# 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 (TSO) 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 TTR-4100 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.”

**Operation:**

The TTR-4100 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 TTR-4100 is as follows:

**12M10V1D**

Where:

“12M10” - The necessary bandwidth as measured in the Occupied Bandwidth section below.

“V” – A sequence of pulses which is a combination of the foregoing or is produced by other means. In the case of TCAS both phase and amplitude modulation is used.

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

“D” – Type of information to be transmitted – Data transmission, telemetry, telecommand.

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

### F.2.1 Mode C-Only All-Call Interrogation

The TTR-4100 supports two types of modulation. The first is referred to as “Mode C” and utilizes the following waveforms.

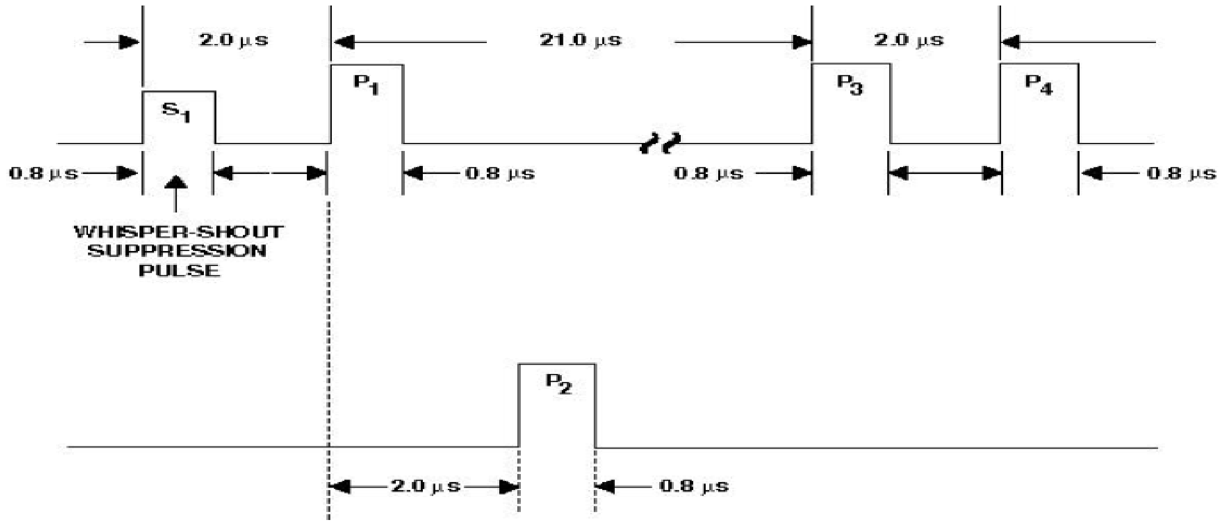


**Figure F-1 – Mode C-Only All-Call Interrogation Pulse Sequence**

Mode C interrogations from TCAS II equipment employ the "Mode-C-Only All-Call" format which consists of three pulses P1, P3, and P4. This normally is preceded by a Mode C "whisper-shout" suppression pulse designated S1. Sidelobe suppression is accomplished by transmitting a P2 pulse via a separate control pattern. These formats are illustrated in the above figure. The pulses have shapes and spacing as tabulated below. The amplitude of P3 is within 0.5 dB of the amplitude of P1 and the amplitude of P4 is within 0.5 dB of the amplitude of P3. A discussion of Whisper-Shout will follow the wave shapes used.

**Table F-2 – Mode-C Pulse Spacing**

(All values in microseconds)

| Pulse Designator | Pulse Duration | Duration Tolerance | Rise Time | | Decay Time | |
|---|---|---|---|---|---|---|
| | | | Min. | Max. | Min. | Max |
| $S_1, P_1, P_2, P_3, P_4$ | 0.8 | ± 0.05 | 0.05 | 0.1 | 0.05 | 0.2 |

The pulse spacing tolerances shall be as follows:
S1 to P1 2 microseconds ± 10 nanoseconds;
P1 to P2 2 microseconds ± 10 nanoseconds;
P1 to P3 21 microseconds ± 10 nanoseconds;
P3 to P4 2 microseconds ± 40 nanoseconds.

## F.2.2 Mode-S Interrogation

The second type of modulation supported by the TTR-4100 is "Mode-S". It is described below.

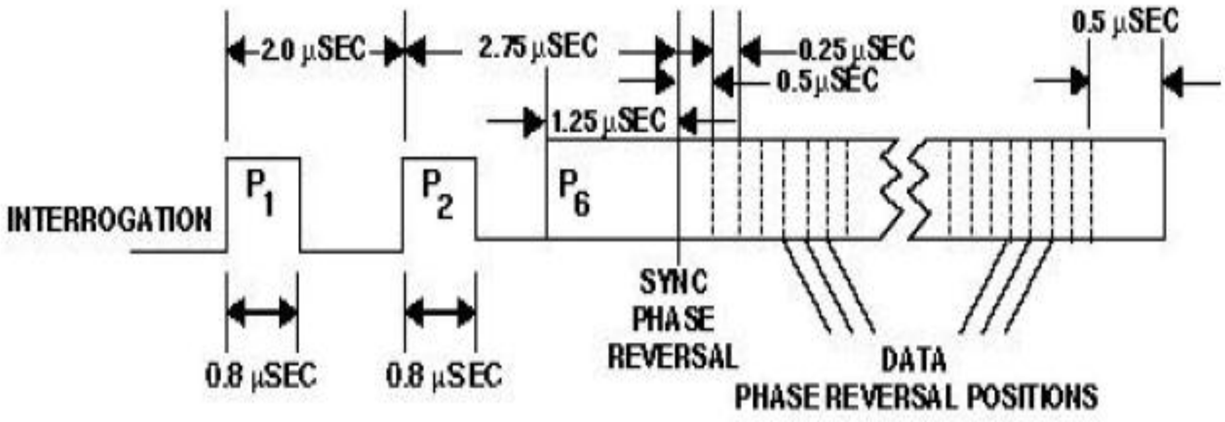


**Figure F-2 – Mode-S Interrogation Pulse Sequence**

Mode S transmissions shall consist of P1, P2, and P6 pulses as shown in the figure above. The pulses shall have shapes and spacing as tabulated below.

**Table F-3 – Mode-S Pulse Spacing**

(All values in microseconds)

| Pulse Designator | Pulse Duration | Duration Tolerance | Rise Time Min. | Rise Time Max. | Decay Time Min. | Decay Time Max. |
|---|---|---|---|---|---|---|
| $P_1$, $P_2$ | 0.8 | ± 0.05 | 0.05 | 0.1 | 0.05 | 0.2 |
| $P_6$ (Short) | 16.25 | ± 0.125 | 0.05 | 0.1 | 0.05 | 0.2 |
| $P_6$ (Long) | 30.25 | ± 0.125 | 0.05 | 0.1 | 0.05 | 0.2 |

The short 16.25 microsecond and long 30.25 microsecond P6 pulses have internal modulation consisting of possible 180 degree phase reversals of the carrier at designated times. The first phase reversal in the P6 pulse is the sync phase reversal and is always present. The presence or absence of a subsequent phase reversal indicates a one or zero in the transmitted code respectively.

*Note 1: The sync phase reversal is the timing reference provided to identify chip positions to Mode S interrogation decoders.*

The duration of a phase reversal in P6 is less than 80 nanoseconds as measured between the 10 degree and 170 degree points of the phase transition. The interval between the 80 percent points of the amplitude transient associated with the phase reversal is less than 80 nanoseconds.

The tolerance on the 0 and 180 degree phase relationships in P6 is ± 5 degrees.

The 90-degree point of each data phase reversal in P6 occurs only at a time (N x 0.25) microseconds ± 20 nanoseconds (N .GE. 2) after the 90 degree point of the sync phase reversal.

*Note 2: 56 or 112 data phase reversals can occur in the 16.25 and 30.25 microsecond P6 pulses respectively. This results in a 4 Mbit/sec data rate within the P6 pulse.*

The spacing from P1 to P2 is 2 ± 40 nanoseconds between leading edges. The spacing from the leading edge of P2 to the 90 degree point of the sync phase reversal of P6 shall be 2.75 microseconds ± 40 nanoseconds. The sync phase reversal of P6 occurs 1.25 microseconds ± 40 nanoseconds after the leading edge.

*Note 3: The P1-P2 pair preceding P6 suppresses replies from ATCRBS transponders to avoid synchronous garble due to random triggering of ATCRBS transponders by Mode S interrogations. A series of "chips" containing the information within P6 starts 500 nanoseconds after the sync phase reversal. Each chip is of 250 nanosecond duration and is preceded by a possible phase reversal. If preceded by a phase reversal, a chip represents logic "1". There are either 56 or 112 chips. The last chip is followed by a 500 nanosecond guard interval which prevents the trailing edge of P6 from interfering with the demodulation process.*

The radiated amplitudes of P2 and the initial first microsecond of P6 are greater than the radiated amplitude of P1 minus 0.25 dB. The maximum envelope amplitude variations between successive phase modulation chips in P6 are less than 0.25 dB.

## F.2.3 Mode-C/Mode-S Interrogation Spectral Mask

The following table provides the spectral mask requirements for TCAS II as defined in RTCA DO-185A. DO-185A is the FAA specified performance requirements that all TCAS II systems must meet.

**Table F-4 – Mode-C/Mode-S Interrogation Spectral Mask**

| Frequency Difference (MHz from 1030 MHz Carrier) | Maximum Relative Power (dB Down From Peak) |
|---|---|
| Between 4 and 6 | 6 |
| Between 6 and 8 | 11 |
| Between 8 and 10 | 15 |
| Between 10 and 20 | 19 |
| Between 20 and 30 | 31 |
| Between 30 and 40 | 38 |
| Between 40 and 50 | 43 |
| Between 50 and 60 | 47 |
| Between 60 and 90 | 50 |
| Greater Than 90 | 60 |

## F.2.4 Control of Synchronous Garble with Whisper-Shout

Aircraft equipped with the TCAS II system provide active surveillance of targets-of-interest that support the generation of collision advisory information. When operating far away from heavily congested airspace, en-route, there is a low probability of the generation of garbled communications due to multiple transmitters operating at the same time in the same spectrum. The equipment provides an automated means of controlling ATCRBS synchronous garble to a level that enables TCAS II to achieve the system requirements when operating within heavily congested airspace by reducing operating power output.

ATCRBS synchronous interference can be controlled by the use of a Mode C whisper-shout interrogation sequence and by the use of a directional transmitting antenna. The degree to which synchronous interference can be reduced depends on the ATCRBS transponder density, the resolution of the whisper-shout interrogation sequence and the azimuth directionality of the transmitting antenna. For a given antenna directionality and de-garble performance, the required degree of resolution is directly proportional to the ATCRBS transponder density; i.e., the lower the ATCRBS density the less resolution is required to provide an equivalent reduction in the level of synchronous interference. TCAS II equipment employs at least a four-beam top-mounted directional interrogation antenna. In conjunction with a four-beam antenna, TCAS II uses the Minimum Basic 6-level whisper-shout sequence, the high resolution whisper-shout sequence or a single interrogation according to selection criteria.

To control ATCRBS synchronous interference and also to reduce the severity of multi-path effects on the interrogation link, a sequence of interrogations at different power levels are to be transmitted during each surveillance update period. Each of the interrogations in the sequence, other than the one at lowest power, is to be preceded by a suppression pulse (designated S1) 2 microseconds preceding the P1 pulse. The combination of S1 and P1 serve as a suppression transmission. S1 is to be at a power level lower than that of P1. The minimum time between successive interrogations is 1 millisecond. All interrogations in the sequence are transmitted within a single surveillance update interval.

Because the suppression transmission in each step is always at a lower power level than the following interrogation, this technique is referred to as whisper-shout. The intended mechanism is that each aircraft replies to only one or two of the interrogations in a sequence. The lowest power interrogation is not preceded by an S1 suppression pulse to ensure that each transponder will respond to at least one of the interrogations in the sequence. A typical population of ATCRBS transponders at any given range may have a large spread in effective sensitivity due to variations in receivers, cable losses, and antenna shielding. Typically, each transponder in the population will respond to two interrogations in the sequence, and will be turned off by the higher power suppression transmissions accompanying higher-power interrogations in the sequence. Given a situation in which several aircraft are near enough to each other in range for their replies to synchronously interfere, it is unlikely they would all reply to the same interrogation and, as a result, the severity of synchronous interference is reduced.

## F.2.4.1 Minimum Basic Whisper-Shout Sequence

The following figure shows the top antenna forward beam timing for six power steps in the Minimum Basic Whisper-Shout sequence. The first pulse of the interrogation serves as the second pulse of suppression.

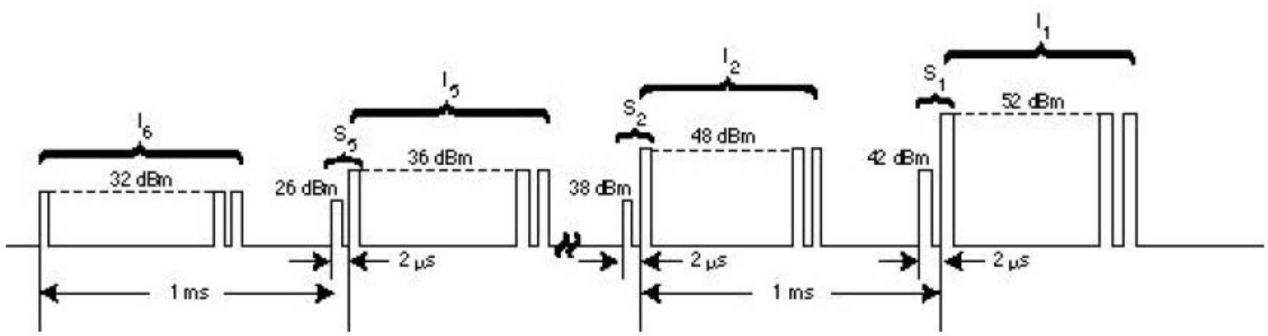


**Figure F-3 – Whisper-Shout Minimum Basic Sequence**

This design is the shortest whisper-shout sequence that has been developed, tested and shown to be effective, when used with a four-beam top-mounted directional antenna, in providing an acceptable level of de-garbling performance in a moderate ATCRBS transponder density of approximately 0.05 ATCRBS-equipped aircraft per sq. nautical mile. Five distinct sub-sequences are defined for use in the four beams of the top-mounted antenna and for the bottom-mounted Omni-directional antenna. The interrogations may be transmitted in any order.

