Aviation Communication & Surveillance Systems	NGT-9000 FCC TEST PROCEDURES AND RESULTS POWER AMP QUALIFICATION			
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-	09-SEP-2019	ECR018906	Initial Release
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1 INTRODUCTION

The NGT-9000 is a Mode-S Transponder that provides Automatic Dependent Surveillance-Broadcast (ADS-B) out on 1090MHz with an integrated GPS receiver. The unit also receives ADS-B data via 978MHz and 1090MHz. Some models support an optional Active Traffic (TAS or TCAS) and/or antenna Diversity functionality. The transponder is available in either Panel Mount or Remote Mount configurations.

The transponder is designed to operate with an input voltage ranging from +14V to +28V VDC.

1.1 Purpose

The purpose of this document is to provide the FCC compliance test procedures and results for the NGT-9000 equipment in both the Panel Mount and Remote Mount Versions.

1.2 Scope

This test report document establishes the FCC compliance test procedures and resultsfor NGT-9000, Part Numbers 9029000-20000 and 9029000-40000.

1.3 References

Table 1-1 Referenced ACSS Documents

Document No.	Revision	Description
9029000-20000	J	NGT-9000D End Item Assembly
9029000-40000	J	NGT-9000RD End Item Assembly
9200-17000-01	AH	Transponder Panel Mount With Diversity
9200-17500-01	R	Transponder Remote Mount With Diversity
9020020-003	G	CCA Drawing (Main CCA)
9029010-002	F	CCA Drawing (GPS-UAT RX CCA)
0040-17001-01	W	Installation Manual
8020133-002	A	NGT-9000 FCC Test Procedures and Results Power Amp Qualification

Table 1-2 Referenced Industry Documents

Source	Document No.	Revision	Description
FAA	AC 20-151B	3/18/2014	Airworthiness Approval of Traffic Alert and Collision Avoidance Systems (TCAS II), Versions 7.0 & 7.1 and Associated Mode S Transponders
FAA	TSO-C112d	6/6/2011	Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment

Table 1-2 Referenced Industry Documents

Source	Document No.	Revision	Description
RTCA	DO-181E	3/17/2011	Minimum Operational Performance Standards for Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment
FAA	AC 20-165A	11/7/2012	Airworthiness Approval of Automatic Dependent Surveillance – Broadcast (ADS-B) Out Systems
FAA	TSO-C166b	12/2/2009	Extended Squitter Automatic Dependent Surveillance - Broadcast (ADS-B) and Traffic Information Service – Broadcast (TIS-B) Equipment Operating on the Radio Frequency of 1090 Megahertz (MHz)
RTCA	DO-260B with Corrigendum 1	12/13/2011	Minimum Operational Performance Standards for 1090 MHz Extended Squitter Automatic Dependent Surveillance –Broadcast (ADS-B) and Traffic Information Services – Broadcast (TIS-B)
FAA	TSO-C147	4/6/1998	Traffic Advisory System (TAS) Airborne Equipment
FAA	TSO-C118a	10/27/2014	Traffic Alert and Collision Avoidance System (TCAS) Airborne Equipment, TCAS I
RTCA	DO-197A, Change 1	7/29/1997	Minimum Operational Performance Standards for an Active Traffic Alert and Collision Avoidance System I (Active TCAS I), Change 1
FAA	AC-20-172A	3/23/2012	Airworthiness Approval for ADS-B In Systems and Applications
FAA	TSO-C154c	12/2/2009	Universal Access Transceiver (UAT) Automatic Dependent Surveillance-Broadcast (ADS-B) Equipment Operating on Frequency of 978 MHz
RTCA	DO-282B with Corrigendum 1	12/13/2011	Minimum Operational Performance Standards (MOPS) for Universal Access Transceiver (UAT) Automatic Dependent Surveillance-Broadcast (ADS-B)
FAA	TSO-C157a	9/9/2011	Aircraft Flight Information Services – Broadcast (FIS-B) Data Link Systems and Equipment
RTCA	DO-267A	4/29/2004	Minimum Aviation System Performance Standards (MASPS) for Flight Information Services-Broadcast (FIS-B) Data Link
FAA	TSO-C195a	2/29/2012	Avionics Supporting Automatic Dependent Surveillance – Broadcast (ADS-B) Aircraft Surveillance Applications (ASA)
RTCA	DO-317A	12/13/2011	Minimum Operational Performance Standards (MOPS) for Aircraft Surveillance Applications (ASA) System
FAA	AC20-138D	3/28/14	Airworthiness Approval of Positioning and Navigation Systems
FAA	TSO-C145c	5/2/2008	Airborne Navigation Sensors Using The Global Positioning System Augmented By The Satellite Based Augmentation System
RTCA	DO-229D, Change 1	2/1/2013	Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment
RTCA	DO-160G	12/8/2010	Environmental Conditions and Test Procedures For Airborne Equipment

Table 1-3: Referenced FCC Documents

Document No.	Description
CFR Title 47 Chapter 1 Part 1 Subpart I	Code of Federal Regulations – Telecommunications Federal Communications Commission Practice and Procedure Procedures Implementing the National Environmental Policy Act of 1969
CFR Title 47 Chapter 1 Part 2 Subpart J	Code of Federal Regulations – Telecommunications Federal Communications Commission Frequency Allocations and Radio Treaty Matters; General Rules and Regulations Equipment Authorization Procedures
CFR Title 47 Chapter 1 Part 87	Code of Federal Regulations, Telecommunication. Part 87 – Aviation Services
CFR Title 47 Chapter 1 Part 87 Subpart D	Code of Federal Regulations – Telecommunications Federal Communications Commission Aviation Services Technical Requirements

1.4 Acronyms and Abbreviations

Table 1-4: Acronyms and Abbreviations

Acronym	Definition
ACSS	Aviation Communication & Surveillance Systems
ADS-B	Automatic Dependent Surveillance – Broadcast
ASA	Aircraft Surveillance Applications
ATCRBS	Air Traffic Control Radar Beacon System
ATE	Automated Test Equipment
CCA	Circuit Card Assembly
CFR	Code of Federal Regulations
CPFSK	Continuous Phase Frequency Shift Keying
CRC	Cyclic Redundancy Check
dB	Decibel
EVAcq	Enhanced Visual Acquisition
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
FET	Field Effect Transistor
FIS-B	Flight Information Service - Broadcast
FPGA	Field Programmable Gate Array
FSK	Frequency Shift Keying
GHz	Giga Hertz
GPS	Global Positioning System
IF	Intermediate Frequency
kHz	kilo Hertz
LDMOS	Laterally Diffused Metal Oxide Semiconductor
LNA	Low Noise amplifier
LO	Local Oscillator

Table 1-4: Acronyms and Abbreviations

Acronym	Definition
LRU	Line Replaceable Unit
MASPS	Minimum Aviation System Performance Standards
Mbps	Megabits per second
MHz	Mega Hertz
MOPS	Minimum Operational Performance Standards
ns	Nanosecond
PC	Personal Computer
PLL	Phase Locked Loop
PPM	Parts Per Million
RF	Radio Frequency
rms	root mean square
RTCA	Radio Technical Commission for Aeronautics
TCXO	Temperature Compensated Crystal Oscillator
TSO	Technical Standard Order
UAT	Universal Access Transceiver
us	Microsecond
UUT	Unit Under Test
VCO	Voltage Controlled Oscillator
VDC	Volts Direct Current

2 GENERAL INFORMATION

2.1 Type Designation

The equipment has been designated by ACSS as NGT-9000, P/N 9029000-20XXX and P/N 9029000-40XXX.

2.2 Service and Rule for Intended Operation

Air Traffic Control
Part 87

2.3 Description of Equipment

2.3.1 NGT-9000 Functionality

The NGT-9000 is a Mode S Transponder that provides 1090 MHz Automatic Dependent Surveillance-Broadcast (ADS-B) information with the following functionality:

- 1090 MHz Mode-S Level 2 transponder functions including the 1090ES ADS-B Input and Output functions.
    - 1090 MHz Mode S Transponder function is available as a single or optional diversity antenna configuration.
- An internally integrated GPS/UAT receive-only module supporting Class Beta 1 GPS functions that provides the required GPS data for ADS-B input and output functions.
    - Note: the NGT-9000 only utilizes the internal GPS as its position source; no external GPS inputs are supported.
- ADS-B traffic (UAT & 1090MHz) and FIS-B weather and FIS-B textual data products will be output from the transponder via serial (RS-422 or RS-232) interfaces to external cockpit displays.
- An ARINC 735B compatible output of traffic (ADS-B, ADS-R, and TIS-B) is supported for conventional traffic (TAS) and CDTI displays.
- Panel mount versions of the transponder will also display the traffic (ADS-B, ADS-R, and TIS-B) and FIS-B products on the touch screen panel. The Remote mount versions do not have the touch screen display.
- The NGT-9000 system also supports an Active Traffic (TAS or TCAS) function.
- The Panel Mount and Remote mount units use identical internal circuit cards, with the exception of the touch screen display. Because of the display, the panel mount versions are mounted horizontally while the remote mount versions are mounted vertically.
- For marketing purposes, various options exist for NGT-9000 that enable or disable diversity antenna function and 1030MHz transmissions (TAS or TCAS function). This is software controlled, this testing is performed with all features enabled.

ACSS is seeking approval for the following FAA TSOs:

a. TSO-C112d Air Traffic Control Radar Beacon System/Mode Select (ATCRBS / Mode S) Airborne Equipment:
    - Level 2dens Class 1 (diversity configuration)
    - Level 2ens Class 1 (non-diversity configuration)

b. TSO-C113a Airborne Multipurpose Electronic Displays

c. TSO-C118a Traffic Alert and Collision Avoidance System (TCAS) Airborne Equipment, TCAS I

d. TSO-C145c Airborne Navigation Sensors Using The Global Positioning System Augmented By The Satellite Based Augmentation System
    - Class Beta 1

e. TSO-C147 Traffic Advisory System (TAS) Airborne Equipment
   - Class A

f. TSO-C154c Universal Access Transceiver (UAT) Automatic Dependent Surveillance-Broadcast (ADS-B) Equipment Operating on Frequency of 978 MHz
   - Class A1S Receive Only

g. TSO-C157a Aircraft Flight Information Services-Broadcast (FIS-B) Data Link Systems and Equipment
   - Class 2

h. TSO-C166b Extended Squitter Automatic Dependent Surveillance - Broadcast (ADS-B) and Traffic Information Service - Broadcast (TIS-B) Equipment Operating on the Radio Frequency of 1090 Megahertz (MHz)
   - Class A2

i. TSO-C195a Avionics Supporting Automatic Dependent Surveillance – Broadcast (ADS-B) Aircraft Surveillance Applications (ASA)
   - Class B1, B5, C1, & C5

2.3.1.1 NGT-9000 Units Tested

Two units will be used in the FCC test process: Serial Numbers LXE13068 (Panel Mount) and LXE13069 (Remote Mount). A complete set of conducted and radiated testing is performed on the Panel Mount version as the baseline. The Remote Mount version uses the same RF circuit cards and interface cables, but does not include the touch screen display, Because of these similarities, the Remote Mount version will be qualified by similarity to the Panel Mount version for all testing except for radiated emissions. Radiated emissions testing is also performed on the Remote mount version because of the different enclosure, mounting orientation and touch screen display.

2.3.1.2 Type of Emission

Transponder Transmissions: 14M0M1D
TCAS/TAS Transmissions: 18M0V1D

2.3.1.3 Frequency Range

Mode S & ATCRBS Transponder Transmission: 1090 MHz ± 1 MHz
TCAS/TAS Transmission: 1030 MHz ± 0.1 MHz

2.3.1.4 Power Rating

500 Watts Peak Effective Isotropic Radiated Power (Pulsed, 1090 MHz)

Note: This assumes 3 dBi antenna gain, per TSO-C112d

1.74 Watts to 500 Watts Peak Effective Radiated Power (Pulsed, 1030 MHz)

Note: This assumes 3 dBi antenna gain, per TSO-147c

2.3.1.5 Antenna Gain/Type

The antenna used for the Transponder function is a standard aviation blade antenna that transmits omnidirectionally at 1090MHz with a minimum gain of 2.0dBi.

The antenna used for the TCAS/TAS function transmits omnidirectionally at 1030MHz with a minimum gain of 2.5dBi.

2.3.2 Schematics

A block diagram and schematics will be provided when the application for certification is filed with the FCC.

2.3.3 User Guide and Installation Manual

An ACSS document, Installation Manual (0040-17001-01) provides instructions for the proper installation of the NGT-9000, both Remote and Panel mount versions, on a given aircraft.

2.3.4 Tune-up Procedure

No field tuning is required. Alignment is performed in the factory.

3 DRAWINGS AND PHOTOGRAPHS

3.1 Drawings

Refer to Table 1-1 for a list of ACSS drawings that will be furnished with the application.

3.2 Photographs

Internal and external photographs of the NGT-9000 units will be provided when the application for certification is filed with the FCC.

3.3 NGT-9000 Models to be Subjected to FCC Compliance Testing

The NGT-9000 panel mount unit (9029000-20000) will be subjected to the full suite of FCC compliance tests with the resulting data submitted to the FCC for certification. The NGT-9000 Remote mount unit (9029000-40000) will be subjected only to the radiated test due to differences in mounting and the aperture presented by the touch screen panel. All TAS/diversity transponder functionality will be enabled during the FCC testing.

3.4 NGT-9000 Models Are Considered Identical

For purposes of FCC compliance testing and certification other than the testing of radiated emissions, all versions of the NGT-9000 units are considered to meet the FCC definition of “Identical,” because the items which provide the transmit and receive functions (the main circuit card and the software) as well as the interface connections and cables are the same in all of the NGT-9000 models.

3.4.1 Conclusion

The full suite of FCC compliance tests will be performed on a NGT-9000D+ (Panel Mount with Diversity and TAS/TCAS) model while radiated emissions testing will also be performed on NGT-9000RD+(Remote Mount with Diversity and TAS/TCAS) model. Test data from the NGT FCC compliance test will be submitted to the FCC to apply for a new certification and FCC identifier for the NGT family of units.

4 EQUIPMENT AND SETUP

4.1 Test Facilities

FCC testing will be performed at the following facilities:

Compliance Testing
1724 S. Nevada Way
Mesa, AZ 85204

4.2 Test Equipment

The test equipment used is listed in each test results section below.

4.2.1 Setup Block Diagram

Setup block diagrams are shown in each test results section below.

4.3 LRU Setup

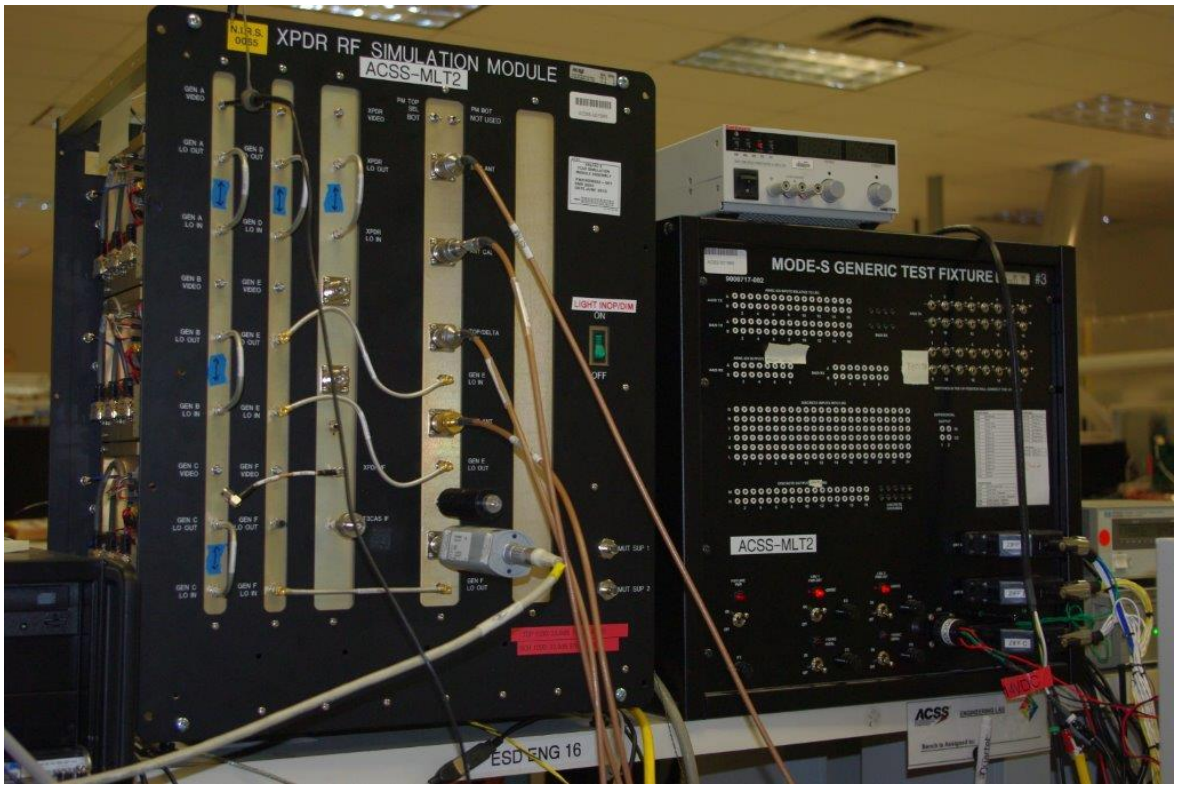

Figure 4-1: Test Equipment Setup (Typical)

Figure 4-2: Test Equipment Setup and Temperature Chamber (Typical)

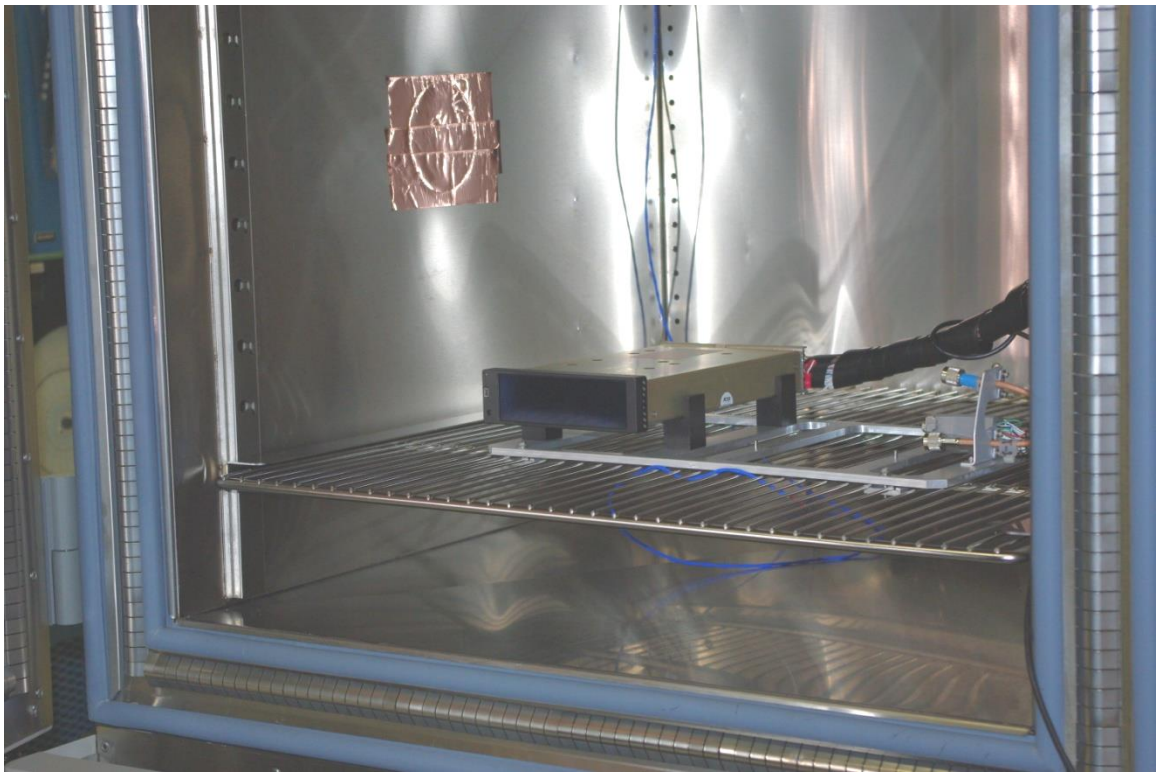

Figure 4-3: NGT-9000 inside the Temperature Chamber (Typical)

4.3.1 Hardware Configuration

A complete suite of FCC testing was conducted on the NGT-9000D+ Panel Mount LRU P/N 9029000-20000 and, for Radiated testing, the NGT-9000RD+ Remote Mount LRU P/N 9029000-40000.

4.3.2 Software Configuration

The part number and CRC of the software used for testing both units, are shown in Table 4-1.

Table 4-1: Software Details Drawings and Photographs

Part Number	CRC	Description
8010-17000-0301	0x30F7F081	Flight SW
8010-17001-0301	0x81AE33F4	Maint SW
8000-17000-0100	0xC3A4C270	Firmware
8010-14020-0302		Bootloader
9021105-011	0xB085C320	GPS/UAT Composite
9021100-010	0xE16FB1D7	GPS/UAT RX
9021120-005	0xB04CB80B	GPS/UAT Firmware
9021110-005	0x05D924A5	GPS/UAT Bootloader

4.4 Photographs

Photographs of the test equipment will be provided when the application for certification is filed with the FCC.

5 TEST SCHEDULE

FCC testing will commence in July of 2019.

6 FCC COMPLIANCE TEST PROCEDURES

47CFR2.1041 states that for equipment operating under the authorized radio services, the measurement procedures are specified in the rules governing the particular device for which certification is requested. For equipment operating in the authorized radio services, measurements are required as specified in sections 2.1046 (RF Power Output), 2.1047 (Modulation Characteristics), 2.1049 (Occupied Bandwidth), 2.1051 (Spurious Emissions at Antenna Terminals), 2.1053 (Field Strength of Spurious Radiation), 2.1055 (Frequency Stability) and 2.1057 (Frequency Spectrum to be Investigated).

Representative test configurations are shown in block diagram format in the test procedures below but may be modified depending on the equipment available at the test facilities. The test equipment used during test will be documented in the test report.

6.1 RF Power Output

47CFR Reference:
2.1046, RF Power Output
87.131, Bandwidth of Emission

Given that the maximum power output of the transmitter located inside the NGT-9000 unit ranges from 870 mW to 350 W at the rear of the unit, the transmitter's peak power output in dBm is calculated as follows:

P_{peak_Max} (dBm, 1090 MHz) = $10Log_{10}(P_{peak}$, W x 1000mW/W)
P_{peak_Max} (dBm, 1090 MHz) = $10Log_{10}$(350 W x 1000mW/W)
P_{peak_Max} (dBm, 1090 MHz) = 55.4 dBm

P_{peak_Max} (dBm, 1030 MHz) = $10Log_{10}(P_{min}$, W x 1000mW/W)
P_{peak_Max} (dBm, 1030 MHz) = $10Log_{10}$(350 W x 1000mW/W)
P_{peak_Max} (dBm, 1030 MHz) = 55.4 dBm

The transmitter's measured peak power output should be approximately 54 dBm (250 W) at the rear of the unit, considering manufacturing tolerances, measurement equipment tolerances and losses in any cables/connectors.

Comment: In this report, the LRU's output power may be referenced in two separate locations, at the antenna or at the rear of the unit. Per Installation Manual, a loss of 1.5dB from the LRU to the aircraft antenna can be assumed. Therefore, when power is referenced to the rear of the LRU, the RF output power at the aircraft antenna can be assumed to be 1.5dB lower than the recorded power.

6.1.1.1 RF Power Output Test Equipment Required

Table 6-1: RF Power Output Test Equipment Required

Block Diagram Reference	Type	Manufacturer	Model
A	NGT-9000 LRU	ACSS	9029000-20000
B	NGT VALFAC	ACSS	9006052-001 and 9000717-002
C	Peak Power Meter		
D	Spectrum Analyzer		

Comment: Equivalent equipment may be used.

6.1.1.2 RF Power Output Test Setup

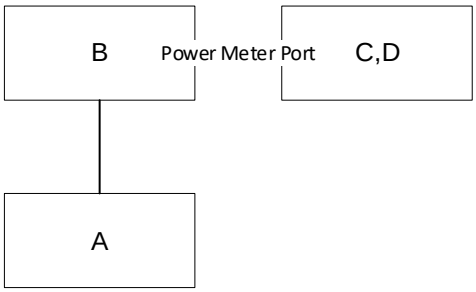

Figure 6-1: RF Power Output Test Setup

6.1.1.3 RF Power Output Test Procedure

1. Connect the equipment as shown in Figure 6-1 above. It is also acceptable to insert a directional coupler between A and B and measure the power at the coupled port.
2. Calculate RF path loss from LRU connector to Power Meter Port on VALFAC.

For Testing XPDR Transmissions:

Using VALFAC Scripts:

- Configure the VALFAC script tool to run DO181E_23221_modes_top.scp, DO181E_23221_modes_bot.scp (Mode S, Long DF-20 replies at 50 Hz on top/bottom antennas, respectively) and then DO181E_23221_atcrbs_top.scp and DO181E_23221_atcrbs_bot.scp (ATCRBS, Mode A replies at 500 Hz on top/bottom antennas with Mode A code set to 0xFFF).

Using IFR:

- Configure the VALFAC TCAS GUI tool with correct APM configuration and select Run.
- To use the IFR, the optional directional coupler must be used for measurements. Instead of connecting the directional coupler to B above, it must be connected to the output of the IFR.
- Setup IFR for ATCRBS:
    - Select C10 and F01 for ATCRBS. Select Mode A reply using front panel switch. Set PRF to 500.
    - Set output Switch to NORM.
- Setup IFR for MODE-S:
    - Select C10 and F02 for MODE-S. Set PRF to 50.
    - Select S Menu and configure for UF=4, RR=12, AA=*LRU Mode-S Address (normally 0000C8)*. (This will solicit a DF-20 Long Mode-S Reply)
    - Set output Switch to NORM.

3. Record the measured output power and frequency using the Peak Power Analyzer and Spectrum Analyzer.

For Testing TAS Transmissions:

1. Open the serial terminal window and connect to Com 1 at 115200 baud.
2. Place UUT in testmode 3 by typing “testmode set 3” in serial terminal.
3. Turn on the TAS functionality by typing “nvm install nvm write 60 1 1” in the serial terminal (the status may be read by typing “nvm install nvm read 60 1”, if it returns “0” then TAS is off).
4. Write TAS enable into DCM by typing “nvm install dcm write 60 1 1”
5. Select whisper shout step 7 with suppression pulse by typing “tcas ws 7c” in serial terminal.

6. Record the measured output power and frequency using the Peak Power Analyzer and Spectrum Analyzer.

6.1.1.4 Test Result Data

The peak power measured during testing is shown in Table 6-2.

Table 6-2: NGT-9000 Peak power output

		NGT-9000 Peak power output and frequency			Limit
Modulation Characteristic		**Measurement**	**Top antenna**	**Bottom antenna**	
TAS	**ATCRBS (1030 MHz)**	Power Output (dBm)	53.32	N/A	≥ 52dBm,< 56dBm
XPDR	**Mode S (1090 MHz)**	Power Output (dBm)	53.82	53.92	≥ 52.5dBm
	ATCRBS (1090 MHz)	Power Output (dBm)	53.78	53.98	≥ 52.5dBm

6.2 Modulation Characteristics

47CFR Reference:
2.1047, Modulation Characteristics
87.141c, Modulation Requirements

6.2.1 Modulation Characteristics Test Equipment Required

Table 6-3: Modulation Characteristics Test Equipment Required

Block Diagram Reference	Type	Manufacturer	Model
A	NGT-9000 Test Unit	ACSS	9092000-20000
B	NGT VALFAC	ACSS	9006052-001 and 9000717-002
C	Peak Power Meter		

Comment: Equivalent equipment may be used.

6.2.2 Modulation Characteristics Test Setup

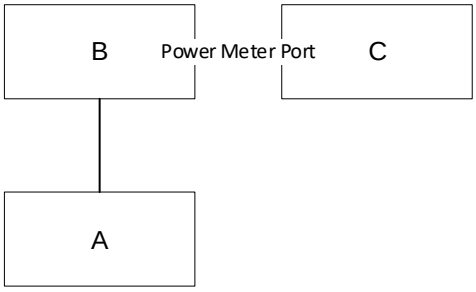

Figure 6-2: Modulation Characteristics Test Setup

6.2.3 Modulation Characteristics Test Procedure

1. Connect the equipment as shown in Figure 6-2 above. It is also acceptable to insert a directional coupler between A and B and measure the power at the coupled port.
2. Calculate RF path loss from LRU connector to Power Meter Port on VALFAC.

For Transponder Modulation Characteristics:

Using VALFAC Scripts:

- Configure the VALFAC script tool to run DO181E_23221_modes_top.scp, DO181E_23221_modes_bot.scp (Mode S, Long DF-20 replies at 50 Hz on top/bottom antennas, respectively) and then DO181E_23221_atcrbs_top.scp and DO181E_23221_atcrbs_bot.scp (ATCRBS, Mode A replies at 500 Hz on top/bottom antennas with Mode A code set to 0xFFF).

Using IFR:

- Configure the VALFAC TCAS GUI tool with correct APM configuration and select Run.
- To use the IFR, the optional directional coupler must be used for measurements. Instead of connecting the directional coupler to B above, it must be connected to the output of the IFR.
- Setup IFR for ATCRBS:
    - Select C10 and F01 for ATCRBS. Select Mode A reply using front panel switch. Set PRF to 500.
    - Set output Switch to NORM.
- Setup IFR for MODE-S:
    - Select C10 and F02 for MODE-S. Set PRF to 50.
    - Select S Menu and configure for UF=4, RR=12, AA=*LRU Mode-S Address (normally 0000C8)*. (This will solicit a DF-20 Long Mode-S Reply)
    - Set output Switch to NORM.

3. Record the modulation characteristics on the Peak Power Meter. Capture pictures of the following data to be shown in the test report:
    - Typical ATCRBS or Mode S reply pulse showing rise and fall times.
    - Mode S reply with pulse position modulation
    - Close up of Mode S reply preamble
    - ATCRBS Mode C reply

For TAS Modulation Characteristics:

1. Open the serial terminal window and connect to Com 1 at 115200 baud.
2. Activate the terminal and type, “testmode set 3”
3. Enter the following command, “tcas ws 7c” for a 50 Hz transmission of the highest power Mode C interrogation (P1 and P3).
4. Record the modulation characteristics on the Peak Power Meter. Capture pictures of the following data to be shown in the test report:
    - Typical ATCRBS Mode C interrogation pulse showing rise and fall times, without S1 Pulse Present.
5. Next, enter the following command, “tcas ws 7t” for a 50 Hz transmission of the highest power Mode C interrogation (S1, P1, and P3).
6. Record the modulation characteristics on the Peak Power Meter. Capture pictures of the following data to be shown in the test report:
    - Typical ATCRBS Mode C interrogation pulse showing rise and fall times, with S1 Pulse Present.

