MXS System Description and Installation Manual

UM06945

February 2022

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1.0 Introduction

This manual provides information intended for use by persons who, in accordance with current regulatory requirements, are qualified to install this equipment. Installation requirements may vary, depending on the specifics of each aircraft, and this manual is intended as a guideline for that purpose. This manual assumes familiarity with the setup and operation of the aircraft systems that interface with the MXS.

1.1 Sagetech Customer Support

Sagetech Avionics is dedicated to making integration of our MXS a straight-forward and simple exercise. We want your experience with Sagetech to be unparalleled in product quality and customer service. If you have questions, contact Sagetech Avionics customer support at:

CustomerSuccess@sagetech.com

We also are interested in your feedback on our products, documents, and customer service.

1.2 Equipment Safety and Precautions

This product uses semiconductors that can be damaged by electrostatic discharge (ESD). When handling, use standard ESD practices to ensure the MXS is not damaged.

1.2.1 RF Port Termination Warning

Important:

Whenever power is applied to the MXS, a 50-ohm load must be connected to the SMA connector of any unused antenna port. Use a commercially available 50-ohm load rated for pulses of 500W with a 1% duty cycle and a maximum VSWR of 1.5:1 between 1030MHz and 1090MHz. A load with a higher VSWR may cause permanent damage to the transponder. (Refer to Section 4.3. *Connecting the RF Antennas)*

1.2.2 Electromagnetic Exposure Statements and Warnings

The MXS equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 87 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in all installations. If this equipment does cause harmful interference to audio or visional reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver
- Connect the equipment into a different power source than receiver.
- Consult the dealer or an experienced RF equipment installation technician for help.

This device complies with FCC Part 87 rules. Operation is subject to the following two conditions:

- This device may not cause harmful interference.
- This device must accept any interference received, including interference that may cause undesired operation.

Exposure Statement

This device meets the FCC requirements for RF exposure in public or uncontrolled environments. A minimum separation of persons to the antenna of 20cm must be observed.

FCC Warnings

Changes or modifications not approved by Sagetech could void the user's authority to operate the equipment.

2.0 System Information

2.1 Specifications

Part Number	10-0000
Certification	USA (FAA): TSO-C112e, TSO-C166b, TSO-C88b **See Section 2.2 for specific TSO information*
Advisory Circulars	AC20-165B, AC43-6D, AC20-172B, AC20-115C, AC20-152
RTCA Compliance	Environmental: DO-160G (see *Environmental Specifications, section 2.9)* Software Category: DO-178C Design Assurance Level C Hardware Category: DO-254, Design Assurance Level C Other: DO-181E, DO-260B, AS8003, ARINC 718
Compliance	ATC Transponder Functionality: 14 CFR 91.215, 91.217, 91.413 ADS-B out functionality: 14 CFR 91.225, 91.227
Export Compliance	ECCN 7A994
Size	Width: 2.52in [64.0mm], Height: 1.00in [25.4mm], Depth: 3.50in [89.0mm]
Weight	<7oz
Chassis Ground	The unit is not required to have a chassis ground. The external chassis is non-conductive
Power Requirements	28VDC 7.5 Watts nominal (20W maximum) 14VDC 7.5 Watts nominal (20W maximum) Inrush Current <6A Normal Operation range: 14-28VDC Minimum and Maximum operating range: 10-32VDC
Electrical Connectors	2x Female SMA Connectors, Female 51pin Micro-D Connector
Interfaces	RS-232, RS-422, Ethernet, GND/Open Discrete Inputs, RF Suppression Bus
Operating Temperature	-40° to +70°C (-40° to +158°F)
Storage Temperature	-55° to +85°C (-67° to +185°F)
Maximum Altitude	55kft
Functionality	Mode S Transponder 1090ES ADS-B In and Out Integrated Altitude Encoder tolerance per AS8002
Operation	Startup Time: <2 seconds to Transmission, <20 seconds for BIT to complete and fully functionality Built in Test: Fault monitoring detailed in SDIM (ICD02373) ADS-B Receive Sensitivity: -79dBm at the antenna, -82dBm at the SMA. Class A2 Mode S Transponder: (Class 1 Transponder) 250W - 500W Level 2[dels]
Scheduled Maintenance	The MXS Transponder must be inspected and tested every 24 months subject to the requirements of FAA documents 14 CFR Part 43 Appendix F.
Repairability	Repairs performed at the FAA certified Repair Station.

2.2 TSO Authorizations

The MXS meets the following TSO's.

TSO NO.	Class/Type	DO-178C/ DO-254 DAL	Function	TSO Title
C112e	Class 1 Level 2[dels]	C/C	ATCRBS / Mode S Transponder Airborne Equipment	Air Traffic Control Radar Beacon System/Mode Select (ATCRBS / MODE S) Airborne Equipment
C166b	Class A2	C/C	1090ES MHz ADS-B and TIS-B Equipment	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)
C88b	N/A	C/C	Altitude Encoder	Automatic Pressure Altitude Reporting Code-Generating Equipment

2.3 TSO Deviations and Incomplete

TSO	Deviation
C112e	Sagetech was granted a deviation from TSO-C112e Paragraphs 3.e and 6.f to use RTCA/DO-178C in place of RTCA/DO-178B.
C112e	Sagetech was granted a deviation from RTCA DO181E §2.2.19.1.12.4 to not implement Air-Initiated Comm-B support. Air-initiated Comm-B messages are neither processed nor transmitted.
C112e	Sagetech was granted a deviation from RTCA DO-181E §2.2.19.2.3.1 to not implement multi-site message support, as it applies to the Comm-B operation of Level 2 transponders.
C112e	Sagetech was granted a deviation from RTCA DO-181E §2.2.19.2.3.2: Multisite Directed Comm-B Transmissions requirement is N/A due to not implementing Air-Initiated Comm-B support and multi-site message support
C112e	Sagetech was granted a deviation from RTCA DO-181E §2.2.19.2.3.3: Multisite Comm-B Closeout requirement is N/A due to not implementing Air-Initiated Comm-B support and multi-site message support.
C112e	Sagetech was granted a deviation from RTCA DO-181E §2.2.19.2.3.4: Automatic Comm-B Closeout requirement is N/A due to not implementing Air-Initiated Comm-B support and multisite message support
C112e	Sagetech was granted a deviation from RTCA DO-181E §2.2.19.2.3.5: Significance of PC Command requirement is N/A due to not implementing Air-Initiated Comm-B support and multisite message support
C166b	Sagetech was granted a deviation from TSO-C166b Paragraphs 3.e and 6.h to use RTCA/DO-178C in place of RTCA/DO-178B.
C88b	Sagetech was granted a deviation from TSO-C88b Paragraphs 3.e and 6.h to use RTCA/DO-178C in place of RTCA/DO-178B.
C88b	Sagetech was granted a deviation from TSO-C88b Paragraph 3.d to use RTCA/DO-160G in place of RTCA/DO-160E.

2.4 FCC ID

Model	FCC ID
MXS 10-0000	YT5MX

2.5 Device Marking

REFERENCE ONLY

The Part number 10-0000 includes the released hardware and software configuration.

2.6 Continued airworthiness

Every 24 Calendar months the MXS must be checked for Transponder and Altitude Encoder performance. The Transponder must be tested, inspected and found to comply with 14 CFR Part 91.413 as described in 14 CFR 43 Appendix F. The altitude Encoder must be tested to ensure correspondence to the primary flight altimeter, as described in AC 43-6D and 14 CFR 43 Appendix E in order to meet the maintenance requirements of 14 CFR Part 91.411. If the difference between the automatic reporting output and the altitude displayed at the altimeter shall not exceed 125 feet.

2.7 Installation Approvals and System Limitations

1. This article meets the minimum performance and quality control standards required by the applicable technical standard orders (TSOs). Those installing this article, on or in a specific type or class of aircraft, must determine that the aircraft installation conditions are within the applicable TSOs standards. TSO articles must have separate approval for installation in an aircraft. The article may be installed only according to 14 CFR parts 43 or the applicable airworthiness requirements.

2. All antennas used in the installation must meet the requirements specified in this manual.
3. The GPS receiver must use antenna meeting the requirements specified in this manual.

4. It is the installer's responsibility to ensure the ADS-B Out system is compliant with AC 20-165A, 14 CFR 91.225 (b) and 91.227 when installed in accordance with Sagetech's installation instructions.

5. The MXS Transponder may be optionally configured to support single or diversity antenna installations.

Note: If the MXS is configured for single antenna installations, a 50-ohm termination is required on the Top antenna port.

2.8 Regulatory Compliance

Aircraft using Sagetech's MXS Transponder need to evaluate their need to be compliant with 14 CFR 91.215, 91.225, and 91.227. While in airspace with transponder equipage requirements specified in 14 CFR 91.215, MXS must be maintained to 14 CFR Part 91.413. While in ADS-B out airspace specified 14 CFR Part 91.225, MXS must be configured to meet requirements of 14 CFR 91.225 and 91.227.

For MXS to be compliant with the ADS-B out requirements of 14 CFR 91.225 and 91.227, a compliant position source must be used. See section 4.2 for more information.

To meet 14 CFR 91.225 and 91.227 with no limitations, active in-flight control is necessary. The Sagetech provided User Interface GUI can be used or the flight computer can be programed to communicate with the MXS via the Sagetech protocol defined in ICD02373. Section 7 details the power up and configuration process using the Sagetech provided MX Com Test GUI.

Additional Guidance for ADS-B out installations and approvals can be found in AC-20-165B and for ADS-B in applications reference AC 20-172B.

2.9 Environmental Specifications

The MXS was designed and verified to perform its intended function while operating in the environments listed in Table 2-1.

Table 2-1 List of Environmental Operating Conditions

Environment	DO-160G Section	Category
Temperature and Altitude **Operating Low Temp** **Operating High Temp** **Short-Time Operating Low Temp** **Short-Time Operating High Temp** **Loss of Cooling** **Ground Survival Low Temp** **Ground Survival High Temp** **Altitude** **Decompression Test** **Overpressure Test**	4	B4F1 -40 °C +70 °C -40 °C +70 °C N/A -55 °C 85 °C 55,000 Feet N/A N/A
Temperature Variation	5	S1(1)
Humidity	6	B
Operational Shocks & Crash Safety	7	B
Vibration	8	S (Zone 1; Curve C) U (Zone 1; Curve G)
Explosion Proofness	9	E
Magnetic Effect	15	Y
Power Input	16	BXI(2)
Voltage Spike	17	B
Audio Frequency Conducted Susceptibility – Power Inputs	18	B
Induced Signal Susceptibility	19	ACX
Radio Frequency Susceptibility (Radiated and Conducted)	20	TT
Emission of Radio Frequency Energy	21	BB
Lightning Induced Transient Susceptibility	22	B2K3L3 *B2K1L1 for power lines
Electrostatic Discharge	25	A

Note: The Altitude Encoder is only calibrated to go up to 55kft. It can be calibrated to 85kft upon request.

3.0 System Overview

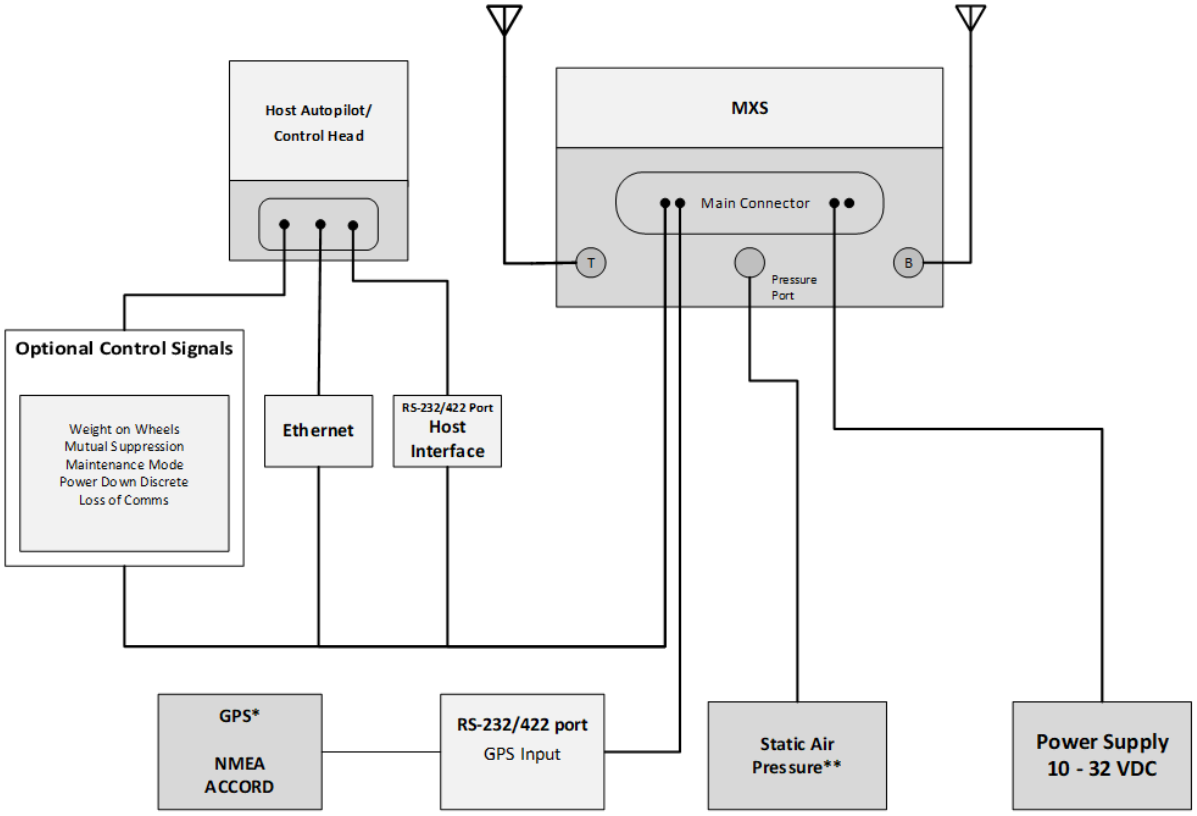
The MXS provides transponder functions within the Secondary Surveillance Radar (SSR) system. The SSR system provides situation awareness to Air Traffic Control (ATC) and the remote pilot.

3.1 System Description

An installed MXS interfaces to a Host (typically a Flight Computer or Autopilot)[1], GPS Sensor, Barometric Pressure Source, and Aircraft Control Signals.

Figure 3-1 is a block diagram depiction of the maximum integration of MXS. A minimum Mode C/Mode S installation is shown in Figure 3-2.

[1] In this document, the messaging protocol used to communicate between the MXS, and the host (typically a Flight Computer or Autopilot) will be referred to as the "Host Interface". See Section **Error! Reference source not found.** and Table 6-2 for more information about the serial and Ethernet data protocol used for the Host Interface, and the pins used for serial communications on the Main Connector. See Section ICD02373 for definitions of the message types comprising the Host Interface.



Note: If GPS is lost then ADS-B functionality will not be available.

* GPS Data can also be sent from Host computer using Sagetech's interface protocol format.
** Barometric Altitude data is required. Altitude data can either be sent from the host computer to the MXS or the internal sensor can be used.

