AUTOMATIC DEPENDENT SURVEILLANCE - BROADCAST (ADS-B) SYSTEM OPERATIONS/TRAINING MANUAL

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Prepared By:
Freestate Electronics, Inc.
6530 Commerce Court
Warrenton, VA 20187

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Approved by:
Freestate Electronics, Inc.
Name: Ronald M. Harris
Title: President
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1 GENERAL INFORMATION

1.1 Overview of the ADS-B Test Set System

The Automatic Dependent Surveillance - Broadcast (ADS-B) Test Set is designed to assist in the development, maintenance, certification, and test of either air or ground based ADS-B equipment and systems. An ADS-B Test Set System, comprised of three ADS-B Test Sets, generates the signals required to verify receiver compliance with the operational test standards established in RTCA document DO-260A.

The ADS-B generates 1090 MHz signals that allow full characterization of ADS-B receiver performance. This capability includes the generation of fully programmable ADS-B squitter signals, ATCRBS or Mode S Fruit, or pulse modulated RF. Data content and transmission timing may be either static or random. The format and data content of all transmission signals generated by the ADS-B Test Set may be logged to disc to assist in the verification of receiver performance.

The ADS-B generates continuous wave (CW) and pulsed RF signals. Pulsed signal transmissions are created in response to either internal or external triggers. A receiver within the ADS-B Test Set verifies the data content of signals generated by an ADS-B transmitter.

Control of ADS-B instrument operations is through either a GPIB interface to a dedicated Operator Control Subsystem (OCS) laptop computer or through a user designed control system connected to either the GPIB interface or the rear panel serial port.

The ADS-B Test Set features include:

- ATCRBS and Mode S Fruit generation
- Random data and timing of Fruit signals
- Mode S Squitter Signal generation
- High accuracy output levels, from 0 dBm to -95 dBm
- Generation of signals to verify receiver preamble functions
- Generation of signals to verify receiver error correction functions

1.2 ADS-B Test Set - Physical Description

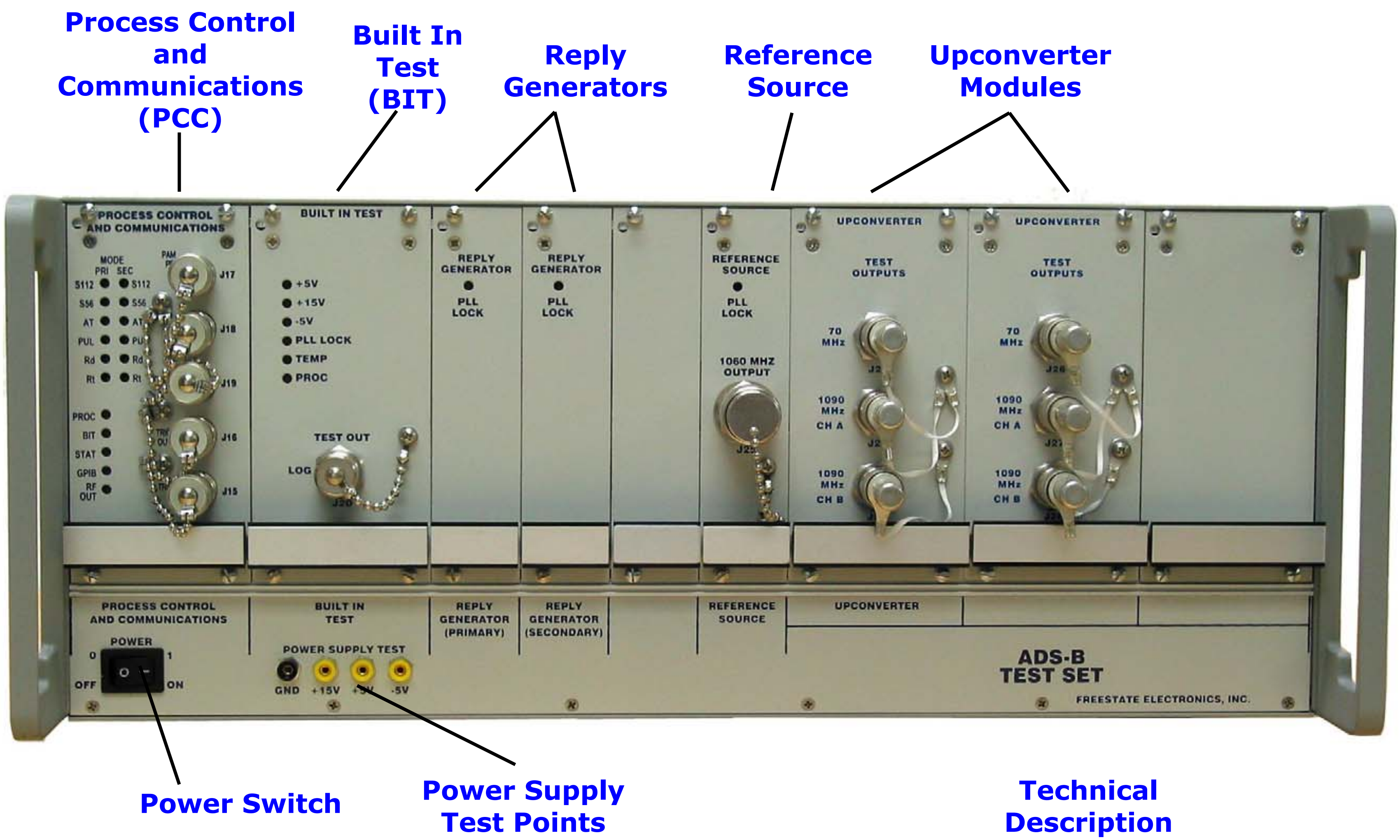
The ADS-B electronics are contained within a 7" high by 19" wide chassis configured to mount into any standard equipment rack. All signal processing and generation takes place within seven plug-in modules. Included are two (primary and secondary) Reply Generator Modules, two Upconverter Modules, one Reference Source Module, one Built In Test Module, and one Process Control and Communications Module. Each module uses blind-mate style connectors that interface with a mating connector on a motherboard assembly. This configuration simplifies the removal of any module for test or repair purposes. The MTTR of any module is under five minutes. All modules are completely shielded to minimize EMI and RFI effects. Detailed chassis and module descriptions are found in Section 5.

1.2.1 ADS-B Front Panel Overview

Figure 1 shows the modular structure of the ADS-B mechanical design. The chassis design is based upon concepts inherent in the industry standard VXI chassis. However, because of rigorous RF signal specification requirements (phase, amplitude, and isolation) the mechanical design varies somewhat from VXI standards.

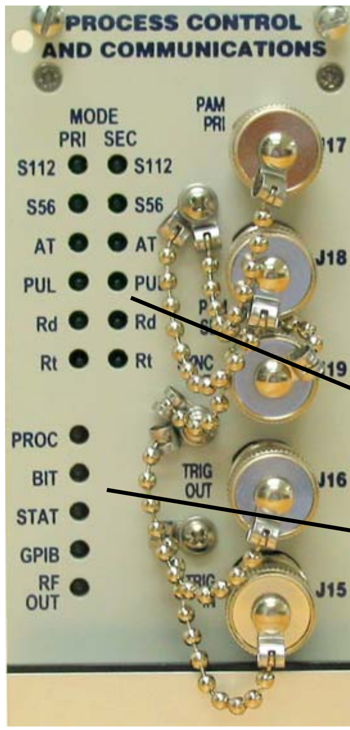
The seven plug-in modules are easily discerned. Blank filler panels fill voids in the front panel where required. In addition to the plug-in modules, the chassis also houses two power supplies plus a signal-interconnect motherboard. Power supply monitoring test points are located on the chassis front panel. Handles protect the front and rear panels from damage.

Figure 1. ADS-B Front Panel



1.2.2 Module Test Ports and Status Indicators

1.2.2.1 PCC Module Test Ports and Status Indicators



Transmit modulation and timing data signals are available at front panel test connections of the PCC Module. Status indicators, also on front panel of the PCC Module, provide important insight into the operating condition of the ADS-B instrument. The PCC Module test ports and status indicators are discussed below.

PAM PRI and SEC Data. Signals at J17 – PAM and J18 - PAM SEC indicate the timing and characteristics of all pulsed RF signals from the two signal generation channels of the ADS-B unit. These signals are routed directly to the Pulse Amplitude Modulation (PAM) circuit within the primary and secondary Reply Generator Modules. A TTL low signal enables the generation of RF output signals from the ADS-B.

TRIG OUT Data. A trigger pulse signal at J16 – Trigger Out is created for every transmission event from the ADS-B. This pulse is the zero time reference for all transmissions. The implementation of transmission time delays, as set through the use of the OCS controls, is referenced to this time mark.

TRIG IN. The input J15 –External Trigger In, is the connection through which pulse triggers are applied to the ADS-B.

NOTE

The time between consecutive trigger signals must be greater than time it takes for the ADS-B to generate a transmission. Make sure that the time delay settings are appropriate for the repetition rate of the applied trigger signal. The ADS-B will (1) ignore trigger signals received while generating a transmission from a previously detected trigger, and (2) generate a dropped trigger alarm.

SYNC OUT Data. A trigger pulse signal at J19 - SYNC OUT of the master ADS-B unit is used to synchronize the timing of transmission events of slave ADS-B units. Connect a short, 3 foot or less, 50 ohm cable between J19 of the master unit and J15, Trig In, of the slave units. The Sync Out pulse occurs slightly in advance of the Trigger Out signal to account for the inherent time delay of the cables between the units.

Mode Indicators. Two rows of Mode Indicators on the front panel of the PCC Module display the setup and trigger status of each generator channel of the ADS-B.

Each row of indicators displays the transmission signal type for a given signal generator channel, primary or secondary. A transmission event causes the LED associated with the event to momentarily turn GREEN. Transmissions indicators include 112 bit Mode S (S112), 56 bit Mode S (S56), ATCRBS (AT), and pulse (PUL). An ADS-B transmission is defined as an S112 event. Indicators also illuminate when random data (Rd) and random time (Rt) processes are in use.

Status Indicators. A single row of Status Indicators on the front panel of the PCC Module display the operational status of the ADS-B unit.

PROC LED. The PROC LED indicates the status of monitored processor functions within the PCC Module. This LED normally flashes green once a second. When processes are suspended the LED is yellow. When the ADS-B is processing a reset command the LED is red.

BIT LED. The BIT LED indicates the status of monitored BIT functions such as internal temperature, power supply voltages, memory integrity, etc. The LED is normally green. A red LED indicates a failure.

STAT LED. The STAT LED indicates the status of both signal generator channels. If both channels are off, the LED will also be off. If the PROC LED is yellow (suspended operations), a blinking red STAT LED indicates a failed calibration, excessive operating temperature, or a power supply problem. If the PROC LED is yellow, a blinking yellow STAT LED indicates a dropped signal trigger (check trigger setup). The STAT LED is normally a solid green.

GPIB LED. The GPIB LED indicates the status of communications over the IEEE-488 interface. The LED is green when the interface is active.

RF OUT LED. The RF OUT LED is green when one of the primary RF output channels of the ADS-B, either channel A or B, is selected for use.

The RF OUT LED is yellow when the BIT signal path, internal to the ADS-B, is selected.

1.2.2.2 BIT Module Status Indicators and Test Port

Status indicators on the BIT Module front panel provide additional insight into the operating condition of the ADS-B instrument. The BIT module, see Figure 1, measures and monitors the output voltage of the DC power supplies (+15V, +5V, and -5V) and the air temperature internal to the chassis. The BIT module also monitors the status of the processor and PLL circuits within the module. The status of all monitored processes is communicated to the PCC Module.

+5V LED. A green LED is illuminated when the +5V output is at +5±0.25 volts. A red LED is illuminated when an out of tolerance condition is detected.

+15V LED. A green LED is illuminated when the +15V output is at +15±0.5 volts. A red LED is illuminated when an out of tolerance condition is detected.

-5V LED. A green LED is illuminated when the -5V output is at -5±0.25 volts. A red LED is illuminated when an out of tolerance condition is detected.

PROC LED. The PROC LED indicates the status of monitored processor functions within the BIT Module. This LED normally is a solid green. A problem with the BIT processor is indicated by a red LED.

TEMP LED. The TEMP LED indicates the status of the internal temperature of the ADS-B unit. If the internal temperature is not within 0ºC and 65ºC a fault condition (red LED) will be displayed.

PLL LOCK LED. The status of both PLL circuits within the BIT Module is indicated by the PLL Lock LED. Normal operation is indicated by a green LED. A fault condition is indicated by a red LED.

LOG Signal Test Port. This port provides an accurate and repeatable video signal that corresponds to the power level of the selected 1090 MHz signal. For normal operation the 1090 MHz signal is derived from the rear panel 1090 MHz RF Input interface (J30). During BIT operations signals are from modules internal to the ADS-B instrument. Dynamic performance of the log amp is sufficient for pulse signal evaluation.

1.2.2.3 Reply Generator Module Status Indicator

PLL LOCK LED. The status of the PLL circuit within the Reply Generator Module is indicated by the PLL Lock LED. Normal operation is indicated by a green LED. A fault condition is indicated by a red LED.

1.2.2.4 Reference Source Module Status Indicator and Test Port

PLL LOCK LED. The status of the PLL circuit within the Reply Generator Module is indicated by the PLL Lock LED. Normal operation is indicated by a green LED. A fault condition is indicated by a red LED.

1060 MHz REFERENCE Test Port. The Local Oscillator signal that is used to convert 70 MHz IF signals to 1090 MHz is found at this interface. To generate a 1090 MHz output from the ADS-B unit the LO signal is at 1020 MHz. By default the output is OFF, and the LO signal will be at a level of less than -40 dBm. Refer to the REFLVL and REFOE IEEE-488 commands to adjust signal level.

1.2.2.5 Upconverter Module Test Ports

Front Panel 1090 MHz Outputs. Signals at the active 1090 MHz test output ports are approximately 20 dB below the level of signals at the corresponding rear panel outputs. For instance, if the rear panel Channel A output signal is at a level of -10 dBm, the Channel A 1090 MHz Test Output signal level will be approximately –30 dBm.

Front Panel 70 MHz Outputs. Signals at the 70 MHz test output ports are approximately 23 dB below the level of signals at the corresponding rear panel outputs. For instance, if the rear panel Channel A output signal is at a level of -10 dBm, the 70 MHz Test Output signal level will be approximately –33 dBm.

1.2.3 ADS-B Rear Panel Overview

Figure 2 shows the rear panel of the ADS-B. The rear panel includes various RF and data interfaces, the AC power input connector, and the fuse holder. Detailed descriptions of the use and function of each interface can be found by using the blue text links.

AC power is applied through an industry standard IEC filtered power connector located on the chassis rear panel. The ADS-B Test Set operates from 115 to 230 VAC, at 50 - 60 Hz. The specified operational temperature range is from +10ºC to +50ºC.

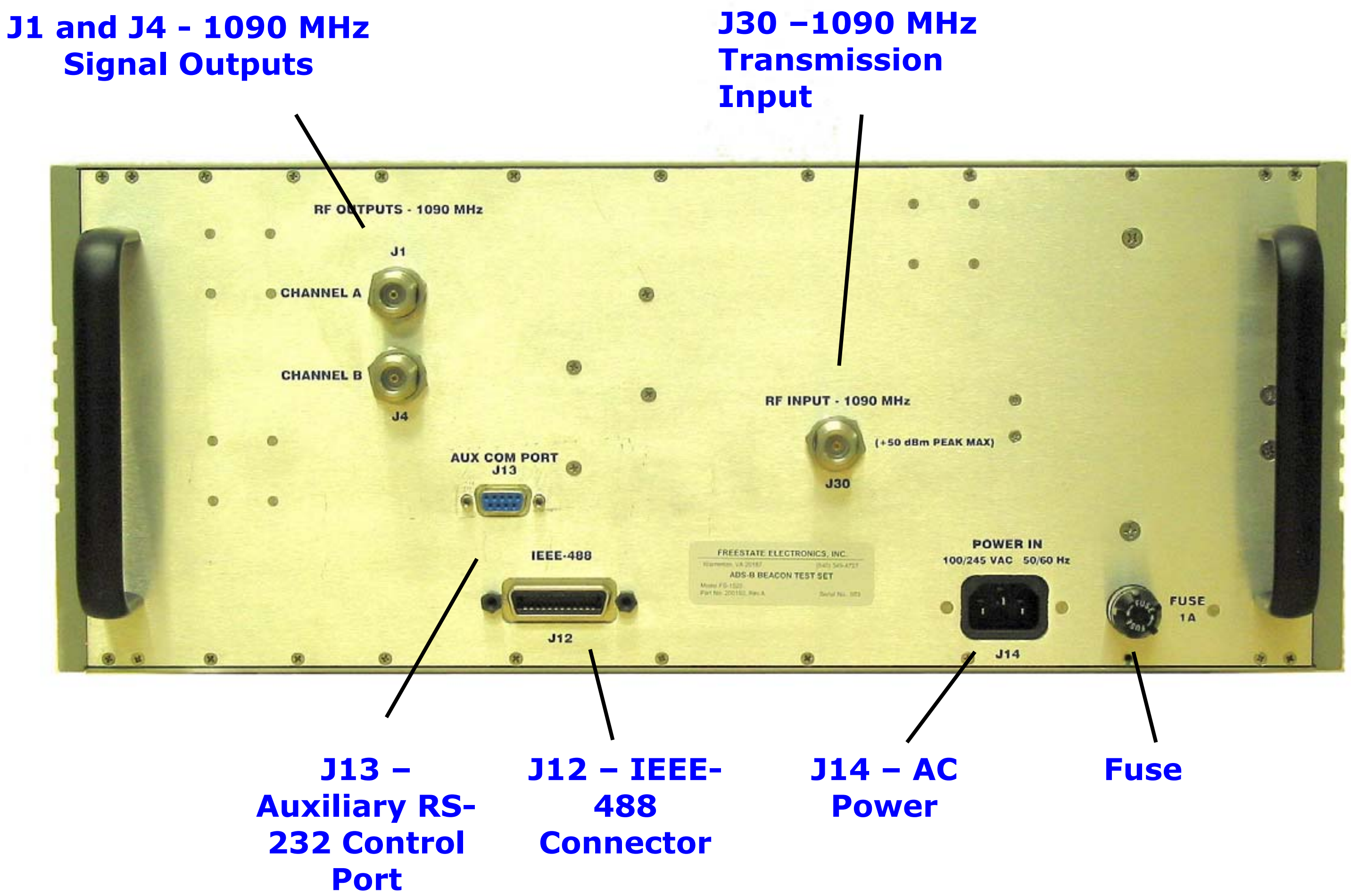
1.2.3.1 1090 MHz Signal Outputs, J1 and J4

Signals generated by the ADS-B instrument are routed through either the Channel A (J1) or Channel B (J4) ports to ADS-B receiver equipment. The output level of each of the two signal generator channels is programmed independently, from 0 dBm to -95 dBm.

