SDR-OMNI
AVIONICS TEST SET

2023-CLS-TIC-0001

USER MANUAL

Revision D, 8 March 2024

PRESENTED BY:

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NOTICE:

The information contained in this manual is subject to change without notice.

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WARRANTY

The Tel-Instrument Electronics Corp. warrants that each product Tel-Instrument Electronics Corp. manufactures is free from defective material and workmanship for a period of two (2) years subject to the following terms and conditions. Tel-Instrument Electronics Corp. will remedy any such warranted defect subject to the following:

- This warranty requires the unit to be delivered by the owner to Tel-Instrument Electronics Corp. intact for examination, with all transportation charges prepaid to the factory, within two (2) years from the date of sale to original purchaser. Tel-Instrument Electronics Corp. will solely determine when such defect exists.
- This warranty does not extend to any of Tel-Instrument Electronics Corp. products which have been subject to misuse, neglect, accident, improper installation, or used in violation of operating instructions. This warranty does not extend to units which have been repaired, calibrated, or altered in any way by a facility that is not approved, in writing, by Tel-Instrument Electronics Corp. to perform such work. This warranty does not apply to any product where the seals or serial number thereof has been removed, defaced, or changed, nor to accessories not of Tel-Instrument Electronics Corp. manufacturing.
- This warranty is in lieu of all other warranties expressed or implied and all such other warranties are hereby expressly excluded. No representative or person is authorized to assume for Tel-Instrument Electronics Corp. any other liability or warranty in connection with the sale of Tel-Instrument Electronics Corp. products.
- This warranty does not cover or include batteries (batteries have a separate 90-day warranty).
- Additional information regarding the applications and maintenance of this equipment will be available from time to time.

Obtaining Warranty Service

If the SDR-OMNI requires service or repair under the warranty, follow these steps to ensure proper handling:

NOTE

The SDR-OMNI must be returned in its original shipping container. If the original shipping container is not available, inform Customer Support of this when contacting them.

1. Contact Tel-Instrument Electronics Corp. Customer Support using the contact information below. Customer Support will review the matter and, if validated, Return Material Authorization (RMA) number and form.
   - +1 (201) 933-1600 (telephone)
   - +1 (201) 933-7340 (fax)
   - https://www.telinstrument.com
2. Pack the SDR-OMNI in accordance with *Packing and Shipping for Warranty Service*.

Packing and Shipping for Warranty Service

Before shipping the SDR-OMNI for warranty service, ensure that:

- You have an RMA number and completed form from Tel-Instrument Electronics Corp. Customer Service.
- You have the original shipping container. If you do not have the original shipping container, contact Tel-Instrument Electronics Corp. Customer Service.
- You have paid the freight charges to ship the SDR-OMNI. Freight charges for shipping the product to Tel-Instrument Electronics Corp. are the responsibility of the owner. However, Tel-Instrument Electronics Corp. will pay the return shipping charges if the problem is determined to be covered under the warranty.

CAUTION

DO NOT ship the SDR-OMNI without packing it in a shipping container. Shipping it without a shipping container may damage the SDR-OMNI.

NOTE

DO NOT ship any SDR-OMNI units before contacting Tel-Instrument Electronics Corp. Customer Service.

DO NOT return any product without receiving an RMA number and form from Tel-Instrument Electronics Corp. Customer Service.

To ensure prompt tracking and handling, the SDR-OMNI must be returned with the completed RMA form.

The SDR-OMNI must be returned in its original shipping container. If the original shipping container is not available, contact Customer Service.

1. Wrap the SDR-OMNI in bubble sheeting or plastic wrap.
2. Place the SDR-OMNI into its original packaging material and shipping container.
3. Place the RMA form on top of the SDR-OMNI unit inside the shipping container before sealing the shipping container.
4. Provide the following information either in or written on the shipping container:
    - The assigned RMA number written in bold letters on the outside of the shipping container.
    - Model, Serial Number, and specific details about the problem.
    - Point of contact (POC) name, return address, telephone number, and email address.
5. Use packing tape and seal all seams. If an industrial box stapler is used, be sure the staples do not protrude through the box to prevent injury to personnel and damage to the equipment.
6. Firmly affix the shipping label and ship the SDR-OMNI to the following address:

    Tel-Instrument Electronics Corp.
    One Branca Road
    East Rutherford, NJ 07073
    (201) 993-1600
    Attn: Repair Department

SAFETY PRECAUTIONS

The following are general safety precautions that are not related to a particular test or procedure. These are recommended procedures that all personnel must apply during operation and maintenance. The operator must have general knowledge of electrical theory and the dangers associated with it.

1. Before performing any series of tests, thoroughly read and understand all procedures before performing them.
2. The various SDR-OMNI connectors, switches, and controls can be located by referring to Chapter 3.
3. Take the time to learn the proper operation and function of the SDR-OMNI. Complete knowledge of the Test Set and its capabilities greatly reduces the time it takes to complete the tests.
4. Pay particular attention to **WARNINGS**, **CAUTIONS**, and **NOTES** and that may accompany some test and operational procedures.
5. Observe all standard safety procedures when working with live voltages. The potential for electric shock exists any time the SDR-OMNI is removed from its case.
6. **DO NOT** service or adjust the unit alone. Always be in the presence of another person when working with live voltages.
7. Thoroughly inspect the equipment and the local area for potential hazards. Loose clothing and jewelry should be removed anytime the test set is being utilized or serviced.
8. Be familiar with general first aid procedures and Cardiopulmonary Resuscitation (CPR).
9. Ensure the test equipment and tools you use are in good operational condition and not damaged in any way.
10. Use only approved replacement parts. Failure to use factory approved parts may cause damage to personnel, the test set, and possibly void the warranty.

WARNINGS

WARNING

An operating procedure or practice that, if not correctly followed, could result in death or personal injury.

CAUTIONS

CAUTION

An operational procedure or practice that, if not followed correctly, can result in damage to or destruction of equipment.

NOTES

NOTE

An operating procedure or condition that requires emphasis.

ELECTROSTATIC DISCHARGE (ESD)

The SDR-OMNI internal parts are ESD sensitive. An ESD may damage integrated circuits or semiconductors located within the SDR-OMNI. Only qualified personnel should service the SDR-OMNI to prevent damage. While performing tests or maintenance, users must adhere to the following guidelines to avoid ESD. These guidelines are meant only as a reminder; users must consult local directives and follow standard operating procedures before servicing or repairing the SDR-OMNI.

- Wear a properly grounded wrist strap and remain in contact with an approved grounding point.
- Do not touch the connector pins or backplanes of ESD Sensitive circuits or parts.
- Ensure soldering irons are grounded before use.
- Do not remove any components or disconnect any connectors located in the SDR-OMNI with the power “ON”.
- Properly ground all test equipment being used. Refer to the test equipment operating manual for information.
- Place all removed components or parts in or on an approved conductive package.

Most ESD devices or circuits and common points are readily identified using several different methods. See Figure 1 for example ESD labels.

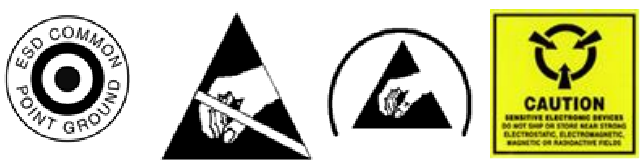

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Figure 1. Example ESD Labels

The European Conformity (CE) (International Electric Commission (IEC)) marking symbols may be used in different locations throughout the manual and are also located on and in the SDR-OMNI. Observe these warnings and markings and follow standard electrical safety anytime you use live circuits. See Figure 2 for example markings.

2023-CLS-TIC-0003

Figure 2. Example CE Markings

CHAPTER 1 INTRODUCTION

1.1 SCOPE

This manual is intended to familiarize the user with the operating procedures necessary to properly use the SDR-OMNI Avionics Test Set.

1.2 FEATURES

The SDR-OMNI is a lightweight, software-defined radio frequency (RF) test set for testing RF avionics in the 200 kilohertz (kHz) to 1.6 gigahertz (GHz) range. The SDR-OMNI is designed to test all basic navigation and communications avionics functions common to modern civil and commercial aircraft, with provisions for certain military avionics test requirements.

It uses software defined signal processing to test complex avionics navigations and communication signals.

The SDR-OMNI can be powered by either battery or AC adapter. The SDR-OMNI includes a lithium-ion (Li-Ion) battery that lasts 6 hours with continuous operation or 24 hours on a 20% duty cycle. The SDR-OMNI also includes an AC adapter (100-240 Volts AC (VAC), 47-63 hertz (Hz)) that can power the device and charge the battery.

1.3 COMPLIANCE

This Product Meets or Exceeds the essential requirements of applicable European Directives as follows:

- EN 55022, B
- EN 61000-4-2, L2&3, B
- EN 61000-4-4, L2&3, B
- EN 61000-3-2, A
- EN 61000-4-3, L3, A
- EN 61000-4-6, L3, A

CHAPTER 2 PREPARATION FOR USE

This section contains all necessary information on the initial unpacking, inspection, and setup of the SDR-OMNI. Each SDR-OMNI has already undergone a comprehensive series of tests, full calibration, and Quality Assurance checks before shipment from Tel-Instrument Electronics Corp.

2.1 UNPACKING

1. After receiving the SDR-OMNI, inspect the shipping container for damage. Note any damage in case the SDR-OMNI unit is also damaged.
2. Remove the SDR-OMNI from the shipping container and packaging material. Retain the shipping container and packaging material for future shipment or storage.

WARNING

DO NOT use a damaged SDR-OMNI. Using a damaged SDR-OMNI may cause death or serious injury.

3. Inspect the SDR-OMNI for damage to casing, connectors, switches, buttons, and display screen. If damage is found, DO NOT use the SDR-OMNI and contact Tel-Instrument Electronics Corp. Customer Service in accordance with the Warranty. Make sure to inform Customer Service if the shipping container is also damaged.
4. Verify that all the accessory items listed in Table 2-1 were received.

2.2 ACCESSORIES PROVIDED

Table 2-1. Accessories Included with the SDR-OMNI Avionics Test Set

DESCRIPTION	TIC PART NUMBER	QUANTITY
Transit Case, Rugged	64030103	1
AC Power Adapter/DC Charger (& AC Power Cord)	88000183/ 74000002	1 each
L-Band Directional Antenna	40030046	1
Telescopic Antenna	40030023	1
GPS Antenna	40030036	1
Wi-Fi Antenna	40030035	1
VSWR Return Loss Bridge	40200231	1
VSWR Open/Short Calibration Load	31020162	1
Kickstand Mount	88000185	1
Headset	75011002	1
TAP-OMNI Antenna Coupler	90000150	1

DESCRIPTION	TIC PART NUMBER	QUANTITY
TAP-OMNI Whip Antenna Adapter	54000044	1
10-Meter Antenna Coupler Cable	75010601	1
3-Meter Direct Connect Cable	75010605	1
VSWR Bridge Connect Cables, 12 in (BNC-male to N-male)	75010600	2
Insertion Loss Calibration Cable, 12 in (BNC-male to BNC-male)	75010599	1
USB Adapter Cable (A-male to Micro B-male)	75010598	1
USB Adapter Cable (A-female to Micro B-male)	75010603	1
Aircraft Audio Test Cable – civil	75010582	1
CD-ROM – Manual & Download Utility Program	90008147	1
RF Adapter Kit		
Adapter, TNC-female to BNC-male	48040171	1
Adapter, N-male to TNC-female	48040178	1
Adapter, N-male to BNC-female	48040167	1

2.2.1 Transit Case

The Transit Case (Figure 2-1) safely stores the SDR-OMNI and its accessories while they are not in use. The Transit Case can be carried using the carrying handles, or the Transit Case can be rolled using the two wheels and extendable handle. The Transit Case can be secured shut with two latches.

Additionally, four metal grommets can be used to secure the Transit Case shut with zip ties or locks (not included). The Transit Case cover has a rubber gasket to prevent water from entering the Transit Case. The Transit Case has a foam lining and a tray insert to organize and protect the SDR-OMNI and its accessories.

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Figure 2-1. Transit Case

2.2.2 AC Power Adapter/DC Charger

The AC Power Adapter/DC Charger (24 Vdc) (Figure 2-2) charges the battery and supplies power to the unit for operation. See Table 8-2 for power specifications.

2023-CLS-TIC-0005

Figure 2-2. AC Power Adapter/DC Charger (24 Vdc)

2.2.3 Telescopic Antenna

Most HF/VHU/UHF radio checks will be performed over-the-air using the supplied Telescopic Antenna (Figure 2-3). The length of the antenna should be adjusted for the wavelength of the frequency band being tested (refer to Table 2-2 and Table 2-3).

Many basic functional tests (such as Very High Frequency (VHF) Omnidirectional Radio (VOR), Instrument Landing System (ILS) Localizer (LOC), Glideslope (GS), and Marker Beacon (MB)), Emergency Locator Transmitter (ELT), Selective Calling (SELCAL), and Communication (COMM) tests) can be performed by a single operator from the cockpit. The Telescopic Antenna can be extended out of the passenger door or the pilot's window. Otherwise, the SDR-OMNI should be placed 10 to 30 feet (3 to 9 meters) from the unit under test (UUT) antenna with an unobstructed line-of-sight.

Hangars, ramp equipment, and other aircraft may interfere with test signals. If unexpected test results are observed, first attempt to move the SDR-OMNI to a location that could minimize multi-path interference and retest.

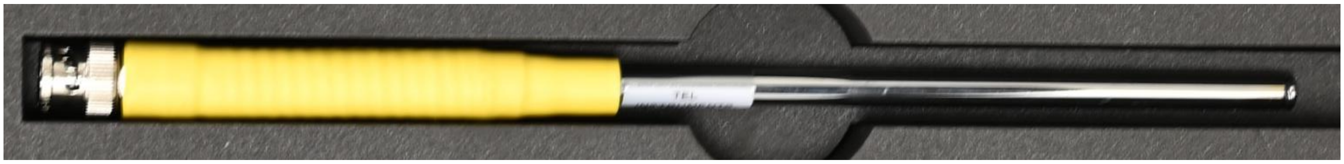

Figure 2-3. Telescopic Antenna 2023-CLS-TIC-0006

Table 2-2. NAV Frequencies

FUNCTION TESTED	ANTENNA LENGTH
MB (75.0 MHz)	Fully Extended
VOR (108.00-117.95 MHz)	28.5 inches (72 cm)
LOC (108.10 – 111.95 MHz)	28.5 inches (72 cm)
GS (329.15 – 335.00 MHz)	9.5 inches (24 cm)

Table 2-3. COMM Frequencies

FREQUENCY TESTED	ANTENNA LENGTH
HF 29 – 88 MHz	Fully Extended
VHF 108-118 MHz	28.5 inches (72 cm)
VHF 118-156 MHz	24 inches (61 cm)
VHF 156-174 MHz	18 inches (45 cm)
UHF 225 – 299 MHz	11 inches (28 cm)
UHF 300 – 406 MHz	Base section only – fully collapsed

2.2.4 L-Band Directional Antenna

The L-Band Directional Antenna (Figure 2-4) has a flexible neck and guide arrows to properly position the antenna for L-Band (Transponder, TCAS, UAT) testing. The antenna is vertically polarized, so the flat portion of the antenna must be oriented vertically when pointing at the aircraft’s ATC, TCAS, or DME antenna.

2023-CLS-TIC-0007

2.2.5 Wi-Fi Antenna

The Wi-Fi Antenna (Figure 2-5) enables the SDR-OMNI to connect to a wireless network.

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Figure 2-5. Wi-Fi Antenna

2.2.6 GPS Antenna

The GPS Antenna (Figure 2-6) enables the SDR-OMNI's internal GPS receiver to receive GPS signals.

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Figure 2-6. GPS Antenna

2.2.7 Kickstand Mount

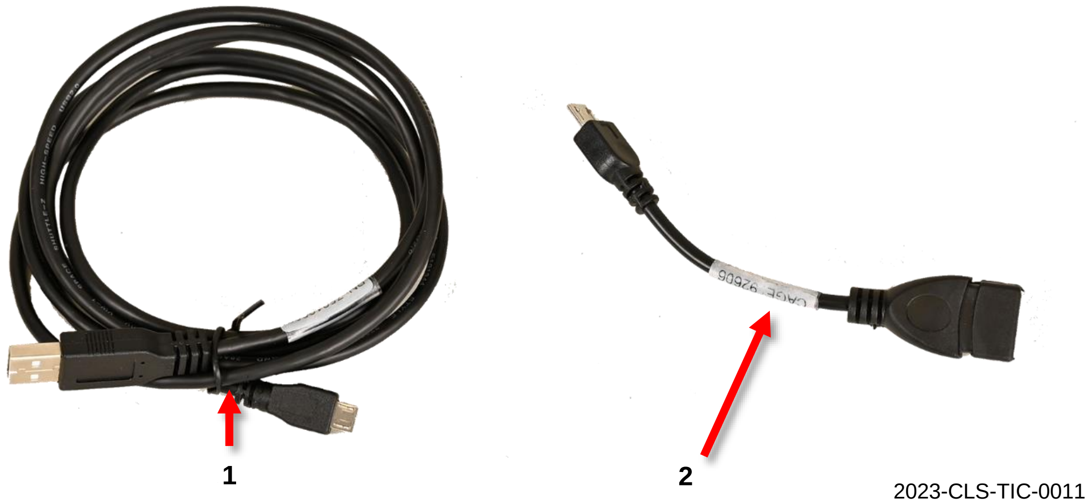
The Kickstand Mount (Figure 2-7) supports the SDR-OMNI so it can be placed in a comfortable position for viewing.

2023-CLS-TIC-0010

Figure 2-7. Kickstand Mount

2.2.8 Micro USB Adapter Cables

Two Micro-B USB Adapter Cables (Figure 2-8) are provided. The Micro-B Male to USB-A Male Cable (1) is used to connect the SDR-OMNI to a personal computer (PC) for uploading a new program file into the SDR-OMNI and downloading test reports. A second cable, USB-A Female to Micro B- Male Cable (2), is also provided for future applications.

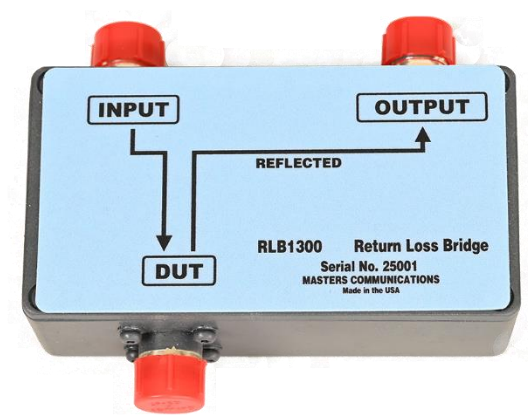


LEGEND
1 MICRO-B MALE TO USB-A MALE CABLE
2 MICRO-B MALE TO USB-A FEMALE CABLE

Figure 2-8. Micro USB Adapter Cables

2.2.9 VSWR Return Loss Bridge

The VSWR Return Loss Bridge (Figure 2-9) is used for making VSWR and Distance-to-Fault (DTF) measurements using the SDR-OMNI.



2023-CLS-TIC-0012

Figure 2-9. VSWR Return Loss Bridge

2.2.10 VSWR Open/Short Calibration Load

The VSWR Open/Short Calibration Load (Figure 2-10) is used during the VSWR calibration process. One side is an open circuit, and the other side is a short circuit.

Figure 2-10 VSWR Open/Short Calibration Load 2023-CLS-TIC-0013

2.2.11 VSWR Bridge Connect Cables

Two identical 12-inch VSWR Bridge Connect Cables (Figure 2-11) are provided to connect the SDR-OMNI to the INPUT and OUTPUT ports on the VSWR Return Loss Bridge. They have a BNC-male on one end and an N-male on the other end.

2023-CLS-TIC-0014

Figure 2-11 VSWR Bridge Connect Cables

2.2.12 Insertion Loss Calibration Cable

The Insertion Loss Calibration Cable (Figure 2-12) is a 12-inch BNC-male to BNC-male cable that connect the ANT-A and ANT-B ports on the SDR-OMNI during the Cable Loss calibration procedure.

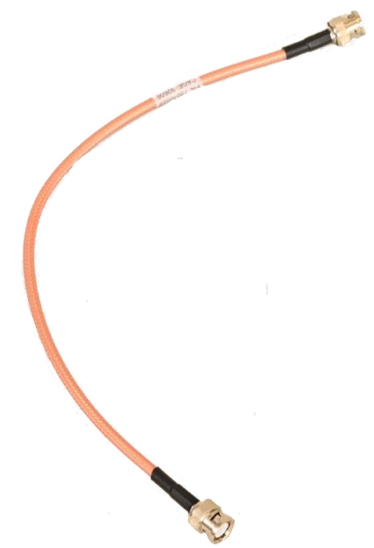


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Figure 2-12 Insertion Loss Calibration Cable

2.2.13 Headset

The Headset (Figure 2-13) can be used to listen to HF, VHF, or UHF COMM radio voice transmissions from an aircraft and for transmitting voice from the SDR-OMNI to the aircraft COMM radio.

2023-CLS-TIC-0016

Figure 2-13 Headset

2.2.14 TAP-OMNI Antenna Coupler & Whip Antenna Adapter

The TAP-OMNI Antenna Coupler (Figure 2-14) is designed to fit over a shark fin style ATC Transponder antenna to provide a high level of RF attenuation and prevent the testing of the aircraft transponder/ADS-B device from interfering with ATC operations. It also enables the test operator to obtain much more accurate and repeatable power and sensitivity readings, as it greatly reduces multi-path and uncertainty when compared to over-the-air testing with a directional antenna.

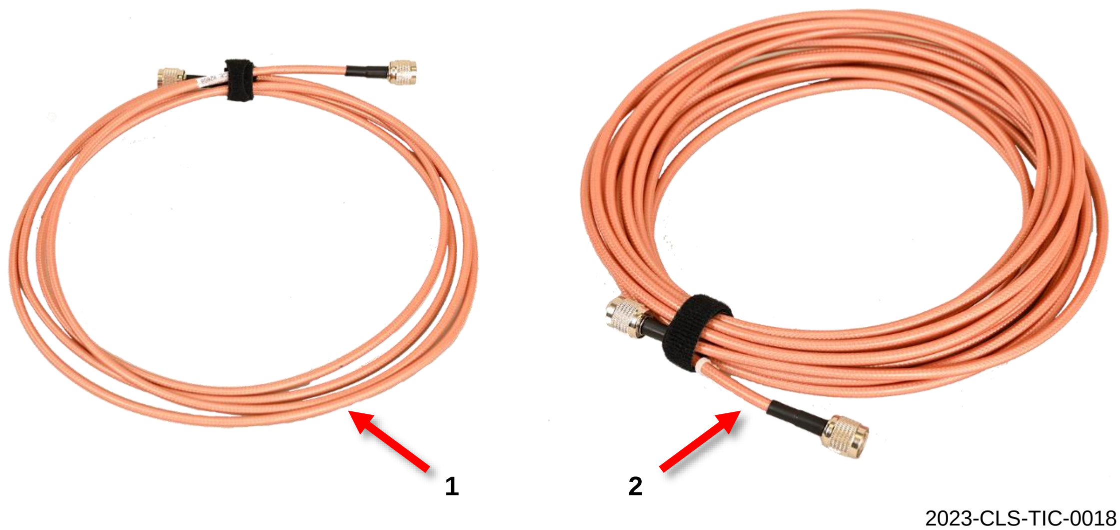
A Whip Antenna Adapter is also included in the SDR-OMNI kit. It is used when testing aircraft that have a short L-Band dipole transponder antenna. The whip adapter fits into the bottom of the TAP-OMNI, which is then placed over the dipole antenna and clamped into place. The whip adapter serves to center the dipole antenna in the TAP-OMNI so that the operator can obtain repeatable test results.

LEGEND
1 TAP-OMNI ANTENNA COUPLER
2 WHIP ANTENNA ADAPTER

Figure 2-14 TAP-OMNI Antenna Coupler & Whip Antenna Adapter

2.2.15 3-Meter Direct Connect & 10-Meter Antenna Coupler Connect Cables

Two RG-400 RF cables with TNC-male connectors on each end (Figure 2-15) are provided. The 3-Meter Direct Connect Cable (1) connects the SDR-OMNI directly to a transponder, bypassing the antenna. The 10-Meter Antenna Coupler Connect Cable (2) connects the SDR-OMNI to the TAP-OMNI Antenna Coupler. Both cables have the cable loss, in dB, marked on the cables. These values will be entered into the SDR-OMNI during the initial setup procedure.

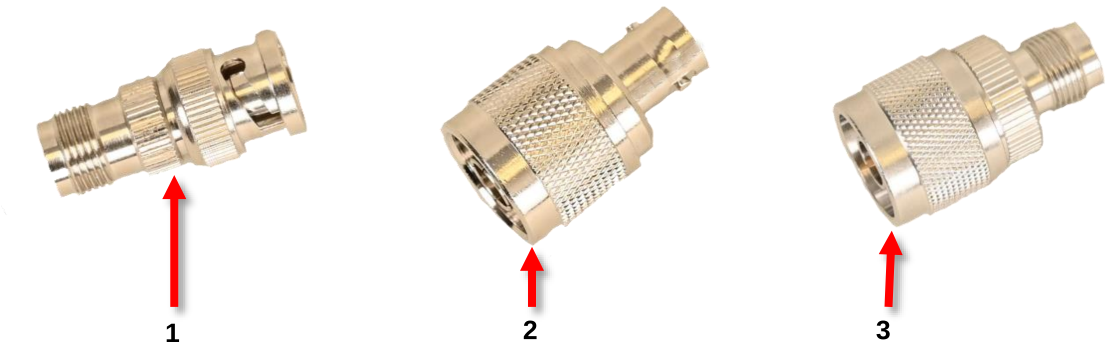


LEGEND
1 **3-METER DIRECT CONNECT CABLE**
2 10-METER ANTENNA COUPLER

Figure 2-15. 3-Meter and 10-Meter Direct Connect Cables

2.2.16 RF Connector Adapters (3)

Three RF connector adapters (ure 2-16) are provided to facilitate connecting the SDR-OMNI to various UUTs: a TNC-female to BNC-male (1); an N-male to TNC-female (2); and an N-male to BNC-female (3).



LEGEND
1 TNC-FEMALE TO BNC-MALE
2 N-MALE TO BNC-FEMALE
3 N-MALE TO TNC-FEMALE

2023-CLS-TIC-0019

2.2.17 Audio Test Cable

An audio test cable (Figure 2-17) is provide with a Civil Phone/Mic plug to SDR-OMNI Test connector.

This cable is used to test aircraft audio systems.

Figure 2-17. Audio Test Cable

2.3 BATTERY

The SDR-OMNI is factory equipped with a rechargeable Lithium-Ion (Li-Ion) battery capable of operating the SDR-OMNI at a 20% duty cycle for up to 6 hours at nominal temperatures. This represents a full day of testing on a single charge.

The unit is capable of operating within a temperature range of -4 to 131 degrees Fahrenheit (°F) (-20 to 55 degrees Celsius (°C)). When operating in lower temperatures, the charge duration will decrease.

To conserve battery charge and maximize the time the unit can be used between recharging, it is advisable to lower the screen brightness and set the Screen Timeout to an appropriate value (from 15 seconds to 5 minutes, or Never – this is done in Global Settings). After the selected period of inactivity the SDR-OMNI will turn off its display. Simply touching the screen will revive it.

If the AC Power Adapter/Charger is plugged in, the SDR-OMNI will NOT turn off the display due to inactivity.

The SDR-OMNI batteries should be charged for a short time each week, regardless of SDR-OMNI usage. A completely discharged battery will require approximately 2 hours to completely recharge. Charging the unit while operating it will take longer to fully charge. Occasional charges of partially depleted batteries will have no adverse effects.

CHAPTER 3 SDR-OMNI OVERVIEW

3.1 CONTROLS

Figure 3-1 illustrates the controls for the SDR-OMNI. Table 3-1 describes the SDR-OMNI controls.

Figure 3-1. Controls for SDR-OMNI

Table 3-1. Description of SDR-OMNI Controls

KEY	NAME	DESCRIPTION
1	Status Indicators	Indicates the GPS and battery status.
2	5-Way Switch	Power ON: Briefly press the OK middle button to turn the unit ON. Power OFF: Hold the OK button for ~5 seconds to turn the power OFF. A “Confirm shutdown” window will appear on the screen. Press “Power Off” to turn off. The Up/Down arrows allow the user to move between active fields on the various test screens.
3	Back Icon	Selecting this virtual button will return to the previous screen.
4	Home/Settings/Set-up Icon	Selecting this virtual button will bring up a small menu that allows the operator to directly navigate to: (1) Home (Home Menu), (2) Settings menu (global settings, for example: Screen Brightness, Screen Timeout, Distance Units, etc.), or (3) Application specific Setup menu

3.2 INDICATORS AND CONNECTORS

Figure 3-2 illustrates the indicators and connectors for the SDR-OMNI. Table 3-2 describes the SDR-OMNI indicators and connectors.

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Figure 3-2 SDR-OMNI Indicators and Connectors

Table 3-2. Description of SDR-OMNI Indicators and Connectors

KEY	NAME	DESCRIPTION
1	Wi-Fi	Receives the Wi-Fi Antenna.
2	GPS	Receives the GPS Antenna.
3	T/R	TNC female - Direct Connect port for direct connection to UUT or to TAP-OMNI Antenna Coupler.
4	Ant-B	BNC female – Port for Telescopic Antenna connection for Over-the-Air (OTA) testing of VOR/ILS/COMM radio/ELT. Also used to connect to VSWR Return Loss Bridge
5	Ant-A	BNC female – Port for L-Band Directional Antenna for OTA testing of ATC Transponders, UAT radios, and TCAS. Also used to connect to VSWR Return Loss Bridge
6	USB	Receives the Micro USB Cable.
7	Headset	Receives the Headset connector.
8	DC Power	Receives the DC Charger plug from the AC Power Adapter/DC Charger.
9	Charging LED	Displays battery charge status: Amber = Charging; Green = Charging complete
10	CH 2	BNC female. Ch 2 Scope / TX Modulation "Q" input, 1 Mohm + 10 pF
11	CH 1	BNC female. Ch 1 Scope / TX Modulation "I" input, 1 Mohm + 10 pF
12	TEST	15 pin HD connector - Receives Audio Test Cables (see Table 3-3 for connector pinout).

Table 3-3. TEST Connector pinout

PIN NUMBER	SIGNAL DESCRIPTION
2	Audio Measurements Input, 10V p-p, 10 kohm AC coupled
3	Audio Signal Generator Out, 4Vp-p Hi-Z, 50 ohm source Z AC coupled
4	Arbitrary Waveform Generator ch 1 / RX video "I" (4Vp-p into hi Z, 50 ohm source Z)
5	Arbitrary Waveform Generator ch 2 / RX video "Q" (4Vp-p into hi Z, 50 ohm source Z)
14	Digital I/O #0, usage: TACAN North trigger, XPDR interrogation trigger output, 3.3V logic
13	Digital I/O #1 future use 3.3V logic
12	Digital I/O #2 future use 3.3V logic
11	Digital I/O #3 future use 3.3V logic
1	Digital I/O #4 usage: comm PTT, XPDR suppression out, open collector 100mA / 60V
15	Digital I/O #5 usage: XPDR suppression in, threshold 5V, 50 kohm, 60 volts max
10	+5Vdc for future accessory use
6	Ground
7	Ground
8	Ground
9	Ground

CHAPTER 4 POWERING ON AND INITIAL SETUP

4.1 POWER ON

NOTE

The SDR-OMNI will not power on if the battery is drained and the AC Power Adapter/DC Charger is not connected.

1. Briefly press the center (OK) button of the 5-Way Switch (Figure 3-1, 1). The unit will power ON. The unit will briefly display the Tel-Instrument Electronics Corp. logo screen (and the current software version will be displayed in the lower right corner), then go blank for approximately 15 seconds while it loads its firmware and runs its self-test routine. The **Home Menu** screen will then appear.

4.2 POWER OFF

The SDR-OMNI can be powered OFF using either the 5-Way Switch or the touch screen.

To power OFF using the 5-Way Switch:

1. From any screen, press and hold the center (OK) button of the 5-Way Switch (Figure 3-1, 1) for approximately 3 seconds. A popup asking to **Confirm shutdown** will appear.
2. Press **Power Off** in the **Confirm shutdown** popup to continue with powering off the SDR-OMNI. Otherwise, press **Cancel** to close the **Confirm shutdown** popup and continue using the SDR-OMNI.

To power OFF using the touch screen:

1. From the **Home Menu**, press the **Home/Settings** (Figure 4-1) button at the bottom of the screen. A popup will display with a **Power Off** option.
2. Press **Power Off**. A popup asking to **Confirm shutdown** will appear.
3. Press **Power Off** in the **Confirm shutdown** popup to continue with powering off the SDR-OMNI. Otherwise, press **Cancel** to close the **Confirm shutdown** popup and continue using the SDR-OMNI.

4.3 HOME MENU

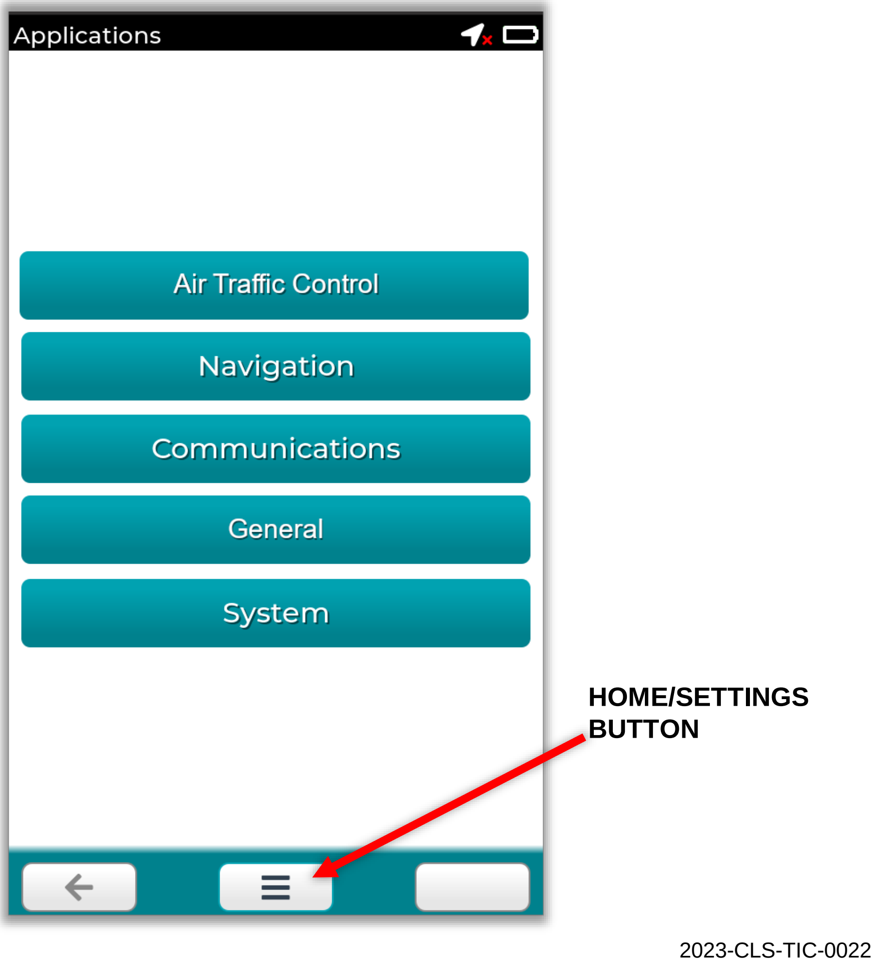


Figure 4-1. Home Menu

4.4 GLOBAL SYSTEM SETTINGS

Several Global settings and parameters should be reviewed and set after the unit is powered ON for the first time. These settings are saved and do not need to be re-entered each time the unit is used.

To access the Settings Menu, press the **Home/Settings** button (Figure 4-1), then select **Settings**. This accesses the Global Settings page (Figure 4-2).

Figure 4-2 Global Settings screen

4.4.1 Brightness

A slider bar controls the screen brightness. To increase battery life, use as dim a setting as practical.

4.4.2 Ignore Alignment Prompt

The SDR-OMNI periodically (every 10 minutes, or if the internal temperature changes by 5º F) runs an RF alignment procedure to ensure maximum accuracy over temperature. This could possibly occur during an extended avionics test (e.g., transmitting VOR/ILS/COMM/UAT or receiving ADS-B OUT data), thereby interrupting the test. Checking this box will suppress the alignment and ensure that the test is not interrupted.