Table 6-4: Signal Analyzer settings for modulation characteristics measurement (or equivalent)

Parameter Item/Function	Parameter Setting Value
Channel / Vertical Scale	5 dB/div
Channel / Vertical Center	40 dBm
Channel / Extensions / Corrections / dB Offset	*Calculated Path Loss*
Channel / Extensions / Averaging	8
Time / Timebase (for pulse width, rise time, fall time, amplitude)	200 ns/div
Time / Timebase (for pulse spacing)	2 us/div
Time / Trigger Delay	0 us
Trigger / Trigger Mode	Normal
Trigger / Trigger Level	+40 dBm
Trigger / Trigger Slope	+
Measure / Freq Ch1	1.06 GHz

6.2.3.1 Modulation Characteristics Test Results

Refer to Appendix A for NGT-9000 test results for modulation related parameters measured during testing.

6.3 Occupied Bandwidth

47CFR Reference:
2.1049, Occupied Bandwidth
87.135, Bandwidth of Emission

Occupied bandwidth is defined in 47CFR2.1049 as *"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."*

6.3.1 Occupied Bandwidth Test Equipment Required

Table 6-5: Occupied Bandwidth Test Equipment Required

Block Diagram Reference	Type	Manufacturer	Model
A	NGT-9000 Test Unit	ACSS	9029000-20000
B	NGT VALFAC	ACSS	9006052-001 and 9000717-002
C	Spectrum Analyzer		

Comment: Equivalent equipment may be used.

6.3.1.1 Occupied Bandwidth Test Setup

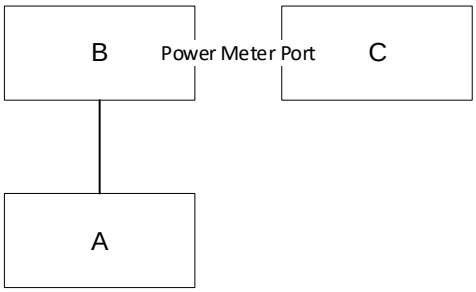

Figure 6-3: Occupied Bandwidth Test Setup

6.3.1.2 Occupied Bandwidth Test Procedure

For XPDR Transmissions

1. Connect the equipment as shown in Figure 6-3 above. It is also acceptable to insert a directional coupler between A and B and measure the power at the coupled port.

Using VALFAC Scripts:

- Configure the VALFAC script tool to run DO181E_23221_modes_top.scp, DO181E_23221_modes_bot.scp (Mode S, Long DF-20 replies at 50 Hz on top/bottom antennas, respectively) and then DO181E_23221_atcrbs_top.scp and DO181E_23221_atcrbs_bot.scp (ATCRBS, Mode A replies at 500 Hz on top/bottom antennas with Mode A code set to 0xFFF).

Using IFR:

- Configure the VALFAC TCAS GUI tool with correct APM configuration and select Run.
- To use the IFR, the optional directional coupler must be used for measurements. Instead of connecting the directional coupler to B above, it must be connected to the output of the IFR.
- Setup IFR for ATCRBS:
  - Select C10 and F01 for ATCRBS. Select Mode A reply using front panel switch. Set PRF to 500.
  - Set output Switch to NORM.
- Setup IFR for MODE-S:
  - Select C10 and F02 for MODE-S. Set PRF to 50.
  - Select S Menu and configure for UF=4, RR=12, AA=*LRU Mode-S Address (normally 0000C8)*. (This will solicit a DF-20 Long Mode-S Reply)
  - Set output Switch to NORM.

2. Using the Spectrum analyzer, use the Occupied Bandwidth measurement function.
3. Set the center frequency to 1090 MHz, Span to 200 MHz, Resolution bandwidth to 2 MHz and Video bandwidth to 6 MHz.
4. Set the detector function to Average rms.
5. Select trace>>max hold and allow the window to fill up with the signal.
6. Record the occupied bandwidth in Table 6-6, below.

For TAS Transmissions

1. Enter the following command in serial terminal, “tcas ws 7t” for a 50 Hz transmission of the highest power Mode C interrogation (S1, P1, and P3).
2. Set the center frequency to 1030 MHz

3. Select trace>>max hold and allow the window to fill up with the signal.
4. Record the occupied bandwidth in Table 6-6, below.

6.3.1.3 Occupied Bandwidth Test Results

Measured occupied bandwidth as mentioned in Table 6-6.

Table 6-6 Occupied Bandwidth

	NGT-9000 Occupied Bandwidth		
	Measurement	**Top antenna**	**Bottom antenna**
TAS	**ATCRBS (1030 MHz)**	7.1634 MHz	N/A
XPDR	**Mode S (1090 MHz)**	8.4484 MHz	7.9775 MHz
	ATCRBS (1090 MHz)	7.6566 MHz	7.6163 MHz

6.4 Spurious Emissions at Antenna Terminals

47CFR Reference:
2.1051, Spurious Emissions at Antenna Terminals
87.139, Emission Limitations

47CFR2.1051 states that the radio frequency voltages 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.

47CFR2.1051 says that curves or equivalent data shall show the magnitude of each harmonic and other spurious emission that can be detected when the equipment is operated under the conditions specified in Sec 2.1049 (Occupied Bandwidth) as appropriate.

6.4.1 Spurious Emissions at Antenna Terminals Test Equipment Required

Table 6-7: Spurious Emissions at Antenna Terminals Test Equipment Required

Block Diagram Reference	Type	Manufacturer	Model
A	NGT-9000 Test Unit	ACSS	9029000-20000
B	NGT VALFAC	ACSS	9006052-001 and 9000717-002
C	Spectrum Analyzer		

Comment: Equivalent equipment may be used.

6.4.1.1 Spurious Emissions at Antenna Terminals Test Setup

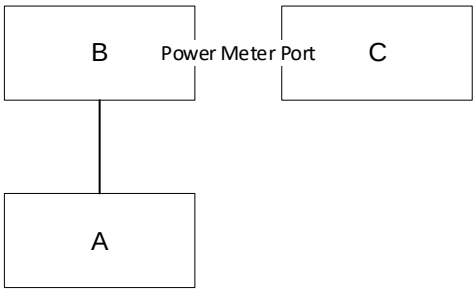

Figure 6-4: Spurious Emissions at Antenna Terminals Test Setup

6.4.1.2 Spurious Emissions at Antenna Terminals Test Procedure

For XPDR Transmissions

1. Connect the equipment as shown in Figure 6-4 above. It is also acceptable to insert a directional coupler between A and B and measure the power at the coupled port.

   Using VALFAC Scripts:
   - Configure the VALFAC script tool to run DO181E_23221_modes_top.scp, DO181E_23221_modes_bot.scp (Mode S, Long DF-20 replies at 50 Hz on top/bottom antennas, respectively) and then DO181E_23221_atcrbs_top.scp and DO181E_23221_atcrbs_bot.scp (ATCRBS, Mode A replies at 500 Hz on top/bottom antennas with Mode A code set to 0xFFF).

   Using IFR:
   - Configure the VALFAC TCAS GUI tool with correct APM configuration and select Run.
   - To use the IFR, the optional directional coupler must be used for measurements. Instead of connecting the directional coupler to B above, it must be connected to the output of the IFR.
   - Setup IFR for ATCRBS:
     - Select C10 and F01 for ATCRBS. Select Mode A reply using front panel switch. Set PRF to 500.
     - Set output Switch to NORM.
   - Setup IFR for MODE-S:
     - Select C10 and F02 for MODE-S. Set PRF to 50.
     - Select S Menu and configure for UF=4, RR=12, AA=*LRU Mode-S Address(normally 0000C8)*. (This will solicit a DF-20 Long Mode-S Reply)
     - Set output Switch to NORM.

2. Measure and plot all spurs below 2000 MHz. Use 200 MHz spans and a 300 kHz IF bandwidth on the Spectrum Analyzer.

For TAS Transmissions

1. Open the serial terminal window and connect to Com 1 at 115200 baud.
2. Activate the terminal and type, “testmode set 3”
3. Enter the following command, “tcas ws 7t” for a 50 Hz transmission of the highest power Mode C interrogation (S1, P1, and P3).
4. Measure and plot all spurs below 2000 MHz. Use 200 MHz spans and a 300 kHz IF bandwidth on the Spectrum Analyzer.

6.4.1.3 Spurious Emissions at Antenna Terminals Test Results

Refer to Appendix A for NGT-9000 test results for Spurious Emissions at the Antenna Terminals

6.5 Field Strength of Spurious Radiation

47CFR References:
2.1053, Field Strength of Spurious Radiation
87.139, Emission Limitations

6.5.1 Field Strength of Spurious Radiation Test Equipment Required

Table 6-8: Field Strength of Spurious Radiation Test Equipment Required

Block Diagram Reference	Type	Manufacturer	Model
A	NGT VALFAC	ACSS	9006052-001 and 9000717-002
B	NGT-9000 Test Unit	ACSS	9029000-20000
			9029000-40000
C	Antenna, Biconical		
D	Antenna, Log Per.		
E	Antenna, Horn		
F	Spectrum Analyzer		
G	Preselector		
H	Quasi-Peak		

Comment: Equivalent equipment may be used.

6.5.2 Field Strength of Spurious Radiation Test Setup

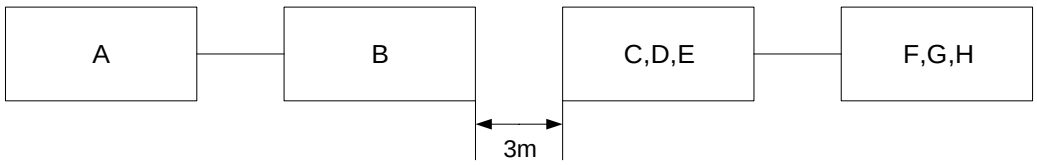

Figure 6-5: Field Strength of Spurious Radiation Test Setup

6.5.3 Field Strength of Spurious Radiation Test Procedure

1. Connect the equipment as shown in Figure 6-5, above. Note that this procedure needs to be performed twice, once with the 9029000-20000 and once with the 9029000-40000. The supply voltage is set to 28VDC.

For XPDR Transmissions:

Using VALFAC Scripts:

- Configure the VALFAC script tool to run DO181E_23222.scp (ATCRBS replies at 500 Hz and Mode S, replies at 50 Hz on top antenna). This will cause the transmitter to radiate at its maximum duty cycle.

Using IFR:

- Configure the VALFAC TCAS GUI tool with correct APM configuration and select Run.
- To use the IFR, the optional directional coupler must be used for measurements. Instead of connecting the directional coupler to B above, it must be connected to the output of the IFR.
- Setup IFR for Interlaced Mode-S and ATCRBS:
    - Select C10 and F05 for INTLCE, Ratio 1:10. Set PRF to 500.
    - Select Mode A with switch on front panel.
    - Select S Menu and configure for UF=4, RR=12, AA=*LRU Mode-S Address (normally 0000C8)*. (This will solicit a DF-20 Long Mode-S Reply)
    - Set output Switch to NORM.

For TAS Transmissions

- Open the serial terminal window and connect to Com 1 at 115200 baud.
- Activate the terminal and type, “testmode set 3”
- Enter the following command, “tcas ws 7t” for a 50 Hz transmission of the highest power Mode C interrogation (S1, P1, and P3), or “tcas ws 7c” for a 50 Hz transmission of the highest power Mode A interrogation (P1 and P3 only)

2. Measure and record all spurious emissions using the appropriate antenna at a distance of 3 meters.

6.5.4 Field Strength of Spurious Radiation Test Results

Refer to Appendix A for NGT-9000 test results for Field Strength of Spurious Radiation test results

6.6 Frequency Stability

6.6.1 Frequency Stability (Temperature Variation)

47CFR Reference:
2.1055, Frequency Stability
87.133, Frequency Stability

6.6.1.1 Frequency Stability (Temperature Variation) Test Equipment Required

Table 6-9: Frequency Stability (Temperature Variation) Test Equipment Required

Block Diagram Reference	Type	Manufacturer	Model
A	NGT-9000 Test Unit	ACSS	9029000-20000
B	NGT VALFAC	ACSS	9006052-001 and 9000717-002
C	Peak Power Analyzer		
D	Spectrum Analyzer		

Comment: Equivalent equipment may be used.

6.6.1.1.1 Frequency Stability (Temperature Variation) Test Setup

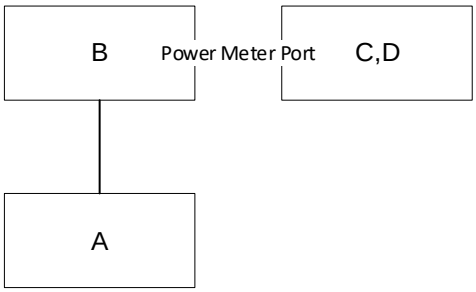

Figure 6-6: Frequency Stability (Temperature Variation) Test Setup for UAT Transmission

6.6.1.1.2 Transponder Frequency Stability (Temperature Variation) Test Procedure

1. Connect the equipment as shown in Figure 6-6 above. It is also acceptable to insert a directional coupler between A and B and measure the power and frequency at the coupled port.

   Using VALFAC Scripts:
   - Configure the VALFAC script tool to run DO181E_23221_modes_top.scp, DO181E_23221_modes_bot.scp (Mode S, Long DF-20 replies at 50 Hz on top/bottom antennas, respectively).

   Using IFR:
   - Configure the VALFAC TCAS GUI tool with correct APM configuration and select Run.
   - To use the IFR, the optional directional coupler must be used for measurements. Instead of connecting the directional coupler to B above, it must be connected to the output of the IFR.
   - Setup IFR for MODE-S:
     - Select C10 and F02 for MODE-S. Set PRF to 50.
     - Select S Menu and configure for UF=4, RR=12, AA=*LRU Mode-S Address (normally 0000C8)*. (This will solicit a DF-20 Long Mode-S Reply)
     - Set output Switch to NORM.
2. Set the temperature chamber to - 30°C and allow the transmitter (non-operating) temperature to stabilize. (Comment: -30°C is used based on FCC part 2, section 2.1055, and not the minimum temperature capability of the NGT-9000).
3. Apply power to the unit and record the transmission frequency.
4. Repeat steps 3 and 4 at -20°C, -10°C, 0°C, +10°C, +20°C, +30°C, +40°C and +50°C. Perform the test using +28 VDC power.
5. Record results in tables similar to Table 6-10 below.

6.6.1.1.3 TAS Frequency Stability (Temperature Variation) Test Procedure

1. Connect the equipment as shown in Figure 6-6 above.
2. Open the Serial Terminal and connect to Com 1 at 115200 baud.
3. Activate and enter the following commands, “testmode set 3” and “tcas ws 7c” (50 Hz rate of highest level whisper/shout step)
4. Set the temperature chamber to - 50°C and allow the transmitter (non-operating) temperature to stabilize.
5. Apply power to the unit and record the transmission frequency.
6. Repeat steps 4 and 5 at –40°C, -30°C, -20°C, -10°C, 0°C, +10°C, +20°C, +30°C, +40°C and +50°C. Perform the test using +28 VDC power.
7. Record results in tables similar to Table 6-10 below.

6.6.1.1.4 Frequency Stability (Temperature Variation) Test Results

The transmission frequency offset and the peak power output values recorded during the temperature variation test are tabulated in Table 6-10.

Table 6-10: Frequency Stability (Temperature Variation) Test Results TAS

Top Antenna		
Measurement	**28VDC**	**Limits**
Temperature Deg C	**Measured Frequency (MHz)**	**Frequency (MHz)**
-30	1030.01	1030 ± 0.1
-20	1030.005	1030 ± 0.1
-10	1030.00625	1030 ± 0.1
0	1030.0025	1030 ± 0.1
10	1029.9975	1030 ± 0.1
20	1029.99625	1030 ± 0.1
30	1029.996430	1030 ± 0.1
40	1029.99125	1030 ± 0.1
50	1029.99125	1030 ± 0.1

Table 6-11: Frequency Stability (Temperature Variation) Test Results XPDR

Top Antenna		
Measurement	**28VDC**	**Limits**
Temperature Deg C	**Measured Frequency (MHz)**	**Frequency (MHz)**
-30	1089.9975	1090 ± 1.0
-20	1090.00125	1090 ± 1.0
-10	1090.005	1090 ± 1.0
0	1090.0025	1090 ± 1.0
10	1089.99625	1090 ± 1.0
20	1089.996254	1090 ± 1.0
30	1089.997275	1090 ± 1.0
40	1089.99375	1090 ± 1.0
50	1089.98875	1090 ± 1.0

6.6.2 Frequency Stability (Primary Power Variation)

47CFR references:
2.1055, Frequency Stability
87.133, Frequency Stability

For the 14 VDC power, 85%/115% = 11.9 VDC/16.1 VDC will be used
For the 28 VDC power, 85%/115% = 23.8 VDC/32.2 VDC will be used

6.6.2.1 Frequency Stability (Primary Power Variation) Test Equipment Required

Table 6-12: Frequency Stability (Primary Power Variation) Test Equipment Required

Block Diagram Reference	Type	Manufacturer	Model
A	NGT-9000 Test Unit	ACSS	9029000-20000
B	NGT VALFAC	ACSS	9006052-001 and 9000717-002
C	Peak Power Analyzer		
D	Spectrum Analyzer		

Comment: Equivalent equipment may be used.

6.6.2.1.1 Frequency Stability (Primary Power Variation) Test Setup

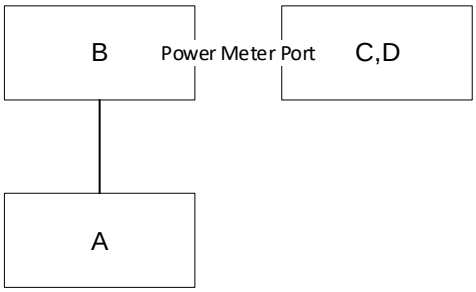

Figure 6-7: Frequency Stability (Primary Power Variation) Test Setup

6.6.2.1.2 XPDR Frequency Stability (Primary Power Variation) Test Procedure

1. Connect the equipment as shown in Table 6-7 above. It is also acceptable to insert a directional coupler between A and B and measure the power at the coupled port.

Using VALFAC Scripts:
- Configure the VALFAC script tool to run DO181E_23221_atcrbs_top.scp and DO181E_23221_atcrbs_bot.scp (ATCRBS, Mode A replies at 500 Hz on top/bottom antennas with Mode A code set to 0xFFF).

Using IFR:
- Configure the VALFAC TCAS GUI tool with correct APM configuration and select Run.
- To use the IFR, the optional directional coupler must be used for measurements. Instead of connecting the directional coupler to B above, it must be connected to the output of the IFR.
- Setup IFR for ATCRBS:

- Select C10 and F01 for ATCRBS. Select Mode A reply using front panel switch. Set PRF to 500.
- Set output Switch to NORM.

2. Apply +28VDC power to the unit and vary the primary power by +/-15% to the values shown in. Record the transmission frequency in Table 6-13.
3. Repeat step 2 for +14VDC power.

6.6.2.1.3 TAS Frequency Stability (Primary Power Variation) Test Procedure

1. Connect the equipment as shown in Table 6-7 above. It is also acceptable to insert a directional coupler between A and B and measure the power at the coupled port.
2. Open the Serial Terminal and connect to Com 1 at 115200 baud.
   Activate and enter the following commands, “testmode set 3” and “tcas ws 7c” (50 Hz rate of highest level whisper/shout step)
3. Apply +28VDC power to the unit and vary the primary power by +/-15% to the values shown in. Record the transmission frequency in Table 6-13.
4. Repeat step 3 for +14VDC power.

6.6.2.1.4 Frequency Stability (Primary Power Variation) Test Results

The transmission frequency offset values recorded during the primary power variation test are tabulated in Table 6-13.

Table 6-13: Frequency Stability (Primary Power variation) Test Results

Top Antenna			
Transmission Type	**Power Supply Voltage (V)**	**Measured Frequency (MHz)**	**Frequency Limit (MHz)**
TAS	11.9	1029.998	1030 ± 0.1
	14	1029.992	1030 ± 0.1
	16.1	1030.008	1030 ± 0.1
	23.8	1030.002	1030 ± 0.1
	28	1029.995	1030 ± 0.1
	32.2	1030.0101	1030 ± 0.1
XPDR	11.9	1089.99323	1090 ± 1.0
	14	1089.99457	1090 ± 1.0
	16.1	1089.99356	1090 ± 1.0
	23.8	1089.99299	1090 ± 1.0
	28	1089.99366	1090 ± 1.0
	32.2	1089.99383	1090 ± 1.0

APPENDIX A COMPLIANCE TESTING RESULTS – MESA, AZ

Appendix A

Compliance Testing Results – Mesa, AZ

FCC Part 2, Part 87

Models: NGT-9000D+ & NGT-9000RD+

Compliance Testing, LLC
Previously Flom Test Lab
EMI, EMC, RF Testing Experts Since 1963

toll-free: (866) 311-3268
fax: (480) 926-3598
http://www.ComplianceTesting.com
info@ComplianceTesting.com

Test Report

Prepared for: Aviation Communication and Surveillance Systems

Model: NGT-9000D+ and NGT-9000RD+

Description: Mode-S transponder

Serial Number: LXE13068, LXE13369

FCC ID: 2ACTZMSS9019

To

FCC Part 87

Date of Issue: August 23, 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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Project No: p1960015

Poona Saber
Project Test Engineer

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All results contained herein relate only to the sample tested.

Test Report Revision History

Revision	Date	Revised By	Reason for Revision
1.0	August 23,2019	Poona Saber	Original Document
2.0	August 29,2019	Poona Saber	Revised material after Mark Smith's review
3.0	August 30,2019	Poona Saber	More revised text

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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

Please refer to http://www.compliancetesting.com/labscope.html for current scope of accreditation.

Testing Certificate Number: **2152.01**

ilac-MRA

A2LA ACCREDITED
TESTING CERT
#2152.01

FCC Site Reg. #349717

IC Site Reg. #2044A-2

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: NGT-9000D+ and NGT-9000RD+
Description: Mode-S transponder

Additional Information:
NGT-9000D+ is the panel mount unit with S/N LXE13068 and NGT-9000RD+ is the remote unit with S/N LXE13369. The panel mount and remote mount units use identical internal circuit cards with the exception of the touch screen display. Both Conducted and radiated testing is done on panel mount unit and only radiated testing is repeated on remote mount unit.

NGT-9000 is a mode S transponder that provides 1090 MHz automatic dependent surveillance-broadcast information and also supports an optional active traffic (TAS/TCAS1) 1030 MHz function.

Following is declared as type of emission for NGT-9000D system:

- Transponder (Compliant with FAA TSO C112d with deviations): 14M0M1D
- TCAS/TAS (Compliant with FAA TSO C118a & TSO C147 with deviations): 18M0V1D
- Frequency range: 1030 ± 0.01 MHz and 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. ATCRBS interrogation mode is available at 1030 MHz from only top antenna.
- Transponder system (1090 MHz) uses pulse position modulation combined with pulse width modulation (M1D) while TCAS uses pulse position and amplitude modulation (V1D)
- In TCAS mode the transmitter always transmits to only one antenna port at a time and the maximum duty cycle is 0.012%
- 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 0.239%
- Unit is powered by 14 Vdc and 28 Vdc

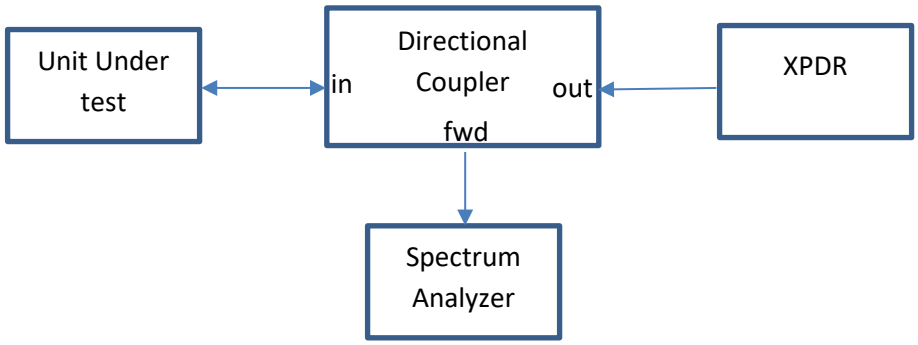
EUT Support Equipment

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 87.139 (i)(1)	Field Strength of Spurious Radiation	Pass	
2.1049, 87.139 (i)(1) 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	
2.1047	Modulation Characteristic	Pass	
2.1055, 87.133(a)	Frequency Stability (Temperature Variation)	Pass	
2.1055, 87.133(a)	Frequency Stability (Voltage Variation)	Pass	

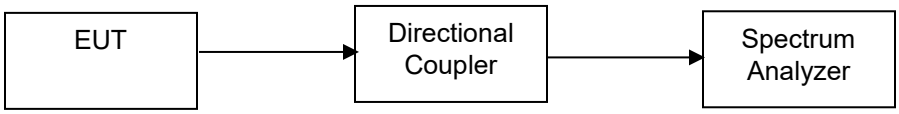
Carrier Output Power (Conducted)
Engineer: Poona Saber
Test Date: 7/9/2019

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 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 RMS power is the peak power multiplied by duty cycle of the Transponder and TCAS 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 FAA TSO-C118a AND TSO-C147 similarly to the output spectrum. In addition the Transponder output power is controlled by the requirements of FAA TSO C112d.

Test Setup



Output Power for TCAS System

Frequency	Antenna	Mode	Measured Power Peak (dBm)	Measured Power Peak (W)	Duty Cycle	Average power (W)	Average power (dBm)
1030 MHz	TOP	C	53.32	214.78	0.012 %	0.0258	14.1

Output Power for Transponder System

Frequency	Antenna	Mode	Measured Power Peak (dBm)	Measured Power Peak (W)	Duty Cycle	Average power (W)	Average power (dBm)
1090 MHz	TOP	ATCRBS	53.78	238.78	0.33%	0.7879	28.96
1090 MHz	Bottom	ATCRBS	53.98	250.03	0.33%	0.825	29.16
1090 MHz	TOP	S	53.82	240.99	0.239%	0.7952	29
1090 MHz	Bottom	S	53.92	246.60	0.239%	0.8137	29.1

See Appendix A for test plots

Conducted Spurious Emissions

Engineer: Poona Saber

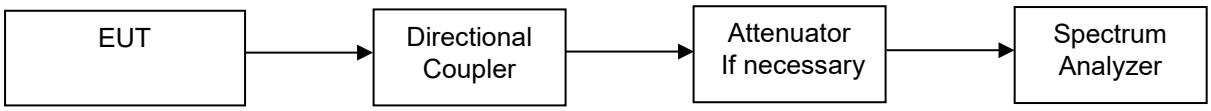
Test Date: 7/10/19

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
1030 MHz	Top	2058	-42.15	14.1	56.25	≥40	PASS
1090 MHz ATCRBS	Top	2180.15	-11.17	28.96	40.13	≥40	PASS
1090 MHz ATCRBS	Bottom	2179	-18.20	29.16	47.36	≥40	PASS
1090 MHz Mode S	Top	2179	-14.14	29	43.14	≥40	PASS
1090 MHz Mode S	Bottom	5449	-19.53	29.1	48.63	≥40	PASS

See Appendix B for test results

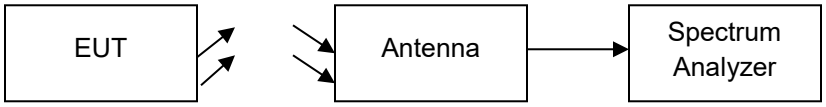
Radiated Spurious Radiation
Engineer: Poona Saber
Test Date: 7/12/19

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.

Radiated measurements are done on both Panel mount and Remote mount units.

Test Setup



See Appendix C for test results

Occupied Bandwidth

Engineer: Poona Saber

Test Date: 7/8/19

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 M1D is 14 MHz and V1D is 18 MHZ.

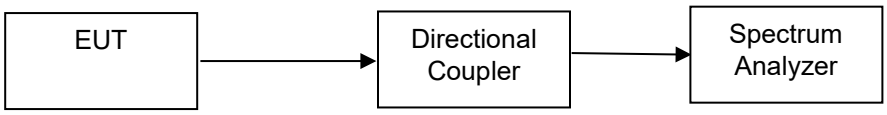
Operation of the TCAS (1030 MHz) system is administrated (licensed) by FAA in accordance with FAA TSO C-118a or TSO C-147. TCAS minimum operational performance standards (MOPS) are provided in RTCA document DO-197A. The allowable -20 dB bandwidth is specified in section 2.2.3.2.1 of DO-197a to be less than 40 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 Appendix D for Test Results

Emission Masks (Occupied Bandwidth)

Engineer: Poona Saber

Test Date: 7/9/19

Test Procedure

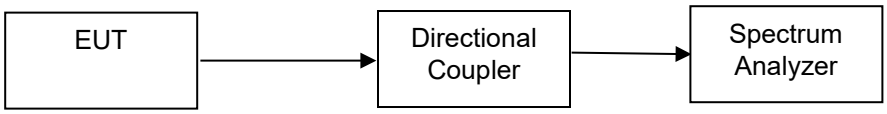
The EUT was connected with a directional coupler to a spectrum analyzer to verify that the EUT meets the required emissions mask requirements of part 87.139 (a) (1) & (2) as below. The RBW was set as close as possible to 1%-5% of the occupied bandwidth to ensure accurate readings.

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 Appendix E for Test Results

Frequency Stability (Temperature Variation)

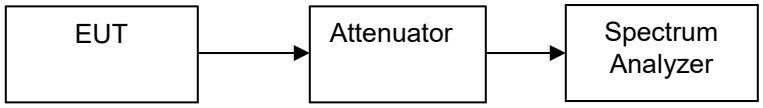
Engineer: Poona Saber

Test Date: 7/10/19

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

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	1030010000	10600.000000	30600.000000
		1030020600	1029979400		-20	1030005000	15600.000000	25600.000000
		1030020600	1029979400		-10	1030006250	14350.000000	26850.000000
		1030020600	1029979400		0	1030002500	18100.000000	23100.000000
		1030020600	1029979400		10	1029997500	23100.000000	18100.000000
		1030020600	1029979400		20	1029996250	24350.000000	16850.000000
		1030020600	1029979400		30	1029996430	24170.000000	17030.000000
		1030020600	1029979400		40	1029991250	29350.000000	11850.000000
		1030020600	1029979400		50	1029991250	29350.000000	11850.000000

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	1089997500	24300.000000	19300.000000
		1090021800	1089978200		-20	1090001250	20550.000000	23050.000000
		1090021800	1089978200		-10	1090005000	16800.000000	26800.000000
		1090021800	1089978200		0	1090002500	19300.000000	24300.000000
		1090021800	1089978200		10	1089996250	25550.000000	18050.000000
		1090021800	1089978200		20	1089996254	25546.000000	18054.000000
		1090021800	1089978200		30	1089997275	24525.000000	19075.000000
		1090021800	1089978200		40	1089993750	28050.000000	15550.000000
		1090021800	1089978200		50	1089988750	33050.000000	10550.000000

Frequency Stability (Voltage Variation)

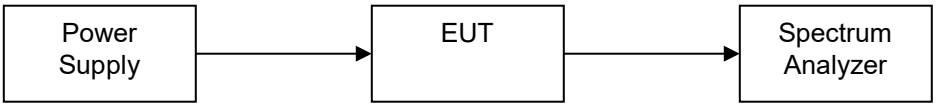
Engineer: Poona Saber

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 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

28 Vdc

Tuned Frequency (Hz)	Frequency Tolerance ppm	Upper Limit (Hz)	Lower Limit (Hz)	Nominal Voltatge	Voltage	Measured Frequency (Hz)	Upper Margin (Hz)	Lower Margin (Hz)
1,030,000,000	20.0	1030020600	1029979400	28.00	23.80	1030002000	18600	22600
		1030020600	1029979400		28.00	1029995000	25600	15600
		1030020600	1029979400		32.20	1030010100	10500	30700
1,090,000,000	20.0	1090021800	1089978200	28.00	23.80	1089992990	28810	14790
		1090021800	1089978200		28.00	1089993660	28140	15460
		1090021800	1089978200		32.20	1089993830	27970	15630

14 Vdc

Tuned Frequency (Hz)	Frequency Tolerance ppm	Upper Limit (Hz)	Lower Limit (Hz)	Nominal Voltatge	Voltage	Measured Frequency (Hz)	Upper Margin (Hz)	Lower Margin (Hz)
1,030,000,000	20.0	1030020600	1029979400	14.00	11.90	1029998000	22600	18600
		1030020600	1029979400		14.00	1029992000	28600	12600
		1030020600	1029979400		16.10	1030008000	12600	28600
1,090,000,000	20.0	1090021800	1089978200	14.00	11.90	1089993230	28570	15030
		1090021800	1089978200		14.00	1089994570	27230	16370
		1090021800	1089978200		16.10	1089993560	28240	15360

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 Table 1. 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.