1.2.3.2 1090 MHz Signal Input, J30

Signals from an external ADS-B transmitter are applied to the dedicated interface, J30. Acceptable signal levels are +30 dBm to +50 dBm. In no case should applied peak power exceed +50 dBm.

Figure 2. ADS-B Rear Panel



1.2.3.3 RS-232 Control Port, J13

The Auxiliary RS-232 serial communications interface, J13, is located on the rear panel of the ADS-B. The serial interface conforms to the protocols listed in ANSI/TIA/EIA-232F. The interface operates at 9600 baud, with 8 data bits, 1 stop bit and no parity bit. Handshaking should be turned off.

1.2.3.4 IEEE-488 Control Port, J12

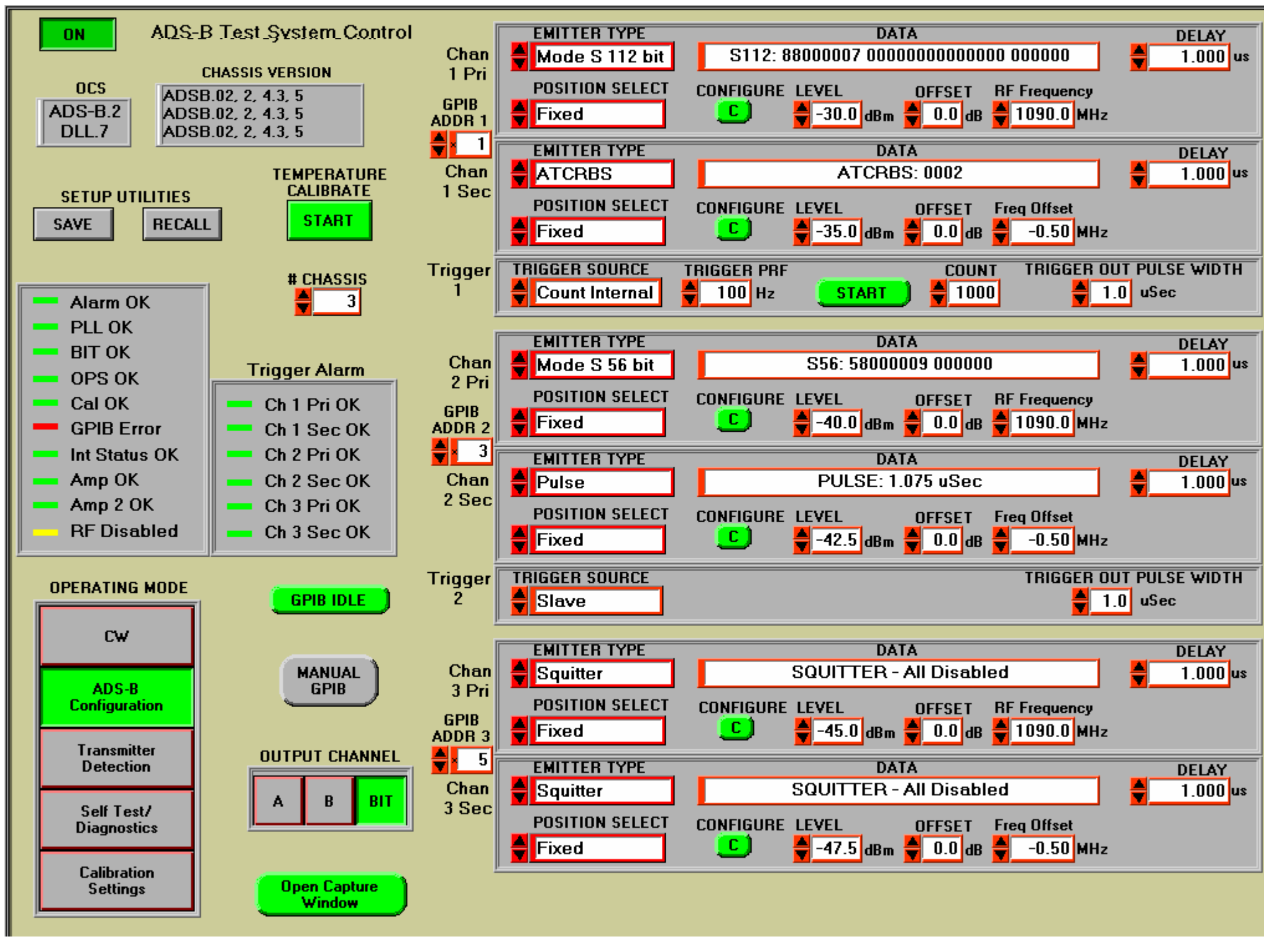
The IEEE-488 communications interface, J12, is located on the rear panel of the ADS-B. All pin name and numbering assignments are per IEEE-488 standards.

1.3 Operator Control Subsystem (OCS)

The ADS-B Operator Control Subsystem (OCS) provides a straightforward means to control and monitor the operation of up to three ADS-B instruments. The OCS consists of a Pentium laptop computer configured with an IEEE-488 PCMCIA (or USB) interface adapter and LabVIEW® based virtual instrument control software. Communication between the OCS and the ADS-B unit is through the IEEE-488 interface. The ADS-B IEEE-488 Command Set, FSE Document No. 200006, lists the commands, responses, and data formats required for proper remote control of the ADS-B unit.

As shown in Figure 3, the OCS software creates a simulated ADS-B instrument control panel from which all of the functions of the ADS-B unit can be controlled. A menu bar allows the operator to choose from five different ADS-B operational modes: the CW Mode, the ADS-B Transmit Configuration Mode, the Transmit Signal Detection Mode, the Self Test/Diagnostics Mode, and the Calibration Settings Mode. A selected set of operational conditions and parameters are controlled in each mode of operation. All changes to control settings are automatically communicated to the ADS-B. A detailed description of OCS functions, and of the various modes of ADS-B operation, can be found in the OCS sections of the following chapter.

Figure 3. Typical OCS Control Panel, 3 ADS-B Instrument Configuration



2 SYSTEM OPERATION

The ADS-B System includes two primary components, the ADS-B Test Set and the Operator Control Subsystem (OCS). The OCS computer uses a Microsoft Windows® operating system. The OCS software is fully compliant with Windows® system requirements. The following discussions assume a familiarity with the Windows operating system.

2.1 System Startup

CAUTION

Always check the system configuration before making signal connections. The application of high-energy RF signals to inappropriate I/O connectors may damage the ADS-B unit.

Use the following checklist when starting the system:

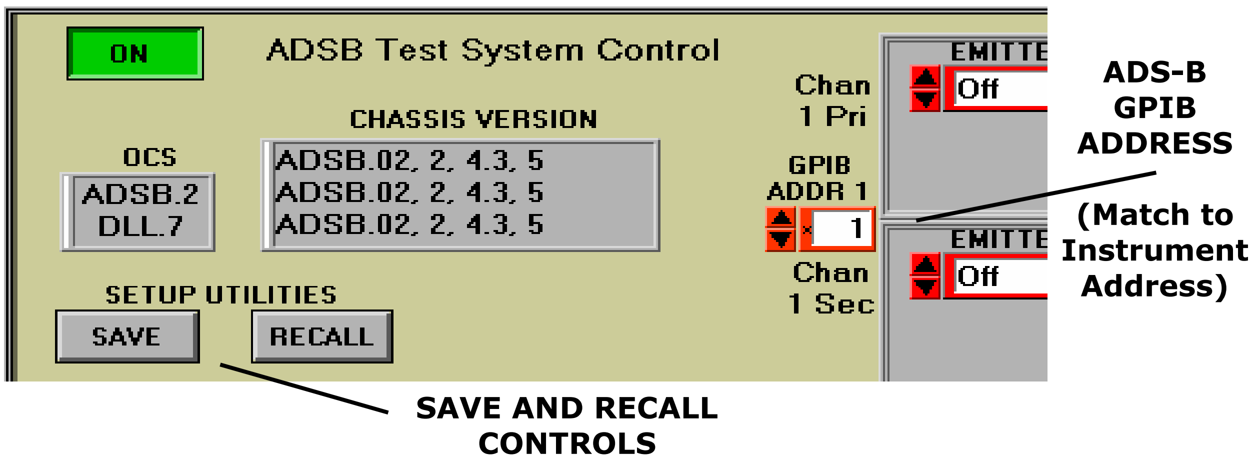
1. Verify the required operating configuration. If the ADS-B is to be connected to ADS-B transmitter equipment carefully plan cable runs and connections before the application of signals. CAUTION: The application of high-energy RF signals to inappropriate I/O connectors may damage the unit.
2. Verify that the laptop computer is connected to the ADS-B through the GPIB (IEEE-488) control port. The IEEE-488 adapter plugs into either the laptop computer's PCMCIA slot or USB port.
3. Verify that the ADS-B and the laptop computer are properly connected to a 110/220 VAC, 50/60 Hz power source.

4. Apply power to the ADS-B. The Phase Locked Loop (PLL) indicators should illuminate GREEN on the Built In Test Module, the Reply Generator Modules, and the Reference Source Module. Upon completion of all Built-In-Test (BIT) diagnostic tests the PROC LED on the PCC Module front panel will flash on (green) and off once every second. The BIT diagnostic test will require a few minutes to complete.
5. Apply power to the OCS computer. After Windows is fully loaded, activate the OCS software by double clicking on the "ADS-B" icon located on the desktop screen.
6. The OCS will automatically verify the GPIB connection to the ADS-B and will load default operational parameters. By default, the OCS places the ADS-B into the ADS-B Configuration operating mode. When the ADS-B Configuration mode control turns green the OCS virtual instrument panel is active and ready for operator input.

2.2 GPIB Address Setup

The GPIB address shown in the upper left area of the OCS window bus must agree with the address of each ADS-B instrument in a system. The address of each instrument is entered directly into the control boxes, or can be set through the use of the UP/DOWN arrows at the sides of the control boxes. ADS-B instruments are usually delivered with the GPIB address set to 1. More information on how to set the GPIB address of an ADS-B instrument is available in Section 5.2.5.2.1, PCC IEEE-488 Address Configuration and Calibration Setup.

Figure 4. OCS Shutdown Switch and IEEE-488 Address Select

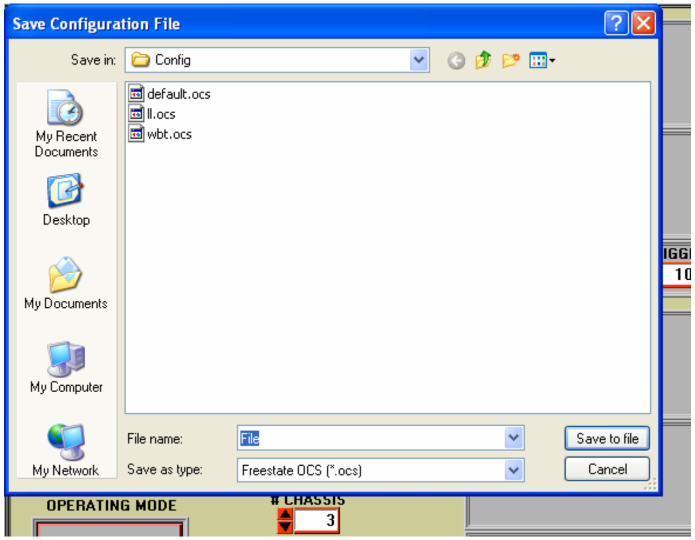


2.3 ADS-B Setup Save/Recall Functions

The operational settings of the ADS-B may be saved to and recalled from a file using these controls.

To save the current operating parameters to a file click on the "SAVE" control, as shown in Figure 4. This opens a Save Configuration window as shown below. Either enter a name for the file to be created or select any file from the list displayed (it is not recommended to save to other than the default folder). Click on the "Save to File" control. After the file is saved the OCS will resume normal operation.

To recall a previously saved setup click on the "RECALL" control. Pick the desired file from the displayed list. The OCS will recall all saved operational parameters, load these into the ADS-B, and reset the OCS control panel settings.



2.4 Shutdown

Close the OCS control panel by clicking the graphical ON Switch in the upper left menu area as seen in Figure 4.

Note

GPIB bus timeout errors will be generated if the ADS-B unit is turned off before the OCS software is disabled.

3 OCS OPERATION AND CONTROLS

The OCS operating screen, see Figure 3, is a non-resizable window displayed on the Windows® operating system desktop. It consists of numerous controls and displays organized by function. A description of each control is provided in the text that follows.

3.1 System Status

The System Status panel (see Figure 5) displays the status of important ADS-B operating conditions and functions. The OCS monitors these on a continuous basis. Four colors are used to display function status.

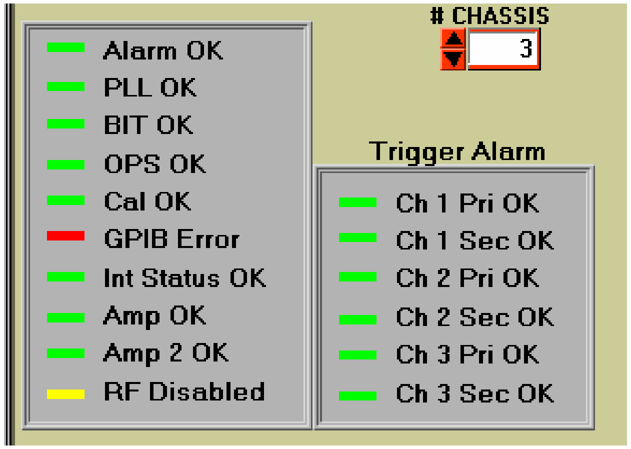
Green indicates that the function is operationally active and working properly.

Yellow is a cautionary indicator. The function is either inactive or in an indeterminate state.

Red indicates that the function is in a failure mode. Critical function failures detected by the OCS force the ADS-B into STANDBY Mode. Normal ADS-B operations can resume only after the fault is corrected.

The status of all monitored functions and operational conditions is displayed through the selection of the Self Test/Diagnostics Mode. See Sections 4.4.1.6, and 7.2 for corrective actions in case of a failure.

Figure 5. System Status Display



3.1.1 Alarm Status Indicator

The Alarm Status Indicator displays the condition of the ALARM status register of the ADS-B. Functions monitored include output signal calibration process, internal temperature, and power supply voltages. A fault condition for any of these functions results in a red indicator and an "Alarm Error" message.

3.1.2 Phase Lock (PLL) Indicator

The Phase Lock Indicator displays the status of the PLL status register of the ADS-B. The condition of all ADS-B phase locked loop circuits is monitored. Any detected fault condition results in a red indicator and a "PLL Error" message.

3.1.3 BIT Status Indicator

The BIT Status Indicator displays the condition of that portion of INTERR status register of the ADS-B related to BIT RF circuit test results. All RF control circuits are monitored. Any detected fault condition results in a red indicator and a "BIT Error" message.

3.1.4 Calibration Indicator

The Calibration Indicator changes to yellow and displays a "Cal Output" message whenever an internal recalibration of the ADS-B output signal level is recommended. Recalibration is recommended when the internal temperature of the ADS-B has changed significantly since the last calibration. When calibration of the ADS-B is indicated, use the Temperature Calibrate control to adjust the output level of the ADS-B.

3.1.5 GPIB Status Indicator

The GPIB Status Indicator displays the status of the GPIB link to the ADS-B. Any detected fault condition results in a red indicator and a "GPIB Error" message.

3.1.6 Internal Status Indicator

The Internal Status Indicator displays the status of that portion of INTERR status register of the ADS-B related to processor or memory function. Any detected fault condition results in a red indicator and an "Int Status Error" message.

3.1.7 RF Output Indicator

The RF Output Indicator is yellow whenever the output signal from the ADS-B is disabled. It is green when the use of either Channel A or Channel B is selected.

3.1.8 OPS Status Indicator

The OPS Status Indicator displays the status of the OP status register of the ADS-B. It is yellow, and an "OPS Suspend" message is displayed, if ADS-B operations are stopped or suspended. Changing signal parameters may temporarily suspend the generation of transmissions.

3.1.9 Amp and Amp2 Setting Status Indicators

The AMP setting Status Indicator is yellow, and an "AMP Conflict" message is displayed, if the output signal level is uncalibrated at the chosen control setting. The AMP2 Status Indicator applies to the settings of the second signal generator channel.

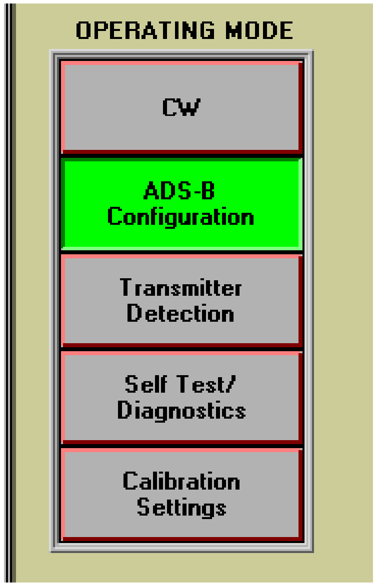
3.1.10 Trigger Indicators

The ADS-B monitors the correspondence between the number of trigger pulses and the number of transmission events. If a trigger is dropped, because there is a mismatch between the timing of transmission events and the application of event triggers, a yellow indicator is displayed. Primary and secondary signal generator channels have independent trigger alarm circuits.

3.2 Mode Select

The setting of the Mode Select control determines the operating mode of the ADS-B. The selected mode is highlighted as shown in the illustration below. A complete description of each operating mode can be found within the ADS-B Operational Mode Selection section.