If critical parametric testing is desired, this box should be unchecked so that the SDR-OMNI always operates at the highest accuracy.

4.4.3 Screen Timeout

This option sets the interval that the screen will be on *in the absence of any touchscreen activity, except when a test is in process (i.e., when the user has selected a test function, the screen will not turn off).* Touching the screen will reset the screen timeout counter. Selections are: 15 seconds, 30 seconds, 1 minute, 5 minutes, and Never. If the screen times out, simply touching the screen will turn it back on.

4.4.4 Power Off on Idle

This option sets the interval after which the unit will automatically power OFF *in the absence of any touchscreen activity, except when a test is in process (i.e., when the user has selected a test function, the unit will not turn off).* Touching the screen will reset the screen timeout counter. Selections are: Never, 5 minutes, 10 minutes, 15 minutes, and 30 minutes. If the unit turns off, you will need to press the OK button on the side to turn it back on.

4.4.5 Position Source

For ADS-B IN and OUT tests, the SDR-OMNI needs to have a valid GPS position. This can be obtained using one of the three **Position Source** (4) options:

1. **GPS**: This selects the real time position determined by the internal SDR-OMNI GPS receiver (clear view of sky is required). This is best selected if the unit is to be used outside on a tarmac or in a hangar with a GPS repeater.
2. **Saved**: A previously saved position. This is recommended if the unit is to be used in a hangar with no GPS repeater.

   First, select GPS as the position source, then take the unit outdoors for several minutes until it gets a GPS position fix (indicated when the Update button in the Saved Position row becomes active).

   Press the Update button to save that position, then select Saved for the Position Source. The unit will now use this saved position when testing ADS-B devices.
3. **Manual:** A manually entered position, with Lat and Lon entered in decimal degrees. This allows for any valid Lat/Lon to be entered, and is recommended for lab testing, or anytime a real-time GPS position would be difficult to acquire.

   When Manual is selected, Manual Position Lat/Lon entry boxes (5) are displayed. The left box is Latitude (South is negative) and the right box is Longitude (West is negative).

4.4.6 Distance Units

This option (6) allows the user to select **Feet** or **Meters** for cable length, antenna distance to UUT, and altitude data.

4.5 CHARGING THE BATTERY

Figure 4-3 AC Power Adapter/DC Charger

1. Connect the AC Power Cord (Figure 4-3, 1) to the AC Power Adapter/DC Charger (2).
2. Plug the DC Plug (4) into the SDR-OMNI DC (VDC) power jack.
3. Connect the AC Power Cord (1) plug into a suitable 100 to 240 Volts AC (VAC), 50/60 hertz (Hz) outlet.
4. Verify that the Power Indicator (3) on the AC Power Adapter/DC Charger (2) lights.
5. Observe the Charging LED (Figure 3-2, 9) on the left side of the SDR-OMNI, next to the DC Charger connector. When steady yellow, the SDR-OMNI is charging. The Battery Status icon (Figure 3-1, 1) in the upper right corner of the screen will also show a charging status. **When charging is complete, the LED will turn OFF.** If the LED is flashing, a charging fault has occurred.
6. The Battery Status icon in the upper right portion of the screen gives an approximate indication of the state of the battery charge.

4.6 RETRIEVING AND PRINTING TEST REPORTS

Saved test reports that were generated by the FAA Part 43 Transponder Test, the FAR 91.227 ADS-B OUT Test, and the ELT Test can be viewed by going to: **Home Menu -> System -> Test Reports**. View the test report by pressing the small **File** icon on the right. The **Trash Can** icon will delete the report.

4.6.1 Retrieving and Printing via PC or Laptop

1. Connect the SDR-OMNI to a PC or laptop USB port using the 75010598 USB cable (the longer of the two cables, see Figure 2-8).
2. With the unit power ON, open a browser and enter the following address: **http://sdromni-0501.local/**.
   The Test Reports Webpage (Figure 4-4) will display. If this is unsuccessful, enter **http://192.168.78.1/**
3. Select **View** to view the desired PDF report. Print using the local printer if desired.

SDR-OMNI Test Reports

Type	Job ID	Date	Actions
Part 43 Auto Test	N3217J	02/20/2023 16:20	Delete View
Part 43 Auto Test	N2048N	02/20/2023 16:19	Delete View

2023-CLS-TIC-0024

Figure 4-4. Test Reports Webpage

4.7 UPDATING SDR-OMNI SOFTWARE

Tel-Instrument Electronics (TIC) occasionally issues new software updates to add features, fix bugs, and improve the user experience.

These updates are available on the TIC website (www.telinst.com). The user must first register under **Technical Support** to gain access to the latest software version.

Software updates are done using a PC or laptop running Microsoft Windows 10 or later.

4.7.1 Installing the SDR-OMNI Updater Program

First, the user must install the **SDR-OMNI Updater Program** on the PC or laptop computer. The installation file is found on the CD-ROM that was part of the SDR-OMNI accessories kit. This program can also be downloaded from the TIC website.

Once downloaded and selected, install this program on the PC or laptop.

4.7.2 Download latest SDR-OMNI file from TIC website

On the TIC website, go to the SDR-OMNI product page. Go to the Downloads tab and download the Current Software Version file to your computer. It is suggested that you create a folder called **SDR-OMNI Updates** to store the file.

The filename should be: SDR-OMNI-rX.Y.Z.swu.

4.7.3 Connect USB Cable 75010598 and Run SDR-OMNI Updater Program

1. Run the SDR-OMNI Updater Program (Figure 4-5) that has been installed on the PC/laptop.
2. Select **Help** in the upper left to view the Instructions.
3. Ensure the SDR-OMNI is getting power from its charger (see Paragraph 4.5).
4. Connect the SDR-OMNI to the PC/laptop using the longer supplied USB cable 75010598 (Figure 2-8).
5. Make sure the SDR-OMNI is powered OFF (see Paragraph 4.2).
6. Use the "Browse" button to search for and select the *.swu file to be loaded into the SDR-OMNI.
7. Click **Start** on the program.
8. Press and hold the "OK" button on the right side of the SDR-OMNI. Hold until the screen says **USB DFU Active**.
9. Progress will be shown on the Updater program screen. When the update is complete, **Program successfully completed** (Figure 4-6) will be displayed and the SDR-OMNI will reboot itself. The new software version should briefly be shown on the lower right corner of the splash screen and will be available from the Home menu via **System->About->Versions**.

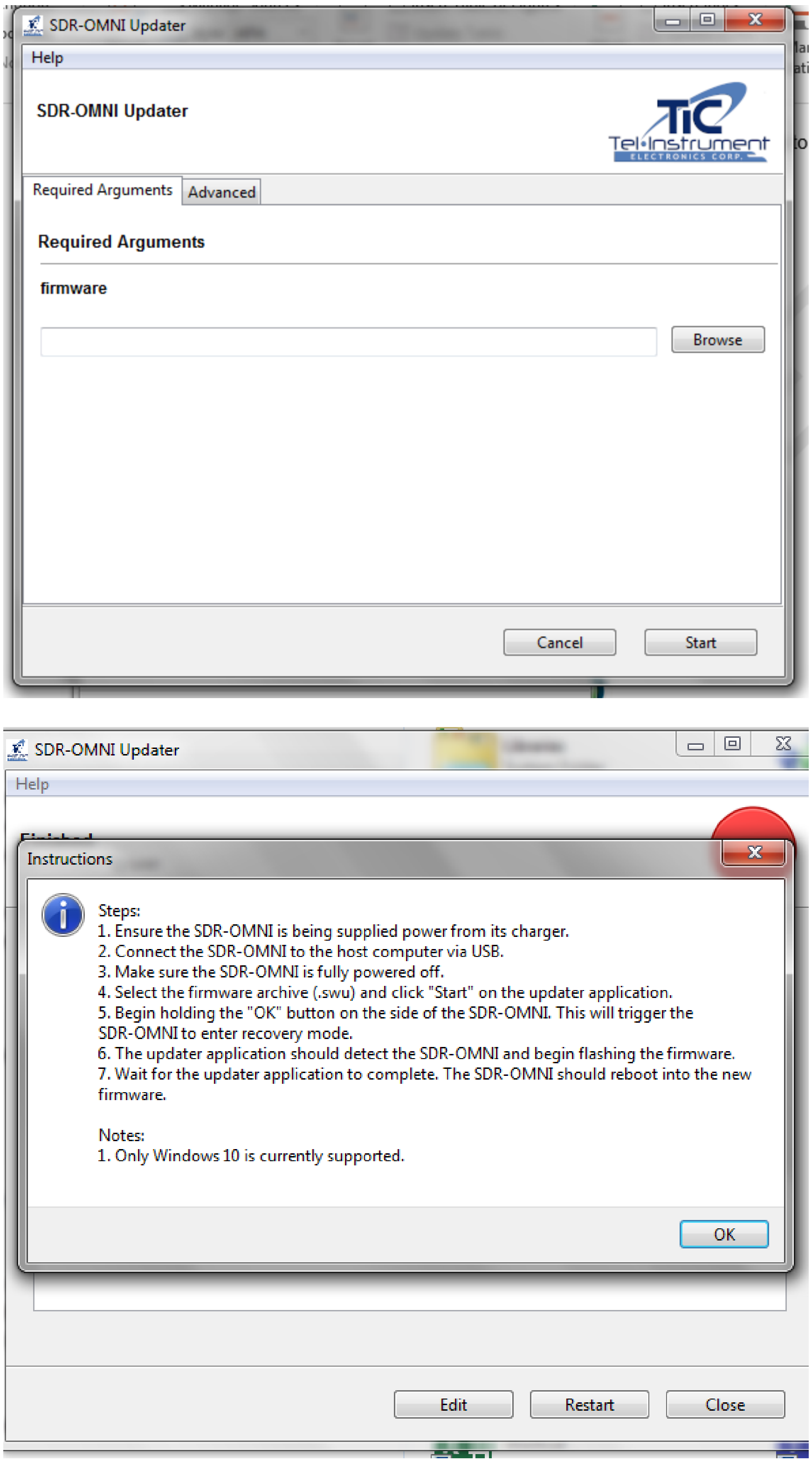
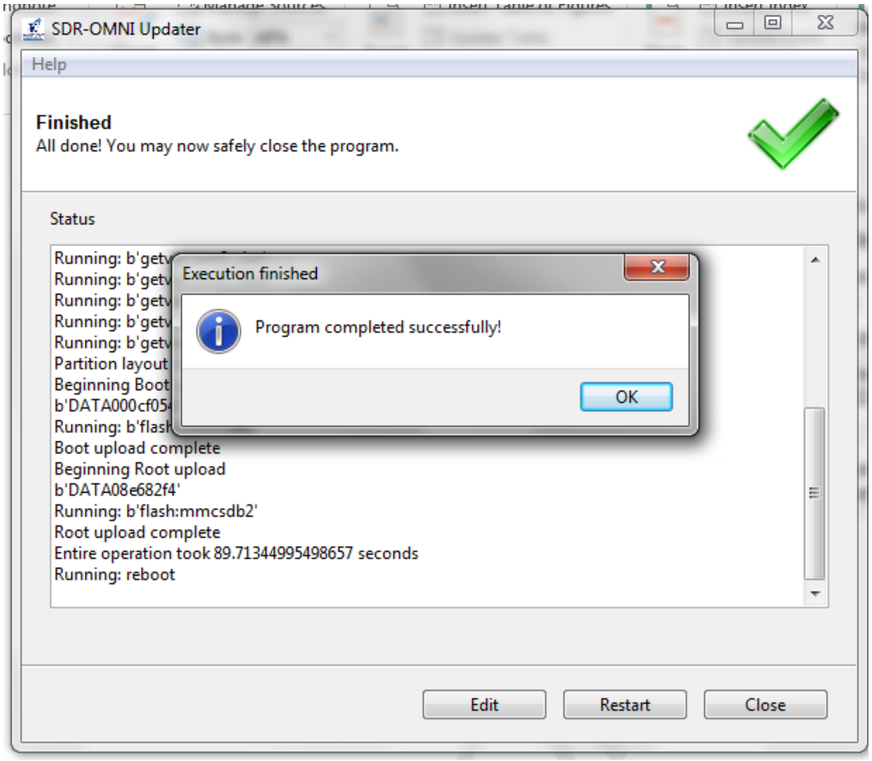


Figure 4-5 SDR-OMNI Update Program and Help Instructions 2023-CLS-TIC-0025



2023-CLS-TIC-0026

Figure 4-6 Successful Software Update

4.8 ADMIN MODE (TBD)

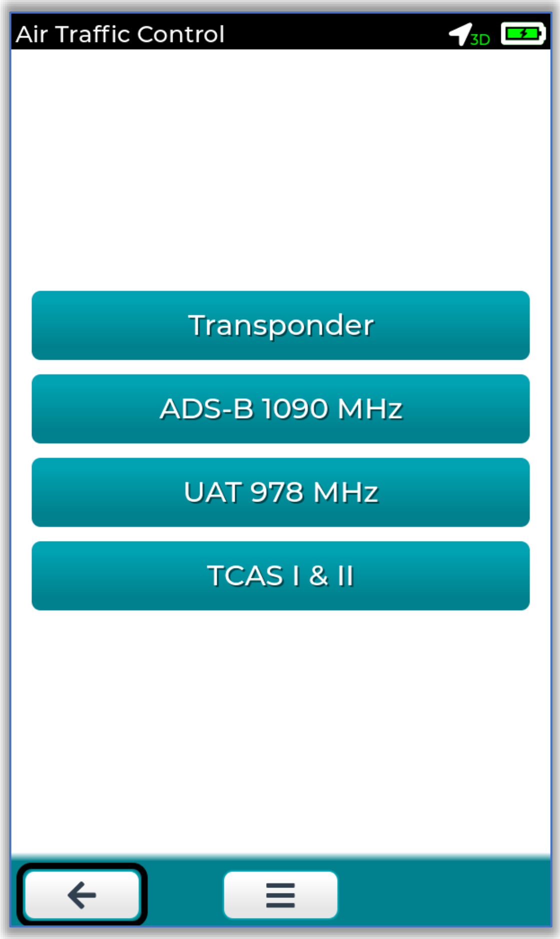
The SDR-OMNI features an Administration Mode whereby the high-level Test Equipment Administrator can specify stored preset test steps that are not able to be modified by the local user. This could prove useful in a production environment where a standardized test procedure is to be accomplished every time. The user can then select the test and then quickly step through the test steps without having to enter a new value or parameter each time.

CHAPTER 5 AVIONICS TESTING USING THE SDR-OMNI

5.1 TESTING ATC TRANSPONDERS

The SDR-OMNI has been designed to rapidly recertify Mode S ATC transponders according to US Federal Aviation Regulations Part 43, Appendix F. This is the primary ATC transponder test function. In addition, there are several other transponder test functions available in the Transponder Menu page; each is described below.

From the Home Menu screen (see Paragraph 4.3), select **Air Traffic Control**. The Air Traffic Control Menu screen (Figure 5-1) will appear.



2023-CLS-TIC-0027

Figure 5-1 Air Traffic Control Menu

5.1.1 Transponder Setup

1. Select **Transponder**. The **Transponder Setup** popup screen (Figure 5-2) will appear.
2. This screen is used to select the connection method for testing the transponder – either Direct Connect, TAP-OMNI Antenna Coupler, or Over-the-Air using the L-Band Directional Antenna.

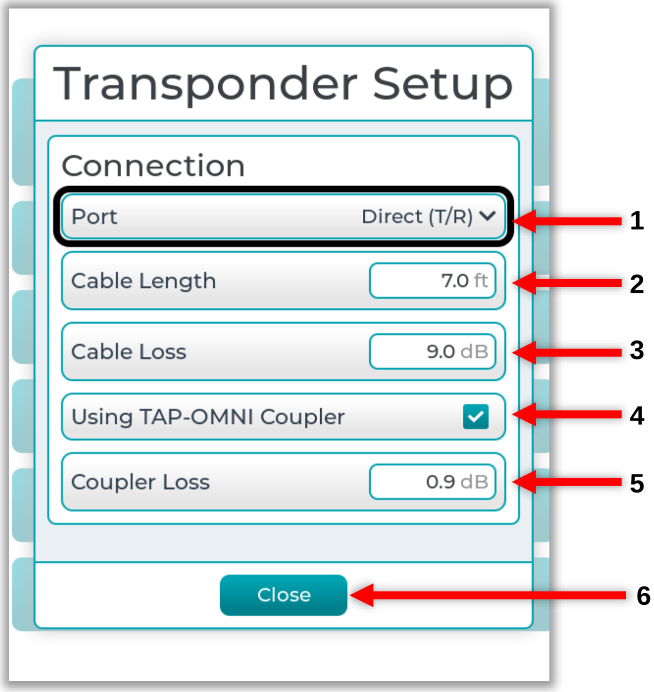


Figure 5-2 Transponder Setup Popup – Direct Connect

5.1.2 Direct Connect or TAP-OMNI Antenna Coupler Testing

Before beginning any ATC Transponder test, the SDR-OMNI needs to know which connection port will be used. For **Direct Connect** testing **OR** testing with the **TAP-OMNI** antenna coupler, select the **Direct T/R** port (Figure 5-2, 1) setting.

Direct Connect Testing

1. Connect the transponder to the **Direct T/R** TNC connector using the TIC-supplied 3 meter (10 foot) direct connect cable (Figure 2-15). It may be necessary to use one of the supplied RF adapters to make the connection (see Paragraph 2.2.16).
2. Make sure the **Cable Length** (Figure 5-2, 2) and **Cable Loss** (3) (marked on the cable) are correct; if not, enter the correct values. If an RF adapter is used, add 1 dB per adapter to the Cable Loss value.

TAP-OMNI Antenna Coupler Testing

1. Check the **Using TAP-OMNI Coupler** checkbox (4).
2. Connect the 10 meter (33 foot) direct connect cable (Figure 2-15) from the SDR-OMNI to the TAP-OMNI coupler (Figure 2-14). Attach the coupler to the desired antenna of the transponder system under test.
3. Verify the **Cable Length** (Figure 5-2, 2) and **Cable Loss** (3) (marked on the cable) are correct; if not, enter the correct values. The **Coupler Loss** value of 0.9 dB (5) is added to the Cable Loss to compute accurate power and sensitivity readings.
4. Select **Close** (6)**.**

5.1.3 Over-the-Air (OTA) Testing with L-Band Directional Antenna

1. Connect the L-Band Directional Antenna (Figure 2-4) to the **ANT-A** Antenna A connector (see Paragraph 3.2) in the top of the unit.
2. Select **Antenna A** in the Port field (Figure 5-3, 1).
3. **Using Antenna Cable** (2): Check this box only if an extension cable is inserted between the SDR-OMNI and the L-Band Directional Antenna. If this box is checked, the operator will be asked to enter the cable length and the cable loss.
4. **Antenna Distance to UUT** (3): Enter the distance from the SDR-OMNI antenna to the UUT antenna.

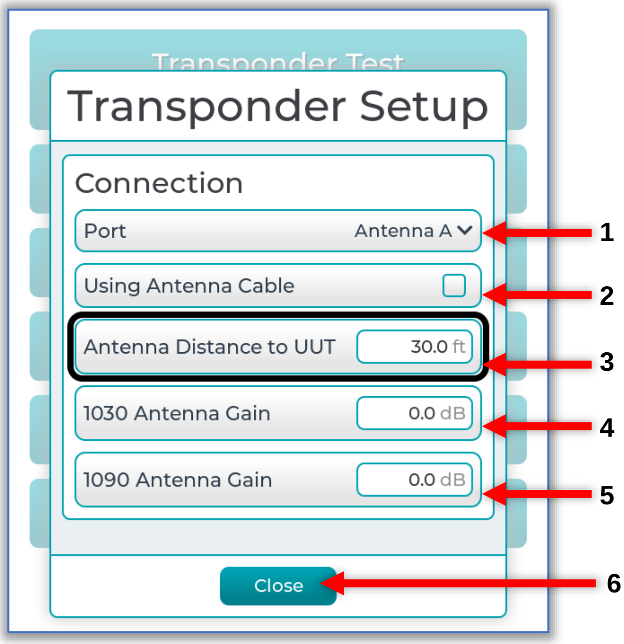
NOTE: Over-the-Air Testing with L-Band Directional Antenna

Position the SDR-OMNI so that it has an unobstructed line-of-sight to the aircraft antenna to be tested. If testing a *dual transponder* installation, make sure that the other transponder is OFF or in STANDBY so that it does not reply.

The use of the TAP-OMNI antenna coupler is highly recommended to minimize the possibility of receiving multipath reflections from hangar walls and doors and other structures and to obtain the most accurate power and MTL sensitivity measurements.

When testing Diversity transponders, the TAP-OMNI coupler will minimize the reception of squitters from the non-tested antenna. If testing a Diversity transponder over-the-air using the directional antenna, ensure that that the non-tested antenna is not visible from the test set location – either by locating the test set under (or over) the wing, or under or above the fuselage.

5. **1030 Antenna Gain** (5): Enter the value marked on the supplied L-Band Directional Antenna. This value is stored and only needs to be done the first time the test set is used.
6. **1090 Antenna Gain** (6): Enter the value marked on the supplied L-Band Directional Antenna. This value is stored and only needs to be done the first time the test set is used.
7. Select **Close** (7).

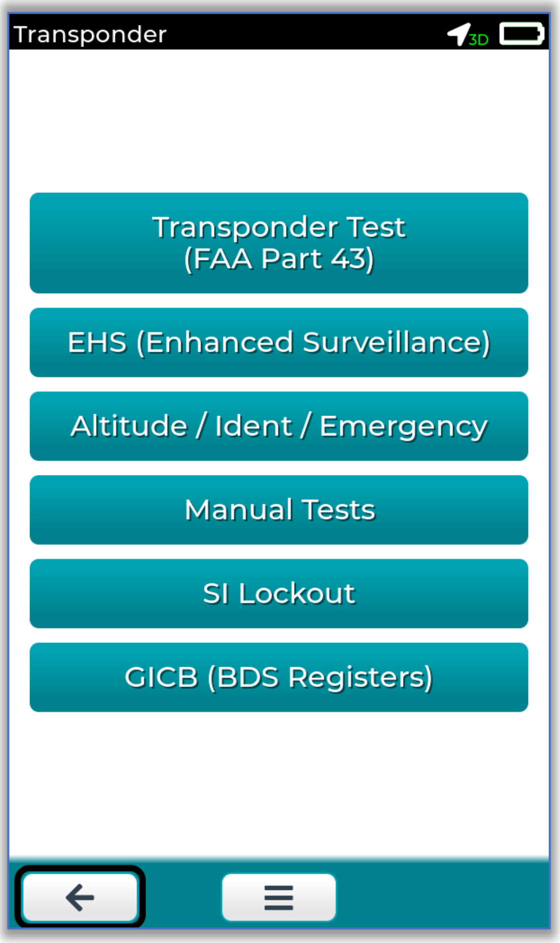


2023-CLS-TIC-0029

Figure 5-3 Transponder Setup popup - Antenna

5.1.4 Identifying the Transponder UUT Type and Capability

Once the proper port and associated parameters are set and the popup menu is closed, the **Transponder Test Menu** (Figure 5-4) will appear. Before selecting any of the listed tests, a discussion of how the SDR-OMNI interrogates and identifies transponders is in order.



2023-CLS-TIC-0030

Figure 5-4. Transponder Test Menu

Prior to starting a selected test, the SDR-OMNI goes through a very rapid *Target ID* procedure to determine what type of transponder it is testing: **ATCRBS** (Modes 3A and 3C only) or **Mode S**. If a Mode S transponder is detected, it determines whether it is a *Diversity Transponder* (with Top and Bottom antennas) and the extent of its Communications Capability.

During this *Target ID* period, the unit:

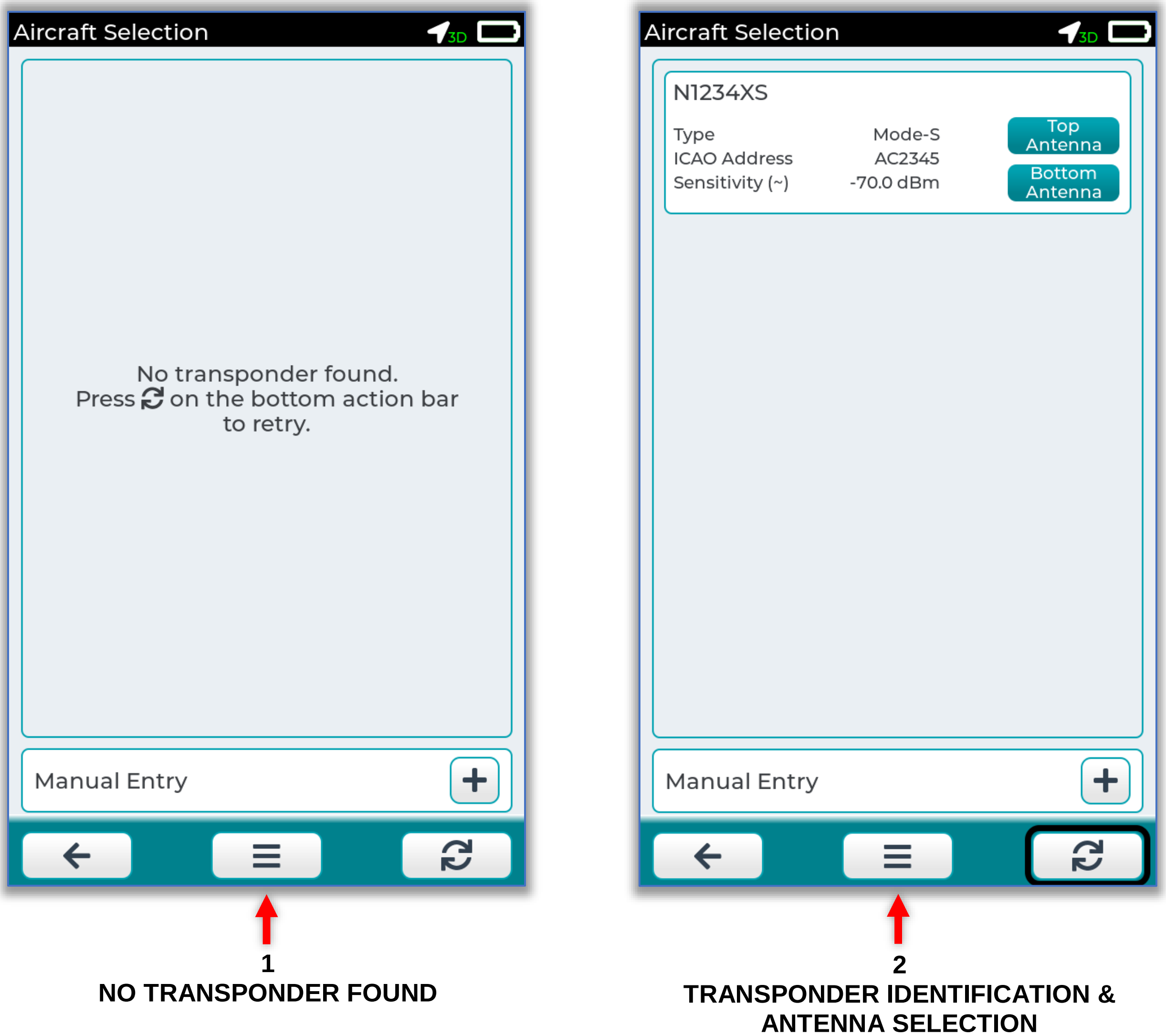
1. Interrogates using the *ATCRBS/Mode S All-Call (long P4)* format, ensuring that all transponders will reply.
2. Beginning at an output power of -94 dBm, interrogation power is increased by 2 dB until a 90% reply rate is detected. This is the coarse UUT receiver sensitivity, known as MTL (minimum trigger level).
3. During this Target ID period, if a Mode S reply is detected, it captures the UUT 24-bit Mode S address and switches to Mode S selective interrogation and requests the UUT's communications capability and Single/Dual antenna status (Diversity).

4. If an ATCRBS reply is detected, the SDR-OMNI switches to ATCRBS interrogations and assumes that the UUT is ATCRBS only.
5. If no reply is detected to the ATCRBS/Mode S All-Call interrogations, the SDR-OMNI stops interrogating and begins listening for DF11 squitters for 6 seconds. The message **Listening for Squitters…** is displayed.
6. If a transponder has still not been detected, the unit displays: **No transponder found. Press ⟳ on the bottom action bar for retry** (Figure 5-5, 1). At this point, the operator needs to troubleshoot the system to determine why the transponder is not replying. Common reasons:
   a. The ATC Transponder cockpit control is OFF or in STANDBY.
   b. The aircraft is in the GROUND mode and the bottom antenna is being interrogated. The bottom antenna of a Mode S transponder will not reply to interrogations when in the GROUND mode. Refer to the Aircraft Maintenance Manual (AMM) to determine how to put the aircraft into the AIR mode.
   c. The wrong antenna is being tested (common on large aircraft with dual diversity transponders). Make sure that all the ATC antennas are properly identified and located.

NOTE

You can have the SDR-OMNI search again for a transponder by selecting the retest icon in the lower-right.

7. Once the Transponder UUT has been identified, the screen will display the identified transponder as shown in Figure 5-5 (2). It will display the Type (ATCRBS or Mode S), the 24-bit ICAO aircraft Mode S address (in hexadecimal), and the coarse UUT receiver sensitivity.
8. If a Mode S diversity transponder with top and bottom antennas was identified, both **Top Antenna** and **Bottom Antenna** buttons will be active. If a single antenna installation was identified, only the **Bottom Antenna** button will be active.
9. Press the button for the desired antenna to be tested. This transponder Target ID process is common to all ATC Transponder tests on the ATC Transponder Test Menu.



2023-CLS-TIC-0031

Figure 5-5. Aircraft Selection

5.1.5 No Transponder Found: Manual Entry of Mode S Address or ATCRBS Interrogation

If no transponder was detected during the Target ID period, the operator may manually enter the Mode S aircraft address (in hexadecimal), if known, of the transponder UUT. This will allow the SDR-OMNI to proceed with testing. Or, ATCRBS can be selected to allow Mode 3/A and 3/C interrogations to begin.

1. Press the **Manual Entry +** at the bottom of the screen (Figure 5-5, 1).

Press **Edit** (Figure 5-6). The **Manual Entry** popup screen (

Figure 5-7. Target Transponder Manual Entry – ATCRBS Options (left)

2. Figure 5-8) will appear.

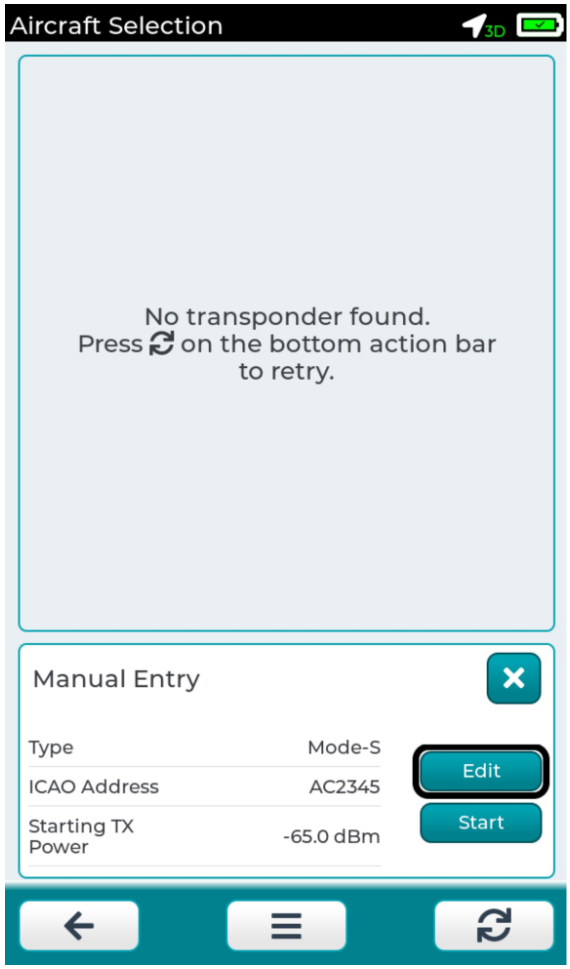


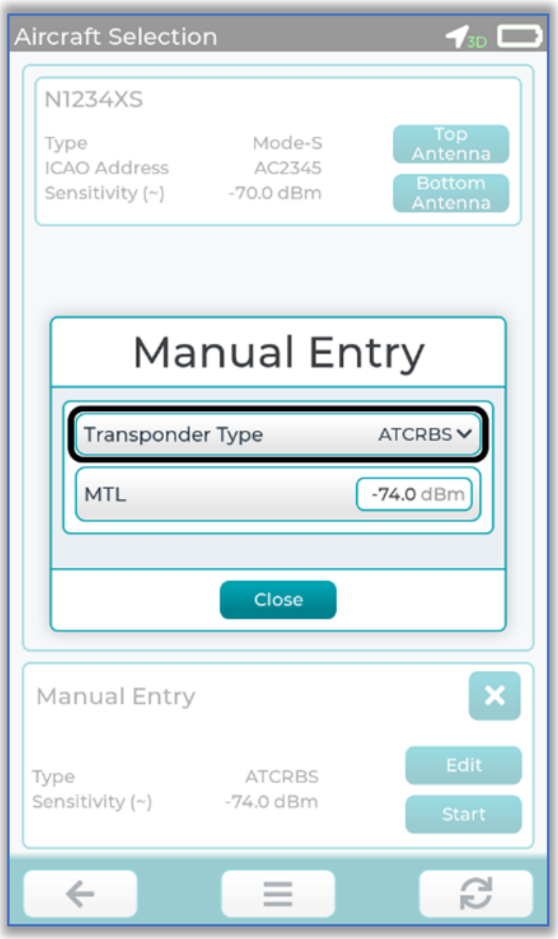
Figure 5-6. No Transponder Found Screen

3. If basic ATCRBS interrogations are desired, select **Type: ATCRBS** (Figure 5-7).

If the target UUT Mode S aircraft address is known, select **Type: Mode S** (

Figure 5-7. Target Transponder Manual Entry – ATCRBS Options (left)

4. Figure 5-8) and enter the **Mode-S Address**. This will be the address to which selective interrogations will be directed during the Mode S portions of the ensuing transponder test.
5. The initial test set interrogation power can be changed by editing **Starting TX Power.** The default of -65 dBm will generally work just fine, but the user has the option to enter a higher or lower initial transmit power.
6. Select **Close**, then select **Start**. The selected transponder test will then begin.



