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Test Report

Prepared for: Aviation Communication and Surveillance Systems

Model: T3CAS Integrated Platform

Description: TCAS and Transponder

Serial Number: TQE01187 & TQE01100

FCC ID: P8CT3C-16

To

FCC Part 87

Date of Issue: September 9, 2016

On the behalf of the applicant:	**Aviation Communication and Surveillance Systems** **19810 N. 7th Ave.** **Phoenix, AZ 85027**
Attention of:	**Mark D. Smith** **623-445-6643** **Mark.D.Smith@l-3com.com**

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Poona Saber
Project Test Engineer

Test Report Revision History

Revision	Date	Revised By	Reason for Revision
1.0	August 19, 2016	Poona Saber	Original Document

Table of Contents

ILAC / A2LA

Compliance Testing, LLC, has been accredited in accordance with the recognized International Standard ISO/IEC 17025:2005. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer joint ISO-ILAC-IAF Communiqué dated January 2009).

The tests results contained within this test report all fall within our scope of accreditation, unless noted in the table below

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Non-accredited tests contained in this report:

N/A

Standard Test Conditions Engineering Practices

Except as noted herein, the following conditions and procedures were observed during the testing:

All tests and measurement data shown were performed in accordance with FCC Rules and Regulations, Volume II; Part 2, Sub-part J, Sections 2.947, 2.1033(c), 2.1041, 2.1046, 2.1047, 2.1051, 2.1053, 2.1055, 2.1057 and the following individual Parts: FCC Part 87.

Measurement results, unless otherwise noted, are worst-case measurements.

Environmental Conditions		
Temperature (ºC)	**Humidity (%)**	**Pressure (mbar)**
24-25.3	24.1-32.2	956-962

Model: T3CAS Integrated Platform
Description: TCAS and Transponder
Additional Information: T3CAS system has two RF transmit functions: TCAS (1030 MHz) and Transponder (1090 MHz).

Following is declared as type of emission for T3CAS system:

- Transponder (DO-181C) 14M0M1D
- TCAS (DO-185B) 20M0V1D
- Frequency range: 1030 ± 0.01 MHz and 1090 ± 1 MHz
- TCAS Function: There are two sub-modes operation for TCAS system called interrogation modes: ATCRBS and Mode S. Both are at 1030 Mhz. ATCRBS is pulse position modulation only and Mode S is pulse position modulation combined with differential phase shift keying (DPSK)
- In TCAS mode the transmitter always transmits to only one antenna port at a time.
- The maximum duty cycle of the TCAS transmit mode is 0.3%
- Transponder Function: There are 2 transponder sub-modes called reply modes: ATCRBS and Mode S. Both are at 1090 MHz and are pulse position modulation only.
- In transponder mode all 4 transmit channels are active simultaneously, thereby transmitting into all 4 ports of the directional antenna evert time.
- The maximum duty cycle of the Transponder transmit mode is 0.8%
- There are two installation configurations possible. Both have directional 4 port antenna as the Top antenna. And the variable is whether the bottom antenna is a directional 4 port or Omi-directional 1 port.
- There are 4 identical transmitter lineups/amplifier chains in the T3CAS product. One each for the 0, 90, 180 and 270 channels. At the output of the 4 amplifier chains is a combiner circuit that also is a PIN diode switch to help select the operating mode of the combiner and direct the signal to the correct antenna port(s). There are always Two antennas installed with the T3CAS system.
- If the bottom antenna is an omnidirectional antenna, only the 0 port is used instead of all 4

EUT Support Equipment

Qty	Description	Manufacturer	Model No.	Part No.
1	T3CAS Valfac	ACSS	-	9001045-001
1	T^3CAS RF Simulator	ACSS	-	9001057-001
1	T^3CAS Front Connector Cable	ACSS	-	9000655-001
1	Air Transport Mode S Transponder	ACSS	-	7517800-10007
1	Aircraft Personality Module (APM)	ACSS	-	9000001-11001
1	EMI Bulkhead Panel	ACSS	-	9006045-003
1	T^3CAS Extension Harness	ACSS	-	
1	ATC Test Set	IFR	ATC 1403DL	
1	Power Supply	California Instruments	1501iX	
1	DC Power Supply	Amtek	XHR 100-10	
1	Microwave Filter	Fairview	-	SBPF-1000-2000-05-N
2	Attenuator	Narda	-	N4425-20