Figure 6. Mode Select Panel



To OCS Front Panel

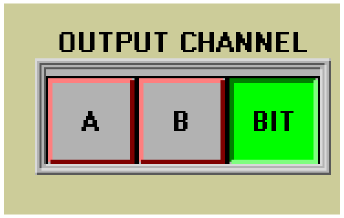
3.3 Output Select

The Output Select control sets the RF signal path through the ADS-B. Control options include the selection of output Channel A, output Channel B, or BIT (Built-In Test). The Channel A and B settings route signals to either the Channel A or the Channel B output connector located on the Rear Panel of the ADS-B. The control setting also determines signal presence at the 1090 MHz Channel A and Channel B test ports located on the front panel of each Upconverter Module.

The BIT setting routes the 1090 MHz signal of each Upconverter Module to the BIT Module. This signal path is automatically chosen whenever the operational mode of the ADS-B is changed. The ADS-B initializes with the BIT path selected.

The selected signal path is highlighted in bright green, as shown below.

Figure 7. Output Select



To OCS Front Panel

3.4 GPIB Control

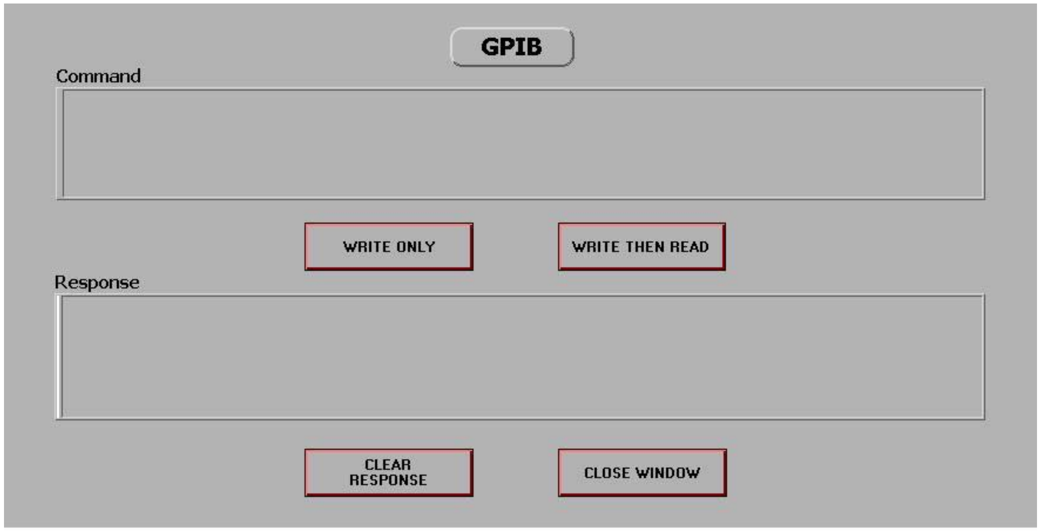
The Manual GPIB control, shown below, opens a GPIB control window (as seen in Figure 8), and a new GPIB session, in which any of the operational parameters of the ADS-B may be set and monitored through the entry of an appropriate GPIB command. This control provides a convenient means of setting and verifying ADS-B operations independent of OCS operations.

Commands are entered into the Command text box and sent to the ADS-B by use of the WRITE THEN READ control. Command responses are displayed in the Response text area. The ADS-B IEEE-488 Command Set document, FSE Document Number 200006, lists and describes the use of all applicable commands. Clicking on the CLOSE WINDOW control closes the GPIB window, and transfers control of ADS-B processes back to the OCS.

The GPIB control should be used with caution since the OCS cannot track changes made to the operational state of the ADS-B through its use. This means that, upon returning to normal OCS control, the OCS may display incorrect ADS-B operating conditions. All OCS operations are suspended while the GPIB command session is open.

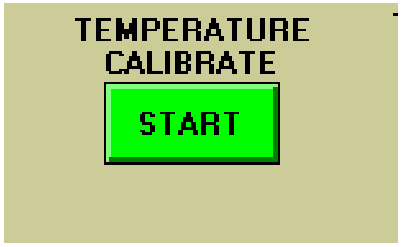
To OCS Front Panel

Figure 8. GPIB Control Window



3.5 Temperature Calibrate Control

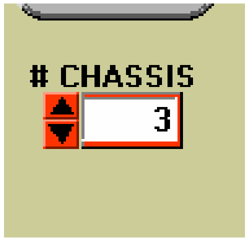
The Calibration Indicator on the OCS System Status Display turns yellow when a significant change in the operational temperature of the ADS-B is detected. This indicates the need to adjust the output level of the ADS-B. Clicking on the Temperature Calibrate control adjusts the amplitude characteristics of the ADS-B so that best performance is maintained. If the calibration process is successful, the Calibration Indicator will turn from yellow to green. The Temperature Calibrate control may also be used to minimize any changes in output amplitude that arise from altering the operating frequency.



To OCS Front Panel

3.6 System Chassis Count Control

The Chassis Count Control is used to add ADS-B instruments to the system. Up to three ADS-B instruments can be controlled at a system level. As the chassis count is increased additional control sections are added to the OCS screen. Although each instrument can perform independent operations, some functions require a master/slave relationship between the units. For instance, the ability to record transmissions from the system will be disabled if units are triggered independently. The OCS has been configured so that the master unit controls are displayed uppermost on the control screen.



To OCS Front Panel

3.7 System Master/Slave Considerations

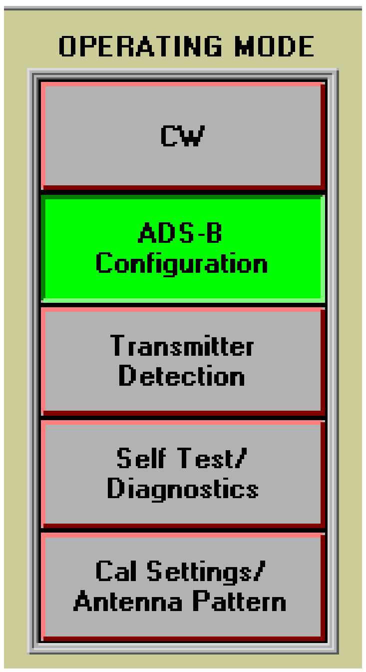
When multiple ADS-B instruments are used to create an ADS-B system, operational considerations and interactions place some limitations on how the integrated system performs. The system operator should be aware of the following factors that apply to the Freestate implementation of the OCS control software:

- The uppermost ADS-B control panel on the OCS screen is intended to control the Master ADS-B unit.
- If signals from other ADS-B units are not triggered slaved to the Master unit (see the Trigger Control description) the transmission capture and record capability will be disabled.
- The transmission capture capability will also be disabled if the signal trigger rate exceeds 500 events per second unless the Count Trigger option is utilized. The Count Trigger capability limits the total number of trigger events to that which can be captured and stored in internal memory.
- The OCS will only allow detection and logging of externally generated transmission signals through the use of the Master ADS-B unit.

4 ADS-B OPERATIONAL MODES

The illustration below indicates the five operational modes of the ADS-B and the OCS controls used to select them. A complete description of any operating mode may be found by clicking on the appropriate text link below.

Figure 9. ADS-B Operational Mode Selection



CW Mode

ADS-B Configuration Mode

Transmission Detect Mode

Self Test/Diagnostics Mode

Cal Settings Mode

4.1 CW Mode

When in the CW Mode the ADS-B creates CW signals that are available at the rear panel of the ADS-B. These signals may then be used in a variety of ways to verify system performance.

4.1.1 Overview

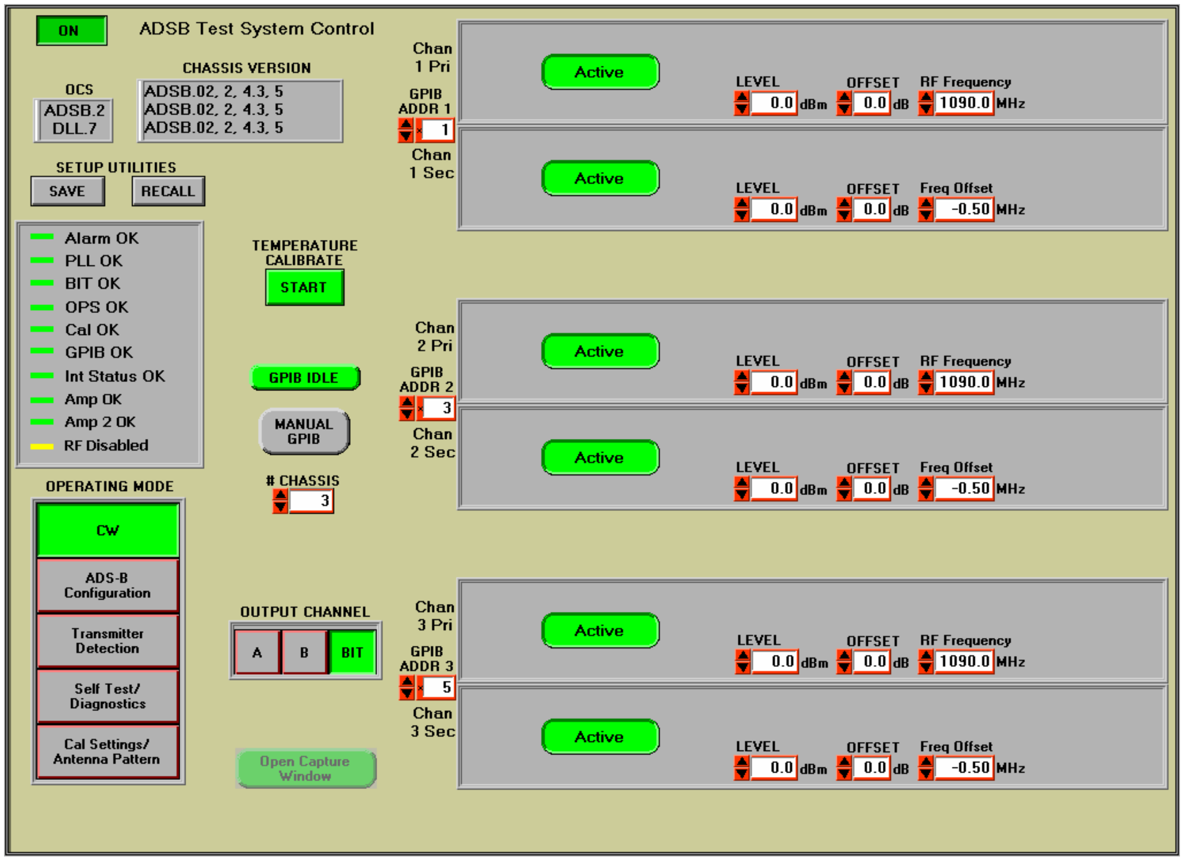
The CW Mode configures the ADS-B to generate signals suitable for analyzing CW characteristics of equipment under test, testing RF components or assemblies, and for verifying system interconnections of the ADS-B to the radar system.

When in the CW Mode the ADS-B generates unmodulated 1090 MHz RF signals. These frequency stable and amplitude accurate RF signals are found at the primary ADS-B outputs, located on the chassis Rear Panel, as well as at test output ports, located on the chassis Front Panel at each of the two Upconverter Modules. The primary outputs consist of two channels, A and B. Only one output channel is active at a time. Test signal ports include a 1090 MHz Channel A output, a 1090 MHz Channel B output, and a 70 MHz output.

4.1.2 CW Mode Operation

Use the OCS Mode control to place the ADS-B into the CW Mode. The CW Mode OCS control panel appears as shown below.

Figure 10. CW Mode OCS Screen



4.1.3 CW Mode Connections

CW signals are routed to the primary ADS-B outputs, located on the chassis Rear Panel, as well as to test output ports, located on the chassis Front Panel at each of the two Upconverter Modules.

The ADS-B has two primary outputs channels, A and B. The Channel A output connector is identified as J1. The Channel B output connector is identified as J4. Only one output channel is active at a time. Output channel selection is made through the use of the Output Select control.

4.1.4 CW Mode OCS Controls

The following OCS controls, as seen on the CW Mode OCS Screen, are used to set the operational parameters of CW signals generated by the ADS-B.

4.1.4.1 RF Frequency. The RF Frequency control sets the frequency of signals from the primary signal generator channel. The frequency can be set from 1080.0 to 1100.0 MHz, in 0.2 MHz steps.

4.1.4.2 RF Frequency Offset. The RF frequency of signals from the secondary signal generator channel is set by this control. This control applies an offset to the frequency of signals from the primary Reply Generator Module. The RF Frequency Offset control allows +/- 2 MHz, in 50 KHz increments, of frequency adjustment of the secondary generator signals relative to frequency of the primary generator signals.

4.1.4.3 Output Level. The output Level control sets the output amplitude of the Channel A and Channel B RF signals. Output signal level can be set to between –95 dBm and 0 dBm in 0.5 dB increments. The output level of each signal generator channel may be adjusted independent of the other.

4.1.4.4 RF Level Offset. The OCS output Offset control allows fine adjustment of the RF output level. The default amplitude offset is 0 dB. The amplitude offset can be adjusted +/- 1.5 dB, in approximately 0.1 dB steps.

4.1.4.5 Active/Inactive. The Active switch enables signal generation through the selected signal generator section. If the Inactive state is selected no RF signals appear at the outputs of the ADS-B unit.

4.2 ADS-B Configuration Mode

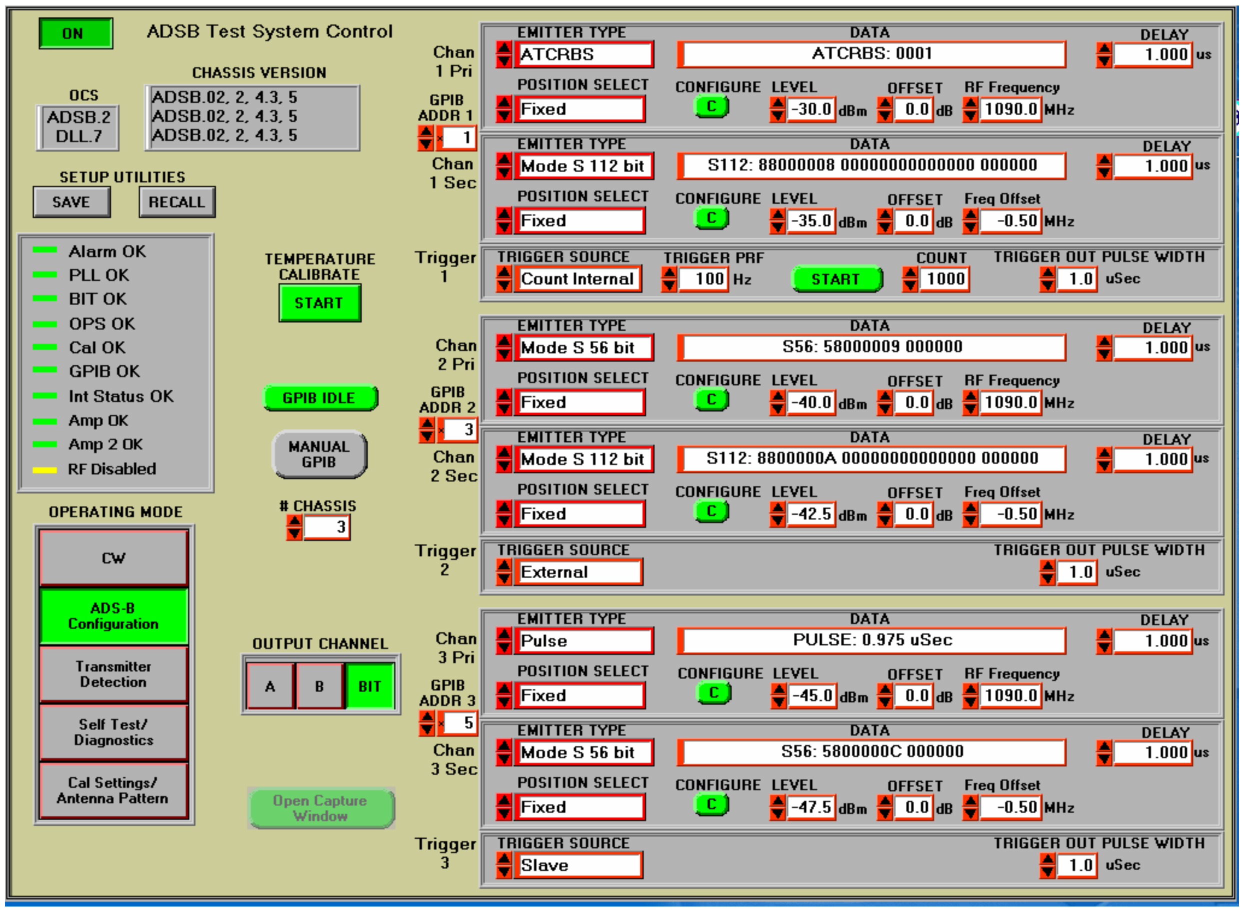
When in the ADS-B Configuration Mode the ADS-B generates pulsed RF transmissions in response to all valid trigger signals. The amplitude of the pulsed reply signals is fixed at operator controlled settings. The operator may choose to generate ATCRBS, 56 bit or 112 bit Mode S, including ADS-B signals. Random timing and data functions may be applied to the generation of the chosen signal type. Signal generation is in response to either internal or external triggers. The pulsed RF transmissions are available at either output, J1 or J4, located at the rear panel of the ADS-B.

4.2.1 ADS-B Configuration Mode Configuration

When the OCS controls the ADS-B, the ADS-B Configuration Mode is the default operating condition.