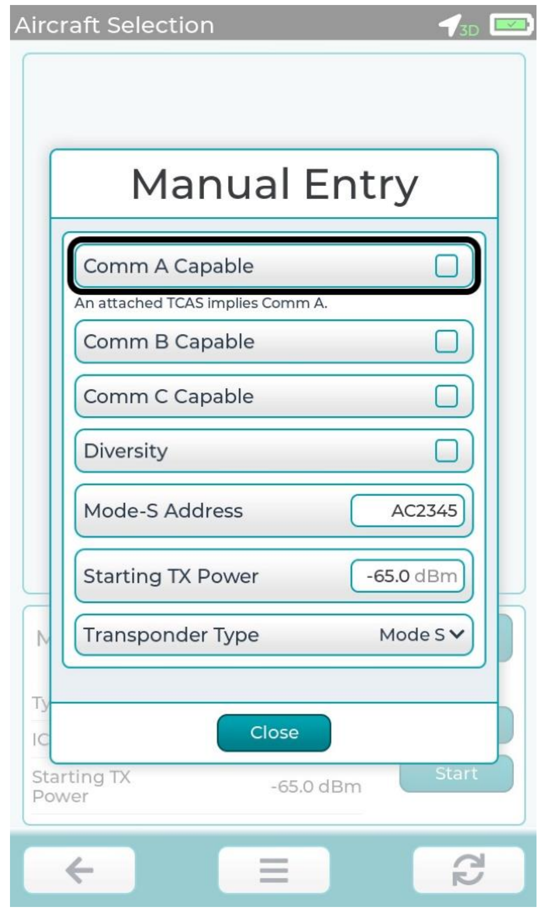


Figure 5-7. Target Transponder Manual Entry – ATCRBS Options (left)

Figure 5-8. Target Transponder Manual Entry – Mode S Options (right)

5.1.6 Testing Dual Antenna Diversity Transponders

When testing a Diversity transponder, note the following:

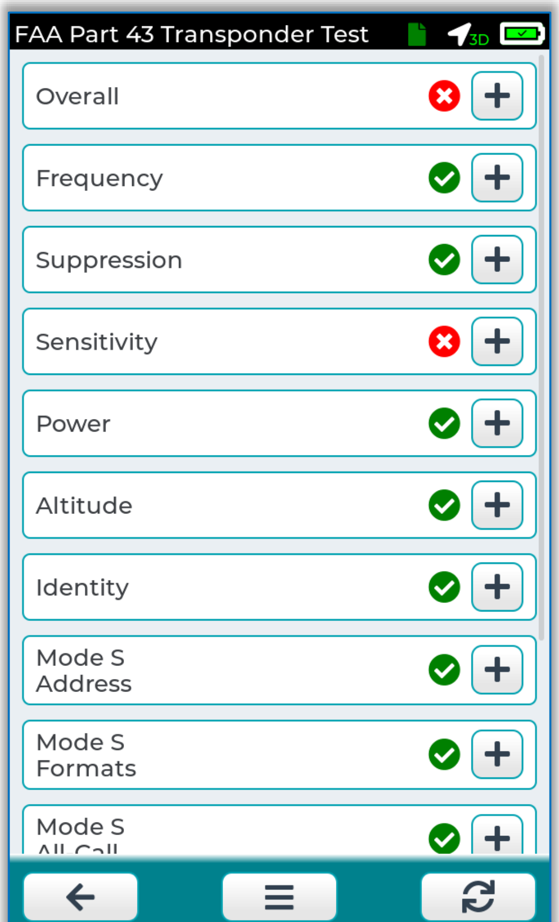
1. FAR Part 43 Appendix F, para. (e) requires at least 20 dB of isolation between the top and bottom antennas. As part of the Part 43 Transponder Test described below, the SDR-OMNI performs this Diversity Test. During this test, it receives, measures, and stores DF11 squitters for a period of 8 seconds. These occur at one second intervals, alternating between top and bottom antennas. It then analyzes the results and determines if there is at least a 20 dB difference in received power between the squitters in the selected antenna time window vs. the squitters in the alternate antenna time window.
2. For this reason, the use of the TAP-OMNI antenna coupler is highly recommended to minimize the possibility of receiving multipath reception of squitters from the non-tested antenna. If testing over-the-air, ensure that that the non-tested antenna is not visible from the test set location – either by locating the test set under (or over) the wing, or under or above the fuselage. Shorter distances, but at least 5 feet, are better.
3. The SDR-OMNI will create a separate test report for each antenna tested. Thus, a complete UUT test will contain a test report for the Top antenna and another report for the Bottom antenna.

5.1.7 Federal Aviation Administration (FAA) Part 43 Transponder Test

This test rapidly and accurately performs the biennial (every 2 years) testing required by the FAA to recertify ATC transponders.

If the aircraft under test has a Diversity transponder with top and bottom antennas, the test should be separately performed on each antenna.

1. Once the **FAA Part 43 Transponder Test** has been selected and the transponder UUT has been identified per Paragraph 5.1.4, the operator should select either the **Top Antenna** or **Bottom Antenna** button. Obviously, if the transponder is ATCRBS only, the SDR-OMNI will not perform Mode S tests.
2. The unit will then begin an automated test lasting approximately 15 seconds for a single antenna transponder and 35 seconds for a Diversity transponder. The test result screen will then display as shown in Figure 5-9. Scroll up to view the entire results.



2023-CLS-TIC-0032

Figure 5-9. FAA Part 43 Test Results

Table 5-1. FAA Part 43 Test Results Description

NAME	DESCRIPTION
Overall	Top level PASS (green check) /FAIL (red X). If any test failed, it will show FAIL.
Frequency	FAR 43 Appendix F para. (a) – Reply frequency error from 1090.000 MHz ATCRBS limit: +/- 3.000 MHz Mode S limit: +/- 1.000 MHz
Suppression	FAR 43 Appendix F para. (b) -- P2 Suppression results - Mode 3/A, Mode C, & Mode S Test limit: P2=P1 <= 1% P2=P1 less 9dB: >= 90%
Sensitivity	FAR 43 Appendix F para. (c) -- Sensitivity results Test limit: ATCRBS: -73 dBm +/- 4; Mode S: -74 dBm +/- 3; Mode 3/A vs. C: < 1 dB
Power	FAR 43 Appendix F para. (d) – RF Peak Output Power results Test limit: ATCRBS: 125 W to 500 W Mode S: 125 W to 500 W
Altitude	FAR 43 Appendix F para. (g) -- Displays reported pressure altitude; ATCRBS vs. Mode S Mode C, Mode S UF4, and Mode S UF20
Identity	FAR 43 Appendix F para. (g) – Displays reported Identity (Squawk code); ATCRBS vs Mode S Mode 3/A, Mode S UF5, and Mode S UF21
Mode S Address	FAR 43 Appendix F para. (f) – Response to valid and invalid Mode S addresses Valid address reply%. Invalid addresses reply% (limit: must = 0%)
Mode S Formats	FAR 43 Appendix F para. (g) – Verifies UF formats & DF replies for which equipped Displays UF formats for which equipped and if valid replies are received
Mode S All-Call	FAR 43 Appendix F para. (h) – Verifies reply to Mode S All-call and ATCRBS/Mode S All-call (long P4)
ATCRBS-Only All-Call Suppress	FAR 43 Appendix F para. (i) – Verifies NO reply to ATCRBS All-Call (short P4) Reply % limit = 0%
Squitter	FAR 43 Appendix F para. (j) – Verify proper squitter at ~ 1 / second DF11:Mode S address squitter
Antenna Diversity	FAR 43 Appendix F para. (e) – Verify >= 20dB isolation between top and bottom antennas Antenna Diversity Isolation: limit >= 20 dB
Back Button	Return to Target ID result (Top / Bottom Antenna)
Menu Button	Displays popup menu: Return Home, Global Settings, and Transponder Setup
Retest Button	Rerun the test.

NOTE: Tests highlighted in yellow above only apply to Mode S transponders. They will not be run on ATCRBS transponders.

3. If all tests passed, all the result icons on the right side of the screen will be green checks.

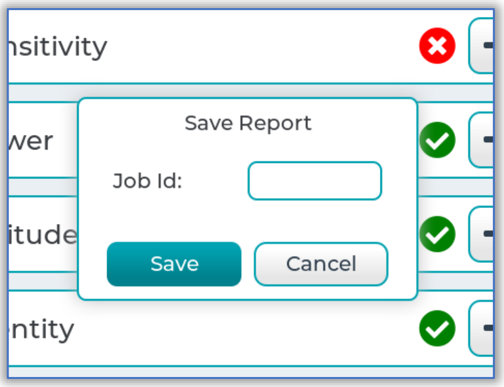
4. If any test failed, the Overall result will show a FAIL red X. In addition, the specific test will show a red X as well. The operator can expand the results by pressing the **+** icon to see the specific test failure. Pressing the Overall **+** expand icon will expand the entire test page and show all test results.
5. The entire test sequence can be rerun by pressing the Rerun button on the lower right corner of the screen. If a failure occurs, troubleshoot the problem and rerun the test until a complete PASS result is obtained.

5.1.8 FAA Part 43 Test Report

Once the operator is satisfied with the test results, he or she can store the result in a printable PDF test report.

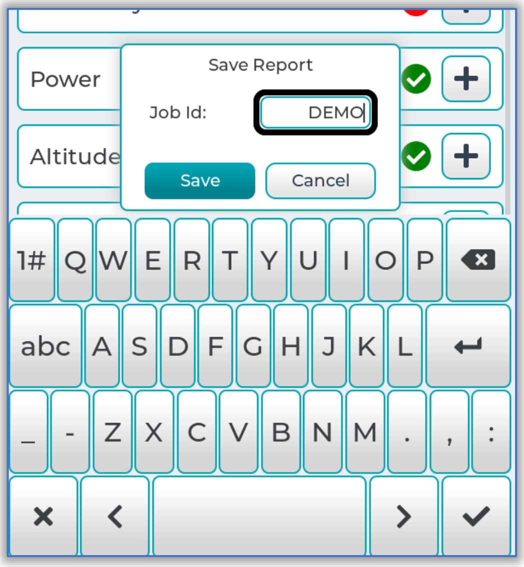
To save a Test Report:

1. Press the **Home** button (Figure 4-1) in the bottom center of the screen. A popup menu will display.
2. Press **Save Report**. Then enter a Job ID (Figure 5-10). When the Job ID field is touched, a popup keyboard appears (Figure 5-11). The operator can then enter a job ID, which could be a work order number, or the tail number of the aircraft. Then press **Save**. The SDR-OMNI will save the test report with the Job ID and a time and date stamp.



2023-CLS-TIC-0033

Figure 5-10 Enter Job ID Popup



2023-CLS-TIC-0034

Figure 5-11. Job ID Entry Keyboard

3. To access and print the Test Report (Figure 5-12), refer to Paragraph 4.6

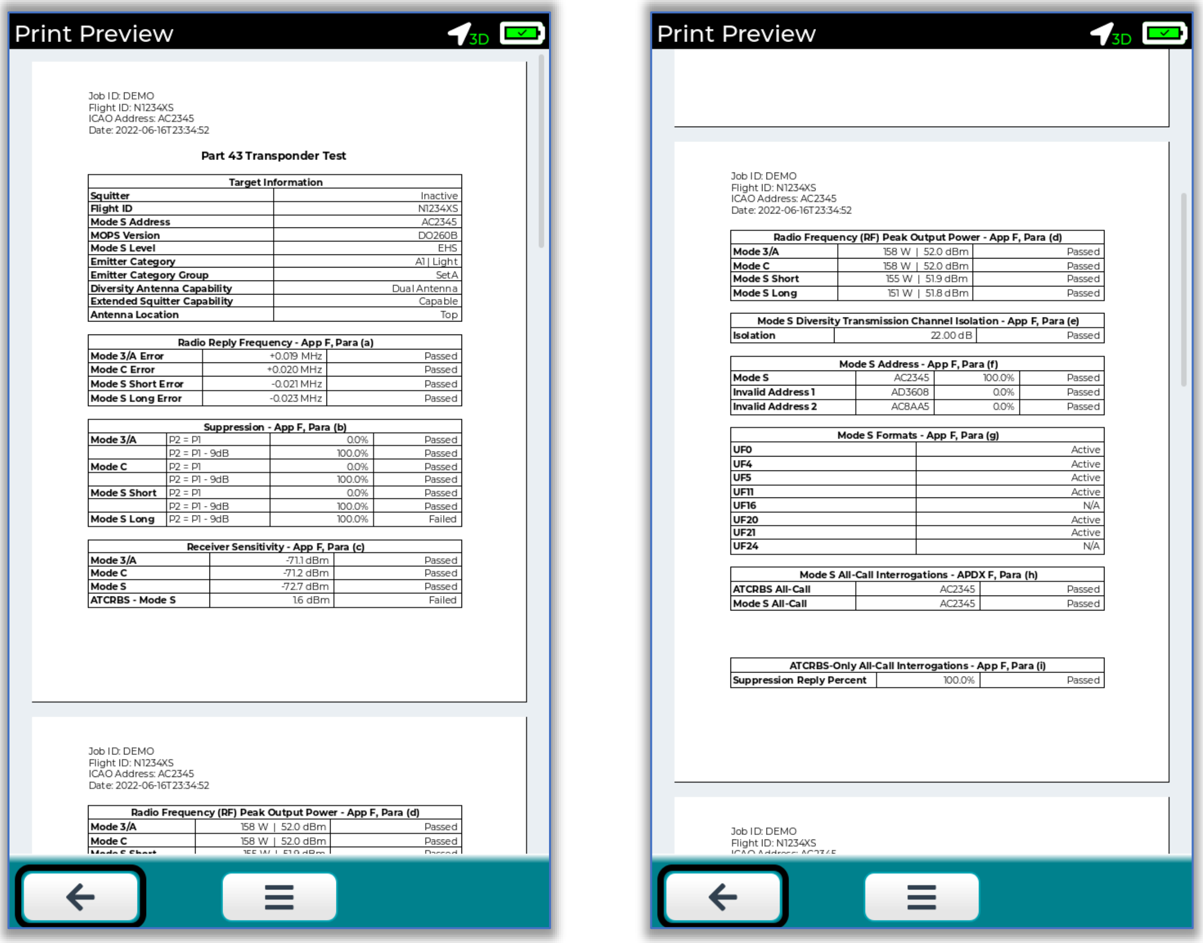


Figure 5-12. Part 43-F Test Report Example 2023-CLS-TIC-0035

5.1.9 BDS Registers – An Explanation

Mode S Transponders store various parameters in an array of 256 data registers, known as BDS (Binary Data Store) code registers. Each register holds 56 data bits. These registers are standardized, and their contents are defined in RTCA Standard DO-181x. Each register is identified by a two-character hexadecimal number, e.g. BDS 5,0 or BDS A, C.

Not all transponders make use of all the defined BDS registers.

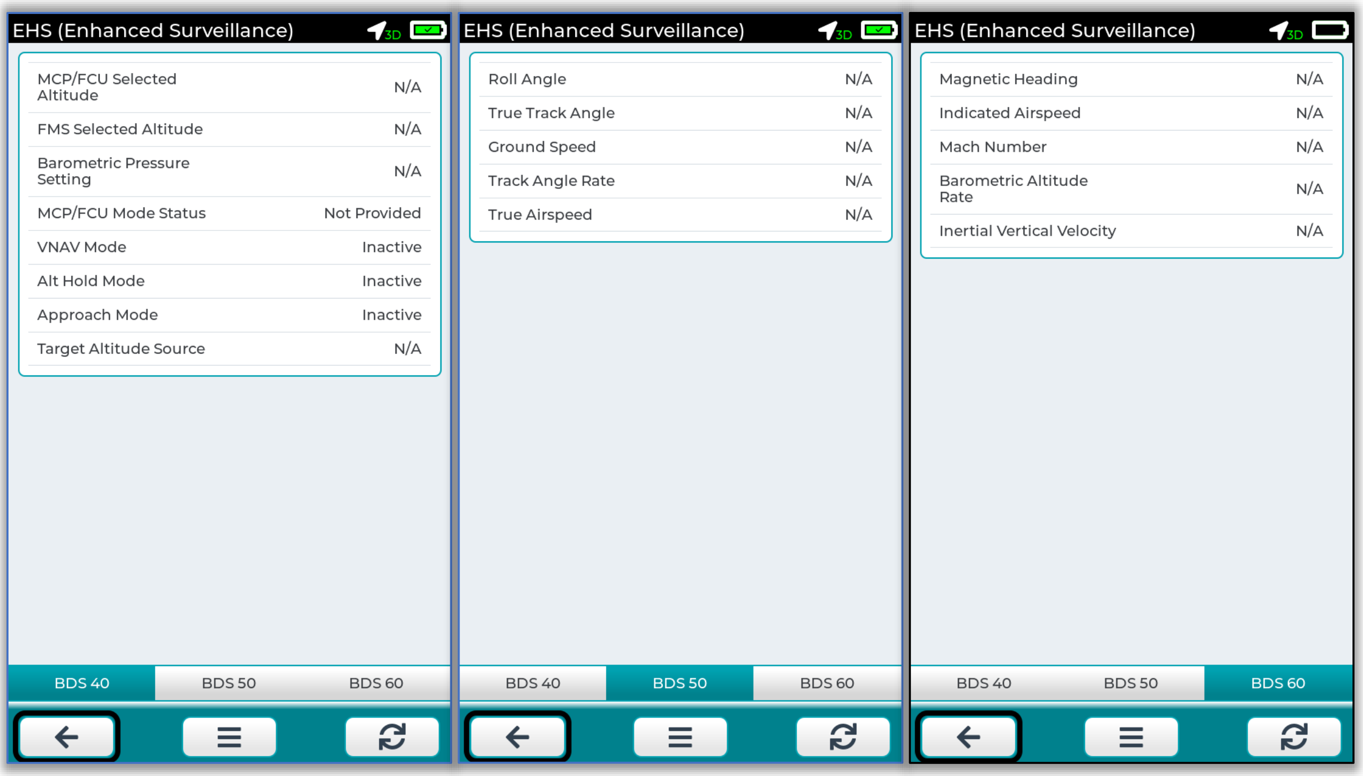
BDS registers can contain data from external systems that are connected to the transponder, such as a GPS receiver, Air Data Computer, Flight Management System, Inertial Reference System, etc.

ATC facilities can interrogate aircraft in flight to request certain flight data parameters that are not normally transmitted in ADS-B OUT squitters, e.g. autopilot modes, flight attitudes, and air data information. This is done via a GICB (Ground Initiated Comm-B) interrogation, which specifies the BDS register number of the data being requested. The SDR-OMNI has the capability to issue a GICB interrogation to any one of the 256 BDS registers.

5.1.10 Enhanced Surveillance (EHS) Tests

The Enhanced Surveillance test interrogates the Mode S transponder under test to obtain flight data from the autopilot, air data system, and inertial navigation system. This data is stored in the transponder in BDS registers 4,0; 5,0; and 6,0. EHS testing is required for some, but not all, aircraft installations. Refer to the appropriate Aircraft Maintenance Manual (AMM).

The screens shown below (Figure 5-13) depict the flight data that is extracted from EHS capable Mode S transponders.



2023-CLS-TIC-0036

Figure 5-13. EHS Data Screens – BDS 4,0; 5,0; 6,0

5.1.11 Ground Initiated Comm-B (GICB)

Any of the 256 BDS registers can be interrogated with the SDR-OMNI (refer to Figure 5-14). Simply enter the 2-digit hexadecimal BDS register number desired. Once the empty BDS Register edit field is pressed, a hexadecimal keyboard will appear.

Enter the 2-digit hex number (do not enter the comma) and press the Enter (checkmark) icon.

The test set will interrogate the Mode S transponder and return the raw digital data (56 bits of 1s and 0s). If the BDS register has defined fields, the unit will display the decoded data in engineering units – see EHS screens above in Figure 5-13 for examples.

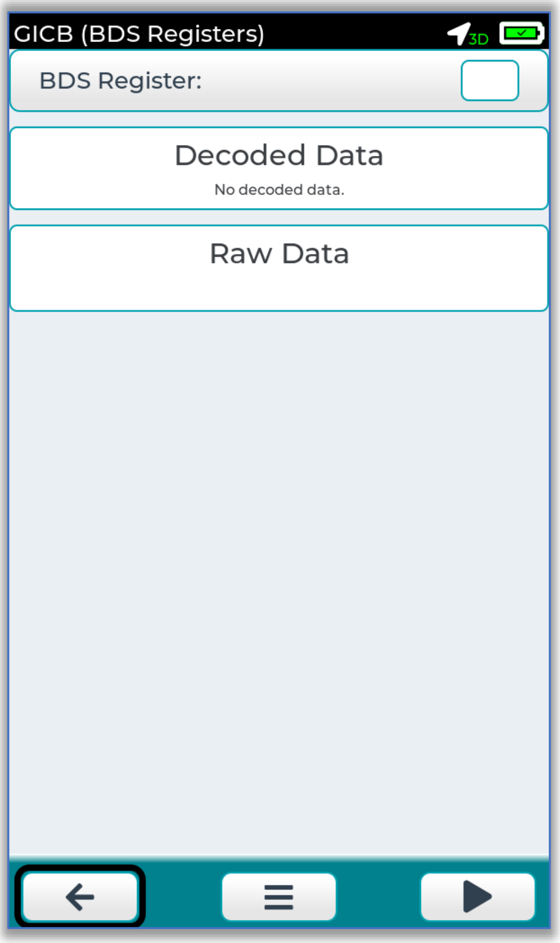


Figure 5-14. GICB - BDS Register Entry Screen 2023-CLS-TIC-0037

5.1.12 Altitude / Ident / Emergency Tests

This test screen is recommended for basic test and troubleshooting purposes. It continuously interrogates Altitude and Identify (Squawk Code) in either Modes 3A and C and/or Mode S (UF 4 and/or UF5).

Use this test screen also to verify transmitted pressure altitude when doing air data system / altimeter tests while the aircraft is “pumped up” to a selected test altitude.

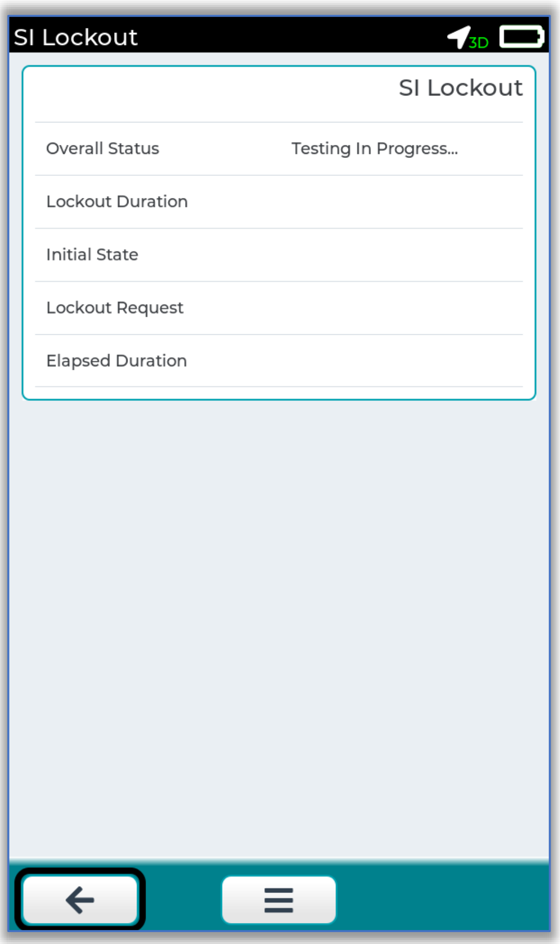
1. **Ident Test**: Press the IDENT button on the aircraft transponder control panel. The **Ident** indicator on the SDR-OMNI screen should illuminate in green and the **Elapsed Time** counter will begin counting the length of time that the IDENT pulse is being replied to Mode 3A/C interrogations. It should be approximately 17 seconds.
2. **Emergency**: When any of the Emergency squawk codes are transmitted from the UUT (7500, 7600, or 7700), the **Emergency status** indicator will highlight and indicate the nature of the emergency. CAUTION: Do NOT select an Emergency squawk code if testing over-the-air!!!

5.1.13 SI Lockout

The SI Lockout Test (Figure 5-15) performs a Selective Interrogation Lockout test, which is a common Mode S transponder test sometimes required by certain AMMs. This tests the requirement that a Mode S transponder “lock out” (i.e. not reply to) Mode S-only All-Call interrogations once it has been issued a multisite interrogator lockout command. This lockout condition should persist for 18 +/- 1 seconds after the last acceptance of an interrogation containing the multisite lockout command.

This is an automated test that requires no additional user input. During this test, the SDR-OMNI:

1. Sends a Mode-S All-Call (UF11) and confirms that the transponder responds.
2. Sends a UF5 with the lockout command and the interrogator code set to a different value and confirms that the transponder responds.
3. Every second for the next 15 seconds, sends a Mode-S All-Call and notes if and when the transponder responds.
4. Every 100ms for the next 3 seconds, sends a Mode-S All-Call and notes if and when the transponder responds.
5. If the transponder responds before 17 seconds or after 19 seconds - FAIL. If it responds between 17 and 19 seconds - PASS.



2023-CLS-TIC-0038

Figure 5-15. SI Lockout screen

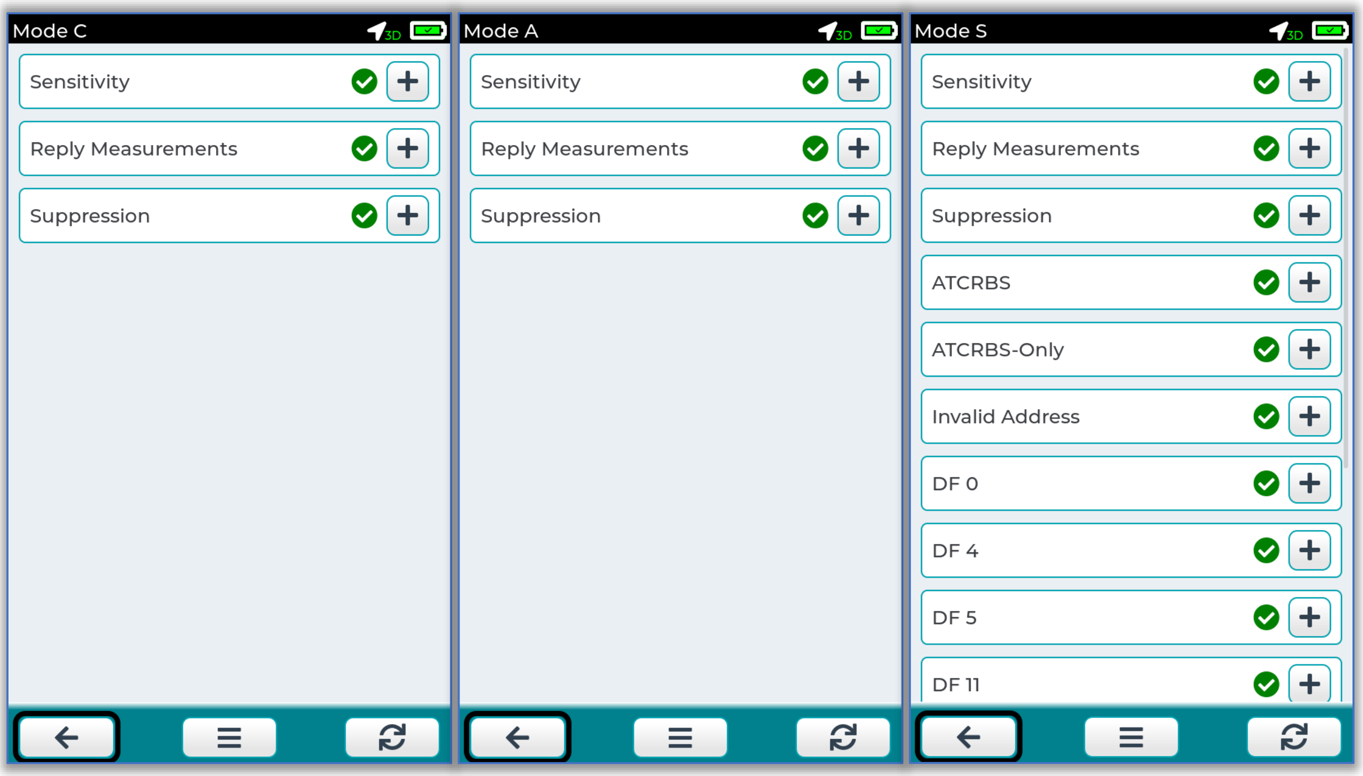
5.1.14 Manual Tests

The Manual Test selection on the ATC Transponder test menu allows the operator to run a suite of tests specific to Mode 3/A or Mode 3/C or Mode S. The test suite includes most of the required Part 43-F tests, as well as additional parametric **Reply Measurements** on the reply pulses, including:

- Reply Delay
- Jitter
- Pulse Widths
- Pulse Positions
- Rise & Fall Times

Refer to Figure 5-16 below for screen shots. Pressing the **Expand (+)** key after each test set will allow the operator to see the detailed results of that test suite.

Pressing the Retest button in the lower right corner will rerun the test suite.



2023-CLS-TIC-0039

Figure 5-16. Mode C, Mode A, and Mode S Manual Test Result Screens

5.2 TESTING 1090 MHZ ADS-B OUT

Testing ADS-B OUT systems requires some knowledge of ADS-B operation. There are two types of ADS-B OUT systems: 1090 MHz Mode S ADS-B, which transmits (squitters) several DF17 BDS registers, and 978 MHz UAT ADS-B, which transmits various Message Elements and is independent of the ATC SSR (secondary surveillance radar) system.

There are numerous on-line tutorial resources that explain in detail how ADS-B systems work and what information they transmit. A simple search of 'ADS-B Tutorial' will yield several good results. Using the SDR-OMNI to test ADS-B systems assumes that the operator has a fundamental understanding of ADS-B systems.

NOTE

To test ADS-B systems, the SDR-OMNI must have a valid local latitude and longitude stored. Refer to paragraph 4.4.5 for an explanation of how to use the internal GPS receiver to capture and store the local position.

5.2.1 GROUND vs. AIR Mode

NOTE

It is important to understand the difference between the GROUND mode and the AIR mode when testing ADS-B OUT systems. Refer to the appropriate AMM or ADS-B installation manual procedure to switch between the two modes.

ADS-B OUT systems transmit different data when on the ground vs. when in the air. A complete test of ADS-B OUT requires that data be captured in both modes. The Mode S transponder typically uses the WOW (weight-on-wheels) signal from the landing gear to switch between modes. When in a hangar or on the ramp, it is typically necessary to override or defeat this signal (or raise the aircraft) in order to switch the transponder to the AIR mode. Refer to the AMM for the proper procedure for the aircraft under test.

For fixed gear aircraft, the switchover usually happens based on GPS groundspeed. Since this is difficult to simulate on a static aircraft, most general aviation Mode S ADS-B systems have a Test Mode that an avionics technician can access to switch to AIR mode. Refer the the ADS-B system installation manual for the proper procedure.

Note that when testing ADS-B OUT systems, the SDR-OMNI is simply a 1090 MHz receiver. It does not interrogate during this test – it simply receives, decodes, and displays 1090 MHz ADS-B OUT transmissions from the aircraft under test.

5.2.2 Testing 1090 MHz ADS-B OUT with the SDR-OMNI

Start at the **Home Menu ->Air Traffic Control ->ADS-B 1090 MHz**. The **1090 ADS-B Setup** popup will display. The connection and antenna setup is identical to that of testing an ATC Transponder (refer to Paragraphs 5.1.2 and 5.1.3).

Once the Setup parameters have been entered and the popup closed, the SDR-OMNI will begin to listen for DF17 Mode S squitters. If testing over-the-air, make sure the L-Band Directional Antenna is pointed toward the aircraft under test. The unit will display an ID box for each aircraft that it detects, as it is possible that it could receive transmissions from other aircraft. Select **Start** in the ID box for the aircraft under test (see Figure 5-17).

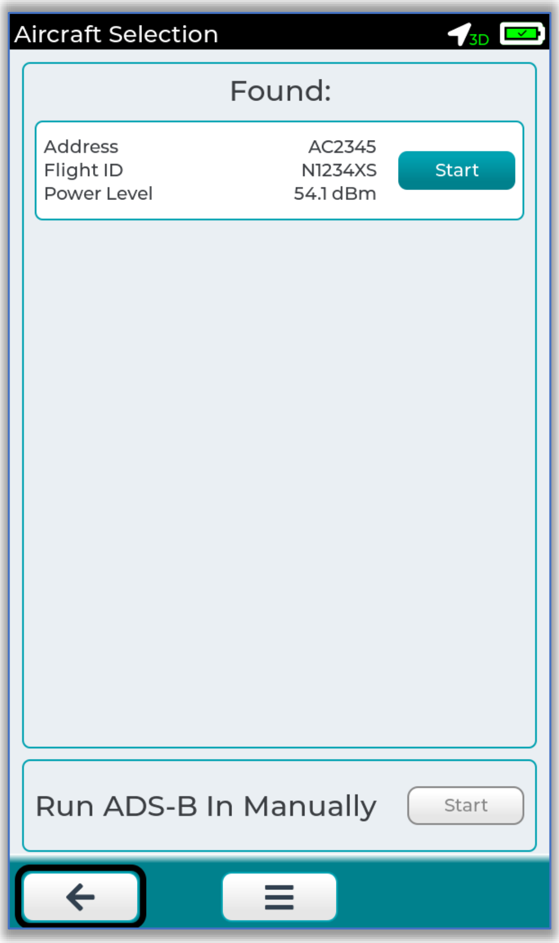


Figure 5-17 ADS-B OUT Target Selection 2023-CLS-TIC-0040

5.2.3 Report Status Explained

The SDR-OMNI will generate a comprehensive report that details the status of the *Minimum Broadcast Message Element Set for ADS-B OUT* required by FAR (Federal Aviation Regulations) 91.227(d) to be transmitted by ADS-B OUT systems. The required data is transmitted in BDS registers 0,5 0,6 0,8 0,9 6,1 and 6,5 (see BDS Register explanation in Paragraph 5.1.9).

This requirement includes:

(1) Data that is transmitted only in GROUND mode (e.g. Aircraft Length/Width)

(2) Data that is transmitted only in AIR mode (e.g. TCAS Operational, RA active), and

(3) Common data that is transmitted in both AIR and GROUND modes.

For this reason, the SDR-OMNI keeps track of the data that it has received and displays the progress at the top of the ADS-B data screen.

Once all the registers have been received – which will require the operator to switch the system from GROUND to AIR mode – all the BDS register indicators will highlight in green (Figure 5-18). This indicates that the SDR-OMNI has all the data necessary to generate a comprehensive report.

The operator can then select the bottom **Home Menu** button and press **Save Report** (see Paragraph 4.6).

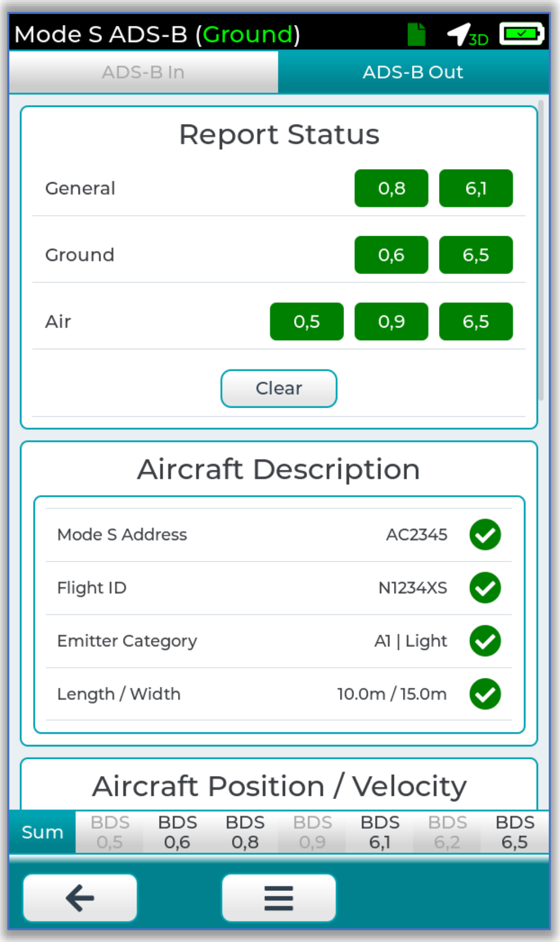


Figure 5-18 FAR 91.227 Report Status – All BDS Registers Received 2023-CLS-TIC-0041

5.2.4 SDR-OMNI ADS-B OUT Real-time Data Display

The SDR-OMNI acts as a real-time ADS-B receiver and data display unit during the ADS-B test. Data is continuously updated as it is received. If the ADS-B OUT system stops transmitting certain data, or all data, the SDR-OMNI affected data fields will eventually time out and display nulls (---).

The ribbon at the bottom of the ADS-B OUT Summary Screen (Figure 5-19) allows the operator to select what is displayed. The specific BDS register display screens will display and decode ALL of the data contained in that BDS register (see Figure 5-20 for examples).