Table 1: Whisper Shout Minimum Power Levels

(in Watts)	Sequence #1		Sequence #2		Sequence #3		Sequence #4		Sequence #5	
	S1	P1/P3	S1	P1/P3	S1	P1/P3	S1	P1/P3	S1	P1/P3
WSL 7									21.88	158.5
WSL 6							21.88	70.79		
WSL 5					9.77	31.62	9.77	31.62	9.77	31.62
WSL 4			4.37	14.13	4.37	14.13	4.37	14.13	4.37	14.13
WSL 3	1.95	6.31	1.95	6.31	1.95	6.31	1.95	6.31	1.95	6.31
WSL 2	0.87	2.82	0.87	2.82	0.87	2.82	0.87	2.82	0.87	2.82
WSL 1		1.26		1.26		1.26		1.26		1.26
P_{total} (W)		10.39		24.51		56.14		126.9		214.6

(in dBm)	Sequence #1		Sequence #2		Sequence #3		Sequence #4		Sequence #5	
	S1	P1/P3	S1	P1/P3	S1	P1/P3	S1	P1/P3	S1	P1/P3
WSL 7									43.4	52
WSL 6							43.4	48.5		
WSL 5					39.9	45	39.9	45	39.9	45
WSL 4			36.4	41.5	36.4	41.5	36.4	41.5	36.4	41.5
WSL 3	32.9	38	32.9	38	32.9	38	32.9	38	32.9	38
WSL 2	29.4	34.5	29.4	34.5	29.4	34.5	29.4	34.5	29.4	34.5
WSL 1		31		31		31		31		31
P_{total} (dBm)		40.2		43.9		47.5		51		53.3

Figure 1: ATCRBS Whisper Shout Interrogations

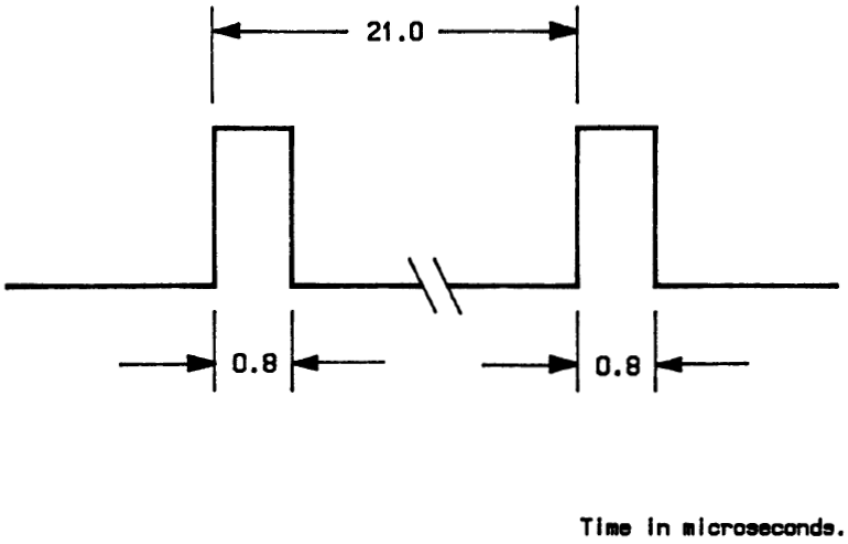


Figure 2 ATCRBS Mode C Interrogation

Pulse Widths:	0.8 ± 0.05 us
Rise Times (10% to 90%):	≥ 0.05 us, < 0.1 us
Fall Times (90% to 10%):	≥ 0.05 us, < 0.2 us

Pulses P1 and P3 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 Figure 1 through Figure 4. 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.

S1 =	-2 microseconds
P1 =	0 microseconds
P3 =	21 microseconds

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 3.

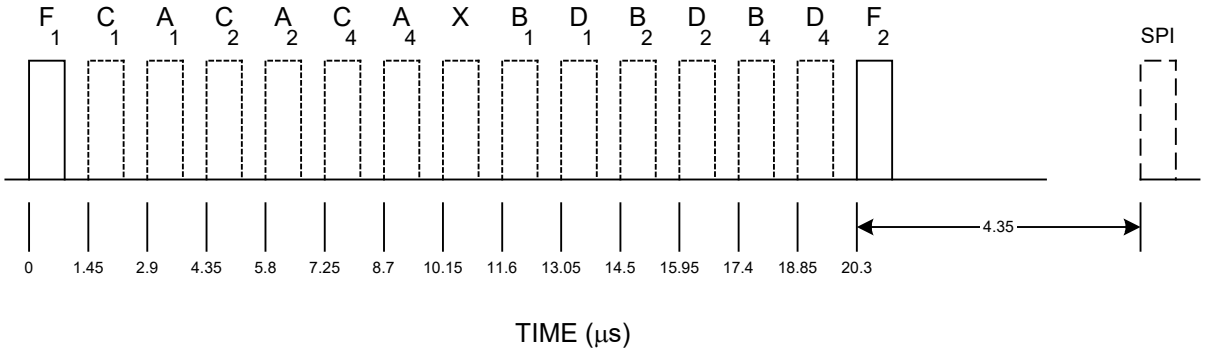


Figure 3: ATCRBS Reply

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 4.

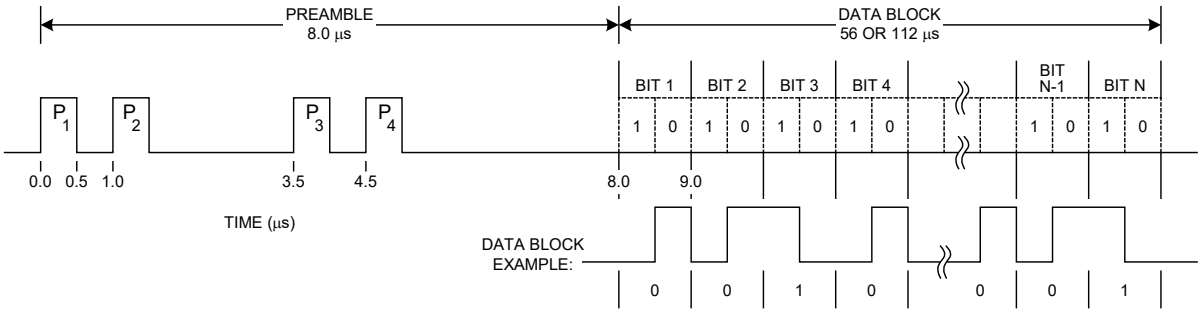


Figure 4: Mode S Reply

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.

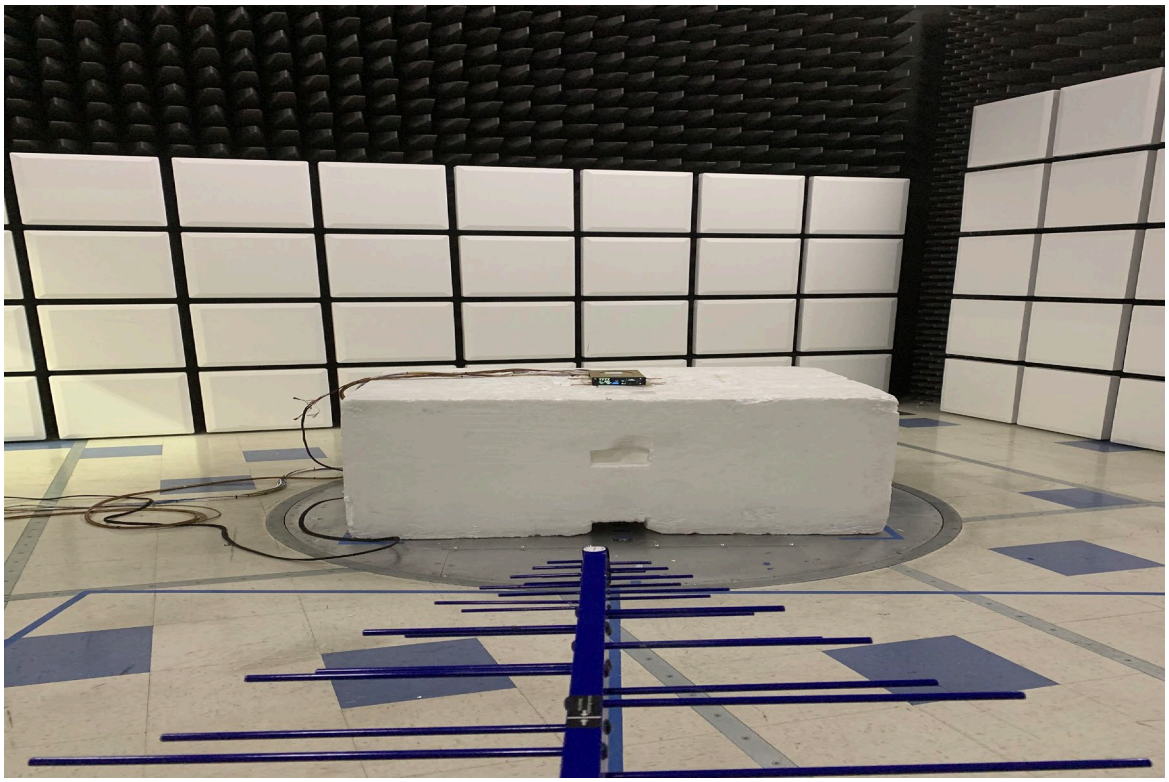
Test Equipment Utilized

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

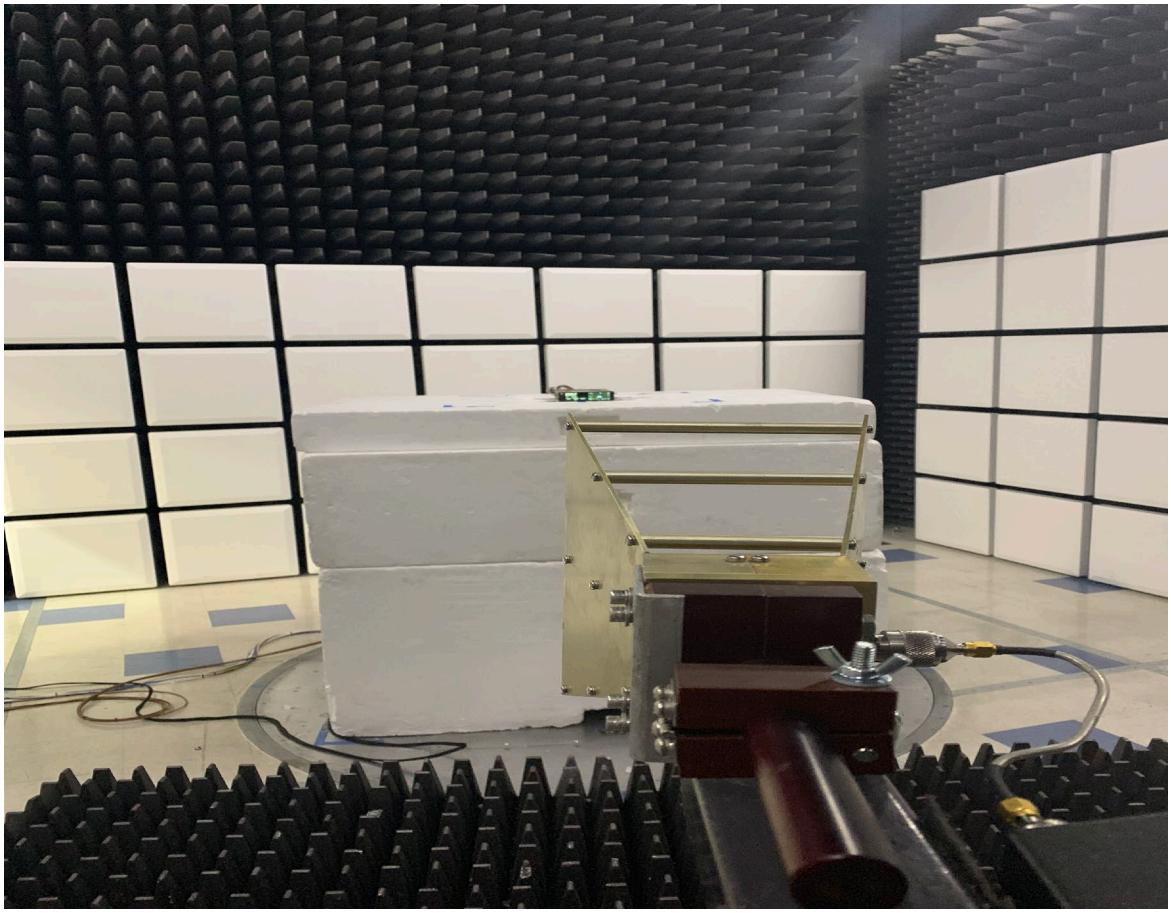
In addition to the above listed equipment standard RF connectors, Coupler and cables were utilized in the testing of the described equipment. Prior to testing these components were tested to verify proper operation.

END OF TEST REPORT

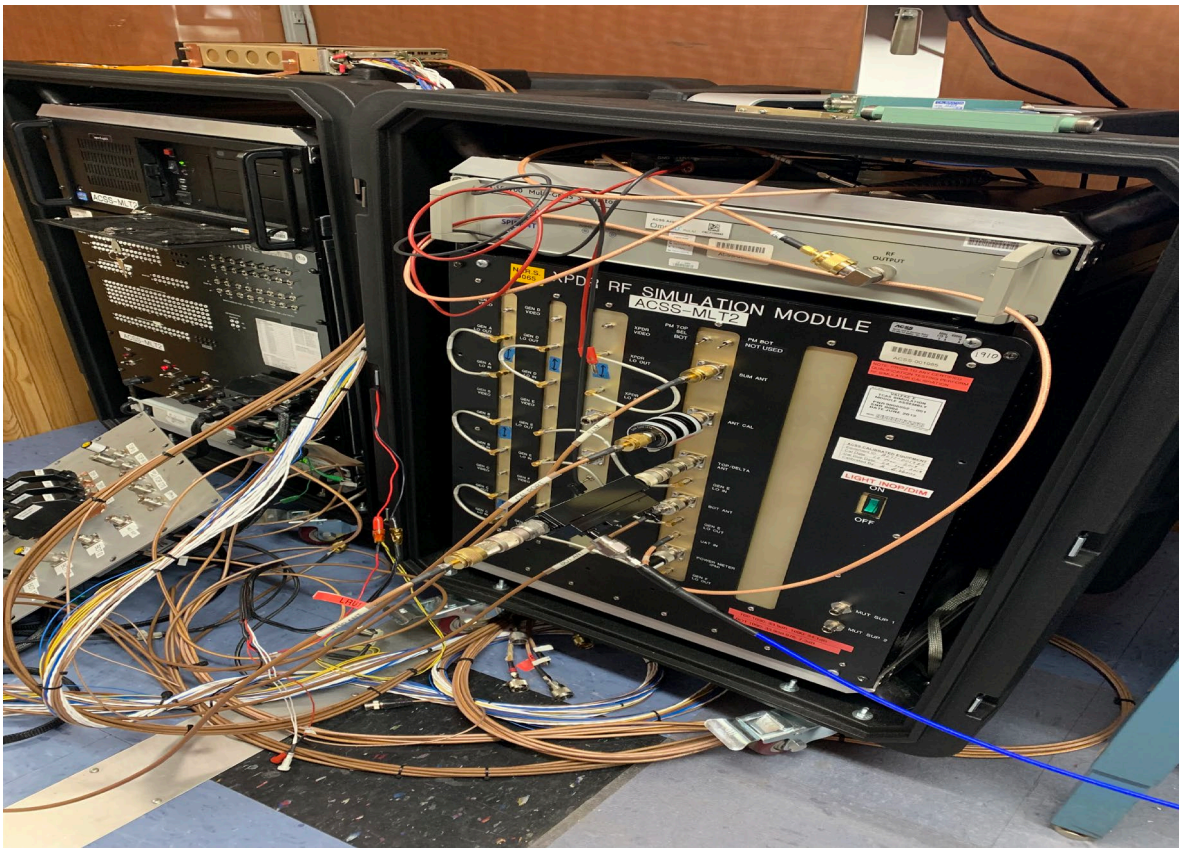
Test Setup Photos
FCC ID: P8CT3C-16



Radiated Testing 30Mhz-1Ghz



Radiated Testing 1-18Ghz

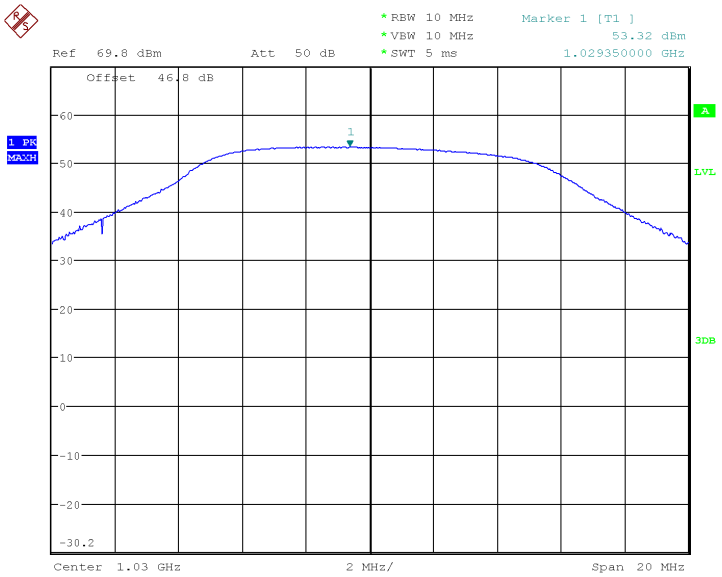


Conducted Testing setup

Annex A

Peak Power at Antenna Port

1030 Mode interogation top.BMP



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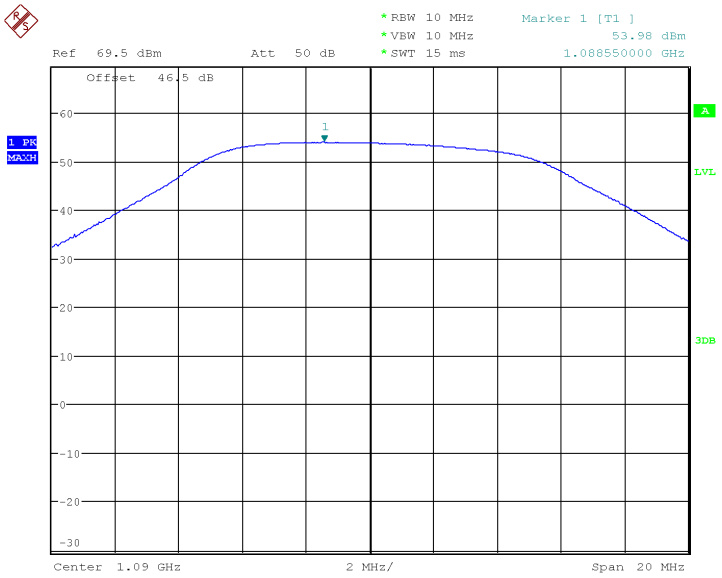
1090 mode ATCRB bottom.BMP



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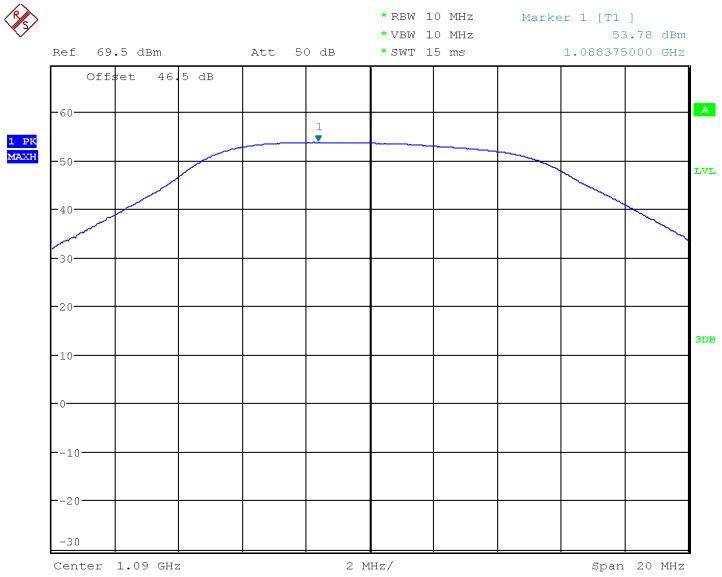
1090 mode ATCRB top.BMP



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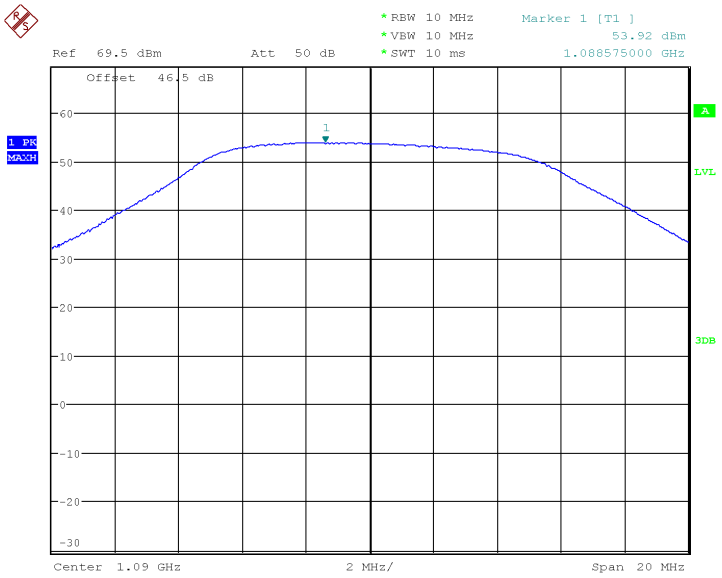
1090 mode S bottom.BMP



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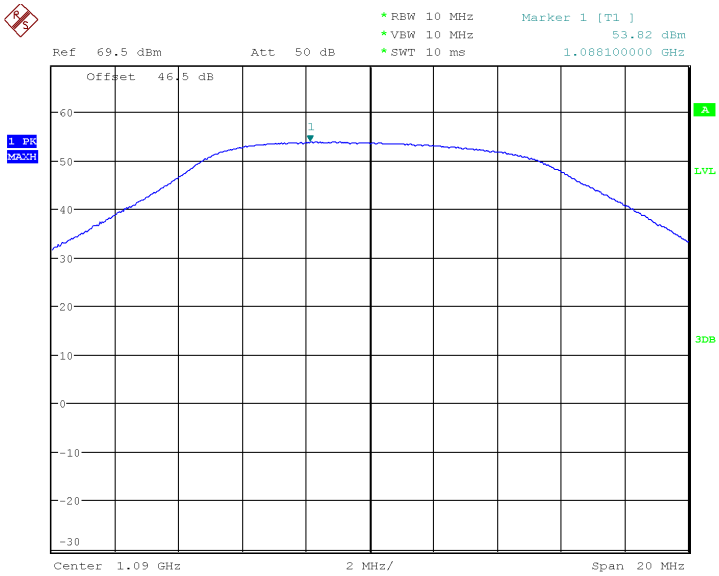
1090 mode S top.BMP



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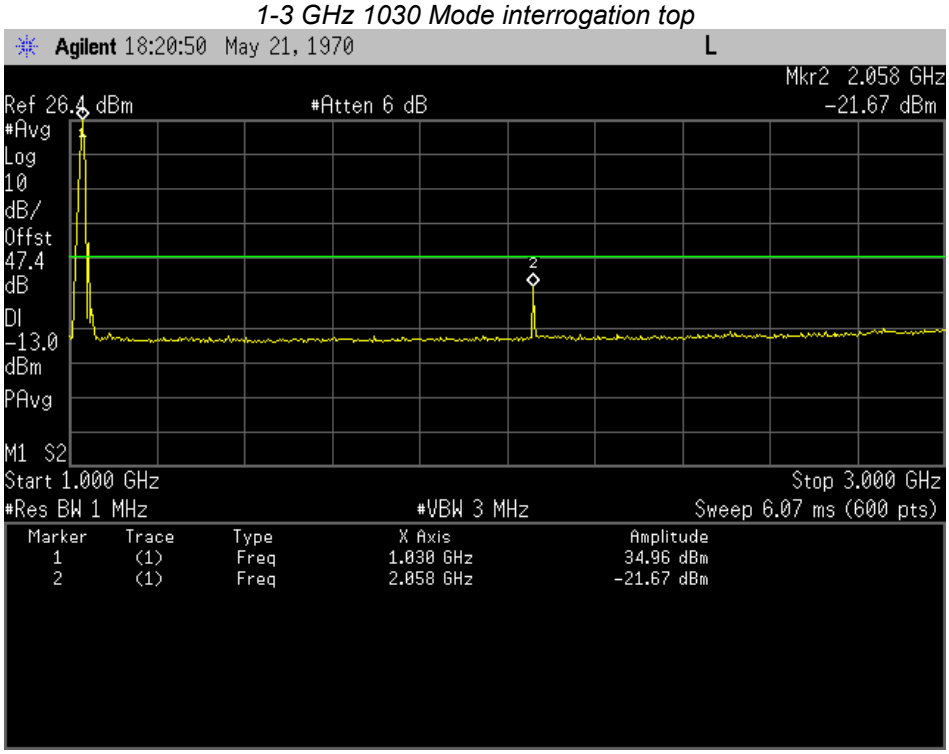
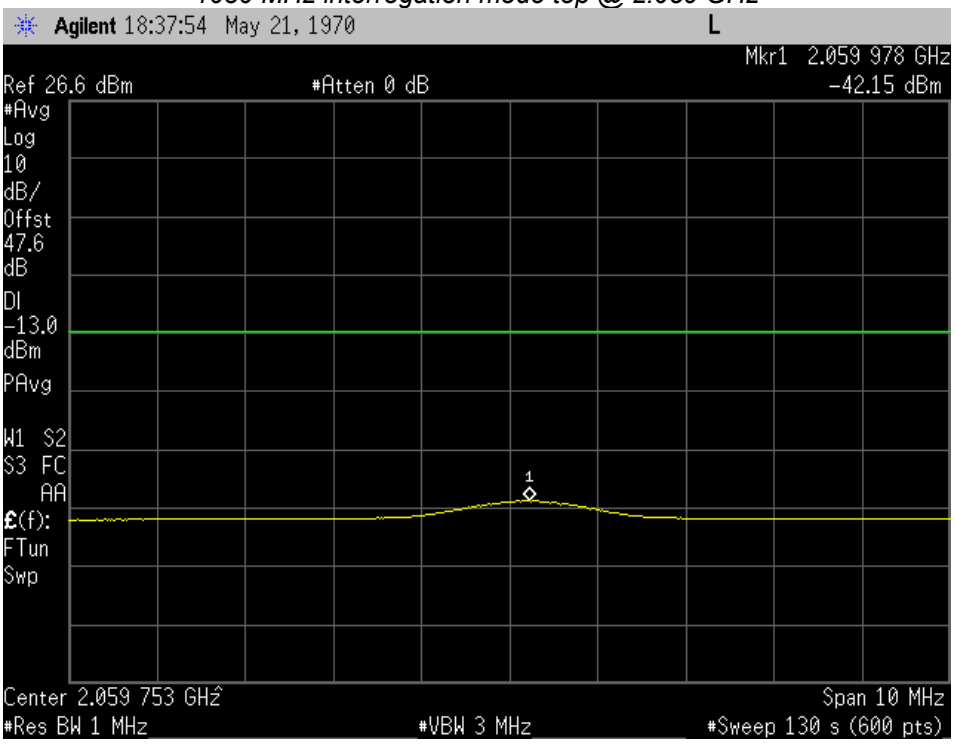
Annex B

Conducted Spurious Emissions

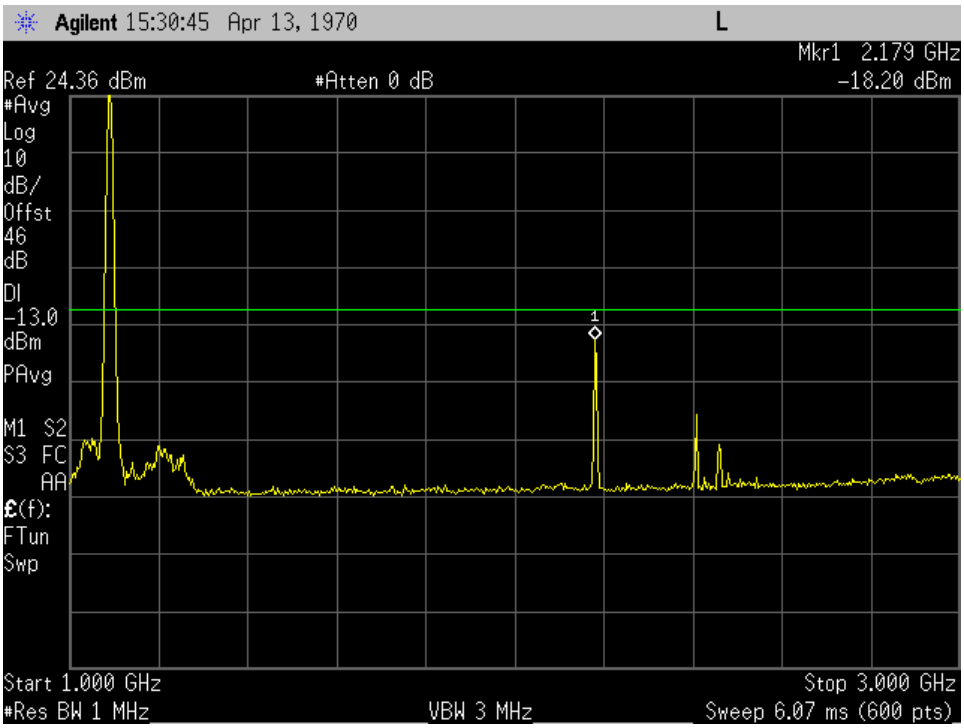
1-3 GHz 1030 Mode interrogation top



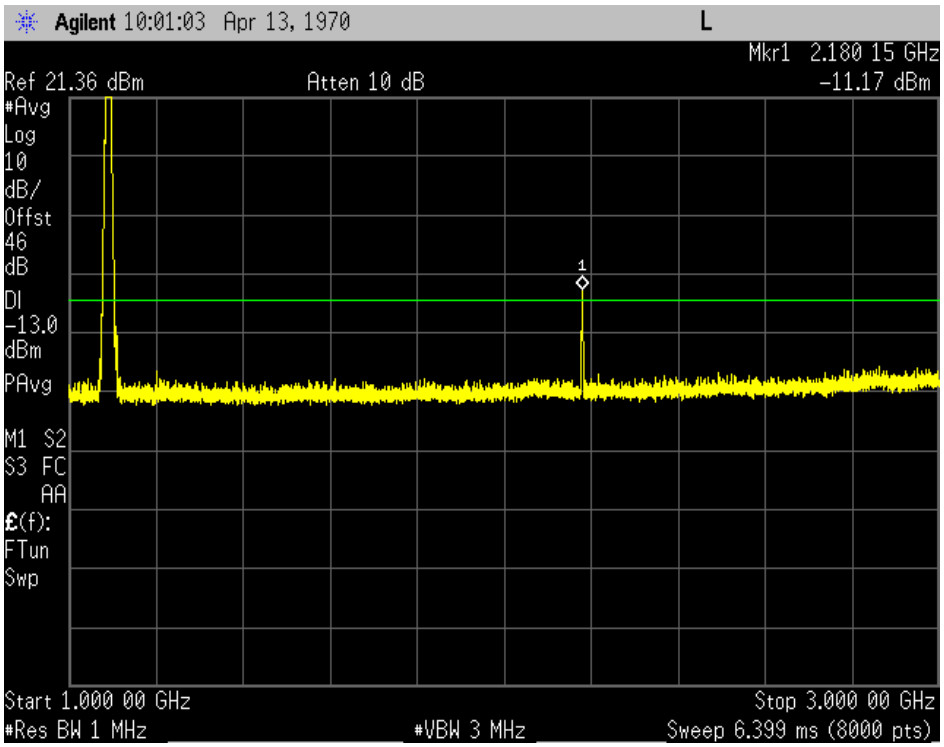
1030 MHz interrogation mode top @ 2.059 GHz