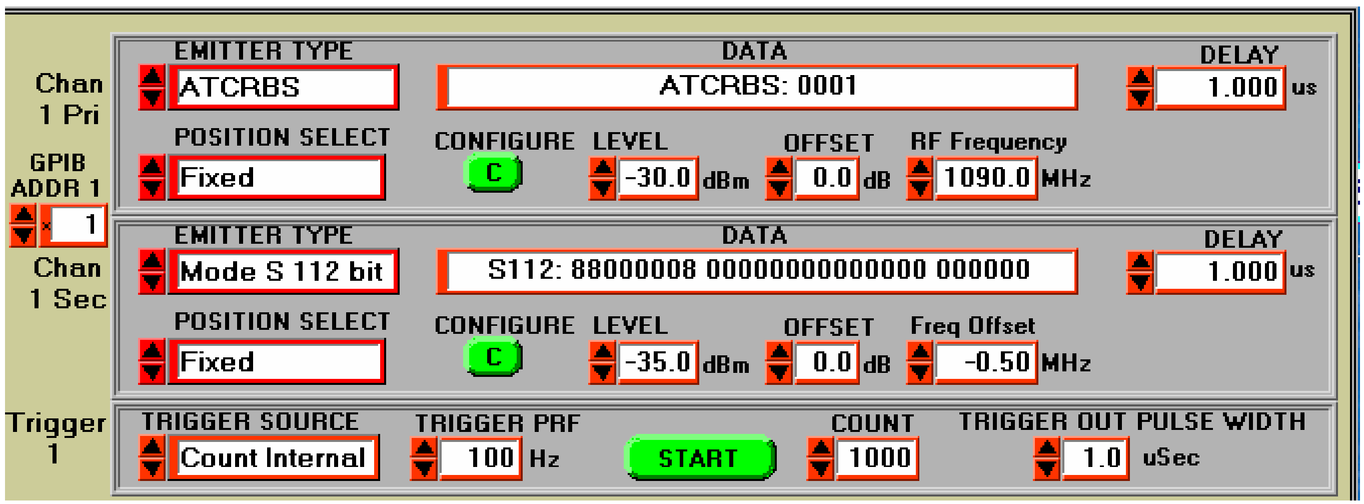
The ADS-B Configuration Mode OCS control panel appears as shown in Figure 11, the ADS-B Configuration Mode OCS Screen. Details concerning the operation of the controls shown in this figure are discussed in the following sections. Pulsed RF signals are available at a variety of ADS-B output ports. Output connections are the same as described in the CW Mode.

Figure 11. ADS-B Configuration Mode OCS Screen



4.2.2 ADS-B Configuration Mode Controls

The OCS controls shown in Figure 11, and highlighted below, are used to set the operational parameters of pulsed signals generated by the ADS-B.



4.2.2.1 RF Frequency. The RF Frequency control sets the frequency of signals from the primary signal generator channel. The frequency can be set from 1080.0 to 1100.0 MHz, in 0.2 MHz steps.

4.2.2.2 RF Frequency Offset. The RF frequency of signals from the secondary signal generator channel is set by this control. This control applies an offset to the frequency of signals from the primary Reply Generator Module. The RF Frequency Offset control allows +/- 2 MHz, in 50 KHz increments, of frequency adjustment of the secondary generator signals relative to frequency of the primary generator signals.

4.2.2.3 Output Level. The output Level control sets the output amplitude of the Channel A and Channel B RF signals. Output signal level can be set to between –95 dBm and 0 dBm in 0.5 dB increments. The output level of each signal generator channel may be adjusted independent of the other.

4.2.2.4 RF Level Offset. The OCS output Offset control allows fine adjustment of the RF output level. The default amplitude offset is 0 dB. The amplitude offset can be adjusted +/- 1.5 dB, in 0.1 dB steps.

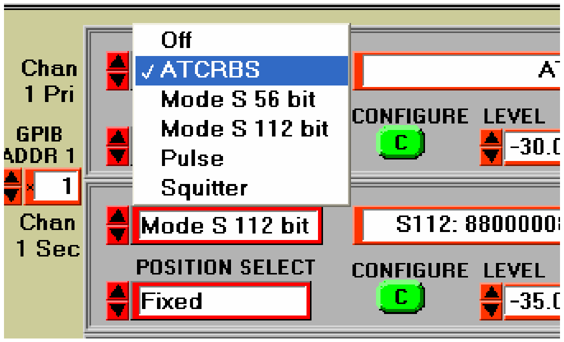
4.2.2.5 Delay (Min, Max). The OCS Delay control applies a time delay to all transmissions from a signal generator channel. This ability is useful to precisely set the time relationship between signals from multiple generators. When a fixed time delay is selected, transmissions are delayed between 0.0 µ Second and 1,600 µ Seconds from an internal trigger time mark. Note that the Delay setting(s) may automatically be adjusted by the OCS if the Trig PRF control setting would otherwise cause a conflict.

When multiple ADS-B units form an ADS-B system, the signal from the SYNC OUT interface of the "master" unit is used to synchronize the timing of signal generation from "slave" units. This maintains the timing accuracy of transmission events.

A random function may be applied to transmission timing. To enable this function the user must select the "Random" option in the Position Select control. In this case, Delay Min and Delay Max controls are available to set the time window in which transmissions are generated on a random basis.

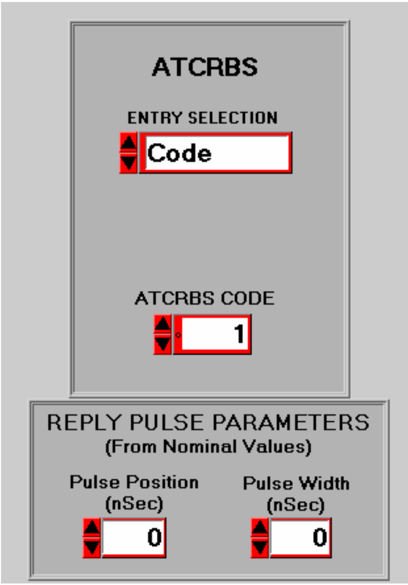
4.2.2.6 Position Select. The Position Select control determines if transmission timing of is on a fixed or random basis.

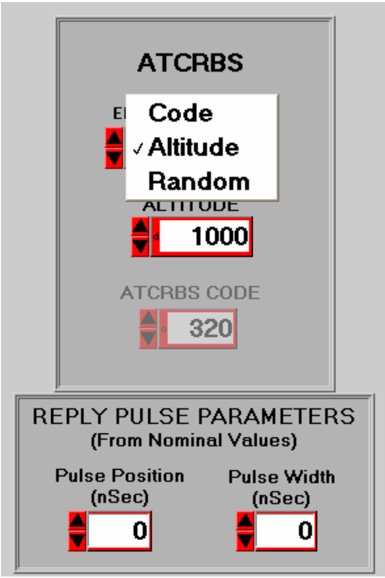
4.2.2.7 Emitter Type. The Emitter Type control, as seen below, sets the output signal type of the selected generator channel. Five transmission types, ATCRBS, 56 Bit Mode S, 112 Bit Mode S, Pulse, and Squitter may be emulated, or generation from the signal channel may be disabled by use of the "OFF" selection. The content of the selected transmission type is set through the use of the Configure control. The Data window, to the right of the Emitter Type control, provides a brief description of the transmitted signal.



4.2.2.8 Configure. The Configure control allows the user to tailor the content of the pulsed RF transmissions. A number of user configurable controls are available for the selected emitter type. These are described below.

4.2.2.8.1 ATCRBS Emitter. The Configure controls that are applicable to ATCRBS type signals are shown in the following figures.





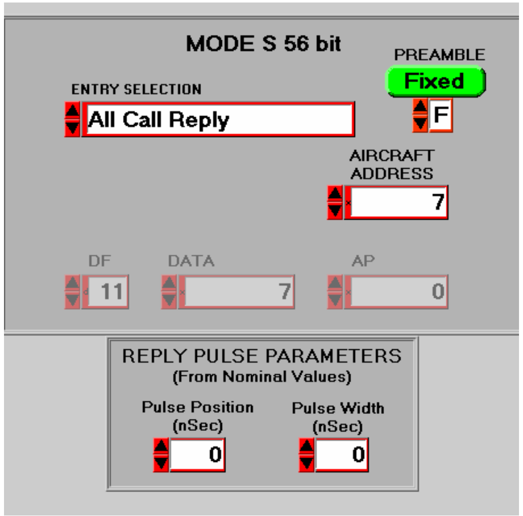
- The Entry Selection control allows selection of an ATCRBS Code, an altitude, or transmissions with random code value.
- The ATCRBS Code control, when enabled, allows direct input of a 4 bit octal code value.
- The Altitude Control becomes available when Altitude is selected in the Entry Selection control, and allows input of an operational altitude. The ATCRBS code applicable to the entered altitude value is indicated in the ATCRBS Code control.

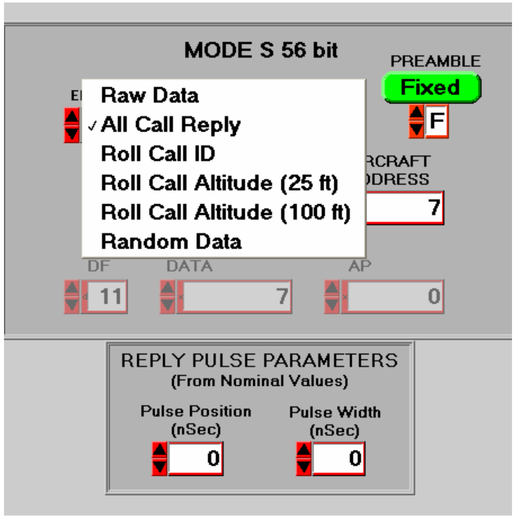
Two controls allow the user to alter the pulse characteristics of the transmitted signals.

- The Pulse Position control varies the spacing between pulses over a range of +/- 250 nanoseconds from nominal settings in 50 nanosecond increments.
- The Pulse Width control adjusts the width of all pulses from +750 to -250 nanoseconds from nominal settings in 50 nanosecond increments.

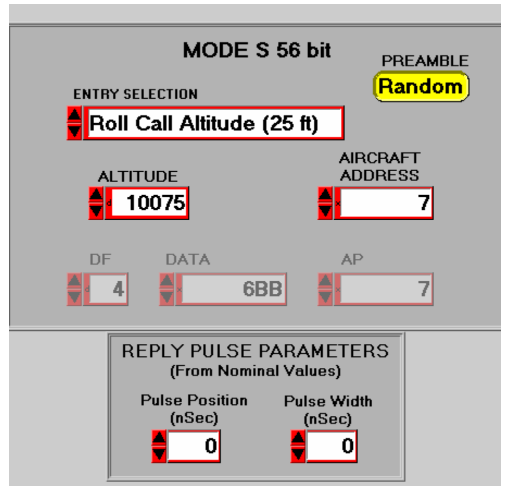
4.2.2.8.2 Mode S 56 Bit Emitter. The Configure controls that are applicable to 56 bit Mode S type signals are shown in the following figures.

- The Entry Selection control allows selection of various methods to create a 56 bit Mode S signal. Note that CRC operations are performed on the selected Mode S data prior to transmission. Entry Selection Options are seen in the figure below.
    - The Raw Data option allows direct entry of any data into the DF, DATA, and AP fields.
    - The All Call Reply option configures the ADS-B unit to generate compliant Mode S All Call (DF=11) transmissions with a user designated Aircraft Address.
    - The Roll Call ID Reply option configures the ADS-B unit to generate compliant Mode S Roll Call (DF=5) transmissions with a user designated ID and Aircraft Address.
    - The Roll Call Altitude Reply options configures the ADS-B unit to generate compliant Mode S Roll Call (DF=4) transmissions with a user designated Altitude (25 or 100 foot data) and Aircraft Address.
    - The Random option configures the ADS-B unit to generate 56 bit Mode S transmissions with random data content.





- The Preamble Control allows the user to configure the content of the preamble to the Mode S message. The "F" setting generates four preamble pulses and is the nominal requirement. When the Random Preamble function is enabled a single, and only a single, preamble pulse <u>may</u> be deleted from the Mode S message. There is a 50% probability that the complete preamble will be transmitted. There is a 12.5% probability that any particular preamble pulse will be dropped.



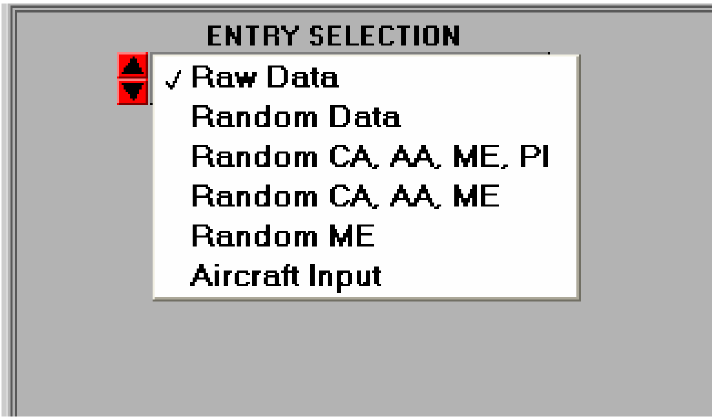
Two controls allow the user to alter the characteristics of the Mode S preamble pulses.

- The Pulse Position control varies the spacing between preamble pulses over a range of +/- 250 nanoseconds from nominal settings in 50 nanosecond increments.
- The Pulse Width control adjusts the width of preamble pulses from +750 to -250 nanoseconds from nominal settings in 50 nanosecond increments.

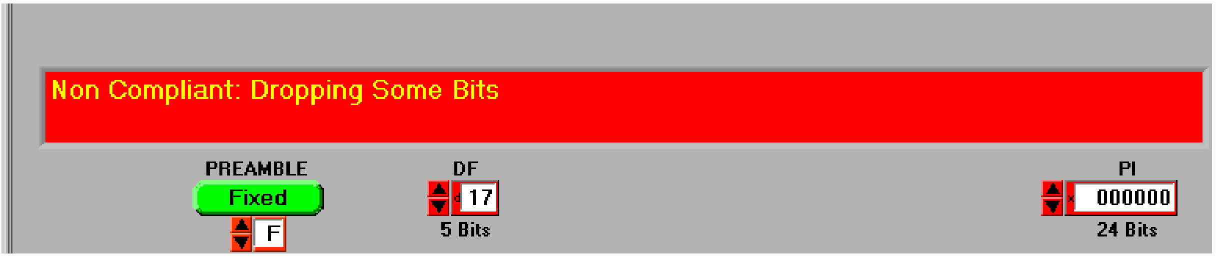
4.2.2.8.3 Mode S 112 Bit Emitter. The Configure controls that are applicable to 112 bit Mode S type signals are shown in the following figures.

- The Entry Selection control allows a choice of methods to create a 112 bit Mode S signal. Note that CRC operations are performed on the selected

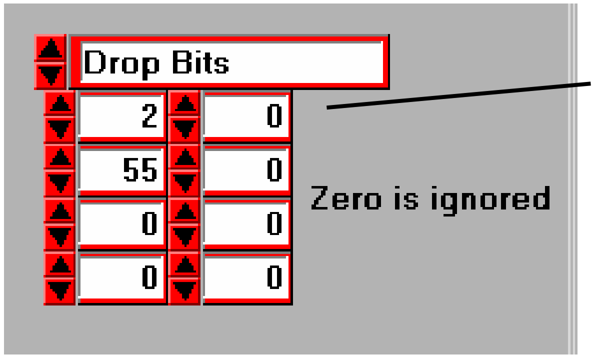
Mode S data prior to transmission. Entry Selection Options are seen in the figure below.



- The Raw Data option allows direct entry of any data into the DF, CA, AA, ME, and PI fields. All RF transmissions will be formatted with the indicated data. If the DF field is set to other than 17, 18, or 19 a non-compliant alert message, similar to as shown below, appears in the control window.



- The Random Data options configure the ADS-B unit to generate compliant Mode S signals with random data sets. Data fields on which the random process is applied are not available for user data entry. Data fields which are static can be set by the operator.



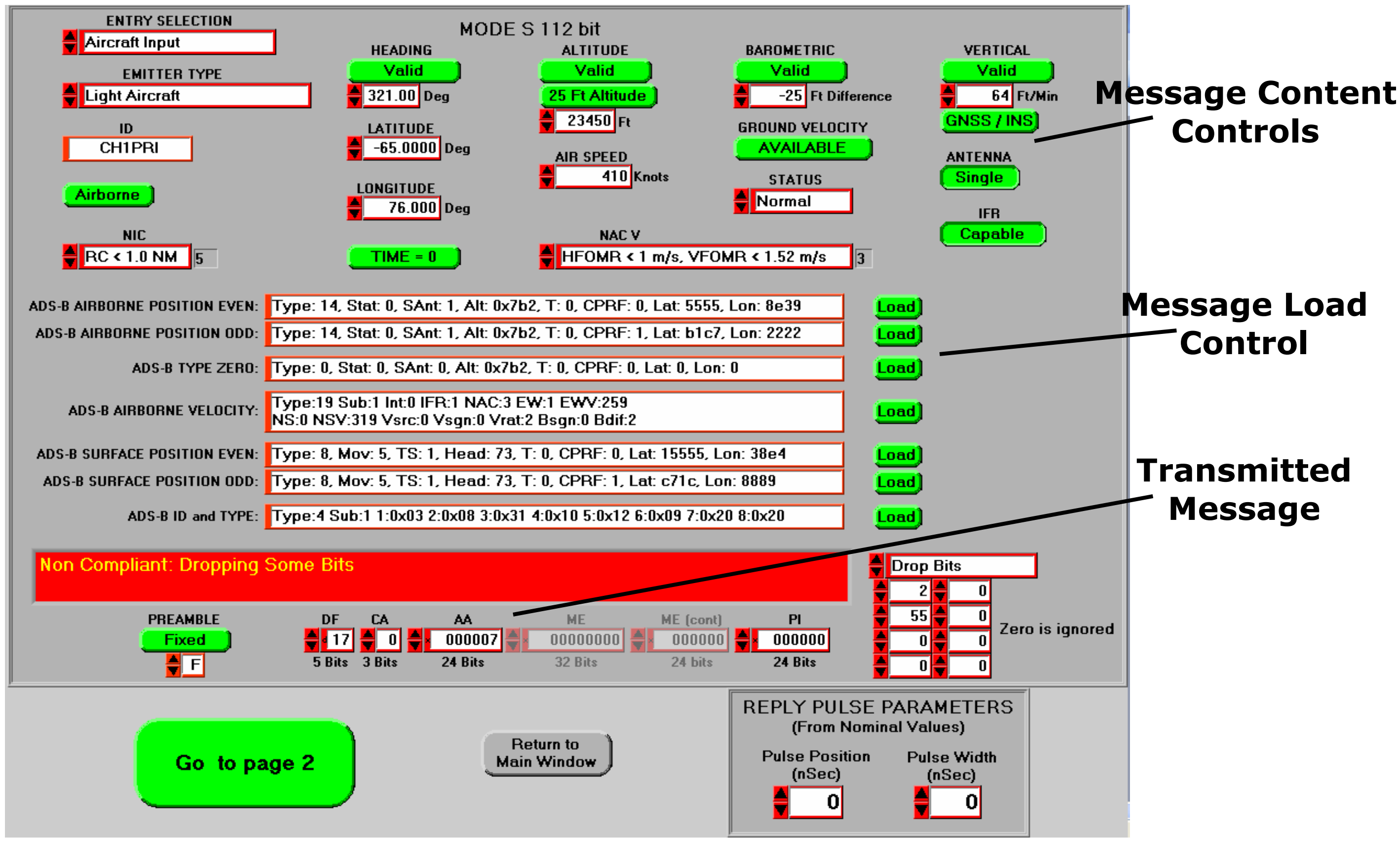
Each control indicates the position of the affected bit, from 1 to 112, in the transmitted message.