SUM: Summary screen – displays data pertinent to the FAR 91.227 message element requirements

BDS 0,5: Airborne Position – airborne position and altitude, surveillance status (AIR mode only)

BDS 0,6: Surface Position – surface position, ground movement, heading or track (GROUND mode only)

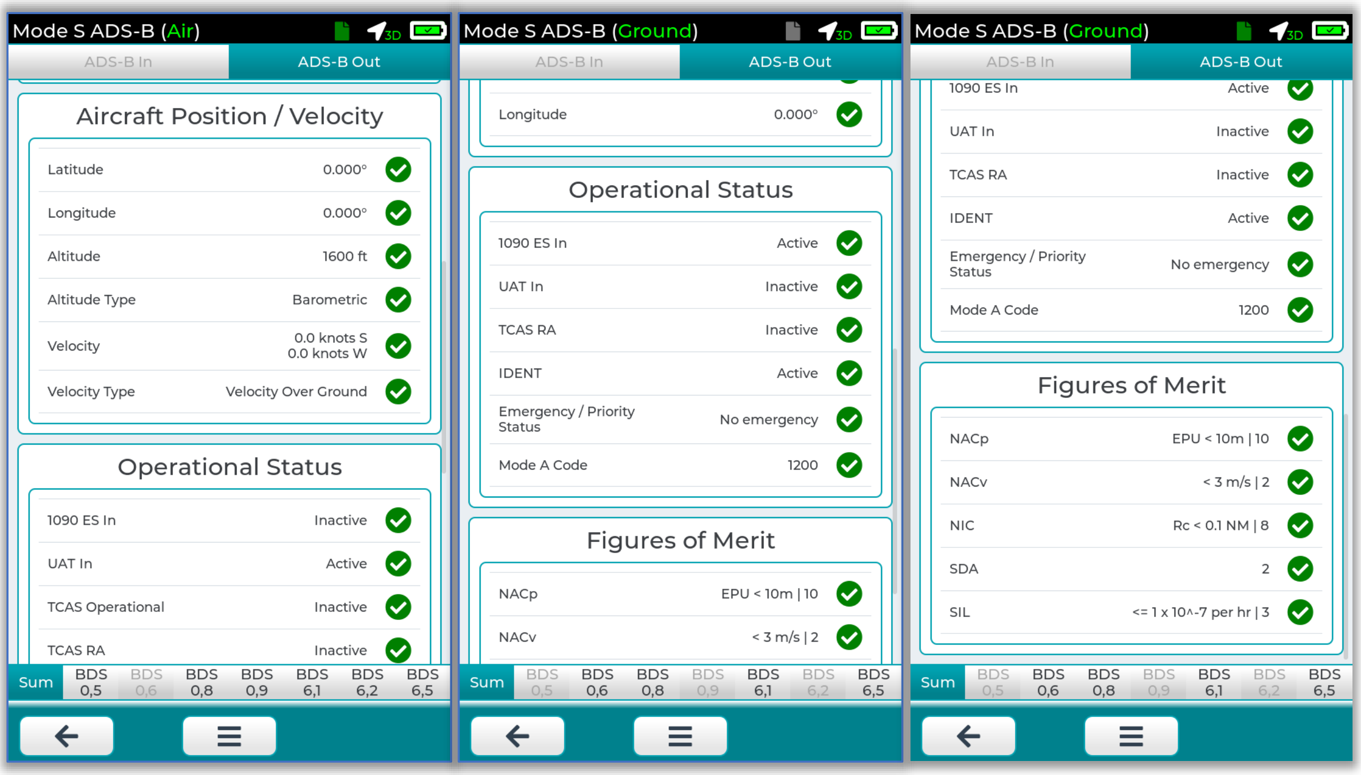
BDS 0,8: Aircraft ID & Category – aircraft ID and emitter category (both modes)

BDS 0,9: Airborne Velocity – aircraft geo (N-S, E-W) or baro (airspeed) velocity, vertical rate, (AIR mode only)

BDS 6,1: Emergency Priority Status – Mode A code, emergency status (both modes)

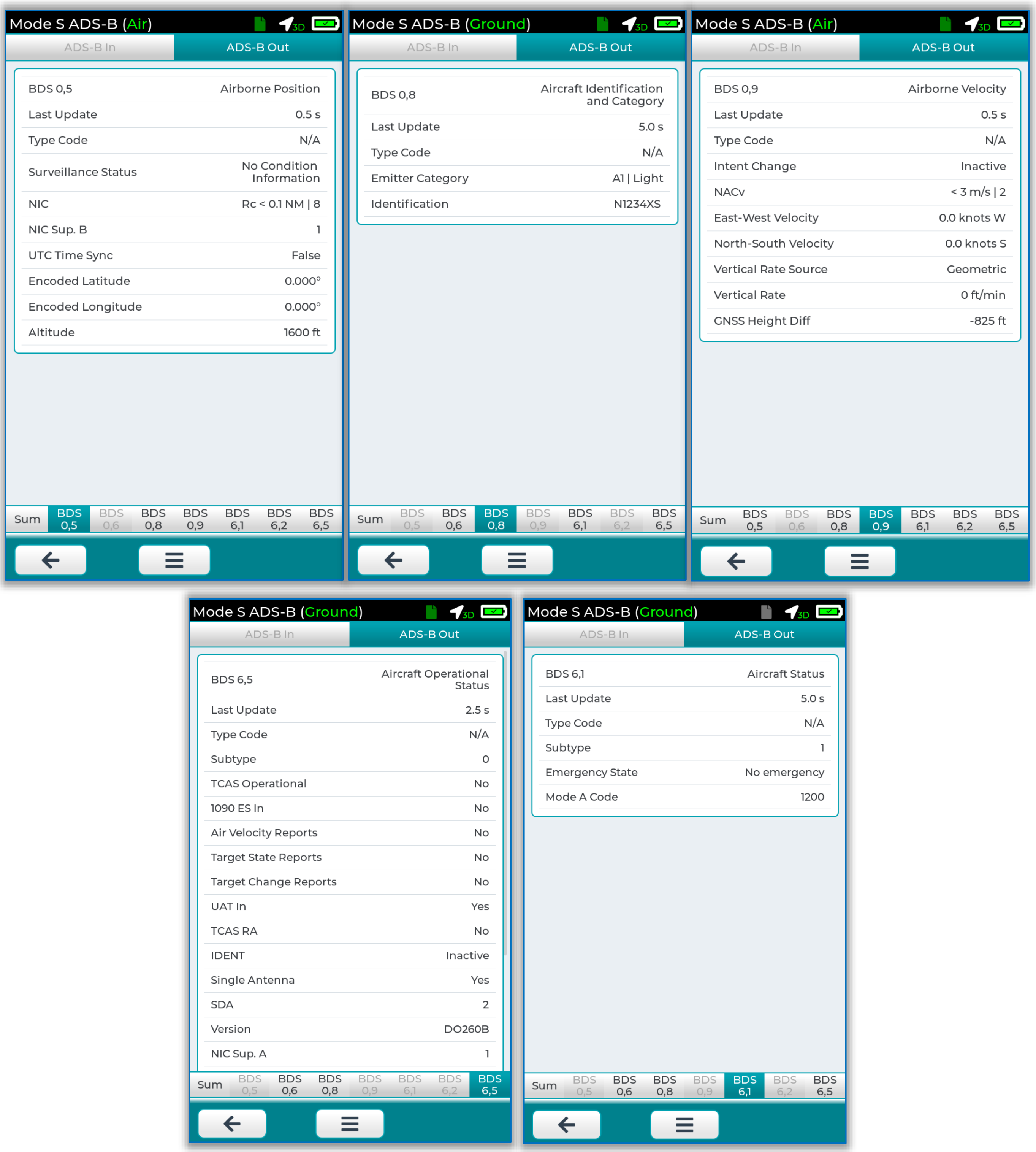
BDS 6,2: Target State & Status – selected flight heading, altitude & baro setting, status bits (AIR mode only)

BDS 6,5: Operational Status – numerous status bits, figures of merit (both modes)



2023-CLS-TIC-0042

Figure 5-19. FAR 91.227 ADS-B OUT Summary Screen (Scrolled)



2023-CLS-TIC-0043

Figure 5-20. BDS 6 Decoded Data Screens

5.3 TESTING 978 MHZ UAT ADS-B OUT

Testing ADS-B OUT systems does require a reasonable familiarity with the theory of operation of ADS-B (Automatic Dependent Surveillance – Broadcast). There are two types of ADS-B OUT systems: 1090 MHz Mode S ADS-B, which transmits (squitters) several DF17 BDS registers, and 978 MHz UAT ADS-B, which transmits various Message Elements (and is independent of the ATC SSR (secondary surveillance radar) system).

There are numerous on-line tutorial resources that explain in detail how ADS-B systems work and what information they transmit. A simple search of 'ADS-B Tutorial' will yield several good results. Using the SDR-OMNI to test ADS-B systems assumes that the operator has a fundamental understanding of ADS-B systems.

5.3.1 GROUND vs. AIR Mode

NOTE

It is important to understand the differences between the GROUND mode and the AIR mode when testing ADS-B OUT systems. Refer to the appropriate AMM or ADS-B installation manual procedure to switch between the two modes.

ADS-B OUT systems transmit different information when on the ground vs. when in the air. A complete test of ADS-B OUT requires that data is captured in both modes. The Mode S transponder typically uses the WOW (weight-on-wheels) signal from the landing gear to switch between modes. When in a hangar or on the ramp, it is typically necessary to override or defeat this signal (or raise the aircraft) in order to make the transponder switch to the AIR mode. Refer to the AMM for the proper procedure for the aircraft under test.

For fixed gear aircraft, the switchover usually happens based on GPS groundspeed. Since this is difficult to simulate on a static aircraft, most general aviation Mode S ADS-B systems have a Test Mode that an avionics technician can access to switch to AIR mode. Refer the ADS-B system installation manual for the proper procedure.

5.3.2 Testing 978 MHz UAT ADS-B OUT with the SDR-OMNI

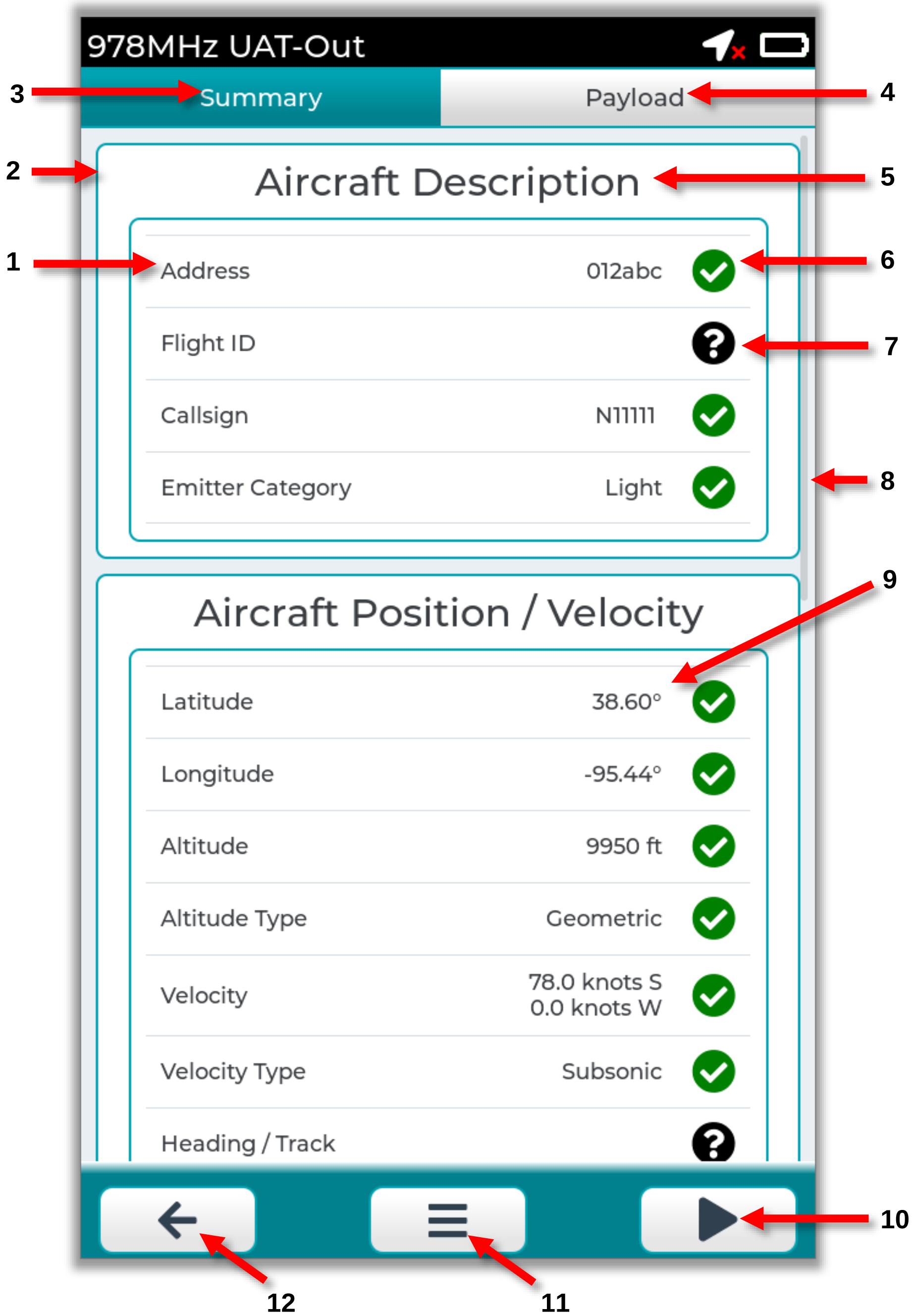
NOTE

To test ADS-B systems, the SDR-OMNI must have a valid local latitude and longitude stored. Refer to Paragraph 4.4.5 for an explanation of how to use the internal GPS receiver to capture and store the local position.

Start at the **Home Menu ->Air Traffic Control ->UAT 978 MHz**, the **UAT Setup** popup will display. The connection and antenna setup is similar to that of testing an ATC Transponder (refer to Paragraphs 5.1.2 and 5.1.3).

Once the Setup parameters have been entered and the popup closed, the SDR-OMNI will begin to listen for 978 MHz Message Element transmissions. If testing over-the-air, ensure the L-Band Directional Antenna is pointed toward the aircraft under test. The unit will display an ID box for each aircraft that it detects, because it could receive transmissions from other aircraft. Select **Start** in the ID box for the aircraft under test.

Figure 5-21 displays an example 978 MHz UAT-Out Summary; Table 5-2 describes the items on this screen. Figure 5-22 displays an example 978 MHz UAT-Out Payload; Table 5-3 describes the items on this screen.



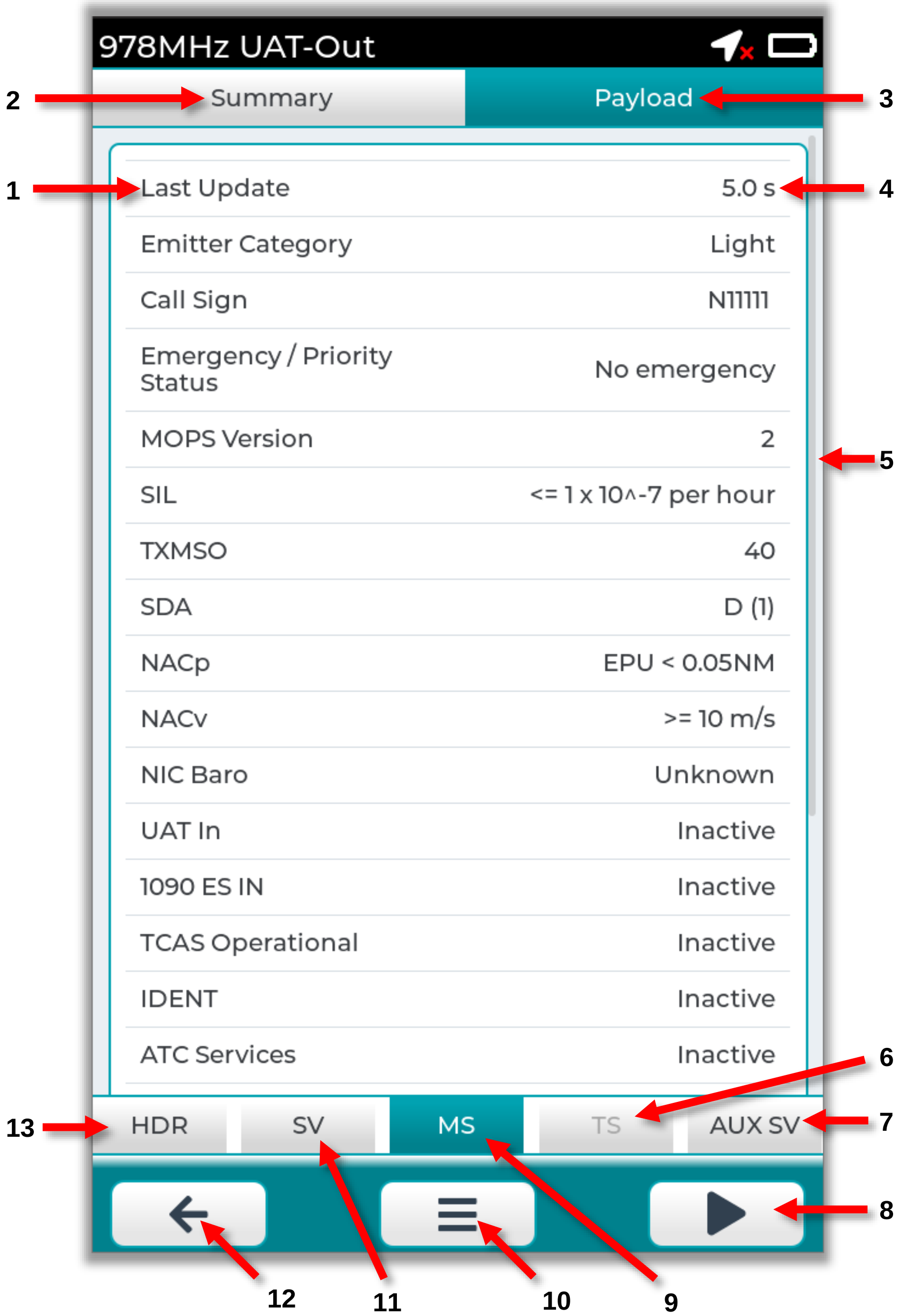
LEGEND
1 TEST NAME
2 TEST CATEGORY
3 SUMMARY
4 PAYLOAD
5 TEST CATEGORY NAME
6 PASS ICON
7 NO INFORMATION ICON
8 SCROLLBAR
9 TEST RESULT VALUE
10 RUN ICON
11 MENU ICON
12 BACK ICON

Figure 5-21. 978 MHz UAT Out Summary

2023-CLS-TIC-0044

Table 5-2. 978 MHZ UAT ADS-B OUT Summary Description

CALLOUT	NAME	DESCRIPTION
1	Test Name	Describes the test performed.
2	Test Category	Test Categories for 978 MHz UAT Out do not expand or collapse.
3	Summary	After **Payload** (4) is selected, this tab will display the Summary test results again.
4	BDS Registers	When selected, displays the Payload.
5	Test Category Name	Describes the test category (2).
6	Pass Icon	Indicates that this test has a PASS state.
7	No Information Icon	Indicates that no information is available for this test.
8	Scrollbar	Indicates current position on the screen.
9	Test Result Value	If a test returns a value, it will display here.
10	Run Icon	When selected, runs the 978 MHz UAT Out test.
11	Menu Icon	
12	Back Icon	When selected, this icon will cause the SDR-OMNI to display the Air Traffic Control menu.



LEGEND
1 RECORD NAME
2 SUMMARY
3 PAYLOAD
4 RECORD VALUE
5 SCROLLBAR
6 TS
7 AUX SV
8 RUN ICON
9 MS
10 MENU ICON
11 SV
12 BACK ICON
13 HDR

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Table 5-3. 978 MHz UAT ADS-B OUT Payload Description

CALLOUT	NAME	DESCRIPTION
1	Record Name	Describes this list of registers
2	Summary	When selected, displays a summary of the 1090 MHz ADS-B Out test
3	Payload	After **Summary** (2) is selected, selecting this tab will display this Payload screen again.
4	Record Value	Displays the value for a register.
5	Scrollbar	Indicates current position on the screen.
6	TS (Target State)	When select, displays the TS element data. If text is gray, TS element is not available. When background is dark and text is white, the TS element is currently displayed.
7	AUX SV (Auxiliary State Vector)	When select, displays the AUX SV element data. If text is gray, AUX SV element is not available. When background is dark and text is white, the AUX SV element is currently displayed.
8	Run Icon	When selected, runs the 978 MHz UAT Out test again.
9	MS (Mode Status)	When select, displays the MS element data. If text is gray, MS element is not available. When background is dark and text is white, the MS element is currently displayed.
10	Menu Icon	Displays the Home/Setting Menu.
11	SV (State Vector)	When select, displays the SV element data. If text is gray, SV element is not available. When background is dark and text is white, the SV element is currently displayed.
12	Back Icon	When selected, this icon will cause the SDR-OMNI to display the Air Traffic Control menu.
13	HDR (Header)	When select, displays the HDR element data. If text is gray, HDR element is not available. When background is dark and text is white, the HDR element is currently displayed.

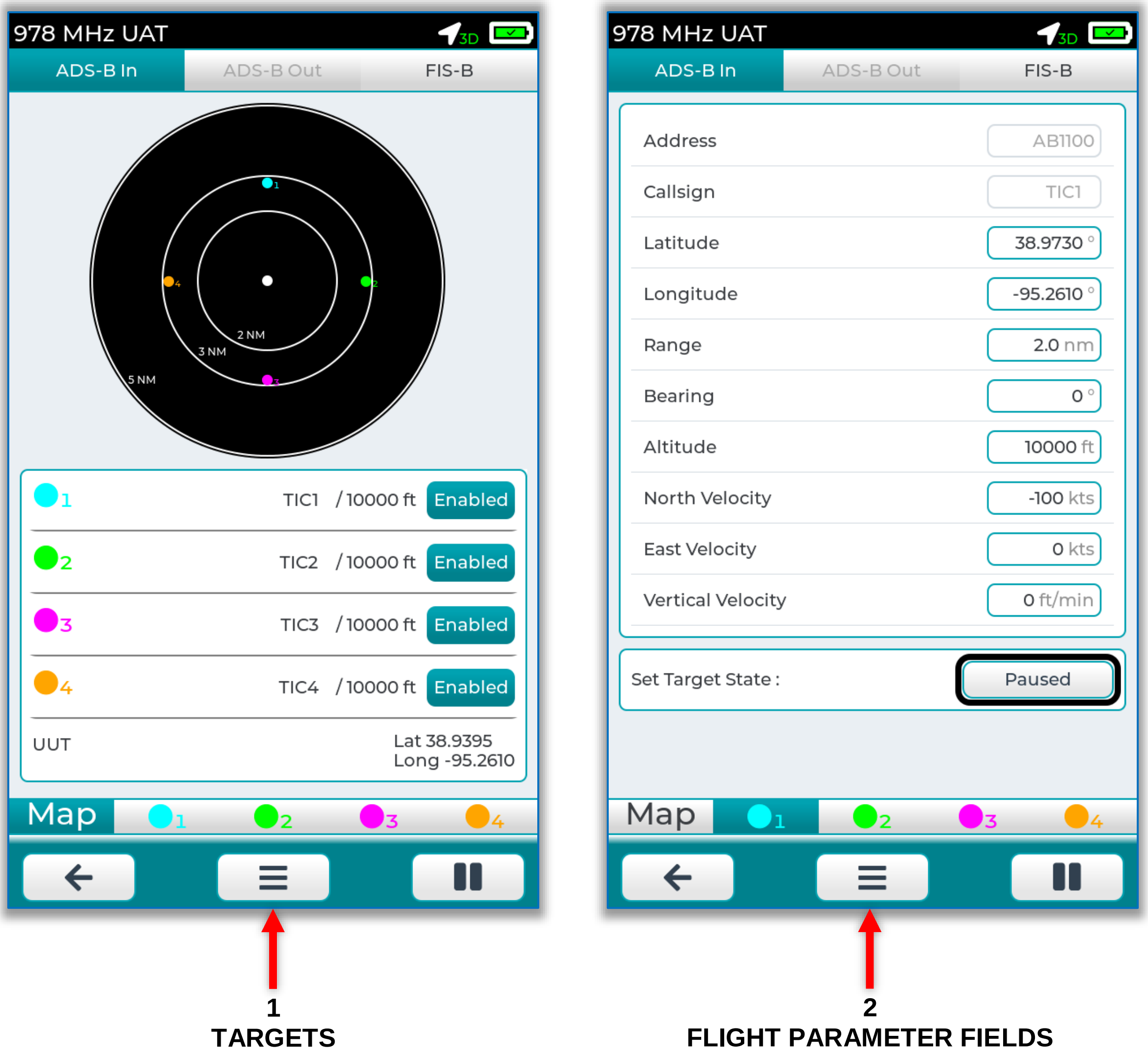
5.4 TESTING 978 MHZ UAT ADS-B IN AND FIS-B

5.4.1 ADS-B IN Traffic Simulation

The SDR-OMNI has the capability to transmit four ADS-B UAT targets to test the ability of UAT ADS-B IN systems to identify and display proximate traffic.

The initial position of the targets is at the four cardinal bearings (0º, 90º, 180º, and 270º) from the aircraft's own position (which is the GPS position saved in the SDR-OMNI), each at a range of 3 nautical miles (nmi) (Figure 5-23, 1).

Each target has independent controls for: Latitude, Longitude, Range, Bearing, Altitude, North Velocity, East Velocity, and Vertical Velocity (2).



2023-CLS-TIC-0046

Figure 5-23. UAT ADS-B IN

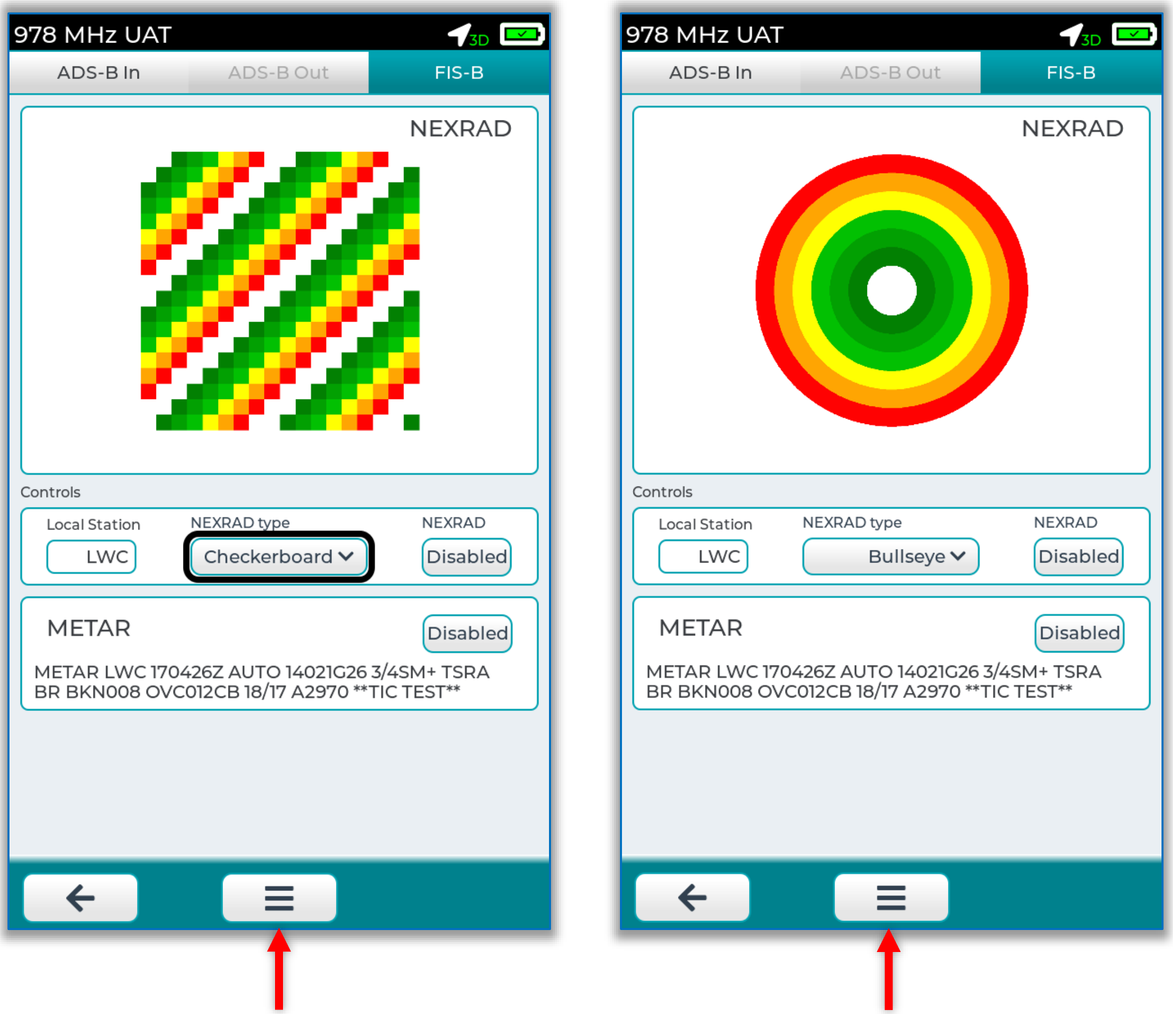
1. From the Home screen, go to **UAT 978 MHz -> UAT Setup.**
2. Select the antenna port (**Antenna A** or **Direct T/R**).
    a. If **Antenna A**, use the L-Band Directional Antenna. Enter the **Antenna Distance to UUT** and point the Directional Antenna toward the aircraft UUT antenna. Press **Close**.
    b. If **Direct T/R**, connect the UAT UUT to the SDR-OMNI T/R port using a supplied cable. Enter the **Cable Length** and **Cable Loss** (marked on the cable). Press **Close**.
    c. **Run UAT-IN Manually** is displayed at the bottom of the screen. Press **Start**.
    d. A map showing four gray, inactive targets (TIC1 through TIC4) will appear. Each target can be made active by pressing the **Disabled** button to the right (which will then display **Enabled**). The target will appear in color and the SDR-OMNI will begin transmitting 978 MHz ADS-B IN messages corresponding to its flight path, and the target will begin moving on the map.
    e. Note the **UUT Position** shown below the four target lines. This is the latitude and longitude that the SDR-OMNI uses as its UUT reference position. It is derived from the GPS position selected in the **Global Settings** (refer to Section 4.4.5).
    f. Verify that the target is acquired and displayed on the aircraft ADS-B IN flight display.
    g. Each target's position and flight path can be individually modified by touching its display line or by pressing its colored/numbered dot on the lower portion of the display. The Flight Parameter data page will display. To edit any of the fields, make sure the target is paused. If the Target State is **Running**, press this button to pause it, then enter new data. Press **Paused** to start the target's transmissions again.

5.4.2 FIS-B Weather Data: Radar Graphics & METAR Transmission

The SDR-OMNI can transmit two different FIS-B NEXRAD radar test patterns (Figure 5-24) to test the UUT's ability to receive and display graphic weather radar data.

It can also transmit a text METAR to test the UUT's ability to receive and display FIS-B text information.

1. From the **ADS-B IN** screen (Figure 5-23), select **FIS-B** in the upper right section.
2. The FIS-B transmissions are initially **Disabled**. Press this button next to either (or both) the NEXRAD and/or METAR controls to **Enable** transmission.
3. The NEXRAD graphic selections are **Bullseye** (Figure 5-24, 2), **Checkerboard** (1), or **Clear.** Clear will transmit null data to clear any previously transmitted NEXRAD image.
4. Make sure that the aircraft UAT display is set up to display FIS-B radar graphics. The NEXRAD graphic image should appear on the aircraft display centered on the UUT position.
5. Note that it may take some time, depending on the UUT, for the entire image to appear on the aircraft display.
6. The **Local Station** edit field allows the operator to enter a four-character text string that identifies the airport code for the METAR. The METAR text cannot be edited.



1
CHECKERBOARD TEST PATTERN

2
BULLSEYE TEST PATTERN

Figure 5-24. NEXRAD Test Patterns

2023-CLS-TIC-0047

5.5 TESTING ACAS/TCAS SYSTEMS

The SDR-OMNI can test 1030 MHz interrogation-based Collision Avoidance Systems by simulating a single intruder aircraft. The intruder can be configured to respond to CAS interrogations as either an ATCRBS target (replying with Mode 3C) or a Mode S target (responding to Mode S All-Call and Selective Interrogations).

To begin testing CAS systems, from the Home Menu, proceed to **Air Traffic Control -> TCAS I & II**. The **TCAS Setup** screen will appear (Figure 5-25 and Table 5-4).

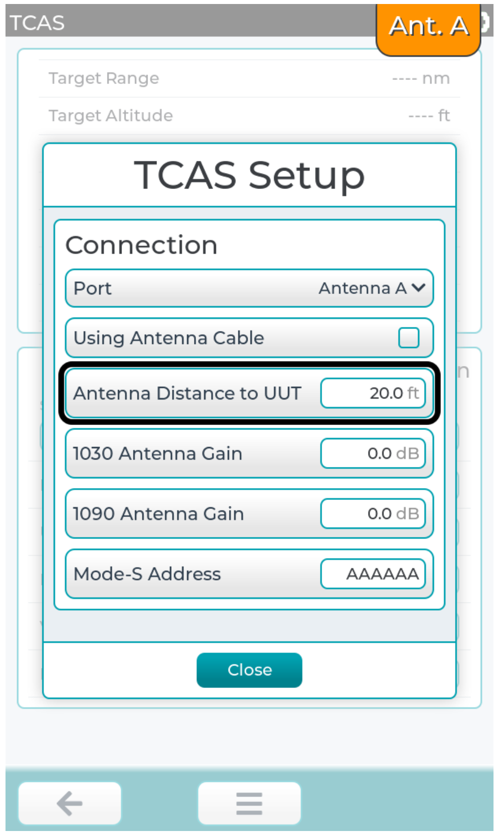


Figure 5-25. TCAS Setup

Table 5-4. TCAS Setup Fields

NAME	DESCRIPTION
Port	Antenna A: This is the only option. Use the L-Band Directional Antenna
Antenna Distance to UUT	Enter the distance from the SDR-OMNI antenna to the UUT TCAS Antenna**. NOTE: Optimal operation occurs between 25 and 75 feet. Operation beyond 100 feet is not recommended**.
1030 Antenna Gain	Enter the 1030 MHz gain that is marked on the sticker on the L-Band Directional Antenna
1090 Antenna Gain	Enter the 1090 MHz gain that is marked on the sticker on the L-Band Directional Antenna
Antenna Cable	If an extension cable is placed between the SDR-OMNI and the L-Band Directional Antenna, enter its loss value (default = 0.0 dB)
Mode S Address	Enter the Mode S address of the simulated intruder. Note – it is usually not necessary to enter a different value than the default address.
Close	Close the Setup Menu and proceed to the TCAS Screen

CAUTION

DO NOT test the TCAS system at a distance closer than 10 feet (3 meters) from the aircraft TCAS antenna under test.

1. Make sure that the aircraft TCAS system is turned on and is configured for TA/RA display. The TCAS system should be tested in accordance with the procedures called out in the aircraft AMM.
2. After completing the **TCAS Setup**, the **TCAS** screen (Figure 5-26) will appear. Make sure that the L-Band Directional Antenna is properly pointed toward the TCAS antenna of the aircraft under test.
3. An optimal position to accomplish the test is at an azimuth angle that allows an unobstructed view of the TCAS antenna (no landing gear, engine nacelles, or ground equipment/structures in the way) and at a distance of 25 to 75 feet (8 to 25 meters). ***Do not test any closer than 10 feet (3 meters).***
4. When the TCAS test screen is selected, the SDR-OMNI will begin listening for 1030 MHz interrogations.
5. The upper portion of the screen contains RF measurements and status data. It will begin displaying received **Power**, **Frequency Error**, and **PRF** if it is receiving valid TCAS interrogations from the UUT.
6. The lower portion of the screen contains the operator controllable parameters.
7. Refer to Table 5-5 for an explanation of each of the TCAS screen fields and controls.
8. Select the desired **Preset Scenario** and intruder **Type** (Mode S or ATCRBS).
9. If the desired scenario is generic (Level, Descend, Climb, or Above), review the **Target Configuration** parameters and edit them as necessary to configure the desired test scenario.
10. Once the scenario has been entered, change the **Direction** to **Toward**. The simulated intruder will begin moving toward the UUT.
11. Confirm that the upper portion of the screen continues to display valid power, range, altitude, PRF, and Tracking Status.
12. Confirm that the cockpit traffic display and audio properly alert the pilot to Traffic Advisories (TAs) and Resolution Advisories (RAs) as required by the AMM test procedure.
13. Press the **Back (<-)** button to end the test.

