Compliance Testing, LLC
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Test Report

Prepared for: ACSS an L-3 Company

Description: Aviation Transponder

Model: NXT-800, NXT-700, NXT-600

Serial Number: NXE10990, NXE11035, NXE11055

FCC ID: 2ACTZNXTVE19

To

FCC Part 87

Date of Issue: September 6, 2019

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@L3Harris.com**

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Poona Saber
Project Test Engineer

Test Report Revision History

Revision	Date	Revised By	Reason for Revision
1.0	August 30, 2019	Poona Saber	Original Document
2.0	September 11, 2019	Poona Saber	-revisions after Clients remarks - Annex B revised - Annex D revised - Annex E revised - Annex F revised
3.0	September 19, 2019	Poona Saber	Revision made on page 5 serial numbers
4.0	September 19, 2019	Trisha Aguilar	Corrected FCC ID
5.0	October 25, 2019	Poona Saber	Revised Annex F Added radiated spurious table on page 10 Added duty Cycle on page 15 and revised on page 5 Added environmental conditions on page 5 Added statement of calibration extension to table of test equipment
6.0	October 29, 2019	Poona Saber	Changed appendix to annex

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ILAC / A2LA

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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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Testing Certificate Number: **2152.01**

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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)**
24-25.5	24 -32	956-962

EUT Description

Model: NXT-800, NXT-700, NXT-600
Description: NXT Mode-S transponder
Serial Number: NXE10990, NXE11035, NXE11055
9008000-10000 (AC/DC power), 9007000-55001 (DC power) and 9006000-55000 (DC power)

Additional Information:
The NXT Mode-S transponder is a diversity Mode-S transponder which contains data link capabilities in addition to Mode-S specific services. The NXT units will meet the following TSO documents:

- TSO-C112d, ATCRBS/mode S airborne Equipment
- TSO-C166b, 1090 MHz ADS-B (transmit only)

The NXT-800 Transponder consists of two versions, one using a 115 VAC, 400 Hz or +28 VDC power supply and another which supports only a +28VDC power supply. For testing purposes both AC and DC radiated emissions were investigated, and both were almost the same. The Higher one is reported

NXT-600 Transponder is designed for a +28 VDC power supply.

NXT-700 Transponder is designed for a +28 VDC power supply.

NXT-600 and NXT-700 share a common circuit card set for the processor, power supply and transceiver. NXT-700 uses the same cards with only a few minor changes to support its mechanical design. The three units have different form factors, rear connectors and rear interconnect circuit card assemblies hence, radiated testing has been performed on all units and conducted testing only on NXT-800 unit.

Following is declared as type of emission for NXT system:

- Transponder (Compliant with FAA TSO C112d with deviations): 18M0M1D
- Frequency range: 1090 ± 1 MHz
- There are two sub-modes operation for 1090 MHz called: ATCRBS reply and Mode S and can be transmitted from both top and bottom antennas.
- Transponder system (1090 MHz) uses pulse position modulation combined with pulse width modulation (M1D)
- In transponder mode the transmitter transmits to two antenna ports, top and bottom. The top and bottom antennas do not transmit simultaneously.
- The maximum duty cycle for transponder ATCRBS transmission is 0.338% and mode S transmission is 0.586%