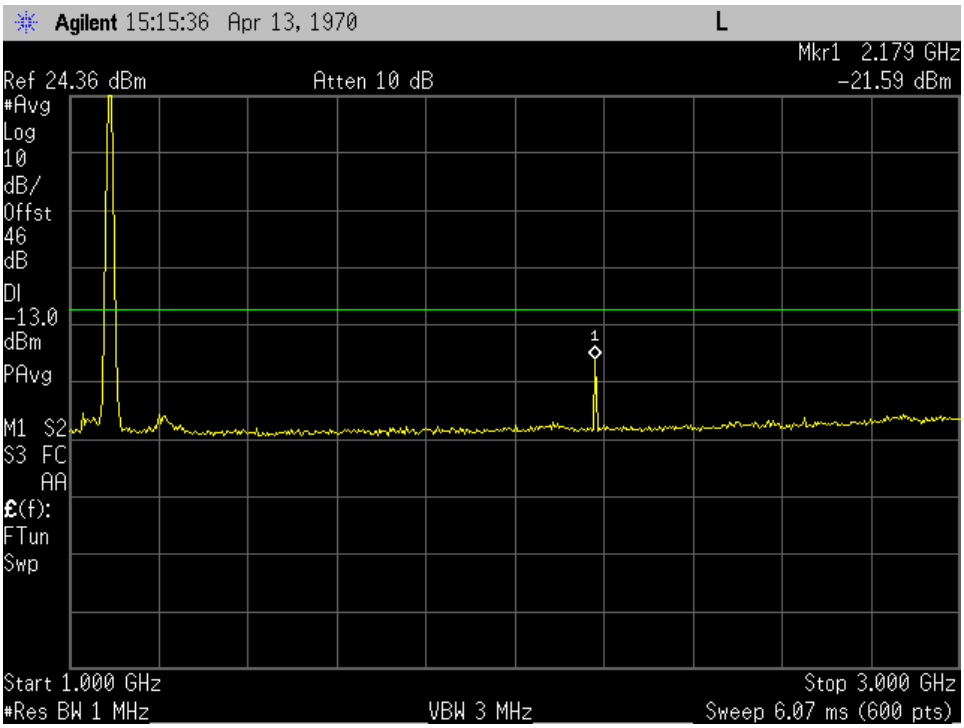
1-3 GHz 1090 ATCRB bottom



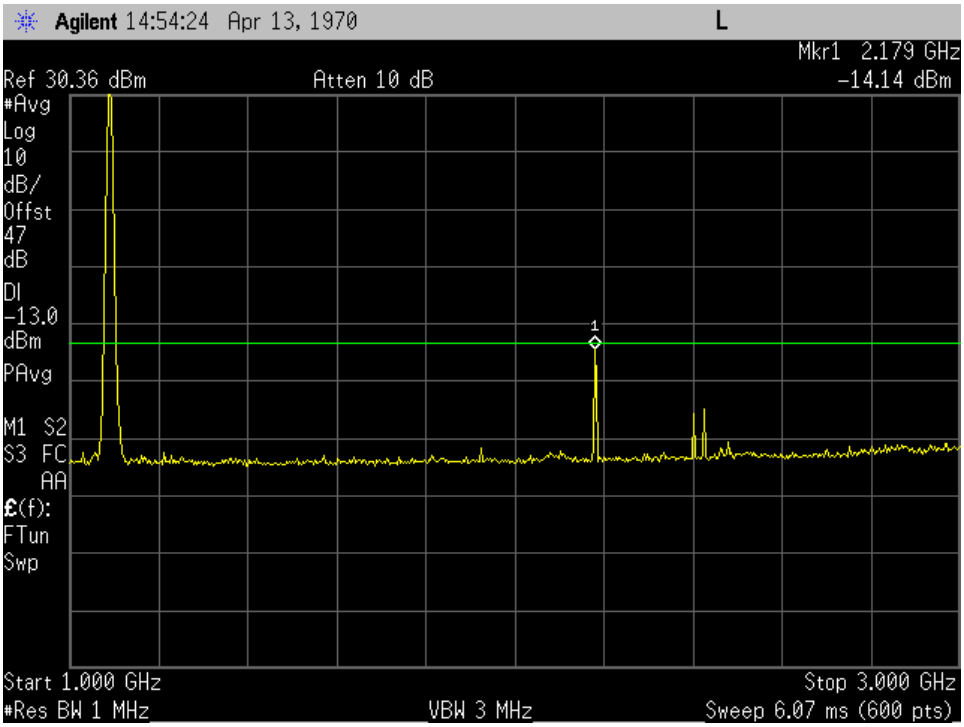
1-3 GHz 1090 ATCRB top



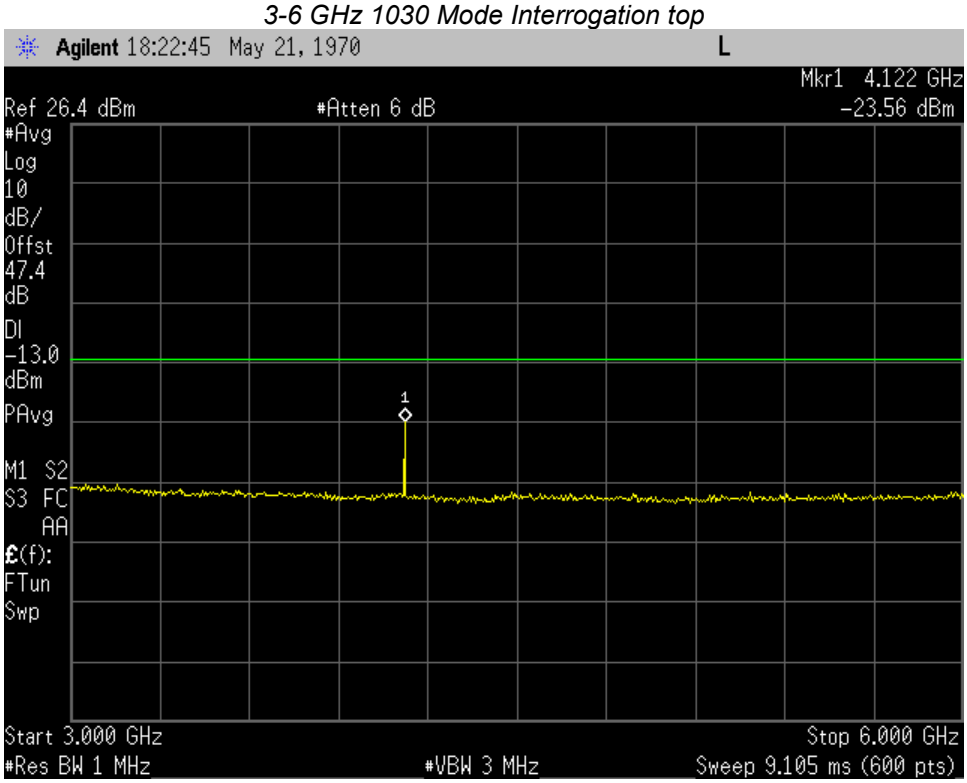
1-3 GHz 1090 Mode S bottom



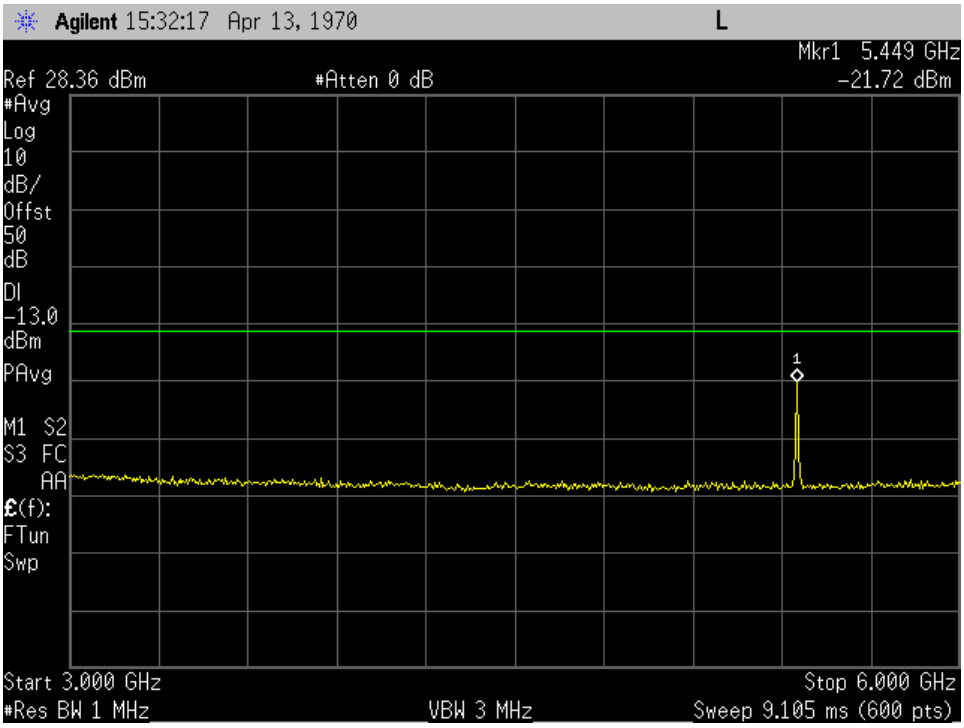
1-3 GHz 1090 Mode S top



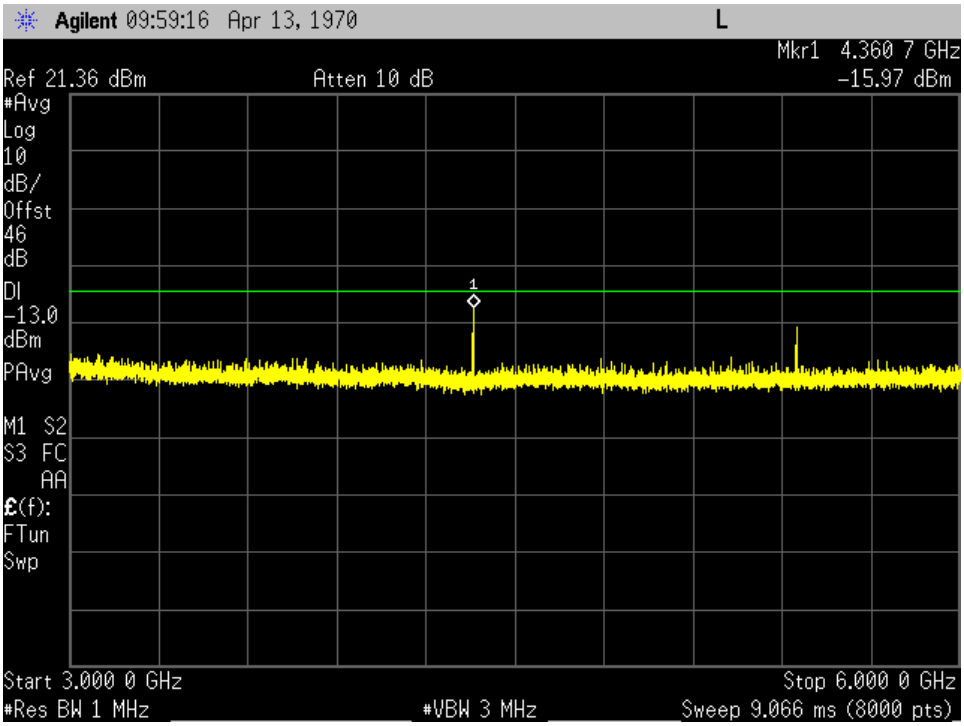
3-6 GHz 1030 Mode Interrogation top



3-6 GHz 1090 ATCRB bottom



3-6 GHz 1090 ATCRB top



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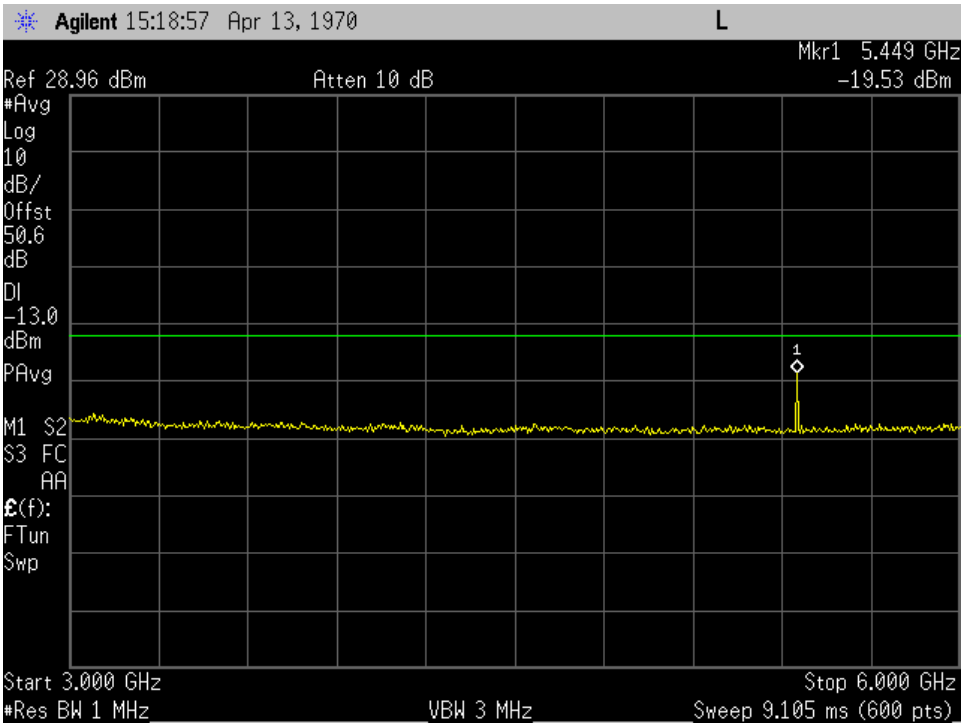
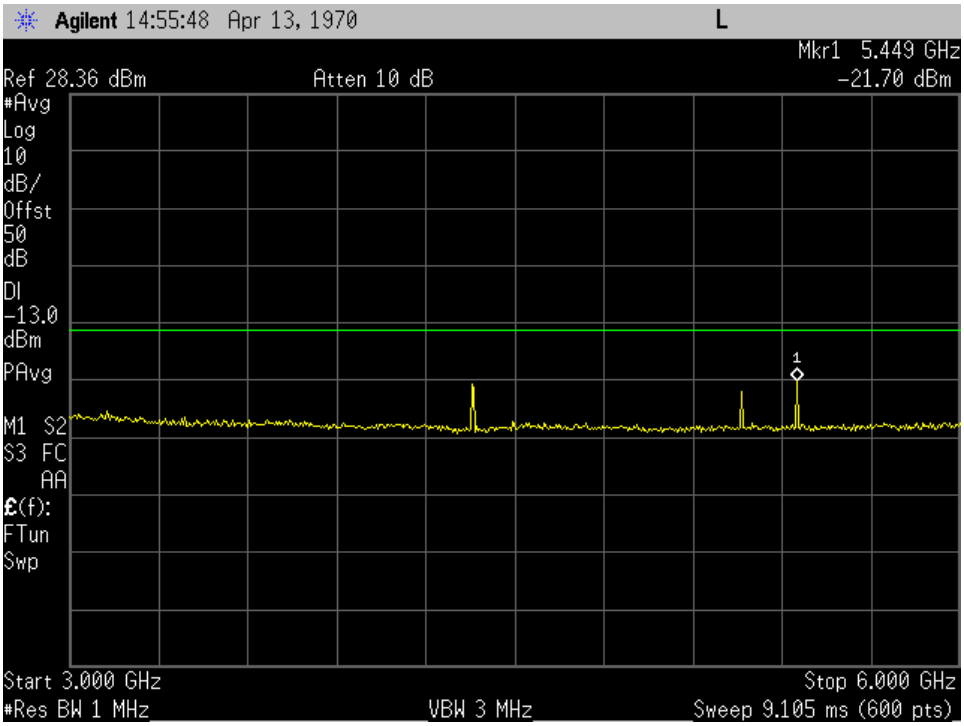
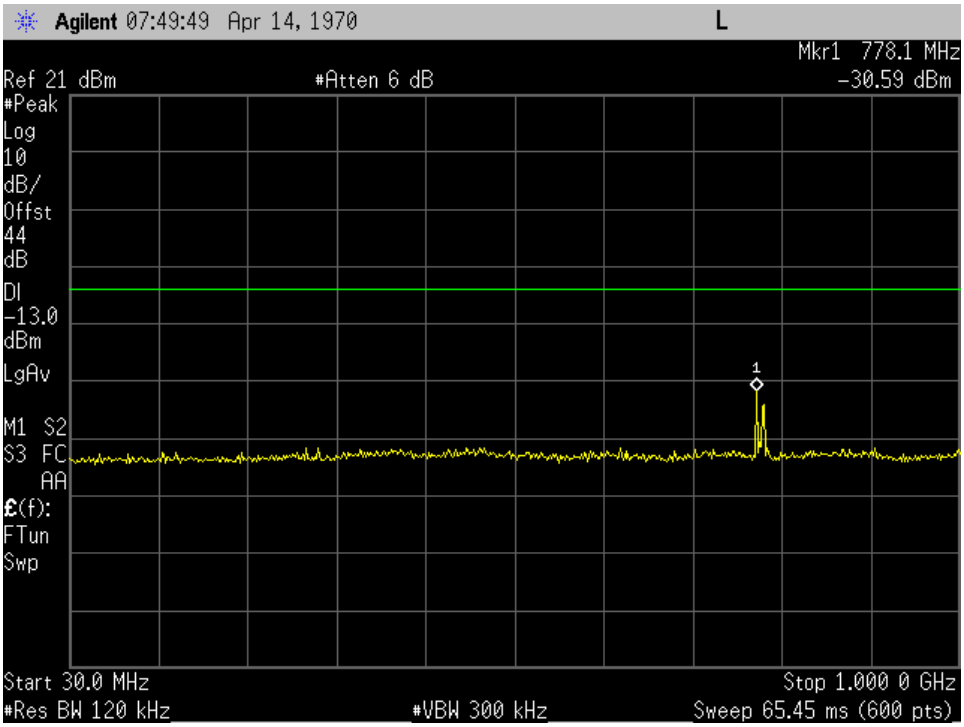