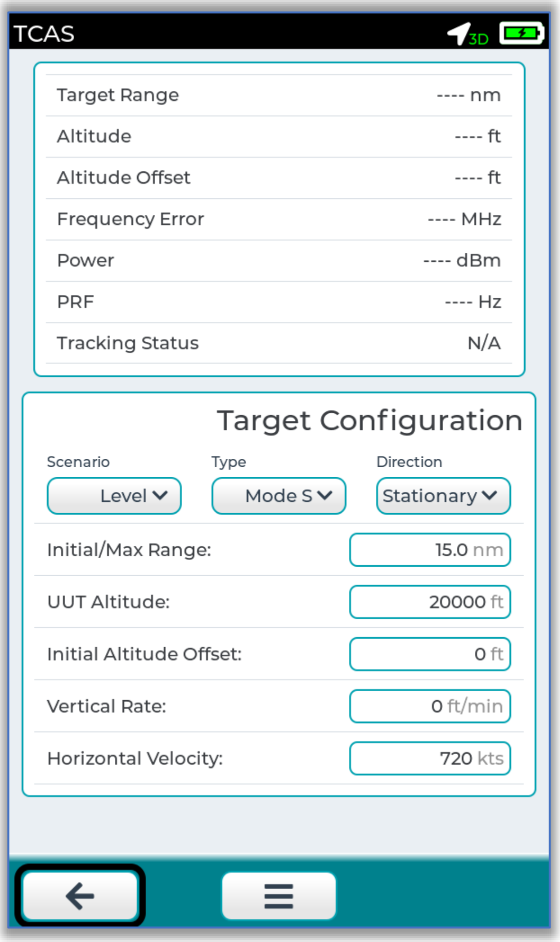


Figure 5-26. TCAS Screen 2023-CLS-TIC-0048

Table 5-5. TCAS Screen Fields and Controls

NAME	DESCRIPTION
Target Range	Displays real-time intruder range from the UUT
Altitude	Displays real-time altitude being reported by intruder
Altitude Offset	Displays real-time difference between intruder altitude and UUT altitude. This will change during Climb or Descend scenarios.
Frequency Error	Measured difference between the UUT interrogation frequency and 1030.000 MHz
Power	Measured power of UUT interrogation (accuracy depends on accurate Antenna Distance to UUT)
PRF	Measured interrogation rate

NAME	DESCRIPTION
Tracking Status	Status of Mode S intruder: **Searching** – Mode S intruder replying to Mode S AllCall; **Tracking –** Mode S intruder replying to Mode S selective interrogations **N/A** – Intruder is ATCRBS, so Tracking/Searching status is not applicable
Load Preset Scenario	Operator may select one of four Built In scenarios (**Above, Climb, Dive, Level)** OR a custom stored scenario. Selection of any of the Built In scenarios will fill the range, altitude, vertical rate, and horizontal velocity fields with default values. The **Climb** and **Dive**, but the operator will be able to freely edit those fields.
Type	Intruder type: Operator may select **ATCRBS** or **Mode S**
Direction	Intruder direction relative to UUT: **Stationary, Toward, or Away** Note: A scenario always begins with the intruder **Stationary**. The operator will generally select **Toward** to begin the test simulation.
Initial/Max Range	Set the initial range of the intruder from the UUT
UUT Altitude	Set to the pressure altitude of the UUT (Either the station pressure altitude or the altitude being simulated by an Air Data Test set if connected)
Initial Altitude Offset	Set the initial altitude difference between the simulated intruder and the UUT altitude. For example, if the UUT Altitude is 1000 ft and the Initial Altitude Offset is set to 2500 ft, the simulated intruder will reply to altitude requests with 3500 ft (1000 + 2500). If set to 0, the intruder will reply at the same altitude as the UUT.
Vertical Rate	Set to the desired Vertical Rate.
Horizontal Velocity	Set to the desired Horizontal Velocity (the closing velocity between the intruder and the UUT)

5.6 TESTING ILS SYSTEMS

The operator must have a working knowledge of Avionics Systems and the UUT requirements. A brief overview of VOR and ILS is included in Appendix C for reference.

The SDR-OMNI can simultaneously simulate LOC, GS, and MB signals. However, each ILS component is separately controlled. **All RF testing of ILS receivers is done via the ANT-B BNC connector on the top of the SDR-OMNI.**

From the Home Menu screen, press **Navigation** to access the Navigation Menu (Figure 5-27).

NOTE

The following tests are not meant to replace the avionics test procedures and criteria required for your equipment. These are general testing procedures to assist the operator in properly operating the SDR-OMNI.

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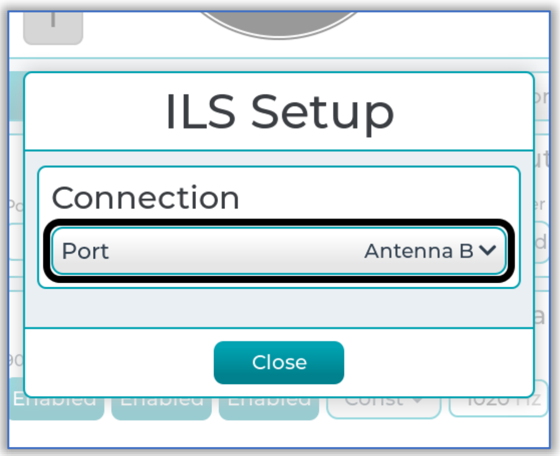
Figure 5-27. Navigation Menu

WARNING

When conducting tests with the aircraft autopilot engaged, any change of navigation signal may cause movement of the associated aircraft control surfaces (elevator, ailerons, rudder). All personnel and ground support equipment must be clear of the control surfaces to prevent death or serious injury.

1. If using the Telescopic Antenna, extend the antenna approximately 3/4 of its total length, to **28.5 inches** (72 cm) (see Paragraph 6.1). **Attach it to the ANT-B connector on the top of the unit**.
2. If directly connecting to an ILS receiver, connect a coaxial cable from the UUT to the ANT-B connector on the top of the unit.
3. From the **Navigation Menu**, select **ILS.** The screen will display the **ILS Setup** popup (Figure 5-28) that reminds the operator that the Antenna B port must be used (there is no other selection). Then select **Close**.



2023-CLS-TIC-0050

Figure 5-28 ILS Setup Popup

4. The **ILS** Test Screen has an upper section that depicts an aircraft ILS indicator, and a lower section with three tabs – one for Localizer, one for Glideslope, and one for Marker Beacon. By selecting one of the three tabs, the RF parameters (output power, frequency, and transmit Enable/Disable) and the modulation parameters can be selected (Figure 5-29 and Table 5-6).

NOTE

The default ILS Test Frequency is 108.10 MHz, with a paired GS frequency of 334.70 MHz.

DO NOT use another frequency unless the UUT has a problem at a specific ILS frequency. Use at other than ILS test frequency 108.10 MHz must be done using direct connection to the ILS receiver or inside an adequately shielded building to prevent harmful interference to aircraft navigation systems (Reference: AC 170-6C).

5. All three ILS RF components are initially turned OFF (Transmitter Disabled). Before turning ON (Enabling) each transmitter, review the Power parameter and set it to the desired value.

> **NOTE**
>
> Output power defaults: Localizer is 0 dBm (1 mW); Glideslope is 0 dBm (1 mW); and Marker +10 dBm (10 mW)

6. Each component (LOC, GS, MB) must be turned on individually by selecting its tab and Enabling the Transmitter.

> **NOTE: Marker Beacon Receiver Testing**
>
> When the SDR-OMNI is being used from the cockpit, on the ramp, or in the hangar with larger aircraft, the transmitted MB signal, even at full power, may be too weak to be received. In this case, move the SDR-OMNI closer to the MB antenna on the underside of the aircraft and repeat the MB test.

7. The ILS indicator display in the upper section of the SDR-OMNI screen simulates what should be seen in the aircraft cockpit. When the transmitters are enabled, the LOC and GS needles will turn yellow. Likewise, the Marker Beacon O, M, and I icons will each highlight when transmitting.

> **NOTE**
>
> The LOC and GS needles can be moved manually by using one’s finger to move them to the desired location. The MB markers can be controlled by touching the O, M, or I icons.
>
> They can also be controlled by selecting the appropriate signal parameters in the lower section of the screen.

8. For further instruction on how to operate the SDR-OMNI for ILS receiver testing, refer to Figure 5-30 and Table 5-7 for Glideslope, and refer to Figure 5-31 and Table 5-8 for Marker Beacon.

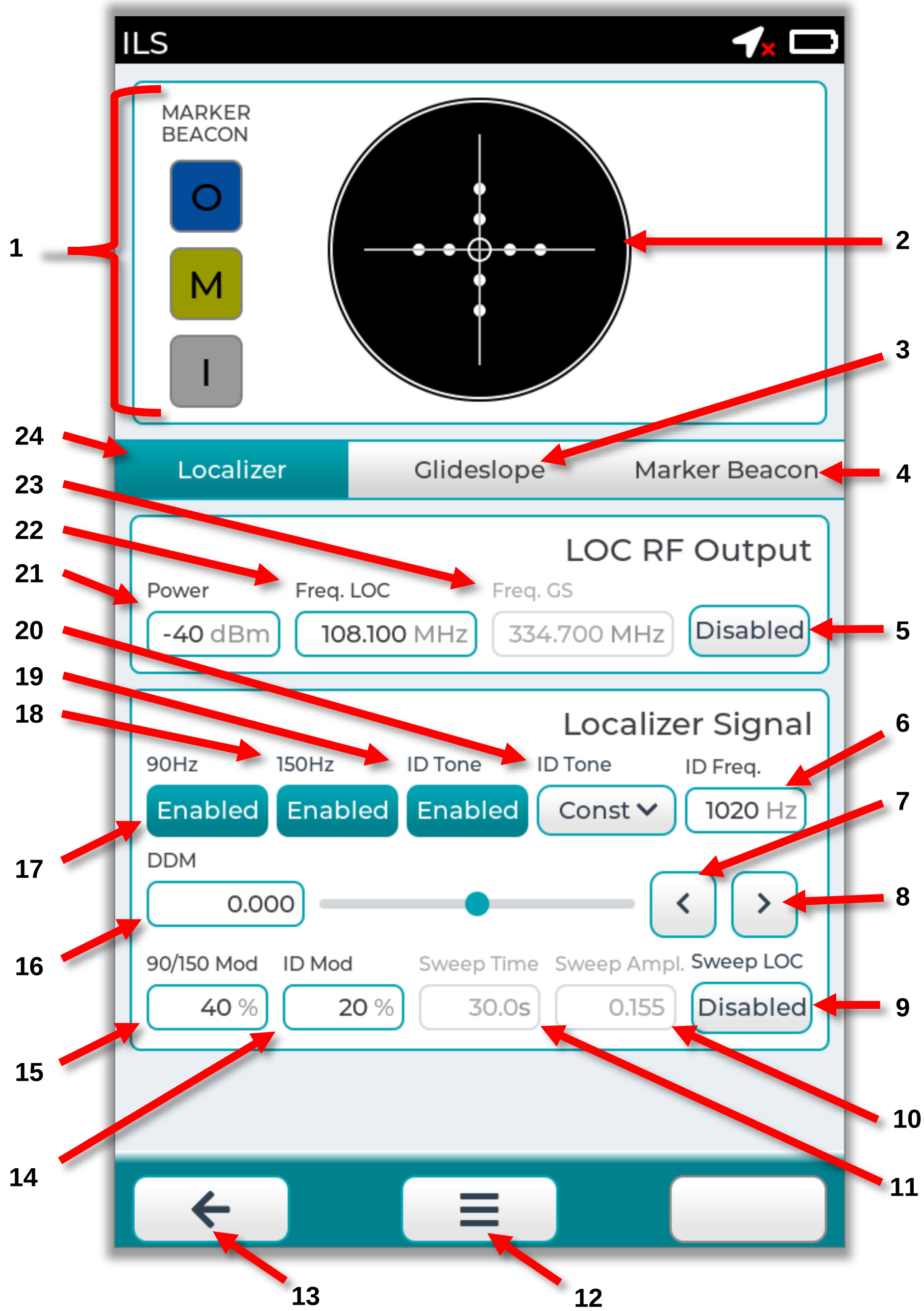


Figure 5-29, ILS Localizer Screen

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Table 5-6. ILS Localizer Screen Field Description

CALLOUT	NAME	DESCRIPTION
1	Marker Beacon Icons	Each icon highlights when the 75 MHz MB transmitter is actively transmitting: Inner Marker [I] 3000 Hz; Middle Marker [M] 1300 Hz; Outer Maker [O] 400 Hz.
2	GS/LOC Indicator	Simulates ILS cockpit indicator. Needles turn yellow when they are active. Movable using one's finger.
3	Glideslope	Glideslope tab: Select to display Glideslope controls.
4	Marker Beacon	Marker Beacon tab: Select to display Marker Beacon controls.
5	LOC RF Transmitter	Turns ON and OFF the LOC RF transmitter. ON=Enabled; OFF=Disabled (default)
6	IDENT Tone Frequency	When selected, operator can enter a frequency (0 – 5000 Hz) for audio Ident tone modulation
7	Prev. Dot	Moves the LOC needle one dot to the left
8	Next Dot	Moves the LOC needle one dot to the right
9	Sweep LOC	For testing Autopilot coupling. When Enabled, this will continuously sweep the LOC signal by + and - Sweep Amplitude over a period of Sweep Time.
10	Sweep Amplitude	Sweep LOC must be Enabled to activate this field. Allows entry of Maximum Amplitude in DDM that the LOC signal will sweep.
11	Sweep Time	Sweep LOC must be Enabled to activate this field. Allows entry of time in seconds required for a complete LOC sweep cycle.
12	Menu Icon	Enables popup menu with 3 selections: (1) Home (stop test and return directly to the Home Menu); (2) Settings (go to Global Settings screen); and (3) ILS Setup (go to ILS Setup screen)
13	Back Icon	Stops test and returns to Navigation Menu
14	IDENT Tone % Modulation	Allows entry of AM modulation percentage of the audio ident tone. Default: 20%. Not normally changed by the operator.
15	90/150 % Modulation	Allows entry of non-standard 90 Hz / 150 Hz modulation %. Not normally changed by the operator.
16	DDM	Displays current LOC DDM (Difference in Depth of Modulation). Selecting this field also allows the operator to manually enter a desired value from -0.399 to 0.399.

CALLOUT	NAME	DESCRIPTION
17	90 Hz	Toggles 90 Hz LOC modulation on and off (Enabled/Disabled). Normally used to check LOC indicator flag operation by disabling.
18	150 Hz	Toggles 150 Hz LOC modulation on and off (Enabled/Disabled). Normally used to check LOC indicator flag operation by disabling.
19	ID Tone	Turns on and off (Enabled/Disabled) audio Ident tone.
20	ID Tone	Selects between Continuous and Morse coded (ITIC) Ident tone
21	Power	Allows operator to enter the LOC RF output power, measured at the ANT-B port. Allowable range: -110 dBm to 0 dBm.
22	Freq. LOC	Allows operator to enter LOC frequency (108.10 to 111.95 MHz, odd tenths of MHz)
23	Freq. GS	Displays the paired Glideslope frequency for reference.
24	Localizer	Localizer tab: Select to display LOC controls

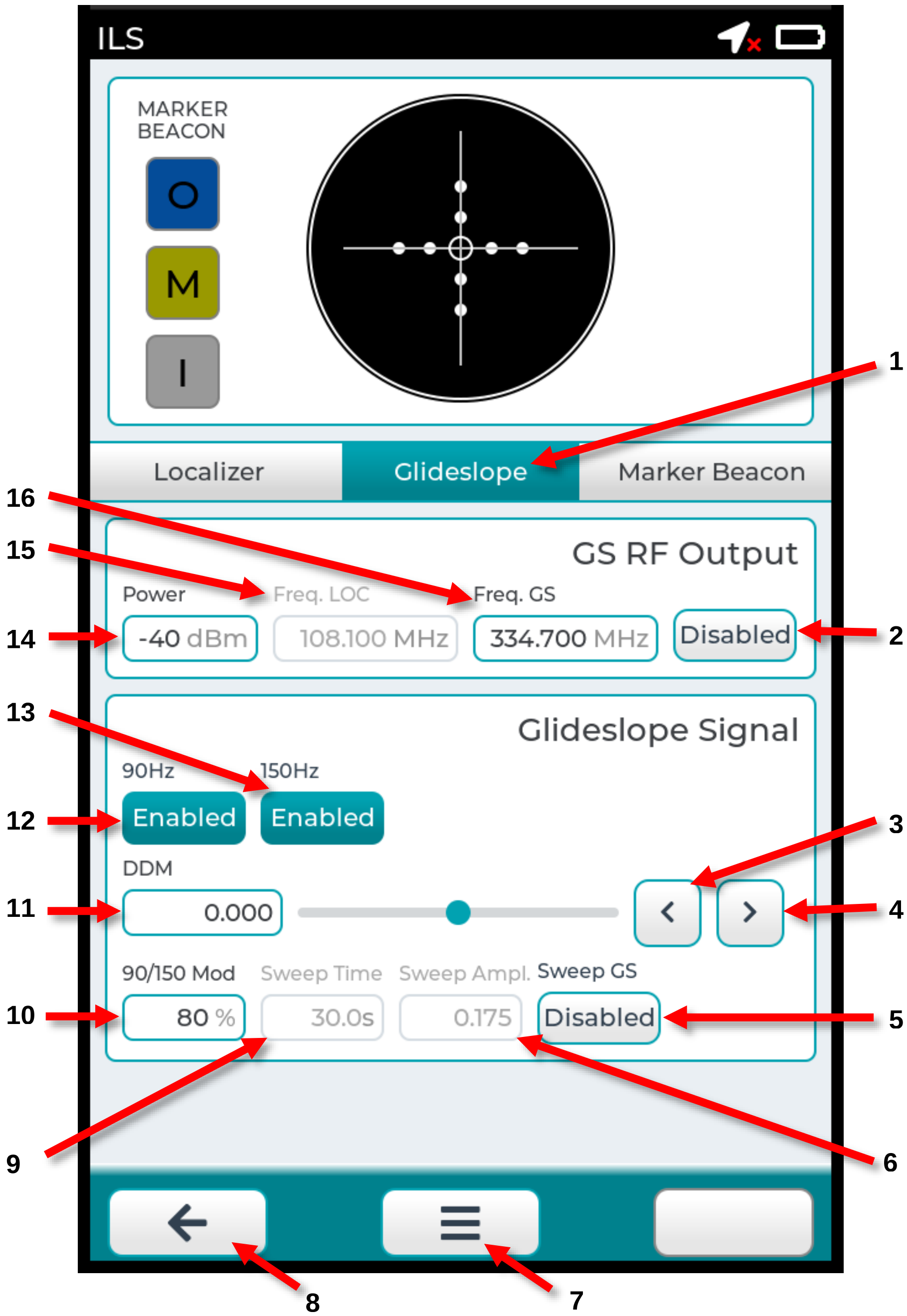

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Table 5-7. Glideslope Description

CALLOUT	NAME	DESCRIPTION
1	Glideslope	Glideslope tab: Displays GS controls when selected
2	GS Transmitter	Turns ON and OFF the GS RF transmitter. ON=Enabled; OFF=Disabled (default)
3	Prev. Dot	Moves the GS needle one dot up
4	Next Dot	Moves the GS needle one dot down
5	Sweep GS	For testing Autopilot coupling. When Enabled, this will continuously sweep the GS signal by + and - Sweep Amplitude over a period of Sweep Time.
6	Sweep Amplitude	Sweep GS must be Enabled to activate this field. Allows entry of Maximum Amplitude in DDM that the GS signal will sweep.
7	Menu Icon	Enables popup menu with 3 selections: (1) Home (stop test and return directly to the Home Menu); (2) Settings (go to Global Settings screen); and (3) ILS Setup (go to ILS Setup screen)
8	Back Icon	Stops test and returns to Navigation Menu
9	Sweep Time	Sweep GS must be Enabled to activate this field. Allows entry of time in seconds required for a complete GS sweep cycle.
10	90/150 Mod	Allows entry of non-standard 90 Hz / 150 Hz modulation %. Not normally changed by the operator. Default = 80%.
11	DDM	Displays current GS DDM (Difference in Depth of Modulation). Selecting this field also allows the operator to manually enter a desired value from -0.799 to 0.799.
12	90 Hz	Toggles 90 Hz GS modulation on and off (Enabled/Disabled). Normally used to check GS indicator flag operation by disabling.
13	150 Hz	Toggles 150 Hz GS modulation on and off (Enabled/Disabled). Normally used to check GS indicator flag operation by disabling.
14	Power	Allows operator to enter the Glideslope RF output power, measured at the ANT-B port. Allowable range: -110 dBm to 0 dBm.
15	Frequency LOC	Displays the paired LOC frequency for reference.
16	Frequency GS	Allows the operator to directly enter the Glideslope frequency

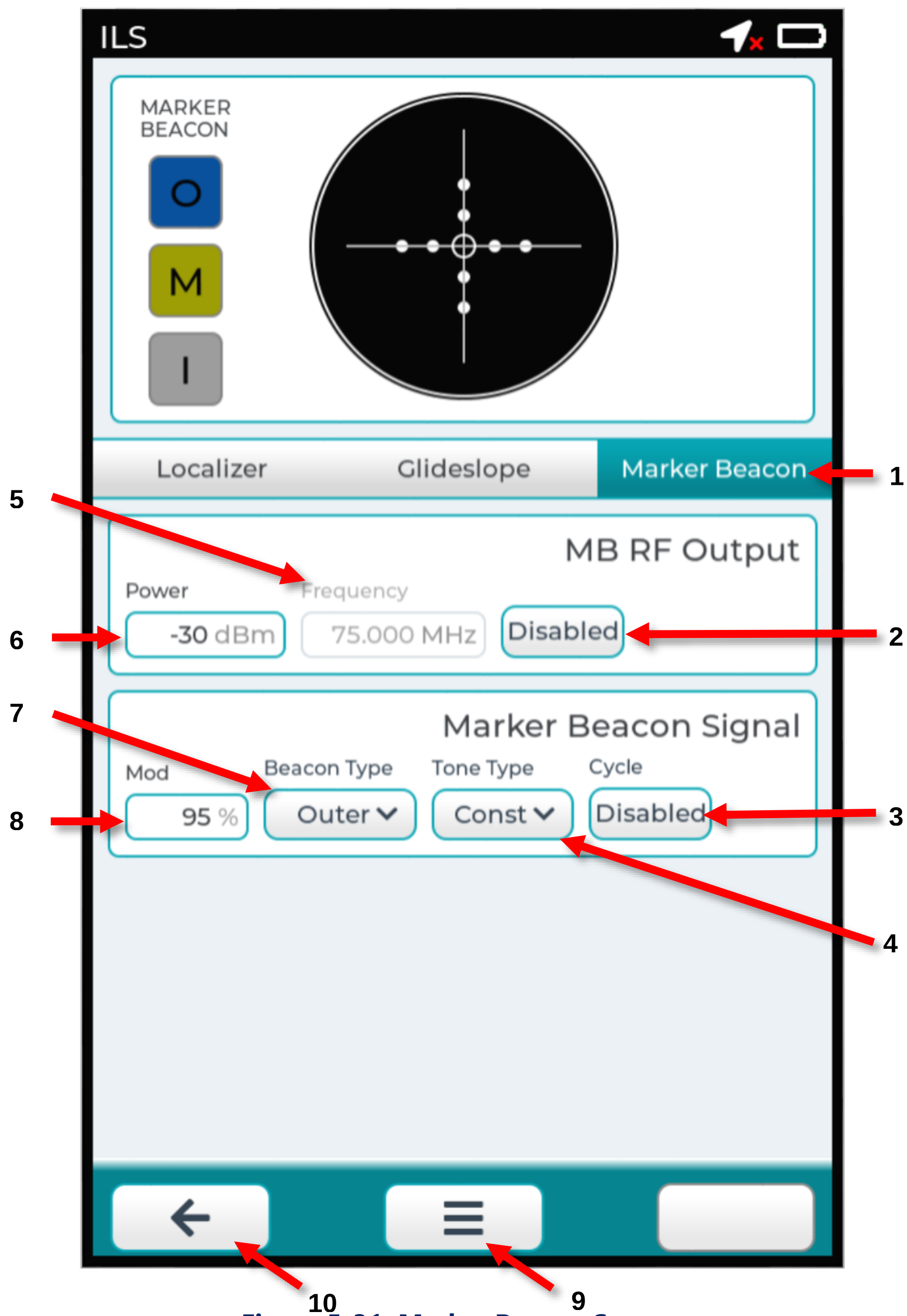

Figure 5-31. Marker Beacon Screen

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Table 5-8. Marker Beacon Field Description

CALLOUT	NAME	DESCRIPTION
1	Marker Beacon	Marker Beacon tab: Select to display MB controls
2	MB RF Transmitter	Turns ON and OFF the MB RF transmitter. ON=Enabled; OFF=Disabled (default)
3	Cycle	When Enabled, begins cycling the 3 markers at a 3 second rate.
4	Tone Type	Selects either Continuous or Morse Code audio modulation
5	Frequency	Displays 75 MHz Marker Beacon carrier frequency. Not changeable.
6	Power	Allows operator to enter 75 MHz marker beacon RF output power, measured at the ANT-B connector. Allowable range: -100 dBm to +10 dBm.
7	Beacon Type	Select Inner, Middle, or Outer.
8	Mod	Allows operator to select the tone modulation percentage. The default is 95%. Not normally changed by the operator.
9	Menu Icon	Enables popup menu with 3 selections: (1) Home (stop test and return directly to the Home Menu); (2) Settings (go to Global Settings screen); and (3) ILS Setup (go to ILS Setup screen).
10	Back Icon	Stops test and returns to Navigation Menu

5.7 TESTING VOR SYSTEMS

For a description of VOR principles of operation, see Appendix C.

WARNING

When testing with the aircraft autopilot engaged, any change of navigation signal may cause movement of the associated aircraft control surfaces (elevator, ailerons, rudder). All personnel and ground support equipment must be clear of the control surfaces to prevent death or serious injury.

1. If using the Telescopic Antenna, attach and extend the antenna to 28.5 inches (72 cm) (see Paragraph 6.1 (page 97)).
2. From the Home Menu, select **Navigation->VOR.**
3. The **VOR Setup** popup screen will display, reminding the operator to use Antenna port B for all VOR system testing, whether over-to-air or direct connection to the VOR receiver. Press **Close**.

4. The **VOR** Test Screen (Figure 5-32) has an upper section that depicts an aircraft VOR indicator, a middle section that controls the RF output parameters, and a lower section that controls VOR modulated signal parameters.
5. The VOR RF Output is initially turned OFF (Transmitter Disabled). Before turning ON (Enabling) the transmitter, review the Power and Frequency values and set them to the desired value. The defaults are **0 dBm** (maximum output power) and **108.00 MHz.**

> **NOTE**
>
> The standard VOR test frequencies are 108.00 and 108.05 MHz. Testing at any other VOR frequency must be done using direct connection to the VOR receiver or inside an adequately shielded building to prevent harmful interference to aircraft navigation systems (Reference: AC 170-6C).

6. The VOR indicator display in the upper section of the SDR-OMNI screen indicates the radial that is being transmitted by the test set when the FROM direction is selected.

> **NOTE**
>
> The VOR needle can be moved manually by touching and dragging it to the desired radial

7. Refer to the Figure 5-32 and Table 5-9 for further instruction on how to operate the SDR-OMNI for VOR receiver testing. All VOR Signal modulation parameters are set to default values that duplicate the modulation values of a normally operating FAA VOR ground station.
8. When finished setting parameters, press the **Enable** button under Transmitter to enable the VOR RF transmission.

> **NOTE**
>
> The modulation parameters of the VOR composite signal (9960 Deviation, 9960 Modulation, 30 Hz Modulation, ID Modulation) should be left at their default values and should not normally be changed by the operator. They are useful for bench testing and troubleshooting of legacy VOR receivers.

9. Place the SDR-OMNI at an appropriate test location. The SDR-OMNI can generally be used in the cockpit by a single operator. The SDR-OMNI can also be placed outside the aircraft with clear line-of-sight to the aircraft VOR antenna(s).
10. Ensure the Aircraft VOR Receiver is ON and tuned to the same frequency as the SDR-OMNI.
11. Verify that the VOR radial indicated in the cockpit matches the SDR-OMNI simulated VOR radial.
12. Change the **TO/FROM** selection and verify the cockpit display indicates either a 180º radial change or the To/From Indicator reverses.
13. Complete the normal VOR test procedure for the aircraft under test.
14. When finished with the VOR test, select the **Back** icon along the bottom of the screen to return to the Navigation Menu, or return to the Home Menu screen.

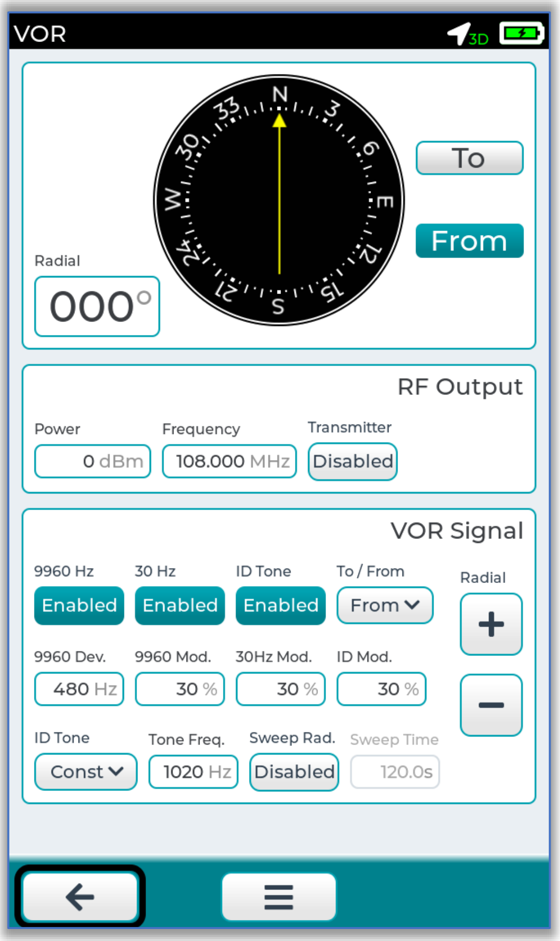

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Table 5-9. VOR Test Screen Field Description

NAME	DESCRIPTION
Radial Box	Displays radial being simulated. Always indicates actual radial being simulated (i.e. – is not affected by TO/FROM. Always indicates FROM radial.) User can edit this field and enter desired radial.
VOR Indicator	Indication of cockpit VOR display. Points to simulated radial when **FROM.** Points to reciprocal radial when **TO**.
TO	Activates TO
FROM	Activates FROM
RF Output - Power	Sets RF output power, measured at the ANT-B BNC connector, from -99 dBm to +2 dBm

NAME	DESCRIPTION
RF Output - Frequency	Allows entry of any valid VOR frequency from 108.00 to 117.95 MHz
RF Output - Transmitter	Controls RF Output ON/OFF. Disabled = OFF; Enabled = ON
VOR Signal - 9960 Hz	Turns on 9960 Hz VOR composite modulation. Enabled = ON; Disabled = OFF. Can be used to check if VOR receiver ‘flags’ when turned OFF. (Default = ENABLED)
VOR Signal – 30 Hz	Turns on 30 Hz VOR composite AM modulation. Enabled = ON; Disabled = OFF. Can be used to check if VOR receiver ‘flags’ when turned OFF. (Default = ENABLED)
VOR Signal - ID Tone	Turns on audio IDENT tone. Enabled = ON; Disabled = OFF.
VOR Signal - To/From	An alternate method to select TO/FROM
VOR Signal - 9960 Dev.	Sets FM deviation of the 9960 Hz composite VOR signal. Not normally changed by the operator. (Default = 480 Hz)
VOR Signal - 9960 Mod	Sets modulation % of 9960 Hz VOR composite signal. Not normally changed by the operator. (Default = 30%)
VOR Signal - 30 Hz Mod	Field to control modulation % of 30 Hz VOR component (default = 30%)
VOR Signal - ID Mod	Field to control modulation % of audio Ident tone (default = 30%)
VOR Signal - ID Tone	Turns on audio Ident tone. Enabled = ON; Disabled = OFF
VOR Signal - Tone Freq.	Sets audio frequency of Ident tone (Default = 1020 Hz)
VOR Signal - Sweep Rad	For autopilot coupling test. Allows VOR signal to be rotated counterclockwise over a specific time period. When “Enabled”, the VOR bearing begins changing at a rate of 360º/Sweep Time. (Default = 120 seconds, giving a sweep rate of 3º per second.)
VOR Signal - Sweep Time	For autopilot coupling test. Sets time period for 360º of counterclockwise sweep.
VOR Signal – Radial +/-	Increments or Decrements VOR radial by 30º

NAME	DESCRIPTION
Back Icon	When selected, stops the test in progress and returns to the Navigation Menu
Menu Icon	Allows operator to directly navigate to: (1) Home (Home Menu), (2) Settings (Global settings), or (3) VOR Setup

5.8 TESTING DME SYSTEMS

Aircraft DME systems are easily and quickly tested using the SDR-OMNI.

1. From the **Home Menu** screen, select **Navigation,** then select **DME**. The **DME Setup** screen (Figure 5-33) will appear.

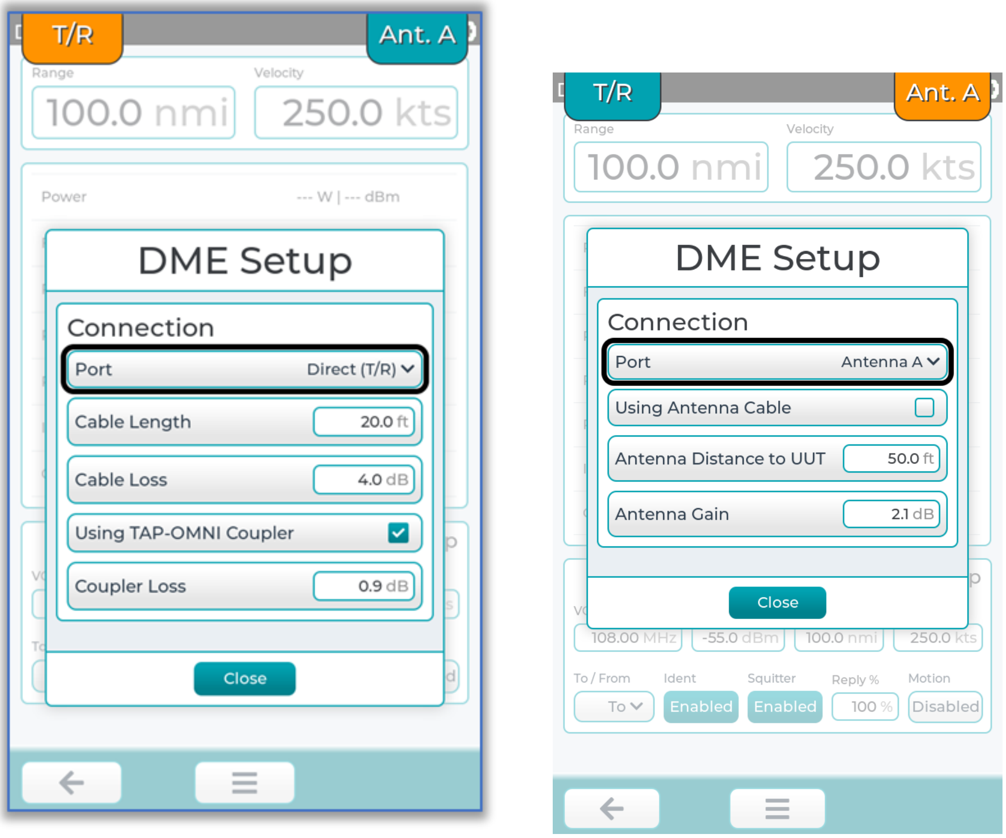


Figure 5-33 DME Setup screens

2. If directly connecting the DME unit under test to the SDR-OMNI using a coaxial cable:
   a. Select the **Direct (T/R)** port.
   b. Then enter **Cable Length** (TIC supplied Direct Connect cables are either 9.9 ft / 3 m OR 32.8 ft / 10 m) for proper computation of the path delay.

c. Enter **Cable Loss**, which is marked on TIC supplied cables. If other coaxial RF adapters need to be used, an additional 1 dB loss for each adapter should be added to this field.

d. If using the TAP-OMNI antenna coupler over the DME antenna, select this checkbox.

3. If testing the DME system over-the-air, there are two options.

   a. Use the TAP-OMNI coupler: Identify the DME antenna and clamp the coupler to it. In this case, select the **Direct (T/R)** port as in step 2 above, and select the **Using Coupler** check box. The unit then shows the additional 0.9 dB loss of the TAP-OMNI coupler.

   b. Use the L-Band Directional Antenna: Attach the antenna to the ANT-A port. From the **DME Setup** screen, select **Antenna A** port. Then enter the estimated **Antenna Distance to UUT**. If an extension coaxial cable has been inserted between the SDR-OMNI connector and the L-Band Directional Antenna, select **Using Antenna Cable** and enter the **Cable Length**.