Figure 3-1 Diagram of MXS Maximum Mode C/Mode S Installation

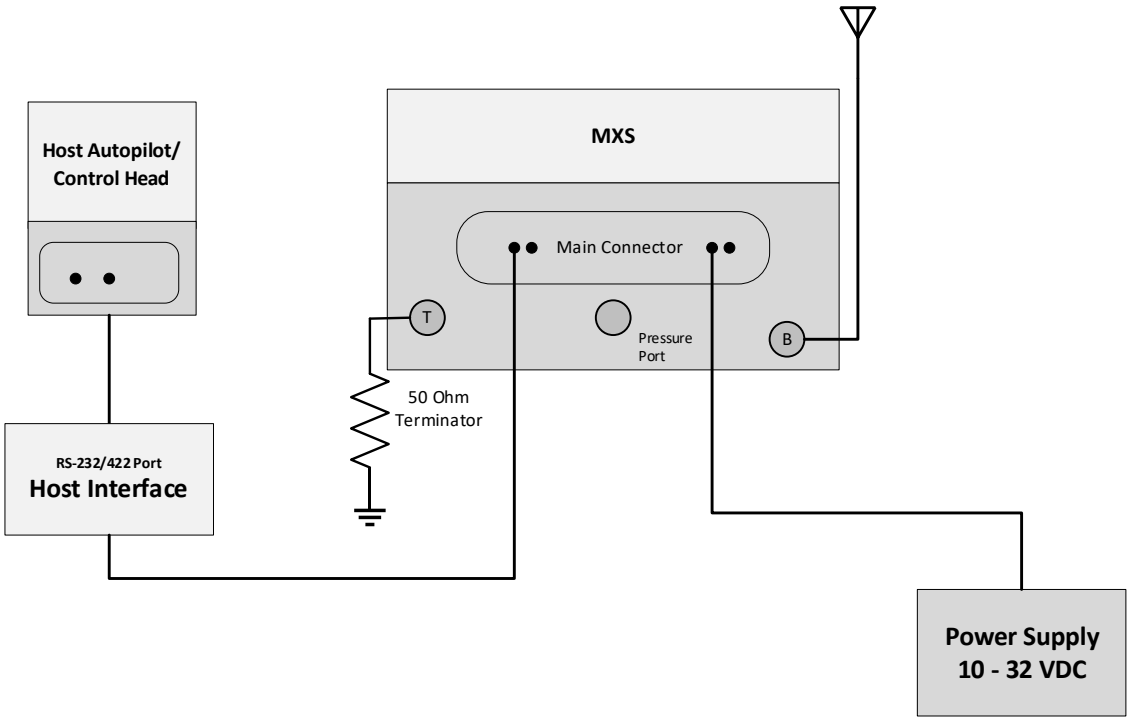


Figure 3-2 System Block Diagram of MXS Minimum Mode C/Mode S Installation

3.2 System Functionality

The MXS transponder performs the following basic functions:

3.2.1 Transponder

- Verified to meet the applicable requirements of DO-181E for a Mode S Class 1, Level 2 transponder.
- Interacts with air traffic control (ATC) by transmitting and receiving standard secondary surveillance radar pulses per ICAO requirements. The transponder replies to ATCRBS interrogations with a squawk code and pressure altitude data.
- Provides Mode S replies (includes data such as ICAO address and call sign) and is capable of being selectively interrogated.

3.2.2 ADS-B In

- Verified to meet the applicable requirements of DO-260B for a Class A2 ADS-B Receiver.
- The MXS receives Automatic Dependent Surveillance-Broadcast In (ADS-B), Extended Squitter (ES) messages that have been transmitted automatically from surrounding planes and the Air Traffic Control (ATC) system.
- ES messages report Position, Velocity, Identification and Category, Target State and Status, and Aircraft Operational Status. From this data, MXS generates ADS-B, TIS-B and ADS-R reports for delivery to the flight computer which communicates the data to the user.

- Transponders with ADS-B In are useful for sense and avoid applications by providing the user with surrounding traffic information with a nominal range of 120 nautical miles (NM).

3.2.3 ADS-B Out

- Verified to meet the applicable requirements of DO-260B for a Class A2 ADS-B Transmitter.
- Provides Flight computer-controlled Automatic Dependent Surveillance-Broadcast Out (ADS-B) capability.
- Transmits Extended Squitter (ES) and Acquisition Squitter messages at regular intervals, providing Position, Velocity, Identification and Category, Emergency/Priority Status, Target State and Status, Aircraft Operational Status, and other aircraft data. There is no way to disable Acquisition squitter independently of the Mode S functionality
- Altitude data for the ES can be based on the MXS's integrated altitude encoder, or one provided external to the MXS.
- GPS data, also included in the ES, is provided to the MXS from an external source.

3.2.4 Altitude Encoder

- Verified to meet the applicable requirements of AS8003 for a Pressure Altitude Encoder.
- Computes own-ship barometric altitude with an integral pressure sensor and encoder.
- Calibrated up to 55,000ft. Can be calibrated up to 85,000ft upon request.

3.2.5 Attributes of the MXS transponder include the following

- GPS input is accepted from the Host Interface command link, or from NMEA or Accord GPS sensors over serial communication ports.
- Supports antenna diversity (dual antennas located on the top and bottom of the aircraft).
- Supports aircraft system installations of one or two Transponder/ADS-B L-Band antennas
- Integrated pressure altitude sensor and encoder that provides required altitude data when the static pressure port is connected to a static air pressure line.
- The MXS measures approximately 3.50in (89.0mm) x 2.09in (53.0mm) x 1.00in (25.4mm). (see Section 5.1)
- Operating temperature is -40°C to +70°C[2]
- Storage temperature is -55°C to +85°C.
- Nominal input supply voltage range is 14-28 VDC.
- Aircraft Flight computer communication is either RS-422, RS-232 or Ethernet using the Host Interface protocol defined ICD02373

3.2.6 Control Interface

The MXS has a control and configuration serial interface that is used to configure the equipment at installation time as well as command and control the device during operation. Typically, the MXS is

[2] Refer to Section 4.6 Cooling Requirements.

connected to an autopilot or flight computer on an unmanned aircraft or a control interface on a manned aircraft.

At the time of installation, the control interface allows the user to input specific information about the aircraft that is used in Mode S and ADS-B messages. The interface also allows the user to configure the Baud rate of Com0 and Com1, set the IP address (which will be used for ethernet communication) configure the weight on wheels “method” and select Single or Diversity Antenna installation. This data will be saved in nonvolatile memory and loaded on every power up.

While operating the MXS the serial interface allows the user to change the operating mode, enable Ident, change emergency status, and get critical system and transponder health information.

To comply with 14 CFR 91.225 with no operating limitations, dynamic control is required.

The MXS Serial interface is defined in ICD02373.

Table 3-1 Control Interface

Communication Interface	Specifications
Ethernet	IEEE 802.3 10Base-T
RS-232	Configurable bps (8N1) Com0 or Com1
RS-422	Configurable bps (8N1) Com0 or Com1
RS-485 Half Duplex Interface by connecting 422 Rx and Tx lines R+ with T+ and R- with T-	Configurable bps (8N1) Com0 or Com1, MXS does not have logic to avoid packet collision; Host interface must manage packet transmit and receive timing.

4.0 Installation

This section explains the installation of the MXS unit and its connections. Table 4-1 lists the sections documenting MXS installation.

Table 4-1 Installation Sections

Installation Step	Description
4.1	Mounting the MX
4.2	Connecting the GPS Interface
4.3	Connecting the RF Antennas
4.4	Routing and Connecting the Antenna Cable
4.5	Connecting the Altitude Sensor/Encoder to the System Static Pressure
4.6	Cooling Requirements

MXS requires the following additional equipment:

- GPS Receiver
- Transponder Antenna
- Control Interface with Annunciation

Figure 4-1 shows a labeled diagram of MXS's connectors and mounting holes, which should be used as a reference during the installation process.

Note: The Main Connector and its connection to the MXS are described in *Section 5.2 Mechanical Connection* and Section *6.0 Electrical Characteristics.*

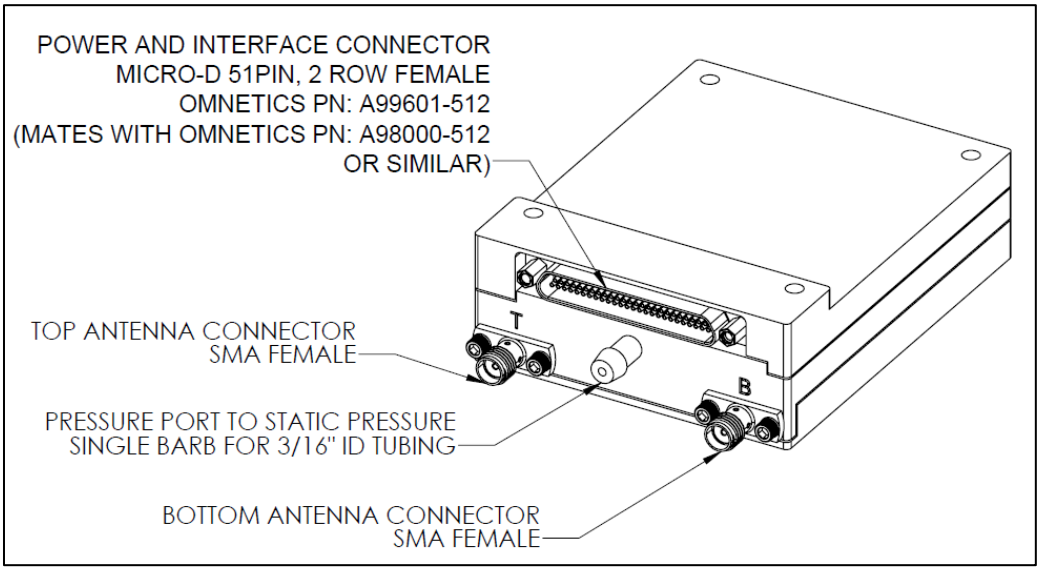


Figure 4-1 Diagram and Identification of MXS Connectors and Mounting Holes Mounting the MXS

4.1 Mounting the MXS

- The MXS needs to be mounted in a location protected from weather.
- MXS should be mounted away from sources of excess heat to better guarantee an operating environment within its designed temperature range. Mount on a heat sink, if necessary, to maintain device junction temperature below 85°C. With adequate airflow and lower ambient operating temperatures, the MXS can be mounted directly to the airframe.
- Refer *to Section 5.1 Dimension, Weight & Material* for mounting dimensions.
- Sagetech recommends applying Loctite 242 Thread locker to the machine screw threads or using locking washers or locking nuts.
- The hardware listed in Table 4-2 are potential candidates for use in custom installation.

Table 4-2 List of Common Mounting Parts and Vendors

Description	Vendor	Vendor PN	Quantity
Machine Screw, Round Head, PH1, .112(#4)-40 Thread Size, 1", Zn Plated Steel	McMaster-Carr	90279A115	2
Machine Screw, Round Head, PH1, .112(#4)-40 Thread Size, 1-1/4", Zn Plated Steel	McMaster-Carr	90279A117	2
Flat Washers, Black-Oxide Steel Oversized Washer for Number 4 Screw Size, 0.125" ID, 0.25" OD	McMaster-Carr	98029A024	8
Locknut, low-Strength Steel Nylon-Insert, Zinc-Plated, 4-40 Thread Size	McMaster-Carr	90631A005	4

4.2 Connecting the GPS Interface

GPS data must be provided to the MXS from the aircraft system in one of three ways:

1. NMEA data sent via RS232/RS422 to COM0 or COM1. MXS accepts GGA, GLL, RMC and VTG NMEA sentences. If NMEA Protocol is used, then SIL and SDA are set to 0 automatically.
2. The proprietary Accord Binary data sent via RS232/422 to COM0 or COM1(a TSO-C145c compliant solution). MXS accepts: The Navigation Packet, the Auxiliary Navigation Packet, and the Status Packet. If Accord protocol is used the SIL is set to 3 and the SDA is set to 2 automatically.
3. Sagetech defined GPS message protocol as defined in ICD02373 and can be sent to COM0, COM1, or ethernet. If the Sagetech navigation message is used, then the SIL and SDA is set by the install message.

Per AC 20-165A an appropriate position source must be used. The total latency measured from the time when the position is measured to when the position is transmitted must be less than or equal to 2.0 seconds. The MXS will reflect the updated position information within 100milliseconds from receiving the position message.

The NexNav Mini LRU PN:21001 meets the requirements per AC 20-165A as it holds a TSO-C145. The MXS is compatible with the Accord Binary protocol that the 21001 outputs.

For other TSO'd GPS receivers that use an alternative protocol the data must be translated to either the Accord Binary format or Sagetech Defined format.

The MXS will not function correctly if multiple sources of position information are sent into the device. User must send one source at a time.

Note: See 6.1 Main Connector *for more information about the serial data protocol and the pins used for serial communications on the Main Connector.*

4.3 Connecting the RF Antennas

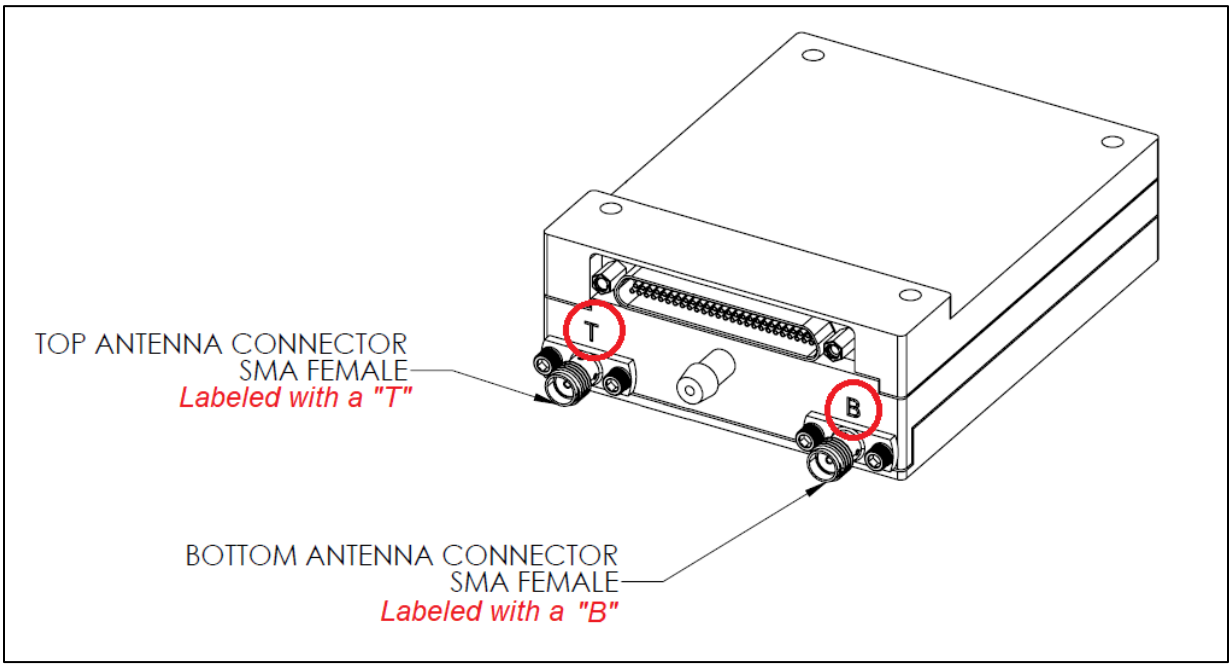


Figure 4-2 Connectors to Top and Bottom Antenna

In the diversity configuration, top and bottom-located antennas connect to the MXS using the left and right-side female SMA connectors. Assuming the orientation shown in Figure 4-2, the top antenna connects to the left connector (labeled 'T') and the bottom antenna (labeled 'B') connects to the right connector. Whenever power is applied to the MXS, a 50-ohm load must be provided to both of the SMA connections. Ensure that the antenna(s) selected provide a 50-ohm termination for the MXS.