Test Results Summary

Specification	Test Name	Pass, Fail, N/A	Comments
2.1046, 87.131	Carrier Output Power (Conducted)	Pass	
2.1051, 87.139(i)(1)	Unwanted Emissions (Transmitter Conducted)	Pass	
2.1053	Field Strength of Spurious Radiation	Pass	
2.1049, 87.139 87.135	Emission Masks and Occupied Bandwidth	Pass	
2.1047	Audio Low Pass Filter (Voice Input)	N/A	The EUT does not contain an audio input
2.1047	Audio Frequency Response	N/A	The EUT does not contain an audio input
2.1047	Modulation Limiting	N/A	
2.1055, 87.133(a)	Frequency Stability (Temperature Variation)	Pass	
2.1055, 87.133(a)	Frequency Stability (Voltage Variation)	Pass	

Carrier Output Power (Conducted)

Engineer: Poona Saber

Test Date: 8/16/16

Test Procedure

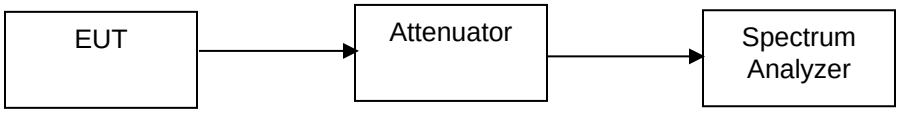
The Equipment Under Test (EUT) was connected through attenuator directly to a spectrum analyzer with the RBW > OBW and the VBW set to 3 X RBW which set the RBW greater than the transmit signal ensuring there was no signal suppression while measuring a modulated signal. The peak readings were taken for TCAS and Transponder systems for both ATCRBS(C) and S modes and the result was then compared to the limit.
The Average power is the peak power multiplied by duty cycle of 0.298% for TCAS and 0.936% for Transponder system.

Section 87.131, for Radio navigation equipment Note 7 specifies “Frequency, emission and maximum power will be determined by appropriate standards during the certification process.
TCAS output power is controlled by the requirements of RTCA document DO-185B similarly to the output spectrum. In addition the Transponder output power is controlled by the requirements of RTCA document DO-181E.

When operating in TCAS mode into a directional antenna, the maximum output power of the active port of the T3CAS unit is specified to be 55.5 +/- 2 dBm (224 W– 562 W). These transmissions are limited to one output port at a time.
When operating in TCAS mode into an omnidirectional bottom antenna, the maximum output power of the bottom 0 degree port of the T3CAS unit is specified to be 56.0 +/- 2 dBm (251 W – 631 W). These transmissions are limited to the bottom 0 degree port only.

When operating in Transponder mode into a directional antenna, the maximum output power of each port of the T3CAS unit is specified to be 53.4 +/- 2 dBm (138 W – 347 W). In this mode, the unit is transmitting to all 4 antenna ports simultaneously.
When operating in Transponder mode into an omnidirectional antenna, the maximum output power of the bottom 0 degree port of the T3CAS unit is specified to be 57.0 +/- 2 dBm (316 W – 794 W). These transmissions are limited to the bottom 0 degree port only.

Test Setup



Output Power for TCAS System

Frequency	Antenna	Mode	Measured Power Peak (dBm)	Measured Power Peak (W)
1030 MHz	TOP 0	C	54.54	284.4
1030 MHz	TOP 90	C	54.72	296.4
1030 MHz	TOP 180	C	54.54	284.4
1030 MHz	TOP 270	C	54.59	287.7
1030 MHz	Bottom 0	C	55.37	344.3
1030 MHz	TOP 0	S	54.28	267.9
1030 MHz	TOP 90	S	54.74	297.85
1030 MHz	TOP 180	S	54.75	298.5
1030 MHz	TOP 270	S	54.39	274.78
1030 MHz	Bottom 0	S	55.01	316.9

Output Power for Transponder System

Frequency	Antenna	Mode	Measured Power Peak (dBm)	Measured Power Peak (W)
1090 MHz	TOP 0	C	52.62	182.8
1090 MHz	TOP 90	C	51.83	152.4
1090 MHz	TOP 180	C	52.55	179.8
1090 MHz	TOP 270	C	52.45	175.79
1090 MHz	Sum of 4 top ports simultaneously		58.4	690.79
1090 MHz	Bottom 0	C	57.42	552.97
1090 MHz	TOP 0	S	52.87	193.6
1090 MHz	TOP 90	S	52	158.4
1090 MHz	TOP 180	S	52.55	179.8
1090 MHz	TOP 270	S	52.88	194
1090 MHz	Sum of 4 top ports simultaneously		58.6	725.8
1090 MHz	Bottom 0	S	57.42	552.97

Note: Power results for bottom antenna in directional mode is the same as respective top antenna at each mode

See Appendix A for test plots

Conducted Spurious Emissions

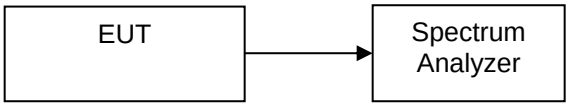
Engineer: Poona Saber

Test Date: 8/17/16

Test Procedure

The EUT was connected directly to a spectrum analyzer to verify that the EUT met the requirements for spurious emissions. The Limit was based on rule part 87.139 and spurious emission measurement procedures of KDB 971168 D01 were followed.

