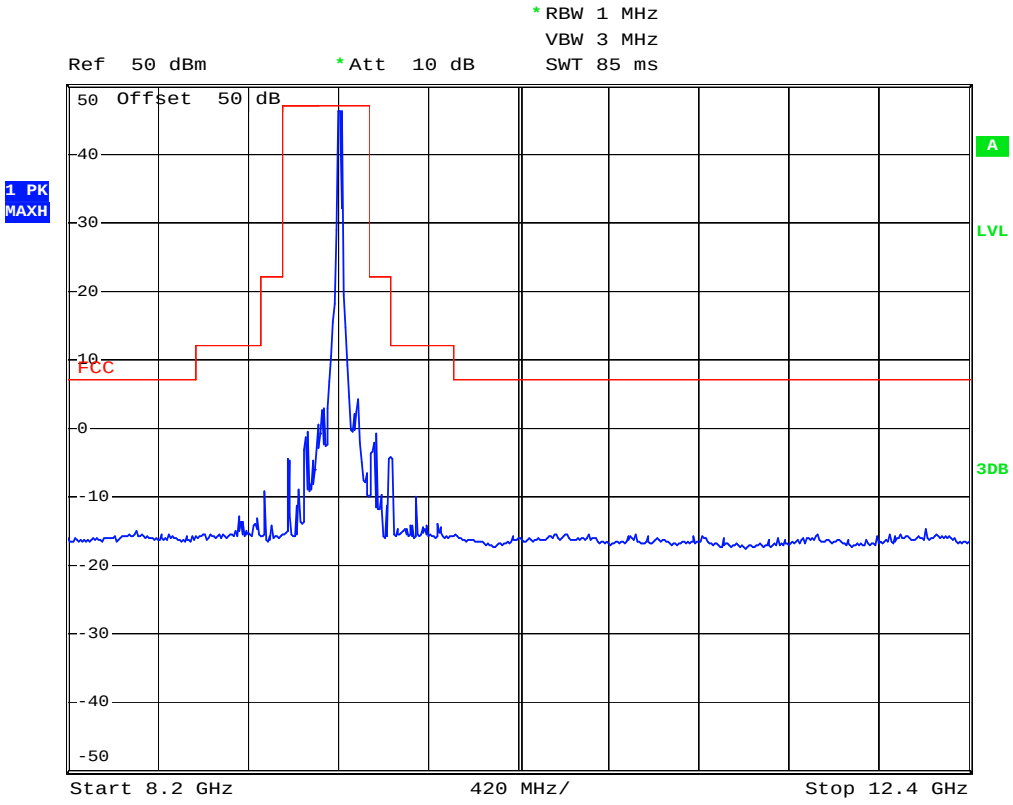
There were no emissions within 20 dB of the FCC Limit of 40 dBc.

Note: Since the antenna terminal is X-Band waveguide (WR-90), frequencies below the cutoff frequency (8.2 GHz) were not measured.

The test results are listed in Table F-17. The tables contain all data that was within 20 dB of the FCC limit. Reference plots for each scan are indexed in the tables.

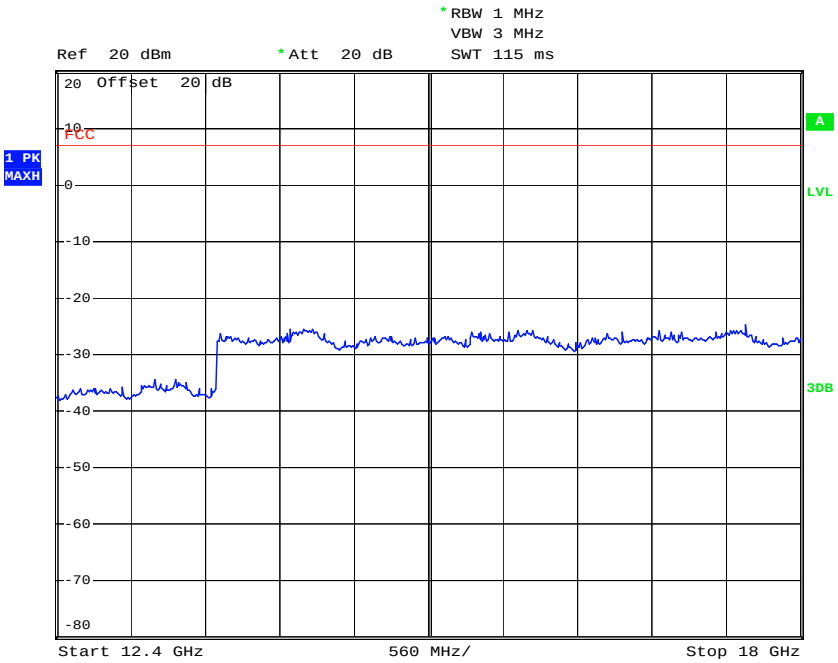
Table F-17 – Conducted Spurious Emissions