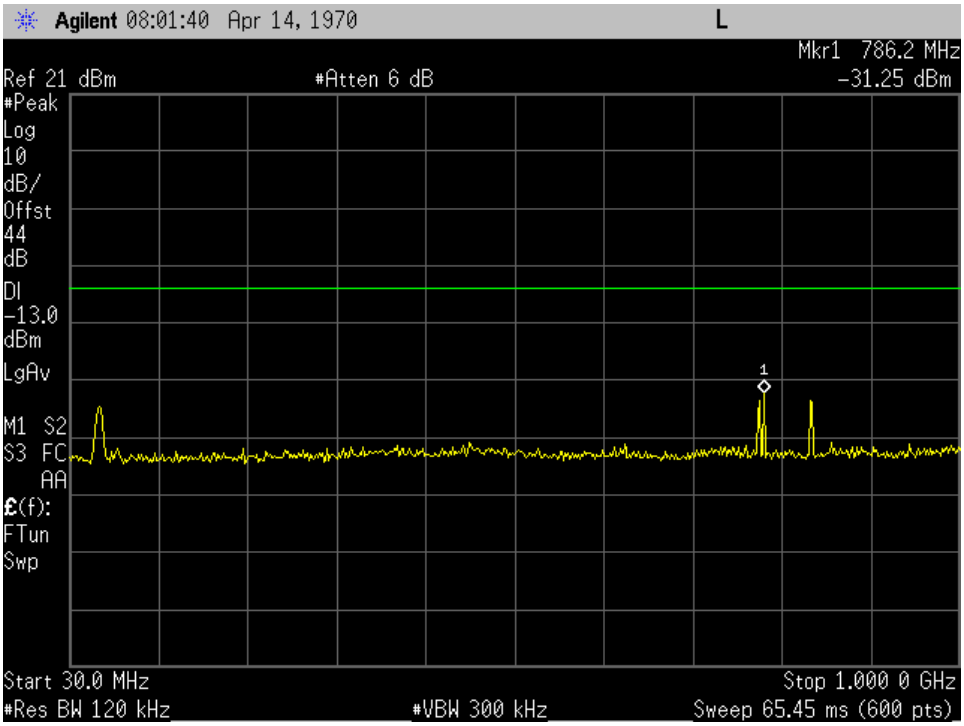
3-6 GHz 1090 Mode S top



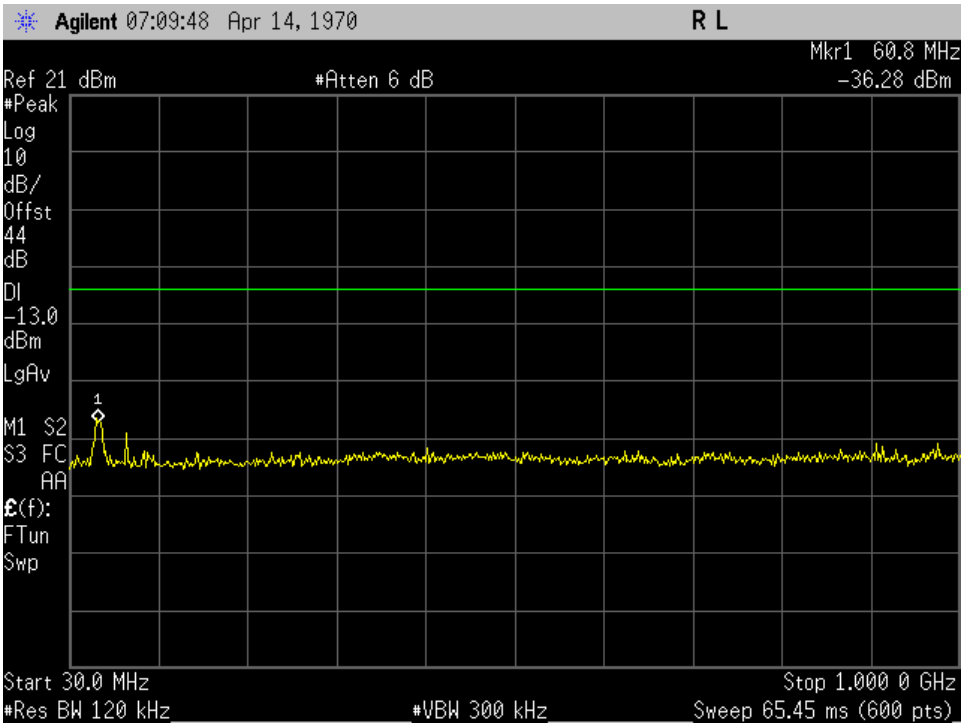
30 MHz-1GHz 1030 interrogation top



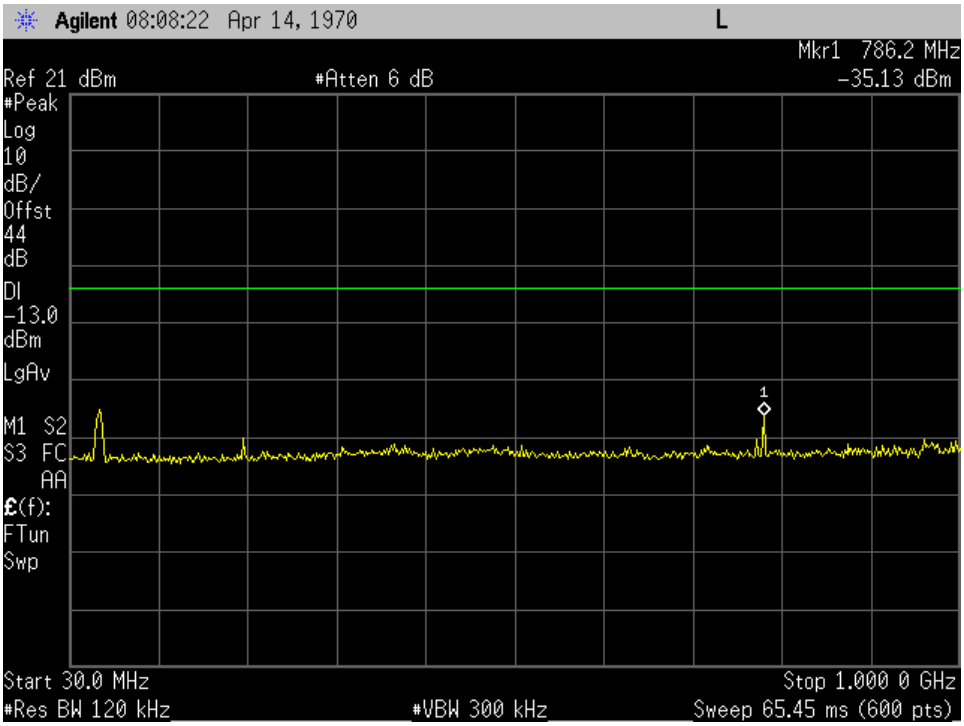
30 MHz-1GHz 1090 ATCRB bottom



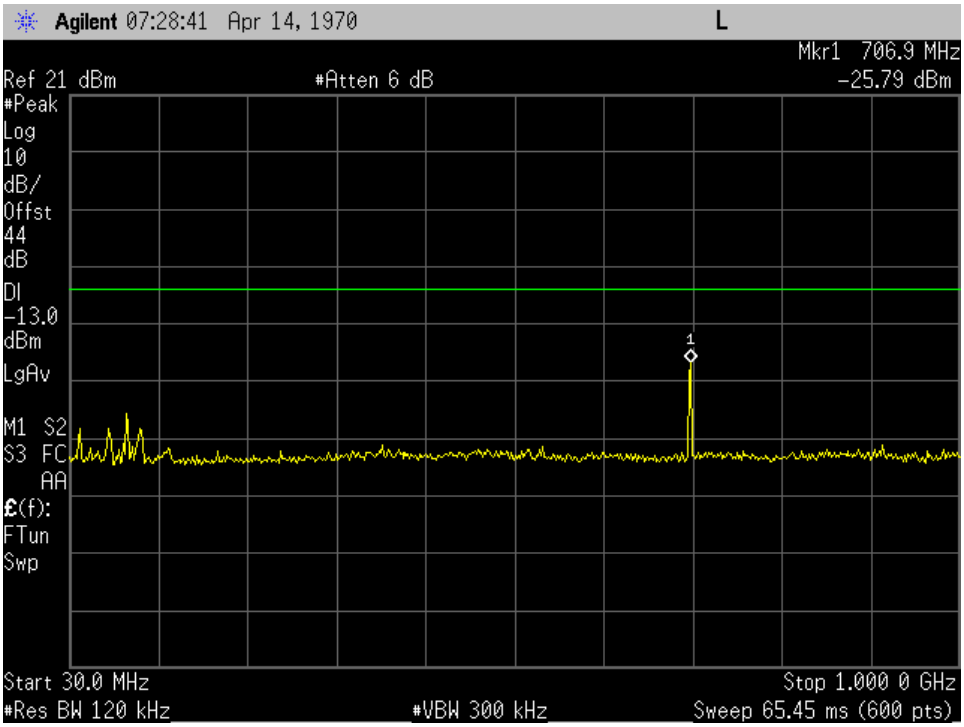
30 MHz-1GHz 1090 ATCRB top



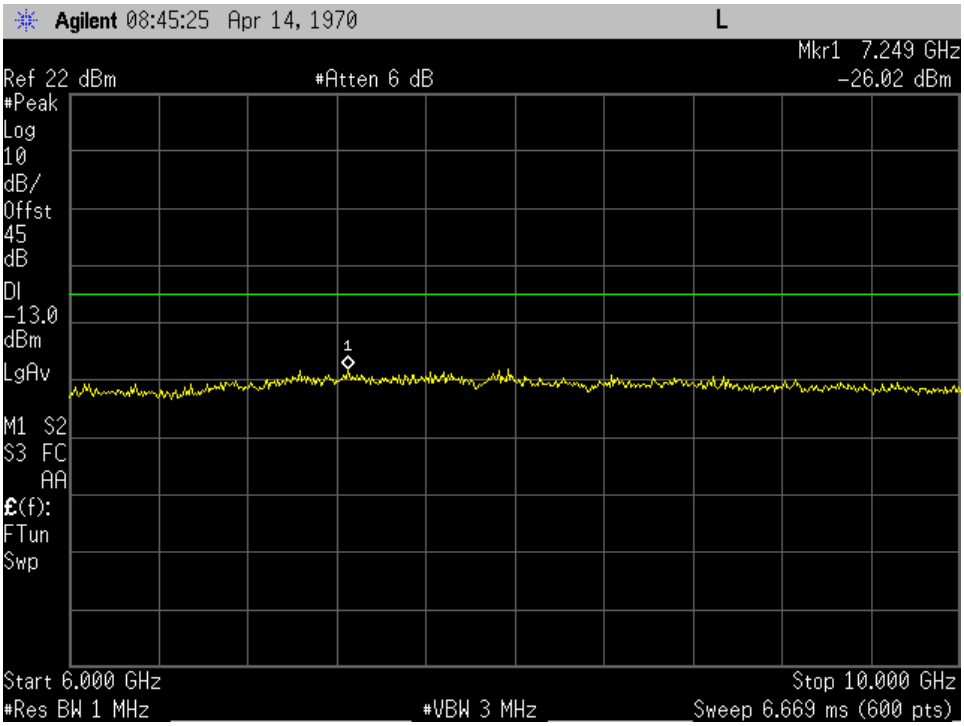
30 MHz-1GHz 1090 Mode S bottom



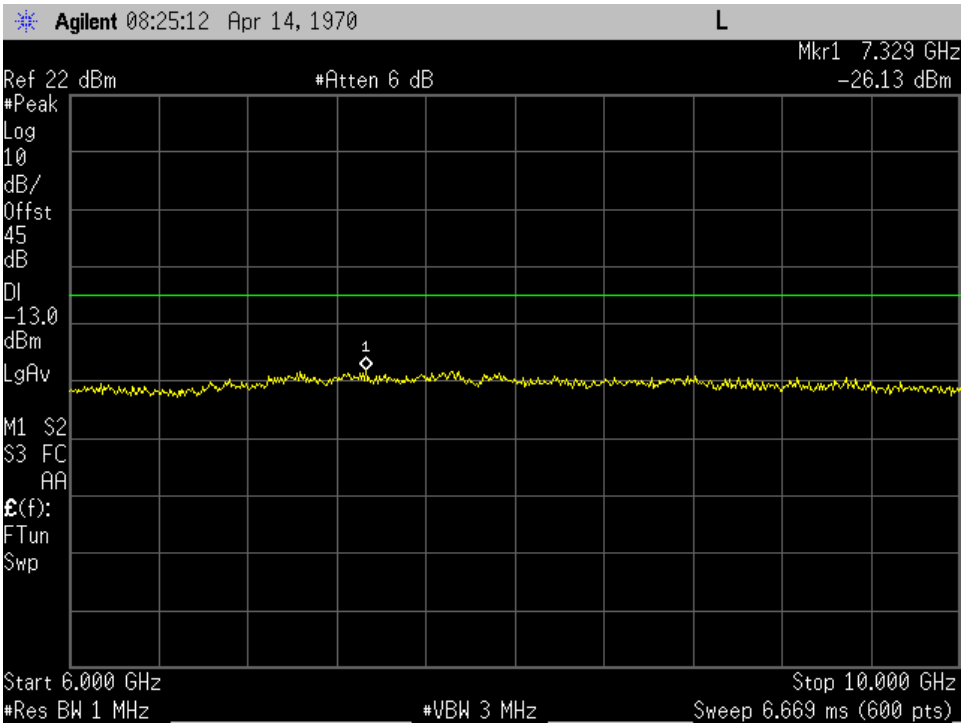
30 MHz-1GHz 1090 Mode S top



6-10 GHz 1030 interogation top



6-10 GHz 1090 ATCRB bottom



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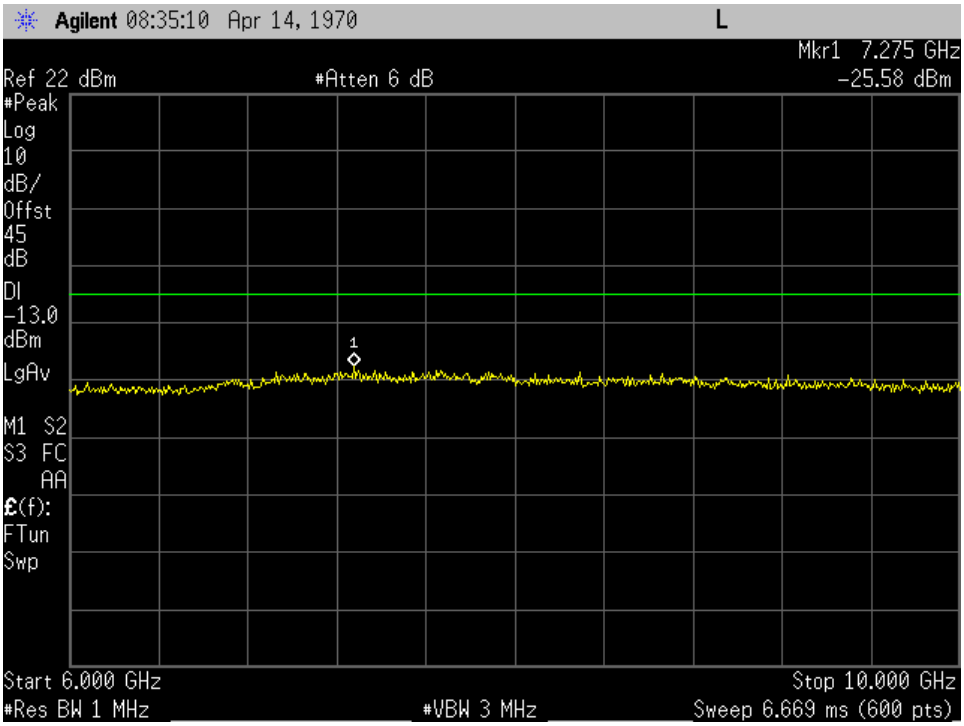
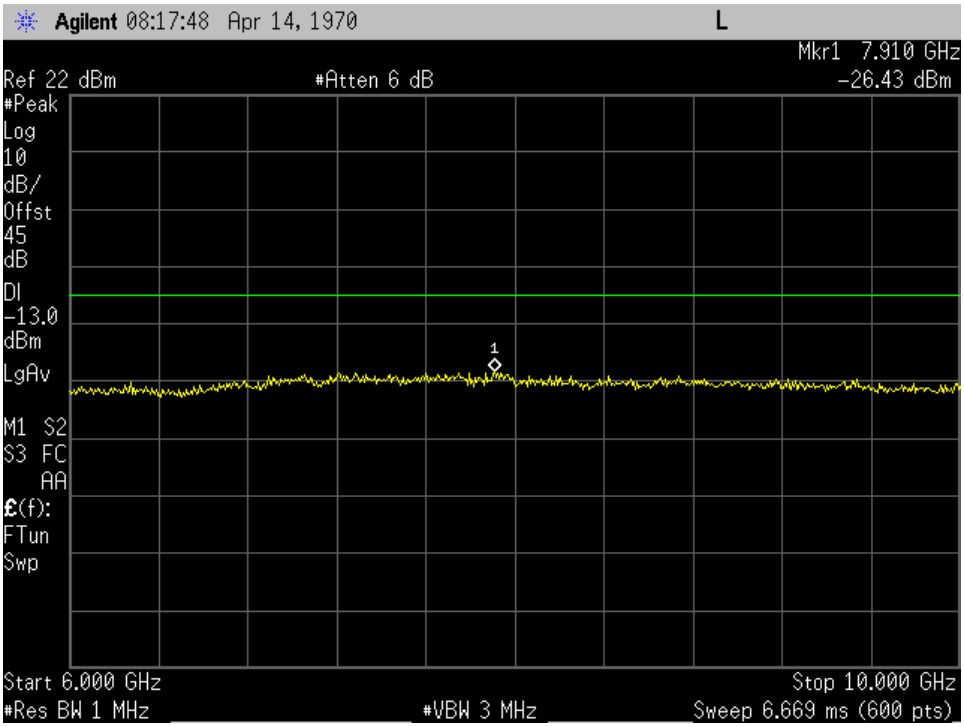
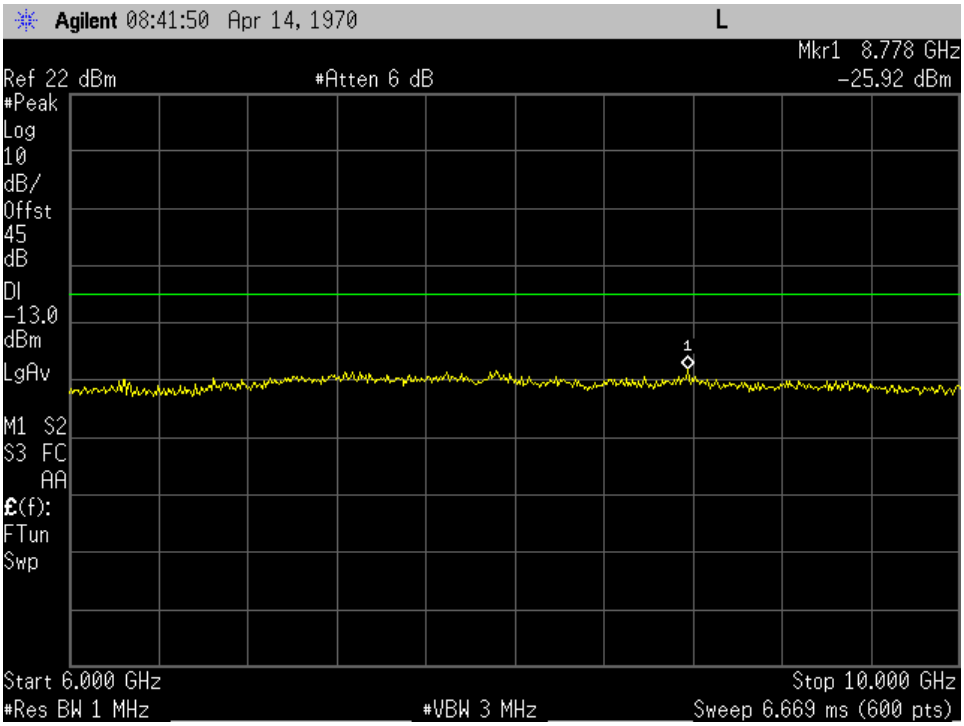


6-10 GHz 1090 Mode S bottom



6-10 GHz 1090 Mode S top



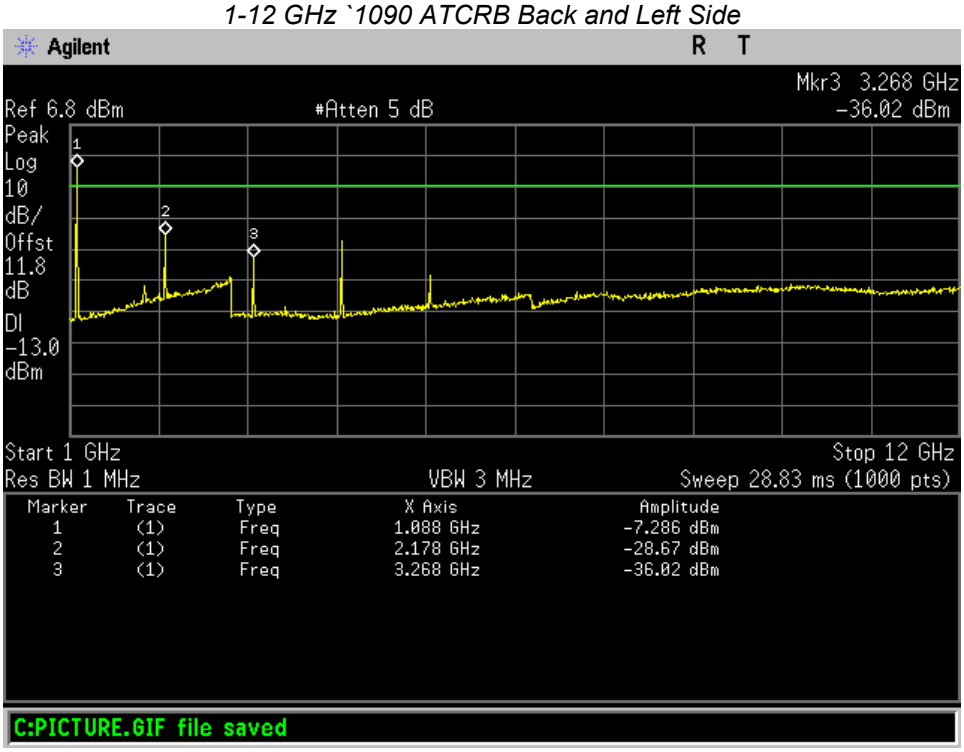
Annex C

Radiated Spurious

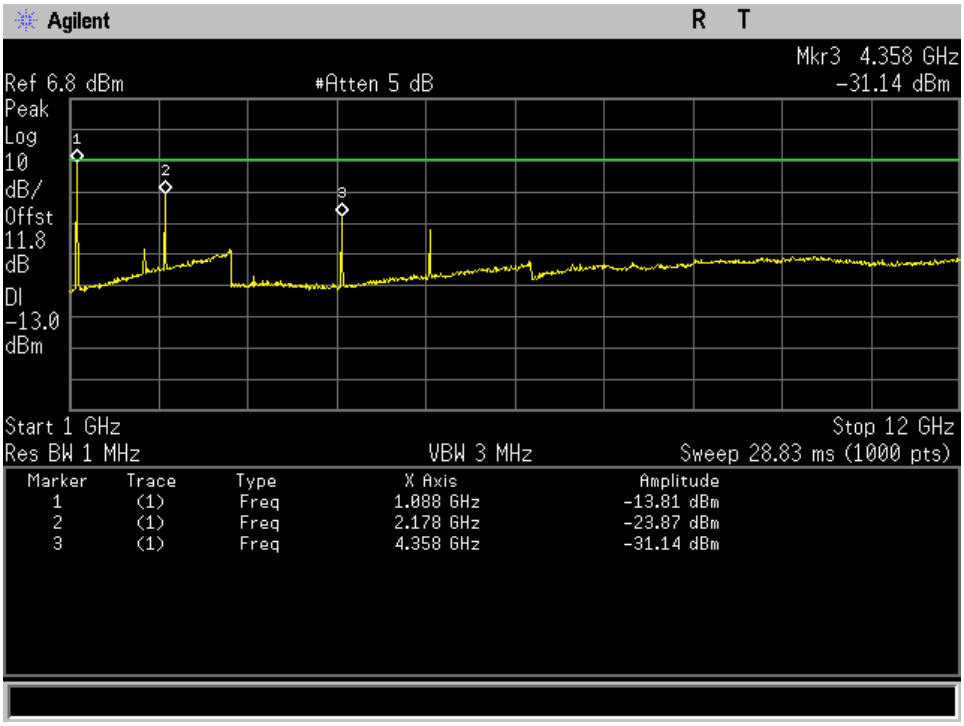
Panel Mount and Remote Mount units

Panel Mount

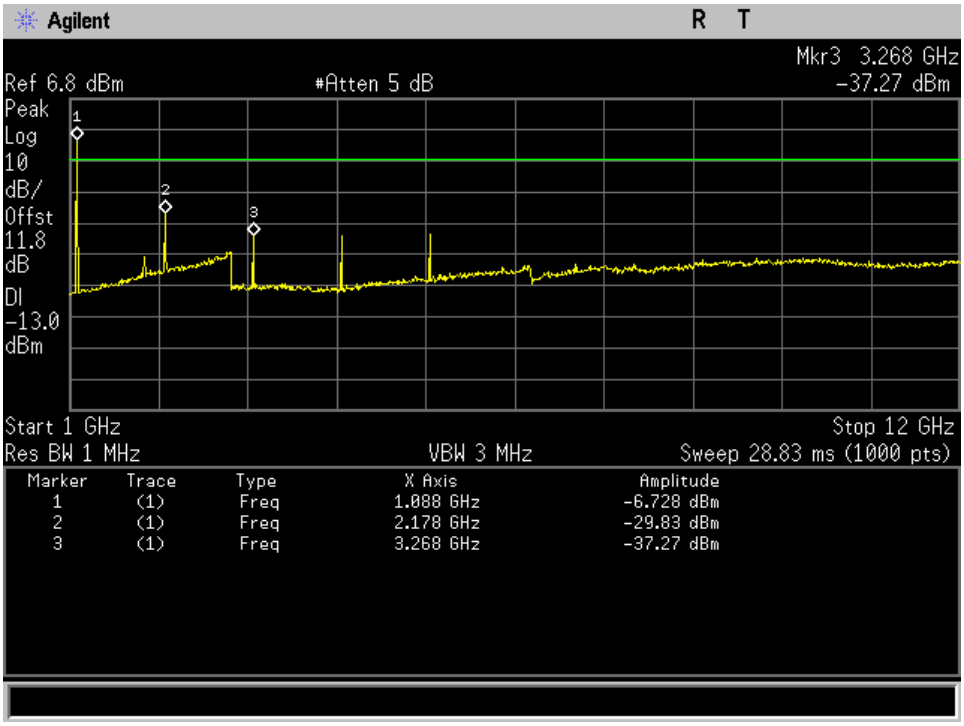
1-12 GHz `1090 ATCRB Back and Left Side



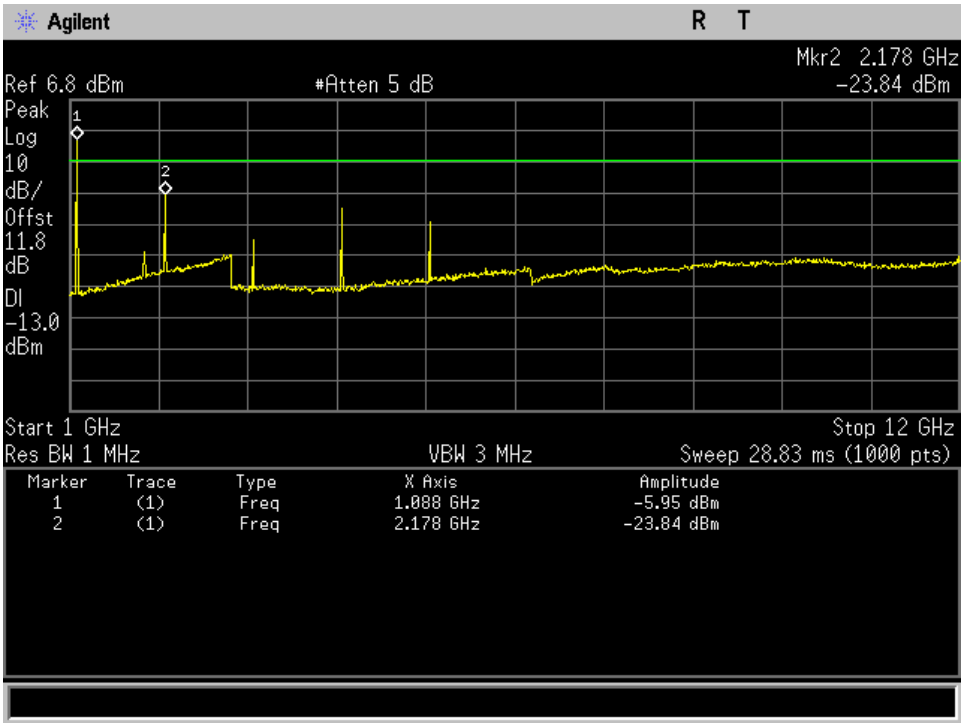
1-12 GHz `1090 ATCRB Front and Right Side



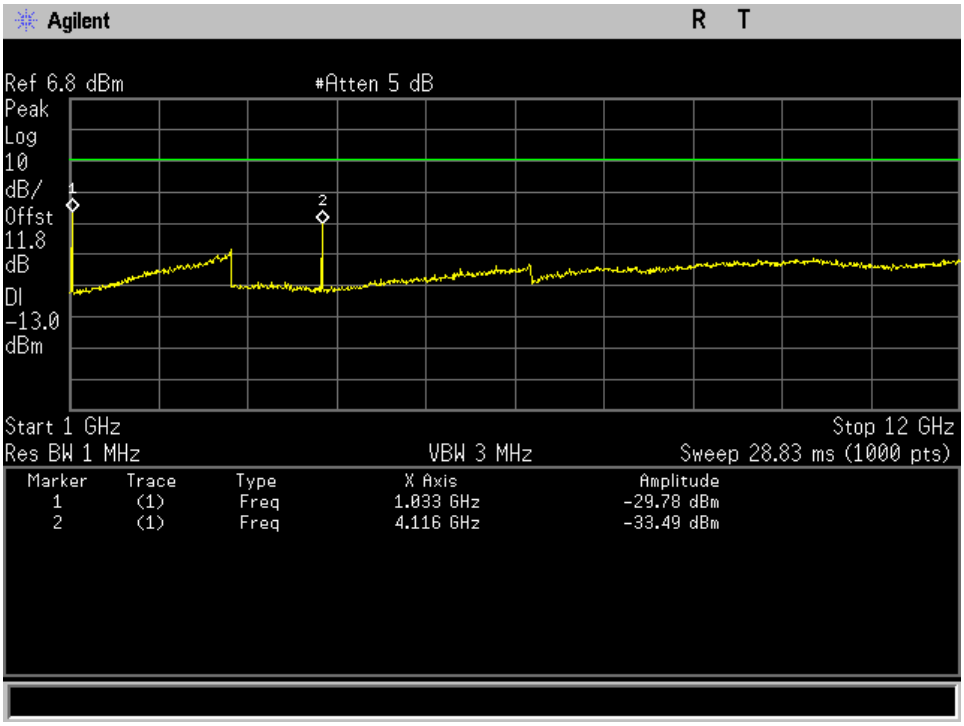
1-12 GHz `1090 Mode S Back and Left Side



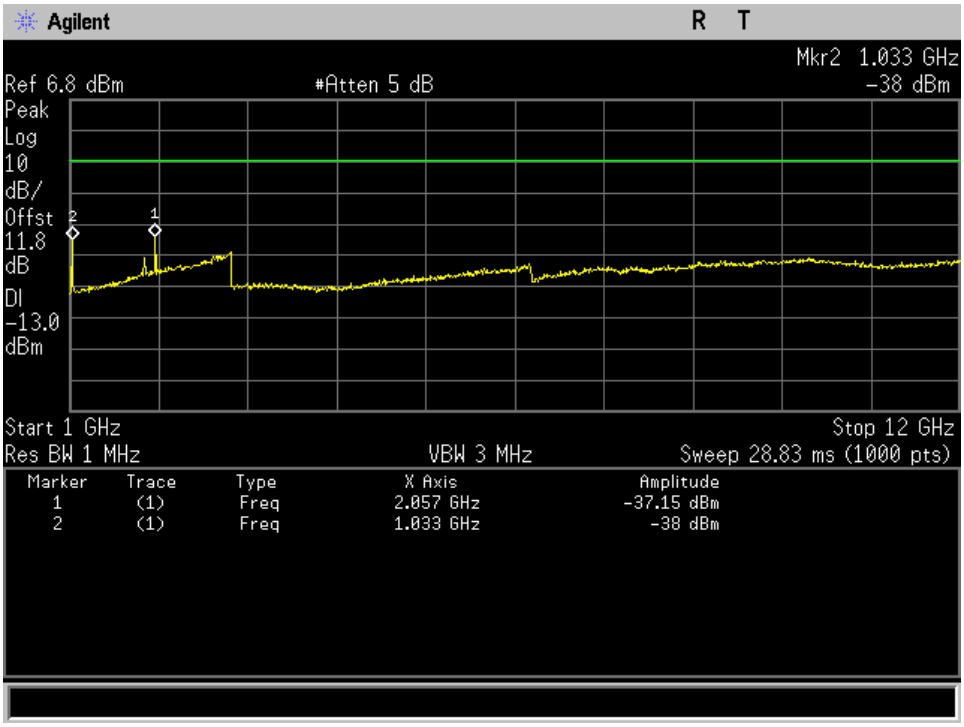
1-12 GHz `1090 Mode S Front and Right Side



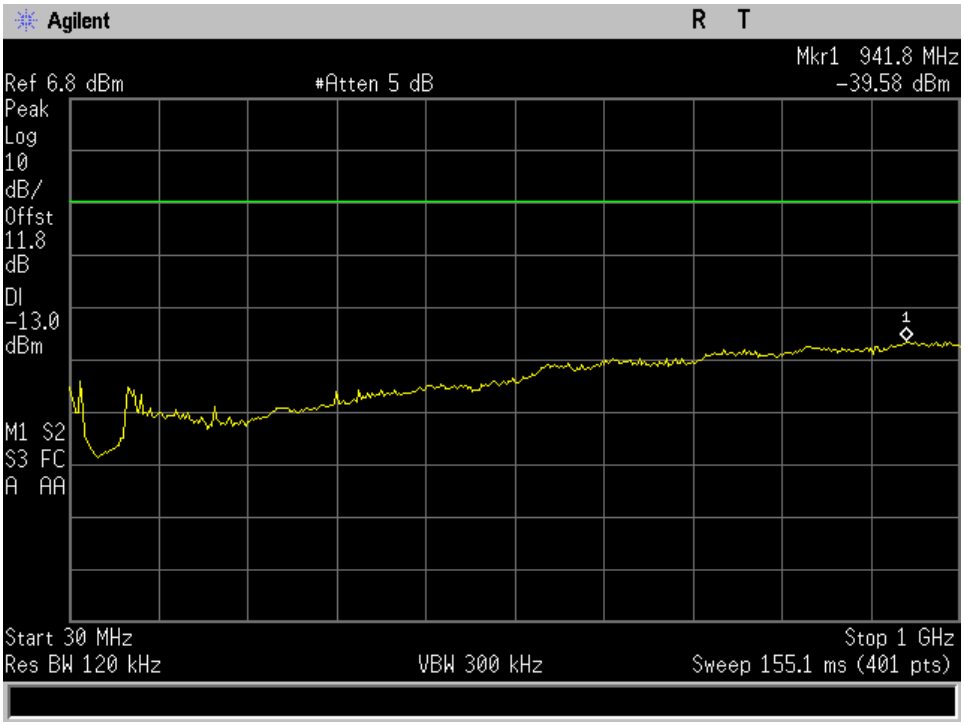
1-12 GHz `1030 TCAS Back and Left Side



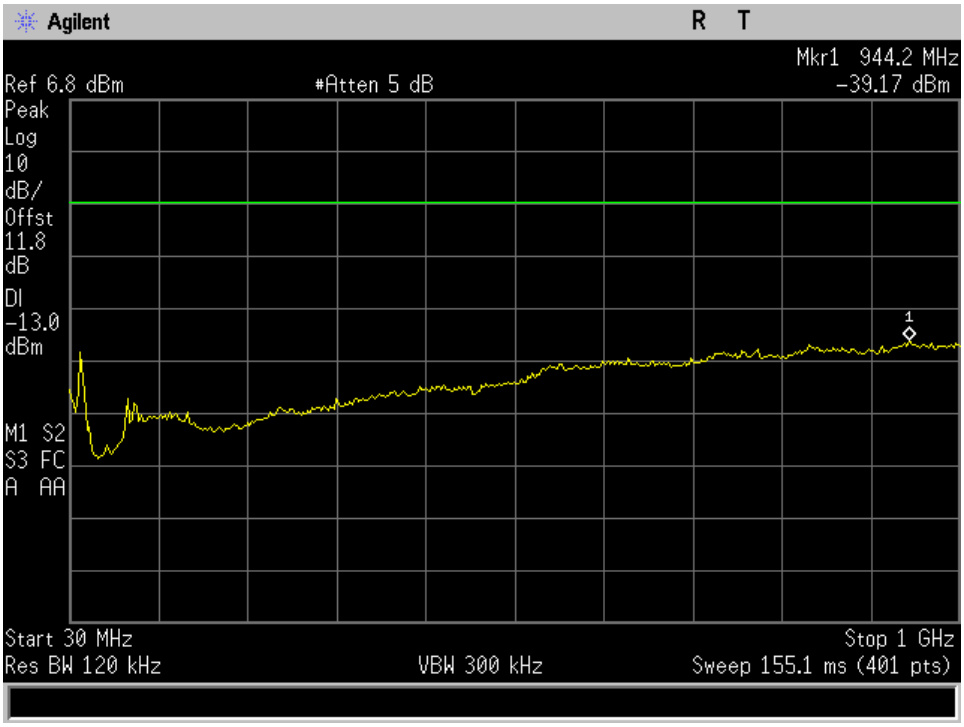
1-12 GHz `1030 TCAS Front and Right Side