Test Setup



See Appendix B for test results

Field Strength of Spurious Radiation

Engineer: Poona Saber

Test Date: 8/18/16

Test Procedure

The EUT was setup in accordance with ANSI C63.26D15 2015 and tested per KDB 971168. The antenna was replaced with non-radiating matched load. The EUT is placed on non-conductive platform at a height of 0.8 meters above the ground plane of the semi-anechoic chambers for emissions below 1 GHz and at a height of 1.5 meter for emissions above 1 GHz. The EUT was rotated 360 degrees and the receive antenna raised and lowered to find the maximum emissions from 30MHz to the 10th harmonic of the fundamental. The EUT was set to the maximum power level allowed and the limit was set to 10log(P) – {43+10log(P)}
RBW is set to 100Khz for measurements below 1Ghz and 1Mhz for measurements above 1Ghz.

See Appendix C for test results

Occupied Bandwidth

Engineer: Poona Saber

Test Date: 8/17/16

Requirement

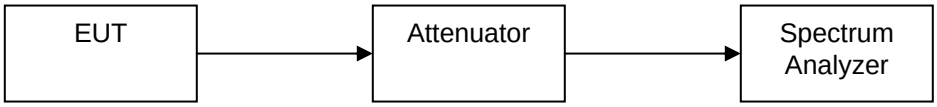
Based on rule part 2.1049 the occupied Bandwidth is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers are each equal to 0.5 % of the total mean power of the given emission.

Based on section 87.137 Authorized Bandwidth for Emission M1D is 14 MHz and V1D is 20 MHZ.
Operation of 1030 MHz system is administered (“licensed”) by FAA. TCAS Minimum Operational Performance Specifications (MOPS) are provided in RTCA document DO-185B and Based on section 2.2.3.3 of RTCA DO-185B for allowable spectrum the bandwidth for V1D is declared as 20 MHz

Test Procedure

The following procedure shall be used for measuring (99 %) power bandwidth
The spectrum analyzer center frequency is set to the nominal EUT channel center frequency. The frequency span for the spectrum analyzer shall be set wide enough to capture all modulation products including the emission skirts.
The RBW shall be in the range of 1 % to 5 % of the anticipated OBW, and the VBW shall be set ≥ 3 × RBW.
Set the detection mode to peak, and the trace mode to max-hold.

Test Setup



See Appendix D for Test Results

Emission Masks (Occupied Bandwidth)

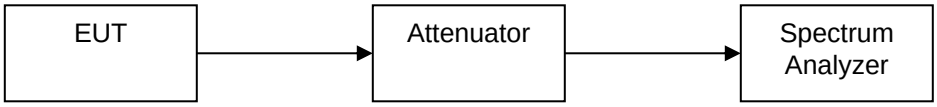
Engineer: Poona Saber

Test Date: 8/17/16

Test Procedure

The EUT was connected directly to a spectrum analyzer to verify that the EUT meets the required emissions mask. A reference level plot is provided to verify that the peak power was established prior to testing the mask. The transmitter is digital modulation therefore no data input is required to measure the emission mask. The RBW was set as close as possible to 1% of the occupied bandwidth to ensure accurate readings.

Test Setup



See Appendix E for Test Results

Frequency Stability (Temperature Variation)

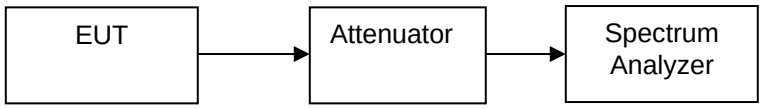
Engineer: Poona Saber

Test Date: 8/19/16

Test Procedure

The EUT was placed in an environmental test chamber and the RF output was connected directly to a frequency counter. The temperature was varied from -30ºC to 50ºC in 10ºC increments. After a sufficient time for temperature stabilization the RF output frequency was measured.
The frequency tolerance Limit that is used is based on rule part 87.133 (@) band (7) 950 to 1215 MHz which is 20 PPM