Emission Band	Spurious Frequency (GHz)	Emission Level (dBm)	40 dBc Limit (dBm)	Margin (dB) vs 40 dBc Limit	Reference Figure
8.2 to 12.4 GHz	None	N/A	+7	> 20 dB	Figure F-9
12.4 to 18.0 GHz	None	N/A	+7	> 20 dB	Figure F-10
18.0 to 26.5 GHz	18.935	-18.09	+7	25.09	Figure F-11
26.5 to 40.0 GHz	None	N/A	+7	> 20 dB	Figure F-12



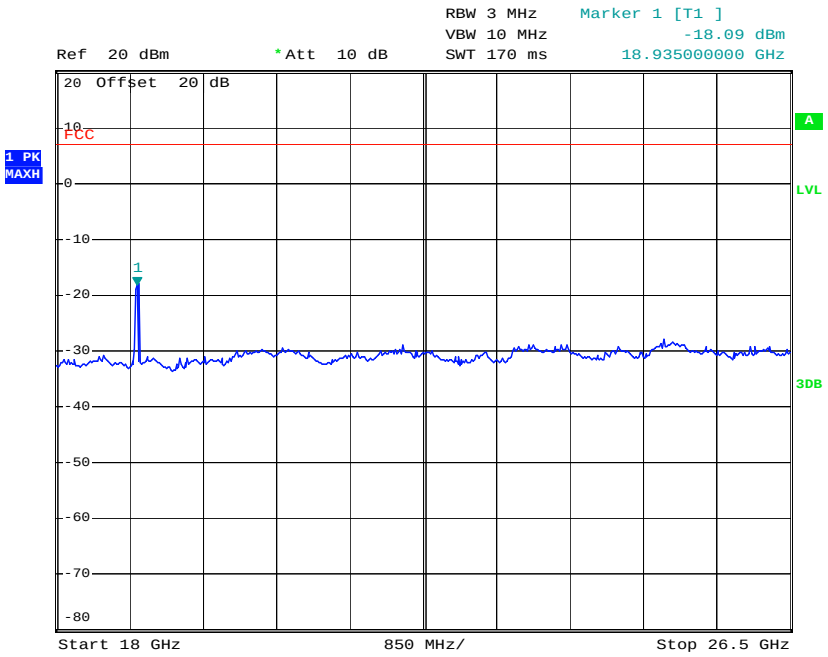
Date: 5.DEC.2008 18:25:16

Figure F-9 – Conducted Spurious Emissions, 8.2 – 12.4 GHz



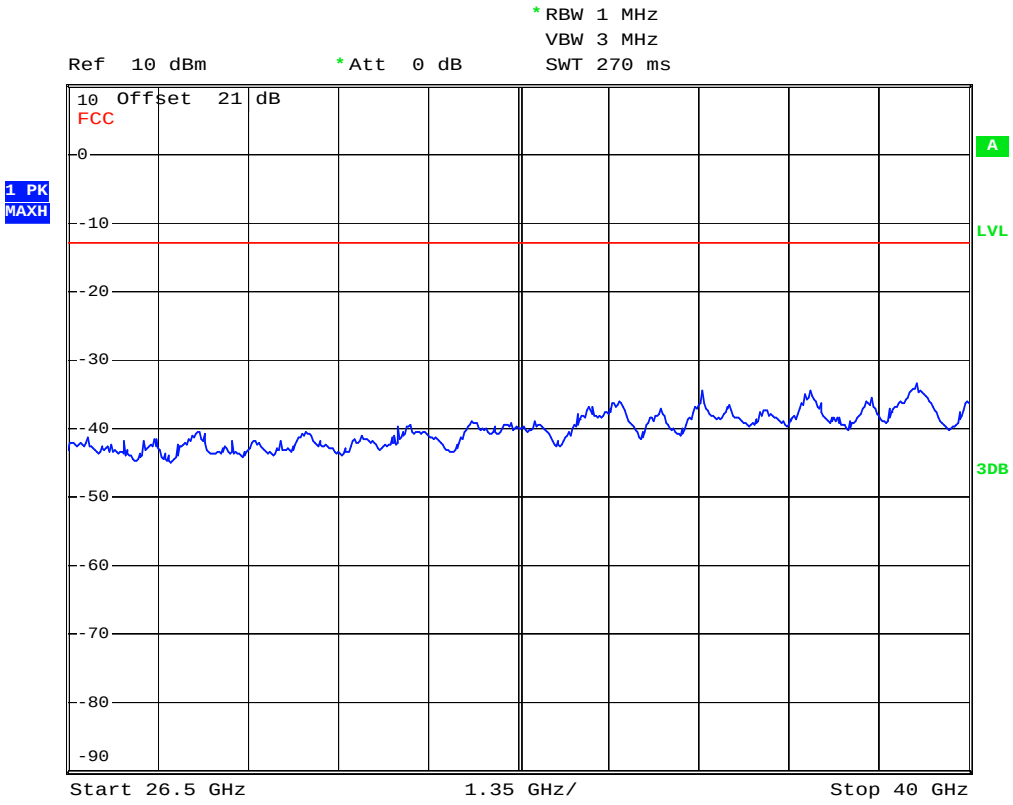
Date: 8.DEC.2008 09:24:32

Figure F-10 – Conducted Spurious Emissions, 12.4 – 18.0 GHz



Date: 10.DEC.2008 18:01:49

Figure F-11 – Conducted Spurious Emissions, 18.0 – 26.5 GHz



Date: 22.DEC.2008 09:27:48

Figure F-12 – Conducted Spurious Emissions, 26.5 – 40 GHz

F.8 Field Strength of Spurious Radiation (2.1053)

Requirements:

47 CFR Section 2.1053

(a) Measurements shall be made to detect spurious emissions that may be radiated directly from the cabinet, control circuits, power leads, or intermediate circuit elements under normal conditions of installation and operation. Curves or equivalent data shall be supplied showing the magnitude of each harmonic and other spurious emissions. … ….Information submitted shall include the relative radiated power of each spurious emission with reference to the rated power output of the transmitter, assuming all emissions are radiated from halfwave dipole antennas.

(b) The measurements specified in paragraph (a) of this section shall be made for the following equipment:

(2) All equipment operating on frequencies higher than 25 MHz.

47 CFR Section 2.1057(a) …the spectrum shall be investigated from the lowest radio frequency generated in the equipment without going below 9 kHz, up to at least the frequency shown below:

(1) If the equipment operates below 10 GHz: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

47 CFR Section 87.139(a) "… the mean power of any emission must be attenuated below the mean power of the transmitter (pY) as follows:

(1) When the frequency is removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth the attenuation must be at least 25 dB.

(2) When the frequency is removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth the attenuation must be at least 35 dB.

(3) When the frequency is removed from the assigned frequency by more than 250 percent of the authorized bandwidth the attenuation for aircraft station transmitters must be at least 40 dB; and the attenuation for aeronautical station transmitters must be at least 43+log10(pY) dB.

The RTA-41XX has a nominal peak power of 50 Watts.

The Spurious Radiation test Requirements are shown below in Table F-18.

Table F-18 – Spurious Radiation Test Requirements (87.139(a)(3))

Frequency Band	Emission Level	Absolute FCC Limit (Peak)
Below 8800 MHz	-40 dBc	+7.00 dBm
From 8800 MHz to 9100 MHz	-35 dBc	+12.0 dBm
From 9100 MHz to 9200 MHz	-25 dBc	+22.0 dBm
From 9600 MHz to 9700 MHz	-25 dBc	+22.0 dBm
From 9700 MHz to 10000 MHz	-35 dBc	+12.0 dBm
Over 10000 MHz	-40 dBc	+7.00 dBm

Assuming the worst case requirement of 40dBc, the maximum field strength is computed by the following procedure:

FCC Limit = 40 dBc

Limit (Watts) = Ptx(average) * $10^{\frac{-FCC\ Limit(dBc)}{10}}$

This level is converted to a field strength value "E" based on a dipole radiator:

$E^2 = (30 * G * L) / R$ Where: G = 1.64 (dipole gain)
L = Limit (Watts)
R = 1 meter (Test distance)
E = Field strength (volts/meter).