If only one antenna is used, that antenna must be connected to the bottom SMA connector on the MXS. In this case, the following should be done:

- The unused top antenna connector must be replaced with a 50-ohm termination rated for 0.25W minimum (CW). (Refer to Table 4-3 for a suitable supplier and vender part number for the terminator.)
- Antenna Diversity must be disabled using the host/MXS Installation Message (Type 0x01) (see ICD02373).

Table 4-3 List of Common Mounting Parts and Vendors

Description	Vendor	Vendor PN
CONN TERMINATOR PLUG SMA 50OHM	Amphenol	**132360**

The antenna(s) used by MXS should be mounted on the outside of the aircraft according to the antenna manufacturer's installation instructions, with additional requirements and guidance provided below and in Table 4-4.

- The MXS should have its own antenna(s). An exception can be made for a high-quality diplexer that enables antenna sharing between an MXS and other UAT ADS-B equipment. Further guidance on diplexer use can be found in RTCA documents DO-282B and DO-260B, the minimum operational performance standards for UAT, and 1090 MHz ADS-B, respectively.
- Minimize the distance between the MXS and its antenna(s). The antenna cable(s) must have no more than 2dB of signal loss from the MXS to the antenna. The 2dB loss equates to approximately 3 meters of aircraft quality RF cable.
- Take care to locate the antenna(s) away from any objects that may disrupt the ground plane for the antennas, such as doors and landing gear.
- Do not place the antenna(s) near engine exhaust.
- Try to keep the antenna(s) located at least 36” away from other antennas on the aircraft. The antennas should be located as close to the centerline of the fuselage as space allows, while trying to keep the antennas on a flat surface.
- A ground plane is required for most antennas appropriate for MXS. Failure to provide a adequate ground plane can result in degradation of antenna performance. Ground plane radius should be roughly the same length as the antenna.
- Use antenna(s) designed for aviation transponders, with the characteristics documented in Table 4-4. Table 4-5 shows some example antennas that can be used.
- Torque mating SMA connectors to 7-10 lb. · in [80-110 N · cm].
- Take care not to over-torque the antennas attempting to reduce a gap between the antenna and the mounting surface; torque the antenna to the manufacturer’s instructions.

Note: MXS performance (range) may be hindered or damage to the MXS could result if installation does not meet all of the requirements above.

Table 4-4 MXS Antenna Requirements

Antenna Requirements	
Frequency	1030 to 1090 MHz
Polarization	Vertical
Nominal Impedance	50 Ω
VSWR	<1.5:1 between 1030 to 1090 MHz
RF Power	500 W Peak
Radiation Pattern	The gain must not be less than the gain of a matched quarter-wave stub minus 3 dB over 90 percent of a coverage volume from 0 to 360 degrees in azimuth and from 5 to 30 degrees above the ground plane when installed at the center of 1.2 m (4 foot) diameter (or larger) flat circular ground plane.
Mounting Location	Center of fuselage on the Top and/or Bottom side is ideal location.

Table 4-5 Example Antennas

Description	Vendor	Vendor PN
Transponder Antenna	RAMI	**AV-22**
Transponder Antenna Blade	RAMI	**AV-74**

4.4 Routing and Connecting the Antenna Cable

Attach the antenna cable to the antenna SMA connector(s) shown in Figure 4-2.

A suitable antenna cable consists of a male SMA connector, a length of co-axial cable, and a suitable connector for the antenna. For example, if using a simple monopole antenna with a BNC female connector, the antenna cable will need a BNC male connector. A cable part number for this example is provided in Table 4-6.

Table 4-6 Antenna Cable Connector Parts

Part Description	Manufacturer	Part Number
SMA Male to BNC Male Right Angle Cable 24”	Pasternack	PE3C0040-24

The antenna cable must have no more than 2dB of signal loss from the MXS to the antenna. This includes losses in the connector and cable. Generic and custom-built cables can be obtained from suppliers such as Pasternak, Richardson, and Aircraft Spruce.

Maintain coax cable minimum bend radius per manufacturers specifications.

4.5 Connecting the Altitude Sensor/Encoder to the System Static Pressure

MXS’s integral pressure sensor and encoder can provide altitude data for Extended Squitters and interrogation replies when the altitude encoder port (see Figure 4-3) is connected to the aircraft static pressure source.

Plumb the altitude encoder connection to a static pressure line that shares the same source as the main aircraft altimeter. The pressure barb is sized 0.18" (or 3/16”) Internal Diameter (ID) tubing. A typical installation will have a T or Y fitting in the static pressure line with one end running to the MXS. Suitable Y-barbed tube fittings are available from suppliers such as McMaster-Carr.

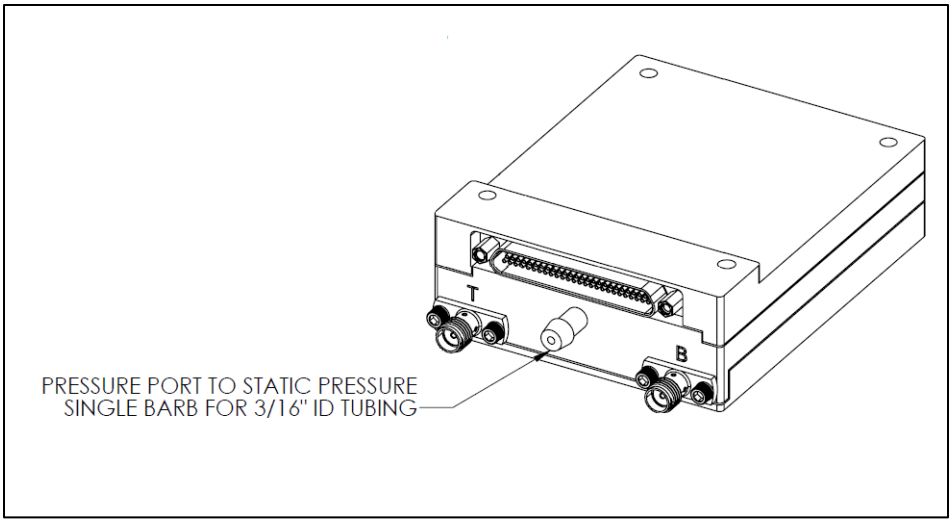


Figure 4-3 Pressure Altitude Encoder Port to Static Pressure

4.6 Cooling Requirements

The MXS is designed such that its case conducts thermal load to the aircraft frame through the bottom (Non-Labeled) side. The transponder can be firmly mounted directly to the aircraft, or to other components within the aircraft.

- The transponder should be mounted away from sources of excess heat to better guarantee an operating environment within its designed temperature range.
- To meet the required Mean Time Between Failures (MTBF), the Internal Circuitry shall not exceed 85°C.
- The MXS can still operate above this temperature up to the temperature protection limit of 110°C, however, above 85°C the MTBF will degrade. For example, if the ambient temperature is 55°C and the temperature rise of the MXS is 35°C (see plots below) then the MXS internal junction temperature would be 85°C and the MTBF will have degraded performance.
- If the temperature protection limit is hit the MXS will cease transmissions until the device has cooled down to a safe operating temperature. Once below the safe temperature threshold, the transponder will automatically continue transmitting without any required actions of the operator or host computer.
- Internal temperature can be monitored by requesting the Health Monitor Response Message (see *ICD02373)*
- The plots below characterize the thermal performance of the MXS in 2 different scenarios and at various transmit duty cycles.

Figure 4-4 Cooling Methods vs. Device Temperature[3] shows average internal device temperature and self-reported temperature of the SoC under the following conditions:

[3] Cooling method testing was performed with a SQUAWK code of 7777, with Emergency mode and X Bit off. One Mode A reply equates to 0.00063%.

- (a) device on insulated closed-cell foam pad, natural convection only on top and side surfaces.
- (b) device on insulated closed-cell foam pad, ducted forced air cooling at 20.1 LFM on top and side surfaces.

The temperature protection limit at 110 °C applies to the average internal device temperature. The average device temperature is representative of the majority of PCBA components within the device. The SoC within the device typically operates at a temperature delta of ~10°C above the average device temperature and triggers overtemperature protection at a correspondingly higher temperature of 120°C.

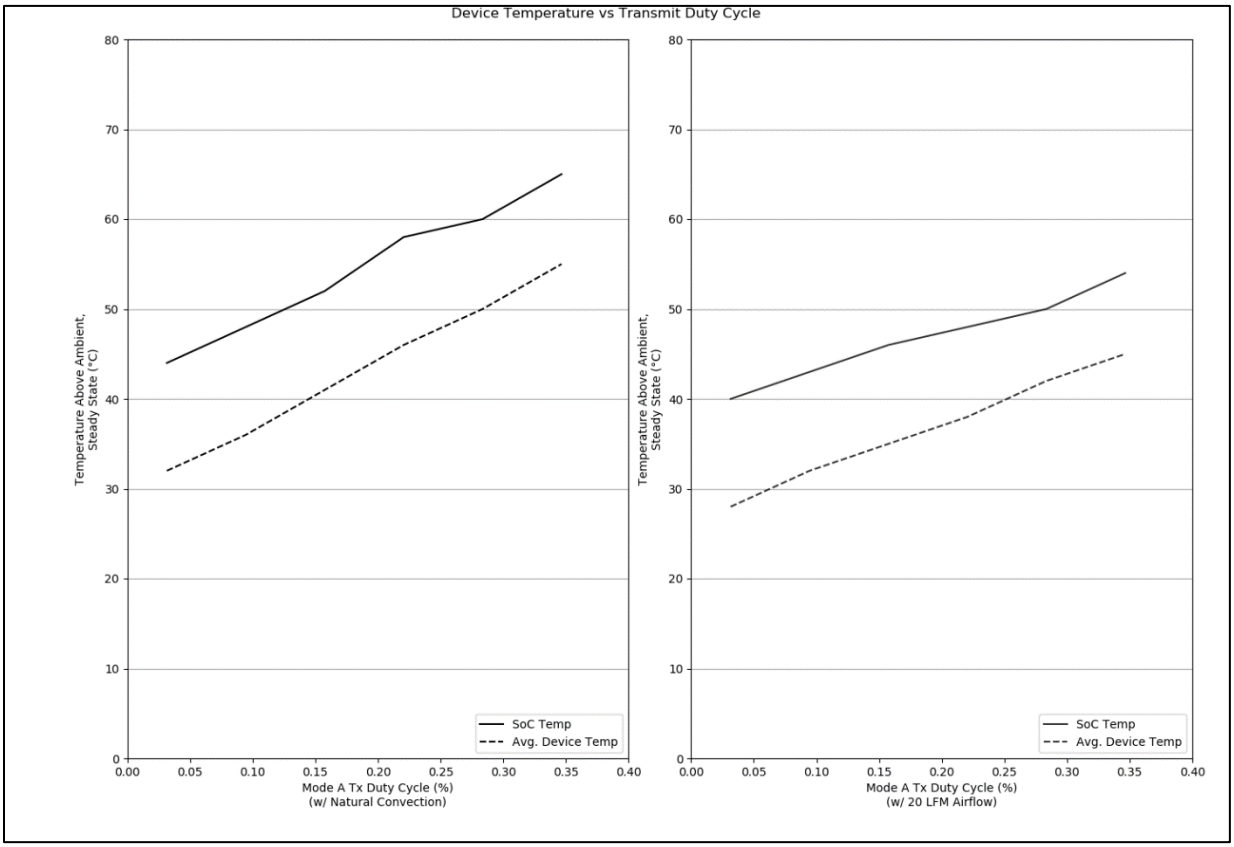


Figure 4-4 Cooling Methods vs. Device Temperature

5.0 Mechanical Characteristics

5.1 Dimension, Weight & Material

The MXS measures approximately 3.50in (89.0mm) x 2.09in (53.0mm) x 1.00in (25.4mm).

Table 5-1 lists the weight, color, and material attributes of the MXS. Figure 5-1 shows MXS dimensions.

Table 5-1 Mechanical Attributes

Weight:	**<7oz**
Finish:	COATED PER MIL-PRF-85285 TY I, CL H COLOR LIGHT GRAY PER FED-STD-595/26373. FINISH COAT APPLIED OVER PRIMER MIL-PRF-23377, TY I, CL N.

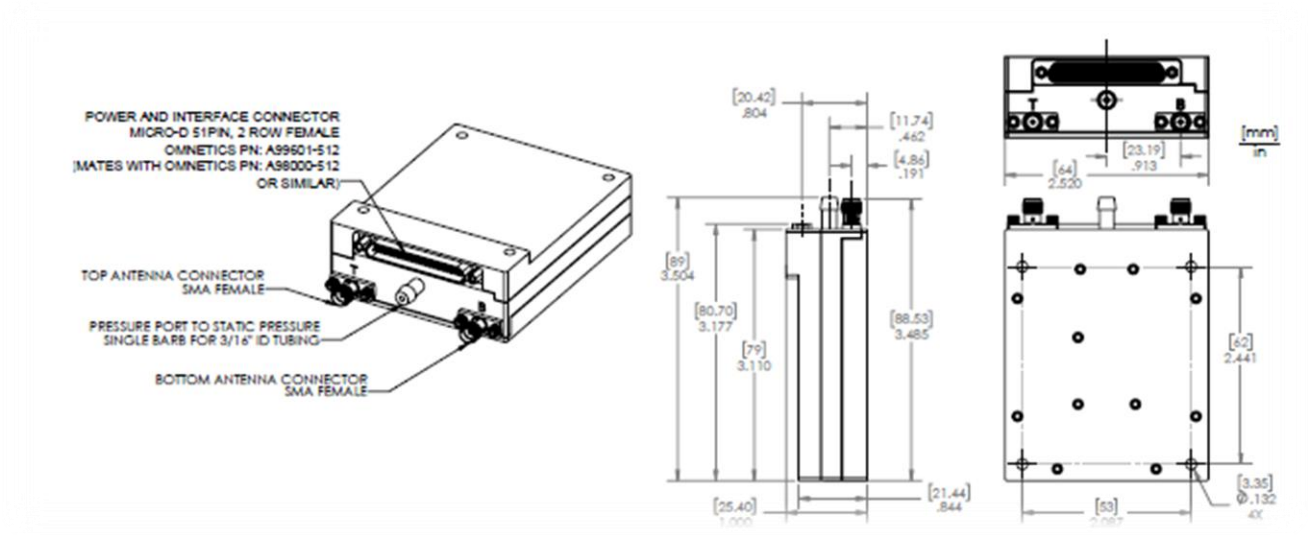


Figure 5-1 MXS Dimensions

5.2 Mechanical Connection

The MXS has the following connectors/ports:

- One 51-Pin Micro D-Sub connector, connecting to the host and power.
- Two Transponder/ADS-B L-Band SMA antenna connectors.
- One Pressure Altitude Sensor/Encoder port to static port to static pressure, barbed fitting for 0.18" (or 3/16") ID tubing.

The locations of these connectors and ports are shown Figure 5-2.