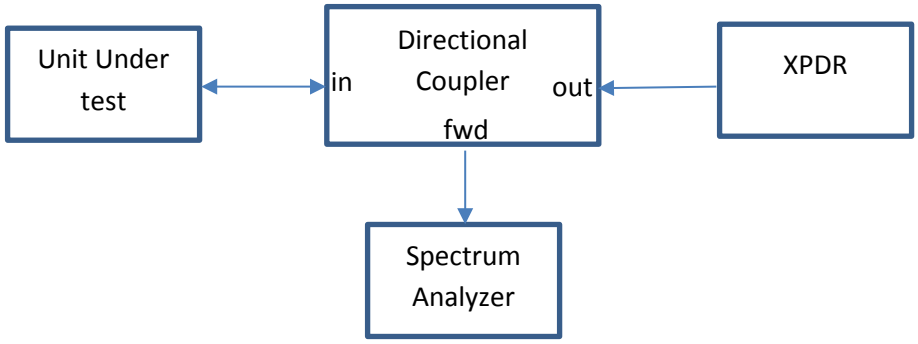
EUT Support Equipment

Qty	Description	Manufacturer	Model No.	Part No.
1	XPDR RF Simulation Module	ACSS	-	ACSS-001985
1	Mode S generic test Fixture	ACSS	-	ACSS-001969
1	ATC Test Set	IFR	ATC 1400A	
1	Transponder test set	IFR	SI-1404	
1	DC Power Supply	Agilent	N5746A	
1	AC Power Supply	Elgar	CW1251	
1	Oscilloscope	Tektronix	TDS 3054B	0175
1	Directional Coupler	Narda	3003-20	11210
1	Directional coupler	Narda	27002SC-40	
1	Directional Coupler	Werlatone	C3910-10	
1	10 dB 50 Watts attenuator	pasternack	NA	PE7392-10
2	Dell Computers	Dell	NA	

.XPDR RF Simulation Module is comprised of RF generators and attenuators that are controlled by an FPGA card in the test computer. We use this to send interrogations and receive replies from the UUT.

.Mode-S Generic Test Fixture is used to control the power applied to the UUT (via DC power supply) as well as providing the UUT with the necessary discrete inputs to facilitate normal operation and test operations.

Test Setup with Directional coupler and Support Equipment



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(i)(3)	Emission Masks (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	The EUT does not contain an audio input
2.1047	Modulation Characteristic	Pass	
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

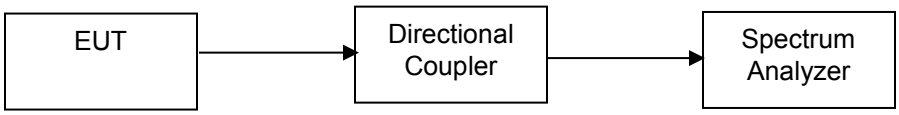
Test Date: 8/23/19

Test Procedure

The Equipment Under Test (EUT) was connected through a directional coupler 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 and Average readings were taken for Transponder system for both ATCRBS(C) and S modes and the result was then compared to the limit.

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.
The Transponder output power is controlled by the requirements of FAA TSO C112d.

Test Setup



Output Power for Transponder System

Frequency	Antenna	Mode	Measured Power Peak (dBm)	Measured Power Peak (W)	Average power (dBm)	Average power (W)
1090 MHz	Top	ATCRBS	58.06	639.73	29.52	0.89
1090 MHz	Bottom	ATCRBS	58.42	695.02	30.27	1.06
1090 MHz	Top	S	58.04	636.07	31.73	1.48
1090 MHz	Bottom	S	58.34	682.33	32.42	1.74

See Annex A for test plots

Conducted Spurious Emissions

Engineer: Poona Saber

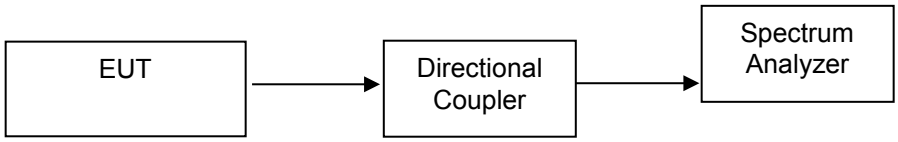
Test Date: 8/23/19

Test Procedure

The EUT was connected through 3 different directional couplers covering the range from 30MHz- 10GHz with attenuators in line if necessary, to spectrum analyzer to verify that the EUT met the requirements for spurious emissions based on the requirement of FCC part 87.139 (a)(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.