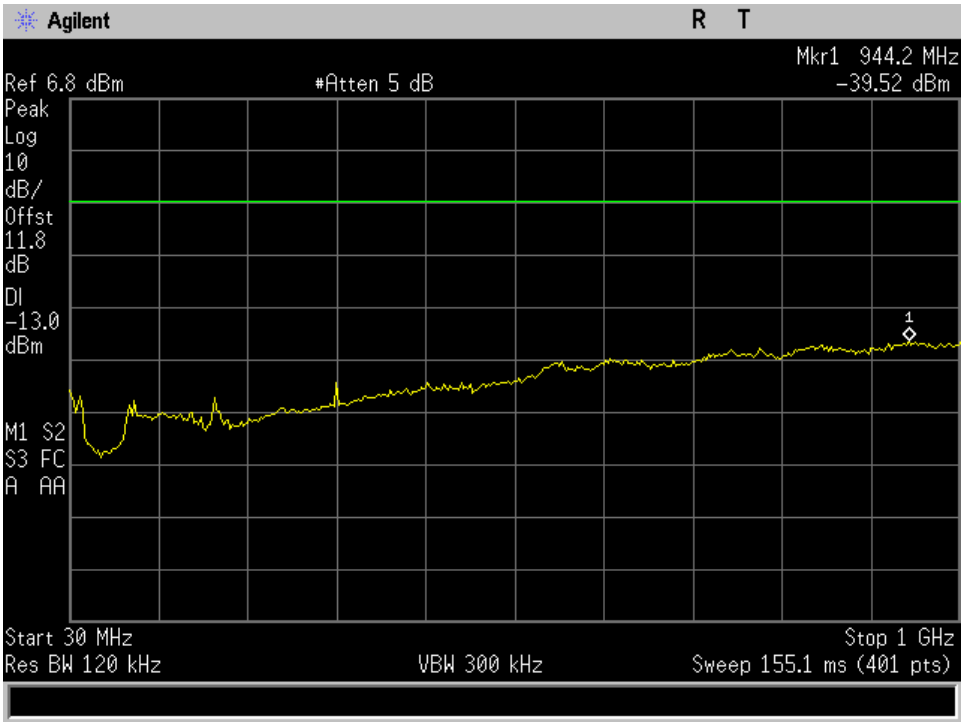
30 MHz-1GHz `1030 TCAS Back



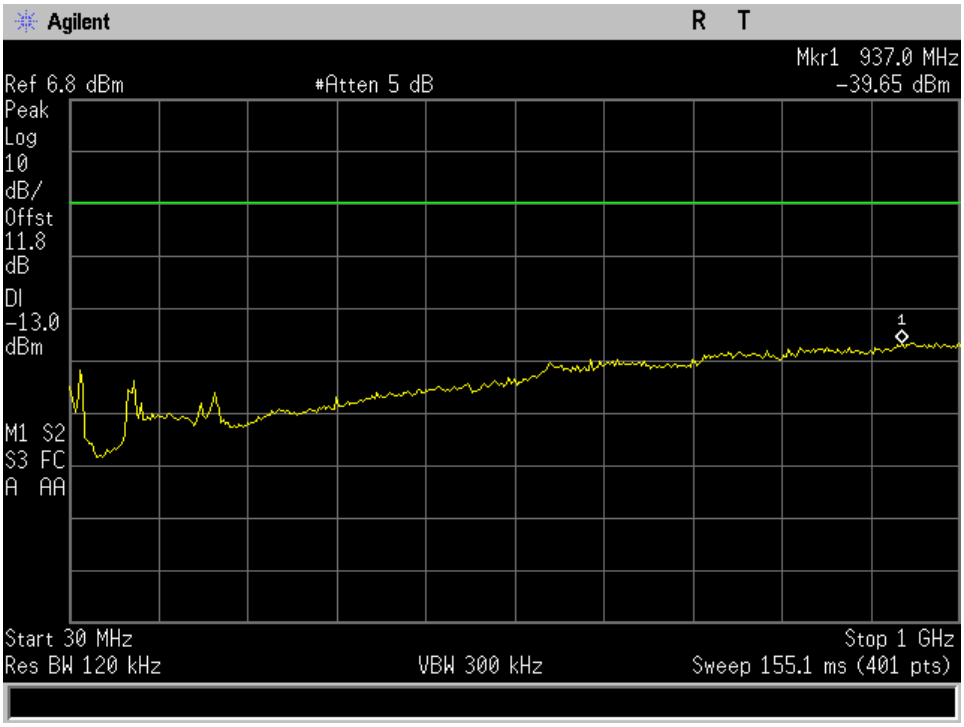
30 MHz-1GHz `1030 TCAS front



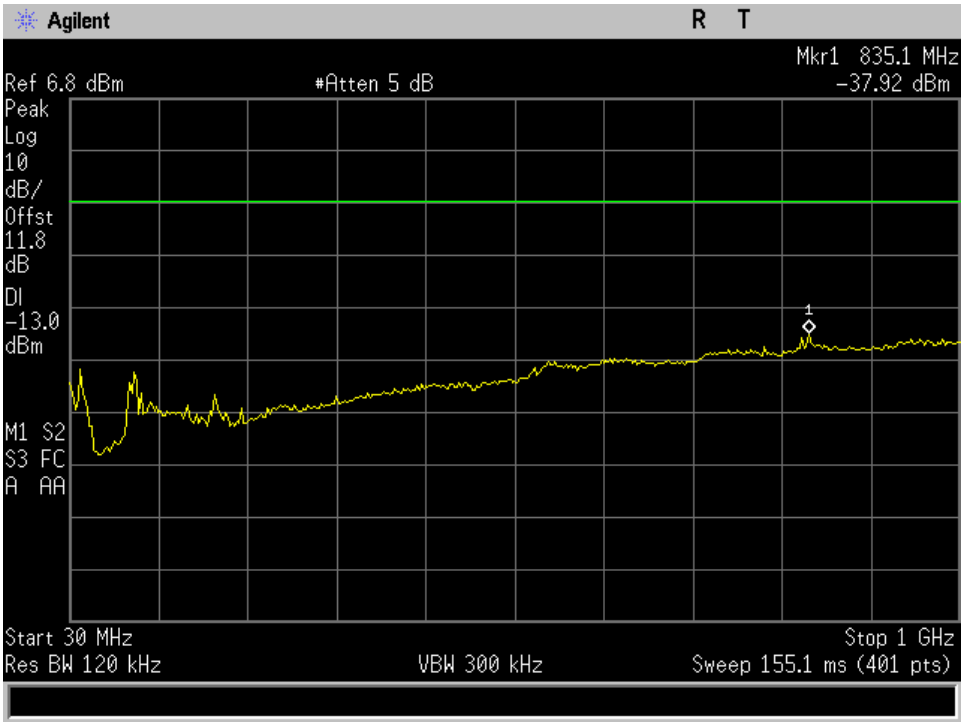
30 MHz-1GHz `1030 TCAS left Side



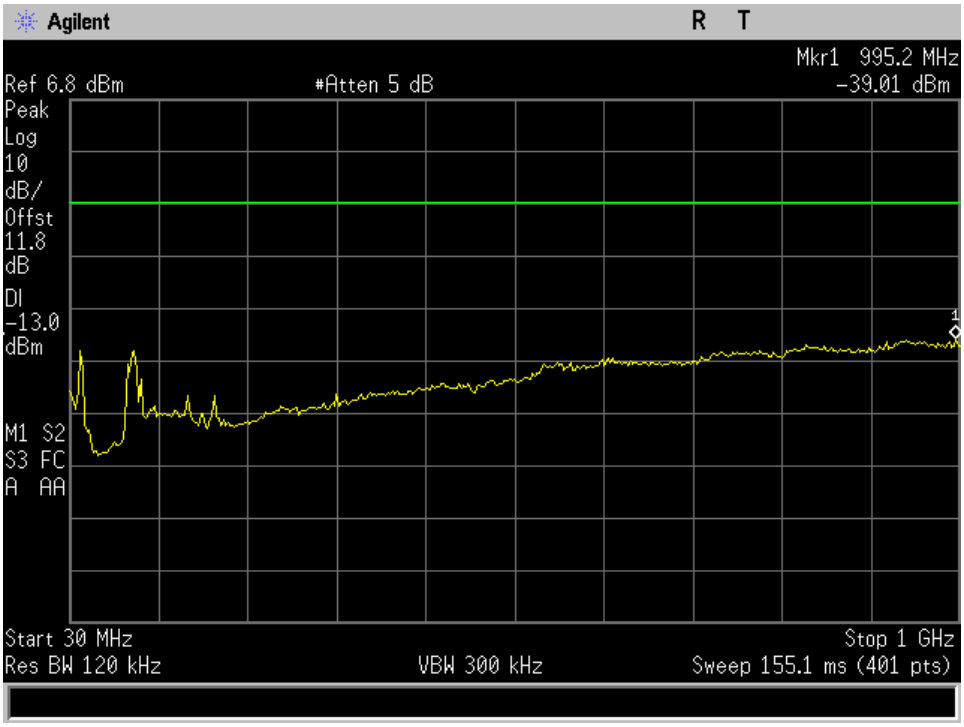
30 MHz-1GHz `1030 TCAS Right Side



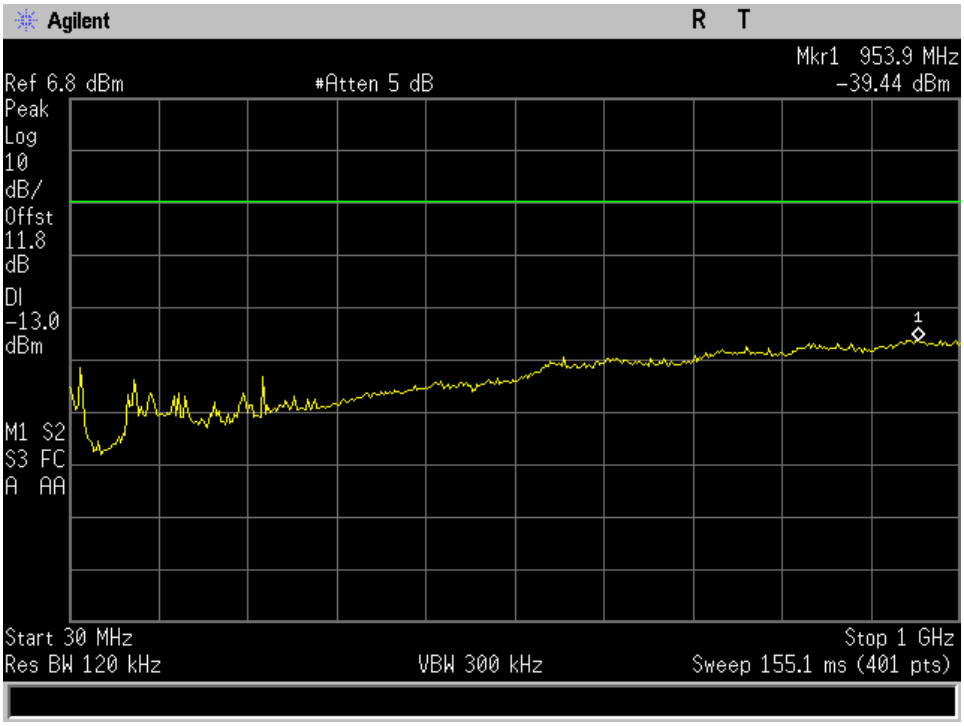
30 MHz-1GHz `1090 ATCRB back and left Side



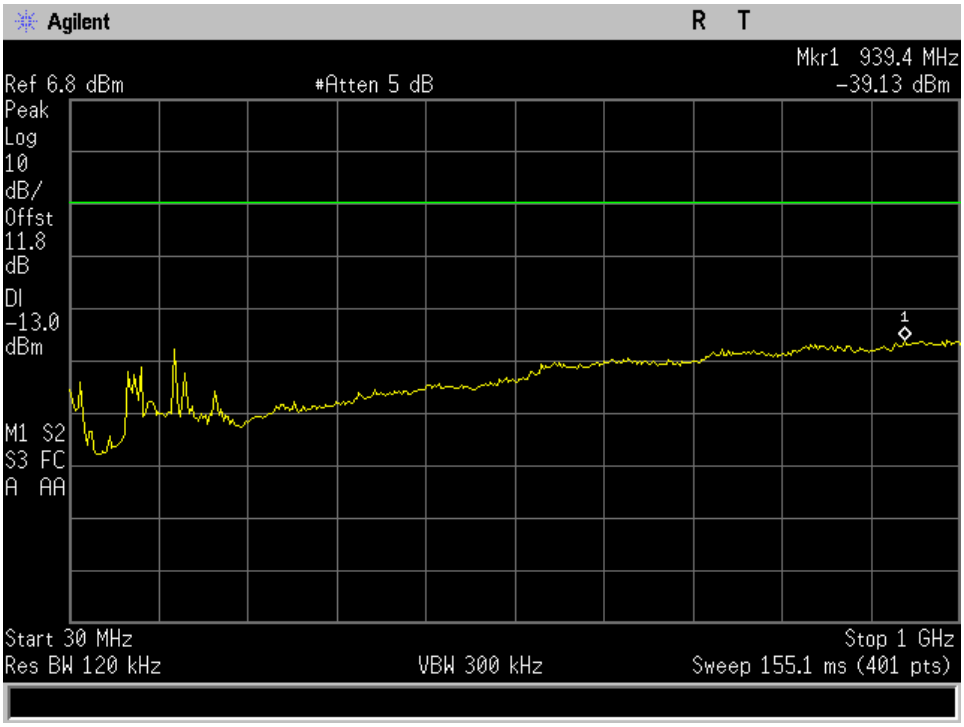
30 MHz-1GHz `1090 ATCRB Front and Right Side



30 MHz-1GHz `1090 Mode S back and left Side

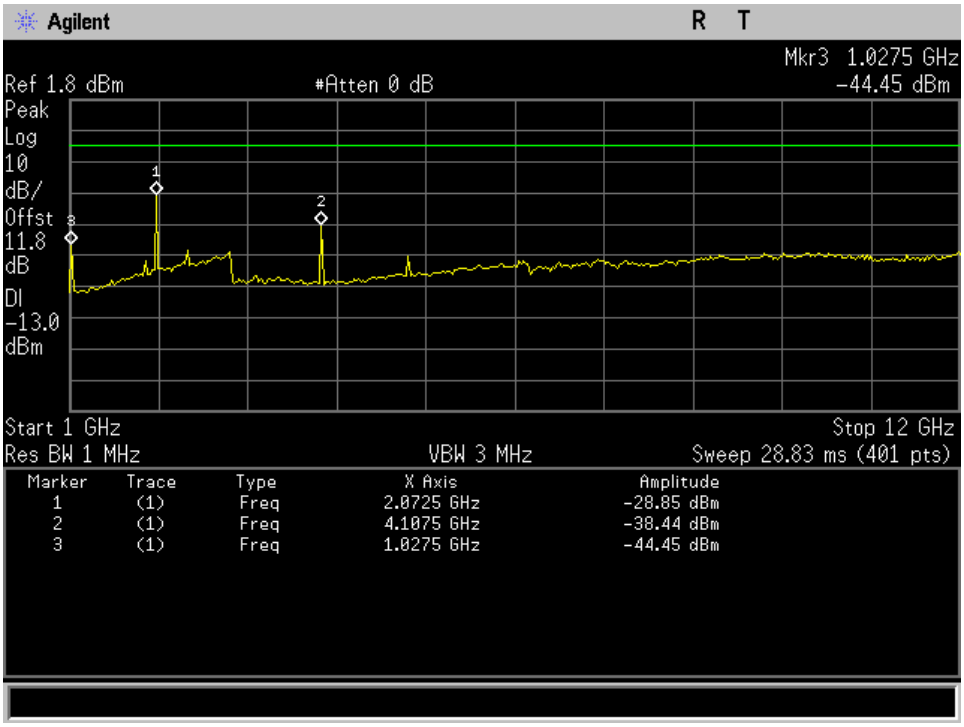


30 MHz-1GHz `1090 Mode S Front and Right Side

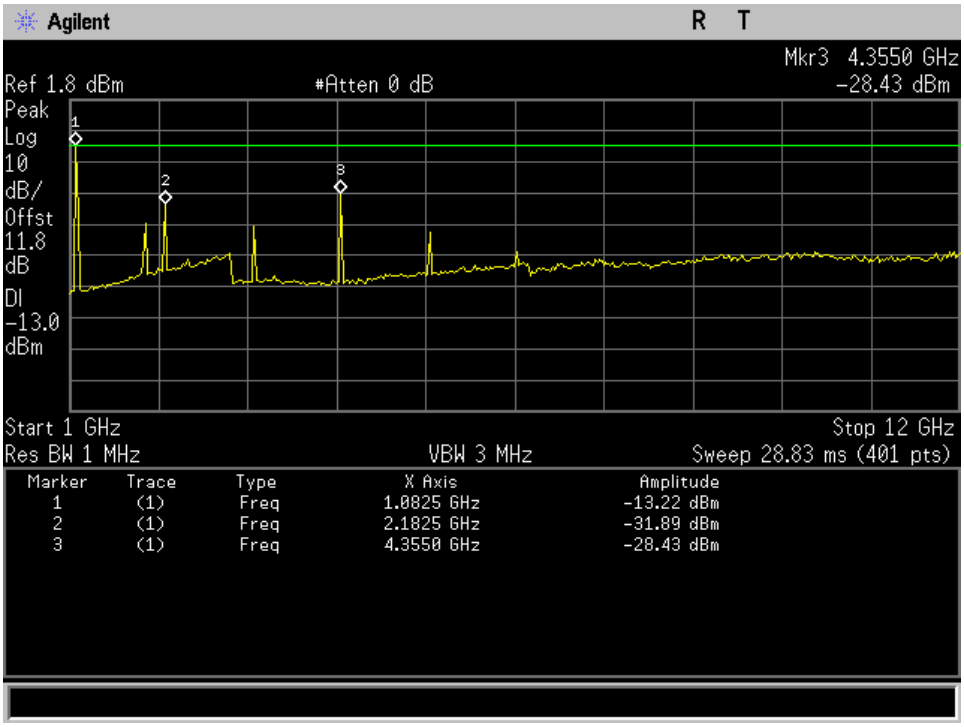


Remote Mount

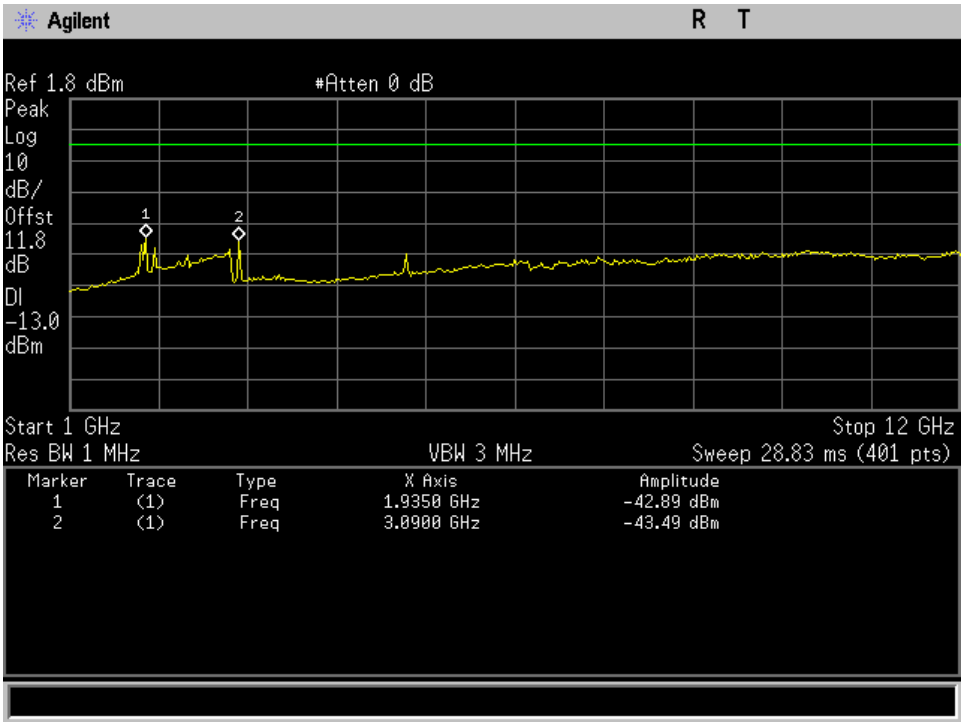
1-12 GH Back 1030 MHz with Notch filter



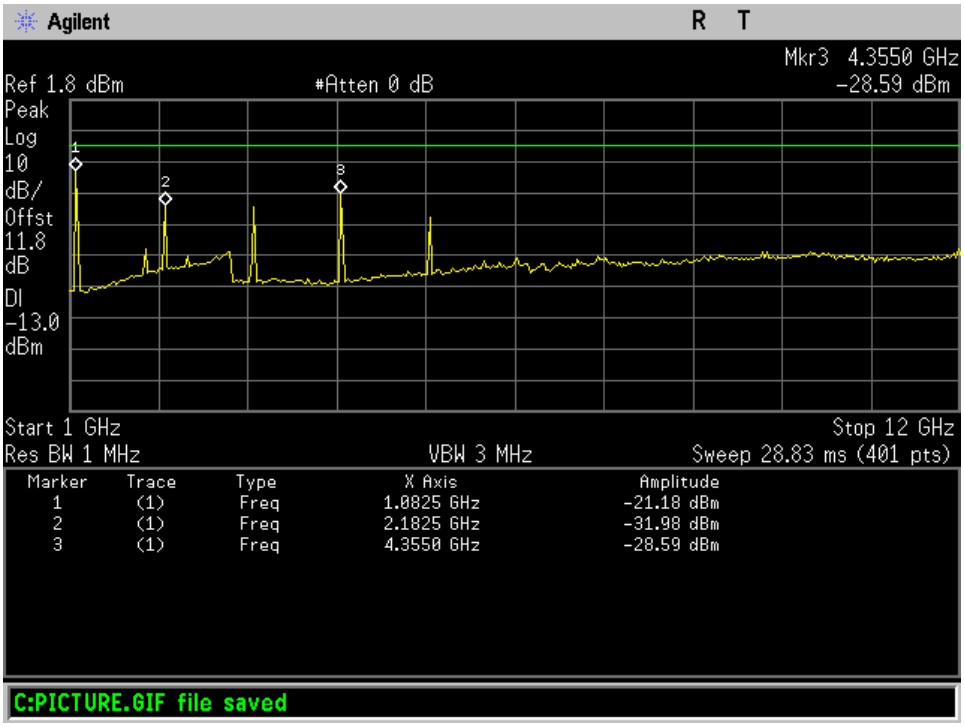
1-12 GH Back 1090 MHz with Notch filter



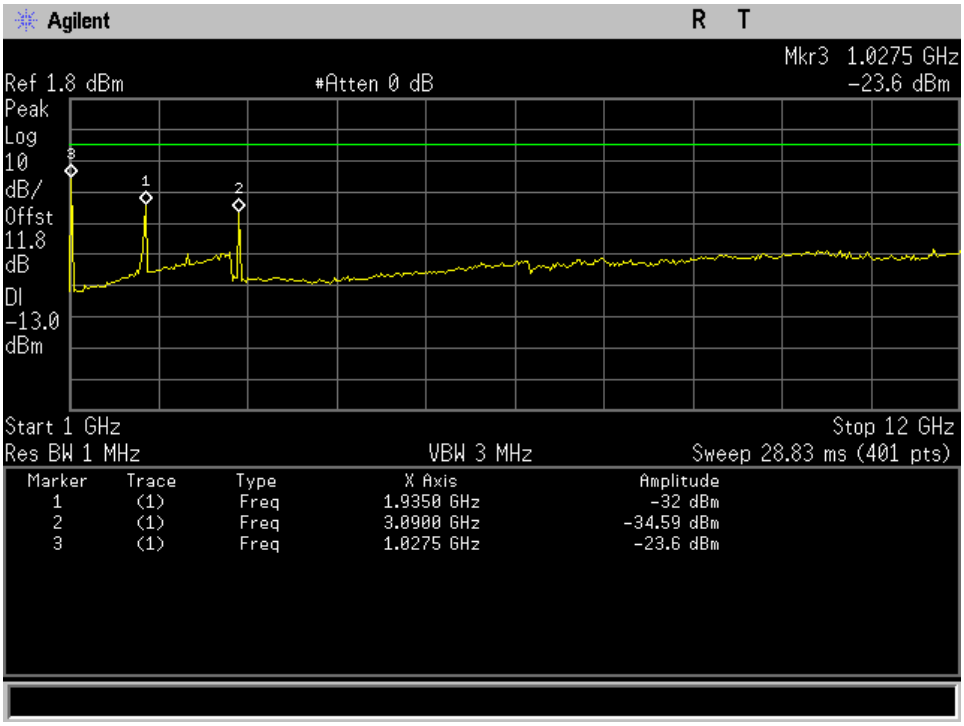
1-12 GH Front 1030 MHz with Notch filter



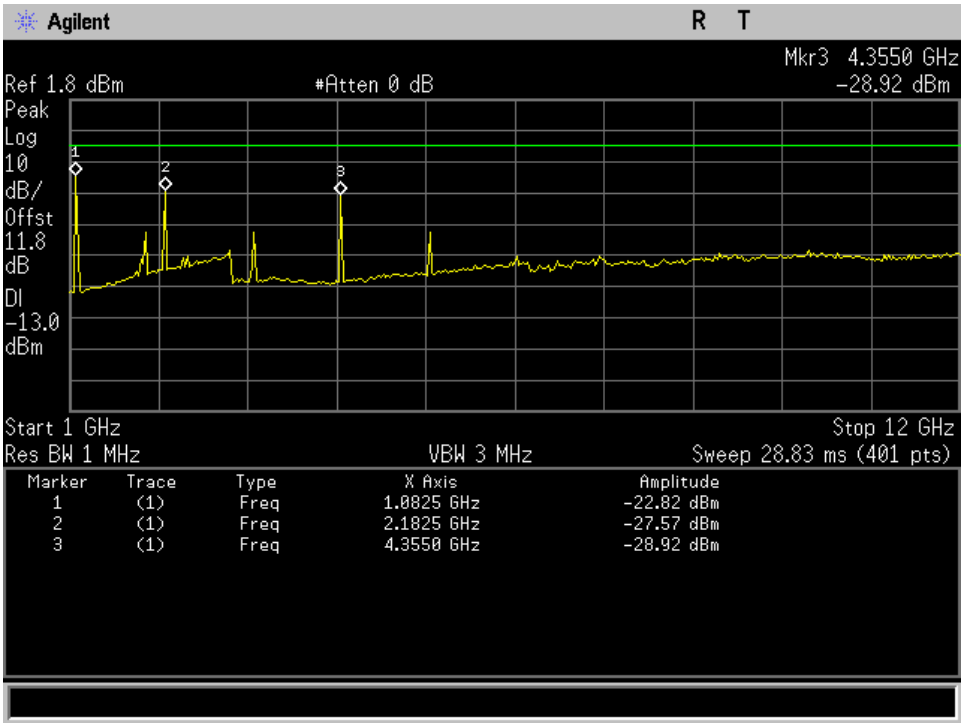
1-12 GH Front 1090 MHz with Notch filter



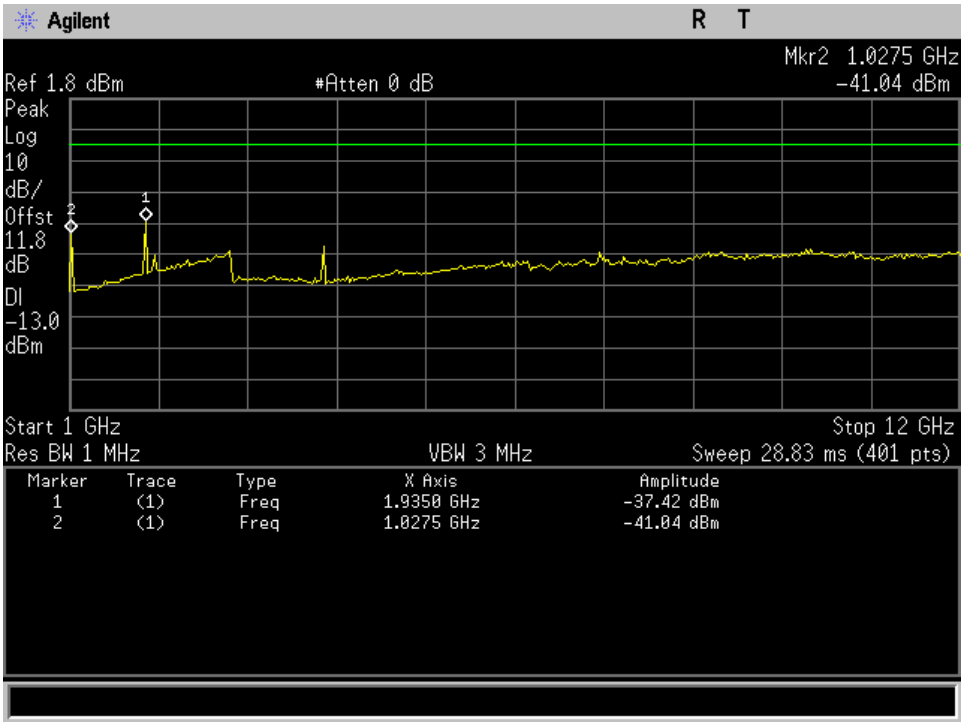
1-12 GH left 1030 MHz with Notch filter



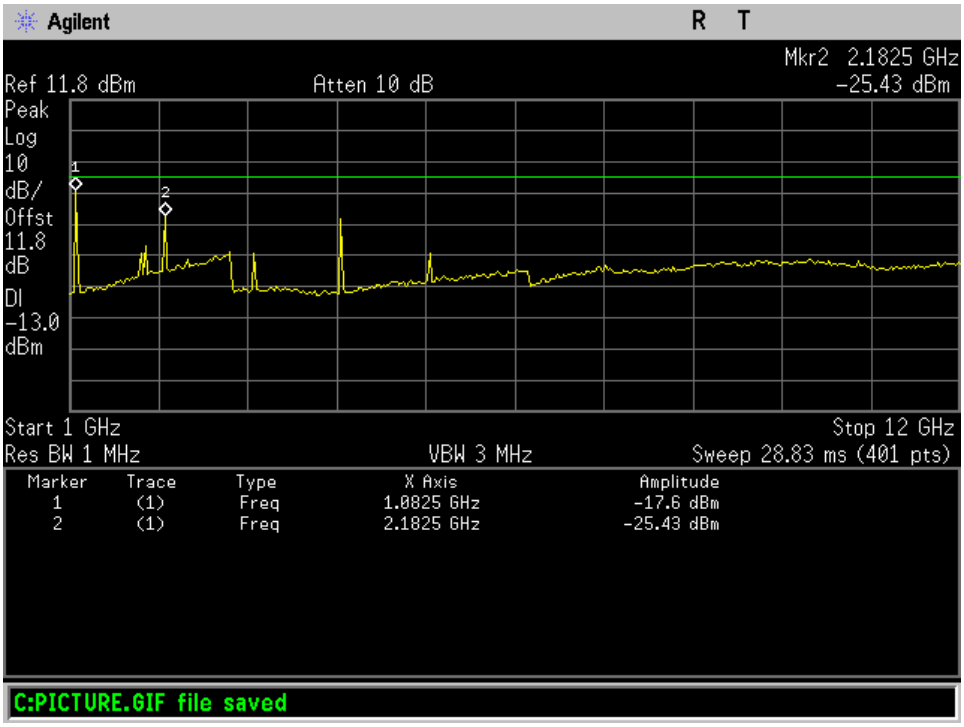
1-12 GH left 1090 MHz with Notch filter



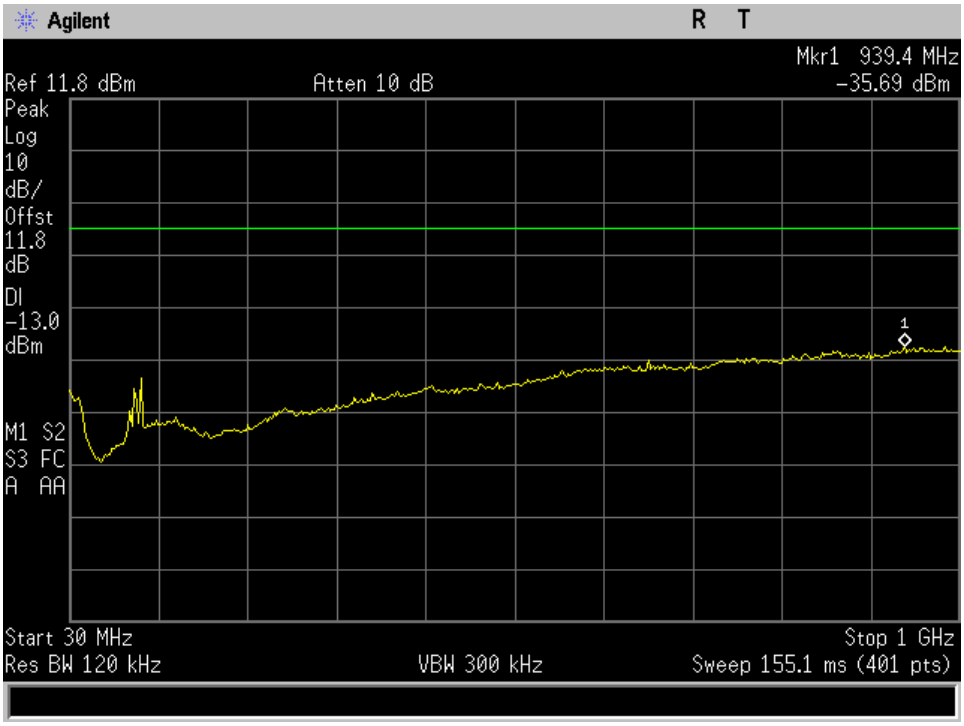
1-12 GH Right 1030 MHz with Notch filter



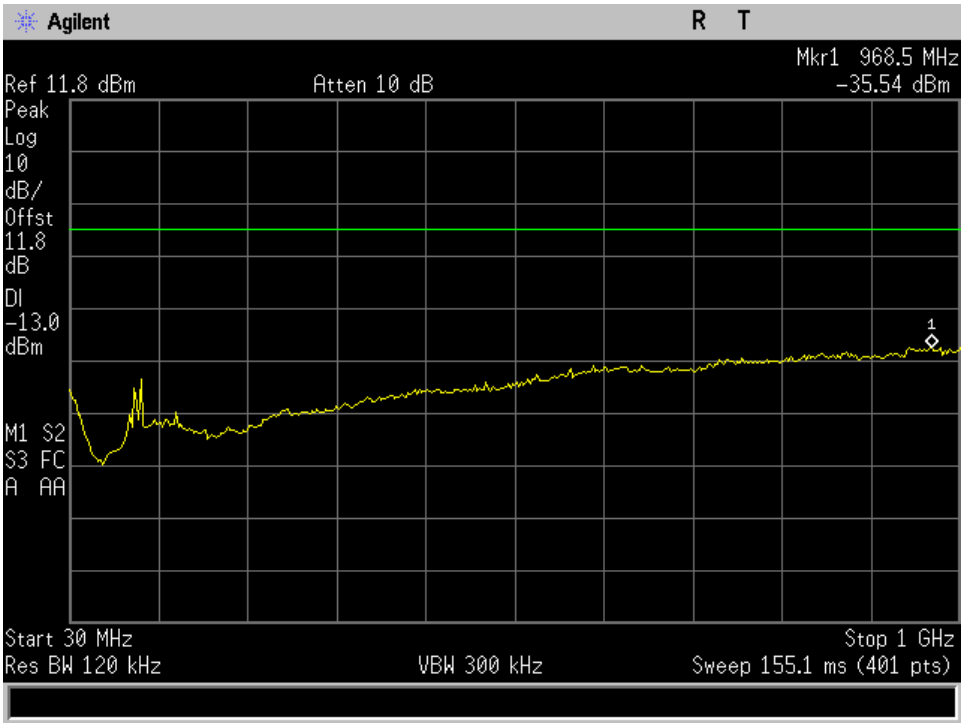
1-12 GH Right 1090 MHz with Notch filter