Test Setup



Measurement Results

1030 MHz

Tuned Frequency (Hz)	Frequency Tolerance ppm	Upper Limit (Hz)	Lower Limit (Hz)		Temperature centigrade	Measured Frequency (Hz)	Upper Margin (Hz)	Lower Margin (Hz)
1,030,000,000	20.0	1030020600	1029979400		-30	1029998420	-22180.000000	19020.000000
		1030020600	1029979400		-20	1029999920	-20680.000000	20520.000000
		1030020600	1029979400		-10	1029999500	-21100.000000	20100.000000
		1030020600	1029979400		0	1029999580	-21020.000000	20180.000000
		1030020600	1029979400		10	1029998500	-22100.000000	19100.000000
		1030020600	1029979400		20	1030000200	-20400.000000	20800.000000
		1030020600	1029979400		30	1030000230	-20370.000000	20830.000000
		1030020600	1029979400		40	1030000230	-20370.000000	20830.000000
		1030020600	1029979400		50	1030000140	-20460.000000	20740.000000

1090 MHz

Tuned Frequency (Hz)	Frequency Tolerance ppm	Upper Limit (Hz)	Lower Limit (Hz)		Temperature centigrade	Measured Frequency (Hz)	Upper Margin (Hz)	Lower Margin (Hz)
1,090,000,000	20.0	1090021800	1089978200		-30	1089998580	-23220.000000	20380.000000
		1090021800	1089978200		-20	1089998920	-22880.000000	20720.000000
		1090021800	1089978200		-10	1090000000	-21800.000000	21800.000000
		1090021800	1089978200		0	1089999580	-22220.000000	21380.000000
		1090021800	1089978200		10	1090000170	-21630.000000	21970.000000
		1090021800	1089978200		20	1090000080	-21720.000000	21880.000000
		1090021800	1089978200		30	1090000250	-21550.000000	22050.000000
		1090021800	1089978200		40	1090000250	-21550.000000	22050.000000
		1090021800	1089978200		50	1090000670	-21130.000000	22470.000000

Frequency Stability (Voltage Variation)

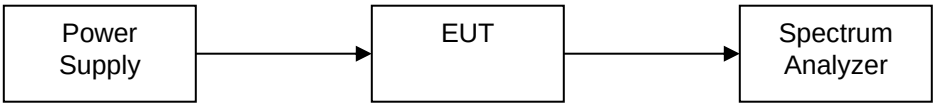
Engineer: Poona Saber

Test Date: 8/19/16

Test Procedure

The EUT was placed in a temperature chamber at 20±5°C and connected directly to a spectrum analyzer. The power supply voltage to the EUT was varied from 85% to 115% of the nominal value and the RF output was measured. This was measured with both a 400 Hz 115 VAC supply and a variable DC voltage source.
The frequency tolerance Limit that is used is based on rule part 87.133 (@) band (7) 950 to 1215 MHz which is 20 PPM

Test Setup



Test Results

4MCU

Tuned Frequency (Hz)	Frequency Tolerance ppm	Upper Limit (Hz)	Lower Limit (Hz)	Nominal Voltage	Voltage	Measured Frequency (Hz)	Upper Margin (Hz)	Lower Margin (Hz)
1,030,000,000	20.0	1030020600	1029979400	115.00	97.75	1029999375	-21225	19975
		1030020600	1029979400		115.00	1029993375	-27225	13975
		1030020600	1029979400		132.25	1029999374	-21226	19974
1,090,000,000	20.0	1090021800	1089978200	115.00	97.75	1090000167	-21633	21967
		1090021800	1089978200		115.00	1090000000	-21800	21800
		1090021800	1089978200		132.25	1090000150	-21650	21950

6MCU

Tuned Frequency (Hz)	Frequency Tolerance ppm	Upper Limit (Hz)	Lower Limit (Hz)	Nominal Voltage	Voltage	Measured Frequency (Hz)	Upper Margin (Hz)	Lower Margin (Hz)
1,030,000,000	20.0	1030020600	1029979400	115.00	97.75	1030000120	-20480	20720
		1030020600	1029979400		115.00	1030000075	-20525	20675
		1030020600	1029979400		132.25	1030000270	-20330	20870
1,090,000,000	20.0	1090021800	1089978200	115.00	97.75	1090000250	-21550	22050
		1090021800	1089978200		115.00	1090000170	-21630	21970
		1090021800	1089978200		132.25	1090000170	-21630	21970