*Note: Most of the interrogations are transmitted from the top antenna because it is less susceptible to multi-path interference from the ground.*

*MINIMUM EFFECTIVE RADIATED INTERFERENCE LIMITING*

| STEP NUMBER | INTERROGATION POWER LEVEL | (dBm) | PRIORITY | MTL (-dBm) |
|---|---|---|---|---|
| 1 | S.........I | 52 | *Note: Each 1 dB* | 74 |
| | Top Antenna | | *reduction in the* | |
| 2 | S.........I | 48 | *sequence follows* | 74 |
| | Forward | | *the priority for* | |
| 3 | S.........I | 44 | *the forward beam* | 72 |
| | Direction | | *in Figure 2-9* | |
| 4 | S.........I | 40 | *(e.g. 1,5,9,··etc)* | 68 |
| 5 | S.........I | 36 | | 64 |
| 6 | .........I | 32 | | 60 |
| 7,8 | S.........I | 48 | *Note: Each 1 dB* | 74 |
| | Top Antenna | | *reduction in the* | |
| 9,10 | S.........I | 44 | *sequence follows* | 72 |
| | Left & Right | | *the priority for* | |
| 11,12 | S.........I | 40 | *the right/left* | 68 |
| | Direction | | *beam in Figure 2-9* | |
| 13,14 | S.........I | 36 | *(e.g. 2/3,6/7···etc)* | 64 |
| 15,16 | .........I | 32 | | 60 |
| 17 | S.........I | 43 | *Note: Each 1 dB* | 71 |
| | Top Antenna | | *reduction follows* | |
| 18 | S.........I | 39 | *the priority for the* | 67 |
| | Aft Direction | | *aft beam in Fig. 2-9* | |
| 19 | S.........I | 35 | *(e.g. 4,8,12····etc)* | 63 |
| 20 | .........I | 31 | | 59 |
| 21 | S..I | 34 | *Note: Each 1 dB* | 62 |
| | Bottom Omni | | *reduction in the* | |
| 22 | S..I | 32 | *sequence follows* | 60 |
| | | | *the priority for* | |
| 23 | S..I | 30 | *the bottom ant in* | 58 |
| | | | *Figure 2-9* | |
| 24 | ...I | 28 | *(e.g. 80,81,82··etc)* | 56 |

22 32 42 52

MIN EFFECTIVE RADIATED POWER LEVEL (dBm)

*Notes: "I" indicates ERP of $P_1$, $P_3$, and $P_4$ Interrogation Pulses.*

*"S" indicates ERP of $S_1$ Suppression Pulse.*

*"S.I" means that the $S_1$ ERP is 2 dB less than the interrogation ERP.*

*"S..I" means that the $S_1$ ERP is 3 dB less than the interrogation ERP.*

*"S.........I" means the $S_1$ ERP is 10 dB less than the interrogation ERP*

*In the last steps of each quadrant no $S_1$ pulses are transmitted.*

**Figure F-4 – Whisper-Shout Minimum Basic Step Description**

## F.2.4.2 Higher Capability Whisper-Shout Sequences

The figures below define the high resolution whisper-shout sequence that's used in conjunction with a four-beam top-mounted directional antenna for high density ATCRBS surveillance. This sequence, when used with a top mounted four-beam directional antenna, has been verified to operate successfully in densities up to 0.3 aircraft per square nautical mile. Five distinct sub sequences are defined for use in the four beams of the top-mounted antenna and the bottom-mounted omnidirectional antenna. The interrogations may be transmitted in any order.

| STEP NUMBER | TOP ANTENNA FORWARD DIRECTION | MINIMUM EFFECTIVE RADIATED INTERROGATION POWER LEVEL (dBm) | INTERFERENCE LIMITING PRIORITY | MTL (-dBm) |
|---|---|---|---|---|
| 1 | S..I | 52 | 1 | 74 |
| 2 | S.I | 51 | 5 | 74 |
| 3 | S..I | 50 | 9 | 74 |
| 4 | S.I | 49 | 13 | 74 |
| 5 | S..I | 48 | 17 | 74 |
| 6 | S.I | 47 | 21 | 74 |
| 7 | S..I | 46 | 25 | 74 |
| 8 | S.I | 45 | 29 | 73 |
| 9 | S..I | 44 | 33 | 72 |
| 10 | S.I | 43 | 37 | 71 |
| 11 | S..I | 42 | 41 | 70 |
| 12 | S.I | 41 | 45 | 69 |
| 13 | S..I | 40 | 49 | 68 |
| 14 | S.I | 39 | 53 | 67 |
| 15 | S..I | 38 | 57 | 66 |
| 16 | S.I | 37 | 61 | 65 |
| 17 | S..I | 36 | 64 | 64 |
| 18 | S.I | 35 | 67 | 63 |
| 19 | S..I | 34 | 70 | 62 |
| 20 | S.I | 33 | 73 | 61 |
| 21 | S..I | 32 | 76 | 60 |
| 22 | S.I | 31 | 77 | 59 |
| 23 | S..I | 30 | 78 | 58 |
| 24 | ....I | 29 | 79 | 57 |

27 37 47 57
MIN EFFECTIVE RADIATED POWER LEVEL (dBm)

*Notes:* *"I" indicates ERP of $P_1$, $P_3$, and $P_4$ Interrogation Pulses.*
*"S" indicates ERP of $S_1$ Suppression Pulse.*
*"S.I" means that the $S_1$ ERP is 2 dB less than the interrogation ERP.*
*"S..I" means that the $S_1$ ERP is 3 dB less than the interrogation ERP.*
*In the last steps of each quadrant no $S_1$ pulses are transmitted.*

**Figure F-5 – Whisper-Shout High Resolution Step Description**

| STEP NUMBER | | | MINIMUM EFFECTIVE RADIATED INTERROGATION POWER LEVEL (dBm) | INTERFERENCE LIMITING PRIORITY | MTL (-dBm) |
|---|---|---|---|---|---|
| 25,26 | S..I | | 48 | 2,3 | 74 |
| 27,28 | S.I | TOP | 47 | 6,7 | 74 |
| 29,30 | S..I | ANTENNA | 46 | 10,11 | 74 |
| 31,32 | S.I | | 45 | 14,15 | 73 |
| 33,34 | S..I | | 44 | 18,19 | 72 |
| 35,36 | S.I | LEFT&RIGHT | 43 | 22,23 | 71 |
| 37,38 | S..I | DIRECTIONS | 42 | 26,27 | 70 |
| 39,40 | S.I | | 41 | 30,31 | 69 |
| 41,42 | S..I | | 40 | 34,35 | 68 |
| 43,44 | S.I | | 39 | 38,39 | 67 |
| 45,46 | S..I | | 38 | 42,43 | 66 |
| 47,48 | S.I | | 37 | 46,47 | 65 |
| 49,50 | S..I | | 36 | 50,51 | 64 |
| 51,52 | S.I | | 35 | 54,55 | 63 |
| 53,54 | S..I | | 34 | 58,59 | 62 |
| 55,56 | S.I | | 33 | 62,63 | 61 |
| 57,58 | S..I | | 32 | 65,66 | 60 |
| 59,60 | S.I | | 31 | 68,69 | 59 |
| 61,62 | S..I | | 30 | 71,72 | 58 |
| 63,64 | ....I | | 29 | 74,75 | 57 |
| 65 | S.I | | 43 | 4 | 71 |
| 66 | S..I | | 42 | 8 | 70 |
| 67 | S.I | | 41 | 12 | 69 |
| 68 | S..I | | 40 | 16 | 68 |
| 69 | S.I | TOP | 39 | 20 | 67 |
| 70 | S..I | ANTENNA | 38 | 24 | 66 |
| 71 | S.I | | 37 | 28 | 65 |
| 72 | S..I | AFT | 36 | 32 | 64 |
| 73 | S.I | DIRECTION | 35 | 36 | 63 |
| 74 | S..I | | 34 | 40 | 62 |
| 75 | S.I | | 33 | 44 | 61 |
| 76 | S..I | | 32 | 48 | 60 |
| 77 | S.I | | 31 | 52 | 59 |
| 78 | S..I | | 30 | 56 | 58 |
| 79 | ....I | | 29 | 60 | 57 |

27 37 47 57

MIN EFFECTIVE RADIATED POWER LEVEL (dBm)

*Notes:* "I" indicates ERP of $P_1$, $P_3$, and $P_4$ Interrogation Pulses.
"S" indicates ERP of $S_1$ Suppression Pulse.
"S.I" means that the $S_1$ ERP is 2 dB less than the interrogation ERP.
"S..I" means that the $S_1$ ERP is 3 dB less than the interrogation ERP.
In the last steps of each quadrant no $S_1$ pulses are transmitted.

**Figure F-6 – Whisper-Shout High Resolution Step Description (cont.)**

| STEP NUMBER | | MINIMUM EFFECTIVE RADIATED INTERROGATION POWER LEVEL (dBm) | INTERFERENCE LIMITING PRIORITY | MTL (-dBm) |
|---|---|---|---|---|
| 80 | S..I | 34 | 80 | 62 |
| 81 | S..I BOTTOM | 32 | 81 | 60 |
| 82 | S..I OMNI | 30 | 82 | 58 |
| 83 | ..I | 28 | 83 | 56 |

27 37 47 57

MIN EFFECTIVE RADIATED POWER LEVEL (dBm)

*Notes:* "I" indicates ERP of $P_1$, $P_3$, and $P_4$ Interrogation Pulses.
"S" indicates ERP of $S_1$ Suppression Pulse.
"S.I" means that the $S_1$ ERP is 2 dB less than the interrogation ERP.
"S..I" means that the $S_1$ ERP is 3 dB less than the interrogation ERP.
In the last steps of each quadrant no $S_1$ pulses are transmitted.

**Figure F-7 – Whisper-Shout High Resolution Step Description (cont.)**

## F.3 Special FCC Test Conditions

The equipment provides the following interrogation test modes for use with the bench test procedures.

a. Mode S Test Mode 1
A Mode S interrogation format with a short P6 pulse, but containing a data block whose bit values are all ONE. The interrogation rate shall be 50 per second, nominal.

b. Mode S Test Mode 2
A Mode S interrogation format with a long P6 pulse, but containing a data block whose bit values are all ONE. The interrogation rate shall be 50 per second, nominal.

c. Mode S Test Mode 3
A Mode S interrogation format without the preamble pulses and with a long P6 pulse containing no internal modulation (i.e., a data block whose bit values are all ZERO). The interrogation rate shall be 50 per second, nominal.

d. Mode C Test Mode 1
A standard Mode C only all-call interrogation (see section F.2.4) at a rate of 50 per second, nominal.

e. Whisper-Shout Test Mode 1
A standard minimum basic whisper-shout sequence for the minimum TCAS is defined in subparagraph F.2.8. The interrogation sequence rate shall be 10 per second, nominal.

f. Whisper-Shout Test Mode 2
A standard high resolution whisper-shout sequence for the minimum TCAS is defined in subparagraph F.2.9. The interrogation sequence rate shall be 10 per second, nominal.

g. No-Interrogation Test Mode
A mode in which the TCAS transmitter is programmed to transmit no interrogations but otherwise is active.

Table F-5 lists the Special FCC Test Conditions described above and lists which FCC test paragraphs utilized these conditions.

**Table F-5 – Special FCC Test Conditions**

| Test Section | Test Mode(s) | Notes |
|---|---|---|
| 2.1046 – RF Power Output | Mode C Test Mode 1<br>Mode S Test Mode 2 | Representative Mode C and Mode S waveforms. |
| 2.1049 – Occupied BW | Mode C Test Mode 1<br>Mode S Test Mode 2 | Represents worst case spectrum utilization. Phase transition every bit period. |
| 2.1051 – Spurious Emissions | Mode S Test Mode 2 | Represents worst case spectrum utilization. Phase transition every bit period. Only Mode S used. |
| 2.1053 – Spurious Radiation | Normal Operation | Normal operation software used with test system capable of simulating 2 Mode C and 2 Mode S aircraft. |
| 2.1055 – Frequency Stability | Mode S Test Mode 3 | Un-modulated Mode S pulse used as it generates the narrowest modulation spectrum and provides the best frequency accuracy. |

## 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 TTR-4100 unit utilizes a +28 VDC power supply. The power supply boosts the incoming voltage to a high voltage DC rail for hold-up capacitance storage. The supply then converts the high voltage DC rail to +12 VDC for internal distribution to the various assemblies in the unit. The Transceiver assembly then boosts the system +12 VDC to +32 VDC to be applied to the modulator for the RF power amplifier driver and final transistors. The modulator for the power amplifier transistors regulates the +32 VDC rail to a digitally controlled value around 20 VDC in order to prevent transmitter droop. The transistors draw approximately 40 A’s peak, and around 800 mA average. Transmitter tuning is not required. The test shall be completed by varying the input power input voltage ±15%.

The equipment used for the RF Power Output Test is shown in Table F-6.