The RTA-41XX has a nominal peak power of 50 Watts and a maximum duty cycle of 2%.

Peak Power = 10 * log(50 / 0.001) = 47.00 dBm, Assumed Duty Cycle = 0.02

Ptx(average) = 50 * 0.02 = 1 Watts average

FCC Limit (dBc) = 40

Limit (Watts) =1 W * 10(-40 / 10) = $1x10^{-4}$ W average

$E^2 = 30 * 1.64 * 1*10^{-4} = 4.92*10^{-3}$

E (V/m) =sqrt($4.92 * 10^{-3}$) = 70,000 μV/m average

E (dBμV/m) = 20 * log(70,000 μV/m) = 96.92 dBμV/m

Since the FCC Limit is average power, and the receiver used to detect the radiated power is a peak power reading instrument, the FCC Limit must be converted to peak power, which can be accomplished in two ways. The first method is to simply convert the average limit to peak by taking it out of dB, squaring it, divide by the duty cycle, and convert it back to dB. The second method is to take the difference (in dB) between peak power and average power at a given duty cycle (assumed maximum 2%) and add it to the average limit in dBμV/m.

Method 1:

Limit (average) = 96.92 dBμV/m
Limit (average) =$10^{(103.5/20)}$ = 70,000 μV/m
Limit (peak) =$((70,000)^2)$ / 0.02 = $2.46*10^{11}$ μV/m
Limit (peak) = 10 * log($2.46*10^{11}$ μV/m) = 113.909 dBμV/m

Method 2:

Limit (average) = 96.92 dBμV/m
Peak Power (mW) = $10^{(47 / 10)}$ = 50,000. mW
Average Power (mW) = 50,000 mW * 0.02 = 1,000 mW
Average Power (dBm) = 10 * log(1,000 mW) = 30.0 dBm
Difference (dB) = 47 dBm(peak) – 30 dBm(average) = 17 dB
Limit (peak) = 96.92 dBμV/m + 17 dB = 113.909 dBμV/m

Therefore, the absolute limit of ***113.909 dBμV/m*** is used for these tests.

Test Equipment and Setup:

The equipment used for Field Strength of Spurious Radiation measurements is shown in Table F-19.

Table F-19 – Equipment Used for Spurious Emissions Tests

Equipment	Manufacturer/Model Number	Specific Identification
Receiver/Transmitter Module	Rockwell Collins RTA-4112 (822-2254-949, Rev E)	S/N 3CNFT
Test Harness	Rockwell Collins RTA-41XX Breakout Panel	653-4444-200
DC Power Supply	HP E3634A	460-0142-806
Personal Computer	Dell Precision 380	MBL00270
ARINC 429 PCI Card	Condor Engineering CEI-520-4	N/A
Ethernet Switch	D-Link	DSS-16+
EMI Test Reciever (2 MHz – 18 GHz)	Rohde & Schwarz ESU	469-0074-442
Spectrum Analyzer (18 GHz – 40 GHz)	Rohde & Schwarz FSP40	460-0154-656
Pre-Amplifier (1 GHz – 18 GHz)	Hewlett Packard 8449B, Opt. H02	460-0118-550
Pre-Amplifier (18 GHz – 40 GHz)	A.H. Systems PAM-1840	469-0075-833
Active Monopole Antenna (2 MHz – 25 MHz)	Electro-Metrics RVA30	460-0113-398
Bi-conical Antenna (25 MHz – 200 MHz)	A.H. Systems SAS-200/540	469-0069-226
Antenna, Double Ridge Guide (200 MHz - 1GHz)	EMCO 3106	469-0070-774
Antenna, Double Ridge Guide (1 GHz – 18 GHz)	EMCO 3115	460-0133-793
Antenna, Double Ridge Guide (18 GHz – 40 GHz)	SAS-574	469-0075-832

The test setups for the Field Strength of Spurious Radiation measurements are shown in Figure F-13 through Figure F-15.