Test Setup



Mode	Antenna	Frequency (MHz)	Average Spurious Power (dBm)	Average Fundamental Power (dBm)	dBc	Limit (dBc)	Result
1090 MHz ATCRBS	Top	4360.36	-27.83	29.52	57.35	≥40	PASS
1090 MHz ATCRBS	Bottom	4360.05	-25.84	30.27	56.11	≥40	PASS
1090 MHz Mode S	Top	4359.94	-24.8	31.73	56.53	≥40	PASS
1090 MHz Mode S	Bottom	4359.96	-22.17	32.42	54.59	≥40	PASS

See Annex B for test results

Radiated Spurious Emissions

Engineer: Poona Saber

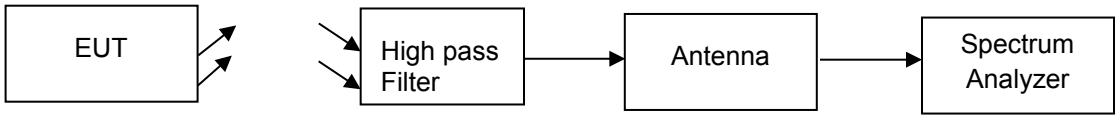
Test Date: 8/21/19

Test Procedure

The EUT was setup and tested in accordance with ANSI C63.26 2015. Both top and bottom antenna ports are connected into the simulator with 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 test distance from measurement antenna is 3 meters and 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 RBW is set to 100 KHz for measurements below 1Ghz and 1Mhz for measurements above 1GHz.

A high pass filter was used to notch down the fundamental and radiated measurements are done on NXT-600, NXT-700 and NXT-800 models. The highest emission of both ATCRB and mode S is presented on the plots.

Test Setup



Mode	Frequency (MHz)	Average Spurious Power (dBm)	Average Fundamental Power (dBm)	dBc	Limit (dBc)	Result
NXT 600	6540.12	-31.84	29.52	61.36	≥40	PASS
NXT 700	6539.94	-34.88	30.27	65.15	≥40	PASS
NXT 800	6540.14	-21.45	31.73	53.18	≥40	PASS

See Annex C for test results

Occupied Bandwidth

Engineer: Poona Saber

Test Date: 8/22/19

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.

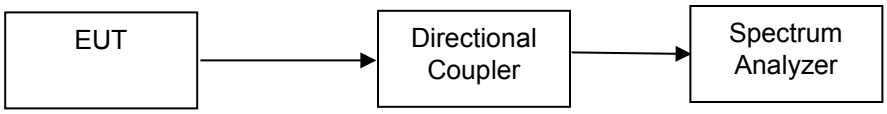
Based on section 87.137 Authorized Bandwidth for Emission designator M1D is 18 MHz.

Similarly, operation of the transponder (1090 MHz) system is administered by FAA in accordance with FAA TSO C-112d. Transponder MOPS are provided in RTCA document DO-181E. The allowable -20dB bandwidth is specified in section 2.2.4.2.3 of DO-181E to be less than 46 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 Annex D for Test Results

Emission Masks (Occupied Bandwidth)

Engineer: Poona Saber

Test Date: 8/22/19

Test Procedure

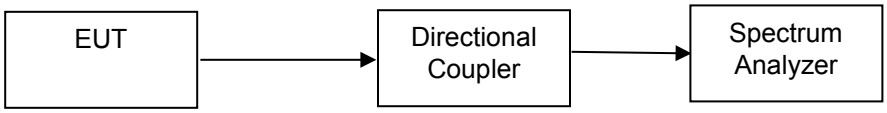
The EUT was connected with a directional coupler to a spectrum analyzer to verify that the EUT meets the required emissions mask requirements of part 87.139 (a) (1) & (2) as below. The RBW was set as close as possible to 1%-5% of the occupied bandwidth to ensure accurate readings.

a) Except for ELTs and when using single sideband (R3E, H3E, J3E), or frequency modulation (F9) or digital modulation (F9Y) for telemetry or telecommand in the 1435-1525 MHz, 2345-2395 MHz, or 5091-5150 MHz band or digital modulation (G7D) for differential GPS, the mean power of any emissions 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.