Modulation Characteristics

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 “

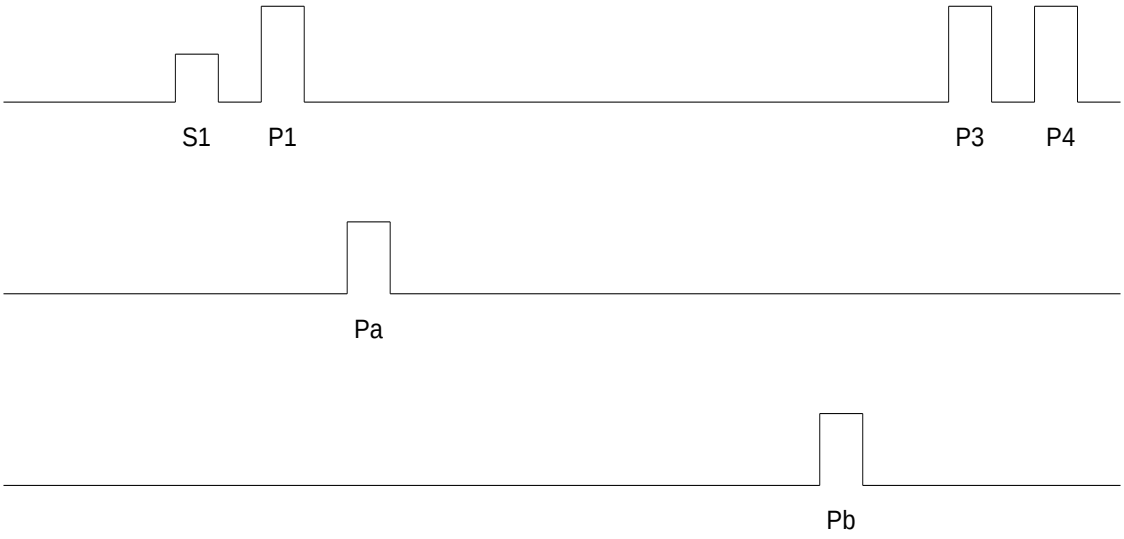
See Appendix F for Modulation characteristics screen captures

Modulation Details

1. ATCRBS Interrogations

Interrogations are sent out on an intentionally jittered 1+0.2 second interval in increasing power levels according to the schedules shown in tables 4, 5, 6. By transmitting the weakest signals first only the closest aircraft will reply. The interrogations progress in a roughly circular pattern weighted toward the front of the aircraft since that is the area from which the greatest closing speeds originate. In areas of high density the sequence is halted when the computer has reached a limit defined by a complex set of three inequalities. In this manner, interference to other TCAS equipped aircraft in the area is minimized since the strongest interrogations are the first to be dropped. The priority of elimination of steps for interference limiting is also shown in tables 4, 5, 6. This priority is inversely related to the order of the step sequence.

Pulse Widths:	0.8 + 0.05 usec
Rise Times (10% to 90%):	+/- 0.05 usec., < 0.1 usec
Fall Times (90% to 10%):	+/- 0.05 usec., < 0.2 usec



ATCRBS Interrogations

Pulses P1, P3, and P4 will appear in all interrogation steps of the whisper / shout sequence and will be at the same power level. Pulse S1 will appear in all steps except the initial step on each antenna direction and at a level two or three dB below the level of P1, etc. according to the schedules shown in figures through this section. The steps occur at intervals of two milliseconds until the entire program is complete. The program length depends upon the individual aircraft installation. Options are available from using either an omni-directional bottom antenna or a directional bottom antenna. The top antenna is always directional. Pulses Pa and Pb are transmitted on the antenna. They are used for suppression of sensitivity of the receiving aircraft to the indicated pulses:

S1 =	-2 microseconds
P1 =	0 microseconds
PA =	2 microseconds
PB =	19 microseconds
P3 =	21 microseconds
P4 =	23 microseconds

2. Mode S Interrogations

Details of the Mode S interrogations are shown in figure below. The preamble and the synchronizing phase reversal (SPR) will appear the same in all interrogations. The data block will be either 56 or 112 chips of 0.25 microseconds, depending upon the type of reply desired. The data chips will be reversed phase from their previous chips if their data bid are 1, they will remain the same phase as the previous chips is their data bits are 0. The allowable transition time of the phase reversals is a maximum of 80 nanoseconds. The Mode S interrogations are transmitted after the whisper/shout sequence of ATCRBS interrogations. When no Mode S equipped aircraft are replying, the TCAS CU sends out Mode S broadcast interrogations based upon a 10 second pattern with 2 or 3 seconds between transmissions on the four lobes of the antenna. The time remaining after the Mode S transmissions are completed is used as a listening period for other un-acquired aircraft.