**Table F-6 – Test Equipment Used for RF Power Output Test**

| Equipment | Manufacturer/Model Number | Specific Identification | Calibration Date |
|---|---|---|---|
| Receiver/Transmitter Module | Rockwell Collins TTR-4100 (822-3075-910) | S/N 4765K | N/A |
| Test Harness | Rockwell Collins TTR-4100 Breakout Panel | N/A | N/A |
| SST-2010 | Rockwell Collins | N/A | N/A |
| TTR-4100 Antenna Simulator | Rockwell Collins | 653-4519-015 | N/A |
| 8-Way Combiner | Mini-Circuits, ZB8PD-2000-S+ | N/A | N/A |
| Spectrum Analyzer | Rohde & Schwarz, FSU | 460-0155-003 | 04/21/2011 |
| DC Power Supply | Agilent 6653A | 469-0077-760 | 08/29/2011 |
| AC Power Supply | Agilent 6812B | 469-0077-787 | 09/28/2011 |
| Attenuator (20 dB) | Weinschel | N/A | N/A |
| Personal Computer | Generic PC | N/A | N/A |
| Ethernet Switch | D-Link DSS-16+ | N/A | N/A |

A functional block diagram of the equipment setup for the RF Power Output Test is shown in Figure F-8.

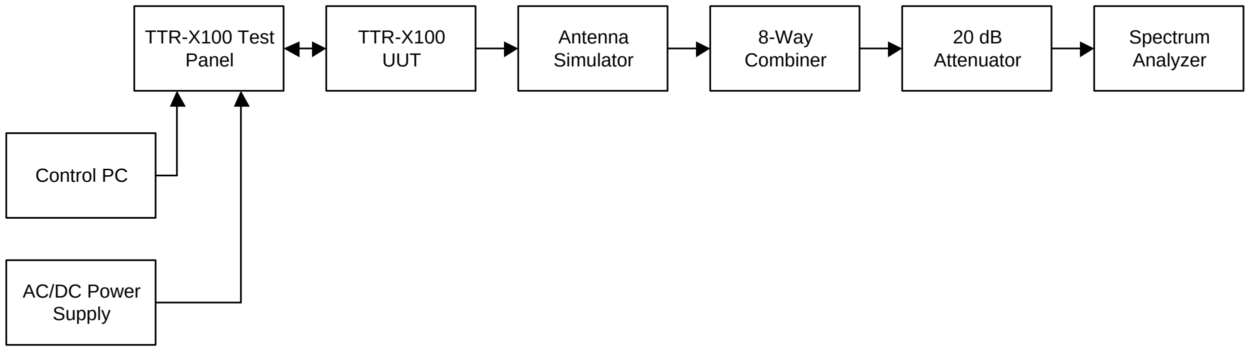


**Figure F-8 – RF Power Output Test Equipment Setup Diagram**

**Test Procedure:**

This test shall measure the RF output power while the primary power input varies up to ±15%. The RF power output shall be measured using both Mode C Test Mode 1 and Mode S Test Mode 2.

For each voltage specified in Table F-7, set the unit to each of test mode and measure the peak RF output power. The power shall be measured through 20 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-7.

**Table F-7 – TTR-4100 RF Power Output**

| **Line Voltage (VDC)** | **Peak Transmitter Power Output (Watts)** | |
|---|---|---|
| | **Mode C** | **Mode S** |
| 23.8 (28 – 15%) | 245 | 245 |
| 25.2 (28 – 10%) | 251 | 251 |
| 26.6 (28 – 5%) | 251 | 245 |
| 28.0 | 251 | 245 |
| 29.4 (28 + 5%) | 251 | 245 |
| 30.8 (28 + 10%) | 251 | 245 |
| 32.2 (28 + 15%) | 251 | 245 |