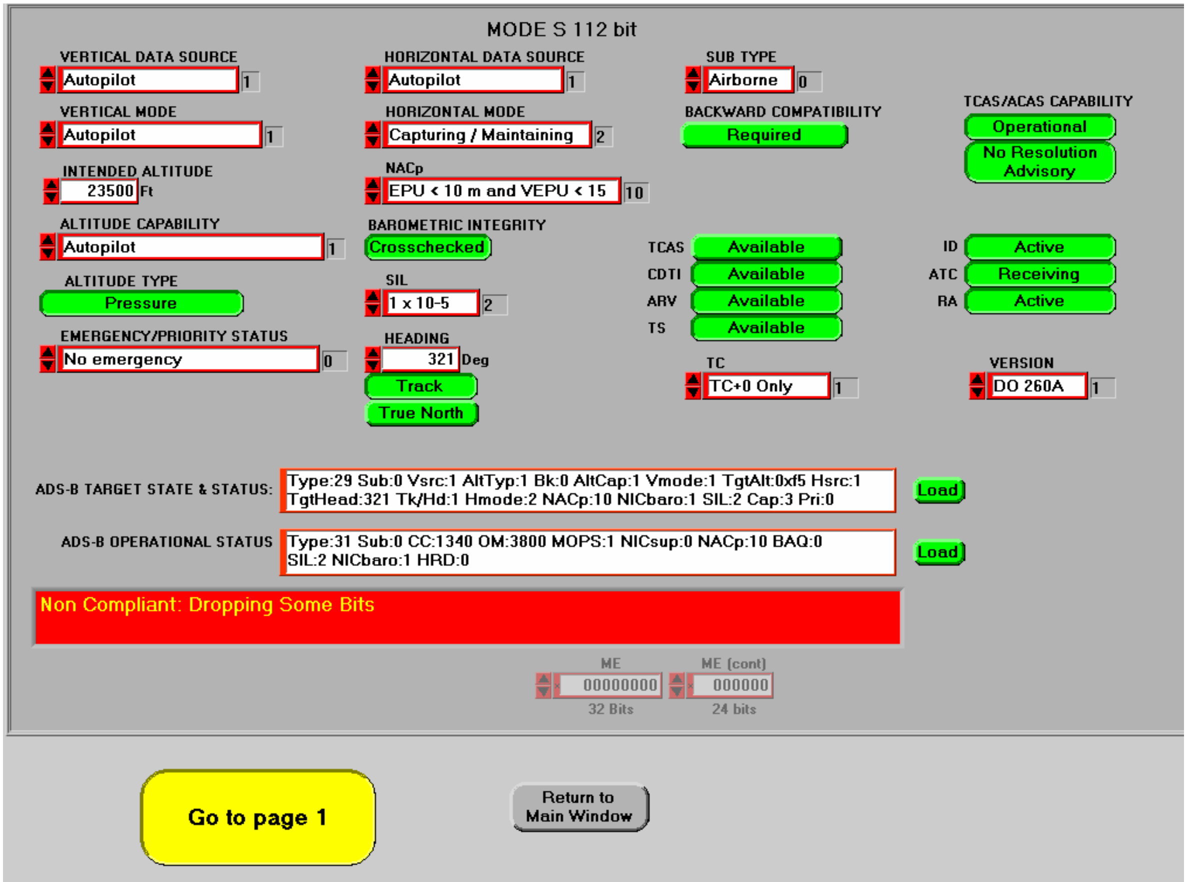
- The Bad Bits Control, above, allows the purposeful introduction of erroneous data into the transmitted message. The erroneous data may consist of either inverted data or dropped data. The inverted data selection alters the timing of the transmitted pulse to that normally occupied by a data bit of the opposite logic sense. The dropped bit selection inhibits the generation of an RF data pulse such that the logic of the data is indeterminate. Up to eight dropped or inverted bit operations may be performed at a time. The CRC of the transmitted message is not affected by use of the bad bit function.
- The Aircraft Input option helps the user to create and select appropriately formatted ADS-B messages for transmission. The

two configuration screens that apply to the Aircraft Input option are seen below. A total of nine different messages may be compiled using the input selection controls of both screens. These include even and odd airborne position, even and odd surface position, airborne velocity, ADS-B ID and Type, ADS-B Type Zero, ADS-B State and Status, and ADS-B Operational Status. As the user makes data parameter selections, the content of all affected messages is automatically updated.

The Load control adjacent to each message selects and loads that message for transmission. The complete message content selected for transmission is indicated near the bottom of the control window. The user may also alter message content by using the controls located in this area. Only the selected and loaded message is transmitted by the ADS-B Test Set.

Erroneous data and preamble functions may be applied to the selected message as explained previously. The user may also alter the pulse width and position of preamble bits from nominal values.


ENTRY SELECTION
Aircraft Input
MODE S 112 bit
EMITTER TYPE
Light Aircraft
ID
CH1PRI
Airborne
NIC
RC < 1.0 NM
5
HEADING
Valid
321.00 Deg
LATITUDE
-65.0000 Deg
LONGITUDE
76.000 Deg
TIME = 0
ALTITUDE
Valid
25 Ft Altitude
23450 Ft
AIR SPEED
410 Knots
NAC V
HFOMR < 1 m/s, VFOMR < 1.52 m/s
3
BAROMETRIC
Valid
-25 Ft Difference
GROUND VELOCITY
AVAILABLE
STATUS
Normal
VERTICAL
Valid
64 Ft/Min
GNSS / INS
ANTENNA
Single
IFR
Capable
Message Content Controls
ADS-B AIRBORNE POSITION EVEN: Type: 14, Stat: 0, SAnt: 1, Alt: 0x7b2, T: 0, CPRF: 0, Lat: 5555, Lon: 8e39
ADS-B AIRBORNE POSITION ODD: Type: 14, Stat: 0, SAnt: 1, Alt: 0x7b2, T: 0, CPRF: 1, Lat: b1c7, Lon: 2222
ADS-B TYPE ZERO: Type: 0, Stat: 0, SAnt: 0, Alt: 0x7b2, T: 0, CPRF: 0, Lat: 0, Lon: 0
ADS-B AIRBORNE VELOCITY: Type:19 Sub:1 Int:0 IFR:1 NAC:3 EW:1 EWV:259 NS:0 NSV:319 Vsrc:0 Vsgn:0 Vrat:2 Bsgn:0 Bdif:2
ADS-B SURFACE POSITION EVEN: Type: 8, Mov: 5, TS: 1, Head: 73, T: 0, CPRF: 0, Lat: 15555, Lon: 38e4
ADS-B SURFACE POSITION ODD: Type: 8, Mov: 5, TS: 1, Head: 73, T: 0, CPRF: 1, Lat: c71c, Lon: 8889
ADS-B ID and TYPE: Type:4 Sub:1 1:0x03 2:0x08 3:0x31 4:0x10 5:0x12 6:0x09 7:0x20 8:0x20
Load
Message Load Control
Non Compliant: Dropping Some Bits
Transmitted Message
Drop Bits
Zero is ignored
PREAMBLE
Fixed
F
DF
17
5 Bits
CA
0
3 Bits
AA
000007
24 Bits
ME
00000000
32 Bits
ME (cont)
000000
24 bits
PI
000000
24 Bits
Go to page 2
Return to Main Window
REPLY PULSE PARAMETERS
(From Nominal Values)
Pulse Position (nSec)
0
Pulse Width (nSec)
0


MODE S 112 bit
VERTICAL DATA SOURCE
Autopilot
1
HORIZONTAL DATA SOURCE
Autopilot
1
SUB TYPE
Airborne
0
VERTICAL MODE
Autopilot
1
HORIZONTAL MODE
Capturing / Maintaining
2
BACKWARD COMPATIBILITY
Required
TCAS/ACAS CAPABILITY
Operational
No Resolution Advisory
INTENDED ALTITUDE
23500 Ft
NACp
EPU < 10 m and VEPU < 15
10
ALTITUDE CAPABILITY
Autopilot
1
BAROMETRIC INTEGRITY
Crosschecked
TCAS Available
CDTI Available
ARV Available
TS Available
ID Active
ATC Receiving
RA Active
ALTITUDE TYPE
Pressure
SIL
1 x 10-5
2
EMERGENCY/PRIORITY STATUS
No emergency
0
HEADING
321 Deg
Track
True North
TC
TC+0 Only
1
VERSION
DO 260A
1
ADS-B TARGET STATE & STATUS:
Type:29 Sub:0 Vsrc:1 AltTyp:1 Bk:0 AltCap:1 Vmode:1 TgtAlt:0xf5 Hsrc:1 TgtHead:321 Tk/Hd:1 Hmode:2 NACp:10 NICbaro:1 SIL:2 Cap:3 Pri:0
Load
ADS-B OPERATIONAL STATUS
Type:31 Sub:0 CC:1340 OM:3800 MOPS:1 NICsup:0 NACp:10 BAQ:0 SIL:2 NICbaro:1 HRD:0
Load
Non Compliant: Dropping Some Bits
ME
00000000
32 Bits
ME (cont)
000000
24 bits
Go to page 1
Return to Main Window

4.2.2.8.4 **Pulse Emitter.** Pulse Width is the only variable parameter available for the user. Pulse width may be set from 0.1 μSec to 1,600 μSec.

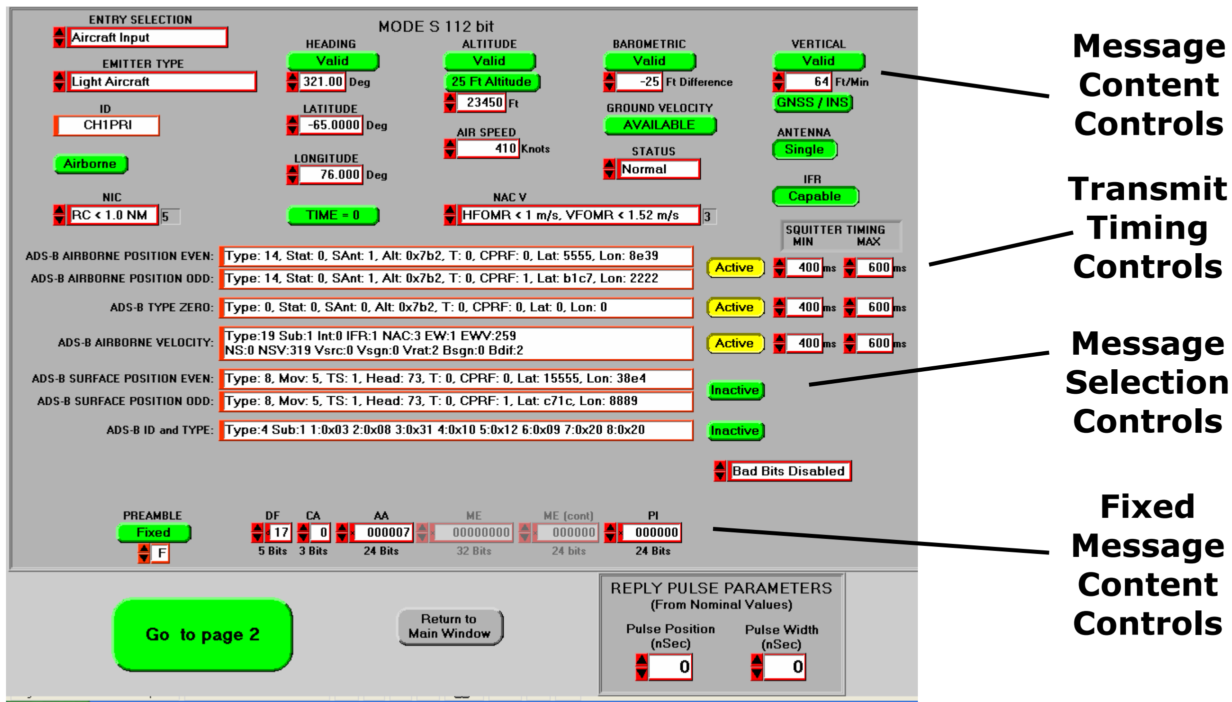
4.2.2.8.5 **Squitter Emitter.** The controls that set the ADS-B Test set to create ADS-B squitter transmissions are very similar to those described above for the Aircraft Input option of the 112 bit Mode S Emitter. Selection of Squitter Emitter, however, sets the Test Set to emulate an ADS-B transmitter, generating multiple squitter messages at the prescribed rate. The user has control over message content and choice of messages to transmit.

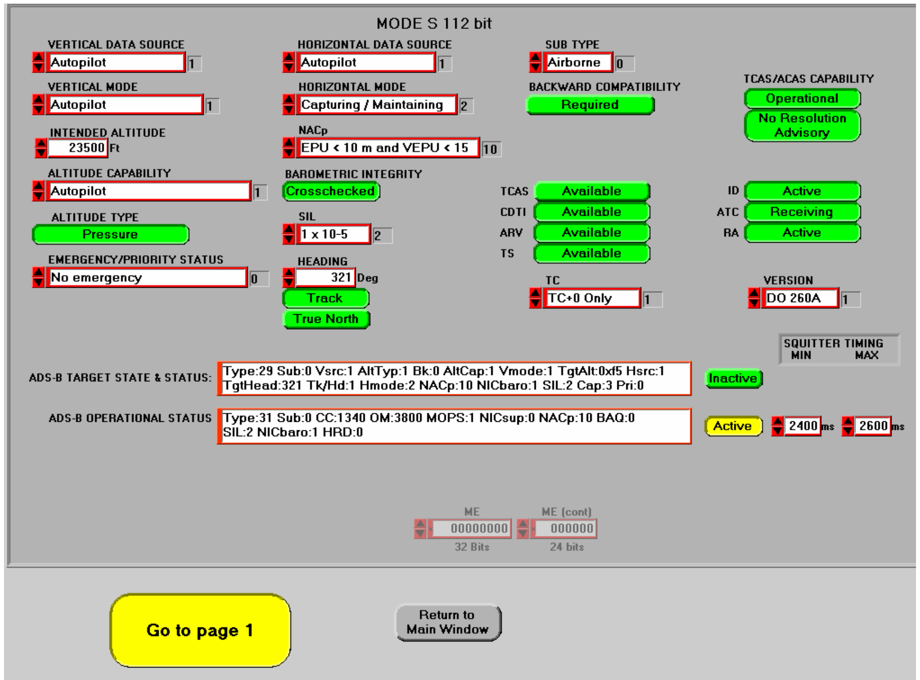
The two configuration screens that apply to the Squitter Emitter selection are seen below. A total of nine different messages may be compiled using the input selection controls of both screens. These include even and odd airborne position, even and odd surface position, airborne velocity, ADS-B ID and Type, ADS-B Type Zero, ADS-B State and Status, and ADS-B Operational Status. As the user makes data parameter selections, the content of all affected messages is automatically updated.

Squitter messages must be "active" to be transmitted. To activate a message, use the control adjacent to the message content field making sure that a green Active indicator is seen. All nine squitter messages may be selected for transmission. When a message is activated two transmit timing controls appear. These set the time period between consecutive message transmissions, with the exact timing of a given transmission being based upon a random function.

Message data fields not directly determined by ADS-B content are set by controls located near the bottom of the window. All transmitted messages will include the data indicated here.

Erroneous data and preamble functions may be applied to the selected message as explained previously. The user may also alter the pulse width and position of preamble bits from nominal values.




MODE S 112 bit
VERTICAL DATA SOURCE
Autopilot
1
HORIZONTAL DATA SOURCE
Autopilot
1
SUB TYPE
Airborne
0
VERTICAL MODE
Autopilot
1
HORIZONTAL MODE
Capturing / Maintaining
2
BACKWARD COMPATIBILITY
Required
TCAS/ACAS CAPABILITY
Operational
No Resolution Advisory
INTENDED ALTITUDE
23500 Ft
NACp
EPU < 10 m and VEPU < 15
10
ALTITUDE CAPABILITY
Autopilot
1
BAROMETRIC INTEGRITY
Crosschecked
TCAS Available
CDTI Available
ARV Available
TS Available
ID Active
ATC Receiving
RA Active
ALTITUDE TYPE
Pressure
SIL
1 x 10-5
2
EMERGENCY/PRIORITY STATUS
No emergency
0
HEADING
321 Deg
Track
True North
TC
TC+0 Only
1
VERSION
DO 260A
1
SQUITTER TIMING
MIN MAX
ADS-B TARGET STATE & STATUS:
Type:29 Sub:0 Vsrc:1 AltTyp:1 Bk:0 AltCap:1 Vmode:1 TgtAlt:0xf5 Hsrc:1
TgtHead:321 Tk/Hd:1 Hmode:2 NACp:10 NICbaro:1 SIL:2 Cap:3 Pri:0
Inactive
ADS-B OPERATIONAL STATUS
Type:31 Sub:0 CC:1340 OM:3800 MOPS:1 NICsup:0 NACp:10 BAQ:0
SIL:2 NICbaro:1 HRD:0
Active
2400 ms
2600 ms
ME
00000000
32 Bits
ME (cont)
000000
24 bits
Go to page 1
Return to Main Window

4.2.2.9 Trigger Source. The OCS Trigger Source controls, see below, determine how transmissions are activated from the ADS-B Test Set, except when squitter generation has been selected (when squitter generation has been selected the timing of signal transmissions is automatic and as set in the Configuration control window). Both signal generation channels use the same set of Trigger controls. Trigger Source options include Off, External, Internal, Internal Count, and Slave (only for the second and third units in a system).

The Off option disables signal generation from the unit.

The External option sets the ADS-B unit to trigger from TTL level pulses as supplied to the input of the TRIG In interface (J15) on the front panel. If the timing of external Trigger signals exceeds the processing time set by the Delay or other control functions, some trigger signals will be ignored and a Trig Conflict alert will be seen in the System Status window.

The Internal trigger option sets the ADS-B unit to generate transmissions at the rate set by the Trig PRF control.