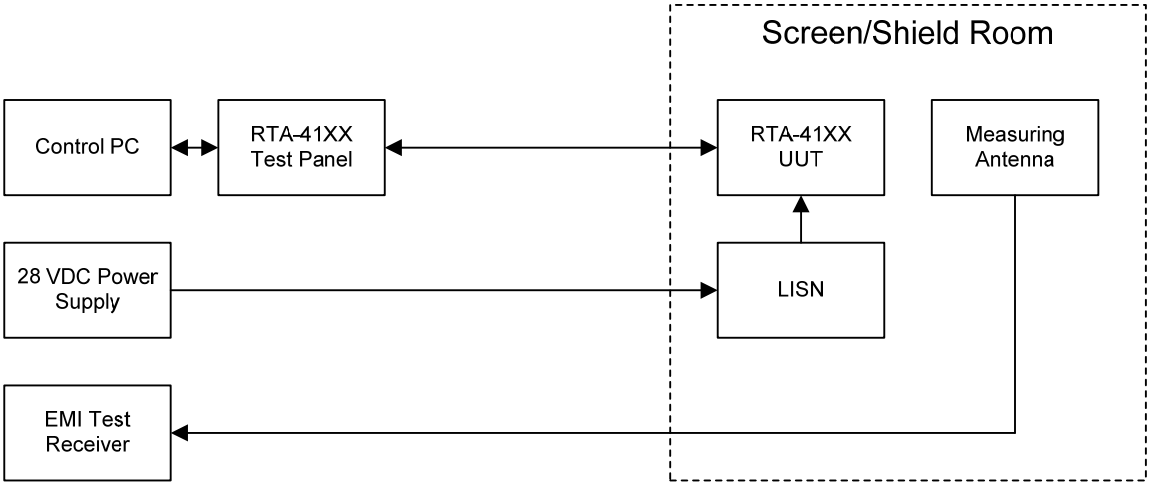


Figure F-13 – Field Strength of Spurious Radiation Test Setup Diagram (2 MHz to 1 GHz)

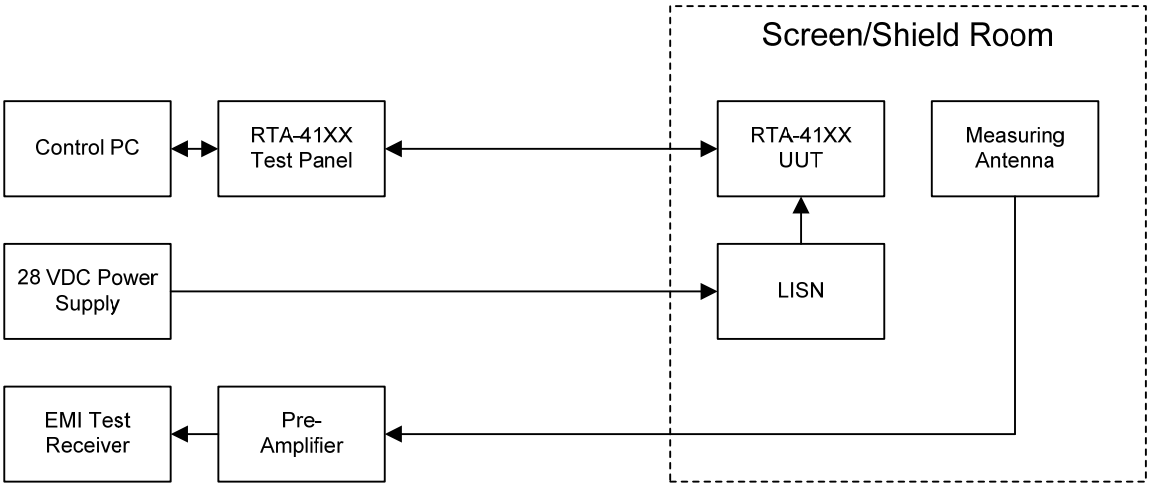


Figure F-14 – Field Strength of Spurious Radiation Test Setup Diagram (1 GHz to 18 GHz)