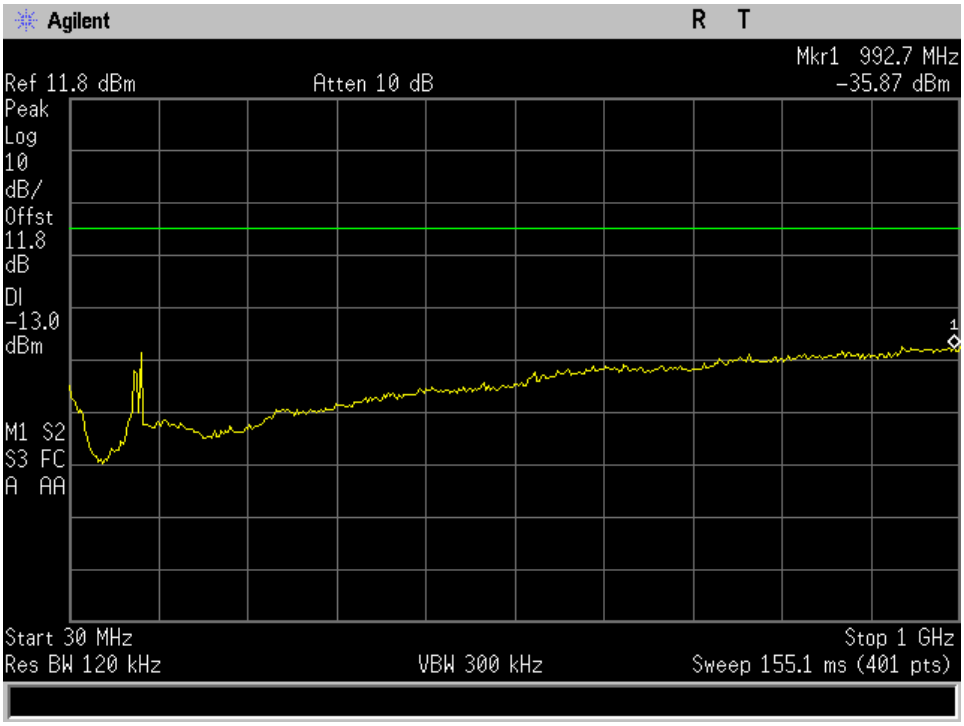
30 MHz-1GHz Back 1030 MHz



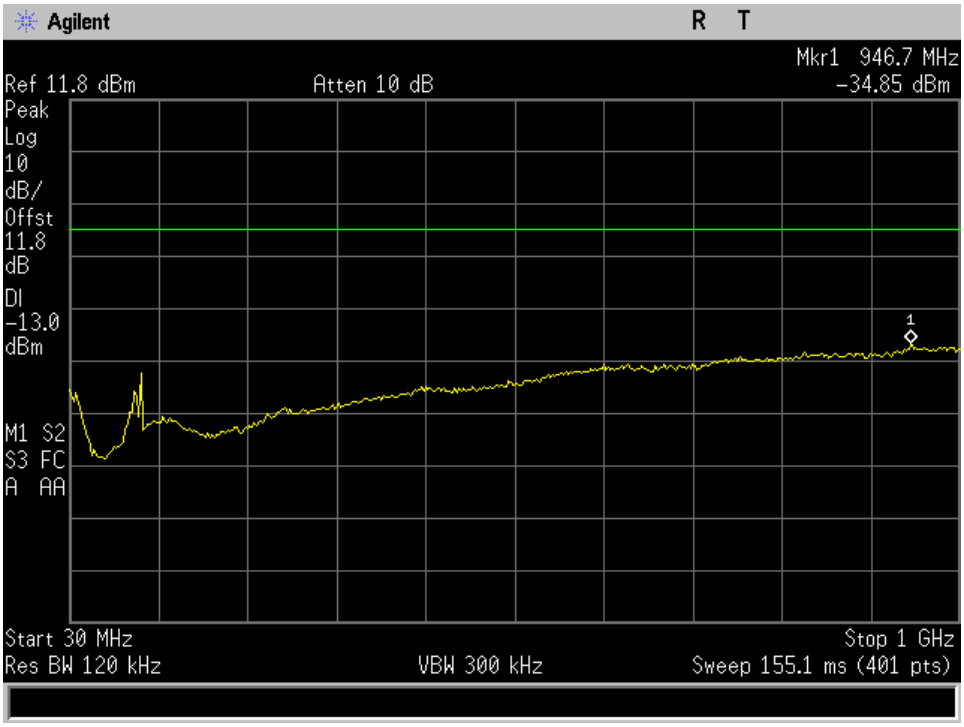
30 MHz-1GHz Back 1090 MHz



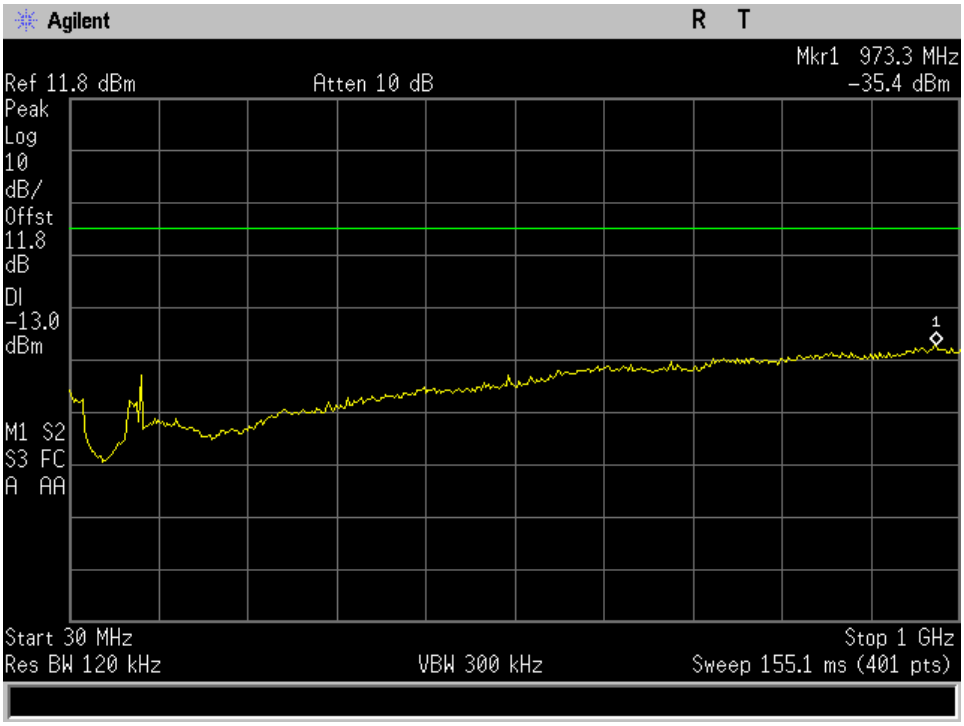
30 MHz-1GHz Front 1030 MHz



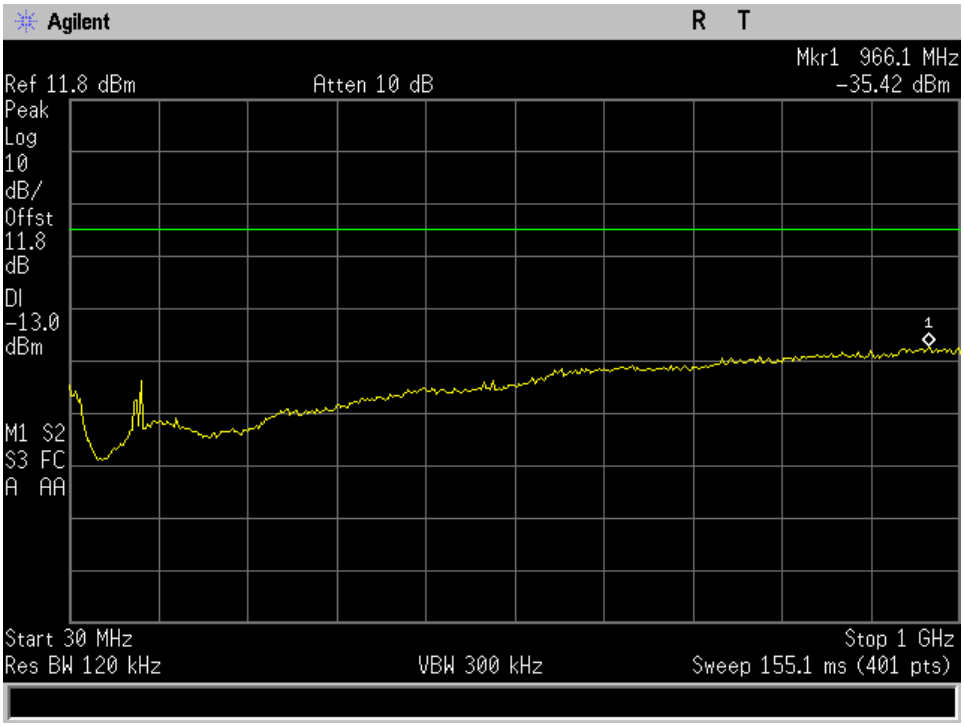
30 MHz-1GHz Front 1090 MHz



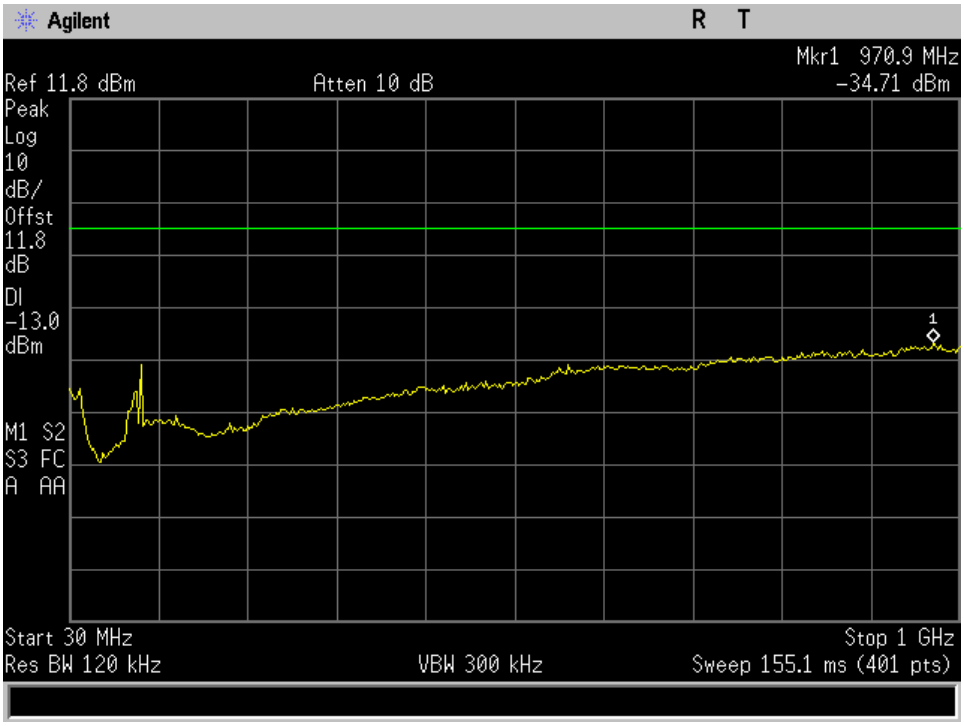
30 MHz-1GHz Left 1030 MHz



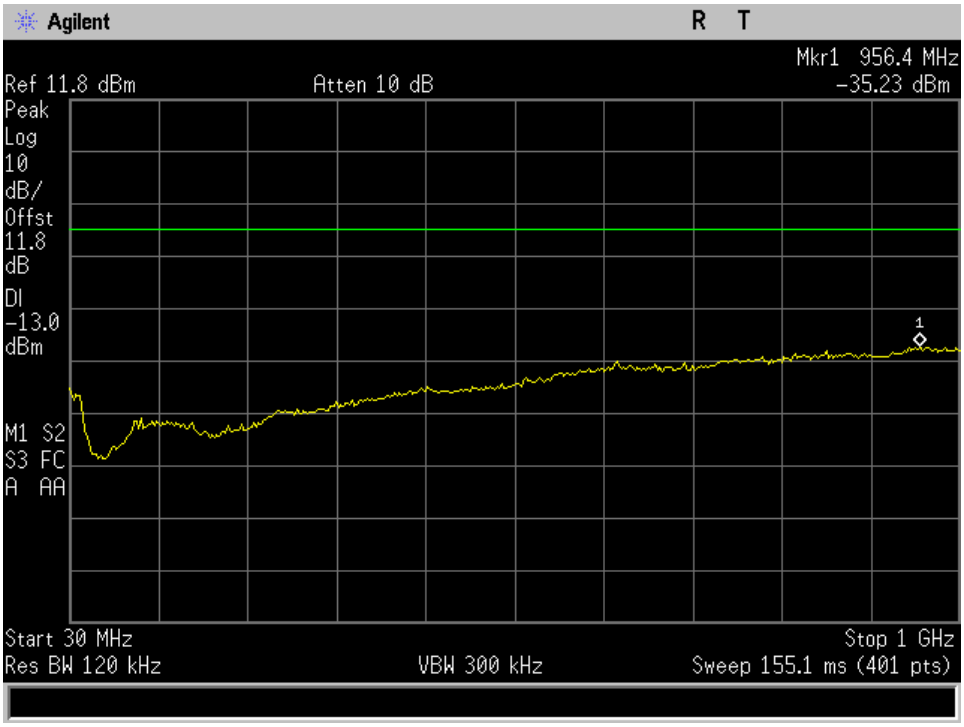
30 MHz-1GHz left 1090 MHz



30 MHz-1GHz Right 1030 MHz



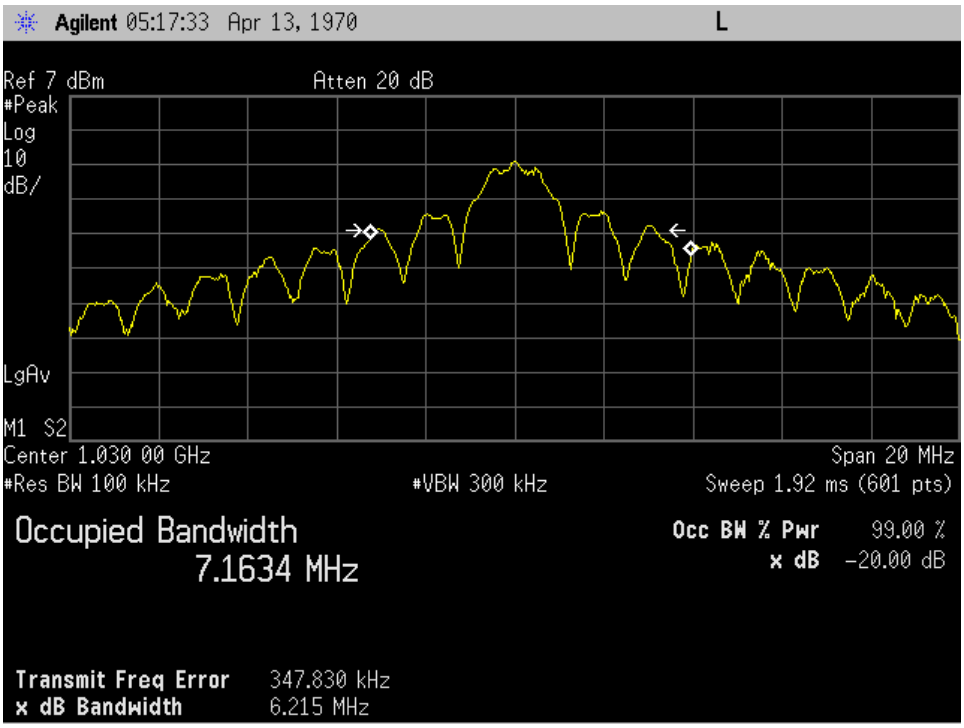
30 MHz-1GHz Right 1090 MHz



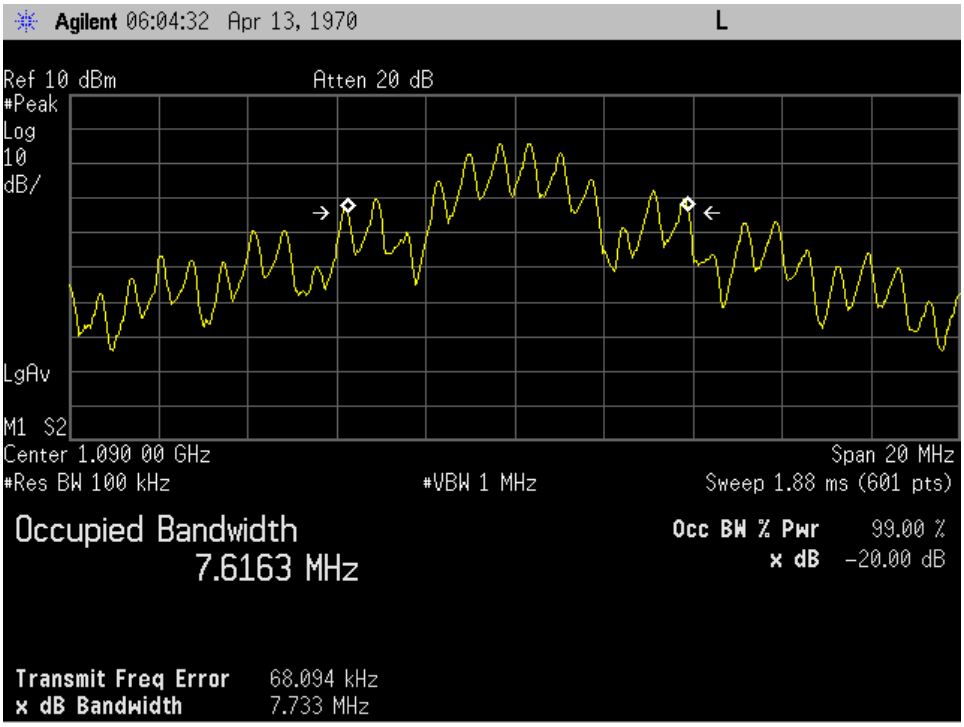
Annex D

Occupied Bandwidth

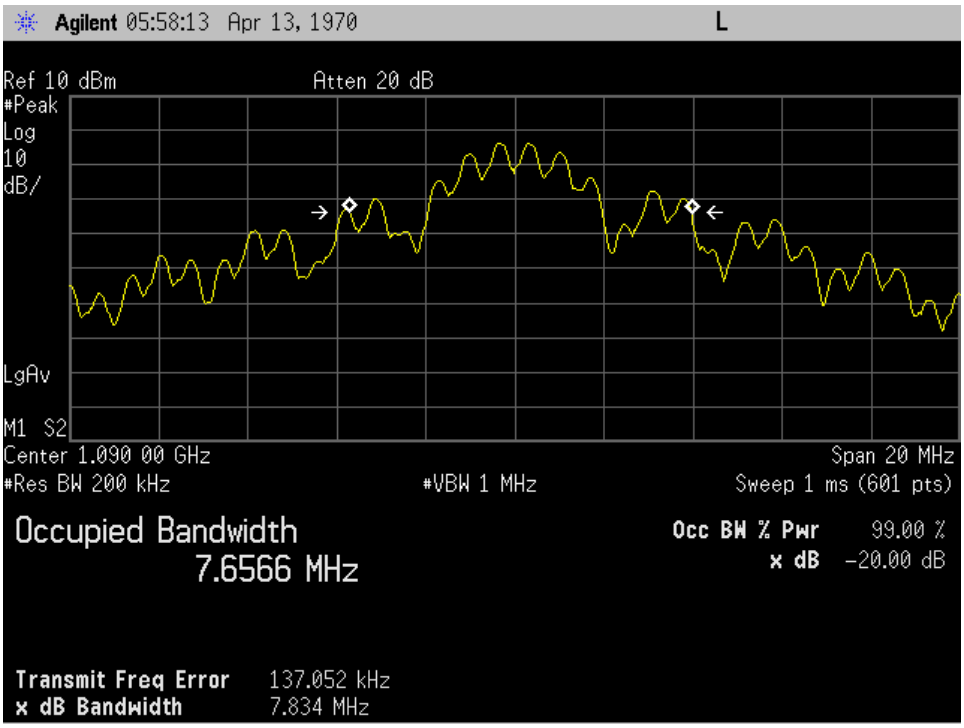
1030 mode TCAS top



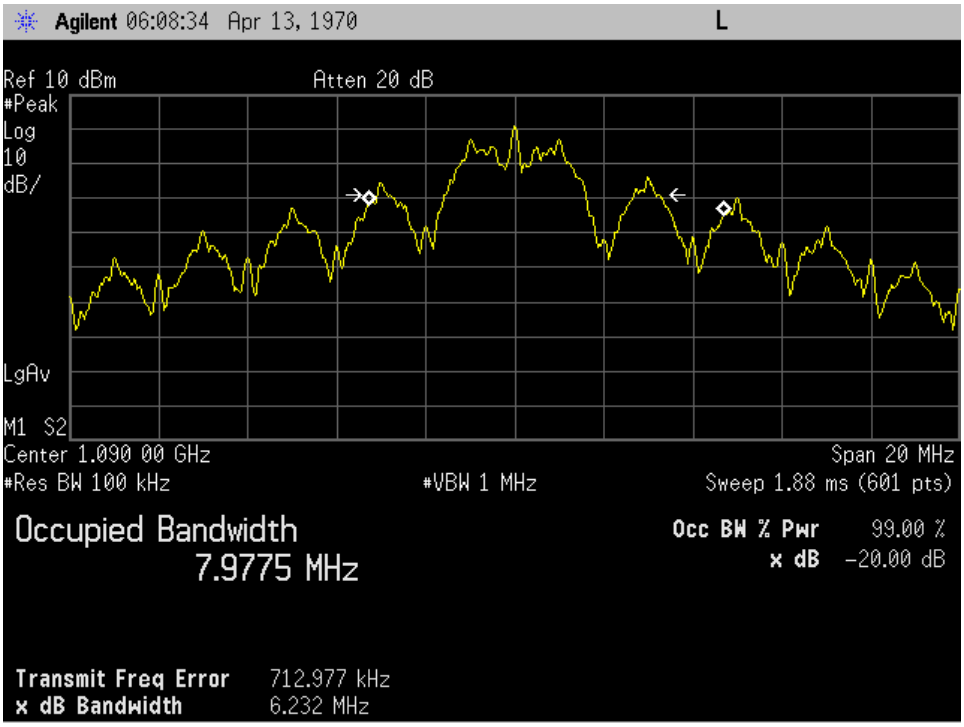
1090 mode ATCRB bottom



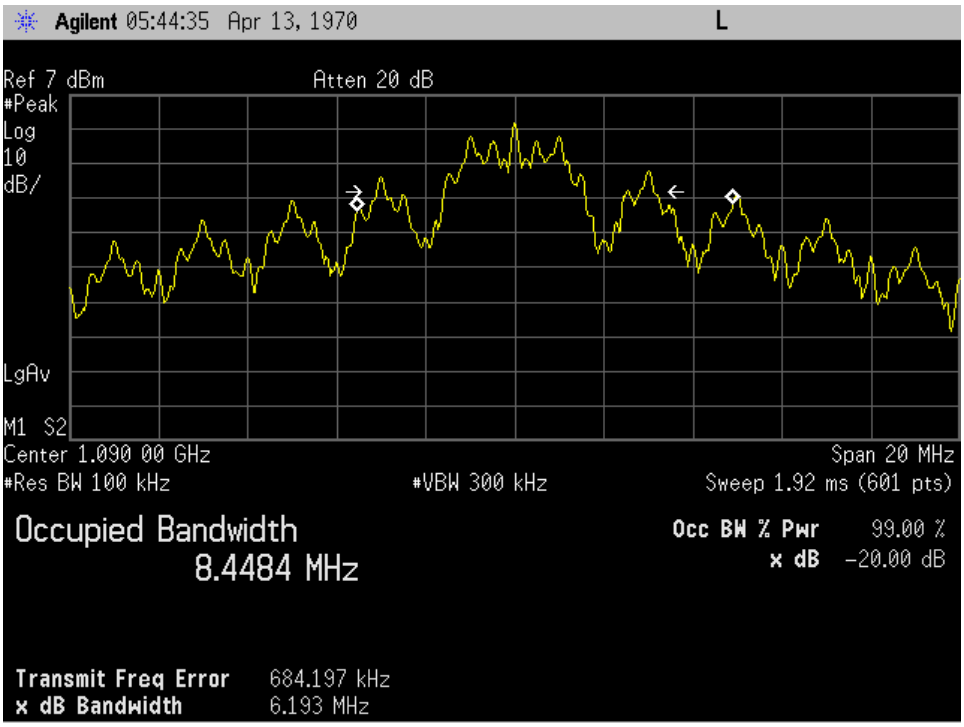
1090 mode ATCRB top



1090 mode S bottom



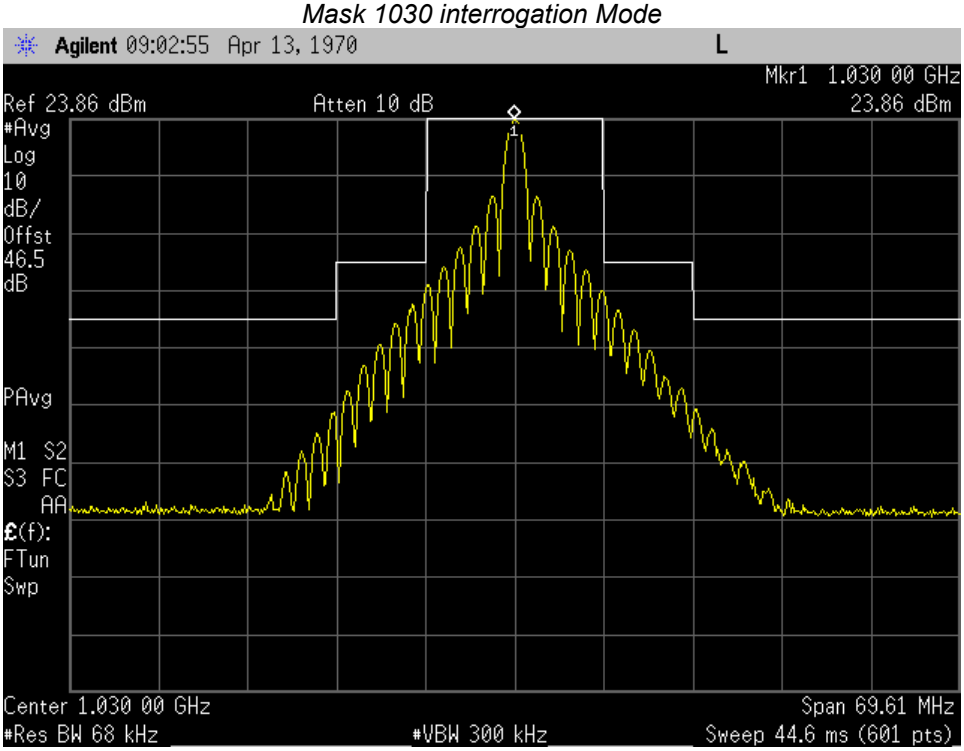
1090 mode S top


Agilent 05:44:35 Apr 13, 1970
L
Ref 7 dBm
Atten 20 dB
#Peak
Log
10
dB/
LgAv
M1 S2
Center 1.090 00 GHz
Span 20 MHz
#Res BW 100 kHz
#VBW 300 kHz
Sweep 1.92 ms (601 pts)
Occupied Bandwidth
8.4484 MHz
Occ BW % Pwr 99.00 %
x dB -20.00 dB
Transmit Freq Error 684.197 kHz
x dB Bandwidth 6.193 MHz