The Count Internal option arms the ADS-B unit to generate a limited number of transmissions, in a “burst” mode, at the rate indicated by the Trigger PRF control. The number of signals the ADS-B generates is set by the Count control. The START control is used to begin the transmission burst.

The Slave option sets ADS-B slave units to accept synchronizing signals (at TRIG IN – J15) from the master ADS-B (SYNC OUT – J19) unit to trigger transmissions. This option allows a good correlation in the timing of multi-unit transmission events and enables the ability to create ADS-B system transmission records.

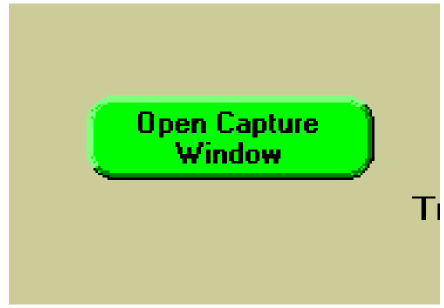
4.2.2.10 Trigger PRF. The Trigger PRF control sets the rate of transmission events. PRF may be set from 10 Hz to 8,000 Hz. In the event there is a conflict between the setting of the Trigger PRF control and the Delay control settings, the OCS will automatically adjust the value of the Delay setting so as to facilitate the Trigger PRF setting.

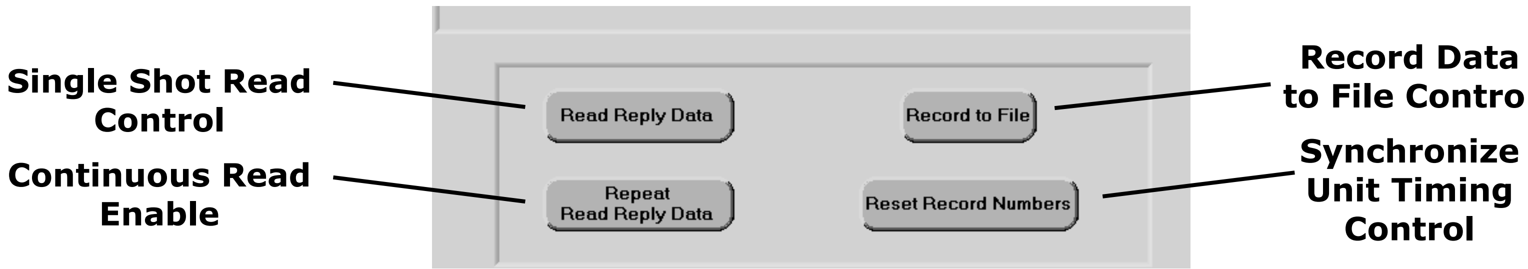
4.2.2.11 Count. The Count control sets the number of transmission events to be implemented when the Count Internal trigger option is selected. The START control begins the generation process. The Count value may be set from 1 to 5,000.

4.2.2.12 Trigger Out Pulse Width. The Trigger Out Pulse Width control sets the width of the pulse signal at the TRIG OUT interface (J16) of the ADS-B unit. A pulse is generated for every transmission event. Trigger pulse width may be set from 0.1 μ Sec to 5.0 μ Sec.

4.2.3 Open Capture Window Controls.

The OCS Open Capture Window control, shown below, is enabled when the Trigger PRF setting is at or below 500 and, if multiple ADS-B units form a system, the second and third ADS-B units use the "slave" Trigger setting. When utilized this control opens a new panel of controls that are used to read and save the message content and structure of each transmission generated by the ADS-B instrument.





4.2.3.1 Reset Record Numbers Control. The Reset Record Numbers control sets the record number of each ADS-B unit in a system to zero. This action makes it possible for the OCS to sequentially read each ADS-B unit, to sort all transmit records, and to then reassemble, display, and log transmit events in the order that they occurred. If records received from ADS-B units can not be reassembled they will be discarded and a "Lost Data" error flag will be generated. *Use the Reset Record feature to synchronize event timing before creating event logs*.

4.2.3.2 Read Reply Data Control. Use this control to read and display the current set of event data from each ADS-B unit in the system. The OCS sorts the retrieved event records so that they are displayed in the order that they occurred. The maximum number of events that can be reported in a single log record from an ADS-B unit is 128.

These are displayed in the open window of the OCS. If the Read Reply Data control is used again all previous event information is overwritten by the new event information. Use the Record to File feature to capture and analyze a complete set of event records.

4.2.3.3 Repeat Read Reply Data Control. Use this control to continuously read and display the event log of each ADS-B unit.

4.2.3.4 Record to File Control. Use this control to record all event information on the OCS hard drive. A Save Log File window automatically opens to allow selection of save file parameters. All transmission event data is saved to the specified file while recording is enabled.

4.3 Transmitter Detection Mode

When using the Transmitter Detection Mode an operator configures the ADS-B to detect and record ATCRBS and Mode S (including ADS-B) 1090 MHz signals at the rear panel interface, J30. The peak power of RF signal levels at J30 must be between +20 dBm and +50 dBm. Exceeding the +50 dBm limit may damage components of the ADS-B instrument. All valid transmit signals are captured, analyzed, and recorded. Signal data that does not meet nominal pulse timing and pulse width constraints is ignored. Recorded information is transferred to and displayed on the OCS automatically. Refer to the ADS-B GPIB Command Set, the READREPLY command, for more information on the format of the displayed and recorded messages.

4.3.1 Reply Capture Control. This control sets the ADS-B to capture a single transmitter message, to capture messages continuously, or to disable the capture function.

4.3.2 Read Reply Data Control. This control reads all the data in the current capture record. Read data is displayed on the OCS.

4.3.3 Log Reply Data Control. This control continuously logs all recorded information to a user specified file on the OCS hard drive. This process will capture and log a minimum of 250 transmissions per second.

Note: Logging of ADS-B transmissions and logging of detected external transmissions cannot occur simultaneously. Use the master ADS-B unit to detect and record external transmission messages when multiple ADS-B units are used in a system.

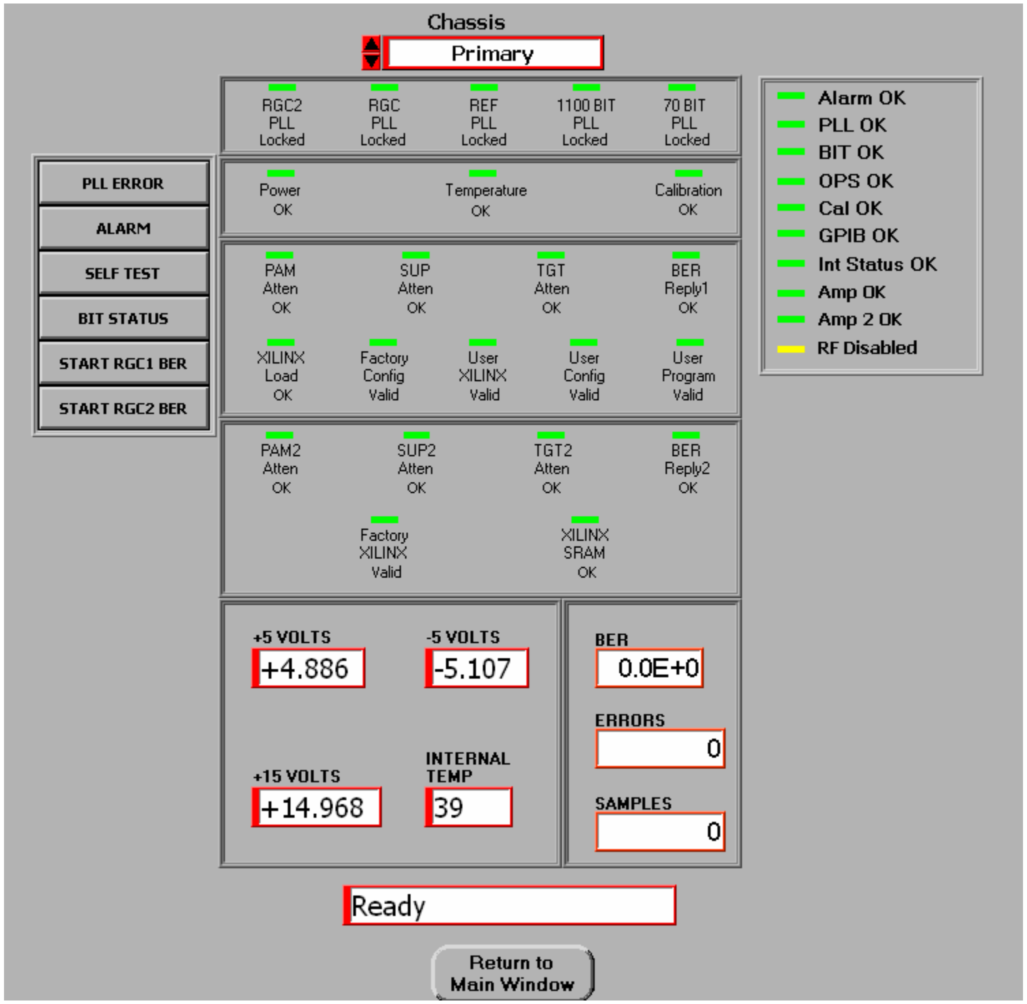
4.4 Self Test/Diagnostics Mode

When the Self Test/Diagnostics Mode is selected, the details of the current status of the ADS-B are displayed as shown in Figure 12. The status display can be used to analyze and investigate operational problems of the ADS-B (see Section 7.2 for more information). If a problem is indicated in the System Status panel the operator should use this mode to begin problem diagnosis.

This operational mode displays the results of all Built-In-Test (BIT) functions. All output amplitude controls are verified by the BIT process. Other functions that are monitored include power supply voltages, phase lock status of all PLL circuits, internal temperature, APG status, processor status, and memory functions. Controls are available to start BER loop tests and to initiate a new self-test routine. Additional information on diagnosing ADS-B operational issues is found in the Trouble Diagnostics section of this manual.

To enter the Self Test/Diagnostics Mode click on the Self Test/Diagnostics Mode control in the Mode Select Panel.

Figure 12. Self Test/Diagnostics Display



4.4.1 Self Test/Diagnostics Mode Controls and Operation

The Standby/Diagnostics Mode OCS control panel appears as shown in Figure 12. The use of these controls is explained in the following sections.

4.4.1.1 PLL ERROR. Clicking on the PLL ERROR control updates the status of the five PLL indicators in the Phase Locked Loop (PLL) Status Panel of the indicator panel display.

4.4.1.2 ALARM. Clicking on the ALARM control updates the status of the Equipment Status Indicators on the indicator panel display.

4.4.1.3 SELF TEST. Clicking on SELF TEST control starts a new BIT sequence. All major ADS-B System functions are evaluated. When complete, test results are displayed in the BIT Function Status Panel. Test failures are indicated by a RED status display.

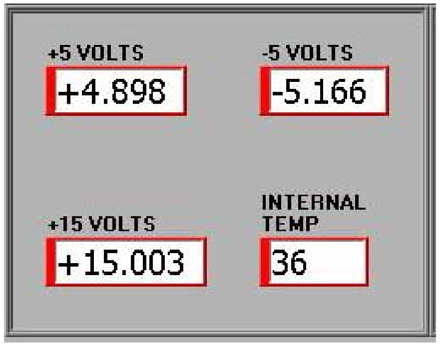
4.4.1.4 BIT STATUS. Clicking the BIT STATUS button updates the status of the power supply voltage readings and the chassis internal temperature display in the Power Supply and Chassis Temperature panel.

4.4.1.5 START RGC1 (RGC2) BER. Clicking the START RGC1 (or RGC2) BER control begins a Bit Error Rate (BER) test process. The BER loop includes the generation of transmission control signals by the PCC Module, the conversion of these data signals to pulsed RF signals in the Reply Generator and Upconverter Modules, and an evaluation of the demodulated RF reply signals by the BIT Module. The PCC Module controls the entire BER test process. It records the number of errors detected and the total number of data samples. These, along with a calculated BER, are displayed in the lower right hand corner of the Self Test/Diagnostics display, **Figure 12.**

4.4.1.6 Self Test/Diagnostics Mode Status Indicators

The definition of each of the status indicators displayed on the Standby/Diagnostics Display panel, Figure 12, is given below. In all cases, a green indicator means that the circuit is functioning normally. Abnormal circuit function is indicated by a red display. Trouble analysis recommendations, based upon the status of the display indicators, are found in the Trouble Diagnostics section of this manual.

4.4.1.6.1 Power Supply and Chassis Temperature Panel



The lower center of the Self Test/Diagnostics display screen includes readouts of the three power supply voltages and of the chassis internal temperature. Clicking on the

BIT **STATUS** control refreshes the voltage and temperature readings.

Voltage Indicators. The measured output voltage of each power supply is indicated. The outputs of the ±5V supply are expected to be within ±0.25 volts of the rated value. The output of the +15V supply is expected to be within ±0.5 volts of the rated value. If any of the supply voltages fall out of the expected operational window then a BIT PWR ALARM is generated (see the Equipment Status Indicators section). Power supply voltage measurements can be verified at the ADS-B Front Panel test points.

Do not operate the ADS-B if power supply voltages are out of tolerance.

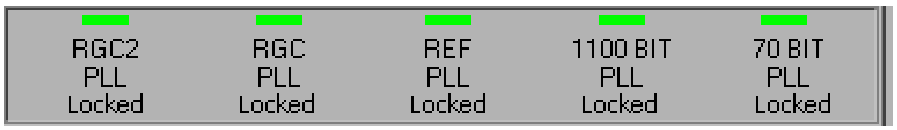
Temperature Indicator. The measured internal temperature of the ADS-B is indicated. The ADS-B will operate with an internal temperature between 0°C and +65°C. If the measured temperature falls out of the design window then a BIT TEMP ALARM is generated (see the Equipment Status Indicators section). Note: After warm-up the internal temperature of the ADS-B is 5 Cº to 10 Cº above ambient.

Do not operate the ADS-B if the ambient or internal temperatures exceed design tolerances.

4.4.1.6.2 Phase Locked Loop (PLL) Status Panel

The upper-most display panel of the Self Test/Diagnostics window reports the Phase Lock status for each of the PLL circuits in the ADS-B. A green status display indicates a normal operating state. A red status display indicates an unlocked condition.

Do not operate the ADS-B if PLL circuit failures are indicated. Trouble analysis recommendations, based upon the status of the display indicators, are found in the Trouble Diagnostics section of this manual.



REF PLL. The status of the PLL circuit within the Reference Source Module is indicated. The REF PLL circuit generates the LO signal for each of the three Upconverter Modules. The output frequency of the ADS-B will be in doubt if the REF PLL indicator is red.

RGC PLL. The status of the PLL circuit within the indicated Reply Generator Module is displayed. The RGC PLL circuit generates the primary output signal of the ADS-B. The output frequency of the ADS-B will be in doubt if the RGC PLL indicator is red.

1100BIT PLL. The status of the 1100 MHz PLL circuit within the BIT Module is indicated. .

70BIT PLL. The status of the 70 MHz PLL circuit within the BIT Module is indicated.

4.4.1.6.3 Equipment Status Indicators

The middle display panel reports the status of some general operating conditions of the ADS-B. A green status display indicates a normal operating state. A red status display indicates a failure condition.

Power Alarm. The status of the power supplies within the ADS-B is indicated (see Section 4.4.1.6.1). If any of the three power supply voltages is out of tolerance a fault condition will be displayed.

Do not operate the ADS-B if power supply voltages are out of tolerance.

Temperature Alarm. The status of the internal temperature of the ADS-B is indicated (see Section 4.4.1.6.1). If the internal temperature is not between 0ºC and 65ºC a fault condition will be displayed.

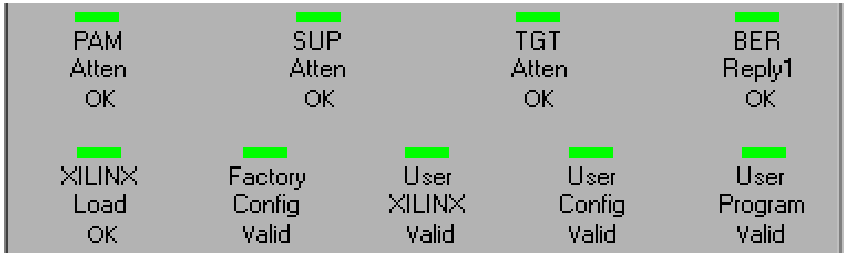
Do not operate the ADS-B if the ambient or internal temperatures exceed design tolerances.

Calibration Alarm. The status of the output level temperature compensation process is indicated. A failure means that the output level of the ADS-B may not meet specification requirements. Operation of the ADS-B is possible, but not recommended when output level accuracy is important.

4.4.1.6.4 BIT Function Status Panel

The BIT Function Status Panel indicates the detailed results of the BIT process. A green status display indicates a normal operating state. A red status display indicates a fault condition. For ADS-B systems with two Reply Generator Modules two sets of BIT Function Status Panels are displayed.

Operation of the ADS-B with any BIT Function Status failure is not recommended. Trouble analysis recommendations, based upon the status of the display indicators, are found in the Trouble Diagnostics section of this manual.



SUP Atten. The condition of the attenuator circuits within the Upconverter Module is indicated. The characteristics of five attenuator circuits (0.5dB, 1 dB, 2 dB, 4 dB, and 8 dB) are verified. A failure means that one or more of the attenuator circuits are problematic.

TGT Atten. The condition of the output level setting attenuator circuits within the Reply Generator Module and the Upconverter Module is indicated. The characteristics of nine attenuator circuits (0.25 dB, 0.5dB, 1 dB, 2 dB, 4 dB, 8 dB, 16 dB, 32 dBA, and 32 dBB) are verified. The final 32 dB step exists within each Upconverter. A failure means that one or more of the attenuator circuits are problematic.

PAM Atten. The condition of the pulse amplitude modulator circuit within the Reply Generator Module is indicated. The ability of the circuit to generate amplitude modulated signals is verified. A failure means that the PAM circuit is problematic.

XILINX Load. The ability of the PCC Module to download a program pattern into the Xilinx FPGA is indicated. A failure means that either the Xilinx FPGA data in the FLASH ROM is corrupt or that there is a problem with the Xilinx hardware.

Factory Config. The status of stored factory calibration constants is indicated. A failure means that the FLASH ROM sector that stores calibration constants is corrupt.