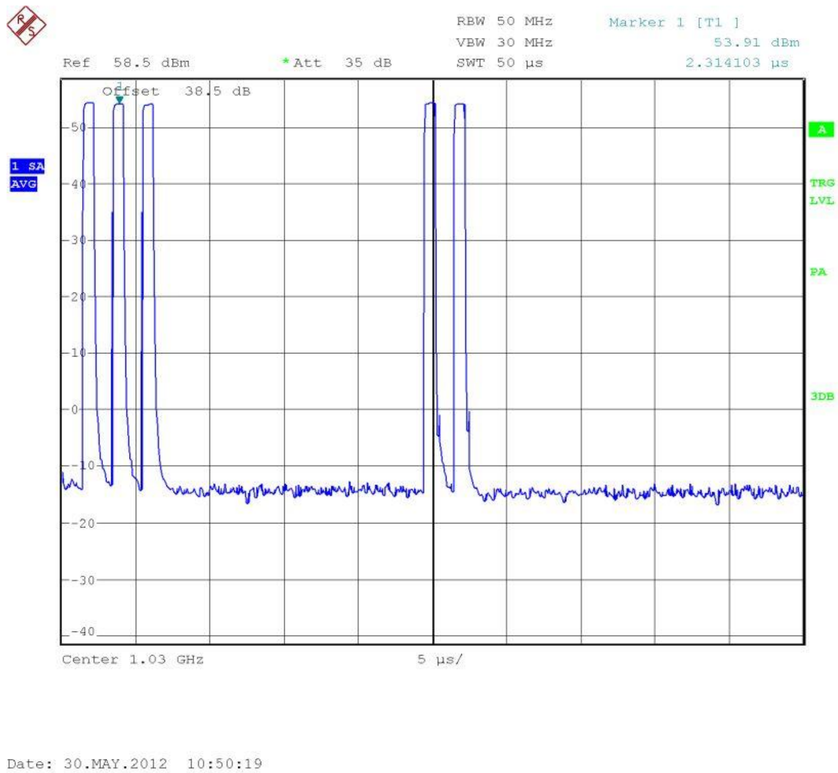


**Figure F-9 – RF Power Output Test – Mode C – +23.8 °C**

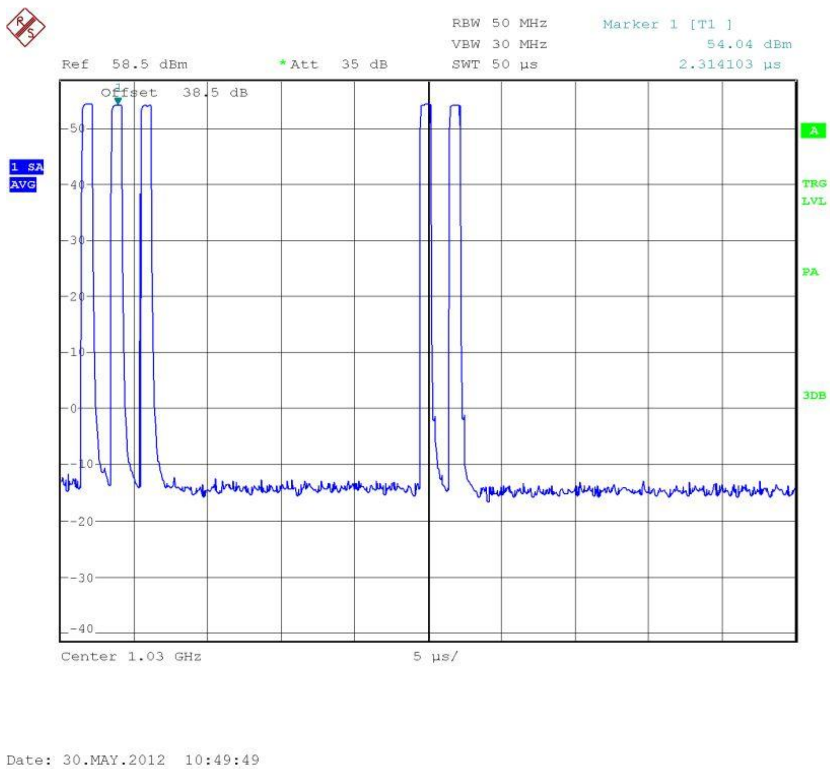


**Figure F-10 – RF Power Output Test – Mode C – +25.2 °C**

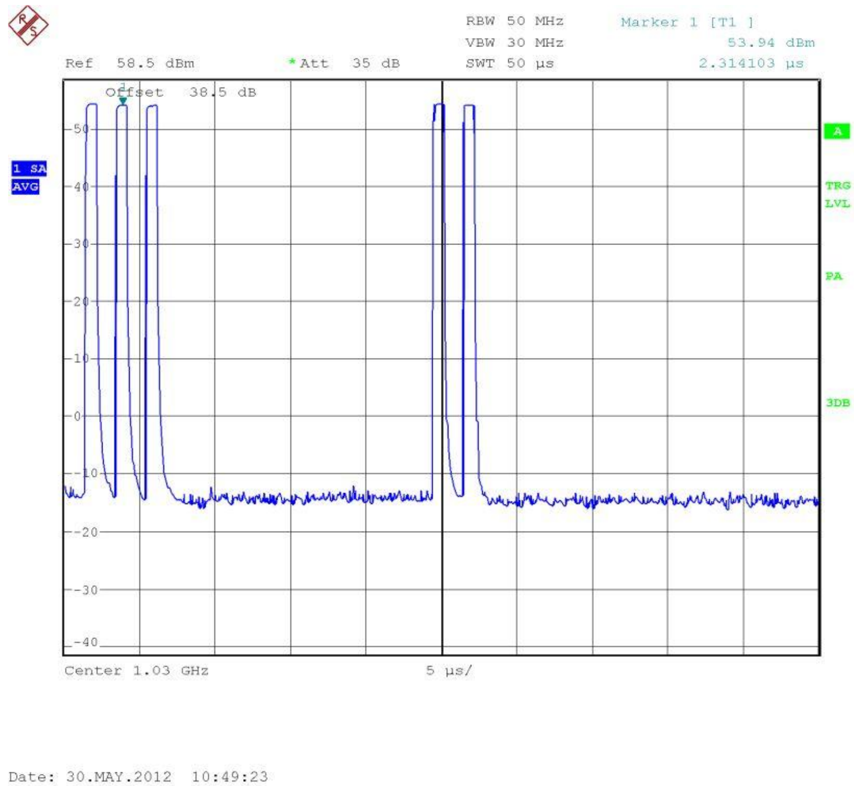


**Figure F-11 – RF Power Output Test – Mode C – +26.6 °C**

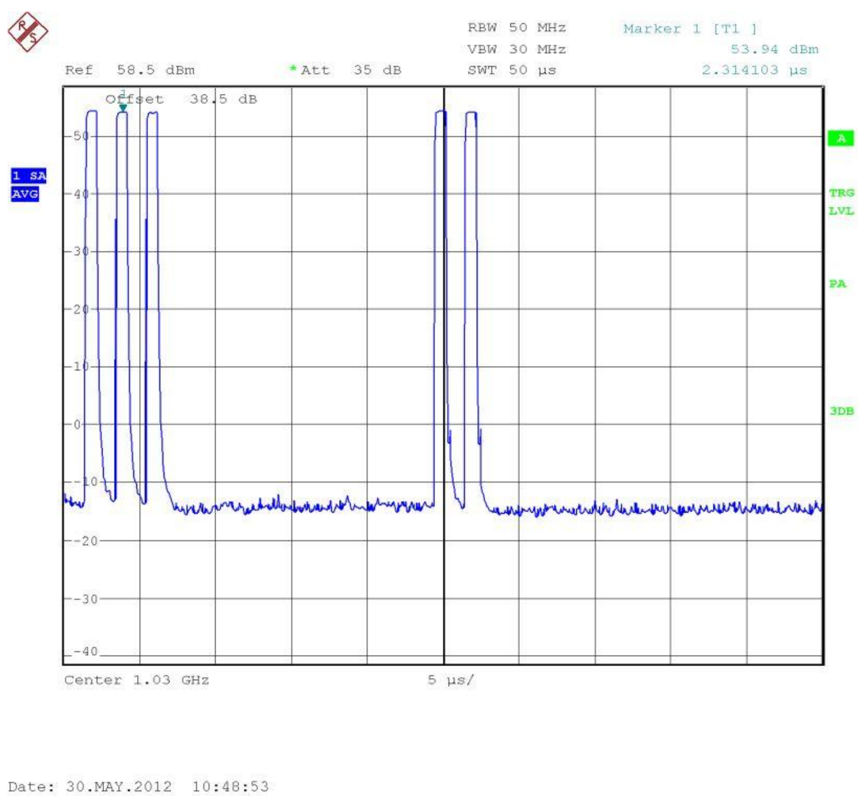


**Figure F-12 – RF Power Output Test – Mode C – +28.0 °C**

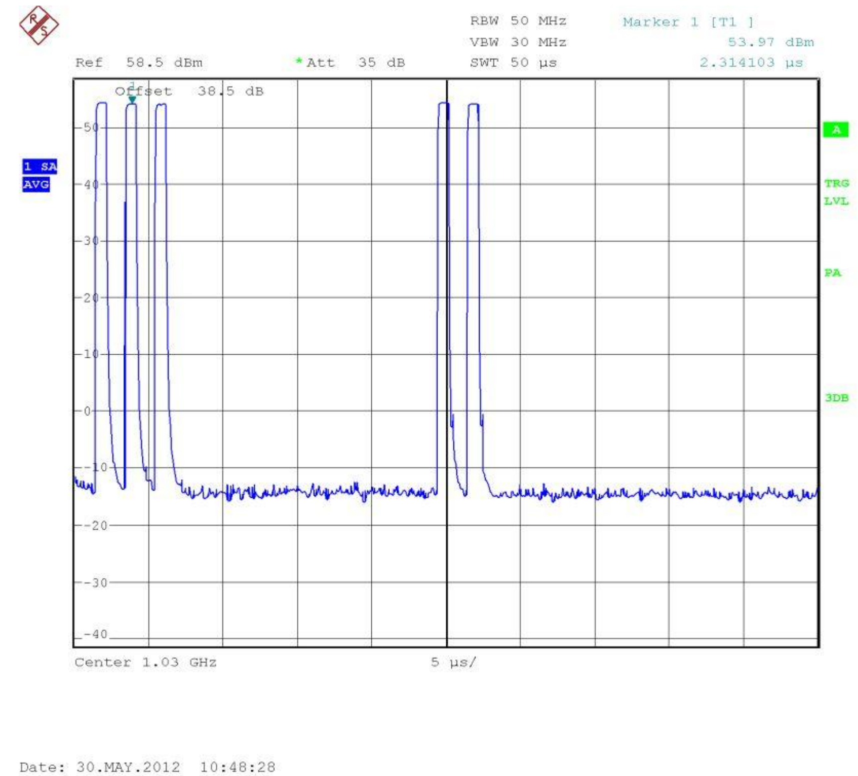


**Figure F-13 – RF Power Output Test – Mode C – +29.4 °C**

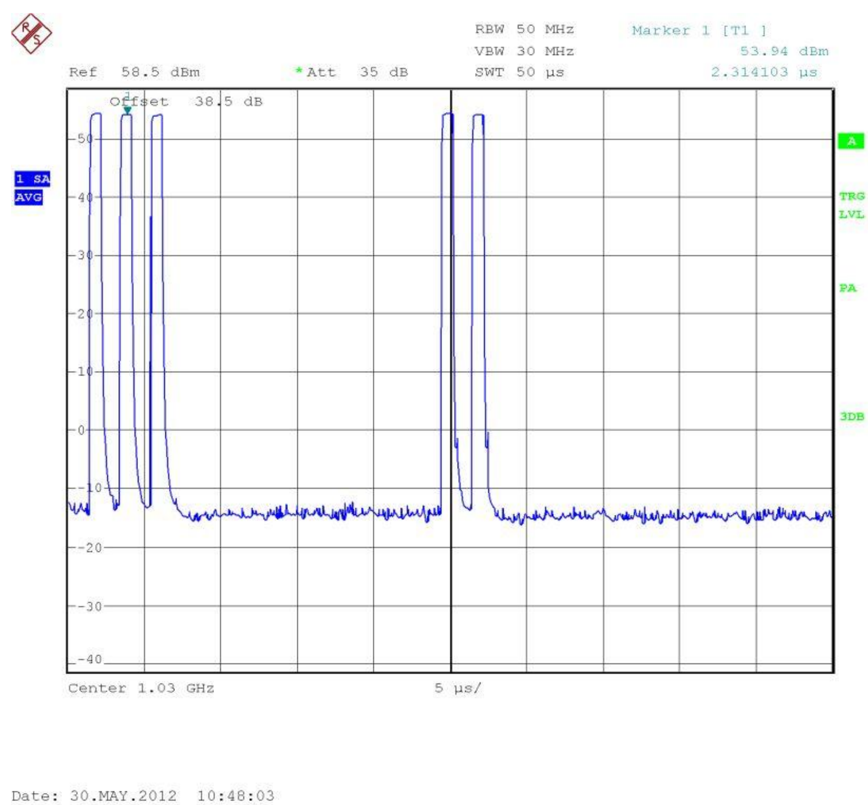


**Figure F-14 – RF Power Output Test – Mode C – +30.8 °C**

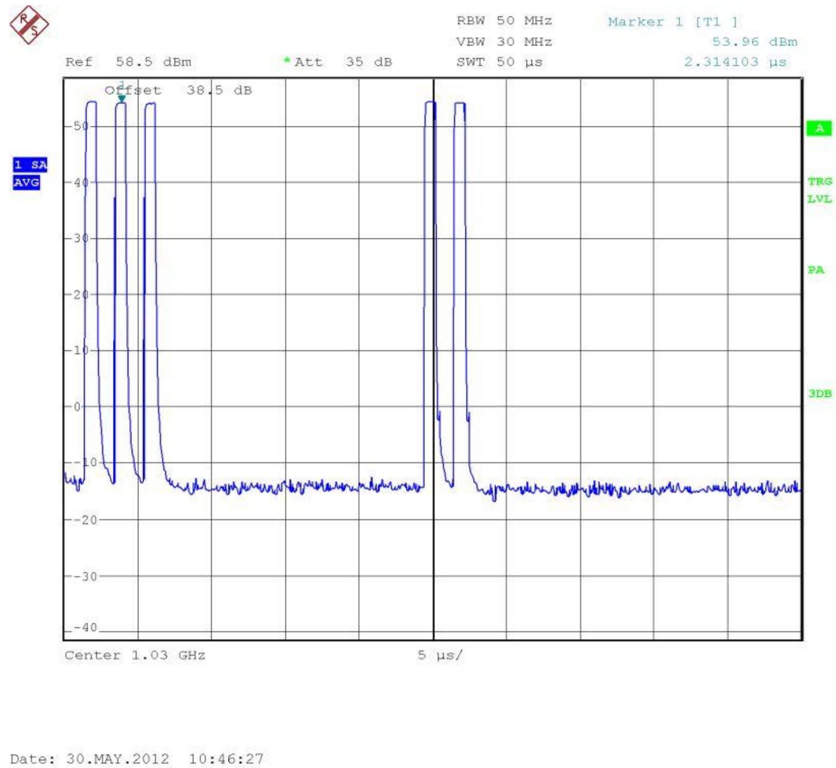


**Figure F-15 – RF Power Output Test – Mode C – +32.2 °C**

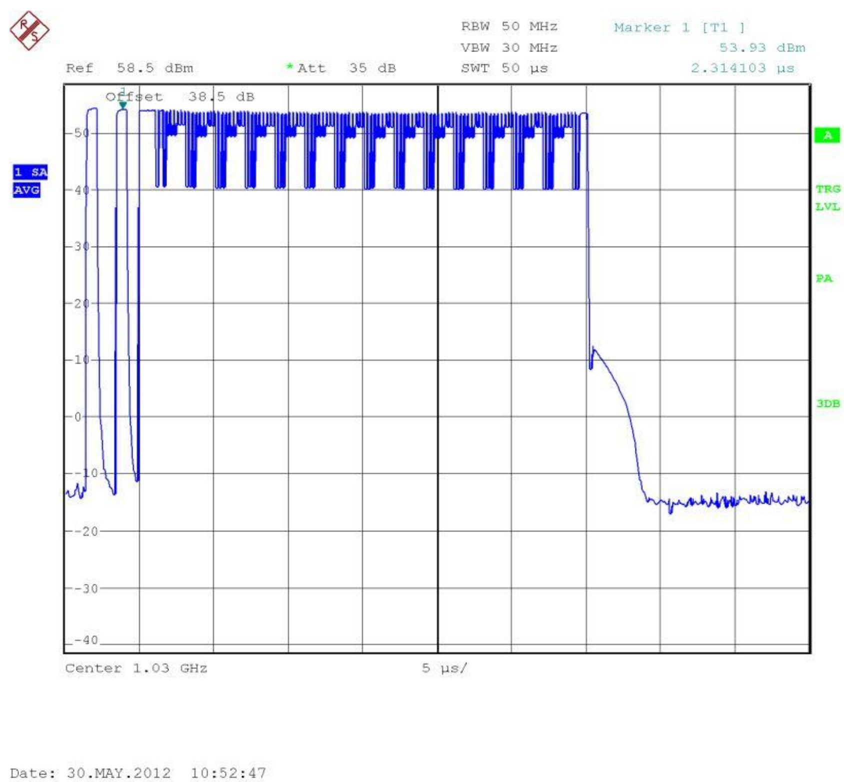


**Figure F-16 – RF Power Output Test – Mode S – +23.8 °C**

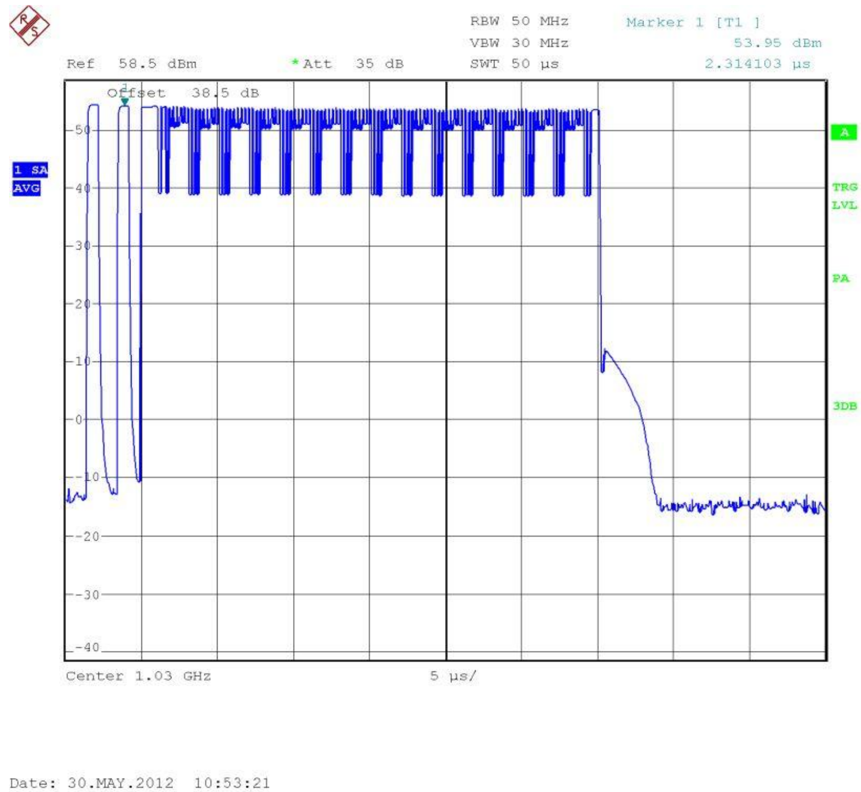


**Figure F-17 – RF Power Output Test – Mode S – +25.2 °C**

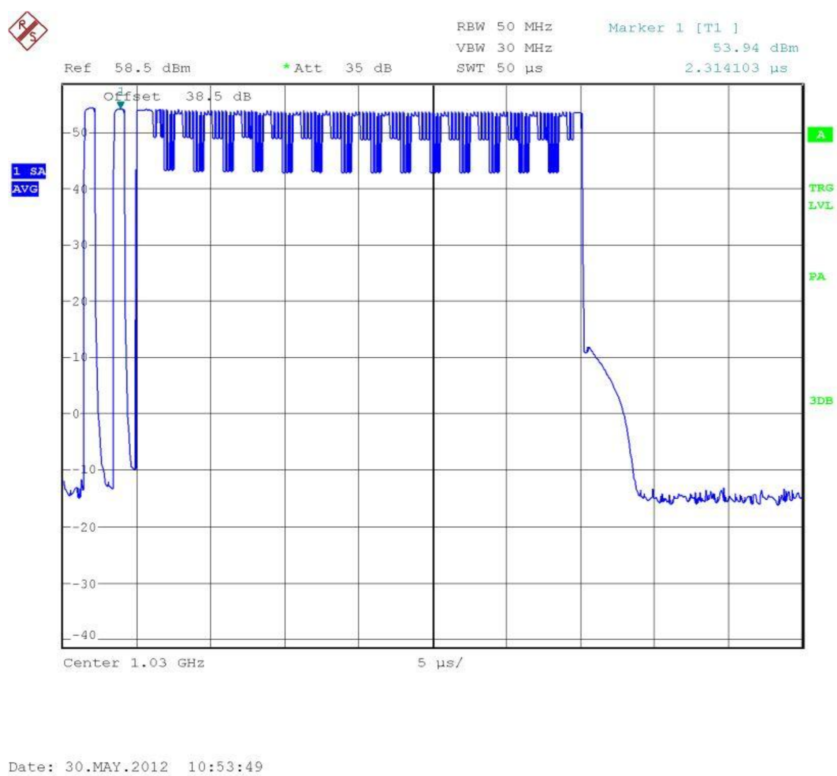


**Figure F-18 – RF Power Output Test – Mode S – +26.6 °C**

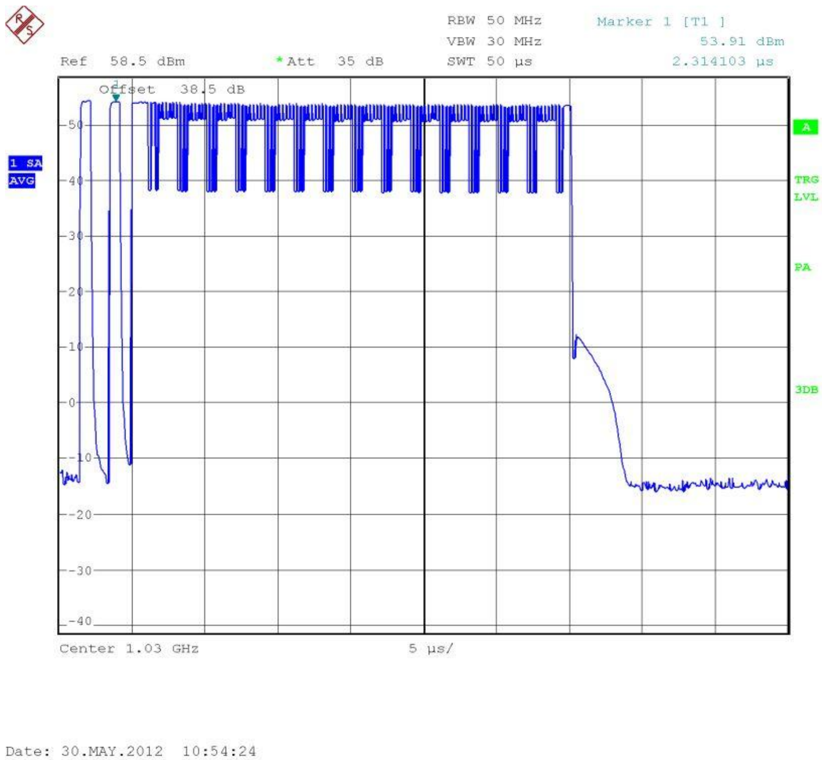


**Figure F-19 – RF Power Output Test – Mode S – +28.0 °C**

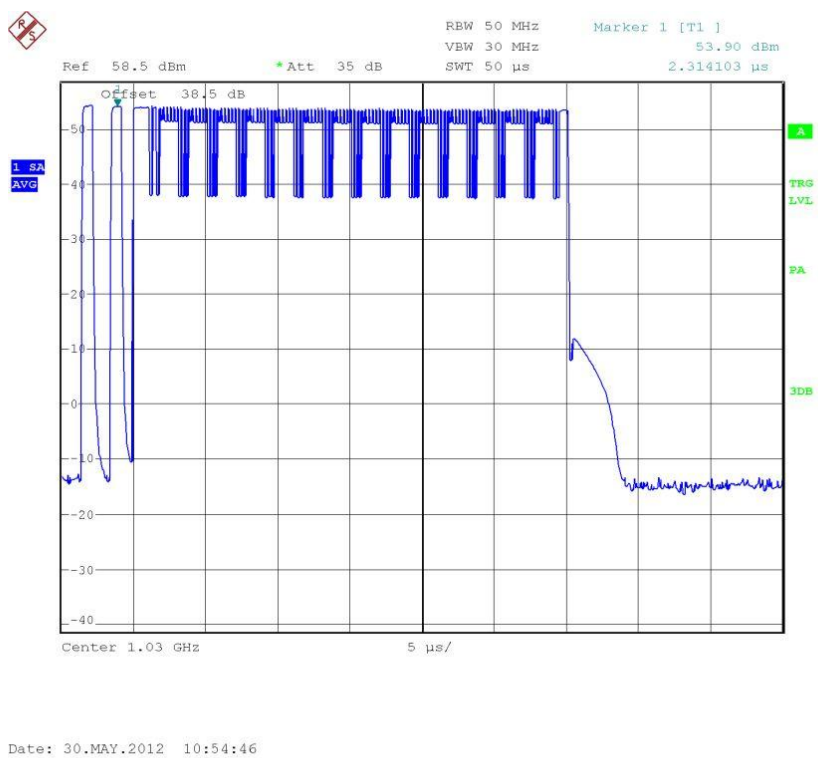


**Figure F-20 – RF Power Output Test – Mode S – +29.4 °C**

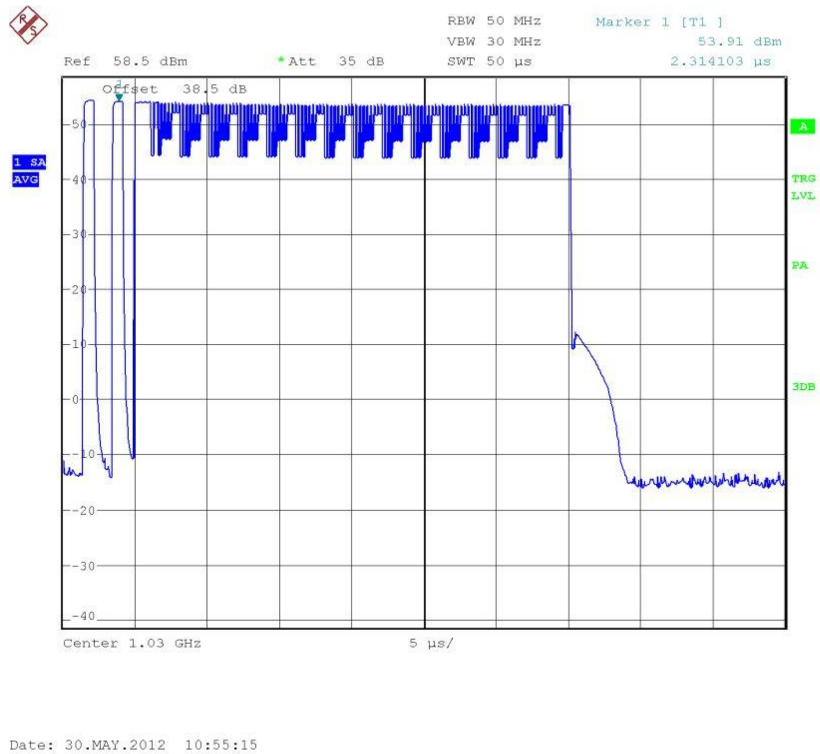


**Figure F-21 – RF Power Output Test – Mode S – +30.8 °C**

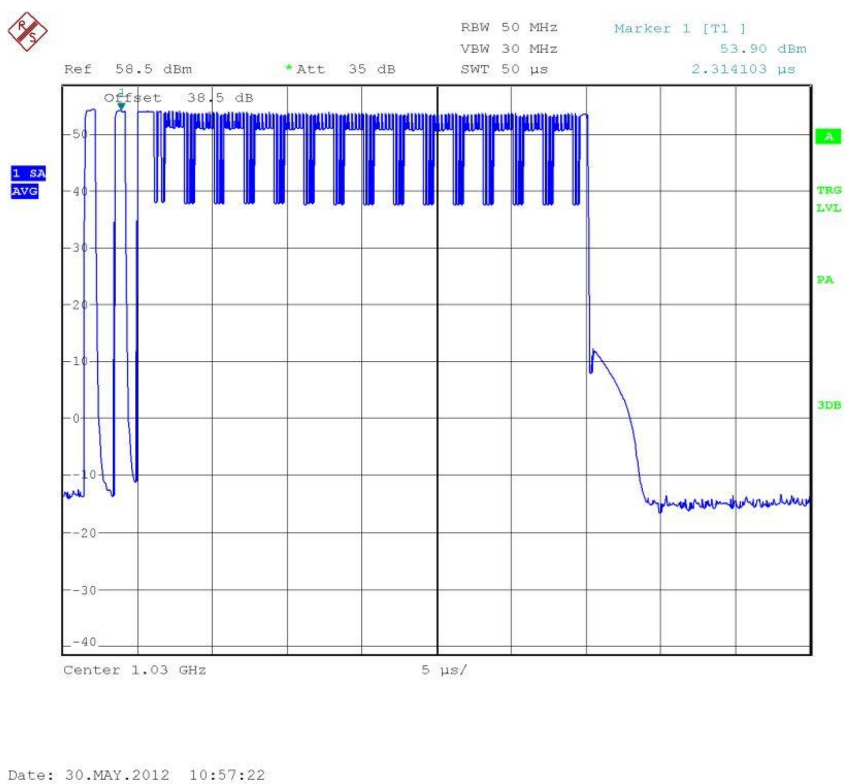


**Figure F-22 – RF Power Output Test – Mode S – +32.2 °C**

## 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 (7) 470 to 2450 MHz Aircraft Stations is 20 ppm.

**Test Equipment and Setup:**

The equipment used for the Frequency Stability tests is shown in Table F-8.

**Table F-8 – Equipment Used for Frequency Stability Test**

| Equipment | Manufacturer/Model Number | Specific Identification | Calibration Date |
|---|---|---|---|
| Receiver/Transmitter Module | Rockwell Collins TTR-4100 (822-3075-910) | S/N 4765P | N/A |
| Test Harness | Rockwell Collins TTR-4100 Breakout Panel | N/A | N/A |
| SST-2010 | Rockwell Collins | N/A | N/A |
| TTR-4100 Antenna Simulator | Rockwell Collins | 653-4519-015 | N/A |
| 8-Way Combiner | Mini-Circuits, ZB8PD-2000-S+ | N/A | N/A |
| Spectrum Analyzer | Rohde & Schwarz, FSU | 460-0155-003 | 04/21/2011 |
| DC Power Supply | Agilent 6653A | 469-0077-760 | 08/29/2011 |
| AC Power Supply | Agilent 6812B | 469-0077-787 | 09/28/2011 |
| Attenuator (20 dB) | Weinschel | N/A | N/A |
| Personal Computer | Generic PC | N/A | N/A |