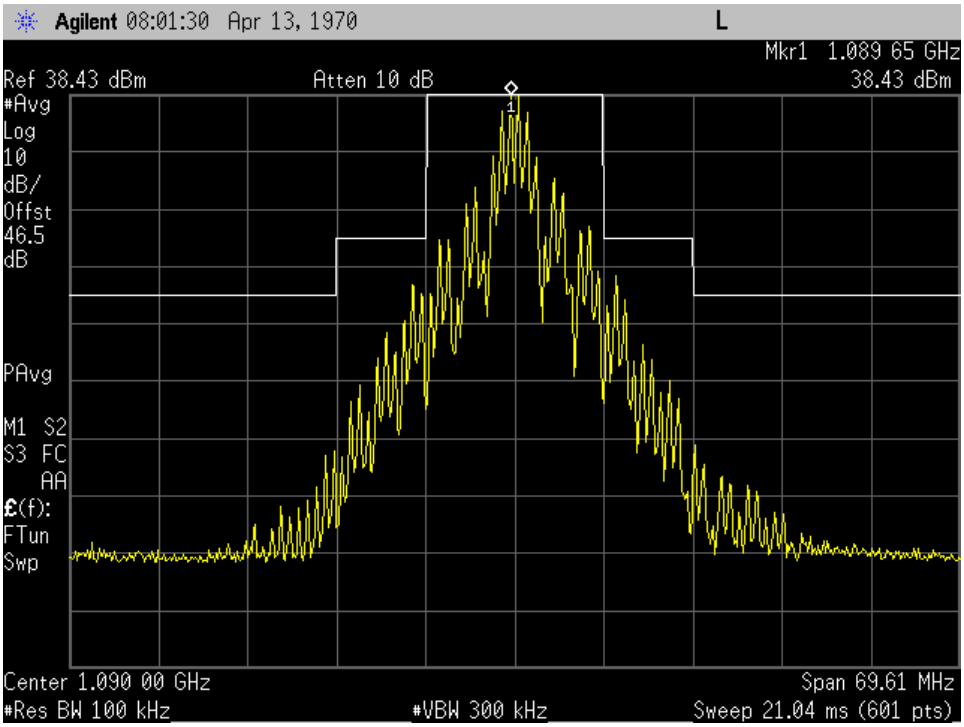
Annex E

Emission Mask

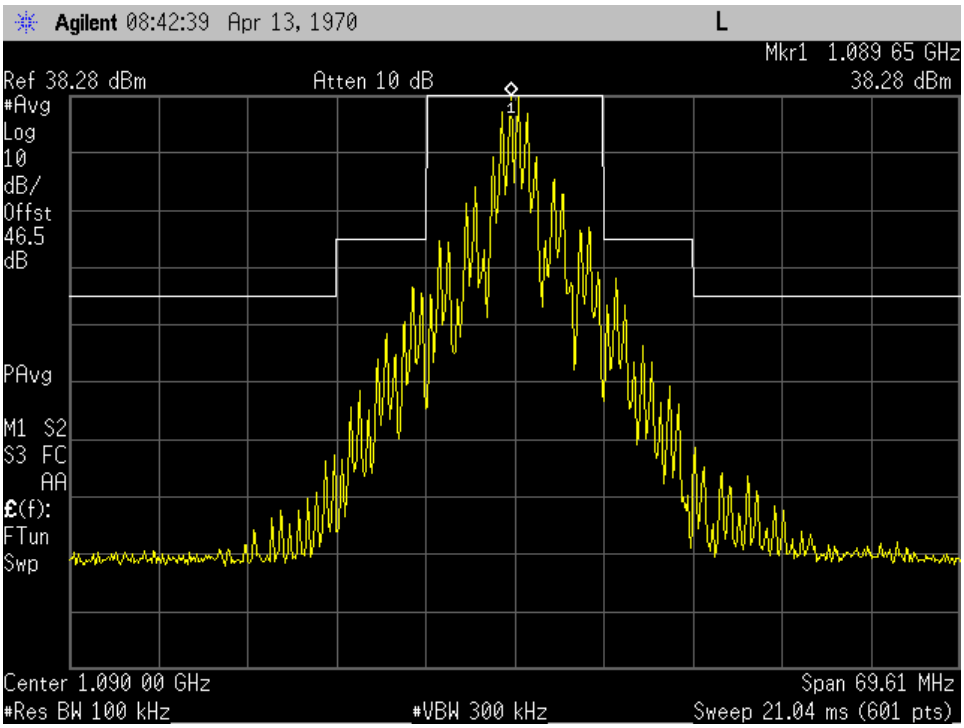
Mask 1030 interrogation Mode



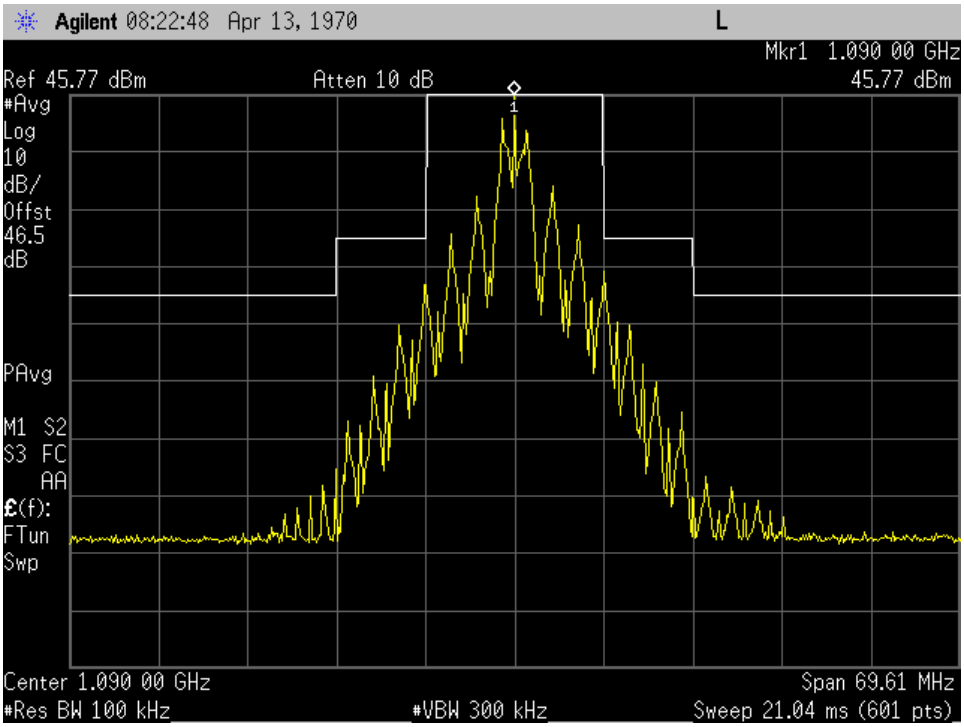
Mask 1090 ATCRB Bottom



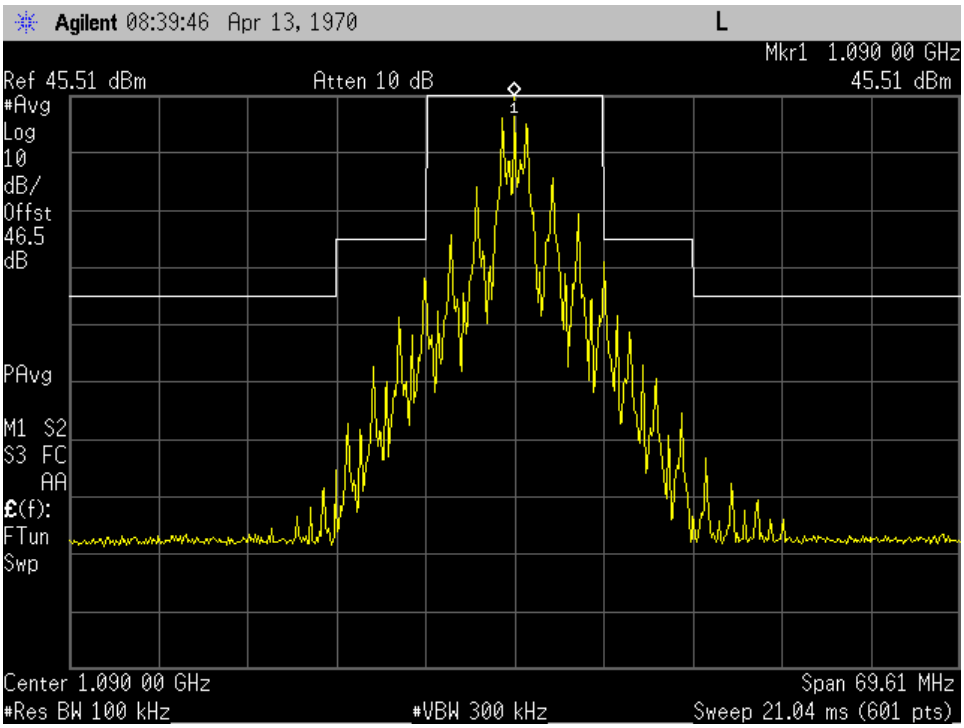
Mask 1090 ATCRB top



Mask 1090 Mode S Bottom



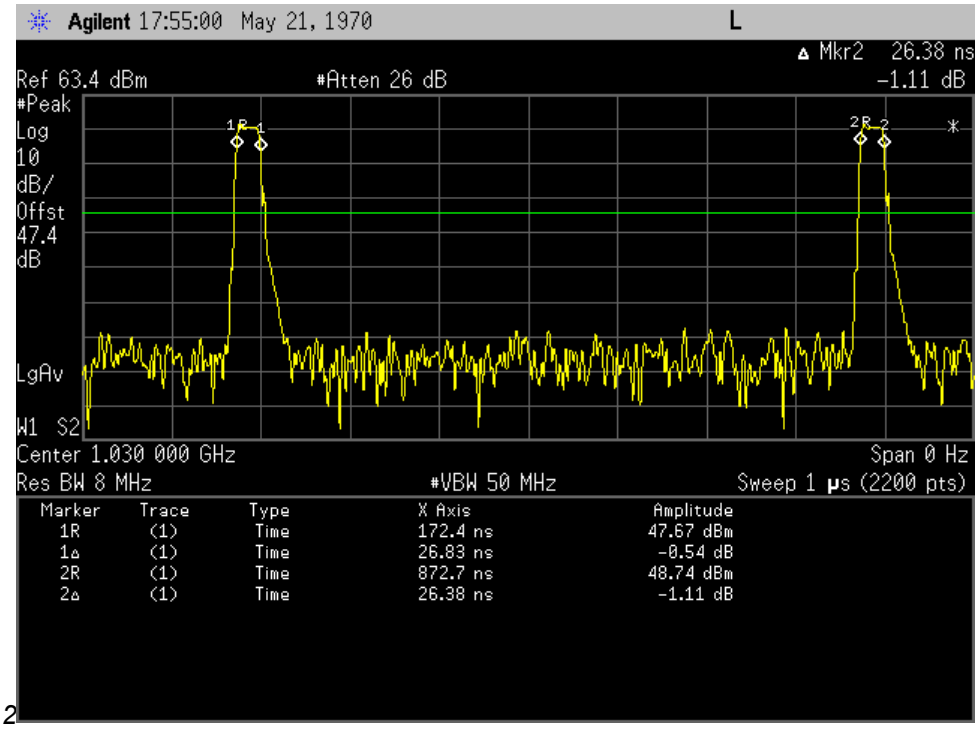
Mask 1090 Mode S top



Annex F

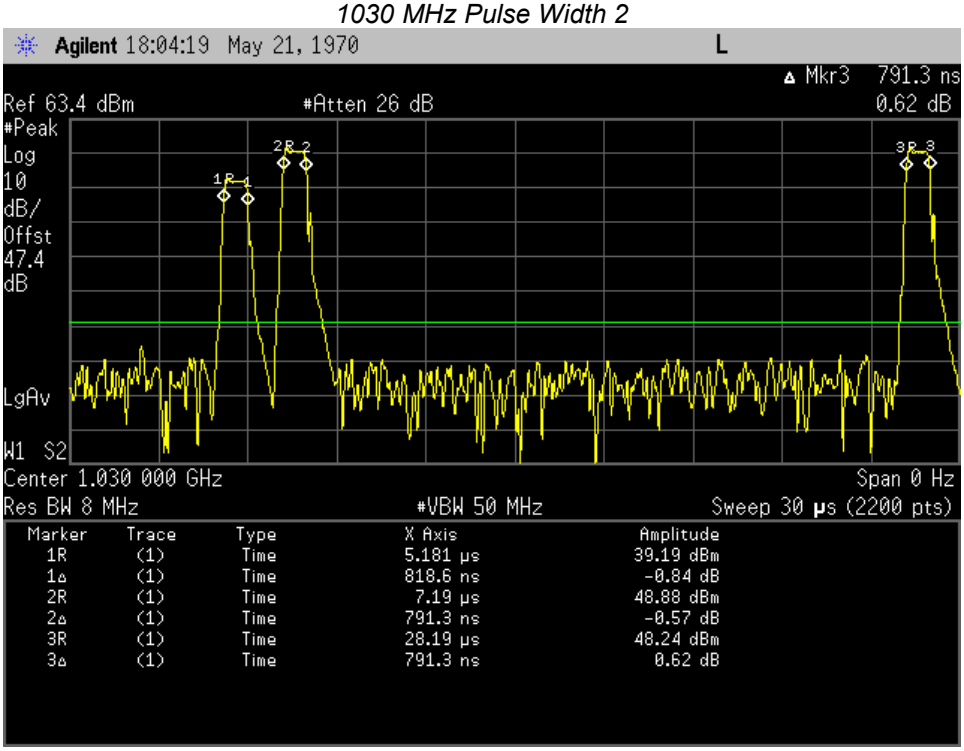
Modulation Characteristics

1030 MHz Pulse Width 1

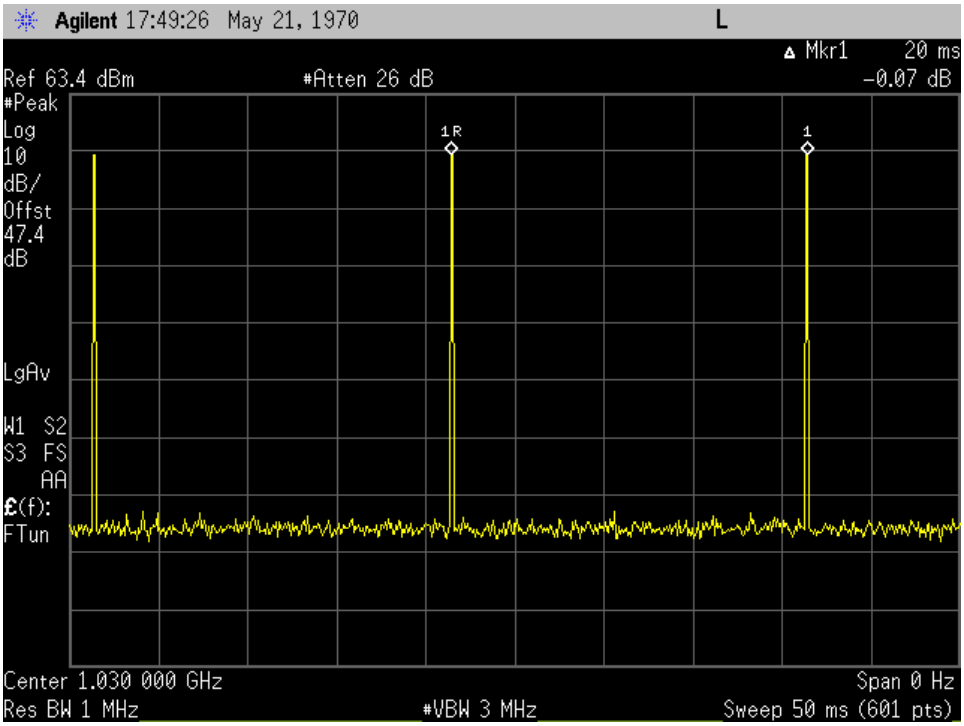


2

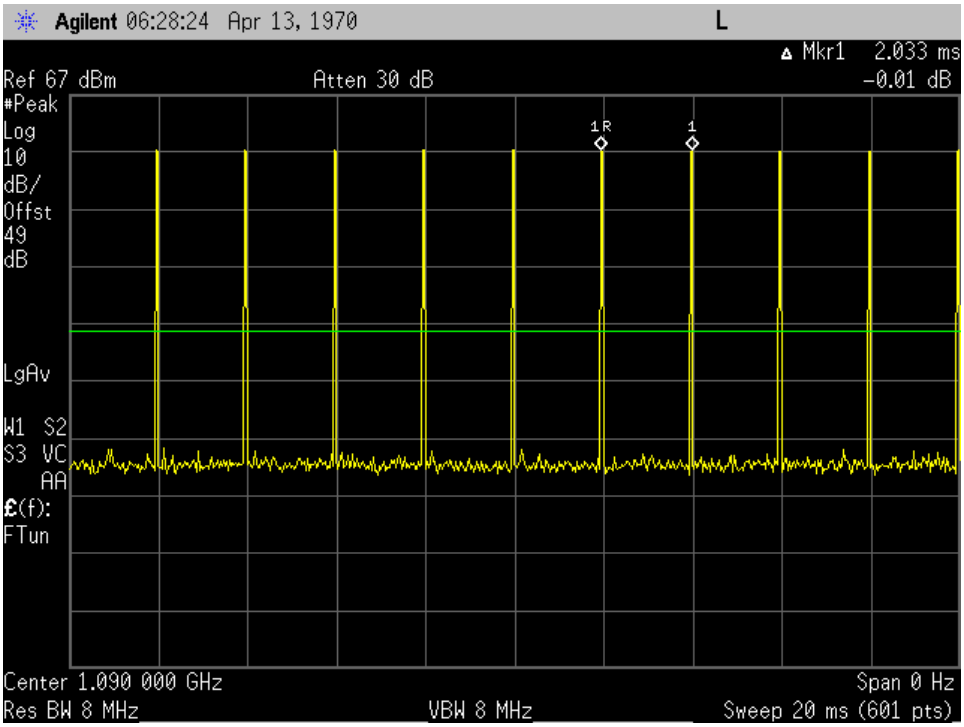
1030 MHz Pulse Width 2



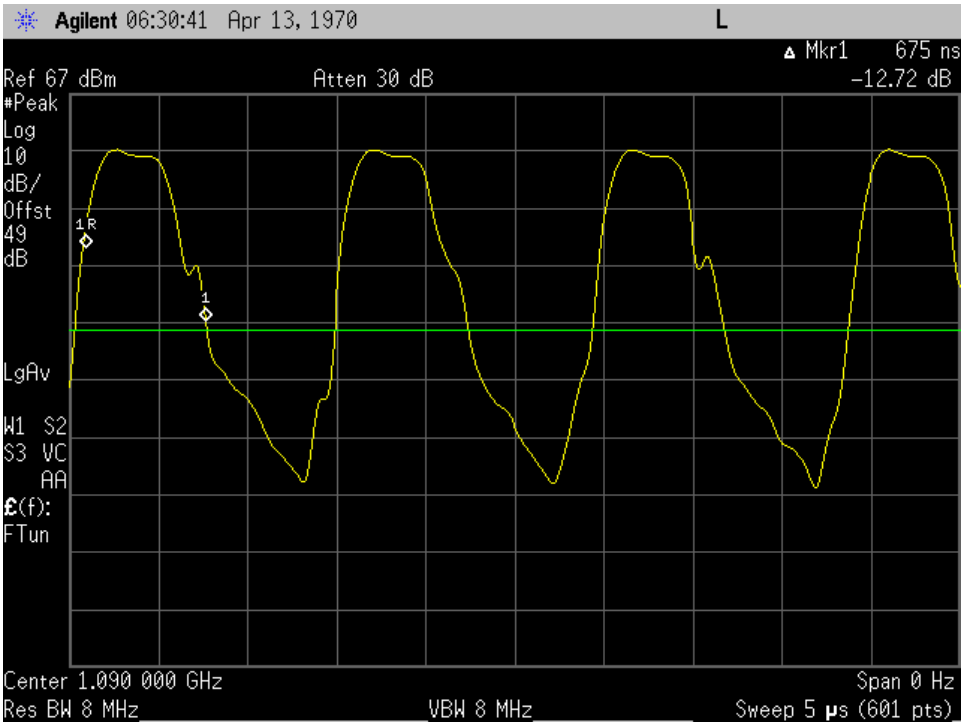
1030 MHz period



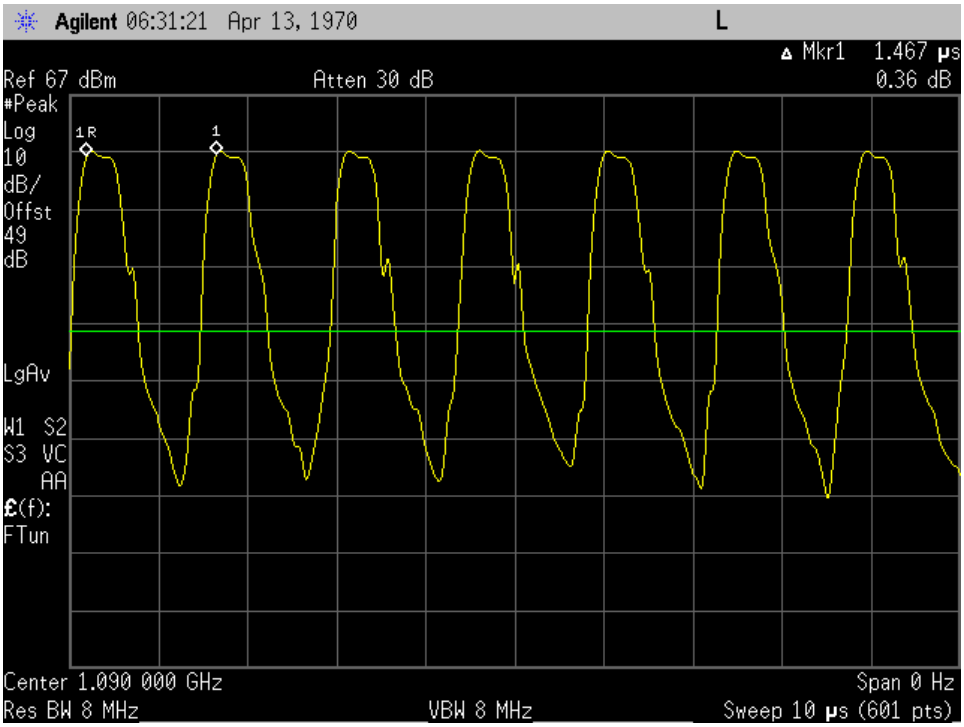
1090 MHz mode ATCRB period



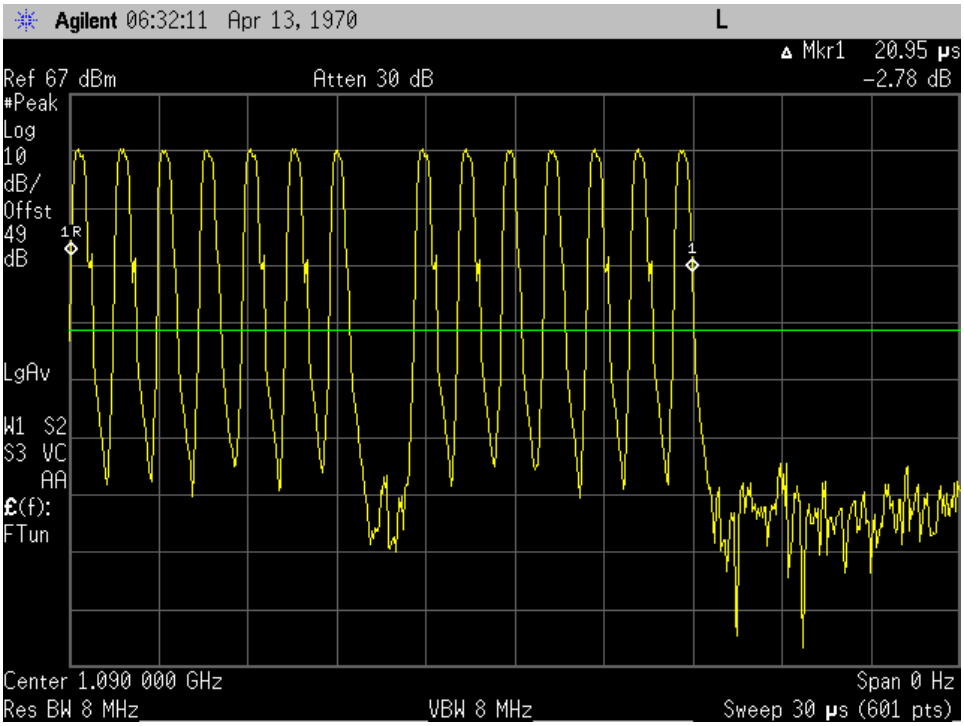
1090 MHz mode ATCRB pulse width



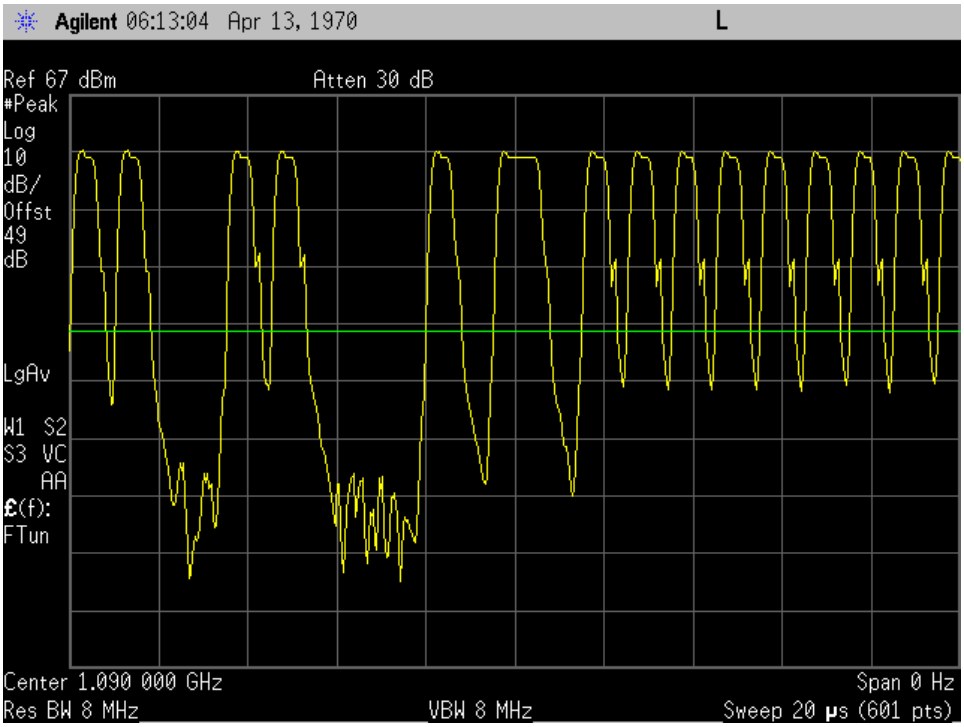
1090 MHz mode ATCRB pulse repetition



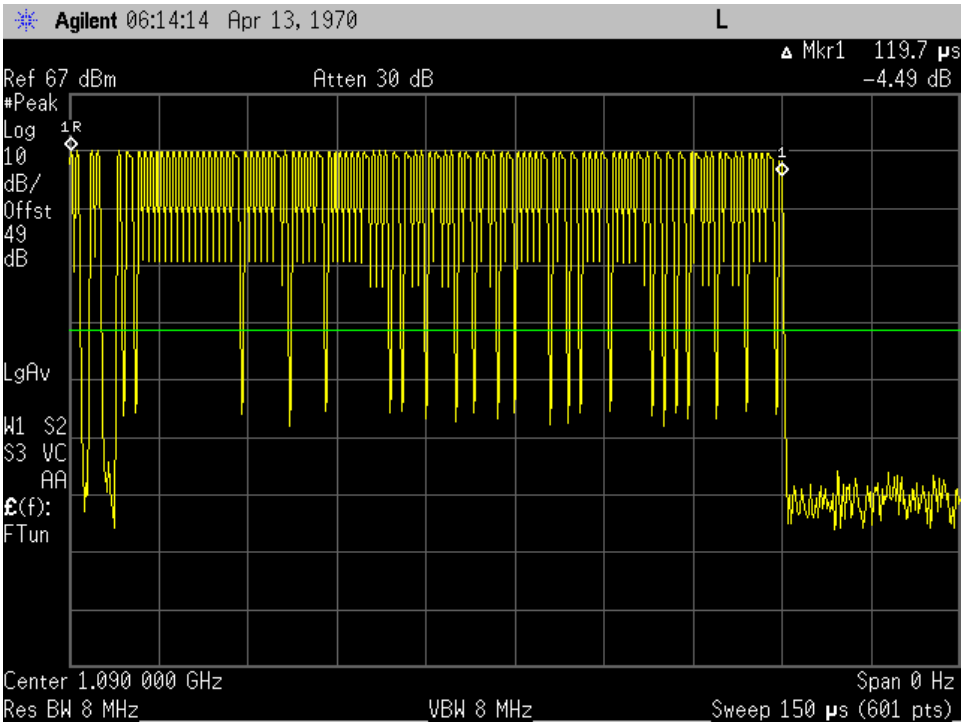
1090 MHz mode ATCRB pulse width



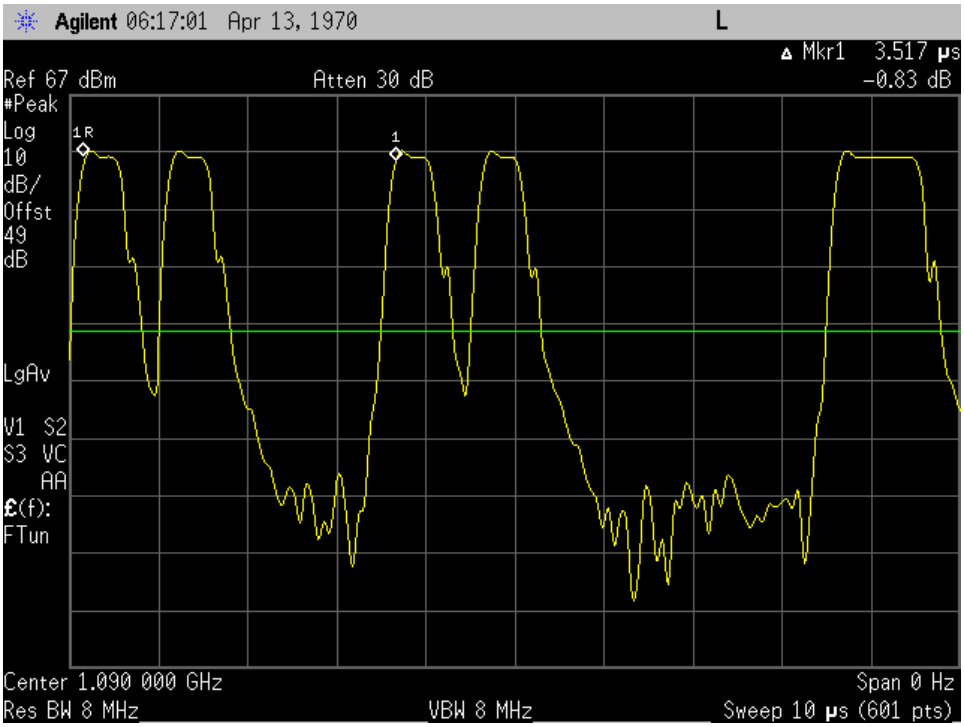
1090 MHz mode S pulse train



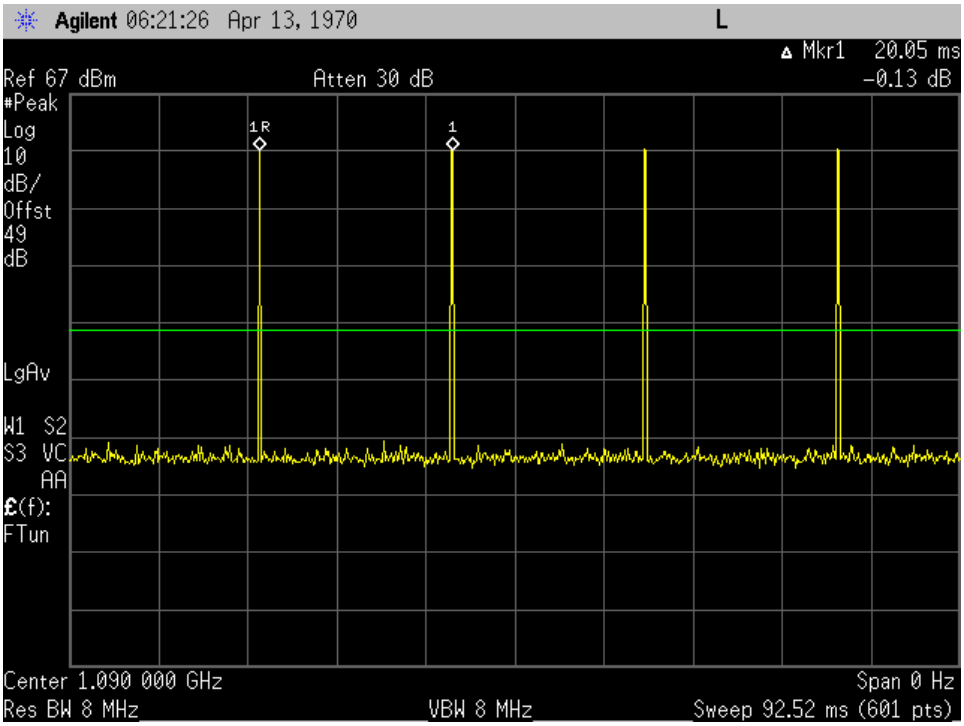
1090 MHz mode S pulse width



1090 MHz mode S P1-P3



1090 MHz mode S period



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