BER Reply. The status of the reply generation BER measurement process is indicated. Control signals from the PCC Module create RF signals in the Reply Generator and Upconverter Modules which are then detected in the BIT Module. The PCC analyzes the detected data versus expectations. A failure means that a BER of less than 1×10^{-4} was measured.

User XILINX. The status of the user programmable sector of the Xilinx FPGA (within the PCC Module) is indicated. A failure means that there is a problem with the Xilinx FPGA hardware.

User Config. The status of the calibration constant sector of the FLASH ROM (within the PCC Module) is indicated. A failure means that this program area did not pass its checksum test.

User Prog. The status of the user program sector of the FLASH ROM (within the PCC Module) is indicated. A failure means that this program area did not pass its checksum test.

4.5 Cal Settings Mode

When selected, the Cal Settings Mode displays a window that includes tools for uploading new calibration data files into the ADS-B. The Cal Settings window, as shown in Figure 13, also displays all of the calibration factors currently in use by the ADS-B. The use of the controls and an explanation of the displayed information are given below.

WARNING

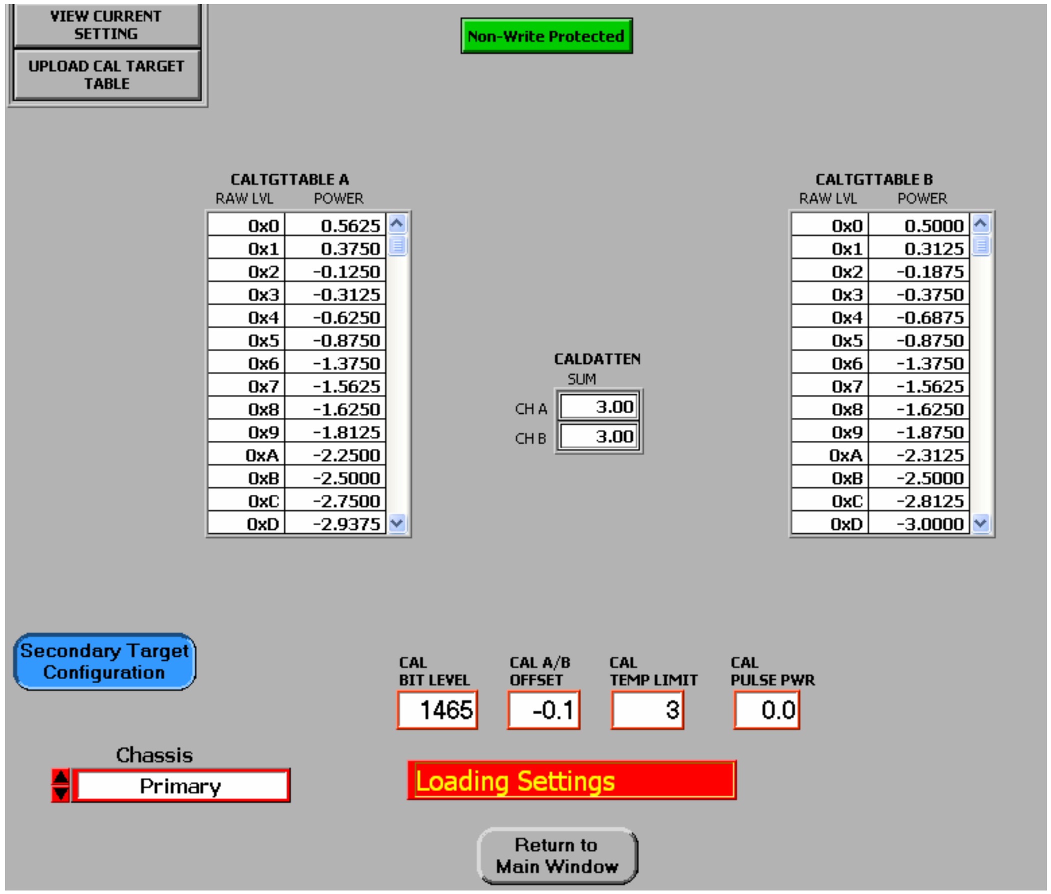
Changing the calibration parameters of the ADS-B can significantly alter the performance of the ADS-B. Do not make any such changes without a thorough understanding of the processes involved.

4.5.1.1 Cal Settings Mode Configuration

To change to the Cal Settings Mode click on the Cal Settings Mode control in the Mode Select Panel.

To change the calibration factors of the ADS-B the files that contain the new information must be properly formatted. File format requirements are explained in the ADS-B IEEE-488 Command Set, FSE document number 200006.

Figure 13. Cal Settings Data Display



NOTE

Most calibration factors cannot be changed unless the Configuration Switch on the side of the PCC Module is set to allow this operation. This condition is indicated by a red "Write Protected" display in the top-center of the Cal settings Mode window. Refer to Section 5.2.5.2.1 for information on configuring the ADS-B to accept calibration files.

4.5.1.2 Cal Settings Mode Connections

The Cal Settings Mode has no special setup or configuration requirements. Calibration information may be transferred from the OCS to the ADS-B through the IEEE-488 interface, J12, through the use of GPIB commands. The data transfer may also take place through the rear panel serial I/O connector, J13 (refer to the ADS-B Rear Panel illustration for connector locations). Most users find that file transfers are easier to accomplish using the serial port. Serial interface commands are identical in format to the GPIB commands.

4.5.1.3 Cal Settings Mode Controls and Operation

The Cal Settings Mode OCS control panel appears as shown in Figure 13. The use of these controls is explained in the following sections.

VIEW CURRENT SETTING. The VIEW CURRENT SETTING control refreshes all of the displayed information. The information displayed in the Cal Settings screen is not automatically updated after changes are made to any of the calibration settings. Clicking the VIEW CURRENT SETTING control retrieves and displays the latest data stored in the non-volatile memory of the ADS-B.

UPLOAD CAL TARGET TABLE. This control allows a new output level calibration table, called a CALTGTTABLE in the GPIB command set, to be chosen and uploaded into the ADS-B. The design of the ADS-B has almost completely eliminated any reason to create and upload a new CALTGTTABLE file. Please contact FSE before performing this operation.

Clicking on the UPLOAD CAL TARGET TABLE control starts the upload sequence. Any properly formatted file may be selected and uploaded. File format requirements are listed in the CALTGTTABLE command description within the IEEE-488 Command Set document. After an appropriate file is selected, the file transfer is completed in less than one second. Use the VIEW CURRENT SETTING control to update the displayed CALTGTTABLE information. Verify that the new ADS-B settings reflect the information in the file used in the upload process.

CAL BIT LEVEL DISPLAY. This display indicates the current setting of this calibration parameter. The CAL BIT LEVEL setting is used to correct the output level of the ADS-B whenever temperature changes are detected.

It is ***not recommended*** that this calibration setting be altered from factory set values. However, a new CAL BIT LEVEL may be created and loaded into the ADS-B. Use the information contained is Sections 4.5.1.1 and 4.5.1.2 as a guideline.

CAL A/B OFFSET DISPLAY. This display indicates the current setting of this calibration parameter. The CAL A/B OFFSET setting is used to align the Channel A and B output levels.

It is ***not recommended*** that this calibration setting be altered from factory set values. However, a new CAL A/B OFFSET may be created and loaded into the ADS-B. Use the information contained is Sections 4.5.1.1 and 4.5.1.2 as a guideline.

CAL TEMP LIMIT DISPLAY. This display indicates the current setting of this calibration parameter. The CAL TEMP LIMIT value sets the range, in ºC, through which the operating temperature of the ADS-B may vary without causing a yellow CALIBRATION alarm (see Section 3.1.4). The center of this range is the temperature of the ADS-B when the last temperature calibration was performed.

It is ***not recommended*** that this calibration setting be altered from factory set values. However, a new CAL TEMP LIMIT may be created and loaded into the ADS-B. Use the information contained is Sections 4.5.1.1 and 4.5.1.2 as a guideline.

5 TECHNICAL DESCRIPTION

5.1 ADS-B Theory of Operation

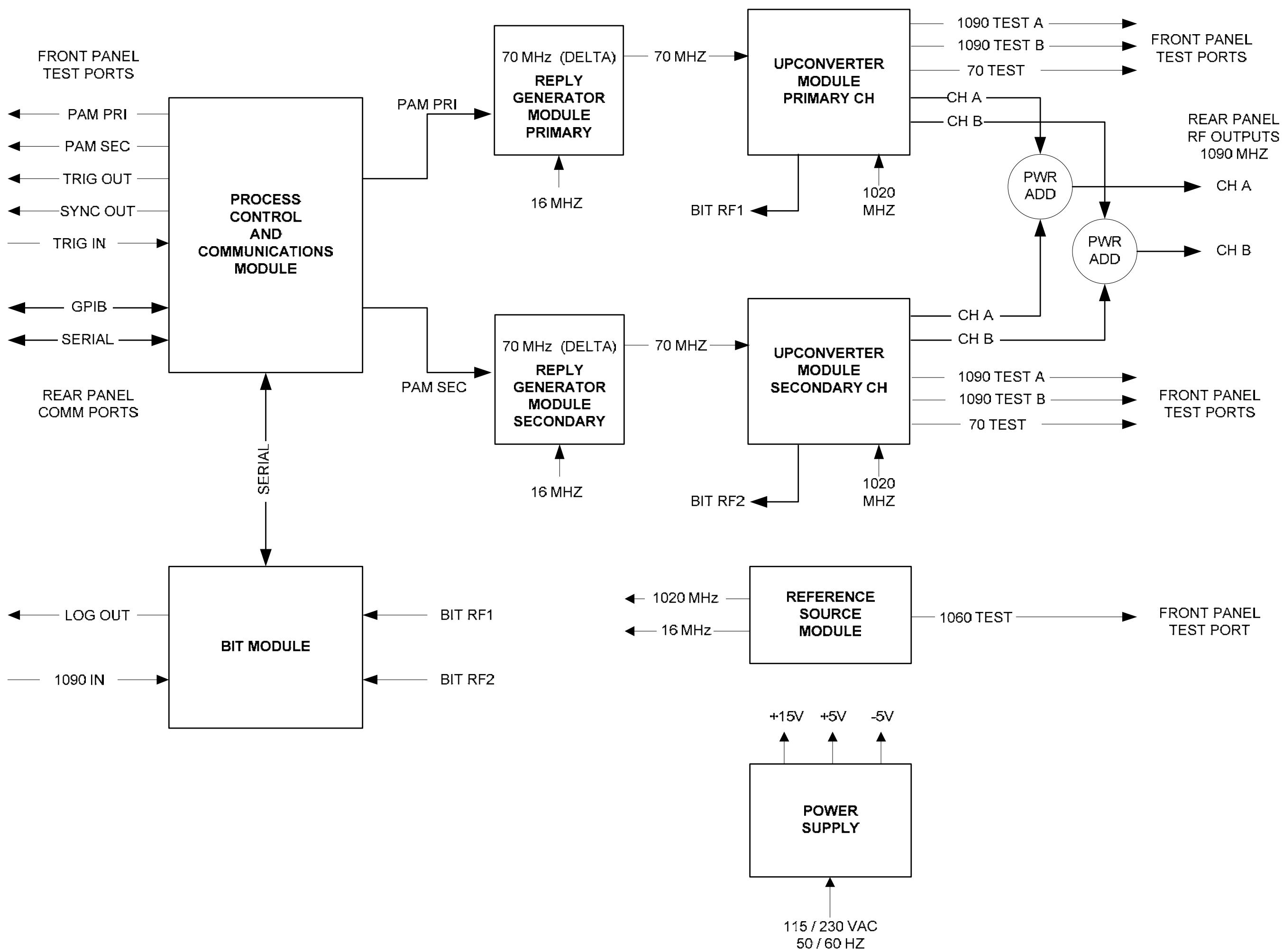
The ADS-B System Block Diagram, Figure 14, illustrates the RF signal paths and other signal interconnections within the ADS-B. As indicated by the Block Diagram, the ADS-B contains seven modules; two Reply Generator Modules, two Upconverter Modules, one Reference Source Module, one Built In Test (BIT) Module, and one Process Control and Communications (PCC) Module. The function of each module is briefly described in the following text.

The PCC Module controls all functions within the ADS-B. It contains circuits that generate the pulse signals that are used to create the 1090 MHz RF transmissions. It processes all user GPIB or serial commands. And, it monitors the status of all RF processes. Refer to the Process Control and Communications (PCC) Module description for more information.

The Reply Generator Module generates and sets the primary characteristics of the RF signals. It contains the circuits that set output signal level. Refer to the Reply Generator Module description for more information.

Each Upconverter Module translates the 70 MHz signals from the Reply Generator to 1090 MHz. Channel A, or Channel B, or BIT output signals are available from each Upconverter. Each Upconverter also has three front panel test ports, one at 70 MHz, and two at 1090 MHz. Refer to the Upconverter Module description for more information.

Figure 14. ADS-B System Block Diagram



The Reference Source Module generates low noise 16 MHz reference signals and two 1020 MHz LO signals. The 16 MHz signals are used as a reference by the PLL circuits within the other modules. The LO signals, at +13 dBm, are routed to each of the Upconverter Modules to convert the 70 MHz IF signals to 1090 MHz. Refer to the Reference Source Module description for more information.

The BIT Module includes circuits to test the signal generation processes. It also measures the status of other system parameters such as power supply voltage and operating temperature. Refer to the Built In Test (BIT) Module description for more information.

5.2 Module Descriptions

5.2.1 Reply Generator

The Reply Generator Module produces a 70 MHz Intermediate Frequency (IF) signal. The Process Control and Communications (PCC) Module controls the timing of amplitude modulation pulses applied to this signal so as to generate ATCRBS, Mode 4, and Mode S (including ADS-B) transmissions. The 70 MHz output signal from this module feed an Upconverter Module, in which the signal is converted to 1090 MHz and then routed to the output interfaces of the chassis.

Figure 15. Reply Generator Front and Rear Views

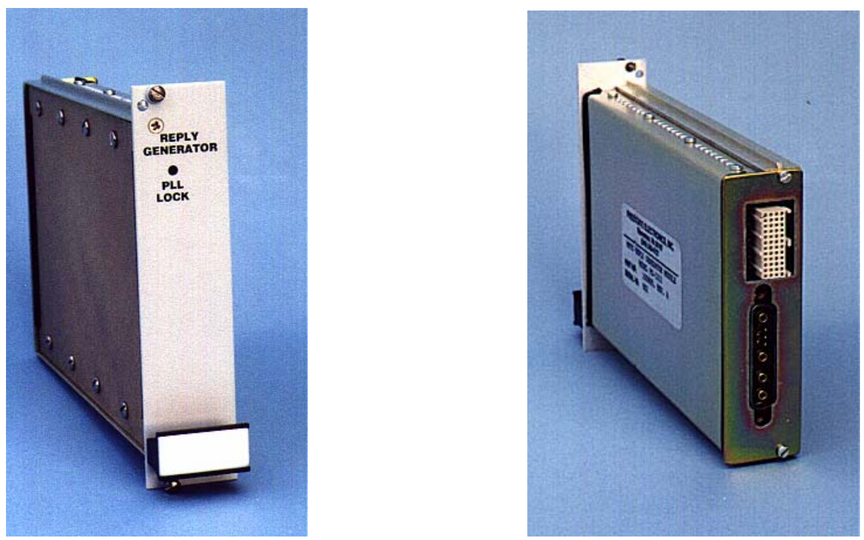
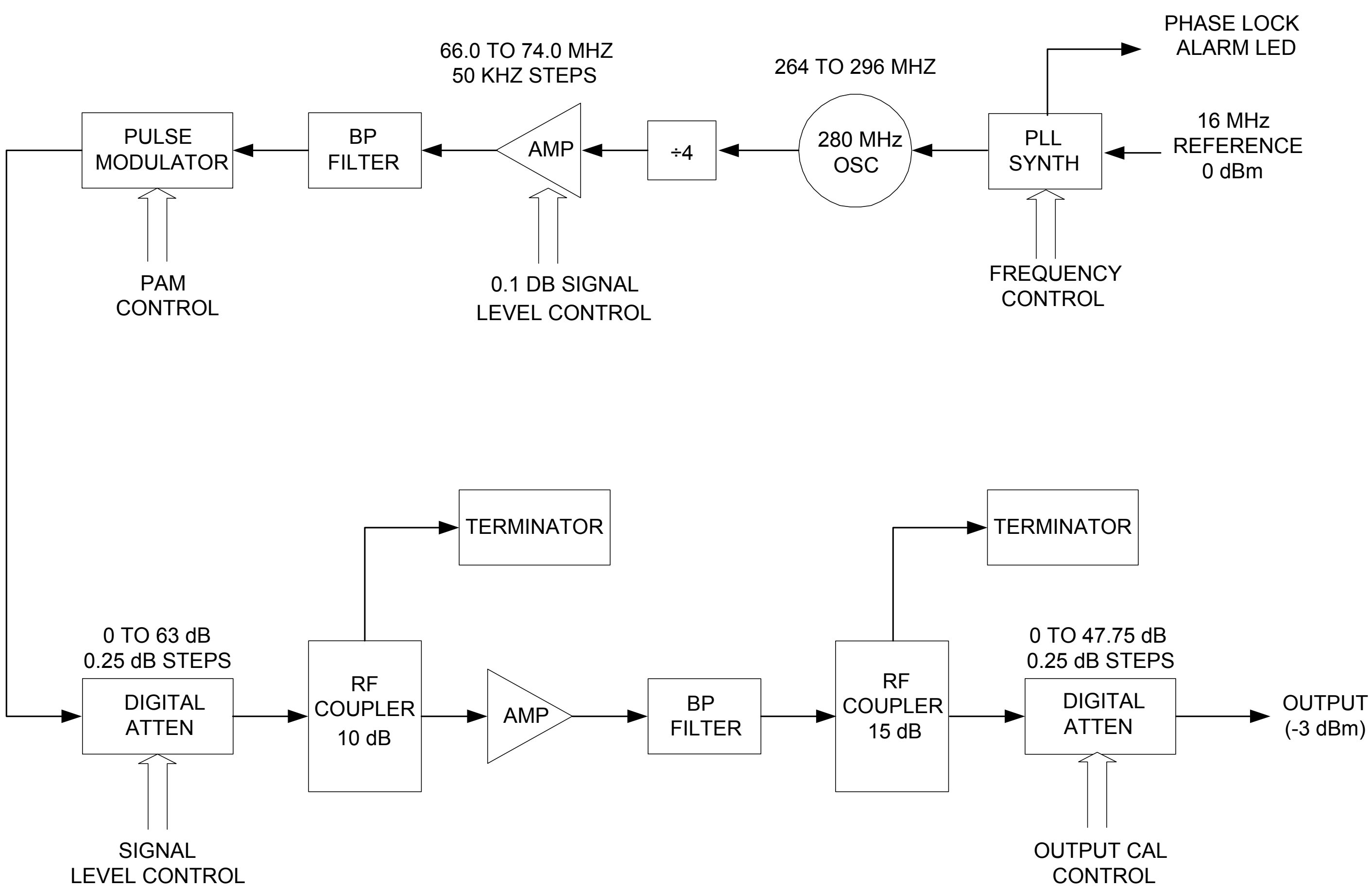


Figure 16. Reply Generator Block Diagram



**REPLY GENERATOR MODULE
BLOCK DIAGRAM
FIGURE 4**

Figure 16, the Reply Generator Module Block Diagram, illustrates the signal processing circuits within the Reply Generator Module. These are described in the following paragraphs.