| Ethernet Switch | D-Link DSS-16+ | N/A | N/A |

The test setup for the Frequency Stability test is shown in Figure F-9.

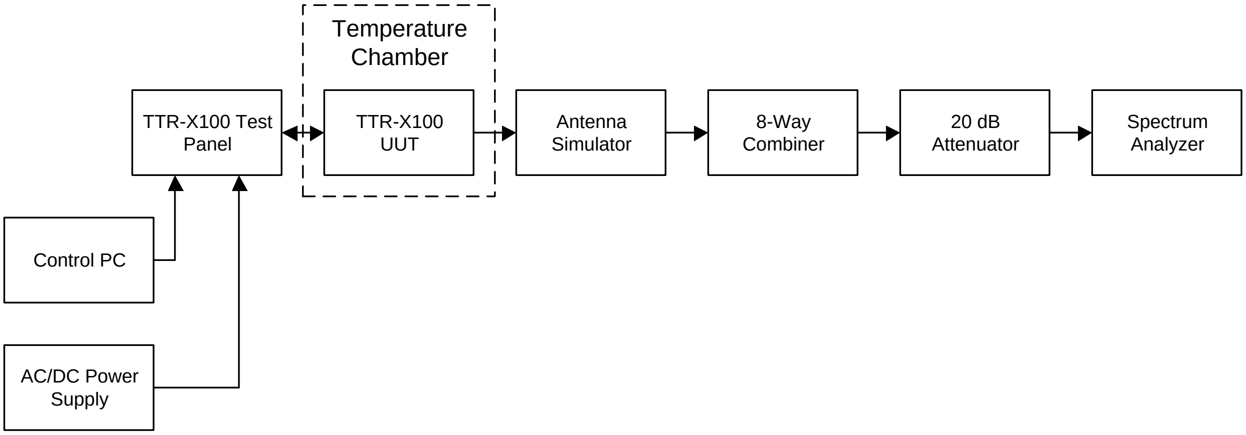


**Figure F-23 – Frequency Stability Test Setup Diagram**

**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 using Mode S Test Mode 3.

For each voltage specified in Table F-9, measure the RF output frequency. The frequency shall be measured through 20 dB of attenuation to avoid damage to the test equipment. The frequency shall be within ±10.3 kHz of the center frequency of 1030 MHz.

**Test Results - Primary Supply Variation:**

Frequency Stability vs Line Voltage test results are shown in Table F-9. There were no out of tolerance frequency variations as a result of line voltage variations.

**Table F-9 – TTR-4100 Transmitted Frequency vs. Input Voltage**

| Line Voltage (VDC) | Frequency (Spectrum Analyzer) (MHz) |
|---|---|
| | Mode S |
| 23.8 (28 – 15%) | 1030.000000 |
| 25.2 (28 – 10%) | 1030.000000 |
| 26.6 (28 – 5%) | 1030.000321 |
| 28.0 | 1030.000000 |
| 29.4 (28 + 5%) | 1030.000000 |
| 30.8 (28 + 10%) | 1030.000000 |
| 32.2 (28 + 15%) | 1030.000000 |

**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 using Mode S Test Mode 3.

For each temperature step specified in, measure the RF output frequency. The frequency shall be measured through 20 dB of attenuation to avoid damage to the test equipment. The frequency shall be within ±10.3 kHz of the center frequency of 1030 MHz.

**Test Results – Temperature Variation:**

Temperature Test results are shown in Table F-10 and Figure F-10. There were no out of tolerance frequency variations as a result of temperature extremes from -55 ºC to +70 ºC.

**Table F-10 – TTR-4100 Transmitted Frequency vs. Temperature**

| Temp. (ºC) | Frequency (Spectrum Analyzer) (MHz) |
|---|---|
| | Mode S |
| -55 | 1030.001900 |
| -50 | 1030.001100 |
| -40 | 1030.000500 |
| -30 | 1029.999700 |
| -20 | 1029.999600 |
| -10 | 1029.999500 |
| 0 | 1029.999300 |
| 10 | 1030.000100 |
| 20 | 1030.000300 |
| 30 | 1029.999900 |
| 40 | 1029.999800 |
| 50 | 1029.999800 |
| 60 | 1029.999400 |
| 70 | 1029.999200 |

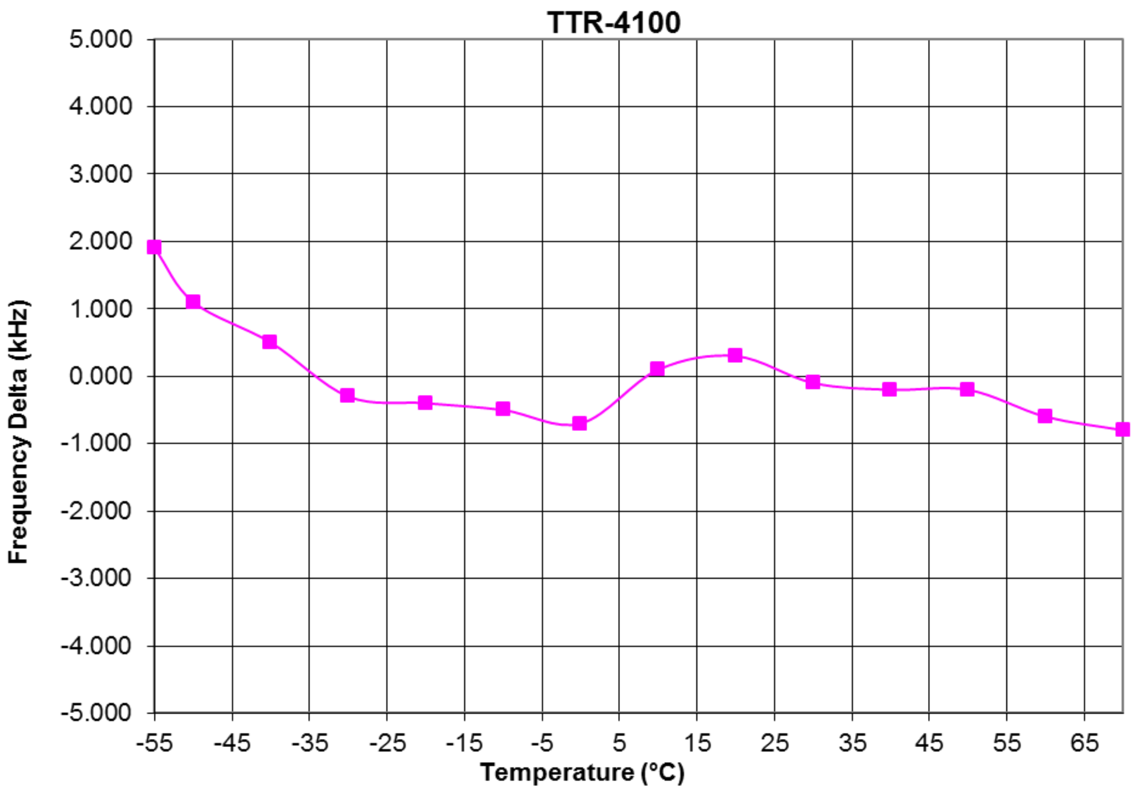


**Figure F-24 – TTR-4100 Transmitter Frequency Stability vs. Temperature**

## 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 (7) 470 to 2450 MHz Aircraft Stations is 20 ppm.

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-11.