4. Once the setup has been entered, select **Close**. The single DME Test screen will be displayed (Figure 5-34 and Table 5-10). All user controllable Setup parameters in are in lower portion of the screen. The center section of the screen displays all the measured parameters of the DME reply. The upper Range and Velocity section allows for quick entry of a new range and velocity, and displays the simulated range and velocity during testing.

5. VORTAC frequencies 108.00 (17X), 108.05 (17Y), and 108.10 (18X) are authorized over-the-air test frequencies. Enter the desired VORTAC test frequency (108.00 is the default) in the lower **Setup** section of the **DME Test** screen. Frequencies other than the authorized test frequencies should be tested by placing the TAP-OMNI antenna coupler over the DME antenna to prevent harmful interference to aircraft navigation systems.

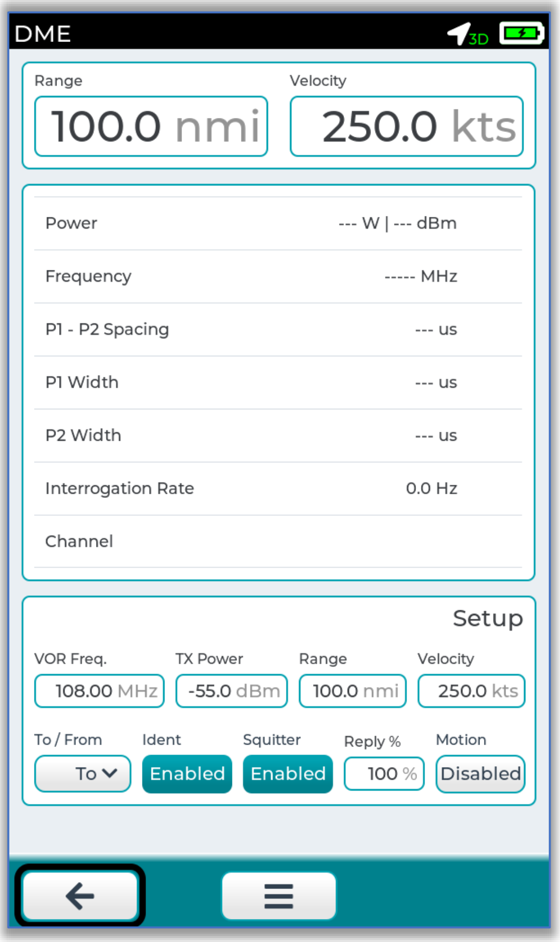


Figure 5-34 DME Test screen 2023-CLS-TIC-0055

Table 5-10 DME Test screen Field Description

NAME	DESCRIPTION
Range	Either field can be used to enter the initial range. When testing, both fields display the simulated range.
Velocity	Either field can be used to enter the velocity. This field can be changed during the test.
Power	Measured RF power from the DME UUT
Frequency	Measured RF frequency of the DME UUT transmitter
P1-P2 Spacing	Measured spacing between P1 and P2 interrogation pulses in microseconds

NAME	DESCRIPTION
P1 Width, P2 Width	Measured pulse width in microseconds of the P1 and P2 interrogation pulses
Interrogation Rate	Rate of DME UUT interrogations
Channel	Displays DME channel being tested (1-126 X, Y)
SETUP PARAMETERS	This section contains the below fields.
VOR Freq.	Field to enter VORTAC frequency paired with DME channel to be tested
TX Power	Enter SDR-OMNI output power (Direct mode: -10 to -90 dBM; Antenna A mode: -33 to -90 dBm)
Range, Velocity	Range and Velocity can be entered in these fields also (in addition to the larger boxes at the top of the screen)
To/From	Selects aircraft moving To or From the station
Ident	Turns ON Audio Ident: Enabled = ON; Disabled = OFF
Squitter	Turns ON Squitter: Enabled = ON; Disabled = OFF
Reply %	Sets the percentage of DME UUT interrogations that the SDR-OMNI will reply to. (Default = 100%)
Motion	Turns ON simulated motion (To or From); Enabled = Motion, Disabled = Stationary

5.9 TESTING ELT SYSTEMS

Modern 406 MHz ELT radios transmit a digital message burst every 50 seconds. ELT radios may also transmit audio siren tones on emergency VHF (121.5 MHz) or UHF (243 MHz) frequencies for ground-based triangulation location.

The SDR-OMNI can test the 406 MHz digital message burst and one of either siren tones using either Direct Connect or Antenna mode. The SDR-OMNI can also test each frequency individually for fault isolation.

CAUTION

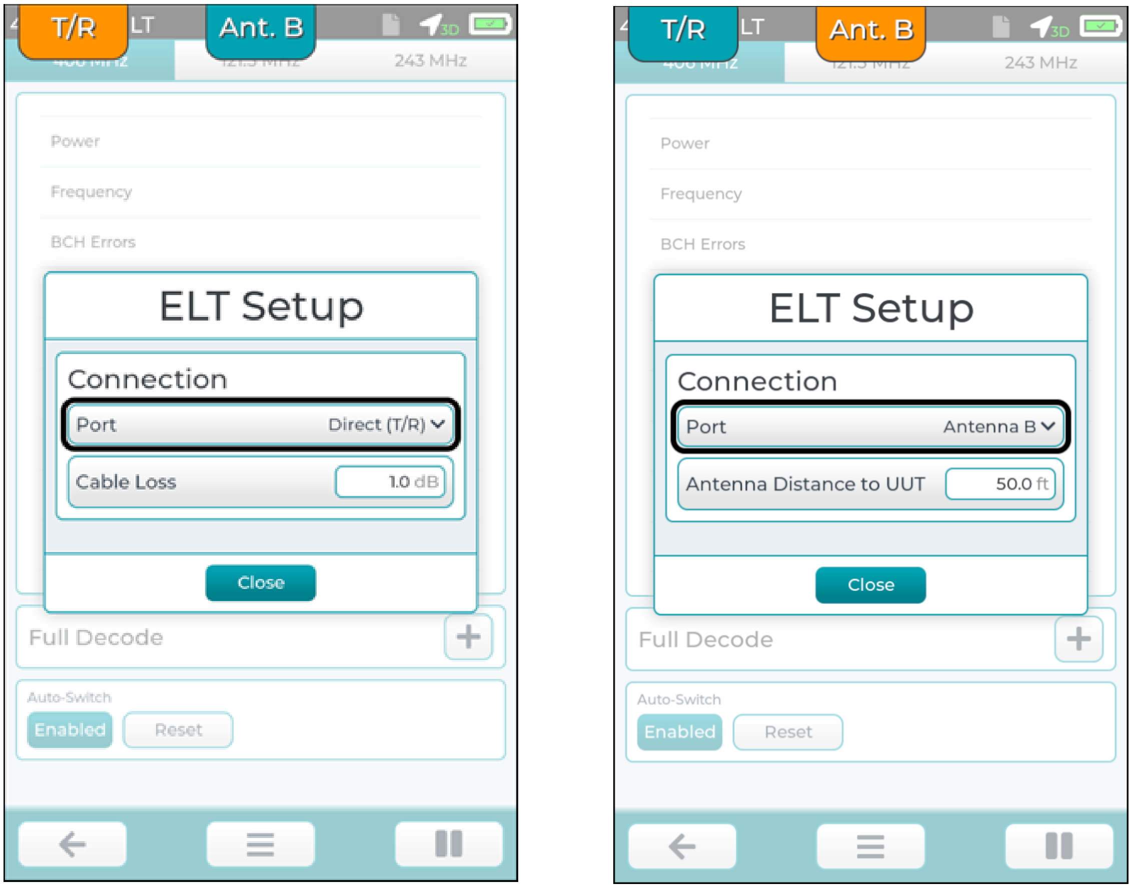
ELT testing must be done during the first 5 minutes after the beginning of the hour. Testing outside of that test window could result in Search and Rescue activities being initiated. Activating a 406 MHz beacon for reasons other than to indicate a life-threatening distress situation or without prior authorization from a Cosmicheskaya Sistyema Poiska Avariynich Sudov (COSPAS, Russian for “Space System for the Search of Vessels in Distress”) -Search and Rescue Satellite-Aided Tracking (SARSAT) Mission Control Center (MCC) is considered an offense in many countries and could result in prosecution.

5.9.1 406 MHz ELT Data Burst

To test a 406 MHz ELT system, from the Home menu, select Communication -> 406 MHz ELT. The ELT Setup screen (

USING DIRECT CONNECT **USING TELESCOPIC ANTENNA**

1. Figure 5-35) will appear.



USING DIRECT CONNECT **USING TELESCOPIC ANTENNA**

Figure 5-35. ELT Setup

2. From the **ELT Setup** screen:

If directly connecting to the ELT transmitter (

USING DIRECT CONNECT **USING TELESCOPIC ANTENNA**

   a. Figure 5-35, 1), select Port **Direct T/R**. Connect a coaxial cable between the SDR-OMNI T/R port and the UUT. Enter the corresponding **Cable Loss**.

   b. If testing over-the-air (2), select **Antenna B** and connect the Telescopic Antenna to the ANT-B connector. Collapse it to its shortest length. Enter the approximate **Antenna Distance to UUT**.

3. Select the **Close** button on the **ELT Setup** screen. The SDR-OMNI will begin listening for a 406 MHz data burst.

4. Verify that the current time is within a valid ELT test window (hour+00 to hour+05). Activate the ELT test button or switch on the ELT UUT or in the cockpit.
5. The ELT UUT should quickly transmit a data burst, which should be received, decoded, and displayed on the ELT test screen (Figure 5-36). Only the most important data fields are initially displayed. Note that if GPS position is not available to the ELT, that information will not be displayed. If the burst was missed, the ELT will transmit another burst in 50 seconds.
6. Verify that the decoded information, such as Country Code and Hex ID, are correct.
7. Expanding the **Full Decode (+)** will display the complete decoding of the message burst.

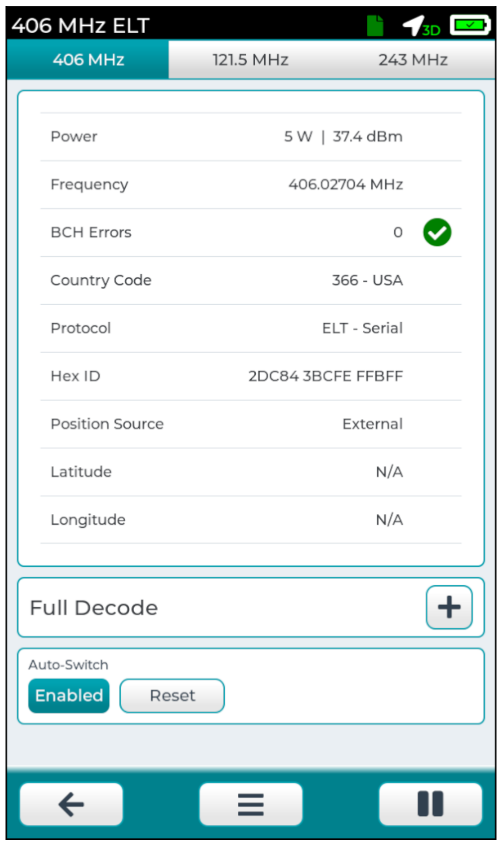


Figure 5-36 ELT Test Screen

5.9.2 121.5 MHz and 243 MHz Audio Siren Test

8. If **Auto-Switch** is enabled and a transmission has been decoded, the 121.5 MHz tab will be selected automatically for a short period of time to detect the audio 'whoop-whoop' siren and make power and frequency measurements. It will then automatically switch to 243 MHz and do the same thing.
9. The headset that is supplied with the SDR-OMNI can be used to listen to the audio sirens on the VHF and UHF emergency frequencies. A slider bar for **Headset Volume** is provided. If the **Auto-Switch** is not enabled, the operator can manually select the 121.5 and 243 MHz tabs. Refer to

a. After receiving the 406 MHz data burst, select the 121.5 MHz tab. This will retune the receiver to 121.5 MHz and allow the user to listen to the audio on the SDR-OMNI headset. The unit will measure and display the received RF power, frequency, and frequency error.

b. If the ELT also transmits on 243 MHz, select the 243 MHz tab, listen to the audio on the headset, and observe the measurements at 243 MHz.

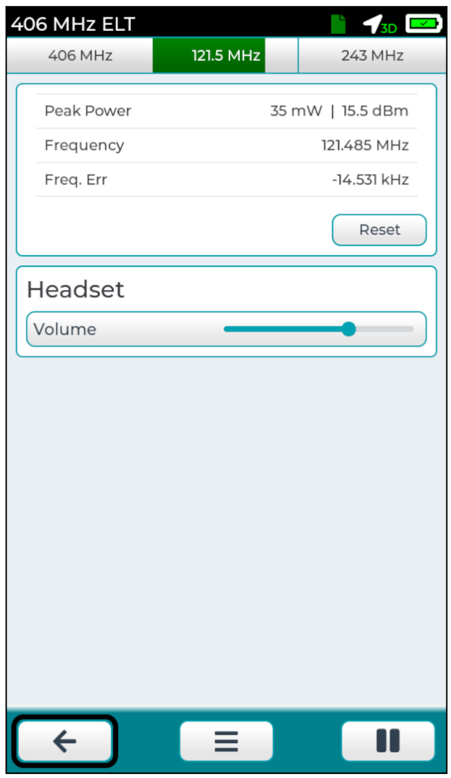


Figure 5-37 VHF/UHF ELT Screen

CAUTION

After testing an ELT, immediately take it out of the TEST mode to avoid transmitting after the allowed test window of 0 to 5 minutes after the hour. Otherwise, SAR (Search and Rescue) activities may be initiated by the civil authorities.

5.9.3 ELT Test Report

Once the data burst from a 406 MHz beacon has been received the SDR-OMNI has enough data necessary to generate a test report. The operator can then select the bottom **Home Menu** button and press **Save Report** (see Paragraph 4.6). An ELT radio transmitting on the emergency VHF and/or UHF frequency will have those measurements added to the test report accordingly.

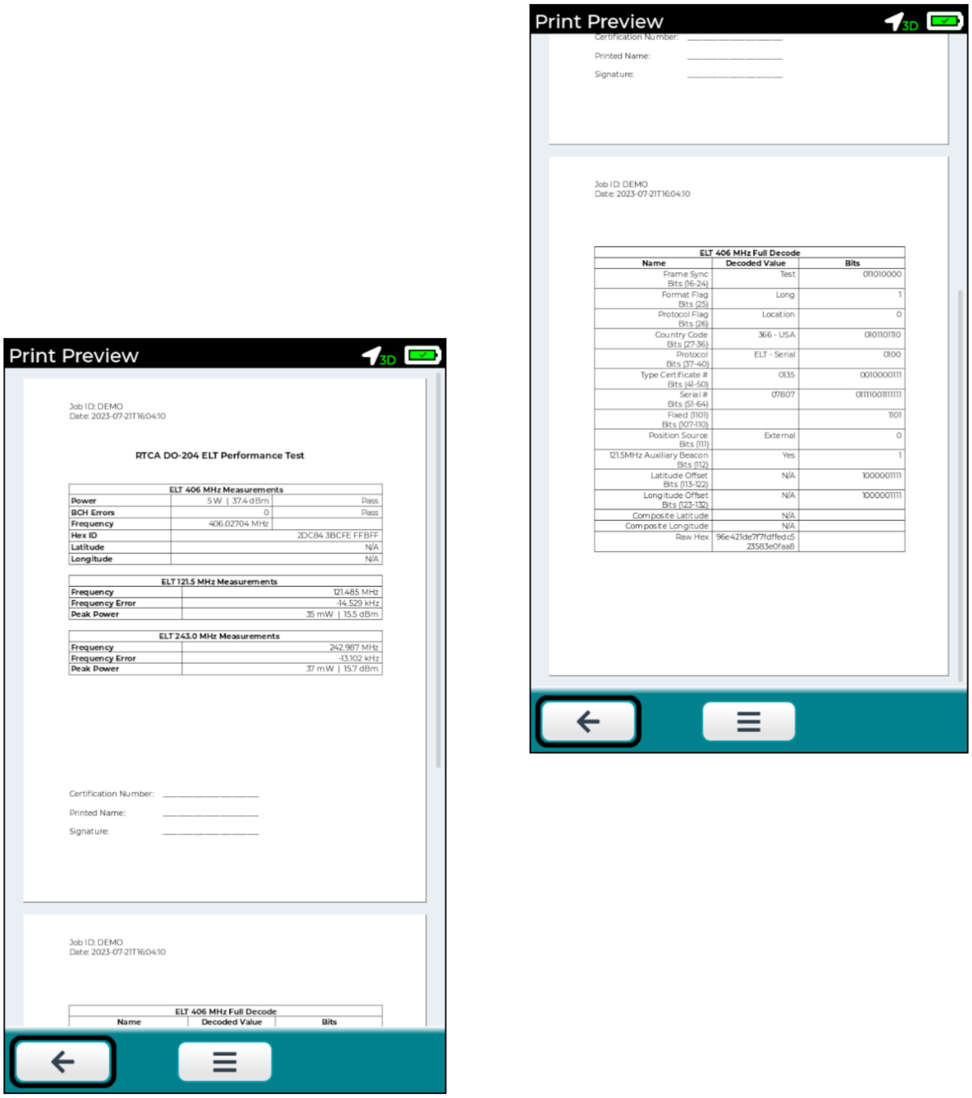


Figure 5-38 ELT Test Report

Description of ELT Test Requirements:

The FAA requires the installation of an ELT on most civil airplanes with statute § 91.207. The ELTs must meet performance standards specified in Technical Standard Order (TSO)-C126x and Cospas-Sarsat Specification C/S T.001. RTCA DO-204A provides the basis for TSO-C126x. Older ELT devices may be meeting the requirements in TSO-C91a, but new ELT equipment must now meet the requirements in TSO-C126x.

For ELT beacons, the transmitter power output shall be within 35 to 39 dBm measured into a 50-Ohm load. The beacon's carrier frequency at the designated center frequency of the appropriate channel listed in the Cospas-Sarsat 406 MHz Channel Assignment Table shall be ±1 kHz, and shall not vary more than ± 5 kHz from that channel center frequency in 5 years. In addition to these requirements, a beacon must be inspected within 12 calendar months after the last inspection for proper installation, battery corrosion, operation of the controls and crash sensor, and the presence of a sufficient signal transmitting from its antenna. RF power must be emitted at 406 MHz and at 121.5/243 MHz, if applicable.

5.10 TESTING AIRCRAFT COMMUNICATIONS (HF/VHF/UHF COMM TRANSCEIVERS)

The SDR-OMNI can perform a Comms check on a broad range of HF, VHF and UHF COMM transceivers from a single, easy-to-use test screen (Figure 5-39 and Table 5-11). Using the supplied headset, the operator can transmit and receive voice to the aircraft cockpit.

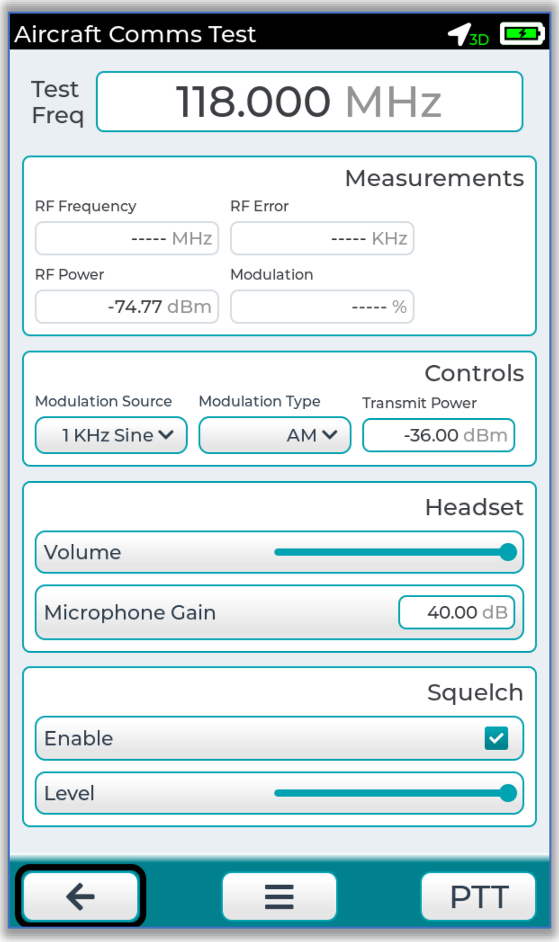


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Figure 5-39. Aircraft COMMs Test screen

Table 5-11. Aircraft COMMs Test screen fields

NAME	DESCRIPTION
Test Freq	RF Carrier Frequency: Operator can enter frequency from 0.200 MHz to 1500.0 MHz
Measurements section	Box in upper portion of screen that displays RF measurements of the aircraft transmitted signal.

NAME	DESCRIPTION
RF Frequency	Measured RF frequency of the aircraft transmitter
RF Error	Difference between measured RF frequency and the Test Frequency
RF Power	Measured RF power: This is accurate only when in **Direct (T/R)**) mode. When using the Antenna B port, this field can be used for relative power measurements
Modulation / (Deviation)	When AM Modulation Type is selected, this displays a rough measurement of the modulation percentage of the received signal. When FM Modulation Type is selected, this displays a rough measurement of the maximum FM deviation of the received signal.
Controls	Box in center section of the screen that contains operator selectable controls for the SDR-OMNI transmitter
Modulation Source	The transmitted signal can be modulated by: (1) an internally generated **1 kHz Sine** wave, or (2) by the headset **Mic**.
Modulation Type	**AM** or **FM** (applies to SDR-OMNI transmitter AND receiver)
Transmit Power	RF Transmit Power control: Direct (T/R) mode range: -36 dBm to -110 dBm Antenna B mode range: +10 dBm to -110 dBm
Headset	Controls for headset **Volume** and **Microphone Gain** (default = 40 dB)
Squelch	Controls to **Enable** receiver squelch and set the squelch **Level**
PTT	Push-to-Talk switch. Press to turn **ON** transmitter. Press again to turn OFF.

5.10.1 Testing Aircraft Transmitters

1. From the Home menu, select **Communication -> Aircraft Communications.**
2. For over-the-air testing, select **Port = Antenna B**. Connect the Telescopic Antenna to the ANT-B connector on the top of the unit. Refer to Table 2-3 to set the length of the antenna per the frequency range to be tested.
3. For Direct Connect testing, select **Port = Direct (T/R)**. Connect the UUT radio to the SDR-OMNI using one of the supplied coaxial cables. An RF connector adapter may be required.

CAUTION

The maximum power that can be transmitted into the SDR-OMNI Direct T/R port is **5 Watts** average power or **25 Watts** of power for no more than 30 seconds, followed by 2 minutes OFF. If the transmitter under test transmits at a higher power, you must insert an appropriately sized RF attenuator in line to prevent damage to the SDR-OMNI.

4. Plug the headset into the connector on the left side of the SDR-OMNI. There is a slider bar for headset volume AND there is a small volume potentiometer on the headset itself. It is recommended to turn the volume pot on the headset all the way up (+) and use the slider bar on the SDR-OMNI for the headset volume.
5. Set the **Test Freq** field to the desired aircraft transmission frequency. From the cockpit, key the transmitter to be tested for ~ 10 seconds. This should be enough time for the SDR-OMNI to lock onto the carrier and measure **RF Frequency, RF Error,** and **RF Power**.

NOTE

When testing over-the-air, the RF Power reading will not be accurate. This measurement is quite useful, however, for comparison testing between 'known good' and 'suspect' radios.

6. An operator in the cockpit can also transmit audio from a cockpit headset or microphone. The SDR-OMNI operator will be able to hear the transmitted audio in the headset. Weak or garbled audio indicates a problem with the aircraft transmitter.
7. If unable to hear the transmitted audio, disable the squelch by unchecking the Squelch checkbox.
8. Or, **Enable** squelch and use the slider bar to set the squelch level to stop undesired noise.

5.10.2 Testing Aircraft Receivers

1. Perform steps 1 – 4 in Paragraph 5.10.1, Testing Aircraft Transmitters.
2. Select the **Test Freq, Modulation Source** and **Modulation Type** to match the aircraft radio under test.
3. Set the **Transmit Power**. Normally set this to the maximum value (refer to Table 5-11) and decrease if necessary.
4. Set the **Modulation Source**. To transmit a 1 kHz audio tone, select **1 KHz Sine**. To transmit voice using the headset microphone, select **Mic**.
5. Make sure the aircraft radio is properly set up to deliver audio over a cockpit speaker or via a pilot headset.
6. Press the **PTT** button in the lower right corner of the SDR-OMNI. If using the headset, talk into the microphone. Verify that the transmitted tone or voice is clearly heard in the cockpit.
7. Make sure to deselect the PTT button to stop the transmission when complete.

5.11 TESTING SELCAL SYSTEMS

The SDR-OMNI is able to transmit dual tone AM modulated SELCAL (Selective Calling) codes on HF and VHF frequencies in order to test SELCAL systems on long-haul aircraft so equipped.

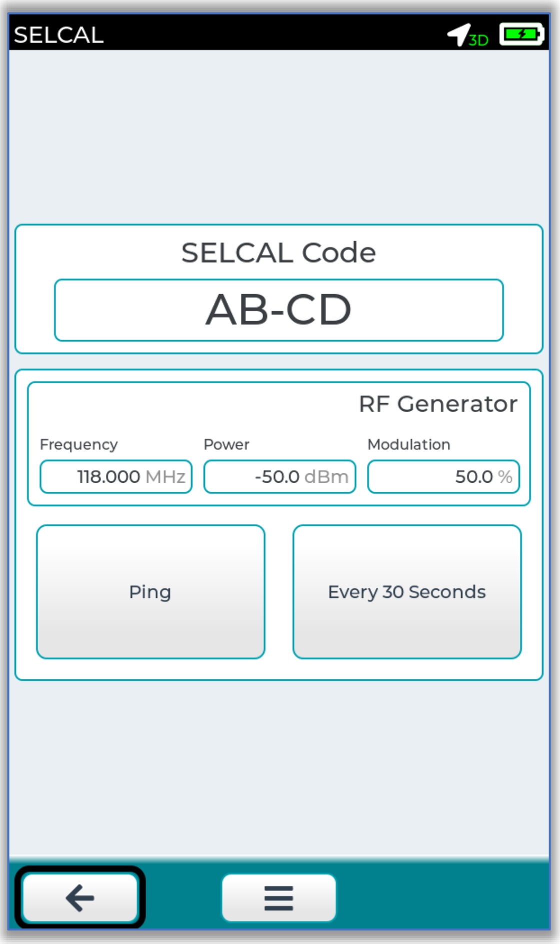

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Figure 5-40. SELCAL Test screen

1. From the Home menu, select **Communication -> SELCAL**.
2. Generally, SELCAL is tested over-the-air. Select **Port -> Antenna B** and use the Telescopic Antenna connected to the **ANT-B** connector. Extend to the appropriate length for the desired frequency. See Table 2-3.
3. Refer to Figure 5-40 and the description of the screen fields in Table 5-12.
4. If testing from the cockpit, stick the antenna out from the pilot's side window.
5. Set the SELCAL code on the SDR-OMNI to the code on the placard on the aircraft panel.
6. Make sure the aircraft cockpit system is enabled to announce the SELCAL chime or SELCAL light.
7. Press either the **Ping** or **Every 30 Seconds** button to initiate SELCAL bursts.
8. Confirm that the aircraft SELCAL system properly announces a SELCAL transmission.

Table 5-12. SELCAL Screen Fields

NAME	DESCRIPTION
SELCAL Code	Four letter code to be transmitted. Edit this field by touching it and entering any valid SELCAL code. Invalid codes will not be permitted.
Frequency	RF transmission frequency. SELCAL systems are typically connected to HF or VHF radios on long haul aircraft
Power	RF transmission power. When testing over-the-air, enter the strongest signal possible = 4 dBm.
Modulation	Default AM modulation = 50%. No normally changed by operator
Ping	Pressing this sends a one-time SELCAL transmission
Every 30 Seconds	Pressing this sends SELCAL bursts every 30 seconds. This continues until pressed again to stop.

5.12 TESTING AIRCRAFT AUDIO SYSTEMS

The SDR-OMNI is able to inject audio signals (from 20 Hz to 20 kHz) at up to 2.0 Vac peak-to-peak into aircraft audio systems and then measure audio distortion as the signal passes through an aircraft audio intercom system (Figure 5-18 and **Error! Reference source not found.**). This is useful for troubleshooting audio intercom squawks.

The Aircraft Audio Test Cable should be used for this test. Connect the D connector to the Test connector port on the front of the SDR-OMNI. The SDR-OMNI will generate an audio signal that is transmitted through the mic plug (tip = signal, sleeve = ground, ring = PTT) into the audio system. Thus, plug the mic plug into a pilot or copilot mic jack to simulate a signal from a cockpit microphone.

Next, plug the headphone plug (tip = signal, sleeve = ground) into a headphone jack where the cockpit mic transmission will be heard to receive that signal.

When connected, activate a 1 kHz audio sine wave by turning ON the Audio Tone Out. Monitor the signal coming through the audio system using the SDR-OMNI headset, and adjust the Audio level so that the input is not being overdriven.

Ensure that the Audio Measurement Filter Bandwidth is set to 300 Hz- 3kHz BP and monitor the measurement results of Audio Level and SINAD or Distortion.

The mic and headphone plugs can be moved around to different jacks in the intercom system to troubleshoot particular channels or connectors that may be problematic.

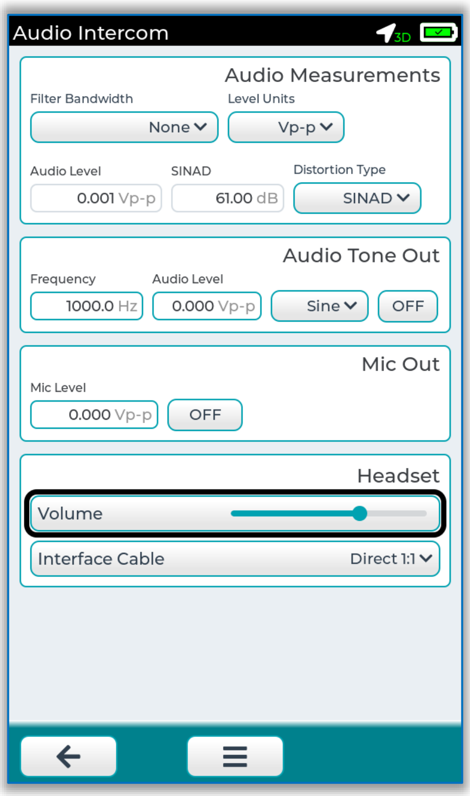

Figure 5-41 Audio Intercom Test Screen

Table 5-13. Audio Intercom Test Screen Fields

NAME	DESCRIPTION
Audio Measurements	Section in the upper portion of the screen that displays measured parameters of the audio input signal
Filter Bandwidth	Determines audio filter type: • 300 Hz – 3 kHz BP (bandpass): default: best filter for audio • 3 kHz LP (low pass) • 15 kHz LP (low pass) • None
Level Units	Selects display of Vp-p (peak-to-peak) or Vrms (root-mean squared)
Audio Level	Displays measured voltage of audio input signal in Vp-p or Vrms
Distortion Type	Selects type of distortion to be displayed: SINAD (signal-to-noise and distortion ration) or THD+N (total harmonic distortion + noise)
SINAD (or Distortion)	Displays SINAD or THD+N, depending on selection above
Audio Tone Out	Section in the center of the screen that allows user to control Audio Output parameters (frequency, level, and type of signal)
Select Waveform	The output signal can be a Sine (default), Square, Triangle, or Ramp. Note that signals that are not sine waves become increasingly distorted at higher frequencies as the harmonics get filtered above 20 kHz
Frequency	Enter an audio frequency from 20 Hz to 20 kHz
Audio Level	Enter a voltage level from 0 to 2.0 Vp-p
OFF / ON	Activates the audio output
Mic Out: Mic Level ON/OFF	Activates the SDR-OMNI headset mic when it is connected and sets its output level.
Headset Volume	When connected, the SDR-OMNI headset listens to the audio input signal. The slider bar sets the volume level to the headset.

CHAPTER 6 ANTENNA AND CABLE TESTING USING THE SDR-OMNI

6.1 VSWR/DISTANCE-TO-FAULT CALIBRATION

Before beginning a series of VSWR or DTF measurements, the operator must run a calibration procedure using the VSWR Open/Short Calibration Load, as described below. Once the unit is calibrated, the calibration data can be saved and restored if the unit is powered off. Note that if the temperature of the test environment changes significantly, the calibration procedure should be rerun.

1. From the Home Menu, select **General**, **-> VSWR/DTF.** The VSWR/DTF Calibration screen will display.

NOTE

If the unit has recently completed the Open/Short calibration procedure and the calibration data has been saved, the operator may re-load the calibration data if the ambient temperature has not changed significantly.

2. Using the two identical **VSWR Bridge Connect Cables** (Figure 2-11), connect the **Return Loss Bridge** (Figure 2-9) to the SDR-OMNI. **Connect the bridge INPUT port to ANT-A and the bridge OUTPUT port to ANT-B.**
3. The **VSWR Open/Short Calibration Load** (Figure 2-10) will be used to calibrate the system prior to making a VSWR measurement. Connect the OPEN side of the load to the DUT connector on the bridge.
4. Press the Open Cal run icon (Figure 6-1). The SDR-OMNI will begin sweeping through its full frequency range. This will take 15-20 seconds. Upon completion, the Open Cal should have a green check mark, indicating success (Figure 6-1, 1).
5. Next, reverse the load and connect the SHORT end to the DUT port on the bridge. Press the Short Cal run icon. After 15-20 seconds, the frequency sweep should complete, and a green check mark should appear next to Short Cal (2).

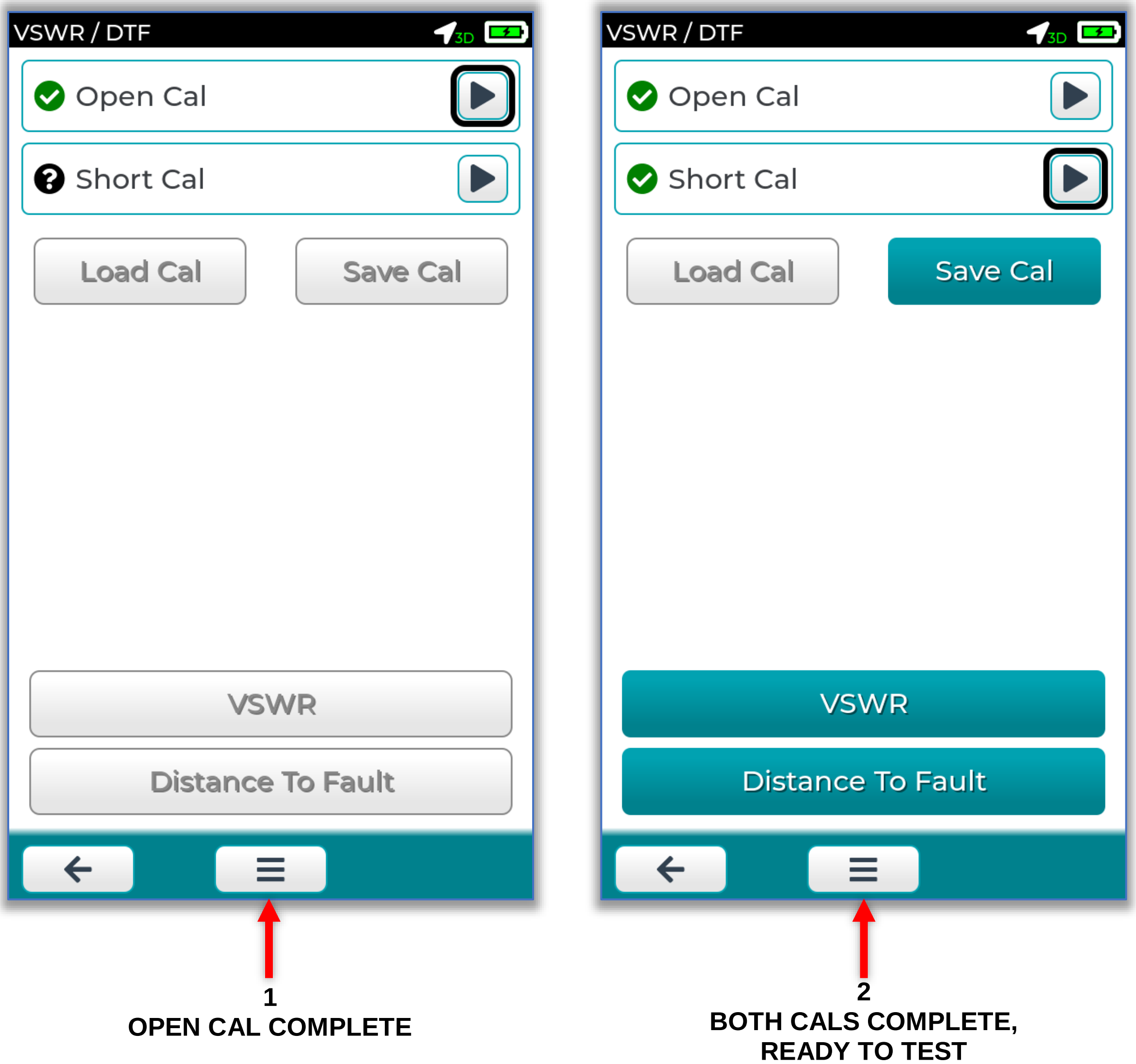

Figure 6-1. VSWR/DTF Screen

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6. The **Save Cal** button should highlight after the two calibration cycles. Press this to save this calibration data. If the SDR-OMNI is powered off, but then used again later in the day to do VSWR measurements, it is not necessary to recalibrate the unit unless the ambient temperature has changed significantly. Simply press **Load Cal** to restore the previous calibration data.
7. Remove the calibration load and connect the test article (e.g. antenna cable) to be tested to the DUT connector on the bridge. This will require a Type N male connector.