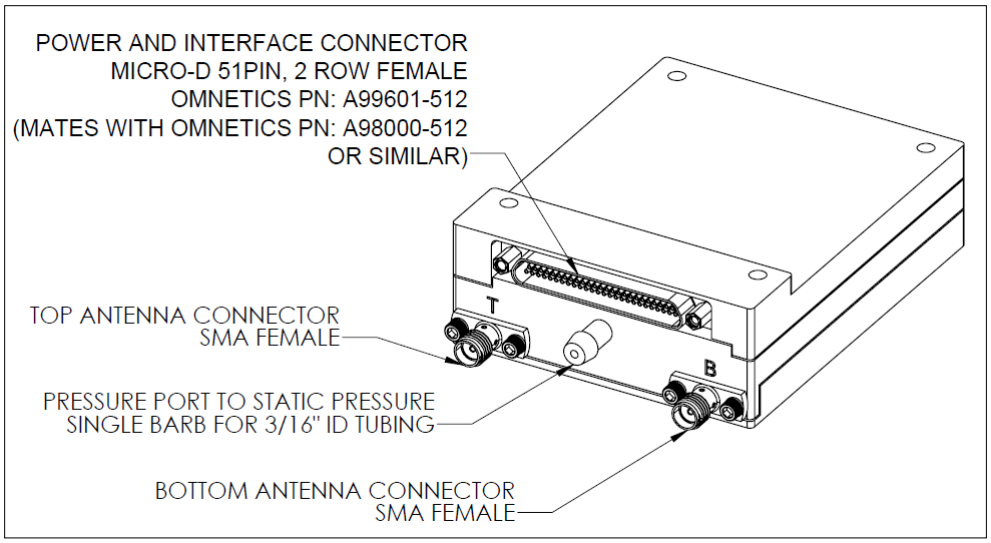


Figure 5-2 Mechanical Connections

5.2.1 MXS Main Connector

The MXS Main Connector is a 51-pin Micro-D type female connector that provides aircraft power and the Host Interface.

Figure 5-3 shows the MXS Main Connector (Omnetics P/N: A99601-512) with pin locations and signal pinout. Figure 5-4 presents an image of the female Micro D-Sub Main Connector's front view, with pin number orientation. Table 6-1 lists the Main Connector 51-pin assignments.

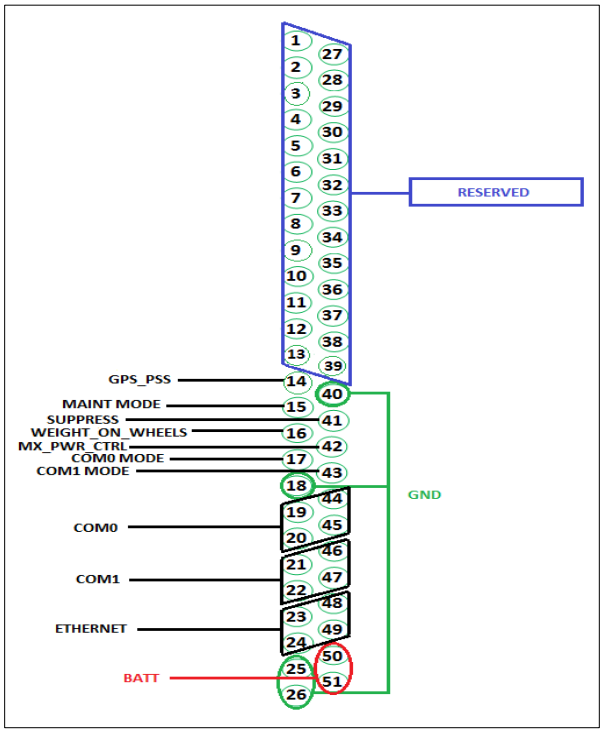


Figure 5-3 MXS Main Connector (Female) Pin Locations

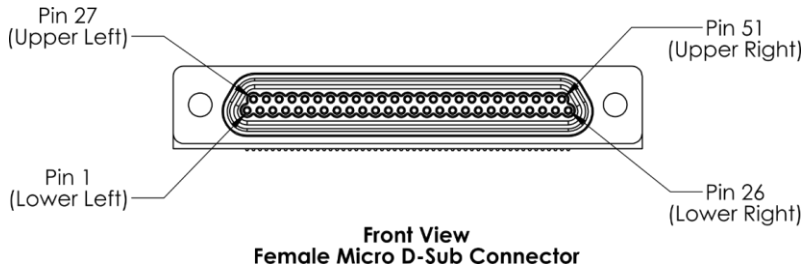


Figure 5-4 Transponder Main Connector - Front View

Connecting the MXS Main Connector to the host requires that a shielded cable be constructed, an example of which is shown in Appendix A –Shielded Cable Assembly Construction. Refer to AC 43.13-1B Chapter 11 for guidance if new power wiring is required.

6.0 Electrical Characteristics

6.1 Main Connector

Table 6-1 lists the pin assignments for the Main Connector. See Figure 5-4 for pin number orientation.

By design, all signals on the Main Connector are protected from damage caused by Indirect Effects of Lightning (DO-160G category K3L3[4]) and Electrostatic Discharge (at 2kV HBM or better) A shielded cable bundle with similar construction to Appendix A is required. Power specific pins are designed to DO-160G category B2K1L1.

Additional Main Connector signal information:

- Power signals are the supply voltage and ground returns provided by the aircraft. The **DC power pins** of the MXS are protected from overvoltage (up to 50VDC) and reverse polarity conditions.
- The **Maintenance Mode** signal is a discrete input that allows the flight computer to perform maintenance functions such as software updates or sending the installation message. To enable Maintenance Mode, connect the Maintenance Mode pin to ground. To disable Maintenance Mode, leave the Maintenance Mode pin unconnected, i.e., floating. During normal operation Maintenance Mode should be disabled.
- MXS **Power Control** signal is used to power down the transponder (near zero power consumption). If the Power Control line is left open, the Transponder is powered. The Transponder will power down when the Power Control line is connected to ground.
- **Weight-on-Wheels (WOW)** signal is an input that indicates whether the aircraft is on the ground or in the air. Grounding the pin indicates that the aircraft is on the ground. Removing the ground indicates the aircraft is in the air. If the WOW signal is not used, the pin may be left unconnected.

[4]A Shielded cable harness must be used to survive indirect lightning effects. Power lines meet the levels unshielded See Section 9.0 Appendix *A –Shielded Cable Assembly Construction*.

- The communication ports (**Com0 and Com1**) can be configured as either a RS-232 or RS-422 serial bus. Selecting the serial communication port bus type is controlled by the state of **Com0-Mode** and **Com1-Mode** signals. The Com-Mode pins will select RS-422 if left open, if grounded they will configure the ports for RS-232. A truth table based on the state of Com0-Mode and Com1-Mode is provided in Table 6-2 *Communication Port Options.*
- **Priority SQUAWK** is a ground/open discrete input to the MXS. When this pin is grounded the SQUAWK code will be automatically set to a preprogrammed SQUAWK code that is set in the Civil Setting message and stored in NVM. When the Pin is open the SQUAWK, code defaults to the value set in the operating message.
- At least one COM port or the Ethernet port must be used for the Host Interface.
- The **ethernet** interface of the MXS only supports a point-to-point connection.
- **Mutual Suppress** is designed to connect to an aircraft's bidirectional suppression bus. Mutual suppression bus is used to desensitize L-Band receivers and block L-Band transmitters when another on-board L-Band equipment is transmitting. This prevents interferences from own-ship L-Band transmitters. It is typically used when aircraft equipage includes Transponders, TCAS and/or DME. MXS stops transmitting and receiving when Mutual Suppression line is driven to high (18V-70V) by an external source. The MXS will return to normal operation within 15 microseconds following the suppression pulse. In the case of a continuously high suppression bus, MXS will automatically return to the unsuppressed state after 12-25ms.
- The nominal mutual suppression output pulse amplitude is 28V +/- 1V. Rise time of the output mutual suppression pulse will be no less than 20V/µs and decay time will be no less than 10V/µs. The suppression bus driver can drive a load between 300Ω to 2.2kΩ, however in the case that the mutual suppression bus is loaded with a resistance of 2.2kΩ the maximum capacitance to maintain a 10V/µs decay time must be 800pF or lower.

Table 6-1 Pin-Out Definition

Pin Number	Signal	Direction	Signal Char.
1	Reserved	No Connect	-
2	Reserved	No Connect	-
3	GND [5]		Ground
4	Reserved	No Connect	-
5	Reserved	No Connect	-
6	Reserved	No Connect	-
7	Reserved	No Connect	-
8	Reserved	No Connect	-
9	GND		Ground
10	Pin 10 - 35 short	Bi-Directional	Pass-through

[5]MXS has a common ground, all pins are internally connected. Ideal installation utilizes all ground pins to provide best ground return path.

Pin Number	Signal	Direction	Signal Char.
11	Reserved	No Connect	-
12	Pin 12 -37 short.	Bi-Directional	Pass-through
13	5V	Power	5 VDC
14	Reserved for GPS-PPS [6]	Input	TTL PPS
15	Maintenance Mode [7]	Input	GND/Open
16	Weight-on-Wheels	Input	GND/Open
17	Com0-Mode [8]	Input	GND/Open
18	GND	Power	Ground
19	Com0-422-RX+ [8 9] Com0-232-RX	Input	RS-422 RX+ RS-232 RX
20	Com0-422-TX+ [8 9] Com0-232-TX	Output	RS-422 TX+ RS-232 TX
21	Com1-422-RX+ [8 9] Com1-232-RX	Input	RS-422 RX+ RS-232 RX
22	Com1-422-TX+ [8 9] Com1-232-TX	Output	RS-422 TX+ RS-232 TX
23	Ethernet-TX+ [9]	Output	IEEE 802.3+
24	Ethernet-RX+ [9]	Input	IEEE 802.3+
25	GND	Power	Ground
26	GND	Power	Ground
27	Reserved	-	-
28	Reserved	-	-
29	Reserved	-	-
30	Reserved	-	-
31	Reserved	-	-
32	Reserved	-	-
33	Reserved	-	-
34	Reserved	-	-
35	Pin 10 - 35 short	Bi-Directional	Pass-through

[6]MXS does not support GPS PPS, this is a future provision. Pin can be left floating (No Connect)
[7]The transponder must be in maintenance mode for the Installation message to be received and processed, otherwise the message is ignored.
[8]RS-422 bus will be selected if pins are left unconnected. The pin must be grounded to select RS-232 bus. (See Table 6-2)
[9]Transmit and receive are from the MXS perspective. Connect as appropriate. There must be at least one COM port connected for control.

Pin Number	Signal	Direction	Signal Char.
36	Reserved	-	-
37	Pin 12 -37 short.	Bi-Directional	Pass-through
38	Reserved	-	-
39	Loss of Communications	Input	GND/Open
40	GND	Power	Ground
41	Suppress [10]	Bi-Directional	
42	MXS Power Control	Input	GND/Open
43	Com1-Mode [8 9]	Input	GND/Open
44	Com0-422-RX- [8 9]	Input	RS-422 RX-
45	Com0-422-TX- [8 9]	Output	RS-422 TX-
46	Com1-422-RX- [8 9]	Input	RS-422 RX-
47	Com1-422-TX- [8 9]	Output	RS-422 TX-
48	Ethernet-TX- [9]	Output	IEEE 802.3-
49	Ethernet-RX- [9]	Input	IEEE 802.3-
50	DC Power [11]	Power	14-28VDC
51	DC Power [11]	Power	14-28VDC

Table 6-2 Communication Port Options

Serial Bus Type/ Required Configuration	Main Connector Interface	
	Signal	Pin
RS-422 Com0 **Com0-Mode pin 17 is left open**	Com0-RX-	44
	Com0-RX+	19
	Com0-TX-	45
	Com0-TX+	20
	Com0-Mode	17
RS-232 Com0 **Com0-Mode pin 17 is tied to ground**	Com0-232-RX	19
	Com0-232-TX	20
	Com0-Mode	17
RS-422 Com1 **Com1-Mode pin 43 is left open**	Com1-RX-	46
	Com1-RX+	21
	Com1-TX-	47
	Com1-TX+	22
	Com1-Mode	43

[10]Mutual suppression circuit designed to requirements in ARINC 718 - Attachment 6.
[11]Both power pins must be connected to aircraft main power.

Serial Bus Type/ Required Configuration	Main Connector Interface	
	Signal	Pin
RS-232 Com1 **Com1-Mode pin 43 is tied to ground**	Com1-232-RX	21
	Com1-232-TX	22
	Com1-Mode	43
Ethernet	Ethernet-TX+	23
	Ethernet-RX+	24
	Ethernet-TX-	48
	Ethernet-RX-	49

7.0 Power up Process

In the following steps an example power up process is shown using a Sagetech provided GUI. The Sagetech MXS GUI communicates with the Sagetech defined protocol as specified in the ICD02373. This GUI simulates a GPS Position for the purpose of testing transponder functionality, but it should not be used to send position information to the transponder in flight. For detailed procedures using the MXS Com Test GUI refer to UM06951.

7.1 Setup Equipment

Configure and connect the system as shown in the following sections of this document:

- 3.1: For block diagram of system.
- 4.0: For installation instructions.
- 6.0: For wiring the host and transponder

7.2 Power Up The MXS

Connect the MXS to the "MXCom-MXSTool" GUI as shown below. Default Baud rate is programmed to 230.4kbaud but the bootloader message always outputs at 38.4kbaud.

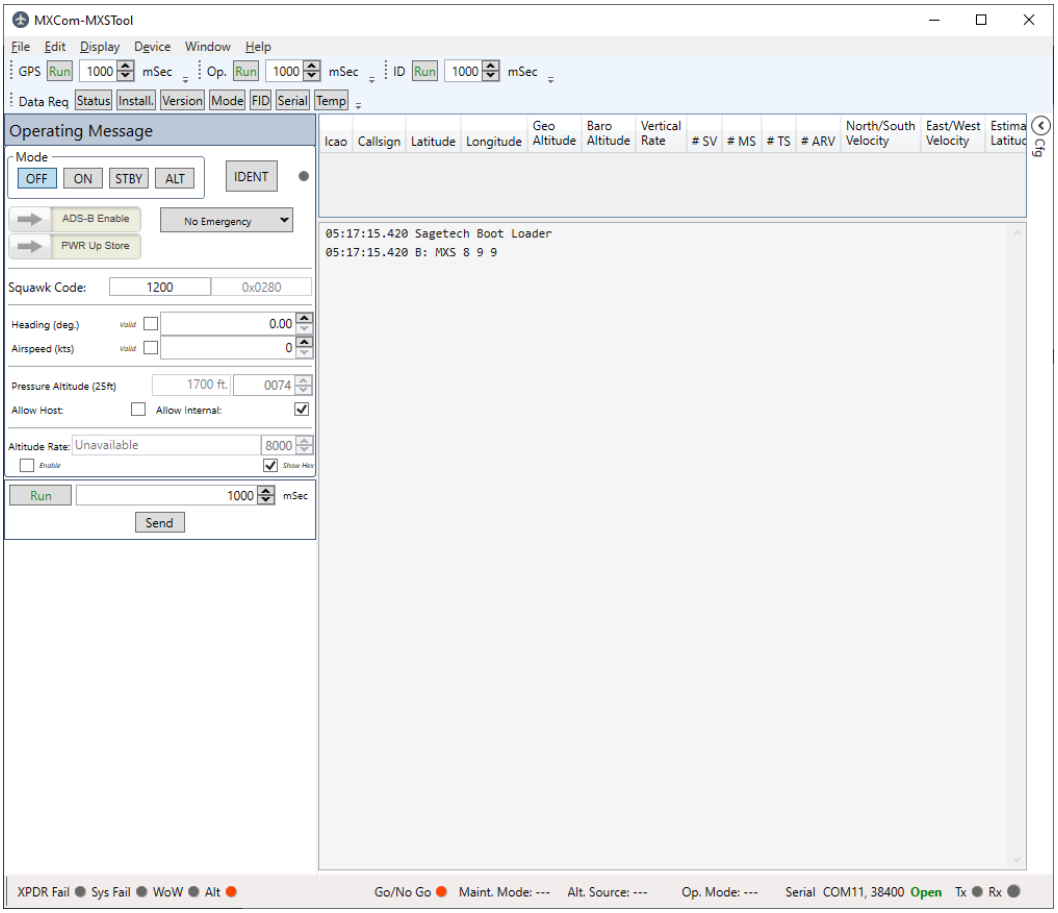


Figure 7-1 MXS Com Test GUI

7.3 Check For the Boot Loader Message

Look for the boot loader message from the MXS, containing version information for the MXS system. Note that this message is automatically sent on COM 0 at 38.4K baud. It requires no response.

```
05:17:15.420 Sagetech Boot Loader
05:17:15.420 B: MXS 8 9 9
```

Figure 7-2 Boot Loader Message

7.4 Send Installation Message

The installation message (Type 0x01) can be set and sent to the MXS by expanding the config (Cfg) tab in the GUI. The MXS must be in OFF mode and the Maintenance Mode Pin must be grounded.