**Table F-11 – Equipment Used for Occupied Bandwidth Tests**

| Equipment | Manufacturer/Model Number | Specific Identification | Calibration Date |
|---|---|---|---|
| Receiver/Transmitter Module | Rockwell Collins TTR-4100 (822-3075-910) | S/N 4765K | N/A |
| Test Harness | Rockwell Collins TTR-4100 Breakout Panel | N/A | N/A |
| SST-2010 | Rockwell Collins | N/A | N/A |
| TTR-4100 Antenna Simulator | Rockwell Collins | 653-4519-015 | N/A |
| 8-Way Combiner | Mini-Circuits, ZB8PD-2000-S+ | N/A | N/A |
| Spectrum Analyzer | Rohde & Schwarz, FSU | 460-0155-003 | 04/21/2011 |
| DC Power Supply | Agilent 6653A | 469-0077-760 | 08/29/2011 |
| AC Power Supply | Agilent 6812B | 469-0077-787 | 09/28/2011 |
| Attenuator (20 dB) | Weinschel | N/A | N/A |
| Personal Computer | Generic PC | N/A | N/A |
| Ethernet Switch | D-Link DSS-16+ | N/A | N/A |

A functional block diagram of the equipment setup for the Occupied Bandwidth Test is shown in Figure F-11.

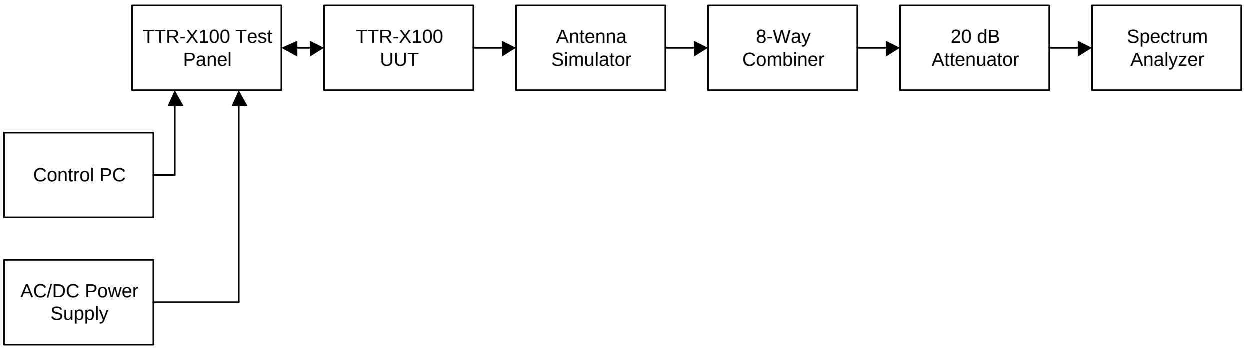


**Figure F-25 – Occupied Bandwidth Test Equipment Setup**

**Test Procedure:**

This test shall measure the occupied bandwidth using Mode C Test Mode 1 and Mode S Test Mode 2. The test shall be completed with a nominal input voltage level of +28 VDC. The occupied bandwidth shall be measured through 20 dB of attenuation to avoid damage to the test equipment.

**Test Results:**

The Rohde & Schwarz FSU spectrum analyzer was set up to automatically measure 99% occupied bandwidth. Table F-12 contains the test result for Mode C and Mode S operating modes.

**Table F-12 – TTR-4100 Occupied Bandwidth Measurement Results**

| Operational Mode | 99% Occupied Bandwidth | Reference Figure |
|---|---|---|
| Mode C | 8.17 MHz | Figure F-12 |
| Mode S | 12.12 MHz | Figure F-13 |

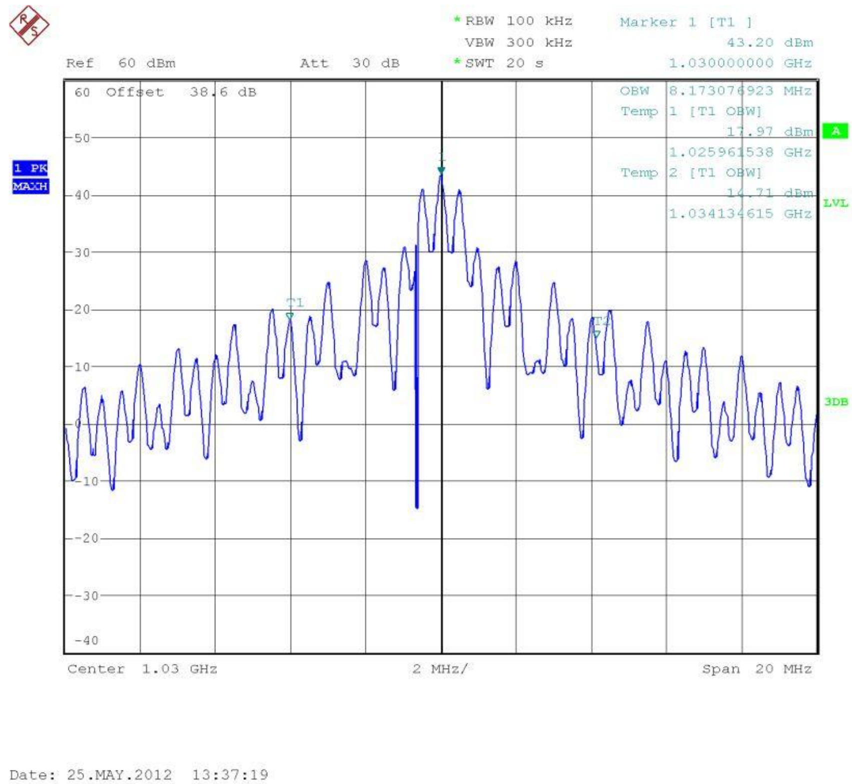


**Figure F-26 – Occupied Bandwidth Measurement – Mode C – 100 kHz RBW**

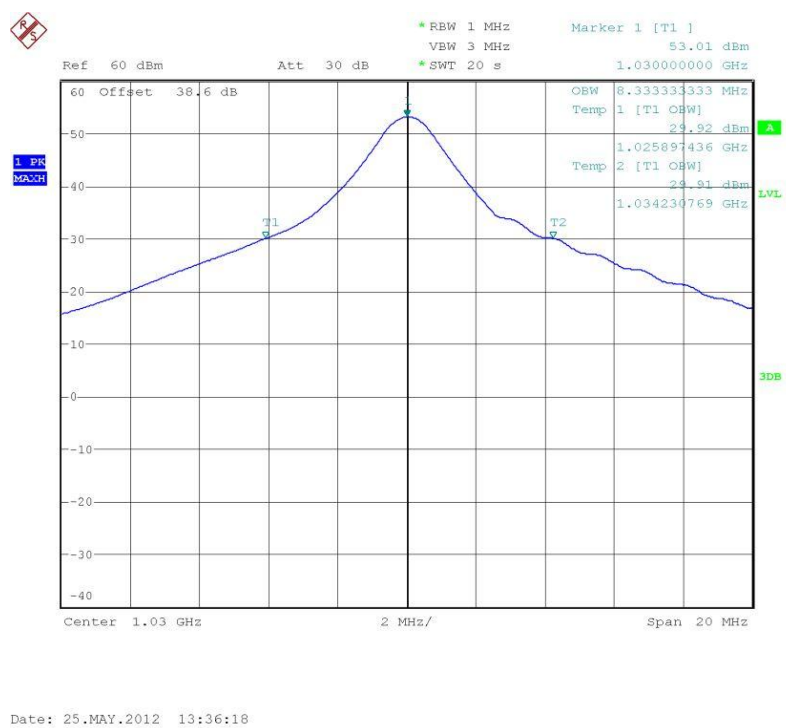


**Figure F-27 – Occupied Bandwidth Measurement – Mode C – 1 MHz RBW**

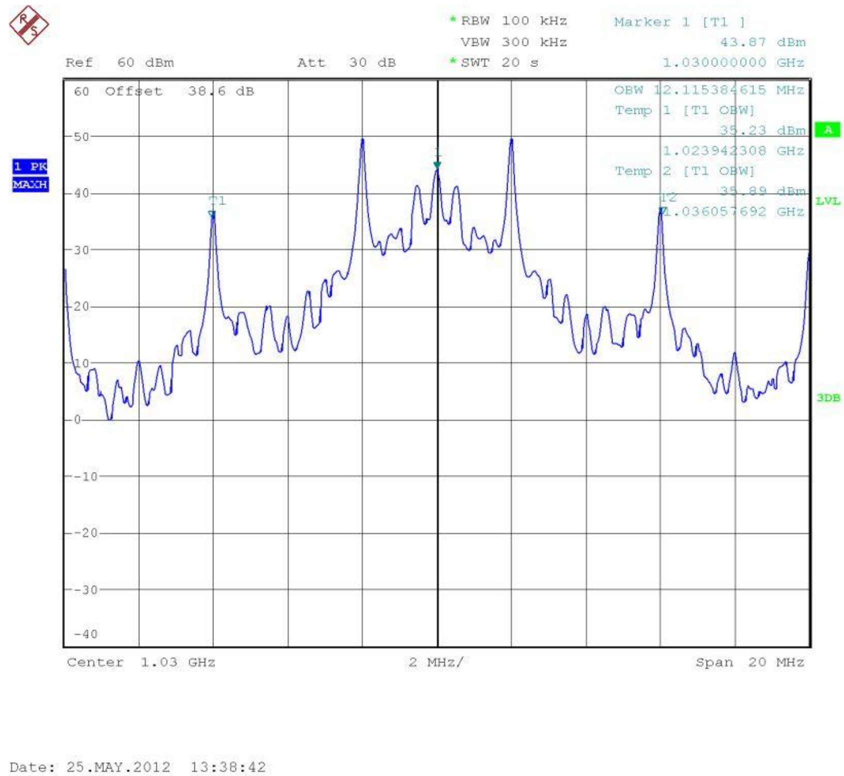


**Figure F-28 – Occupied Bandwidth Measurement – Mode S – 100 kHz RBW**

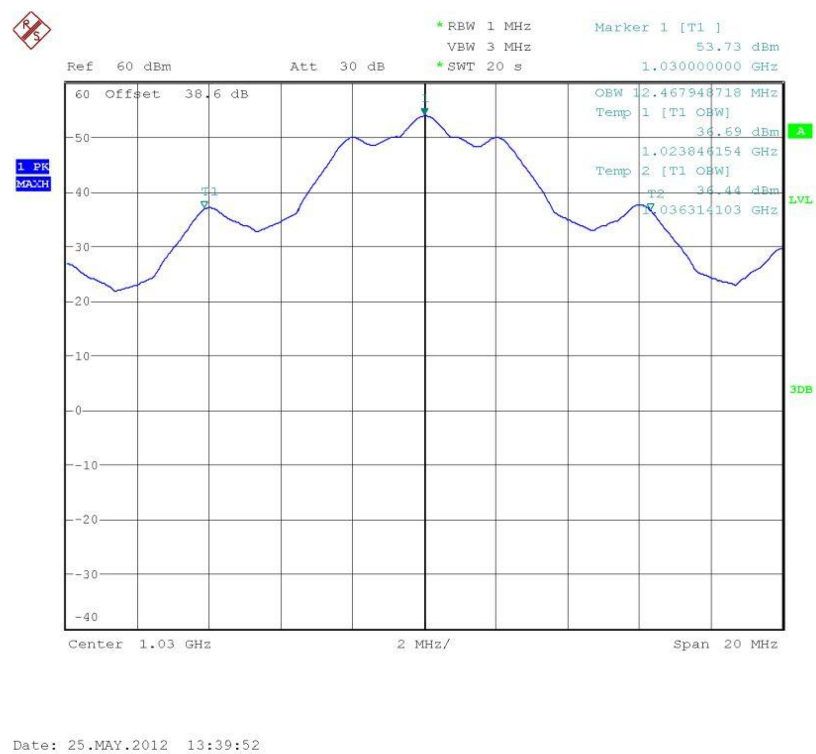


**Figure F-29 – Occupied Bandwidth Measurement – Mode S – 1 MHz RBW**

## 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 TTR-4100 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 1020 to 1040 MHz which is the frequency range allocated for TCAS II equipment per FAA guidelines.

The TTR-4100 has a maximum peak power output of 400 watts. Based on this power level, the absolute limits are calculated as follows using 40 dBc as an example.

$P_{TX\_peak}$ = 251 Watts = 54 dBm

FCC Limit = 40 dBc

Absolute Limit = $P_{TX\_peak}$ (dBm) – FCC Limit (dBc) = +14 dBm

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

The requirements for the Spurious Emissions Test are contained in Table F-13.