Test Setup



See Annex E for Test Results

Frequency Stability (Temperature Variation)

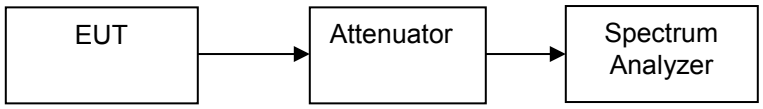
Engineer: Poona Saber

Test Date: 8/26/19

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) 960 to 1215 MHz which is 20 PPM

Test Setup



Measurement Results

Tuned Frequency (Hz)	Frequency Tolerance ppm	Upper Limit (Hz)	Lower Limit (Hz)		Temperature centigrade	Measured Frequency (Hz)	Upper Margin (Hz)	Lower Margin (Hz)
1089975190	20.0	1089996990	1089953390		-30	1089971617	25372.503800	18226.503800
		1089996990	1089953390		-20	1089971650	25339.503800	18259.503800
		1089996990	1089953390		-10	1089971567	25422.503800	18176.503800
		1089996990	1089953390		0	1089971184	25805.503800	17793.503800
		1089996990	1089953390		10	1089971534	25455.503800	18143.503800
		1089996990	1089953390		20	1089971200	25789.503800	17809.503800
		1089996990	1089953390		30	1089971284	25705.503800	17893.503800
		1089996990	1089953390		40	1089971634	25355.503800	18243.503800
		1089996990	1089953390		50	1089971067	25922.503800	17676.503800

Frequency Stability (Voltage Variation)

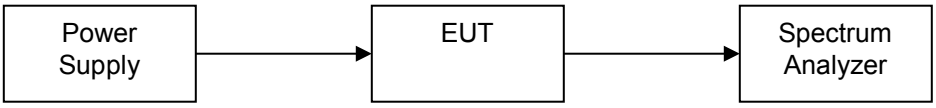
Engineer: Poona Saber

Test Date: 8/26/19

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 a variable DC voltage source at 14 and 28 Vdc.
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

Tuned Frequency (Hz)	Frequency Tolerance ppm	Upper Limit (Hz)	Lower Limit (Hz)	Nominal Voltatge	Voltage	Measured Frequency (Hz)	Upper Margin (Hz)	Lower Margin (Hz)
1089975190	20.0	1089996990	1089953390	115.00	97.75	1089975349	21641	21959
		1089996990	1089953390		115.00	1089975190	21800	21800
		1089996990	1089953390		132.25	1089976602	20388	23212

Tuned Frequency (Hz)	Frequency Tolerance ppm	Upper Limit (Hz)	Lower Limit (Hz)	Nominal Voltatge	Voltage	Measured Frequency (Hz)	Upper Margin (Hz)	Lower Margin (Hz)
1089975248	20.0	1089996990	1089953390	28.00	23.80	1089975273	21717	21883
		1089996990	1089953390		28.00	1089975248	21742	21858
		1089996990	1089953390		32.20	1089976476	20514	23086

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 "

Duty Cycle calculations:

ATCRBS Reply Rate Capability

The ATCRBS duty cycle comes from the requirement to transmit a minimum of 500 ATCRBS transmissions per second. These are nominally 450ns wide pulses with a maximum of 15 possible pulses per transmission.

Duty Cycle = (500 transmissions)*(15 pulses/transmission)*(450ns/pulse)*(100%) = 0.338%

Mode S Reply Rate Capability

The Mode S duty cycle comes from the capability of the unit to transmit the following:

- 34 short Mode S and 16 long Mode S replies per second –
- 60 additional long Mode S replies per second for TCAS compatible transponders –
- 7 additional long squitters and 1 short squitter per second –
- Long Mode S reply/squitter transmits 116 pulses at 500ns each while a short Mode S reply/squitter transmits 60 pulses at 500 ns each. So the total required transmissions is 35 short Mode S transmissions and 83 long Mode S transmissions per second

Duty cycle = (35 transmissions)*(60 pulses/transmission)*(500ns/pulse)*(100%) + (83 transmissions)*(116 pulses/transmission)*(500ns/pulse)*(100%) = 0.586%

See Annex F for Modulation characteristics screen captures

Modulation Details

2 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 1.