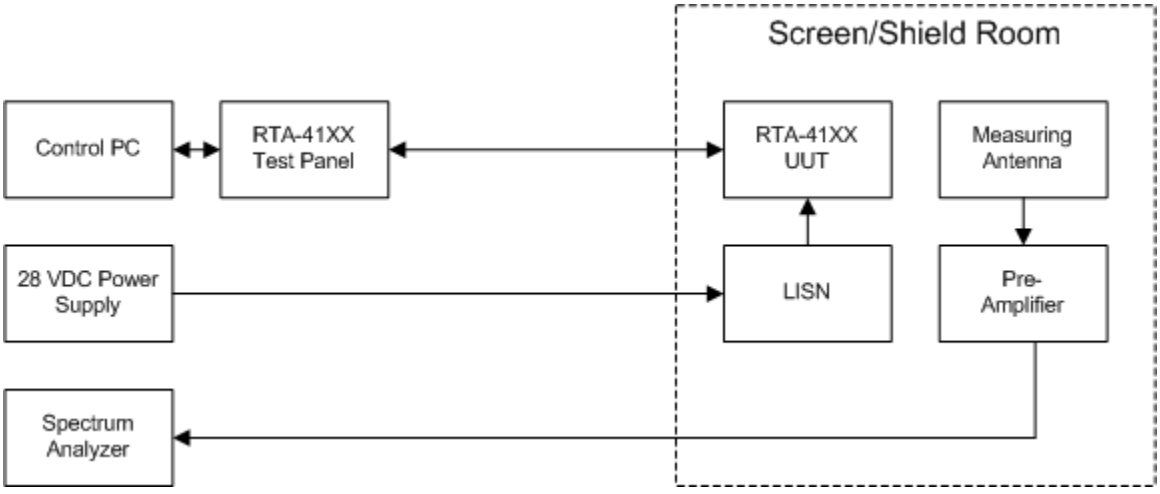


Figure F-15 – Field Strength of Spurious Radiation Test Setup Diagram (18 GHz to 40 GHz)

Test Procedure:

The test procedure from DO-160E, Section 21 shall be used. This procedure is used for the certification of civil aviation electronics. Although DO-160E only specifies testing to 6 GHz, the same test setup and methodology shall be used to measure radiated emissions up to 40 GHz.

The lowest RF oscillator frequency generated in the equipment is 25 MHz, therefore the standard DO-160E start frequency of 2 MHz shall be used for testing.

The radiated emissions shall be taken with the RTA-41XX in Weather plus Turbulence mode. The frequency selection shall be set to normal operation (frequency hopping).

Test Results:

Results are provided in spectral plot forms for vertical and horizontal polarizations from 2 MHz to 40 GHz. Note the rod antenna used for emissions testing below 25 MHZ only provides measurements in the vertical polarization. No emissions (with the exception of the fundamental) exceeded the FCC limit of 113.909 dBµV/m.

Spectrum plots for are shown in Figure F-16 and Figure F-17.