The following information is set with the Installation message:

- ICAO Address
  - A 24-bit number issued to the aircraft. Displayed as 6-digit Hex or 8-digit octal number.
- Aircraft Size
  - The Aircraft size categories are shown as below.

Table 7-1 Aircraft Size

Length (m)	Width (m)
Unknown	Unknown
<= 15	<= 23
<= 25	<= 28.5
<= 25	<= 34
<= 35	<= 33
<= 35	<= 38
<= 45	<= 39.5
<= 45	<= 45
<= 55	<= 45
<= 55	<= 52
<= 65	<= 59.5
<= 65	<= 67
<= 75	<= 72.5
<= 75	<= 80
<= 85	<= 80
<=85*	<= 90*
Reserved	Reserved

**If the aircraft length is greater than 85 or the width is greater than 90 then max value should be entered.*

- Emitter Category
  - The Emitter categories are as shown below:

Table 7-2 Emitter Categories

Emitter Categories
Light (<15500 lbs.)
Small (15500 to 75000 lbs.)
Large (75000 to 300000 lbs.)
High-Vortex Large (aircraft such as B-757)
Heavy (> 300000 lbs.)
High Performance (>5g acceleration and >400 knots)
Rotorcraft
Glider/sailplane
Lighter than air
Parachutist/Skydiver
Ultralight/hang-glider/paraglider
Unmanned Aerial Vehicle (UAV)
Space / Trans-atmospheric vehicle
Surface Vehicle – Emergency Vehicle
Surface Vehicle – Service Vehicle
Point Obstacle
Cluster Obstacle
Line Obstacle
Unknown

- Aircraft Maximum speed
    - Max airspeed of aircraft used in ACAS/TCAS systems. The categories are as shown below:

Table 7-3 Max Airspeed

Maximum Airspeed
Unknown
Up to 75 kt
75 kt to 150 kt
150 kt to 300 kt
300 kt to 600 kt
600 kt to 1200 kt
Over 1200 kt

- Registration
    - The Registration is typically the tail number of the aircraft. This value is used as the callsign unless the Flight ID message is being sent to the MXS.
- Altitude Resolution
    - The altitude resolution that is reported in Mode S and ADS-B can be changed to be either 25’ or 100’ increments for reporting altitudes from -1000 to 50,175 ft. Above 50,175 ft. the transponder will report in 100’ increments. Mode C is always reported in 100 ft. increments.

- Communication setup
  - Baud Rates on Com0 and Com1 can be configured as shown below in Table 7-4, the default baud rate is 230,400 bps.

Table 7-4 Baud Rate Options

Baud Rate Setting
38400 Bits per Second
600 Bits per Second
4800 Bits per Second
9600 Bits per Second
28800 Bits per Second
57600 Bits per Second
115200 Bits per Second
230400 Bits per Second (Default)
19200 Bits per Second
460800 Bits per Second
921600 Bits per Second

  - Ethernet IP address, Port, and Net Mask can all be set in the installation message. The default settings are:
    - IP Address: 10.1.0.50
    - IP Port: 2222
    - Net Mask 255.255.255.0
  - The MXS sets the default gateway to [X].[Y].[Z].1 where [X], [Y], [Z] correspond to the first, second, and third bytes of the IP Address, respectively.

- SIL/SDA - Source Integrity Level (SIL) and System Data Assurance (SDA) values are set following the guidance of AC 20-165B. Depending on the GPS input the SIL, and SDA are set as shown in the table below.

Table 7-5 SIL/SDA settings

Selected Sensor	SIL	SDA
Host	As set by Install Msg	As set by Install Msg
Accord	3	2
NMEA	0	0

The SIL should be set according to the specified integrity level of the GPS. The SDA must report the lowest SDA value of the ADS-B system. If the GPS has a value of less than 2 then the SDA should match that. If the SDA of the GPS is greater than or equal to 2 then the SDA should be set 2.

- Antenna Location
  - The MXS can be configured as a single antenna transponder or as a diversity antenna transponder. If a single antenna configuration is selected, then the bottom port is used

for full power transmissions and a 0.5W rated 50-ohm terminator must be connected to the Top port.

- Heading
  - The heading input type can be configured to True or Magnetic Heading
- True Airspeed (TAS)
  - The airspeed input type can be configured True or Indicated
- Pressure Sensor Heater Switch
  - The Pressure Sensor Heater switch can be enabled or disabled. To guarantee the specified accuracy of the Pressure Altitude Encoder this must be enabled.
- Altitude Encoder offset
  - This field should only be set by an authorized person following 14 CFR 91.41. This configuration filed is used to ensure the altitude encoder properly corresponds to the primary flight altimeter, as described in AC 43-6D.
- Weight on Wheels Connected
  - With this bit selected the MXS will use the state of the GND/Open Discrete input (Pin 16) to determine airborne or ground status. If Pin 16 is grounded the aircraft is in the ground state and if the signal is open it is in the airborne state. If the Air Speed of Ground Speed exceed 60 knots, then the MXS will automatically switch to an airborne state.
  - If this bit is a 0 then the MXS will automatically determine air/ground status based on Air Speed and Ground Speed. An Air Speed greater than 60 knots or a ground speed greater than 30 knots will place the transponder in the airborne state.

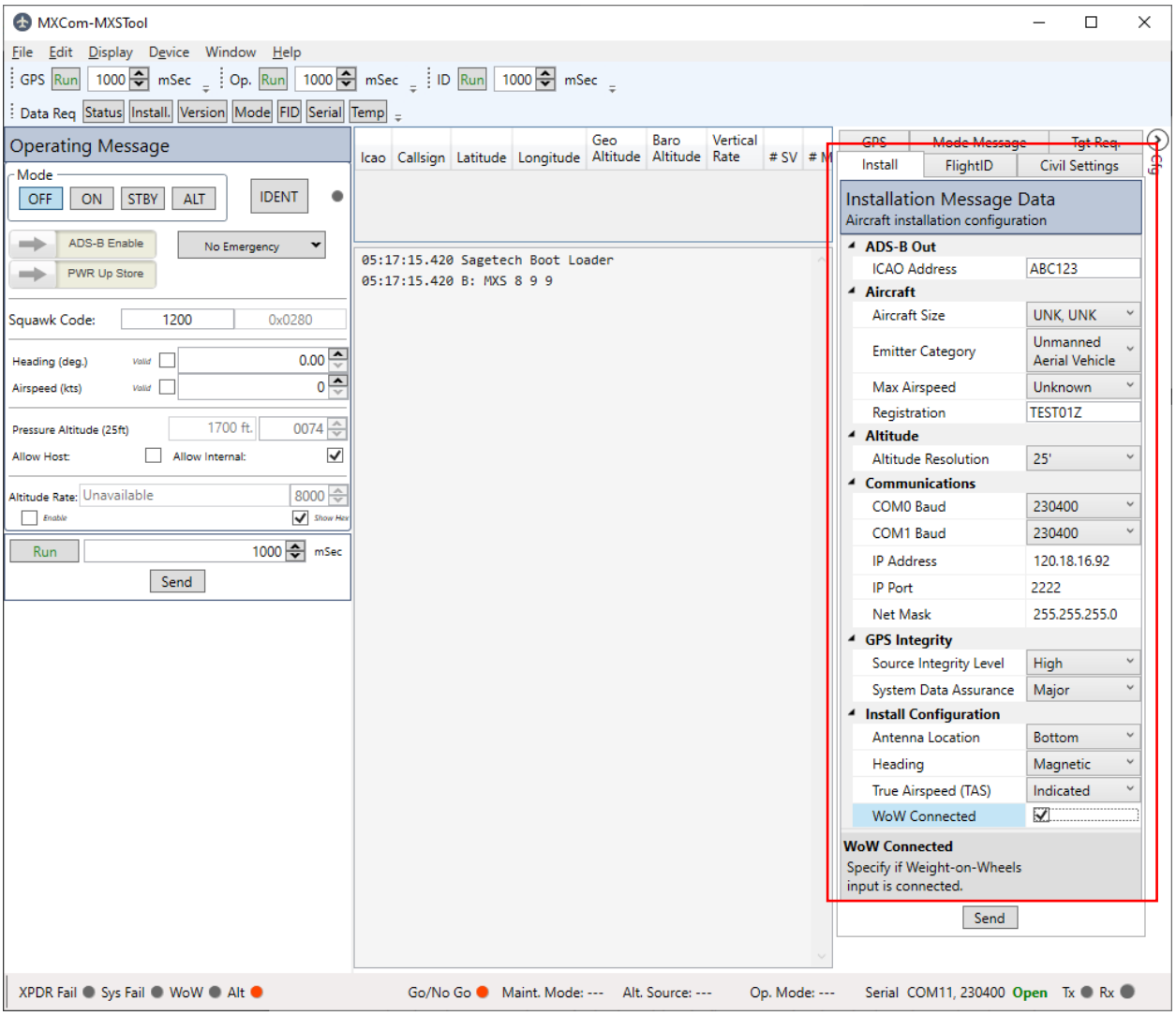


Figure 7-3 Installation Message

7.5 Send GPS Information

Begin regular transmissions of the GPS Navigation Data Message (Type 0x04) to the MXS at 1-5 Hz. (Accord or NMEA can be used in place of this message). The screenshot below uses the simulated GPS. The data in the GPS message can be changed by editing the fields in the GPS message Tab. The specific details on the GPS message are shown in ICD02373.

Note: The information in the bottom bar of the MXS GUI is only updated when an ACK is received in response to a message sent to the MXS. The Go/No-Go light is highlighted green showing that there are no System or Transponder failures.

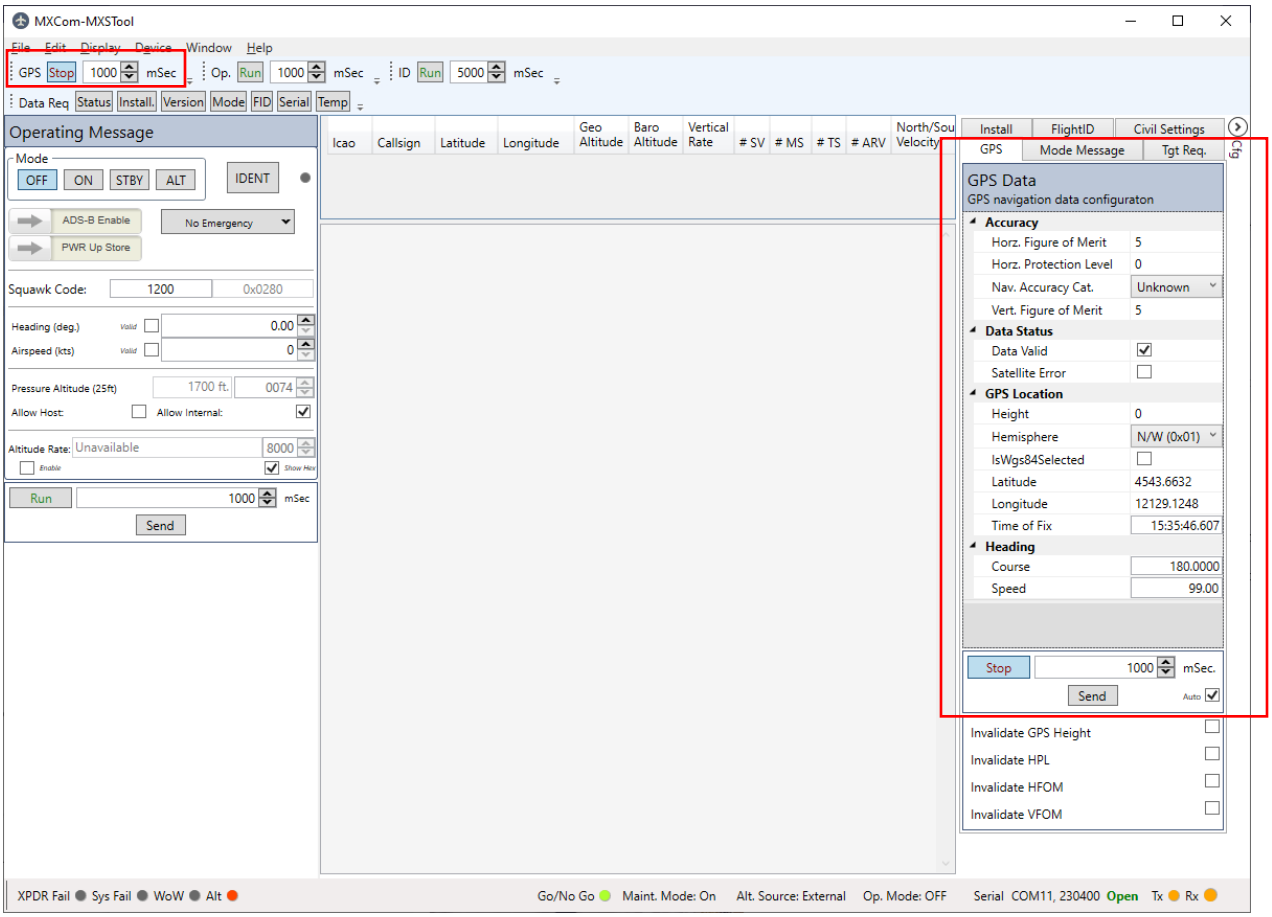


Figure 7-4: GPS Message

7.6 Send Operating message

Begin transmissions of the Operating Message (Type 0x03) to the MXS at 1 Hz. Before going into "On" or "Alt" make sure the antenna is adequately loaded. The data that is contained in the operating message is:

- Operating Mode can be set to:
  - **OFF** – In this mode, transmitting and receiving is disabled. MXS is set to a low power mode with minimal components active. OFF mode is set using the Operating Message. (See ICD02373)
  - **STANDBY** – In this mode, transmitting is disabled, but the ADS-B in functionality is still operational. STANDBY is set using the Operating Message. (See ICD02373). Receiver Self-Test failures are not annunciated if you are in standby mode.
  - **ON** – In this mode the transponder is operational but inhibited from transmitting any pressure altitude information. ON is set using the Operating Message. (See ICD02373)
  - **ALT** – In this mode the MXS is fully operational, including transmitting altitude, if available. ALT is set using the Operating Message in ICD02373.
- ADS-B Enable/Disable
  - Setting ADS-B to enable will enable ADS-B Extended Squitters (DF17)
  - With ADS-B Disabled the MXS will still send Acquisition Squitters (DF11) and it will still receive ADS-B in data once the Target request message is sent. DF17 ADS-B out messages will not be sent.
- Power Up Store Mode
  - If the operating message is sent with this bit selected it will save the operating message settings into NVM. If the MXS is power cycled it will power up as commanded by the last operating message sent with the power up store mode bit selected.
- IDENT
  - The Ident runs for 18 Seconds to help allow ATC to distinguish your aircraft on the Secondary Surveillance Radar (SSR) Every time Ident is selected the 18 second timer is restarted.
- Emergency Status
  - The Emergency Status can be selected from the dropdown menu. The following Emergency conditions can be selected from:
    - No Emergency
    - General Emergency
    - Lifeguard/Medical
    - Minimum Fuel
    - No Communications
    - Unlawful Interference
    - Downed Aircraft
- Squawk Code
  - The 4096 Squawk code is set using this field. If the Priority SQUAWK pin is grounded, then this field is ignored and the SQUAWK code that is programmed into NVM is using the civil settings message (defined in ICD02373) is used. The Squawk Code follows the following logic:

Table 7-6 SQUAWK Code Logic

System Discrete Input User Defined Squawk Enable	Operating Message Squawk Valid	Civil Settings Message User Defined Squawk Valid	4096 Code Setting
De-asserted	Invalid	Invalid	1000
De-asserted	Invalid	Valid	1000
De-asserted	Valid	Invalid	Op Message Squawk
De-asserted	Valid	Valid	Op Message Squawk
Asserted	Invalid	Invalid	1000
Asserted	Invalid	Valid	Civil Settings Squawk
Asserted	Valid	Invalid	1000
Asserted	Valid	Valid	Civil Settings Squawk

- Heading and Airspeed
  - Heading and airspeed information can optionally be sent in to the MXS. If this is done the guidance in AC 20-165B must be followed.
- Altitude Rate
  - Altitude rate (vertical rate) source should be sent in to the MXS following the guidance of AC 20-165B. If vertical rate is sent through the operating message, then the MXS uses that rate otherwise the GPS vertical rate is used.

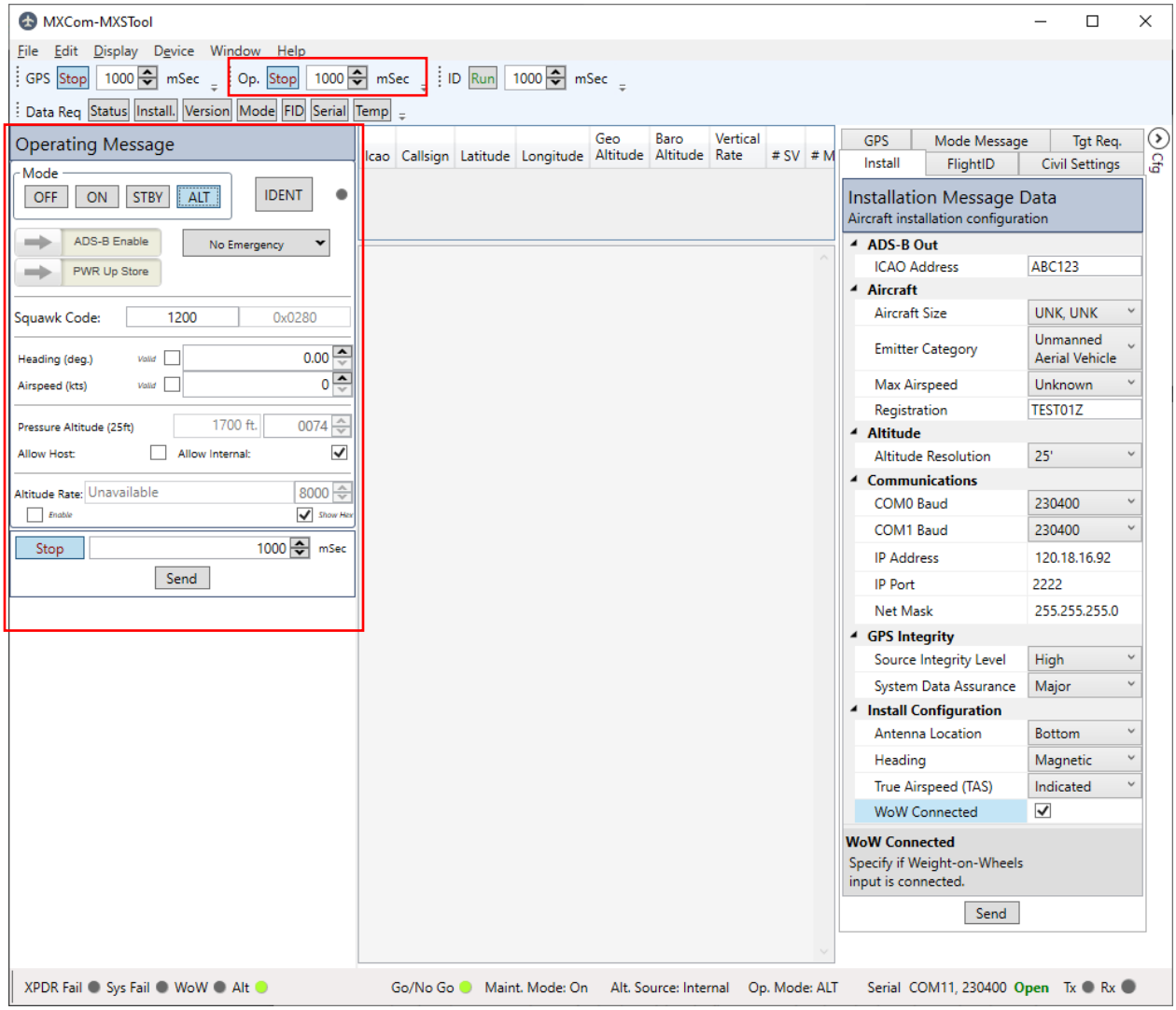
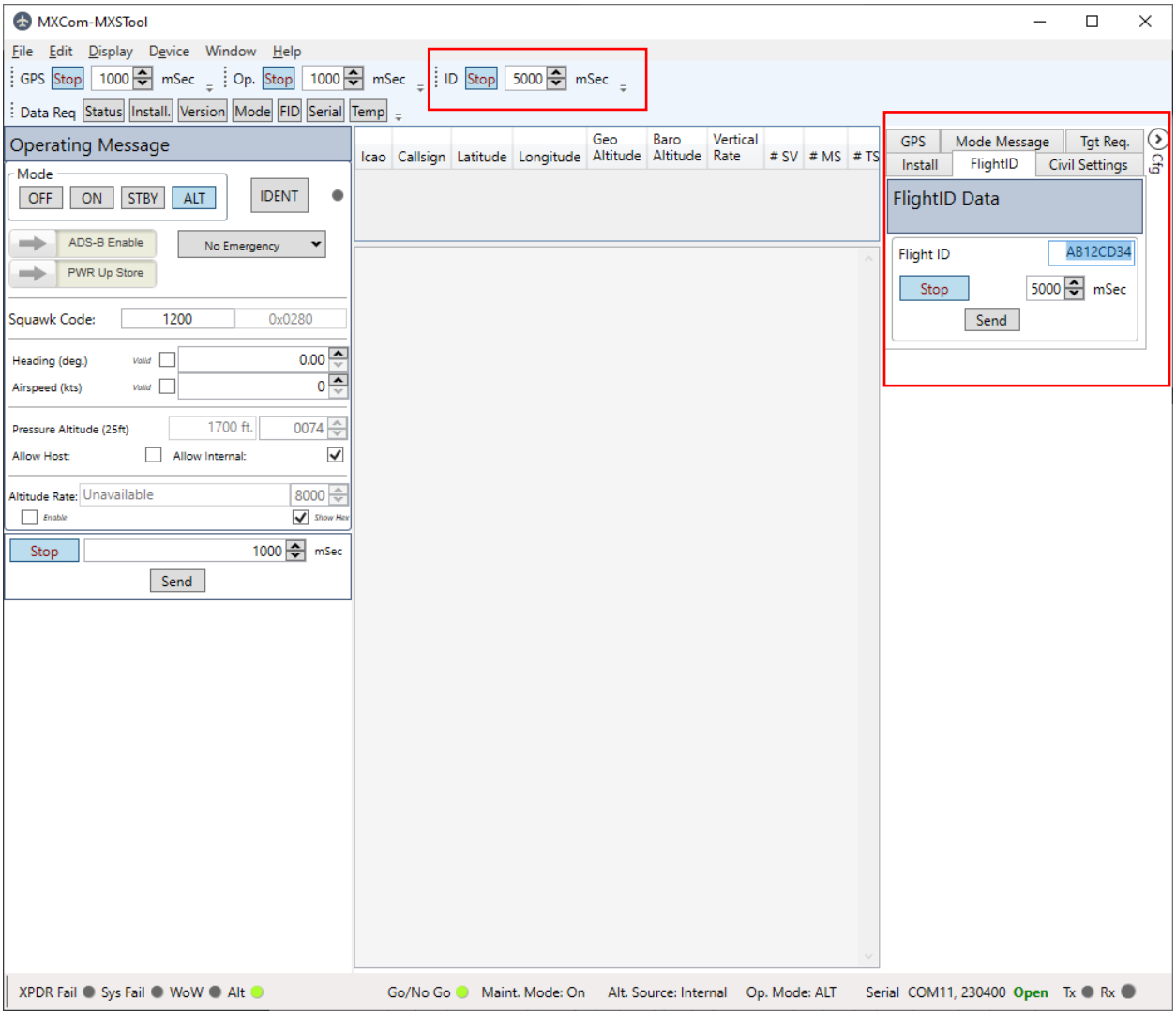


Figure 7-5 Operating Message

7.7 Send Flight ID

If a Flight ID is used, then begin transmissions of the Flight ID Message (Type 0x02) to the MXS at a minimum of 0.2 Hz. The Flight ID value can be changed under the Config (Cfg) tab.

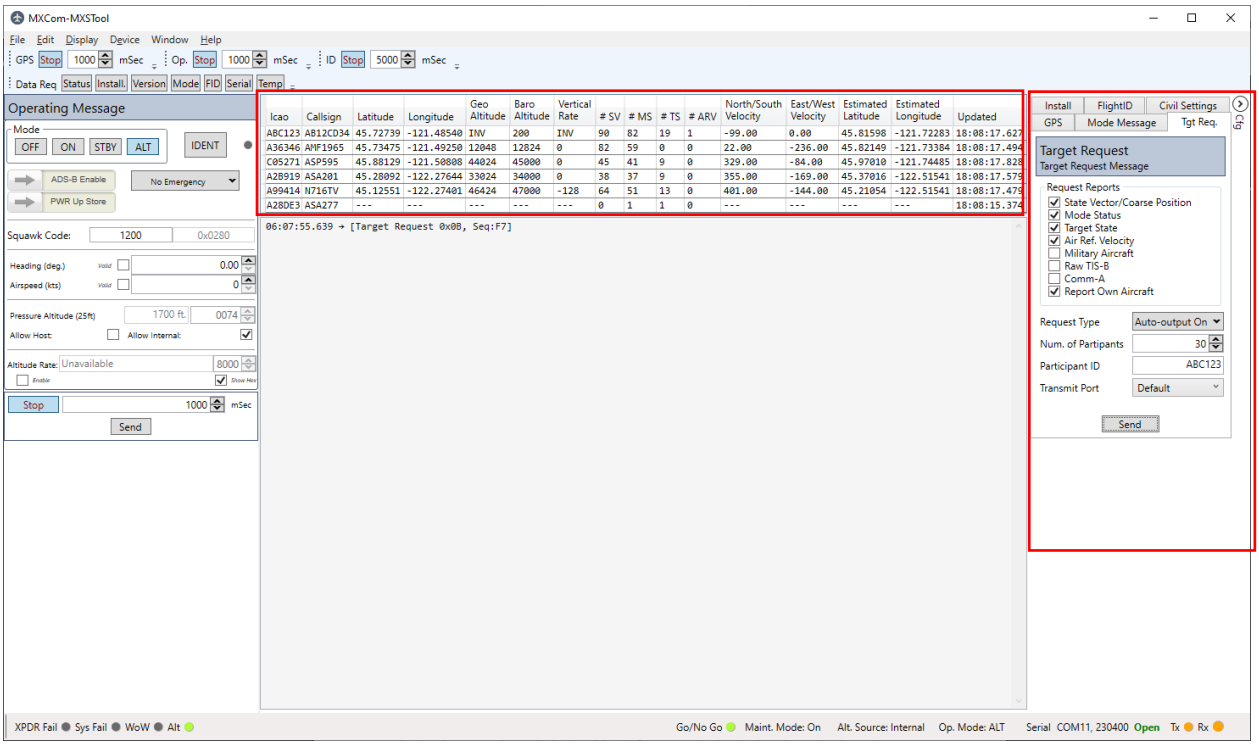


7.8 ADS-B In

ADS-B In data is received by sending the Target Request Message (Type 0x0B). The Target Request message is under the Config (Cfg) tab. Operators can configure the number of targets, report types, transmit port, etc.

ADS-B in data is output in a table format at the top of the GUI. If Auto-output is selected, then the ADS-B In information is automatically output to the selected communication port. If Default is selected, then the reports are sent out to the communication port where the target request message was received.

The MXS will send target updates to the Host/Autopilot within 500ms of receiving the update. For systems that only want the ADS-B In data to be sent upon request and at defined payload lengths the summary report can be used. Individual Target ADS-B In information can be requested via the Target ID report. The Auto-output and summary reports will automatically filter on the closest number of targets in reference to ownship. For Diversity Installations up to 400 targets can be tracked and for single antenna installation 200 targets can be tracked. The Ethernet interface or one of the serial communication ports set at 921.6k baud rate must be used to guarantee performance when using the Auto-output method and tracking 400 Targets per the DO-260B MOPS.