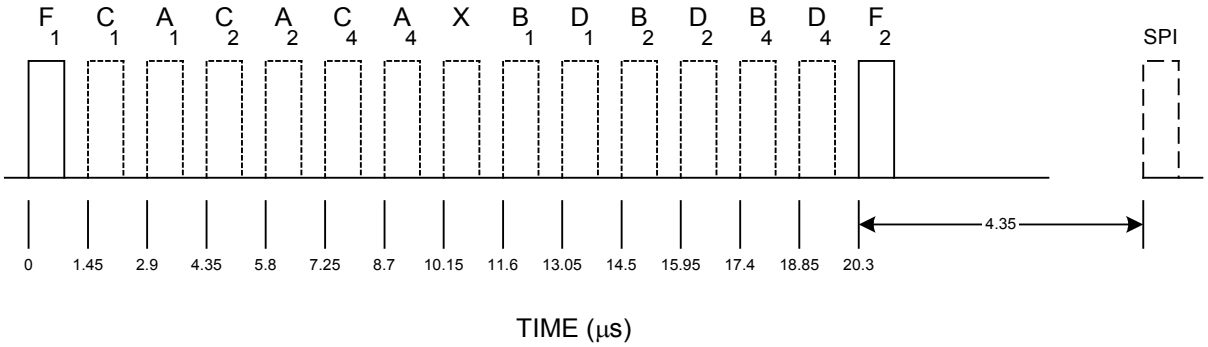


Figure 1: ATCRBS Reply

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

Table 3: 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
X[1]	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

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 the table below.

Table 4: 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

3 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 Figure 2.

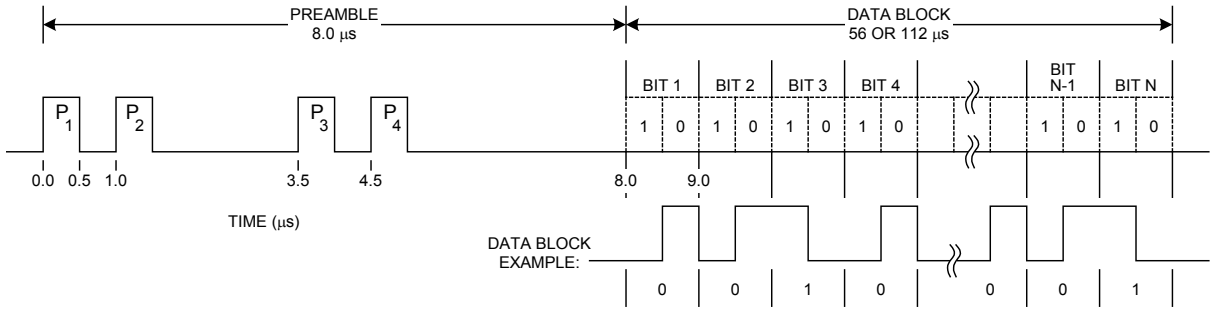


Figure 2: Mode S Reply

1. Mode S Reply
   a. The Mode S preamble consists of four 0.5 ± 0.05 microsecond pulses.
   b. The second, third and fourth pulses are spaced 1.0, 3.5, and 4.5 microseconds respectively from the first transmitted pulse.
   c. 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.
   d. 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
   a. The pulse rise and decay time are as specified in the table below.

Table 5: 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

3. Mode S Reply Pulse Spacing Tolerance
   a. Mode S Reply pulses start at a defined multiple of 0.5 microseconds from the first transmitted pulse.
   b. The pulse position tolerance must 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	ARA	DRG-118/A	i00271	6/16/18	6/16/20
Bi-Log Antenna	Chase	CBL6111C	i00267	3/8/18	3/8/20
EMI Analyzer	Agilent	E7405A	i00379	1/16/19	1/16/20
3 Meter Semi-Anechoic Chamber	Panashield	3 Meter Semi-Anechoic Chamber	i00428	8/15/16	8/15/19 *
PSA Spectrum Analyzer	Agilent	E4445A	i00471	10/16/18	10/16/19
Spectrum Analyzer	Rohde & Schwarz	FSU26	i00501	4/2/19	4/2/20
Preamplifier for 1-18GHz horn antenna	Miteq	AFS44 00101 400 23-10P-44	i00509	N/A	N/A
Temperature Test Chamber	Thermotron	SE-1000-3-3	i00557	Functional Verification	Functional Verification
Hydra Data Bucket	Fluke	2635A	I00343	5/15/19	5/15/20
Network Analyzer	HP	8722D	I00521	7/24/19	7/24/20

- Calibration extension by lab's manager

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