- Preamble Pulse Widths: 0.8 + 0.05 usec
- Rise Times (10% to 90%): < 0.1 usec
- Fall Times (90% to 10%): < 0.2 usec

Mode S Interrogations

Timing of the Mode S interrogations is as follows, referenced to the leading edge of the P1 pulse:

Pulse	Distance
P1	0.0 microseconds
P2	2.0 microseconds
P6	3.5 microseconds
SPR	4.75 microseconds
Bit 1	5.25 microseconds
End P6	19.75 microseconds (56 bits) 33.75 microseconds (112 bits)

Table 1

Mode S Interrogations, Omni-directional Antenna

Nominal Power Levels (dB relative to full power)		
Level	**P1,P3, P4 Pulses**	**S1 Pulse**
00	-13	-16
01	-15	-18
02	-17	-20
03	-19	-22
04	-21	-24
05	-23	-26
06	-25	none

Table 2

Mode S directional Antenna Interrogation Transmission Levels

Nominal Power Levels (dB relative to full power)			
Level	**P1,P3, P4**	**S1 Pulse**	**Pa, Pb Pulse**
D0	0	-3	-2
D1	-1	-3	-3
D2	-2	-5	-4
D3	-3	-5	-5
D4	-4	-7	-6
D5	-5	-7	-7
D6	-6	-9	-8
D7	-7	-9	-9
D8	-8	-11	-10
D9	-9	-11	-11
D10	-10	-13	-12
D11	-11	-13	-13
D12	-12	-15	-14
D13	-13	-15	-15
D14	-14	-17	-16
D15	-15	-17	-17
D16	-16	-19	-18
D17	-17	-19	-19
D18	-18	-21	-20
D19	-19	-21	-21
D20	-20	-23	-22
D21	-21	-23	-23
D22	-22	-25	-24
D23	-23	-25	-25
D24	-24	-27	-26
D25	-25	-27	-27
D26	-26	--	-16 (P4 only)

Table 3

Top Directional/Bottom –Omni-Directional Interrogation Sequence

Bottom Omni-Directional Antenna			
Interference Limiting Priority / Interrogation Level			
98 / 06			
97 / 05			
96 / 04			
95 / 03			
94 / 02			
93 / 01			
92 / 00			
Top Directional Antenna			
Interference Limiting Priority / Interrogation Level			
0°	180°	90°	270°
91 / D26	-	-	-
90 / D25	-	-	-
89 / D24	-	-	-
88 / D23	-	87 / D26	86 / D26
85 / D22	-	84 / D25	83 / D25
82 / D21	-	81 / D24	80 / D24
79 / D20	-	78 / D23	77 / D23
76 / D19	-	75 / D23	74 / D22
73 / D18	72 / D26	71 / D21	70 / D21
69 / D17	68 / D25	67 / D20	66 / D20
65 / D16	64 / D24	63 / D20	62 / D19
61 / D15	60 / D23	59 / D18	58 / D18
57 / D14	56 / D22	55 / D17	54 / D17
49 / D12	48 / D20	47/ D15	46 / D15
45 / D11	44 / D19	43 / D14	42 / D14
41 / D10	40 / D18	39 / D13	38 / D13
37 / D9	36 / D17	35 / D12	34 / D12
33 / D8	32 / D16	31 / D11	30 / D11
29 / D7	28 / D15	27 / D10	26 / D10
25 / D6	24 / D14	23 / D9	22 / D9
21 / D5	20 / D13	19 / D8	18 / D8
17 / D4	16 / D12	15 / D7	14 / D7
13 / D3	12 / D11	11 / D6	10 / D6
9 / D2	8 / D10	7 / D5	6 / D5
5 / D1	4 / D10	3 / D4	2 / D4
1 / D0	-	-	-

(Interrogation sequence is right to left, top to bottom)
Table 4

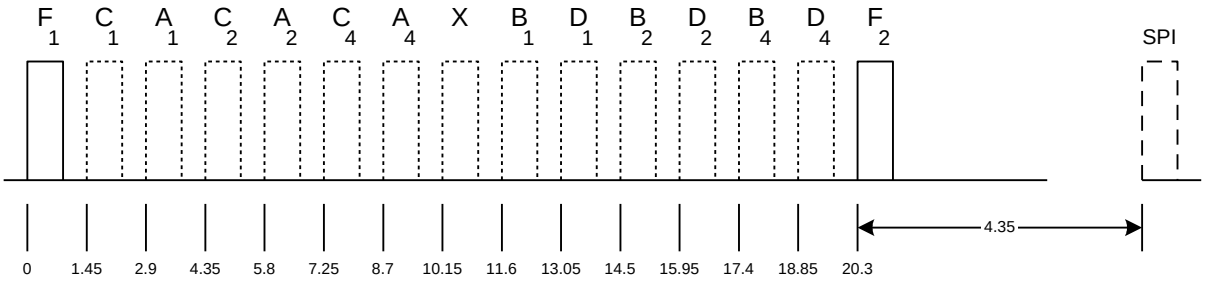
Top Directional/Bottom Directional Interrogation Sequence - Interference Limiting Priority / Interrogation Level