6.2 MEASURING VSWR AND/OR RETURN LOSS

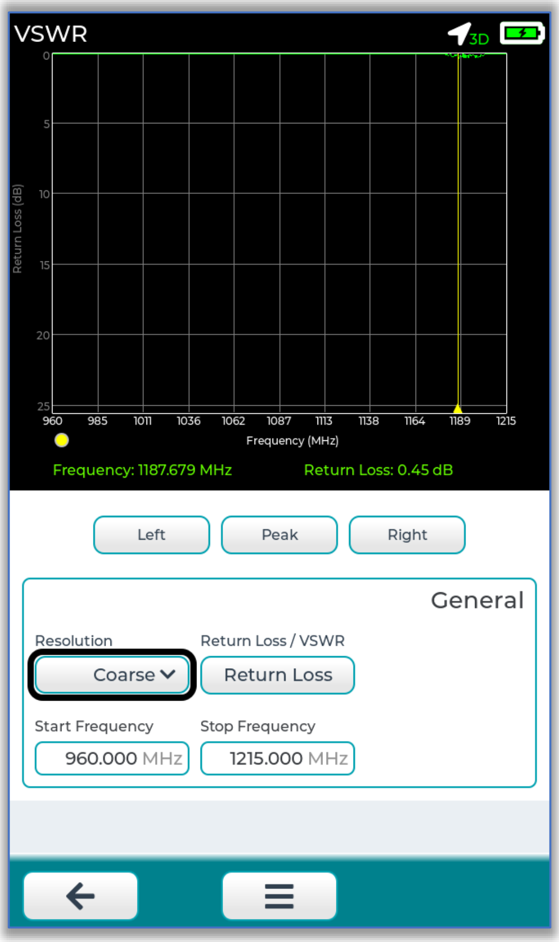
VSWR (Voltage Standing Wave Ratio) and Return Loss both measure the same parameter i.e., the signal reflected back in a transmission line. VSWR is defined as the ratio of the maximum to minimum voltage on a loss-less transmission line (expressed as 3.0:1, 2.0:1). This ratio represented in dB is called Return Loss.

When the test connection is complete, press **VSWR**. The SDR-OMNI will begin sweeping across the selected frequency range and display the results. This may take several seconds for the unit to sweep across the selected frequency range. See Figure 6-2.

NOTE

VSWR will not be selectable until Open Cal and Short Cal have been completed.

1. The controls for the VSWR screen are explained in Table 6-1. The **Return Loss/VSWR** button (Figure 6-2) allows the operator to display the results as either Return Loss in dB or VSWR as a ratio.
2. Enter the desired Start and Stop frequencies for the frequency range of interest. For example, if testing a transponder antenna, which operates from 1030 to 1090 MHz, the operator may want to enter 1000 to 1120 MHz as a range of interest. If testing a VHF antenna, 100 MHz to 140 MHz might be a good range.
3. Pressing the **PEAK** button will move the Frequency Indicator to the frequency with the highest VSWR or Return Loss. Note that the Return Loss scale is inverted – i.e. 0 dB is at the top, with increasing dB loss moving lower on the left hand scale.
4. Operate the controls as necessary (Table 6-1) to troubleshoot the test article at hand.
5. If an unacceptable VSWR is detected, the operator may wish to switch to the **Distance to Fault (DTF)** mode to determine where along the line the problem may be located.



2023-CLS-TIC-0059

Figure 6-2. VSWR Screen

Table 6-1. VSWR Description

NAME	DESCRIPTION
Frequency Indicator	Yellow line that can be moved to a specific frequency of interest. Note that the exact frequency of the Frequency Indicator and the VSWR at that frequency are displayed below the graph in green.
Left	Moves Frequency Indicator to the left
Peak	Moves Frequency Indicator to the frequency with peak (highest) VSWR
Right	Moves Frequency Indicator to the right
Resolution	**Coarse**: fewer frequency points **Detailed**: more frequency points
Return Loss/VSWR	Toggles between displaying **VSWR** (Voltage Standing Wave Ratio) as a simple ratio and **Return Loss** in dB

NAME	DESCRIPTION
Start Frequency	Enter lowest frequency to sweep.
Stop Frequency	Enter upper frequency to sweep
Back Icon	When selected, the VSWR Calibration screen will display
Menu Icon	Go to Home menu or Global Settings Menu

6.3 MEASURING DISTANCE TO FAULT (DTF)

The SDR-OMNI has the ability to accurately measure the distance along a cable where a significant discontinuity or anomaly may be located. It does this in the frequency domain, as opposed to the time domain (like a TDR – Time Domain Reflectometer), by measuring the phase difference between the RF signal transmitted on the ANT-A port and the reflected signal received via the Return Loss Bridge on the ANT-B port.

It does this around a specific center frequency, which is entered by the operator. For accurate distance results, the operator must specify the type of coaxial cable being tested so that its *Velocity Factor* can be used in the distance computation. The Velocity Factor is the ratio of the RF signal velocity to the velocity of light, expressed as a percentage. It is typically in the range of 60% to 90%.

The DTF test sweeps across a limited frequency range around the center frequency. This should be the center of the frequency range under consideration.

1. The **DTF** mode requires the same OPEN/SHORT calibration procedure as described in Section 6.1 above. If that calibration procedure has already been completed, there is no need to recalibrate.

NOTE

DTF will not be selectable until Open Cal and Short Cal have been completed as indicated by green check marks.

2. Select **Distance to Fault** from the calibration screen. The SDR-OMNI will begin DTF testing and display the results (Figure 6-3).
3. **Table 6-3** below explains the operation and controls of the DTF screen. Ensure that the proper coaxial cable type is selected so that the velocity factor is correct. A table of common avionics coaxial cable types is listed in **Table 6-4**.
4. Make sure that the desired **Center Frequency** (10) is correctly set.
5. Set the **Range** (4) to the shortest length that fully spans the length of cable being tested so that the finest distance resolution can be obtained. Refer to **Table 6-2.**

NOTE

Cable loss exceeding 10 dB may mask faults as the amplitude of the fault reflection diminishes with the distance to it. In this case, setting the **Range** to a higher distance should improve the ability of the test set to render an accurate reading.

6. Press the **Peak** button (3) to locate the major discontinuity. The exact distance will be displayed below the graph in green.

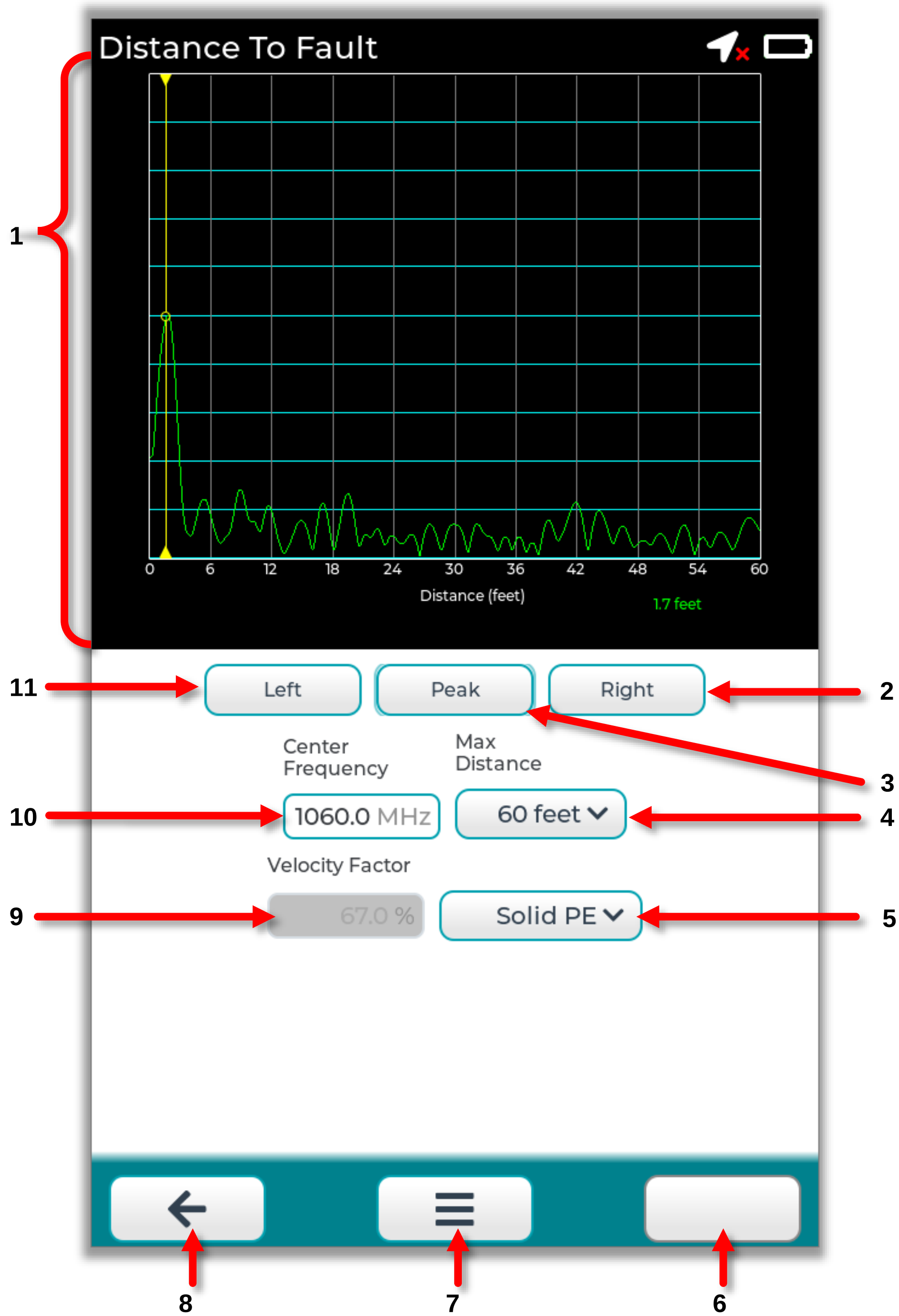
NOTE

To switch distance units between feet and meters, the **Settings** menu can be accessed by the Home/Settings button at the bottom of the screen. Pressing the **Back** button from the Settings screen will return to the DTF screen.

7. Troubleshoot the cabling or antenna system as required. The screen provides a continuous, real-time display so that changing conditions are displayed immediately.

Table 6-2 Distance to Fault Frequency Range vs. Distance Resolution

Selected Range	Frequency Sweep Width	Minimum Center Frequency	Typical Resolution
1500 ft	12.8 MHz	7 MHz	5 ft
600 ft	32 MHz	17 MHz	2 ft
300 ft	64 MHz	33 MHz	1 ft
150 ft	128 MHz	65 MHz	6 in
60 ft	320 MHz	127 MHz	2.5 in
30 ft	640 MHz	321 MHz	1.25 in



LEGEND
1 DISTANCE INDICATOR
2 RIGHT
3 PEAK
4 RANGE
5 VELOCITY FACTORS MENU
6 NOT APPLICABLE
7 MENU ICON
8 BACK ICON
9 VELOCITY FACTOR VALUE
10 CENTER FREQUENCY
11 LEFT

8.

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Figure 6-3. Distance to Fault screen

Table 6-3. Distance to Fault Description

CALLOUT	NAME	DESCRIPTION
1	Distance Indicator	Moves yellow indicator line to a specific distance
2	Right	Moves distance indicator to the right
3	Peak	Moves distance indicator to the peak anomaly
4	Max Distance	When selected, the Max Distance popup menu will display where you may select 1500 feet, 600 feet, 300 feet, 150 feet, 60 feet, or 30 feet.
5	Velocity Factors Menu	Specifies type of dielectric to determine velocity factor. • See Table 6-3
6	Not Applicable	This selection is not applicable for DTF.
7	Menu Icon	Displays the Home/Settings menu.
8	Back Icon	When selected, the VSWR/DTF/Cable Testing screen will display.
9	Velocity Factor	Displays velocity factor being used for distance calculation
10	Center Frequency	Selectable frequency being used for the test
11	Left	Sets DTF Indicator (1) to left position.

Table 6-4. Common Avionics Coaxial Cable Types

COAXIAL CABLE	TYPE	VELOCITY FACTOR
RG-58/A	Solid PE	66%
RG-174	Solid PE	66%
RG-400	Solid PTFE	70%
RG-142	Solid PTFE	70%
RG-316	Solid PTFE	69%

6.4 CABLE LOSS TESTING

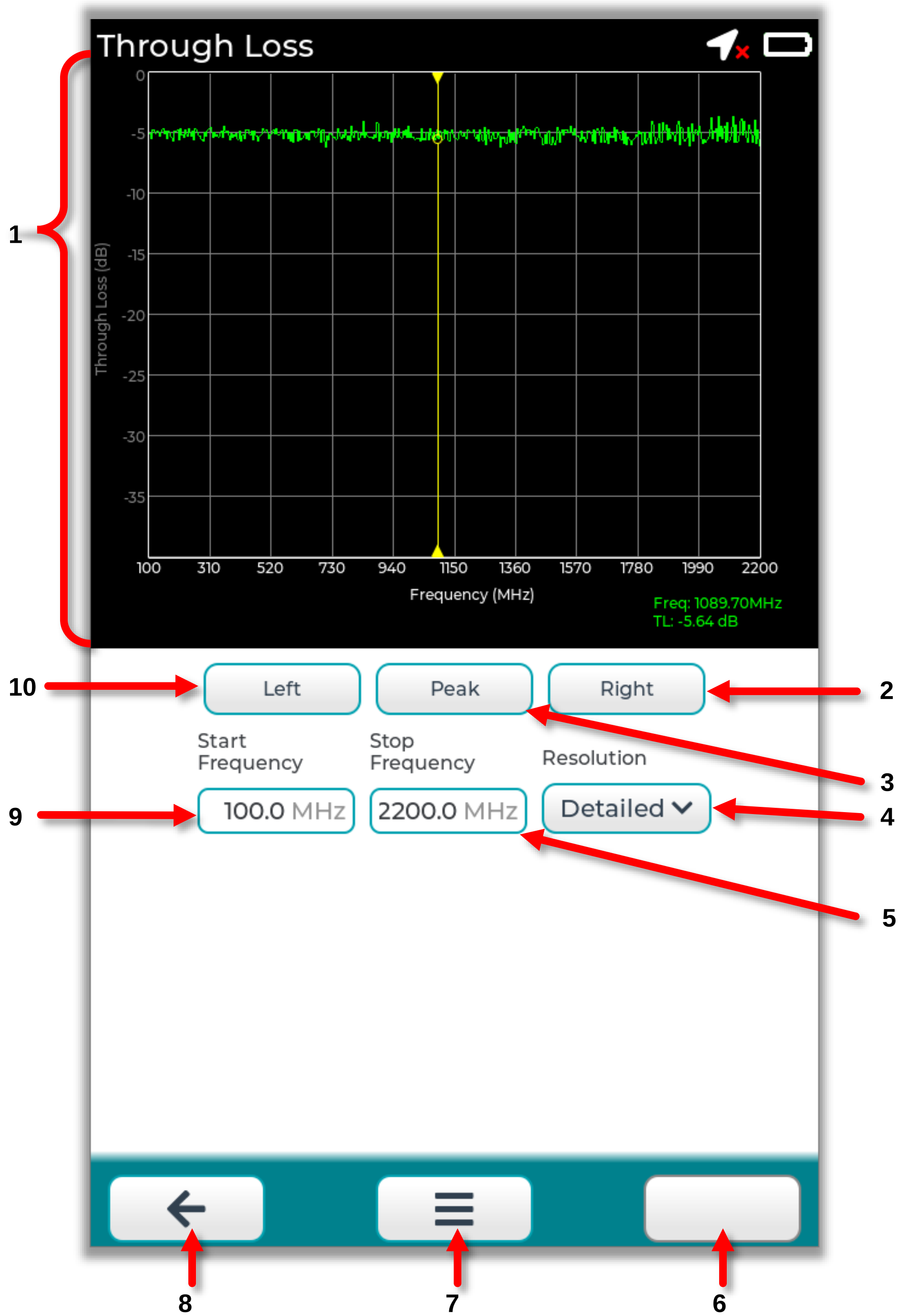
The SDR-OMNI is able to measure the RF path loss (also known as Through Loss or Insertion Loss) between the two end points of an RF coaxial cable. This is particularly useful to determine if a cable is damaged or if the coaxial connectors have been improperly installed.

1. From the **Home** Menu screen, select **General-> Cable Test**. The **Through Loss** screen (Figure 6-4) will appear.
2. Connect the 12” Insertion Loss Calibration Cable (Figure 2-12) between the ANT-A and ANT-B BNC connectors.
3. Press the **Thru Cal** start button. The unit will sweep through its entire frequency range to do a through loss calibration cycle. A green checkmark will appear when complete.
4. The **Save Cal** button should highlight after the calibration cycle. Press this to save this calibration data. If the SDR-OMNI is powered off, but then used again later in the day to do through loss measurements, it is not necessary to recalibrate the unit unless the ambient temperature has changed significantly. Simply press **Load Cal** to restore the previous calibration data.
5. Remove the calibration cable and connect the test article (e.g. a newly fabricated cable) to the ANT-A and ANT-B connectors on the SDR-OMNI. If RF coaxial adapters are required, remember to account for the loss in each adapter (usually 0.5 to 1.0 dB per adapter).

NOTE

Through Loss will not be selectable until Thru Cal has been completed.

4. Select **Through Loss**. The SDR-OMNI will begin the Throughput Loss testing and display the results as a graph of Through Loss in –dB vs. Frequency.
5. Ensure that the **Start Frequency** and **Stop Frequency** are properly set for the operating frequency range of the cable under test.
6. Review the results and change parameters as necessary.



LEGEND
1 **FREQUENCY INDICATOR**
2 RIGHT
3 PEAK
4 RESOLUTION MENU
5 STOP FREQUENCY
6 NOT APPLICABLE
7 MENU ICON
8 BACK ICON
9 START FREQUENCY
10 LEFT

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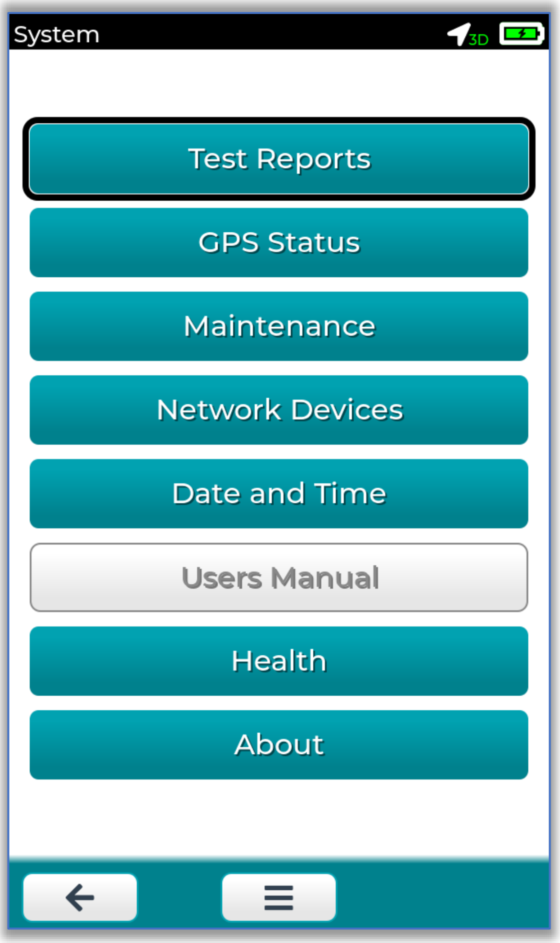
Table 6-55. Through Loss Field Description

CALLOUT	NAME	DESCRIPTION
1	Frequency Indicator	Yellow line indicating loss at a specific frequency
2	Right	Moves Indicator to the right
3	Peak	Sets Indicator to the frequency with the highest loss value
4	Resolution Menu	**Coarse**: fewer frequency points **Detailed**: more frequency points
5	Stop Frequency	When selected, a virtual number keypad will display to enter the Stop Frequency in MHz.
6	Not Applicable	This selection is not applicable for Through Loss.
7	Menu Icon	Displays the Home/Settings menu.
8	Back Icon	When selected, the Through Loss Calibration screen will display
9	Start Frequency	Enter the low end of the frequency range desired
10	Left	Moves Indicator to the left

CHAPTER 7 SDR-OMNI SYSTEM MENU

The SDR-OMNI System Menu (Figure 7-1) is accessed from the Home screen. It allows the operator to access various SDR-OMNI status pages.

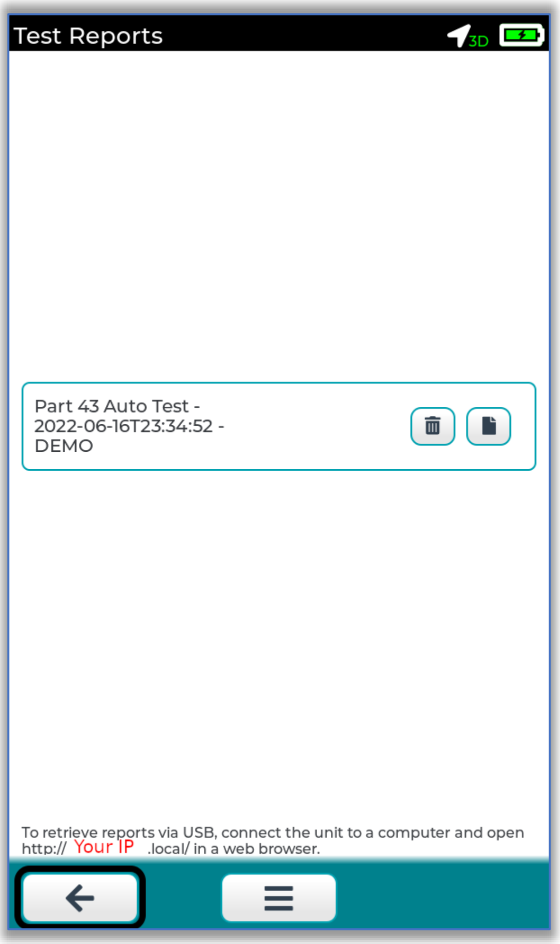


2023-CLS-TIC-0062

Figure 7-1 System Menu

7.1 TEST REPORTS

This lists the Test Reports (in PDF format) (Figure 7-2) that have been saved. Press the File icon to view or the Trash icon to delete. Paragraph 4.6 explains how to print a report using a PC or laptop. See Figure 7-2 for an example.

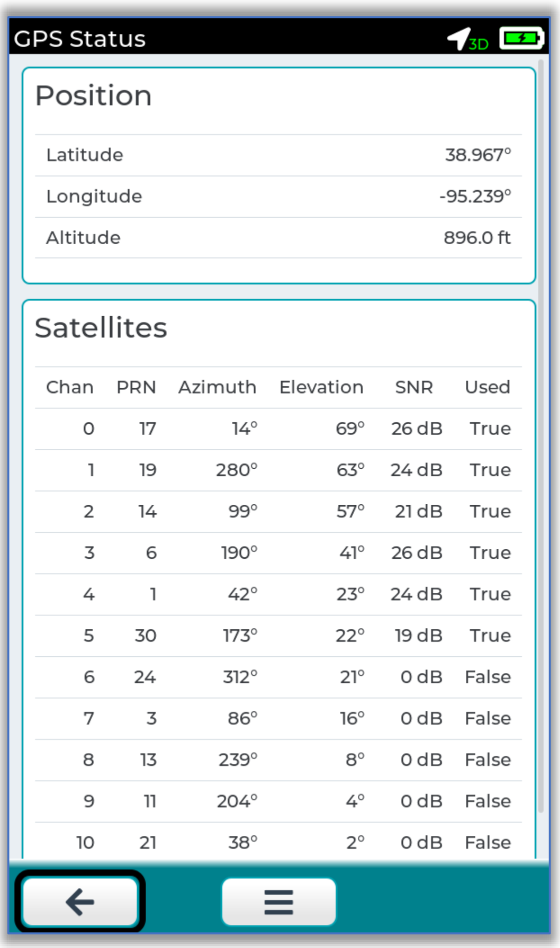


2023-CLS-TIC-0063

Figure 7-2 Test Reports Screen

7.2 GPS STATUS

This page displays the status of the internal GPS receiver. A minimum of four satellites is necessary to generate a position fix. The lower portion of the screen shows the satellites that are being received and their signal strengths. When at least four satellites have been received, the upper portion of the screen will display the position fix: latitude, longitude, and altitude. See Figure 7-3 for an example.



2023-CLS-TIC-0064

Figure 7-3. GPS Status Screen

7.3 MAINTENANCE

This screen is for factory access only.

7.4 NETWORK DEVICES

The Network Devices screen shows internal Ethernet-like IP addresses, Network masks, and communications status of internal communication busses. See Figure 7-4 for an example.

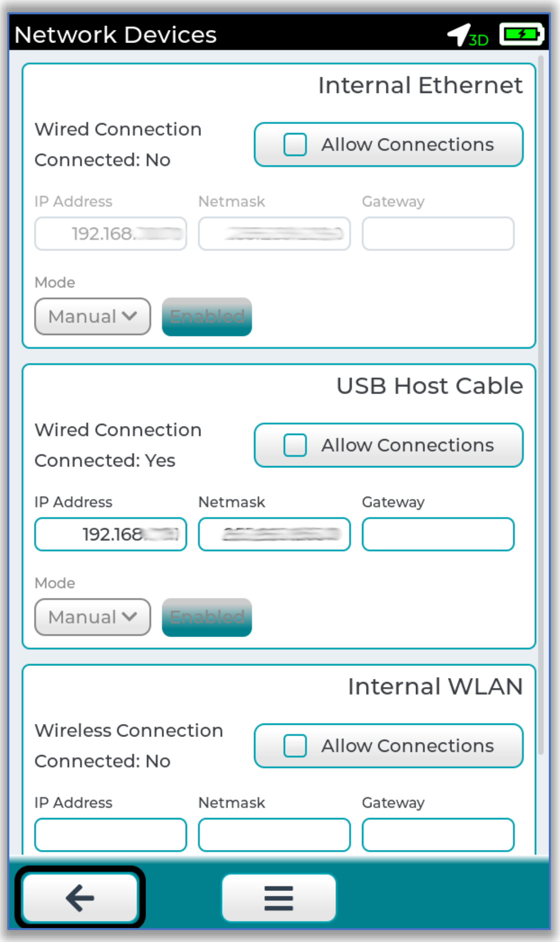


Figure 7-4. Network Devices Screen

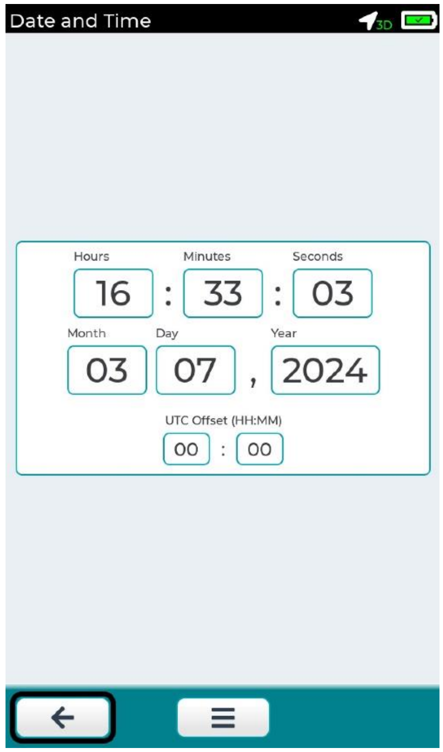


Figure 7-5. Time and Date Screen

7.5 DATE AND TIME

The internal GPS receiver automatically sets the time and date are whenever it has established a position. This screen can be used to override those values until the next GPS fix is established, for whatever reason.

Typically, this screen is used to set the UTC offset so that the correct local time is printed on test reports.

7.6 USERS MANUAL

The PDF User's Manual will be accessible from this screen when this feature is released in a future software update.

7.7 HEALTH

This screen (Figure 7-6) displays the results of the most recent BIT (Built-In Test) test Expand any of the lines to view the detailed result of each module test.

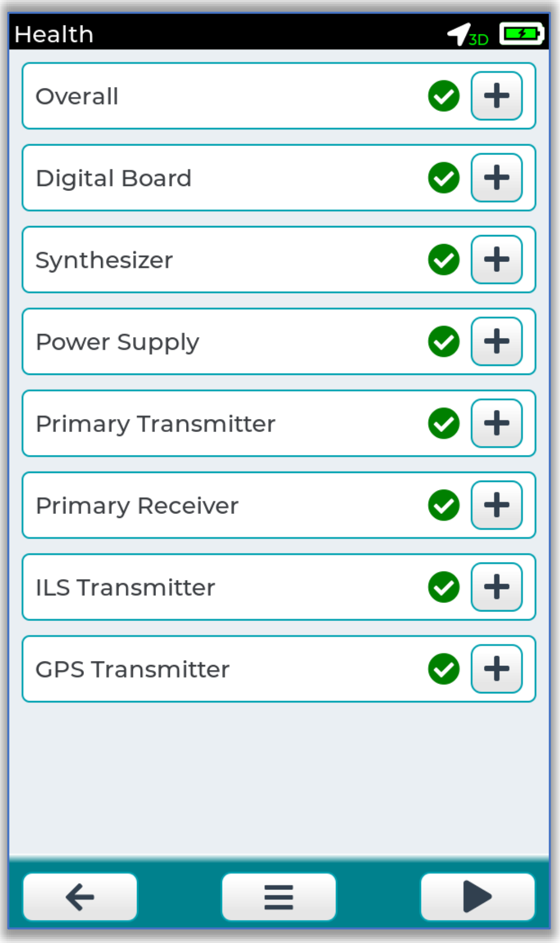


Figure 7-6 SDR-OMNI BIT Health Results screen

Pressing the ► button in the lower right will rerun the BIT test and refresh the results.

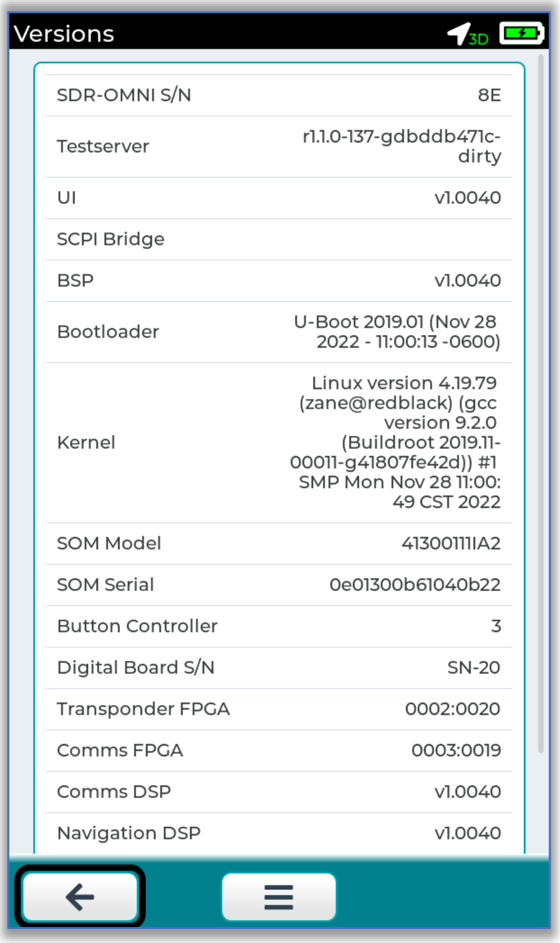
7.8 ABOUT

7.8.1 Open-Source Licenses

This page displays the text from all the Open-Source Licenses that are used in the SDR-OMNI software code.

7.8.2 Versions

This page (Figure 7-5) displays the version of each of the software, FPGA, and DSP components and modules in the SDR-OMNI Code.



2023-CLS-TIC-0066

Figure 7-5 Versions screen

CHAPTER 8 SDR-OMNI SPECIFICATIONS

Table 8-1. Physical and Environmental

SPECIFICATION	DESCRIPTION
SDR-OMNI Size	12 x 7 x 2 inches (30 x 18 x 5 cm)
Weight	SDR-OMNI alone: 4.4 lb. (2.2 kg) With transit case and accessories: 22 lb. (10 kg)
Environmental	MIL-PRF-28800F, Class 1
Temperature	Operating: -4 °F to 131 °F (-20 °C to +55 °C) Storage: -40 °F to 160°F (-40 °C to +71 °C)
Moisture	Splash proof (watertight when in transit case)
Vibration	Random 10-500 Hz
Shock	30 G 1/2 sine
Transit Drop	SDR-OMNI alone: 18 inches (46 cm) Transit case: 3 ft (1 m)
Altitude	Operating: 15,000 ft (4600 m)
Explosive Atmosphere	Yes, except AC adapter/charger which is indoor use only
EMC	EN 61326 and FCC Docket 20780

Table 8-2. Power Specs

SPECIFICATION	DESCRIPTION
Battery	7.5 AH 7.4 V Li-Ion, over 4 hours of continuous operation
External DC	+16 to 24 Vdc +/-10% (2.5A max)
Surge Protection	MIL-STD-704F (+/-50V peak surge)
AC Adapter/Charger	Output: +24 VDC, 2.5A max Input: 100-240 Vac +/-10% 45-65 Hz (indoor use only)

Table 8-3. Features and Capabilities

SPECIFICATION	DESCRIPTION
Air Traffic Control	ATC Transponder modes A, C, S Mode S 1090 MHz ADS-B IN/OUT UAT (978 MHz) ADS-B IN/OUT
Navigation	ILS (including LOC, GS, and MB) VOR ADF NDB
Communications	AM: HF, VHF, and UHF FM: HF, VHF, and UHF Audio generator: single/dual sine, triangle, ramp, square Audio measurements: S/N, distortion, level measurement
Other	406 MHz ELT/PLB Cable test - VSWR, Distance to Fault, Cable Loss (0.2 MHz to 1500 MHz)

Table 8-4. Connectors

SPECIFICATION	DESCRIPTION
RF Direct	N female
Antenna A	BNC female
Antenna B	BNC female
Wi-Fi	Reverse SMA
GPS	SMA
External Power	Captivated Barrel Connector
USB	Micro-B female USB
Headset	3.5 mm TRRS, Android Compatible
Test Connector	15 pin HD, UUT audio in/out, PTT, demodulated output
Aux Input	2 BNC female, external analog input
Computer Interface	Micro-B female USB, Wi-Fi 2.4 GHz

Table 8-5. GPS Receiver

SPECIFICATION	DESCRIPTION
Position	Current test set position and time is available to test applications
Time Accuracy	Test set tracks UTC Time +/-60 ns (when GPS signals are acquired)

Table 8-6. TAP-OMNI Transponder/DME Antenna Coupler

SPECIFICATION	DESCRIPTION
Antenna Compatibility	Standard blade antenna, with adapter for dipole antenna
Antenna attachment	Padded lever actuated clamp retains coupler in any position
Cable	33 ft (10 m) cable attaches to test set Direct T/R connector.
Accuracy	+/- 1 dB (+ test set T/R port accuracy)

Table 8-7. Digital I/O

SPECIFICATION	DESCRIPTION
High Voltage Logic Output	1 channel open collector type
Connector	TEST connector, DB-15 HD
Max voltage	50V peak (output off state)
Max current	100 mA (output on state)

Table 8-8. Headset Connector

SPECIFICATION	DESCRIPTION
Connector	3.5 mm TRRS (Tip = Left, Right, ground, Sleeve = mic)
Compatibility	Android type (also compatible with mono/stereo headphone)
Phone Output level	2 Vp-p max open circuit (mono drives both Left and Right)
Impedance	50 ohms
Mic Input Level	200 mVp-p maximum
Mic Bias	2.2 V/2.2 kilo ohms equivalent circuit to power mic element
Mic Switch	150 ohms nominal threshold, PTT toggle mode can be selected
Typical Usage	Mic can modulate signal generator, receiver audio through headphone

Table 8-9. Audio Measurement Input

SPECIFICATION	DESCRIPTION
Connector	On TEST connector, DB-15 HD
Frequency	20 Hz to 20 kHz at -1 dB (filters off)
Input Impedance	10 kilo ohms
Filters	300Hz - 3 kHz BPF, C-MSG, CCITT
Usage	Connect to headphone or speaker output of UUT audio system
Level Measurement	30mVrms to 10 Vrms
Resolution	1 mVrms
Accuracy	5% of reading + resolution (100 Hz to 10 kHz)
SINAD	3 to 40 dB
Level Range	100 mVrms to 10 Vrms
Resolution	0.1 dB to 20 dB
Accuracy	+/- 0.5 dB at 10 to 12 dB
Distortion	0.5 to 20%
Level Range	100 mVrms to 10 Vrms
Resolution	0.1%
Accuracy	+/- 0.5%
Frequency	300 Hz to 3 kHz (measured frequency)

8.1.1 Applications

Table 8-10. Transponder Mode S / ATCRBS Test Application

SPECIFICATION	DESCRIPTION
Frequency	Accuracy of +/-50 kHz with Mode S, +/-100 kHz SIF modes
Power	Direct +40 to +60 dBm (10 to 1000 w) Antenna: -30 dBm to +20 dBm (calibrated to effective radiated power)
Accuracy	1.5 dB direct, 2 dB over the air (10-foot to 200-foot test distance)
MTL	-90 to -60 dBm direct or antenna effective radiated power level
Accuracy	1.5 dB direct, 2 dB over the air (10-foot to 200-foot test distance)
Pulses	Width and spacing of all pulses measured, indicated pass/fail or listing
Accuracy	+/- 25 ns
Reports	FAA part 43F test automatically performed, results in PDF format.