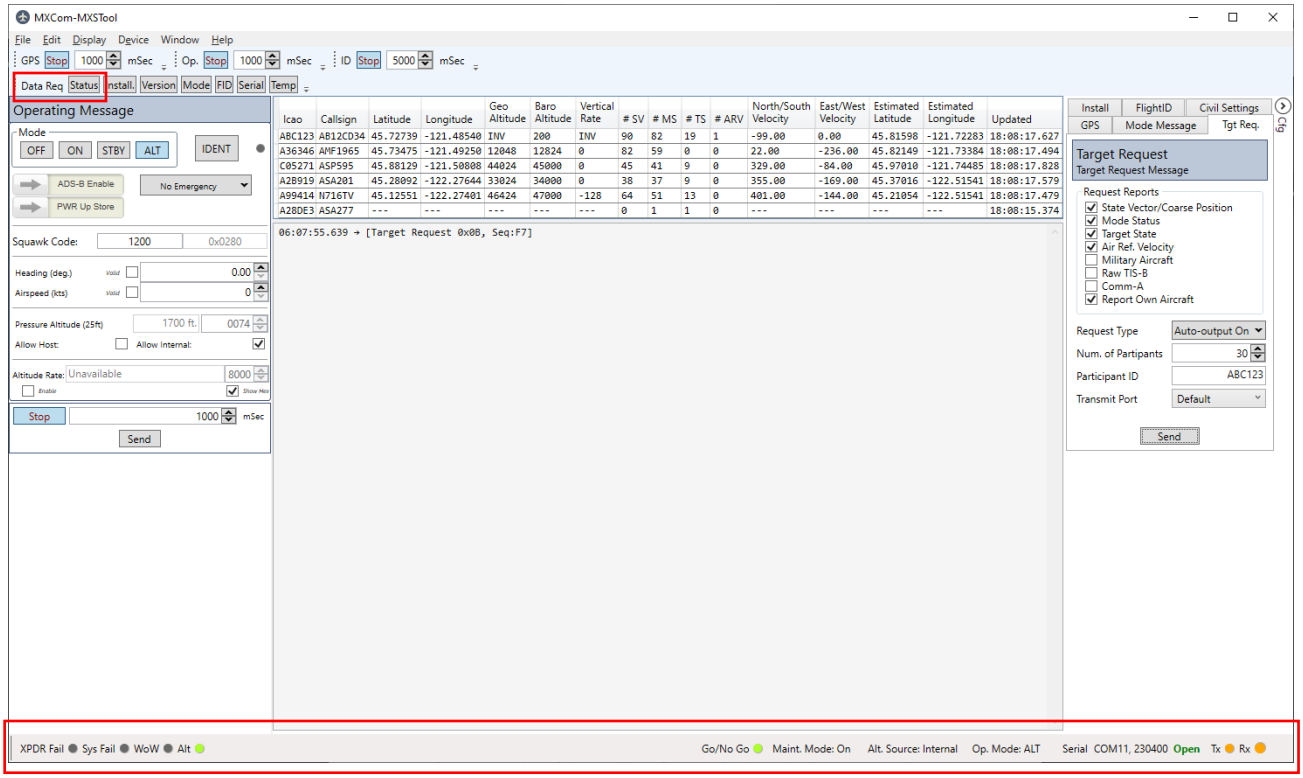


7.9 Monitor Health and Status

Review the Acknowledge (ACK) Messages (Type 0x80) returned after any message sent to the MXS to confirm that the MXS has a healthy BIT status:

- XPDR Fail Flag
- System Fail Flag
- Weight on Wheels
- Maintenance Mode
- Altitude Source

If there is a XPDR or System Fail Flagged, then the Status Response Message (Type 0x83) must be requested to get further detailed information.



7.10 Health Monitoring and Built-in-Test (BIT)

This section describes possible failure announcements by the transponder, events that trigger each failure announcement, and processes to follow when those failures occur.

7.11 System Health and Status Overview

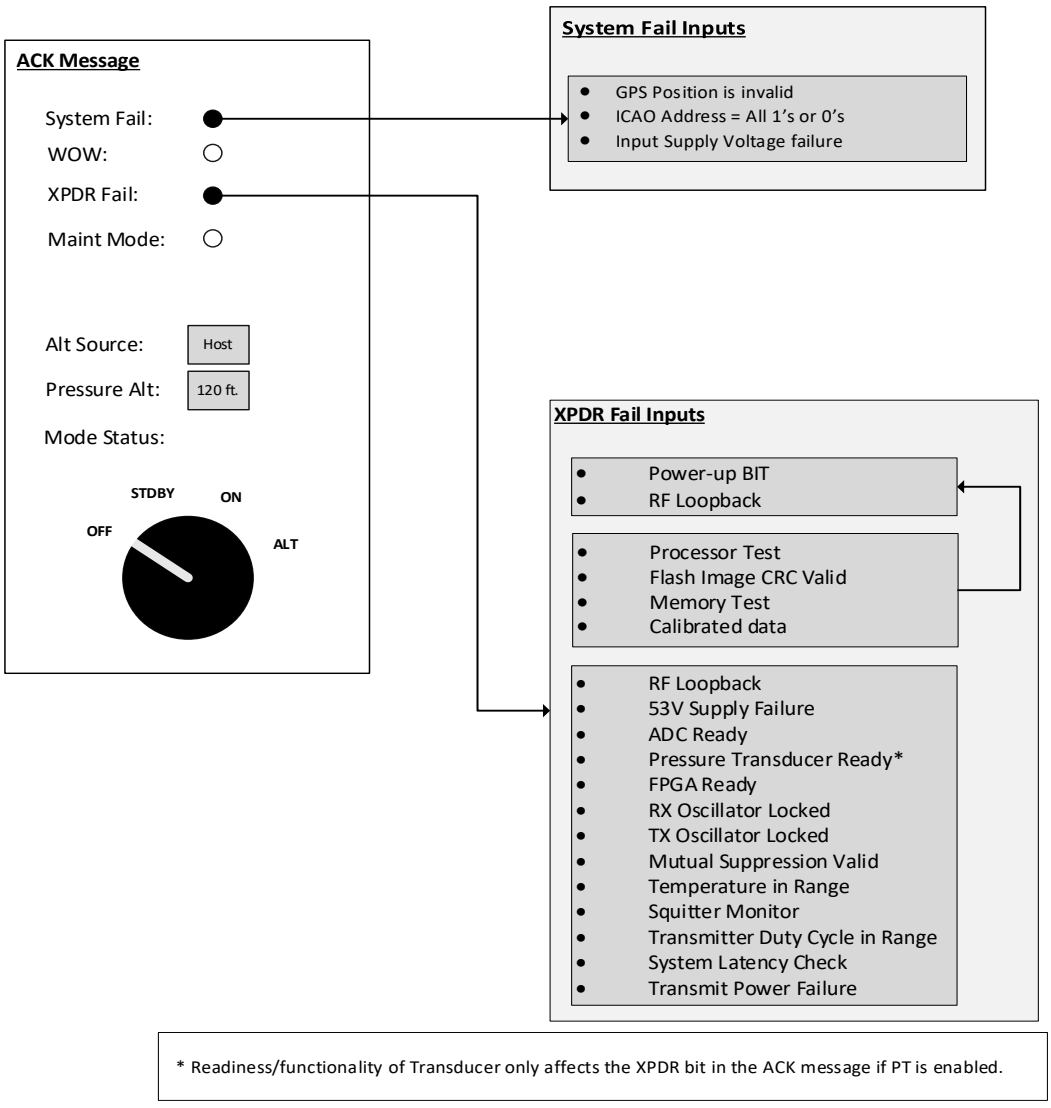
The MXS System health is monitored by reading the ACK message that the MXS will send to the flight computer in response to any message received.

The System Fail monitors the required system inputs to the MXS. For proper operation, the following inputs are required:

- GPS Input (minimum 1 Hz frequency)
- Valid ICAO Address
- Supply Voltage (10-32 VDC)

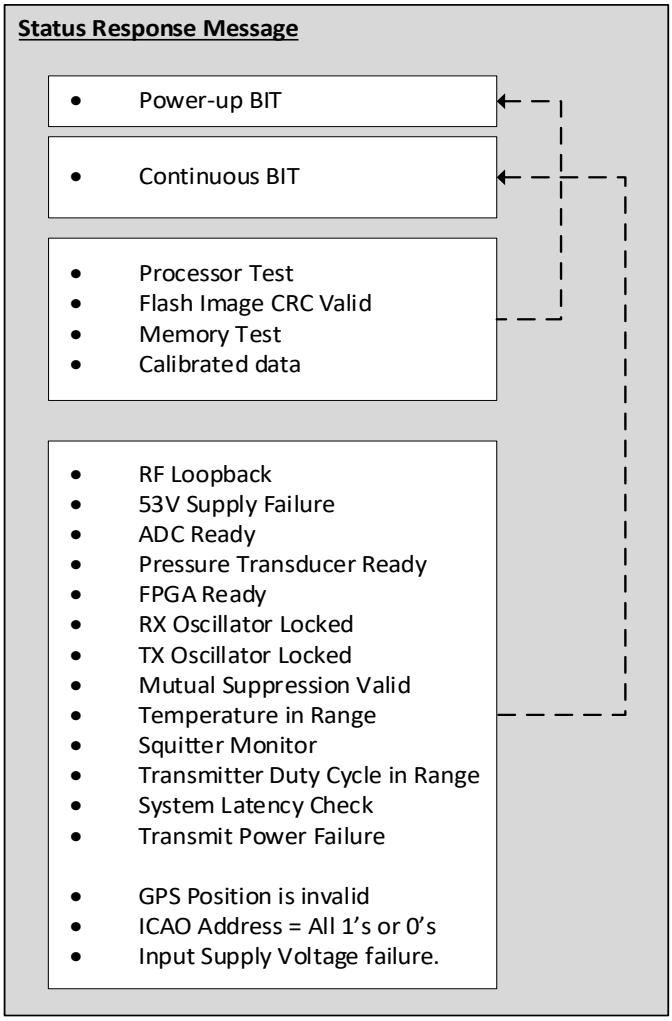
The XPDR Fail monitors the health of the MXS unit itself. The BIT was designed to monitor the critical circuit functions that are necessary for MXS operation. BIT failures will only be annunciated when in STBY, On, or ALT mode.

Other information reported in the ack message is Mode Status (ON/OFF/STBY/ALT), Altitude Source (Host/Internal), Altitude, and the states of the weight on wheels (WOW) and maintenance mode (MAINT) discrete inputs.



7.12 Status Response Messages

If a XPDR Fail or System Fail is reported in the ACK message, then one or more of the conditions shown below in the block diagram has failed. To determine the precise failure, the status response message (Type 0x83) must be requested. The Status response message reports both power up and continuously run Built-In-Test (BIT). If the XPDR Fail is flagged, then this message explains why it has failed. If the System Fail is flagged, then the Status response message should be queried for full System status.


Status Response Message
Power-up BIT
Continuous BIT
Processor Test
Flash Image CRC Valid
Memory Test
Calibrated data
RF Loopback
53V Supply Failure
ADC Ready
Pressure Transducer Ready
FPGA Ready
RX Oscillator Locked
TX Oscillator Locked
Mutual Suppression Valid
Temperature in Range
Squitter Monitor
Transmitter Duty Cycle in Range
System Latency Check
Transmit Power Failure
GPS Position is invalid
ICAO Address = All 1's or 0's
Input Supply Voltage failure.

Byte Name	Bit	Built-In Test (BIT)	What triggers it?	What happens?	What to do about?
BIT0	7 (msb)	**Power-On Tests Pass**	Checks RAM, ROM, I/O, Timing, CPU instruction integrity, and calibration data.	If any of the Power Up BIT tests are failing MXS sets this BIT. Power-Up Fail Flag is latched causing a XPDR fail flag in the ACK message. Persists until next power cycle.	Request Status message to get details about the specific BIT failure.
	6	**Continuous Tests Pass**	Checks 1030MHz/1090MHz receivers, services the watchdog timer, checks for an erroneous ICAO address, monitors the 53V supply, detects memory parity errors and SEUs of FPGA programming, monitors input supply voltage, and monitors internal temperature.	If any of the continuous BIT tests are failing MXS sets this bit. Continuous Bit Fail Flag is latched causing XPDR or System Fail flag in the ACK message. Condition in which a test begins to pass is defined for each test in the table entries below. If Watchdog timer, memory parity or SEU tests fail the MXS will reset the processor	Request the status message to get details about the specific BIT failure. The bit is cleared if failing tests begin to pass.
	5	Reserved			
	4	**Processor Test Passed**	The MXS performs a test of the processor instruction set and passes the numerical result of the test to the FPGA for verification. The MXS accepts the result of this test (Pass or Fail) from the FPGA.	Power-Up Fail Flag is latched causing a XPDR fail flag in the ACK message. Persists until next power cycle.	If flagged, first remedy is to power cycle the unit. If error is still triggered, then the unit is damaged.
	3	**Flash Image CRC Valid**	The MXS computes and verifies the CRC of the software Executable Object Code (EOC), the Firmware Programming file (FPF), and the configuration parameters stored in non-volatile memory.	Power-Up Fail Flag is latched causing a XPDR fail flag in the ACK message. Persists until next power cycle.	If flagged, first remedy is to power cycle the unit. If error is still triggered, then the unit is damaged.
	2	**Memory Test Passed**	The MXS performs a test of the processor RAM by executing a “walking ones” test to verify memory addressing and that each bit can successfully contain a 0 and a 1.	Power-Up Fail Flag is latched causing a XPDR fail flag in the ACK message. Persists until next power cycle.	If flagged, first remedy is to power cycle the unit. If error is still triggered, then the unit is damaged.
	1	**Calibrated**	The calibration data checksum test passed, otherwise the bit is cleared	Power-Up Fail Flag is latched causing a XPDR fail flag in the ACK message. Persists until next power cycle. Unit will function but not at performance specification	Return unit for calibration. Use of uncalibrated units could cause permanent damage.
	0	Reserved	Reserved	Reserved	Reserved

BIT1	7 (msb)	**RF Loopback Test Pass**	The MXS initiates a loop-back test of the 1030 and 1090 MHz RF circuitry and FPGA. The 1030 and 1090 MHz loop-back test is part of the BIT and is ran once at startup and then must be enabled using the Military Settings message. It sends an RF Test signal that switches into the front end of the receivers. The loop-back test passes if and only if a healthy signal is measured by the receiver for all configured antennas. If either loop-back test fails, the MXS sets the 'Loop-Back Fail Flag'. The MXS clears the 'Loop-Back Fail Flag' if both loop-back tests are passing.	Test is part of the Continuous BIT suite of tests. XPDR Fail Flag is set in the ACK message to the Host.	If flagged, first remedy is to power cycle the unit. If error is still triggered, then there could be an RF interference issue on the Platform or in the surrounding area. If the error persists and there is no RF interference, then unit is damaged.
	6	**53V Power Valid**	If the Operational Mode is ALT or ON (hence the 53V supply is enabled to power the transmitter) and the voltage is less than 51 V or greater than 55 V, then the MXS sets the 53V Voltage Failure Indication; else clears it. The 53V Power Valid flag is the invert 53V Voltage Failure indication.	Test is part of the Continuous BIT suite of tests. XPDR Fail Flag is set in the ACK message to the Host.	If this fails, re-send the host "On" or "Alt" operating message. Check to make sure the power supply is not limiting. The unit is damaged if these conditions are checked, and a failure still persists.
	5	**ADC Ready**	This signal is set when 256 consecutive correct framing samples are received from the ADC	Test is part of the Continuous BIT suite of tests. XPDR Fail Flag is set in the ACK message to the Host.	Attempt a Power cycle. The unit is damaged if the failure persists
	4	**Pressure Transducer Ready**	If the MXS is unable to read the pressure sensor, then the MXS set 'Pressure Sensor Failed' to True, else False. The Pressure Transducer Ready flag is the inverted Pressure Sensor Failed bit	Test is part of the Continuous BIT suite of tests. XPDR Fail Flag is set in the ACK message to the Host.	Attempt a Power cycle. The unit is damaged if the failure persists. Alternatively, pressure altitude data may be received from the Host interface. Systems using the Host provide pressure altitude data can ignore this fault
	3	**FPGA Ready**	Processor writes to FPGA firmware register and then reads back an expected value	Test is part of the Continuous BIT suite of tests. XPDR Fail Flag is set in the ACK message to the Host.	Attempt a Power cycle. The unit is damaged if the failure persists