**Table F-13 – Spurious Emission Test Requirements (87.139(a)(3))**

| Frequency Band | Emission Level | Absolute FCC Limit (Peak) |
|---|---|---|
| Below 970 MHz | -40 dBc | +14 dBm |
| From 970 MHz to 1000 MHz | -35 dBc | +19 dBm |
| From 1000 MHz to 1010 MHz | -25 dBc | +29 dBm |
| From 1050 MHz to 1060 MHz | -25 dBc | +29 dBm |
| From 1060 MHz to 1090 MHz | -35 dBc | +19 dBm |
| Over 1090 MHz | -40 dBc | +14 dBm |

**Test Equipment and Setup:**

The equipment used for all Spurious Emissions test is shown in Table F-14.

**Table F-14 – Equipment Used for Spurious Emissions Tests**

| Equipment | Manufacturer/Model Number | Specific Identification | Calibration Date |
|---|---|---|---|
| Receiver/Transmitter Module | Rockwell Collins TTR-4100 (822-3075-910) | S/N 4765K | N/A |
| Test Harness | Rockwell Collins TTR-4100 Breakout Panel | N/A | N/A |
| SST-2010 | Rockwell Collins | N/A | N/A |
| TTR-4100 Antenna Simulator | Rockwell Collins | 653-4519-015 | N/A |
| 8-Way Combiner | Mini-Circuits, ZB8PD-2000-S+ | N/A | N/A |
| Spectrum Analyzer | Rohde & Schwarz, FSU | 460-0155-003 | 04/21/2011 |
| DC Power Supply | Agilent 6653A | 469-0077-760 | 08/29/2011 |
| AC Power Supply | Agilent 6812B | 469-0077-787 | 09/28/2011 |
| Attenuator (20 dB) | Weinschel | N/A | N/A |
| Personal Computer | Generic PC | N/A | N/A |
| Ethernet Switch | D-Link DSS-16+ | N/A | N/A |

A functional block diagram of the equipment setup for Spurious Emissions at Antenna Terminal test is shown in Figure F-14.

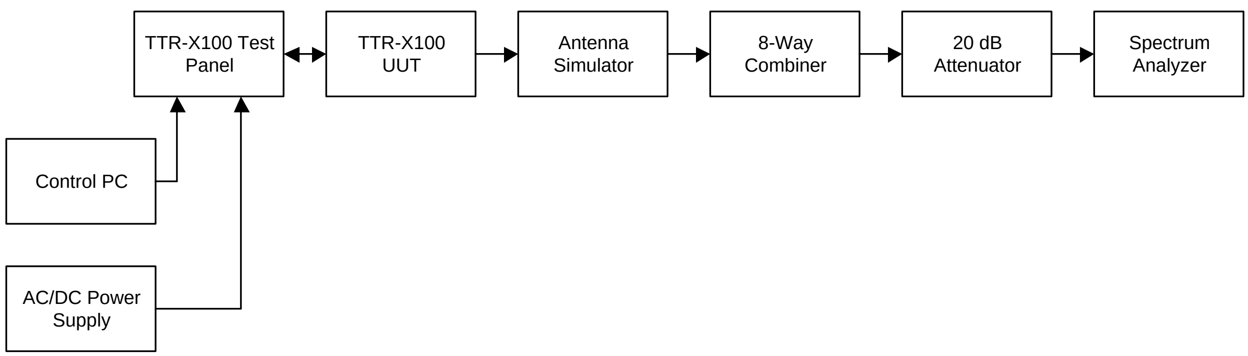


**Figure F-30 – Spurious Emissions of Antenna Terminal Test Setup Diagram (8.2 – 12.4 GHz)**

**Test Procedure:**

This test shall measure spurious emissions at the antenna terminal using Mode S Test Mode 3. The test shall be completed at with a nominal input voltage level of +28 VDC.

**Test Results:**

There were no emissions above the FCC Limit of 40 dBc.

The test results are shown in Figure F-15 through Figure F-16.

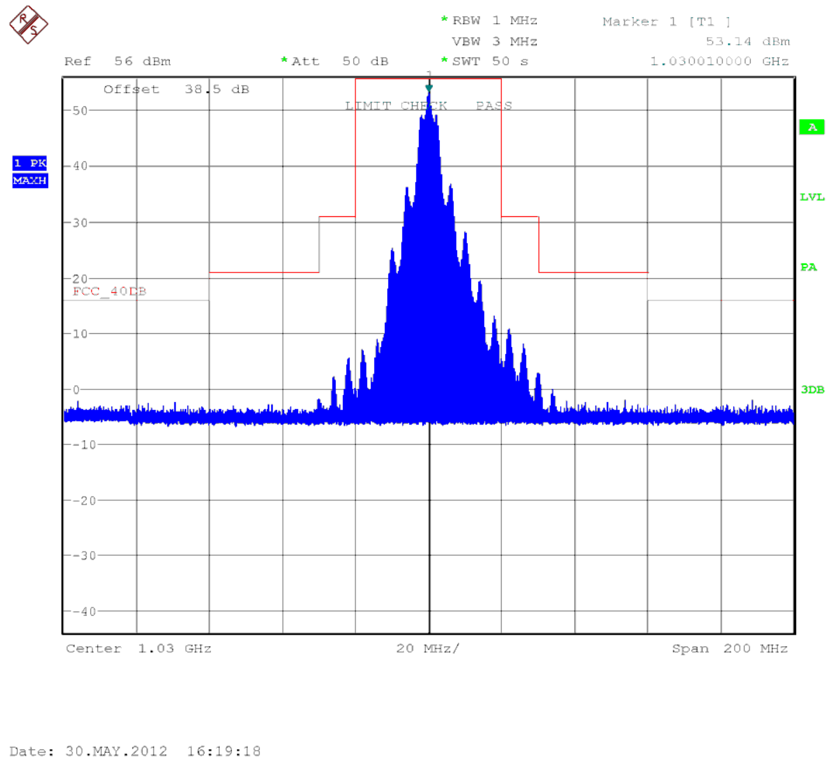


**Figure F-31 – Close-In Conducted Spurious Emissions – TTR-4100**

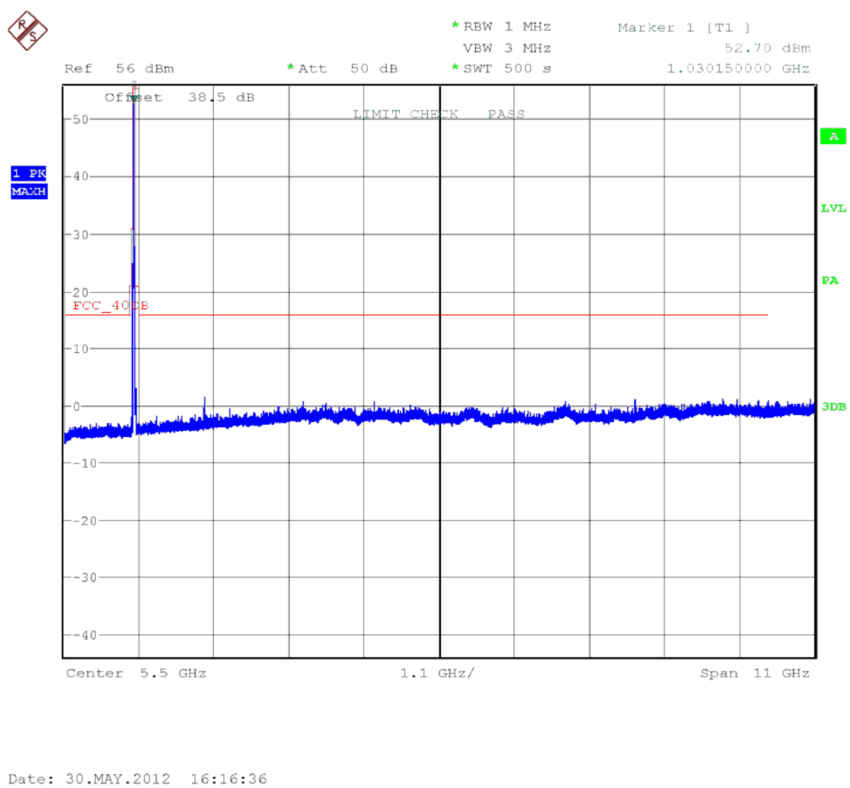


**Figure F-32 – Conducted Spurious Emissions – TTR-4100**

## 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 TTR-4100 has a peak power of 251 Watts.

The Spurious Radiation test Requirements are shown below in Table F-15.

**Table F-15 – Spurious Radiation Test Requirements (87.139(a)(3))**

| Frequency Band | Emission Level | Absolute FCC Limit (Peak) |
|---|---|---|
| Below 970 MHz | -40 dBc | +14 dBm |
| From 970 MHz to 1000 MHz | -35 dBc | +19 dBm |
| From 1000 MHz to 1010 MHz | -25 dBc | +29 dBm |
| From 1050 MHz to 1060 MHz | -25 dBc | +29 dBm |
| From 1060 MHz to 1090 MHz | -35 dBc | +19 dBm |
| Over 1090 MHz | -40 dBc | +14 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 TTR-4100 has a peak power of 251 Watts and a maximum duty cycle of 2%.

Peak Power = 10 * log(251 / 0.001) = 54 dBm, Assumed Duty Cycle = 0.02

Ptx(average) = 50 * 0.02 = 5 Watts average

FCC Limit (dBc) = 40

Limit (Watts) = 5 W * 10^(-40 / 10) = $5x10^{-4}$ W average

$E^2 = 30 * 1.64 * 5*10^{-4} = 0.025\ V^2/m^2$

E (V/m) =sqrt(0.025) = 157,000 μV/m average

E (dBμV/m) = 20 * log(157,000 μV/m) = 103.9 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) = 103.9 dBμV/m
Limit (average) =$10^{(103.927/20)}$ = 157,000 μV/m
Limit (peak) =($(157,000)^2$) / 0.02 = $1.235*10^{12}$ μV/m
Limit (peak) = 10 * log($1.235*10^{12}$ μV/m) = 120.9 dBμV/m

**Method 2:**

Limit (average) = 103.9.0 dBμV/m
Peak Power (mW) = $10^{(54 / 10)}$ = 251,000. mW
Average Power (mW) = 251,000 mW * 0.02 = 5,000 mW
Average Power (dBm) = 10 * log(5,000 mW) = 37 dBm
Difference (dB) = 54 dBm(peak) – 37 dBm(average) = 17 dB
Limit (peak) = 103.9 dBμV/m + 17 dB = 120.9 dBμV/m

Therefore, the absolute limit of ***120.9 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-16.

**Table F-16 – Equipment Used for Spurious Emissions Tests**

| Equipment | Manufacturer/Model Number | Specific Identification | Calibration Date |
|---|---|---|---|
| Receiver/Transmitter Module | Rockwell Collins TTR-4100 (822-3075-001) | S/N 4765N | N/A |
| Test Harness | Rockwell Collins TTR-4100 Breakout Panel | N/A | N/A |
| SST-2010 | Rockwell Collins | N/A | N/A |
| RGS-2000 | BF Goodrich | | N/A |
| 8-Way Combiner | Mini-Circuits, ZB8PD-2000-S+ | N/A | N/A |
| Attenuator (20 dB) | Weinschel | N/A | N/A |
| Personal Computer | Generic PC | N/A | N/A |
| Ethernet Switch | D-Link DSS-16+ | N/A | N/A |
| Line Impedance Stabilization Network | Fischer Custom Communication FCC-LISN-5-50-1-01-DEF-STAN-59-41 | 460-0131-813 | 02/29/2008 |
| Terminator, 50 Ω, 5 W | Narda 370 BNM | 469-0072-406 | 07/15/2010 |
| EMI Test Reciever (2 MHz – 18 GHz) | Rohde & Schwarz ESU | 469-0074-442 | 05/05/2011 |
| Pre-Amplifier (0.1 GHz – 18 GHz) | MITEQ/AFS44-00101800-25-10p-44 | 653-5135-001 | N/A |
| Active Monopole Antenna (150 kHz – 25 MHz) | Electro-Metrics EM-6892 | 469-0069-993 | 06/05/2009 |
| Bi-conical Antenna (25 MHz – 200 MHz) | A.H. Systems SAS-200/540 | 469-0069-226 | 05/20/2010 |
| Antenna, Double Ridge Guide (200 MHz - 1GHz) | EMCO 3106 | 469-0070-774 | 08/26/2009 |
| Antenna, Double Ridge Guide (1 GHz – 18 GHz) | EMCO 3105 | 460-0047-850 | 09/16/2008 |

The test setups for the Field Strength of Spurious Radiation measurements are shown in Figure F-17.