Table 8-11. 1090 ADS-B Test Application

SPECIFICATION	DESCRIPTION
ADS-B Out Test	Reports transponder data, results in FAA part 227 PDF format
ADS-B IN Test	Simulates up to four fixed 1090 ADS-B targets
Dynamic	Four fixed single moving targets (level, climb, dive, pass above)
Sensitivity	For receiver test: -90 to -40 dBm direct, -50 to 0 dBm antenna
Accuracy	+/- 1.5 dB direct, +/-2 dB antenna (5 to 150 feet test distance)

Table 8-12. UAT ADS-B Test Application

SPECIFICATION	DESCRIPTION
ADS-B Out Test	Reports UAT transponder data, results in FAA part 227 PDF format
ADS-B IN Test	Simulates up to four UAT ADS-B targets or a ground uplink test message
Dynamic	Four fixed single moving targets (level, climb, dive, pass above) User programmable scenarios can be programmed and stored
Sensitivity	For receiver test: -90 to -40 dBm direct, -50 to 0 dBm antenna
Accuracy	+/- 1.5 dB direct, +/-2 dB antenna (5-foot to 150-foot test distance)

Table 8-13. 406 MHz ELT Application

SPECIFICATION	DESCRIPTION
Frequency Measurement	+/-0.5 ppm
Power Measurement	+/- 1 dB
Data	Displays raw or decoded message data

Table 8-14. SELCAL Application

SPECIFICATION	DESCRIPTION
SELCAL	Burst or continuous repeat modes
Tone Squelch	20 to 300 Hz in 0.1 Hz steps

Table 8-15. ILS Signal Generators

SPECIFICATION	DESCRIPTION
Three RF signal generators are combined to transmit on antenna port B to allow over the air testing of navigation and autopilot systems requiring a full complement of navigation signals.	
Marker Beacon Generator:	
Frequency	75.0 MHz
Accuracy	0.5 ppm
Level	+10 dBm to -70 dBm
Resolution	0.25 dB
Accuracy	+/- 2 dB
Modulation	AM, 400, 1200, 3000 Hz at 30-95%
Localizer/VOR Generator:	
Frequency	108 to 118 MHz, default 108.0 (VOR) or 108.1 (LOC)
Resolution	50 kHz (or manual 1 Hz)
Accuracy	0.5 ppm
Level	0 dBm to -100 dBm

SPECIFICATION	DESCRIPTION
Resolution	0.25 dB
Accuracy	+/- 2 dB
LOC Modulation	AM, 90 & 150 Hz at 20-40% with variable DDM; 1020 Hz ID 10-30%
VOR Modulation	AM, 30 Hz & 9960 subcarrier 20-40% with variable Bearing, 1020 Hz ID 10-30%, audio tone 20-40%
Glide Slope Generator:	
Frequency	328.6 to 335.4 MHz (linked to LOC frequency)
Resolution	150 kHz (or manual 1 Hz)
Accuracy	0.5 ppm
Level	0 dBm to -100 dBm
Resolution	0.25 dB
Accuracy	+/- 2 dB
Modulation	AM, 90 & 150 Hz at 20-40% with variable DDM

Table 8-16. RF Signal Generator - General

SPECIFICATION	DESCRIPTION
Frequency Range	200 kHz to 2200 MHz
Resolution	1 Hz
Accuracy	0.5 ppm
Tuning speed	100 microseconds to within 1 kHz of final frequency
Modulation	Internal: CW, AM, FM, FSK, + application specific External: mic input via headset jack
Sources	Internal dual audio generators, application specific generators

Table 8-17. RF Signal Generator - Spectral Purity

SPECIFICATION	DESCRIPTION
Residual FM	Less than 30 Hz RMS 50Hz to 15 kHz
Residual AM	Less than 0.1% RMS 50Hz to 15 kHz
Phase Noise	Less than 90 dBc/Hz @ 10 kHz offset
Harmonics	<30 dBc
Non-Harmonics	<50 dBc

Table 8-18. RF Signal Generator - Direct Port Output

SPECIFICATION	DESCRIPTION
Level	-30 dBm to -120 dBm
Resolution	0.1 dB
Accuracy	1.5 dB -30 to -100 dBm, 2.5 dB below -100 dBm
Output Impedance	50 ohms, return loss more than 20 dB to 1 GHz, more than 16 dB above 1 GHz
Input power	25 watts (30 seconds on, 2 minutes off), 1 kW pulse (less than 5 watts average)
Connector	N female
Antenna Port outputs	2 (A & B antennas)
Level	Port A: +7 to -100 dBm; Port B: +4 to -100 dBm
Resolution	0.1 dB
Accuracy	1.5 dB to -80 dBm, 2.5 dB below -80 dBm
Output Impedance	50 ohms, return loss greater than 15 dB
Maximum input	1 watt above 100 MHz, 100 mW below 100 MHz
Connector	BNC female

Table 8-19. RF Signal Generator – Modulation

SPECIFICATION	DESCRIPTION
Internal Modulation Rate	1 Hz to 20 kHz, 0.1 Hz resolution
Internal Waveforms	Sine, Dual Sine, Square, Ramp, Triangle
FM Deviation	0 to 25 kHz
FM Resolution	100 Hz
FM Accuracy	1%
FM Distortion	Less than 1% 20Hz to 10 kHz rate
AM Range	0 to 95%
AM Resolution	1%
AM Accuracy	+/-3% of setting 30% to 90%
AM Distortion	Less than 1% to 30 to 70% depth, less than 5% to 90%
Mic Input	AM, FM, 20Hz to 20 kHz bandwidth

Table 8-20. RF Measurement Receiver

SPECIFICATION	DESCRIPTION
Frequency Range	200 kHz to 2200 MHz
Resolution	1 Hz
Accuracy	0.5 ppm
Tuning speed	100 microseconds to within 1 kHz of final frequency
Modulation	CW, AM, FM, PM, SSB
Level Measurement Accuracy	+/- 2 dB

Table 8-21. RF Measurement Receiver - Measurement Level Range

SPECIFICATION	DESCRIPTION
Antenna	-70 dBm to +20 dBm 30 kHz BW, -40 dBm to +20 dBm 10 MHz BW
Direct	0 dBm to +50 dBm (to +60 dBm for pulse modulated signals)
Sensitivity (Antenna)	-70 dBm for 5 kHz dev 1 kHz rate FM 10 dB SINAD
Headphone Output	demodulated audio available on headset connector.

Table 8-22. RF Measurement Receiver – Modulation Meter

SPECIFICATION	DESCRIPTION
FM Range	100 Hz to 25 kHz (analog)
FM Resolution	10 Hz
FM Accuracy	3% of reading + resolution at 100Hz to 10 kHz rate
AM Range	1% to 95%
AM Resolution	1%
AM Accuracy	5% from 30% to 70% at 100 Hz to 10 kHz rate

Table 8-23. RF Measurement Receiver - Antenna Port

SPECIFICATION	DESCRIPTION
Range	-70 dBm to +20 dBm at 30 kHz BW (+17 below 100 MHz) -40 dBm to +20 dBm at 10 MHz BW (+17 below 100 MHz)
Resolution	0.1 dB
Accuracy	+/- 1.5 dB above -60 dBm, +/-2dB

Table 8-24. RF Measurement Receiver - Frequency Meter

SPECIFICATION	DESCRIPTION
Range	Tuned frequency +/- 1/2 of selected bandwidth
Reading	Frequency or Frequency Error
Resolution	1 Hz, 10Hz
Accuracy	0.5 ppm +/- 1 count, (0.01 ppm with GPS assist) analog signals

Table 8-25. RF Measurement Receiver - Direct Port

SPECIFICATION	DESCRIPTION
Range	1 W to 100 W average, 10 W to 1 kW for pulse only
Resolution	0.1 W for less than 50 watts, 1 W for greater than 50 watts
Accuracy	15% of reading +1 digit.
Max Power	5 W average; non-pulse: 30 seconds on at 25W, 15 seconds on at 50 W (2min off)
Pulse	1% duty cycle to 500 W, 0.5% duty cycle to 1kW

Table 8-26. Audio Signal Generator Output

SPECIFICATION	DESCRIPTION
Connector	On TEST connector, DB-15 HD
Frequency	20 Hz to 20 kHz -1 dB
Max level	2 Vp-p / 0.7 Vrms open circuit; 1Vp-p / 0.35 Vrms into 50 ohms
Min level	3 mVrms (sine), with reduced performance to 0.5 mVrms
Resolution	0.1 mV for less than 100 mV level, 1 mV for greater than 100 mV levels
Level Control	rms or p-p for sine, p-p for other waveforms. Calibrated levels for open circuit
Level Accuracy	5% of setting + resolution
Source Impedance	50 ohms
Waveforms	sine, square, ramp, triangle, dual sine, Avionics SELCAL
Distortion (Sine)	Less than 0.5% at frequencies below 10 kHz and levels above 30 mVrms
Usage	Connect to microphone input of UUT (test set provides PTT control)

Table 8-27. VSWR

SPECIFICATION	DESCRIPTION
Frequency Range	1 MHz to 1.5 GHz
Return Loss Scales	0 to 30 dB, labeled in both dB return loss and VSWR ratio
Accuracy	+/-1 dB at 14 dB (1.5:1), +/-2 dB at 26 dB return loss (1.1:1)
Connector	Signal source port A (BNC), measurement input port B (BNC)
External Detector	Impedance bridge type, 1 MHz to 1.5 GHz, N connector Supports bridge or directional coupler type detector devices
Calibration	Uses open and short

Table 8-28. Distance to Fault

SPECIFICATION	DESCRIPTION
Measurement Type	Swept frequency method, center frequency is user selectable
Ranges	0-30 to 0-1500 feet (9 to 450 m) at 67% velocity factor (max range is dependent on selected velocity factor)
Accuracy	0.5% of selected distance range

CHAPTER 9 ACRONYMS AND ABBREVIATIONS

° ....Degrees

°C ....Degrees Celsius

°F....................Degrees Fahrenheit

A ....Ampere

AC ....Alternating Current

ACAS ....Airborne Collision Avoidance System

ADF ....Automatic Direction Finder

ADS-B ....Automatic Dependent Surveillance – Broadcast

AH ....Ampere Hours

AM ....Amplitude Modulation

ATC ....Air Traffic Control

ATCRBS.........Air Traffic Control Radar Beacon System

AUX SV ....Auxiliary State Vector

BDS................Binary Data Storage

BP...................Band-Pass

BPF ....BP Filter

BW..................Bandwidth

C-MSG ....C-Message

Cal ....Calibration

CCITT.............Consultative Committee on International Telephone and Telegraph

CDI ....Course Deviation Indicator

CE ....European Conformity

cm...................centimeters

COMM............Communication

COSPAS ....Cosmicheskaya Sistyema Poiska Avariynich Sudov (Russian for “Space System for the Search of Vessels in Distress”)

CPR................Cardiopulmonary Resuscitation

CW ....Continuous Wave

dB ....Decibel

dBc ....Decibel relative to Carrier

dBm ....Decibel-Milliwatts

DC ....Direct Current

DDM ....Difference in Depth of Modulation

DME ....Distance Measuring Equipment

DTF ....Distance-to-Fault

E ....East

EHS ....Enhanced Surveillance

ELT ....Emergency Locator Transmitter

EMC ....Electromagnetic Compatibility

EN ....Europäische Norm (German for “European Norm”)

ESD ....Electro-Static Discharge

FAR ....Federal Aviation Regulation

FCC ....Federal Communications Commission

FIS ....Flight Information Service

FM ....Frequency Modulation

FSK ....Frequency-Shift Keying

ft......................Feet

G.....................Gravity (unit of)

GHz ....Gigahertz

GICB...............Ground Initiated Comm-B

GPS................Global Positioning System

GS ....Glide Slope

HD ....High Definition

HDR................Header

HF...................High Frequency

HSI ....Horizontal Situation Indicator

HZ...................Hertz

IEC ....International Electric Commission

ID ....Identification

ILS ....Instrument Landing System

in.....................Inches

kg....................Kilograms
kHz ....Kilohertz
kW ....Kilowatts
Lat ....Latitude
lb.....................Pounds
LED ....Light Emitting Diode
LF ....Low Frequency
Li-Ion ....Lithium-Ion
LOC ....Localizer
Lon ....Longitude
LP ....Low-Pass
LSB.................Lower Side Band
m ....Meter
mA..................Milliamperes
mm ....Millimeter
MB ....Marker Beacon
MCC ....Mission Control Center
Mic..................Microphone
Mode S ....Mode Select
MS ....Mode Status
MTL ....Minimum Trigger Level
mV..................Millivolts
mVrms............Root-Mean-Square Millivoltage
N.....................North; Neill (for connector)
NAV ....Navigation
NDB................Non-Directional Beacon
ns....................Nanosecond
OMB ....Omni Bearing Selector
p-p ....Peak-to-Peak
PC ....Personal Computer
PDF ....Portable Document Format
PE...................Polyethylene
PLB.................Personal Locator Beacon
PM ....Phase Modulation
POC................Point of Contact
ppm ....Parts-Per Million
PTFE ....Polytetrafluoroethylene
PTT................ Push-To-Talk
R.................... Reference
RF.................. Radio Frequency
RMA............... Return Material Authorization
RMS............... Root Mean Square
RX.................. Receive
S .... South
S/N................. Signal-to-Noise
SARSAT .... Search and Rescue Satellite-Aided Tracking
SDR .... Software Defined Radio
SELCAL......... Selective Calling
sic .... Sic Erat Scriptum (Latin for “As it was written”)
SIF .... Standard Interchange Format
SINAD .... Signal-to-Noise and Distortion
SLS................ Sidelobe Suppression
SMA............... Subminiature version A
SSB .... Single-Sideband Modulation
SV .... State Vector
TACAN .... Tactical Air Navigation System
TCAS............. Traffic Collision Avoidance System
THD .... Total Harmonic Distortion
THD+N .... THD plus Noise
Thru .... Through
TIS-B .... Traffic Information System – Broadcast
TNC .... Threaded Neill-Concelman
TS .... Target State
TST................ Test (in Morse Code)
TRRS............. Tip, Ring, Ring, Sleeve
TX .... Transmit
UAT .... Universal Access Transceiver
UHF .... Ultra-High Frequency
USB .... Universal Serial Bus (for connector or wire); Upper Side Band
UTC .... Universal Time Coordinated
UUT .... Unity Under Test

V ....Variable

VAC ....Volts Alternating Current

VDC................Volts Direct Current

VHF ....Very High Frequency

VOR ....VHF Omnidirectional Range

Vp-p ....Peak-to-Peak Voltage

VRMS ....Root-Mean-Square Voltage

W ....Watt (unit of measurement); West

VSWR.............Voltage Standing Wave Ratio

Wi-Fi ....Wireless Fidelity

CHAPTER 10 NAVIGATION SYSTEM PRINCIPLES

10.1 INSTRUMENT LANDING SYSTEM (ILS)

The ILS provided horizontal, vertical and distance guidance using radio antennas and transmitters located at the end of a runway along the centerline. The system has three separate components as described in Table 10-1.

Table 10-1. ILS Components

NAME	GUIDANCE	TRANSMITTED
Localizer (LOC)	Horizontal (left and right)	Very High Frequency (VHF) navigation band from 108.10 – 111.95 Megahertz (MHz), using every odd 100 kilohertz (kHz) channel
Glideslope (GS)	Vertical (up and down)	Ultra-High Frequency (UHF) navigation band from 329.15 – 335.00 MHz
Marker Beacon (MB)	Distance from end-of-runway	75 MHz

The GS frequency is paired with the LOC frequency so that when the pilot selects the LOC frequency, the ILS receiver will automatically select the correct paired GS frequency. However, the MB frequencies are not paired with the ILS receiver.

Both the LOC (Figure 10-1, 2) and GS (3) transmit Radio Frequency (RF) carriers are modulated with a 90 hertz (Hz) signal (4) and 150 Hz signal (5). When an aircraft (6) is receiving both signals, and both signals are received at equal amounts of 90 and 150 Hz modulation, the aircraft is On Course (7). If the aircraft is receiving more modulation of one signal than the other, the receiver will display an Offset to On Course (7) - either Left/Right or Above/Below.

When an aircraft is On Course, a typical Horizontal Situation Indicator (HSI)/Course Deviation Indicator (CDI) instrument (8) will show a GS Deviation Bar (9) with a centered GS Indicator (10) and a LOC Deviation Bar (11) with a centered LOC Indicator (12).

When an aircraft is offset from On Course, a typical HSI/CDI instrument (Figure 10-2, 8) will show an offset the GS Deviation Bar (9) with the GS Indicator (10) and/or LOC Deviation Bar (11) with the LOC Indicator (12). The GS Indicator may be above or below centered while the LOC Indicator may be to the left or right of centered.

The MB provides distance to the runway (Figure 10-3, 1) information for approaching aircraft (2). There are typically three transmitters -- Inner Marker (3), Middle Marker (4), and Outer Marker (5). All three transmit at 75 MHz, modulated at different audio frequencies for identification (see Table 10-2). The Inner marker is modulated at 3000 Hz, Middle at 1300 Hz, and the Outer at 400 Hz. As the aircraft flies over the transmitters, located along the ILS course, the MB receiver receives the signal and illuminates the appropriate light on the instrument panel (Figure 10-4).

The SDR-OMNI also provides Difference in Depth of Modulation (DDM).

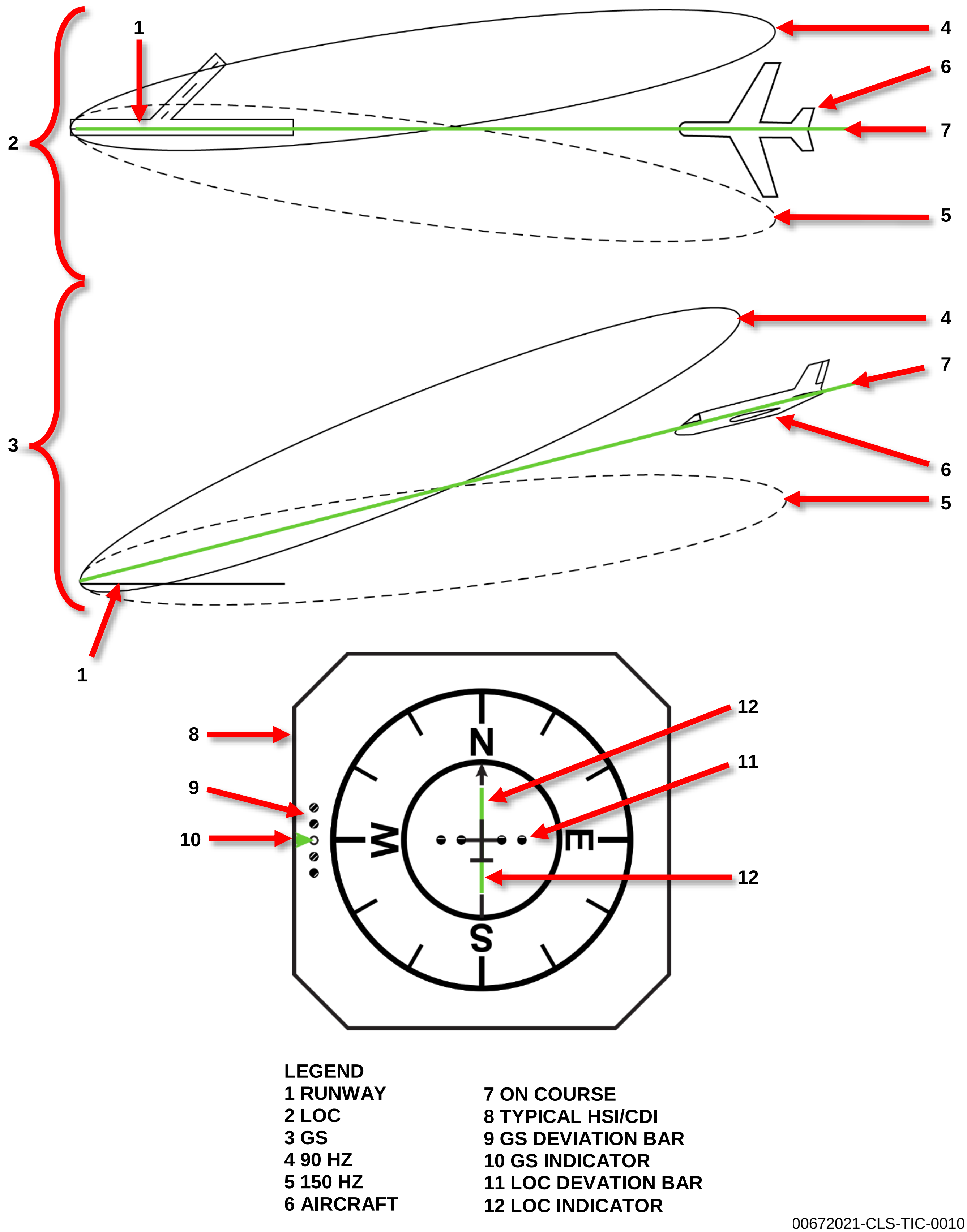
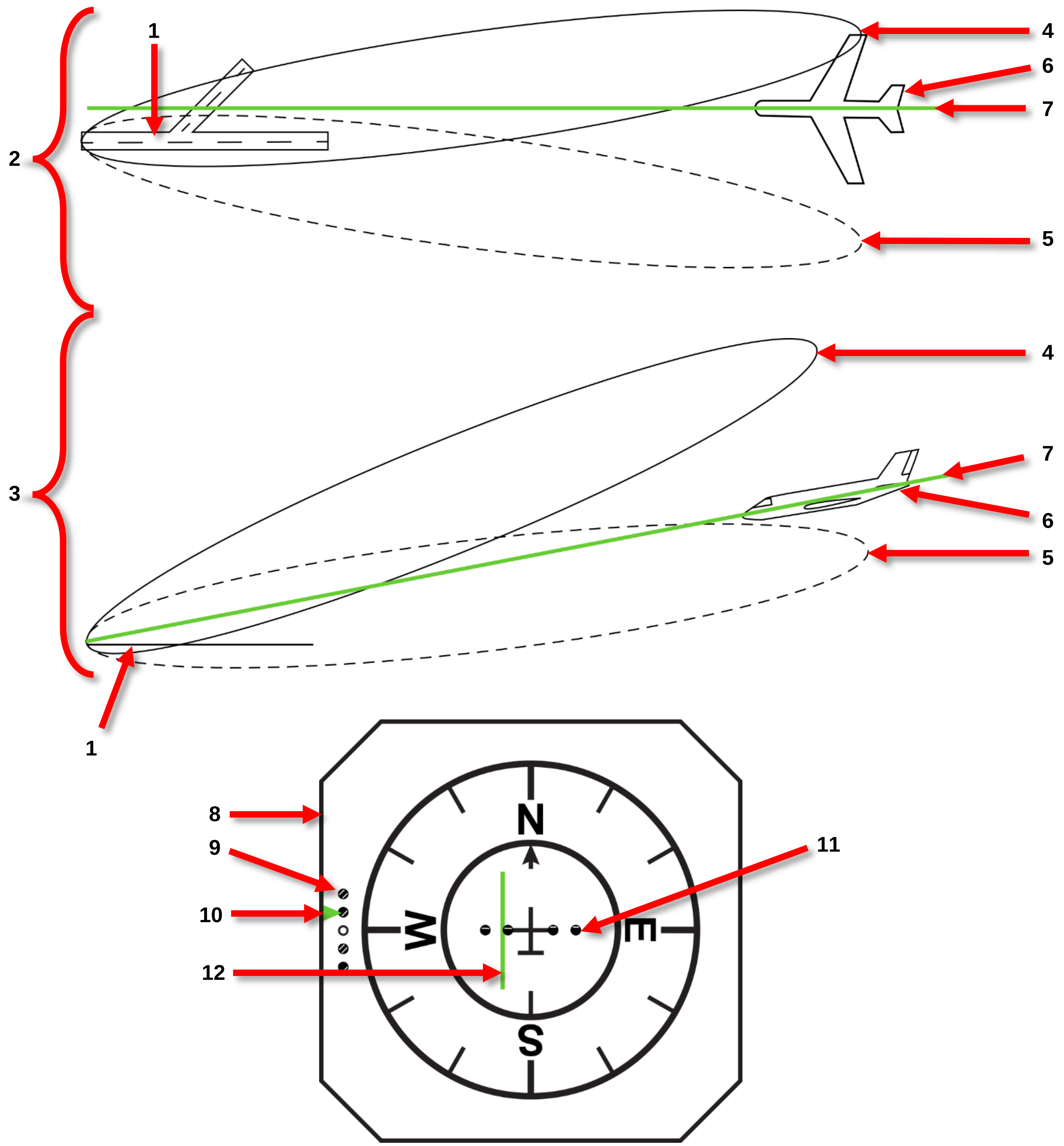


Figure 10-1 Aircraft On-Course with LOC and GS



LEGEND

1 RUNWAY
2 LOC
3 GS
4 90 HZ
5 150 HZ
6 AIRCRAFT
7 OFFSET OF ON COURSE
8 TYPICAL HSI/CDI
9 GS DEVIATION BAR
10 GS INDICATOR
11 LOC DEVATION BAR
12 LOC INDICATOR

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Figure 10-2. Aircraft Offset with LOC and GS

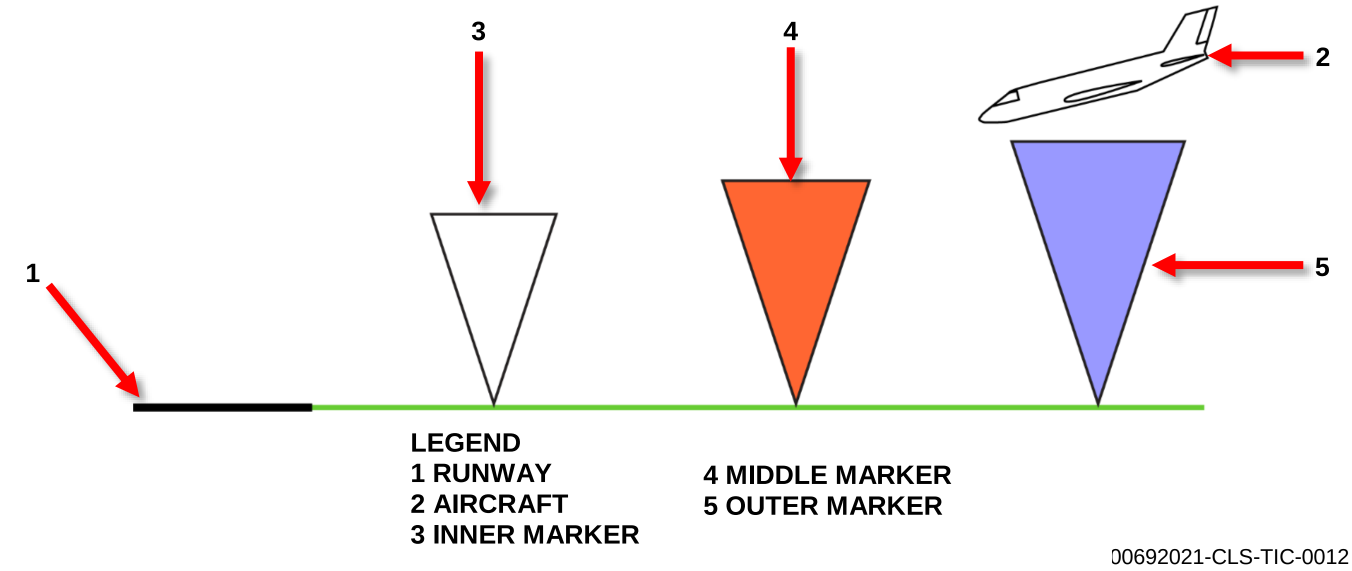

Figure 10-3. Typical MB Locations

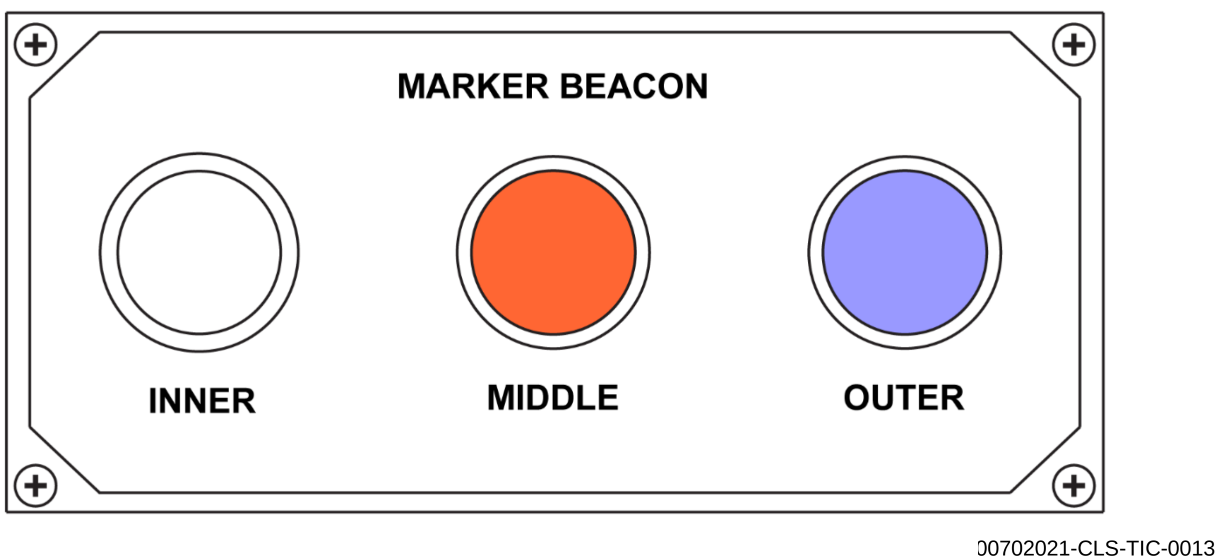

Figure 10-4. Typical MB Display

Table 10-2 Typical MB Approach Characteristics

MARKER	DISTANCE FROM RUNWAY	FREQUENCY/MODULATION	LENS COLOR
Inner	1000 feet (300 meters)	75 MHz/3000 Hz	White
Middle	3000 feet (900 meters)	75 MHz/1,300 Hz	Amber
Outer	4 to 10 miles (6.5 to 16 kilometers)	75 MHz/400 Hz	Blue

10.2 VHF OMNIDIRECTIONAL RANGE (VOR)

VOR is a VHF navigational aid to determine the bearing of an aircraft from a fixed point on the ground. The VOR ground station (Figure 10-5, 1) transmits a VHF carrier modulated with an audio composite of two 30 Hz signals -- a reference and a variable signal. The reference signal is fixed in space, whereas the phase of the variable signal changes depending on the azimuth position of the aircraft. When in line-of-sight of a VOR ground station, the aircraft VOR receiver will detect and compare the phase relationship between the reference and variable signals and translate it to a bearing from the ground station (relative to 0 degrees (º) North).

The reference signal ("R" in Figure 10-5) is a 30 Hz signal which frequency modulates (FM) a 9960Hz subcarrier. The frequency modulated signal is then used to amplitude modulate (AM) the RF carrier.

The variable signal ("V" in Figure 10-5) uses the same carrier frequency but no modulation from the transmitter. The signal is modulated at 30 Hz by the rotation of the antenna.

The 30 Hz AM variable signal and 30 Hz FM reference signal are timed (by the rotation of the antenna) to be in phase at a relative position due north of the VOR station.

Figure 10-5 demonstrates the variable and reference signal relationships at the cardinal directions. At due North (N), the signals are in phase. At due East (E), the signals are 90° out of phase. At due South (S), the signals are 180° out of phase. At due West (W), the signals are 270° out of phase. The VOR received in the aircraft measure this phase difference and displays the information as the correct bearing TO or FROM the ground station.

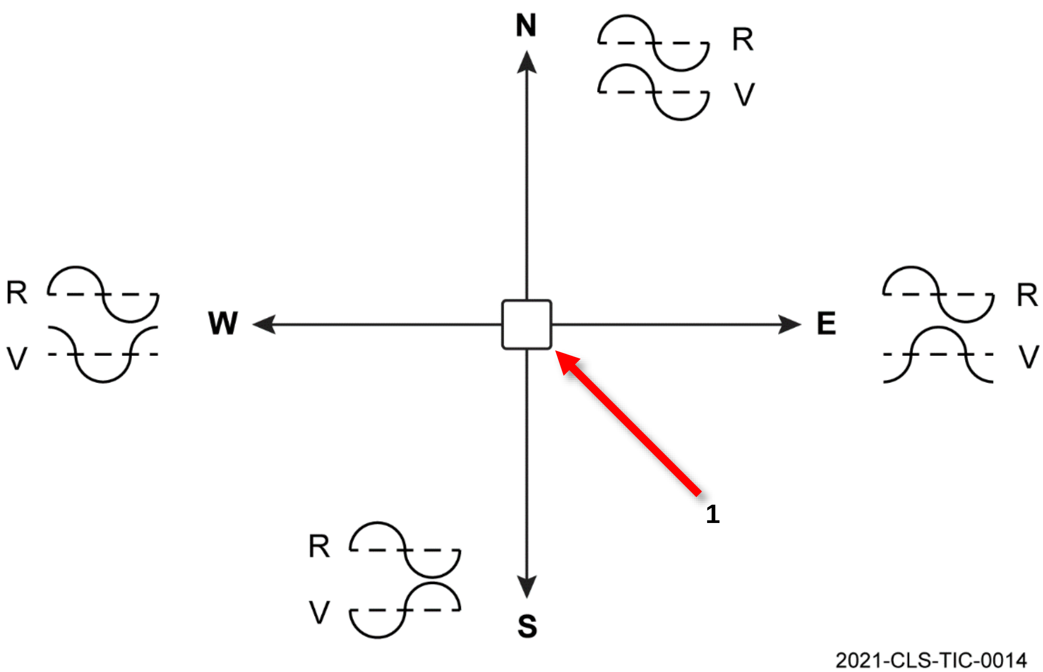

Figure 10-5. Phase Relationship between Variable and Reference Signals