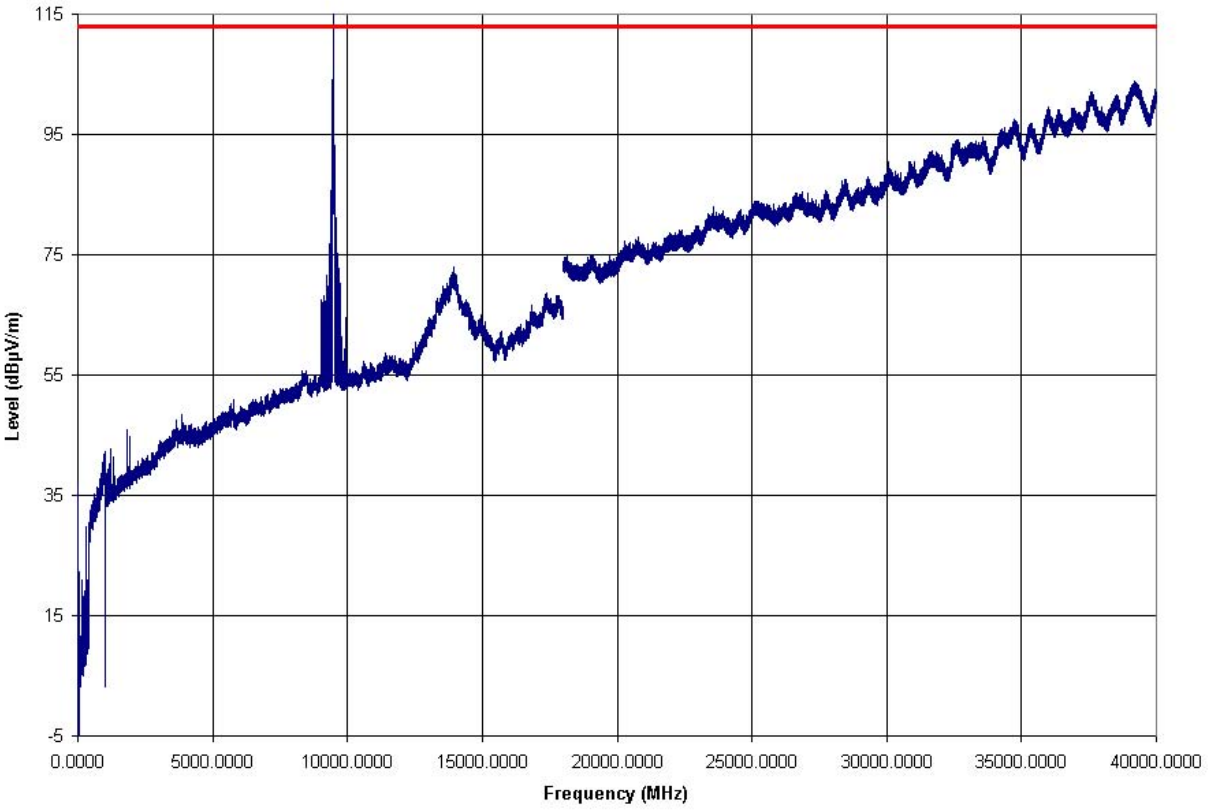


Figure F-16 – Radiated Spurious Emissions, 2 MHz – 40 GHz, Vertical Polarization

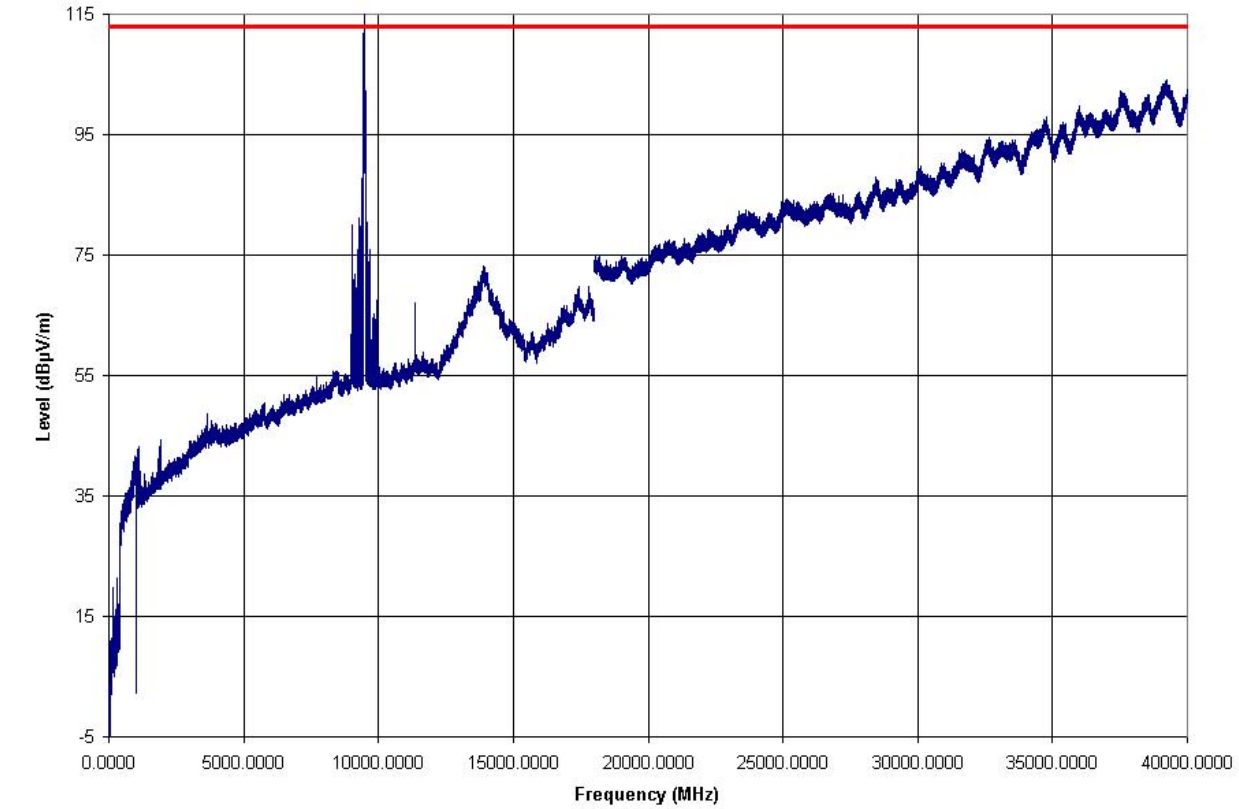


Figure F-17 – Radiated Spurious Emissions, 25 MHz – 40 GHz, Horizontal Polarization