Top Directional Antenna				Bottom Directional Antenna			
0°	**180°**	**90°**	**270°**	**0°**	**180°**	**90°**	**270°**
113 / D26	-	-	-	112 / D26	-	-	-
111/ D25	-	-	-	-	110 / D25	-	-
109/ D24	-	-	-	108 / D24	-	-	-
107/ D23	-	-	-	106 / D23	-	-	-
-	-	105 / D26	104 / D26	-	-	103 / D26	102 / D26
101 / D22	-	-	-	100 / D22	-	-	-
-	-	99 / D25	98 / D25	-	-	97 / D25	96 / D25
95 / D21	-	-	-	94 / D21	93 / D26	-	-
-	-	92 / D24	91 / D24	-	-	90 / D24	89 / D24
88 / D20	-	-	-	87 / D20	86 / D25	-	-
-	-	85 / D23	84 / D23	-	-	83 / D23	82 / D23
81 / D19	-	-	-	80 / D19	79 / D24	-	-
-	-	78 / D22	77 / D22	-	-	76 / D22	75 / D22
74 / D18	-	-	-	73 / D18	-	-	-
-	72 / D26	71 / D21	70 / D21	Interrogations for each sector that has a TA or RA present.			
69 / D17	68 / D25	67 / D20	66 / D20				
65 / D16	64 / D24	63 / D19	62 / D19				
61 / D15	60 / D23	59 / D18	58 / D18				
57 / D14	56 / D22	55 / D17	54 / D17				
53 / D13	52 / D21	51 / D16	50 / D16				
49 / D12	48 / D20	47 / D15	46 / D15				
41 / D10	40 / D18	39 / D13	38 / D13				
37 / D9	36 / D17	35 / D12	34 / D12				
33 / D8	32 / D16	31 / D11	30 / D11				
29 / D7	28 / D15	27 / D10	26 / D10				
25 / D6	24 / D14	23 / D9	22 / D9				
21 / D5	20 / D13	19 / D8	18 / D8				
17 / D4	16 / D12	15 / D7	14 / D7				
13 / D3	12 / D11	11 / D6	10 / D6				
9 / D2	8 / D5	7 / D5	6 / D5				
5 / D1	4 / D9	3 / D4	2 / D4				
1 / D0	-	-	-				
				1/ D17	1 / D23	1 / D21	1 / D21
				1 / D16	1 / D22	1 / D20	1 / D20
				1 / D15	1 / D21	1 / D19	1 / D19
				1 / D14	1 / D20	1 / D18	1 / D18
				1 / D13	1 / D19	1 / D17	1 / D17
					1 / D18	1 / D16	1 / D16
					1 / D17	1 / D15	1 / D15
					1 / D16	1 / D14	1 / D14
					1 / D15	1 / D13	1 / D13
					1 / D14		
					1 / D13		

(Interrogation sequence is right to left, top to bottom)
Table 5

3. ATCRBS Replies

ATCRBS replies are pulse amplitude modulated signals (PAM), and are formed in response to Mode A or Mode C interrogations. Mode A replies consist of a 4096 code which is an identifier and an optional SPI pulse. The Transmitter CCA transmits ATCRBS reply pulse waveforms as shown in Figure below.



ATCRBS Reply

The designator of the information pulses and their positions from the first framing pulse are as follows:

ATCRBS Reply Pulse Characteristics/Position	
Pulse	**Position (μsec)**
FIRST FRAMING PULSE	0.0
C1	1.45
A1	2.90
C2	4.35
A2	5.80
C4	7.25
A4	8.70
X1	10.15
B1	11.60
D1	13.05
B2	14.50
D2	15.95
B4	17.40
D4	18.85
LAST FRAMING PULSE	20.30
SPI	24.65

Table 6

Note 1: The X pulse is referenced here for possible future use.
The ATCRBS Reply Pulse Spacing Tolerance is as follows:

First framing pulse to information/last framing pulse ± 0.1 μsec
Last framing pulse to SPI pulse ± 0.1 μsec
Any 2 pulses in pulse group (except First framing pulse) ± 0.15 μsec

The ATCRBS pulse characteristics are as specified in Table 7.