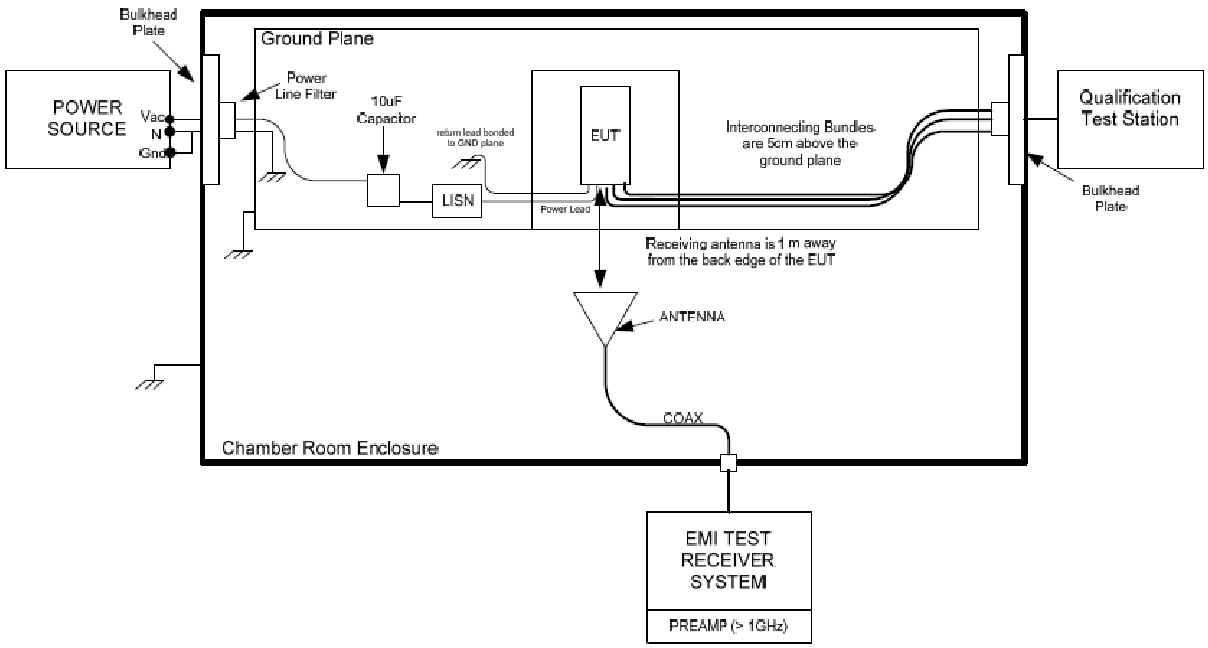


**Figure F-33 – Field Strength of Spurious Radiation Test Setup Diagram**

**Test Procedure:**

The test procedure from RTCA DO-160F, Section 21 shall be used. This procedure is used for the certification of civil aviation electronics.

The lowest critical RF frequency generated in the equipment is 20 MHz. DO-160F specifies a start frequency of 100 MHz so this range was extended down to 150 kHz for testing.

The radiated emissions shall be taken with the TTR-4100 in normal TA mode with two simulated Mode C targets and two simulated Mode S targets.

**Test Results:**

Results are provided in spectral plot forms for vertical and horizontal polarizations from 150 kHz to 10.3 GHz. Note the rod antenna used for emissions testing below 25 MHZ only provides measurements in the vertical polarization. No emissions exceeded the FCC limit of 120.9 dBµV/m.

Spectrum plots for are shown in Figure F-18 and Figure F-19.

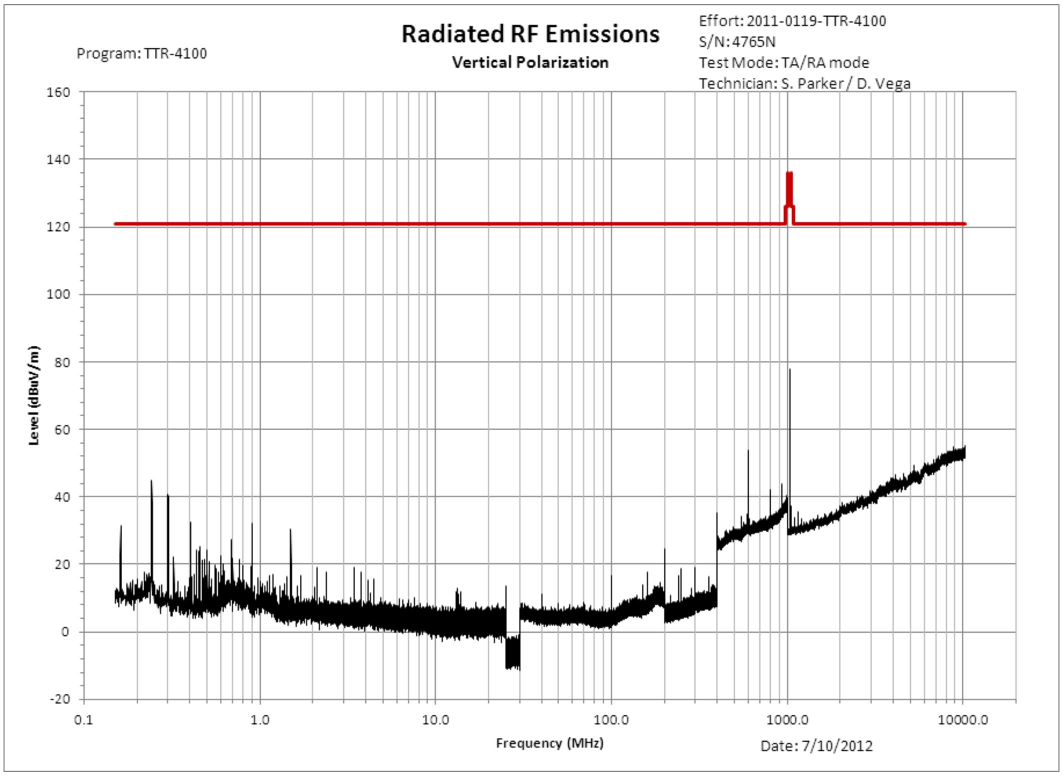


**Figure F-34 – Radiated Spurious Emissions, 150 kHz – 10.3 GHz, Vertical Polarization**

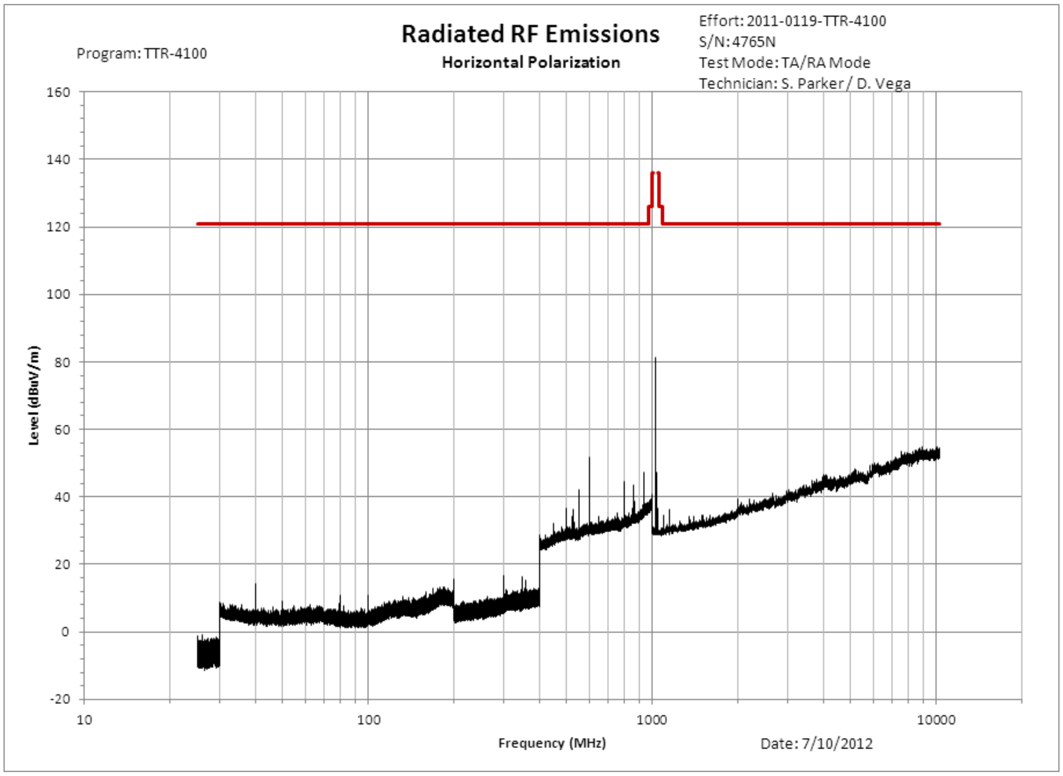


**Figure F-35 – Radiated Spurious Emissions, 25 MHz – 10.3 GHz, Horizontal Polarization**

## F.9 Statement of Traceability

Control and traceability of test equipment used in testing is covered under Rockwell Collins quality policy RC-QMS-P-000. Section 7.6 states:

> "Rockwell Collins determines the monitoring and measurement to be undertaken, and the monitoring and measuring equipment needed to provide evidence of conformity of product to determined requirements. *Rockwell Collins maintains a register of monitoring and measurement devices and defines the process employed for their calibration/verification including details of equipment type, unique identification, location, frequency of checks, check method, and acceptance criteria. Calibrations, inspections, measurements and tests are carried out under suitable environmental conditions.*
>
> Rockwell Collins establishes processes to ensure that monitoring and measurement can be carried out and are carried out in a manner that is consistent with the monitoring and measurement requirements.
>
> There shall be effective separation between the calibration lab and neighboring areas. Access to, and use of, all areas affecting the quality of these activities shall be controlled.
>
> Where necessary to ensure valid results, measuring equipment shall be:
>
> - *Calibrated or verified, or both, at specified intervals or prior to use against measurement standards traceable to international or national measurement standards; where no such standards exist, the basis used for calibration or verification shall be recorded*
> - Adjusted or readjusted as necessary
> - Identified in order to determine the calibration status
> - Safeguarded from adjustments that would invalidate the measurement result
> - Protected from damage and deterioration during calibration, handling, use maintenance, storage and transit.
> - Methods of receipt, retention, and disposal of monitoring and measuring devices shall be documented
>
> *Rockwell Collins has established, implemented and maintains a process for the recall of monitoring and measuring equipment requiring calibration or verification.* In addition, Rockwell Collins assesses and records the validity of the previous measurement results when the equipment is found to not conform to requirements and takes appropriate action on the equipment and any product affected. Records of results of calibration and verification are maintained and made available to customers/regulatory agencies on request. When used in monitoring and measurement of specified requirements, the ability of computer software to satisfy the intended application is confirmed prior to initial use and reconfirmed as necessary. Subcontracted calibrations shall be placed with vendors approved by Rockwell Collins."

## F.10 Test Equipment Calibration Tracking

Rockwell Collins maintains a database for test equipment calibration as covered in RC-QMS-P-000. This database provides information including:

- Last Calibration Date
- Current Calibration Due Date
- Standards Used
- Calibration Procedure

Calibration dates recorded in this report were retrieved from this database.

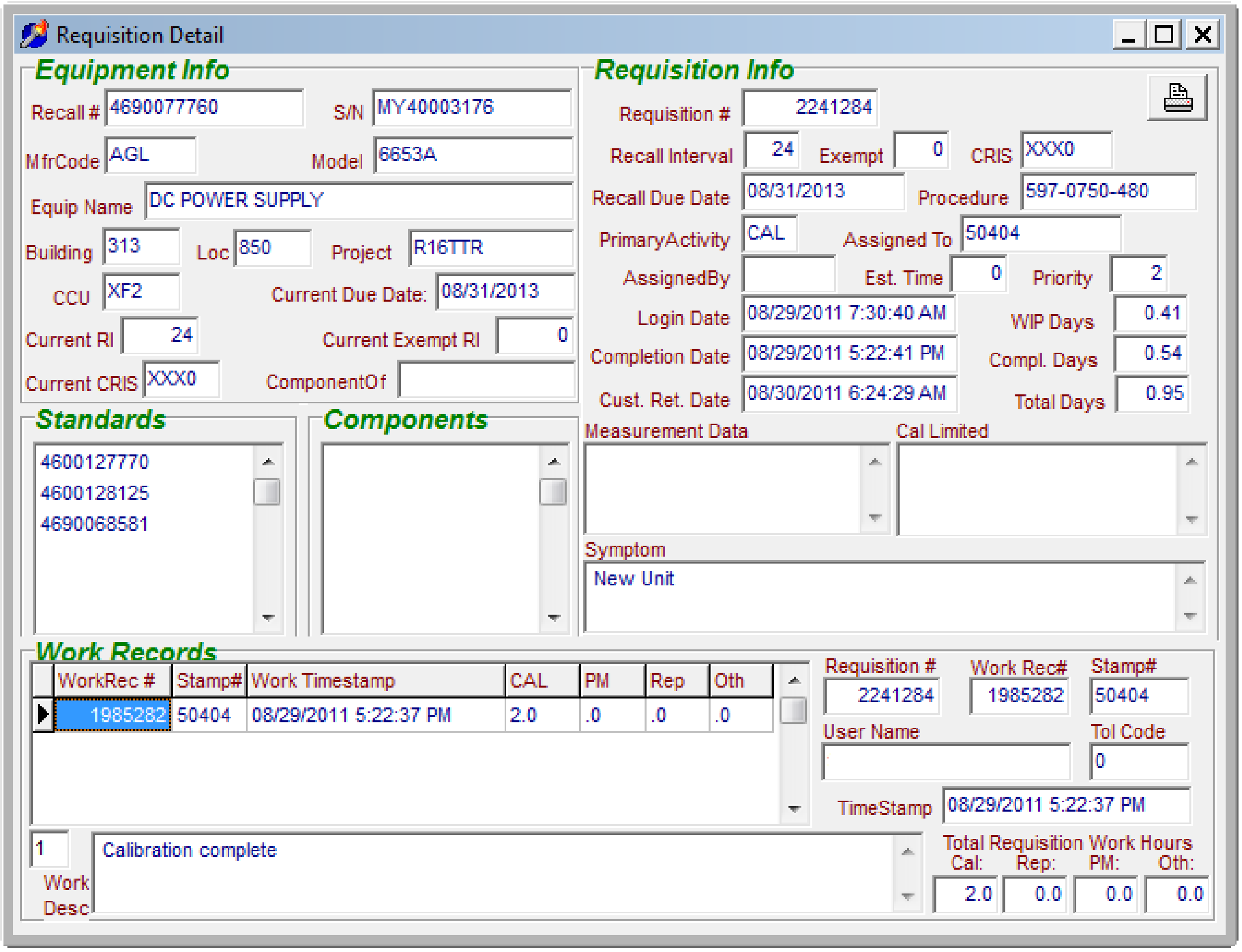


**Figure F-36 – Calibration Database**