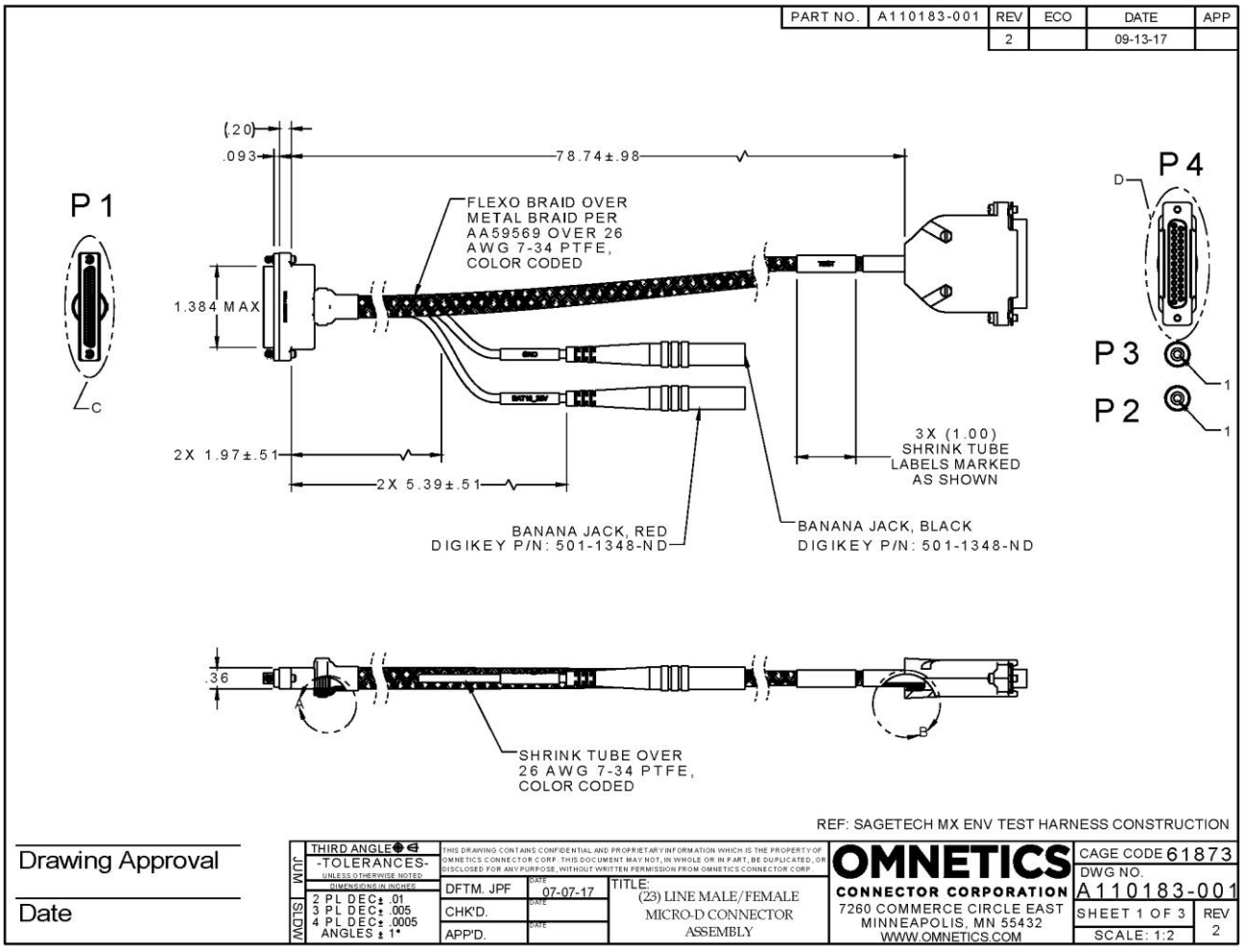
	2	**Rx Oscillator Locked**	The MXS reports a PLL Lock to software when the Rx Oscillator is locked on frequency.	Test is part of the Continuous BIT suite of tests. XPDR Fail Flag is set in the ACK message to the Host.	Attempt a Power cycle. The unit is damaged if the failure persists
	1	**Tx Oscillator Locked**	The MXS reports a PLL Lock to software when the Quadrature Modulator's (ADRF6750) PLL is locked on entry into operational mode. The locked bit is cleared after losing lock for a period greater than 300 microseconds	Test is part of the Continuous BIT suite of tests. XPDR Fail Flag is set in the ACK message to the Host.	Attempt a Power cycle. The unit is damaged if the failure persists
	0	**Mutual Suppression Valid**	When the Mutual suppression output bus is either stuck in a low or high state this bit will flag a fail.	If there is a failure that results in the Suppression output signal being tied to ground or Active High state, then this bit will fail.	Attempt a Power cycle. The unit is damaged if the failure persists
BIT2	7 (msb)	**Temperature In Range**	Internal temp monitored twice per second; if >110°C, all transmissions are disabled until monitor indicates unit has cool down (<110°C)	Test is part of the Continuous BIT suite of tests. XPDR Fail Flag is set in the ACK message to the Host.	Putting the unit in standby mode or powering off (i.e., cutoff power or ground pin 42 for MX Power control) will speed up the cooling process. Provide unit additional cooling such as air flow or improved heat sinking.
	6	**Squitter Monitor Valid**	This test checks software scheduled Squitters against the Squitters sent out in the FPGA. This failure is flagged if the squitter count does not match. This test also checks to ensure that the CRC of the transmitted ADS-B message matches the CRC that was measure via the transmit monitor.	Test is part of the Continuous BIT suite of tests. XPDR Fail Flag is set in the ACK message to the Host.	Attempt a Power cycle. The unit is damaged if the failure persists
	5	**Transmit Rate In Range**	Monitors The transmission duty cycle of the MXS to ensure that an unsafe limit will never be reached that could result in HW damage.	Transmissions are dropped to avoid damage to MXS transmitter hardware. Test is part of the Continuous BIT suite of tests. XPDR Fail Flag is set in the ACK message to the Host.	Determine and eliminate the source of over-interrogation of the MXS. Power Cycle to clear BIT.
	4	**System Latency In Range**	Checks for average event duration time and average loop duration time; events have a limit of 2ms, loops have a limit of 5ms.	Test is part of the Continuous BIT suite of tests. XPDR Fail Flag is set in the ACK message to the Host.	Attempt a Power cycle. The unit is damaged if the failure persists

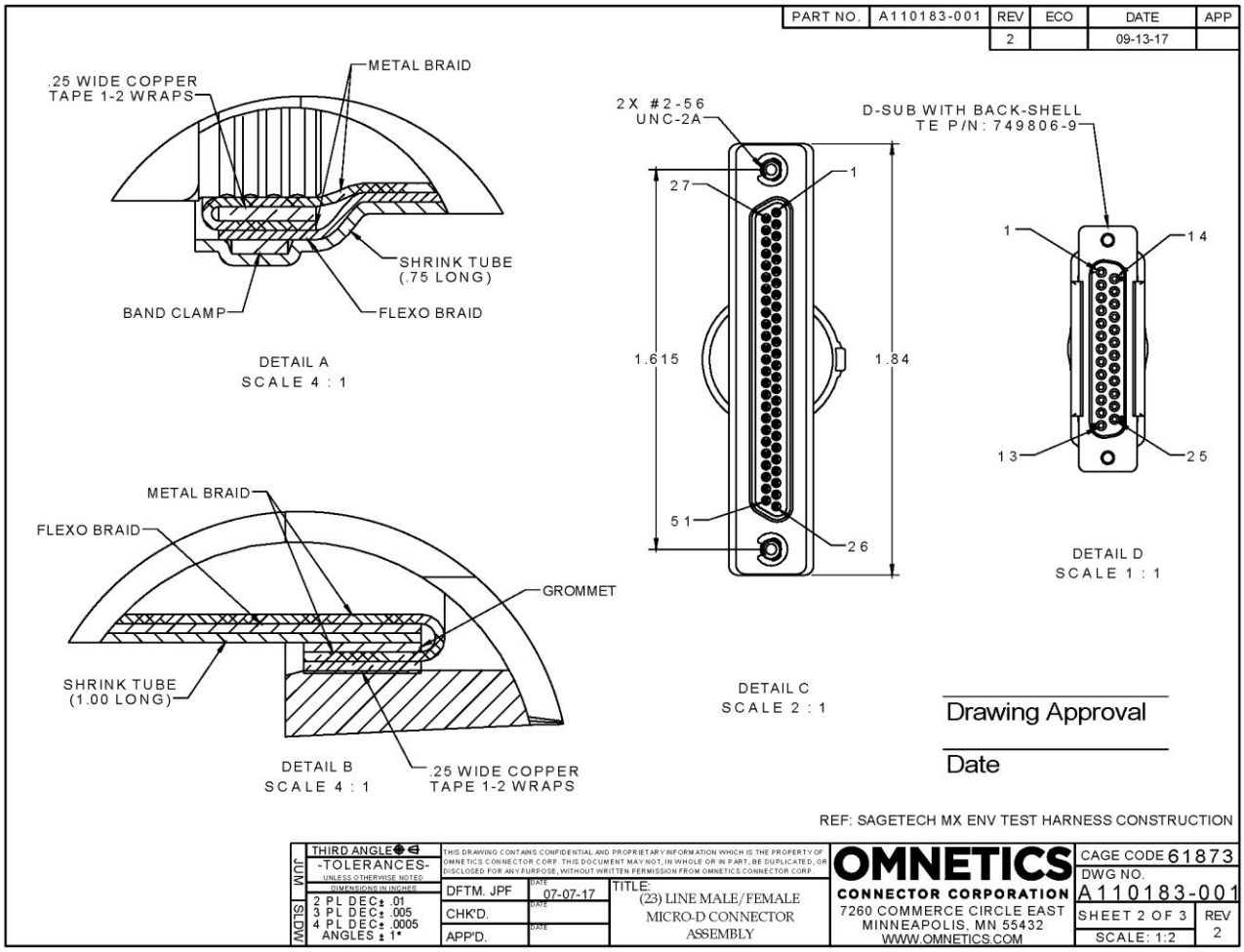
	3	**Transmit Power Failure**	This BIT monitors the Power Output of every transmission and verifies there is no significant reduction in power.	Test is part of the Continuous BIT suite of tests. XPDR Fail Flag is set in the ACK message to the Host.	Attempt a Power cycle. The unit is damaged if the failure persists
	2	Reserved			
	1	Reserved			
	0	Reserved			
BIT3	7 (msb)	**Input Power In Range**	This BIT reads the MXS supply voltage. If the voltage is less than 10 V or greater than 32 V, then the MXS sets the Supply Voltage Failure indication; else clears it. This flag is the inverted Supply Voltage Failure bit.	Test is part of the Continuous BIT suite of tests. XPDR Fail Flag is set in the ACK message to the Host.	Check the supply voltage, if voltage is in range, attempt a Power cycle. The unit is damaged if the failure persists
	6	**ICAO Address Valid**	The MXS quits responding to Mode S interrogations and outputting ADS-B Squitters (DF-17 and DF-11s) if the ICAO Address received in the Host Installation Message (and stored in non-volatile memory) is equal to all zeros or all ones.	Test is part of the Continuous BIT suite of tests. Consequences of a test failure are as stated in row #2. System Fail Flag is set in the ACK message to the Host.	Input a valid ICAO address.
	5	**GPS Position Valid**	Invalid GPS position Data	ADS-B Out messages that normally contain GPS position data (Airborne and Surface Position messages) will have ZEROs entered for GPS position. System Fail Flag is set in the ACK message to the Host.	Provide the MXS with valid GPS position data.
	4	Reserved			
	3	Reserved			
	2	Reserved			
	1	Reserved			
	0	Reserved			

8.0 Revision History

Rev	Summary of Changes	Effective Date	Approval
01	Initial release	Feb 2022	CR00468
02	Update to WOW logic	Feb 2022	CR00498

9.0 Appendix A –Shielded Cable Assembly Construction




PART NO. A110183-001 REV 2 ECO DATE 09-13-17 APP
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METAL BRAID
SHRINK TUBE (.75 LONG)
BAND CLAMP
FLEXO BRAID
DETAIL A SCALE 4 : 1
2X #2-56 UNC-2A
D-SUB WITH BACK-SHELL TE P/N: 749806-9
27
1
1.615
1.84
51
26
1
14
13
25
DETAIL D SCALE 1 : 1
METAL BRAID
FLEXO BRAID
GROMMET
SHRINK TUBE (1.00 LONG)
DETAIL B SCALE 4 : 1
.25 WIDE COPPER TAPE 1-2 WRAPS
DETAIL C SCALE 2 : 1
Drawing Approval
Date
REF: SAGETECH MX ENV TEST HARNESS CONSTRUCTION
THIRD ANGLE
-TOLERANCES-
UNLESS OTHERWISE NOTED
DIMENSIONS IN INCHES
2 PL DEC ± .01
3 PL DEC ± .005
4 PL DEC ± .0005
ANGLES ± 1°
JOM
SLDW
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APP'D. DATE
TITLE: (23) LINE MALE/FEMALE MICRO-D CONNECTOR ASSEMBLY
OMNETICS CONNECTOR CORPORATION
7260 COMMERCE CIRCLE EAST
MINNEAPOLIS, MN 55432
WWW.OMNETICS.COM
CAGE CODE 61873
DWG NO. A110183-001
SHEET 2 OF 3
REV 2
SCALE: 1:2

PART NO.	A110183-001	REV	ECO	DATE	APP
		2		09-13-17	

P1	P2	P3	P4	COLOR	NOTES
1	-	-	-	LEADLESS	-
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3	-	-	-	LEADLESS	-
4	-	-	-	LEADLESS	-
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6	-	-	-	LEADLESS	-
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14	-	-	13	ORANGE	-
15	-	-	12	YELLOW	-
16	-	-	11	GREEN	-
17	-	-	10	BLUE	-
18	-	-	9	VIOLET	-
19	-	-	8	GRAY	
44	-	-	21	ORANGE	
20	-	-	7	WHITE	
45	-	-	20	YELLOW	
21	-	-	6	BLACK	
22	-	-	5	BROWN	
23	-	-	4	RED	
48	-	-	17	VIOLET	
24	-	-	3	ORANGE	
49	-	-	16	BLACK	

P1	P2	P3	P4	COLOR	NOTES
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26	-	1	-	BLACK	-
27	-	-	-	LEADLESS	-
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30	-	-	-	LEADLESS	-
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43	-	-	22	RED	-
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47	-	-	-	LEADLESS	-
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51	1	-	-	RED	-
-	-	-	1	LEADLESS	-
-	-	-	2	LEADLESS	-
-	-	-	14	LEADLESS	-
-	-	-	15	LEADLESS	-
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-	-	-	19	LEADLESS	-

Drawing Approval

Date

REF: SAGETECH MX ENV TEST HARNESS CONSTRUCTION

NOTES:

1. TWIST PAIRS 3-4 TWISTS PER INCH.

THIRD ANGLE
-TOLERANCES-
UNLESS OTHERWISE NOTED
DIMENSIONS IN INCHES
2 PL DEC ± .01
3 PL DEC ± .005
4 PL DEC ± .0005
ANGLES ± 1°

JOM / SLOW

DFTM. JPF DATE 07-07-17
CHK'D. DATE
APP'D. DATE

TITLE: (23) LINE MALE/FEMALE MICRO-D CONNECTOR ASSEMBLY

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SHEET 3 OF 3
REV 2
SCALE: 1:2