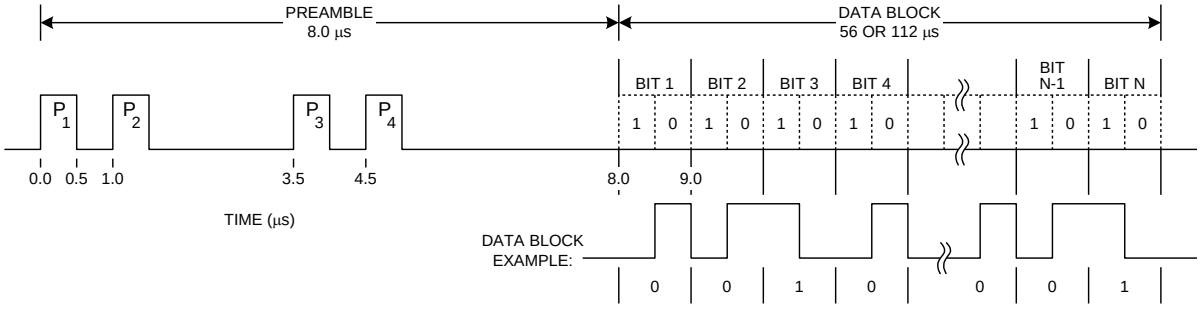
ATCRBS Reply Pulses (in microseconds)						
			Rise Time		Decay Time	
Pulse Designator	**Pulse Duration**	**Duration Tolerance**	**Min.**	**Max.**	**Min.**	**Max**
ATCRBS Reply Pulses	0.45	± 0.10	0.05	0.1	0.05	0.2

Table 7

4. Mode S Replies

Mode S (Short & Long) replies, including preamble, data pulse, pulse shape, pulse spacing tolerance, and delay and jitter characteristics will be as follows.

The Transmitter CCA transmits Mode S reply pulse waveforms as shown in table below.



Mode S Reply

1. Mode S Reply

   The Mode S preamble consists of four 0.5 ± 0.05 microsecond pulses.
   The second, third and fourth pulses are spaced 1.0, 3.5, and 4.5 microseconds respectively from the first transmitted pulse.
   The block of reply data pulses begins 8.0 microseconds after the first transmitted pulse and is either 56 or 112 one microsecond intervals depending on the type of Mode S Reply.
   A pulse with a width of 0.5 ± 0.05 microseconds is transmitted either in the first (data bit "1") or in the second half (data bit "0") of each interval. Also, if a pulse transmitted in the second half of one interval is followed by a pulse transmitted in the first half of the next interval, the two pulses merge. Once the merging occurs, a 1.0 ± 0.05 microsecond pulse is transmitted
2. Mode S Reply Pulse Shape
   The pulse rise and decay time are as specified in Table 8.

Mode S Reply Pulses (in microseconds)				
	Rise Time		Decay Time	
Pulse Designator	Min.	Max.	Min.	Max
Mode S Reply Pulses	0.05	0.1	0.05	0.2

Table 8

3. Mode S Reply Pulse Spacing Tolerance
   Mode S Reply pulses start at a defined multiple of 0.5 microseconds from the first transmitted pulse.
   The pulse position tolerance be ± 0.05 microseconds, measured from the first pulse of the reply.

Test Equipment Utilized

Description	Manufacturer	Model #	CT Asset #	Last Cal Date	Cal Due Date
Horn Antenna	EMCO	3115	i00103	1/20/15	1/20/17
Bilog Antenna	Teseq	CBL 6111Dk	i00349	10/19/15	10/19/17
EMI Analyzer	Agilent	E7405A	i00379	2/11/16	2/11/17
3 Meter Semi-Anechoic Chamber	Panashield	3 Meter Semi-Anechoic Chamber	i00428	11/26/13	11/26/16
Spectrum Analyzer	Agilent	E4407B	i00331	09/18/15	09/18/16
Spectrum Analyzer	Rohde & Schwarz	FSU	I00501	03/25/16	03/25/17
Preamplifier for 1-18GHz horn antenna	Miteq	AFS44 00101 400 23-10P-44	i00509	N/A	N/A
Temperature Test Chamber	Tenney	Tenney Jr	i00027	N/A	N/A
Hydra Data Bucket	fluke	2635A	I00343	5/4/16	5/4/17

In addition to the above listed equipment standard RF connectors and cables were utilized in the testing of the described equipment. Prior to testing these components were tested to verify proper operation.

END OF TEST REPORT