Signals within the Reply Generator Module derive from a Voltage Controlled Oscillator that is phase locked to a low noise, temperature stable signal from the Reference Source Module. The operating frequency of the oscillator is controlled by data inputs from the Process Control and Communications Module. The oscillator output signal frequency may be set anywhere from 264 to 296 MHz with a resolution of 200 kHz. The VCO phase lock status is monitored and is indicated on an LED visible through the module front panel.

The VCO output signal (264 to 296 MHz) is coupled into a high-speed ECL divider IC that reduces the frequency of the input signal by a factor of four. The frequency of the divider output signal ranges from 66 to 74 MHz (50 kHz step size).

A variable gain transimpedance amplifier buffers the signal from the divider circuit. The gain setting of the amplifier is controlled by serial data from the PCC Module. Approximately 0.1 dB output level control is achieved by this circuit. Gain through the amplifier section is about 16 dB.

The three section 70 MHz bandpass filter following the variable gain amplifier greatly reduces all high frequency signal energy, such as harmonics from the preceding amplifier section and residual 280 MHz signals from the VCO. The filter has a 1 dB bandwidth of 26 MHz and an insertion loss of 1 dB.

The filtered 70 MHz signal is routed to the amplitude modulator circuit. The rise and fall times of the RF pulses through the modulator are controlled, with 100 nanoseconds being typical of both characteristics. The PAM achieves an On/Off ratio of 85 dB minimum (typically 95 dB). A signal from the PCC Module controls modulator operation.

The output level of the 70 MHz IF signal is set by the Signal Level digital attenuator. Total available attenuation spans 0 dB to 63 dB in 0.25 dB step increments (an additional 32 dB of target level signal control is found in each Upconverter Module).

After passing through a signal coupler, the IF signal is amplified by a wideband MMIC amplifier with a gain of 20.5 dB. A 70 MHz bandpass filter reduces signal harmonics created in the amplifier by at least 30 dB. Signals at the filter output are at a maximum level of +12.5 dBm.

The filtered IF signal is routed through a 10 dB coupler to a final digital attenuator. This attenuator provides a total amplitude adjustment range of 47.75 dB in increments of 0.25 dB. Signal attenuation levels are set by real time inputs from the PCC Module. The maximum signal level at the output of the Reply Generator Module is -3 dBm.

5.2.2 Upconverter Module

The output of each Reply Generator is cabled into an Upconverter Module. Within the Upconverter Module the signal from the Reply Generator is translated up to the output frequency, 1090 MHz, by the use of a 1020 MHz LO signal generated in the Reference Source Module. The 1090 MHz signal is filtered and then switched through an amplifier/attenuator gain setting circuit before being connected to the selected output channel. Output channel selection and attenuator switch settings are computer controlled from the PCC Module.

Figure 17. Upconverter Front and Rear Views

J26 - 70 MHz Test Output

J27 & J28 – 1090 MHz Test Outputs

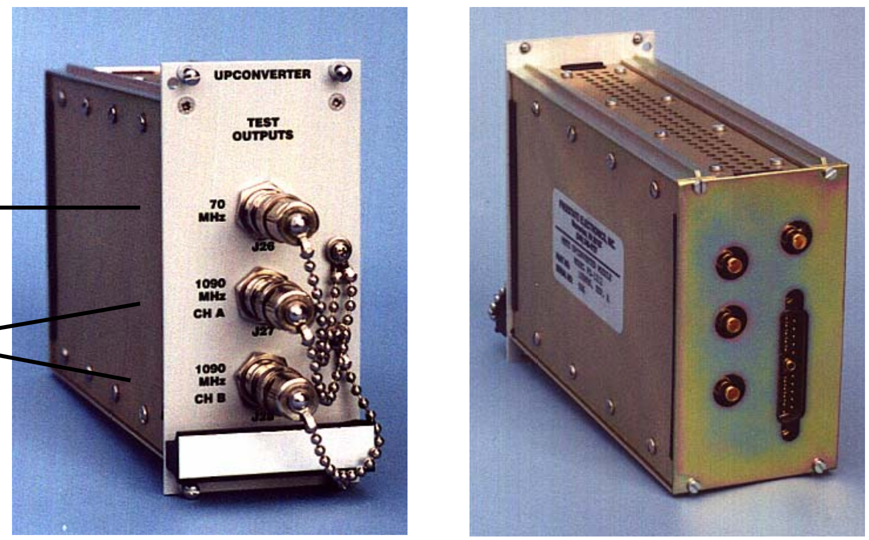


Figure 18. Upconverter Block Diagram

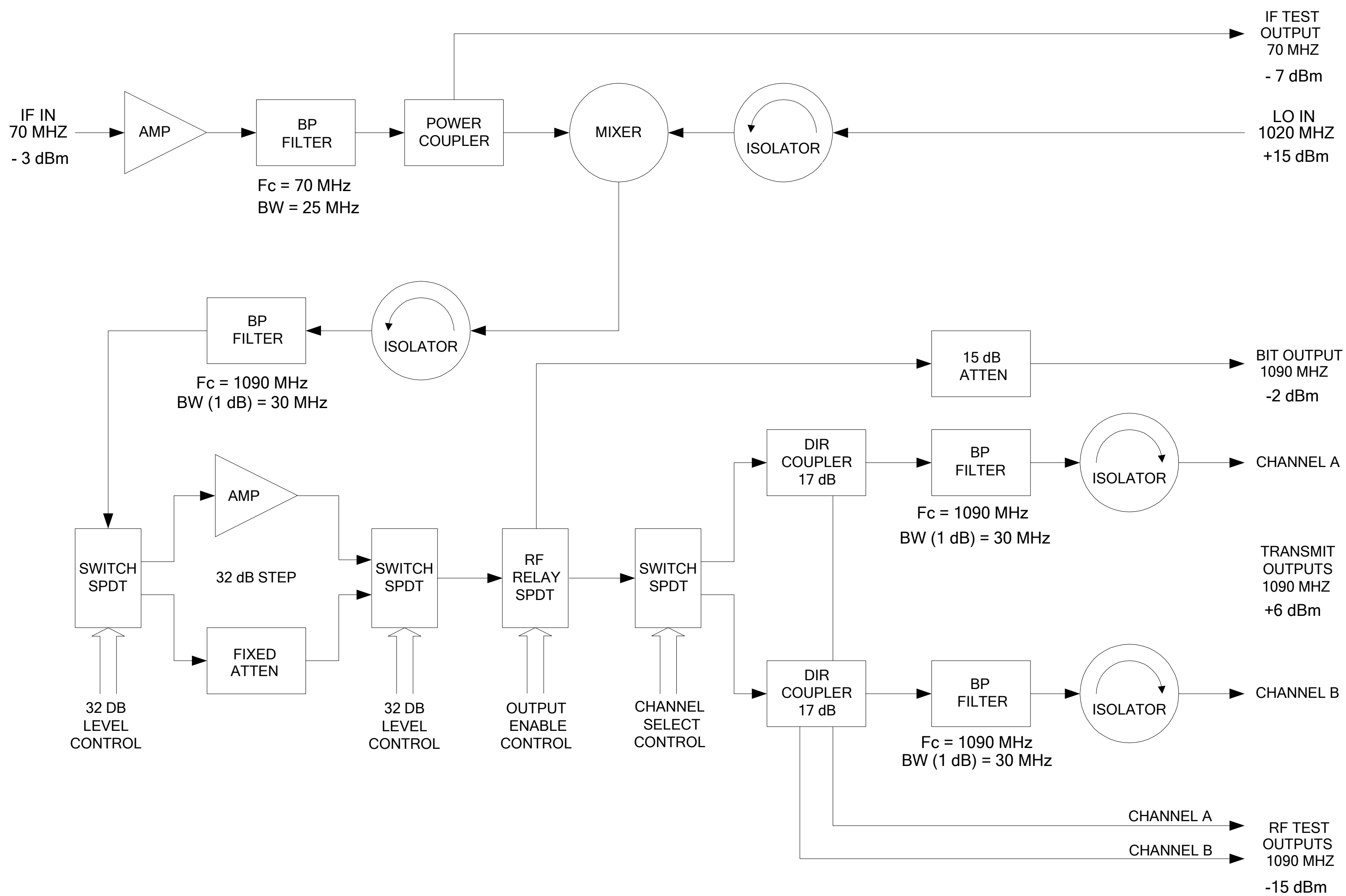


Figure 18, the Upconverter Module Block Diagram, illustrates the signal processing circuits within the Upconverter Module. These circuits are described in the following paragraphs. The two Upconverter Modules in each ADS-B chassis have identical electrical and mechanical characteristics.

The 70 MHz signals from each Reply Generator are routed to the input of a MMIC amplifier that has a signal gain of 20 dB. A five section 70 MHz bandpass filter then eliminates signal harmonics that may be produced in the amplifier. The filter has a 1 dB bandwidth of 25 MHz and at 140 MHz (the signal second harmonic) provides 50 dB of signal rejection. At the output of the filter the maximum signal level is approximately +9 dBm.

The filtered 70 MHz signal is then routed to a 10 dB coupler. The coupled signal is cabled to the 70 MHz Test Output connector located on the front panel of the Upconverter Module. The primary signals from the coupler are converted to 1090 MHz by an RF mixer. At the mixer output port the nominal maximum signal level is -4.5 dBm. A +13 dBm, 1020 MHz LO signal (generated in the Reference Source Module) is used in the signal conversion process.

Three (two in each signal channel) four-section, 1090 MHz bandpass filters reduce undesired mixer products. The second filter also eliminates signal harmonics generated in the amplifier section that precede it. These filters have a 3 dB bandwidth of 30 MHz and an insertion loss of 1.5 dB.

The 1090 MHz signal at the output of the first filter connects to a RF switch network. The network sends the RF signal through either a linear amplifier with a nominal gain of 21 dB, or an attenuator with a nominal attenuation of 11 dB. The attenuator value is set to achieve a total change in RF gain of exactly 32 dB when the signal path switches.

The output of the switched RF section is connected into a high isolation, normally open RF relay. The RF relay insures that no signals exit the ADS-B until set to do so by commands from the PCC Module. When the relay is activated, signal energy passes from the relay output to the channel select switch.

The channel select network routes the output signal to either the Channel A or the Channel B signal line. Selection of the operational output channel is by a control input from the PCC Module. Signals at the selected switch output port are at a maximum level of +9 dBm.

Directional couplers in each output signal line direct a portion of the main output signal to the 1090 MHz test outputs located at the front panel of the Upconverter Module. Signals at either the Channel A or the Channel B Test Output are at a maximum level of -15 dBm.

Each high level signal from the directional coupler passes through a 1090 MHz bandpass filter and an isolator before exiting the module. The isolator provides more than 20 dB of reverse isolation. At the module output, the maximum signal level is +6 dBm.

5.2.3 Reference Source

The Reference Source Module generates a stable, low noise 16 MHz reference signal that is used to phase locked all other ADS-B oscillators. The Reference Source Module also generates two phase-stable 1020 MHz LO signals for use in each of the two Upconverter Modules. Finally, the Reference Source generates a fixed frequency 1060 MHz signal used for test purposes.

Figure 19. Reference Source Module Front and Rear Views

Figure 20, the Reference Source Module Block Diagram illustrates the signal processing circuits within the Reference Source Module. These circuits are described in the following paragraphs.

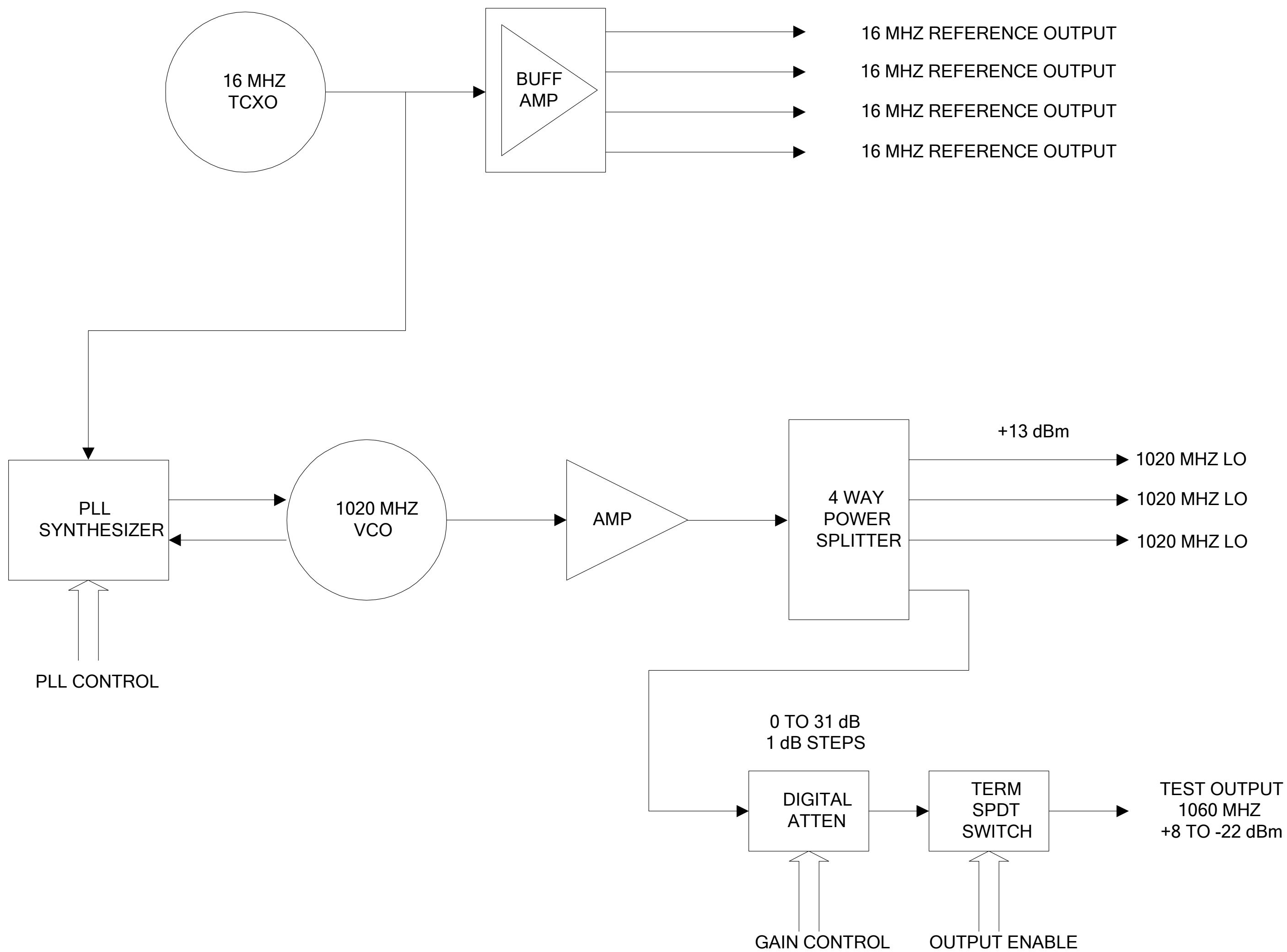
A temperature compensated crystal oscillator produces a low noise, +8 dBm, 16 MHz reference signal. This signal is routed to a buffer amplifier IC that provides four, +3 dBm, and 16 MHz reference signals to the module output connections.

The 1020 MHz LO signal is derived from a VCO that is phase locked to the 16 MHz reference signal. The operating frequency of the oscillator is controlled by data inputs from the Process Control and Communications Module. The output signal frequency is normally fixed at 1020 MHz. However, as the output frequency of the ADS-B is varied from 1080 MHz to 1100 MHz, the LO signals tunes over a frequency range of 1010 MHz to 1030 MHz (in 200 kHz step increments).

The VCO output signal is generated within a high quality, surface mount, hybrid oscillator assembly. The signal output level is +12 dBm. Typical phase noise at a 10 kHz offset is -90 dBc/Hz. The VCO phase lock status is monitored and is indicated on an LED visible through the module front panel.

The phase stable 1020 MHz signal from the VCO is amplified to a level of +20 dBm. The signal from the amplifier output is then directed to a four-way power splitter. The outputs of the splitter, four equal amplitude (+13 dBm) LO signals, are routed to the module output ports, and through a digitally controlled GaAs MMIC attenuator and RF switch to the 1060 MHz Test Output.

Figure 20. Reference Source Module Block Diagram



The GaAs MMIC attenuator permits operator control of the 1060 MHz Test Output signal level. The attenuator IC has 31 dB of control range with a resolution of 1 dB. At the 1060 MHz Test Output signal amplitude may be set between +8 dBm to -21 dBm. A high isolation terminating GaAs RF switch selectively enables or disables the presence of RF energy at the 1060 MHz Test Output port. Input to output switch isolation is greater than 45 dB. The 1060 MHz Test Output port is located at the module front panel. Signal connection is through an N style connector.

5.2.4 Built In Test (BIT)

The BIT Module verifies the basic performance of the ADS-B. The module includes level detector and demodulator circuits, for measuring internal and external signals, and a microcontroller section. The level detector section verifies the amplitude performance of signal generation circuits within the Reply Generator and Upconverter Modules. The microcontroller section controls this process through the generation of timed digital test stimuli in response to commands communicated from the PCC Module.

Figure 21. Built In Test Module Front and Rear Views

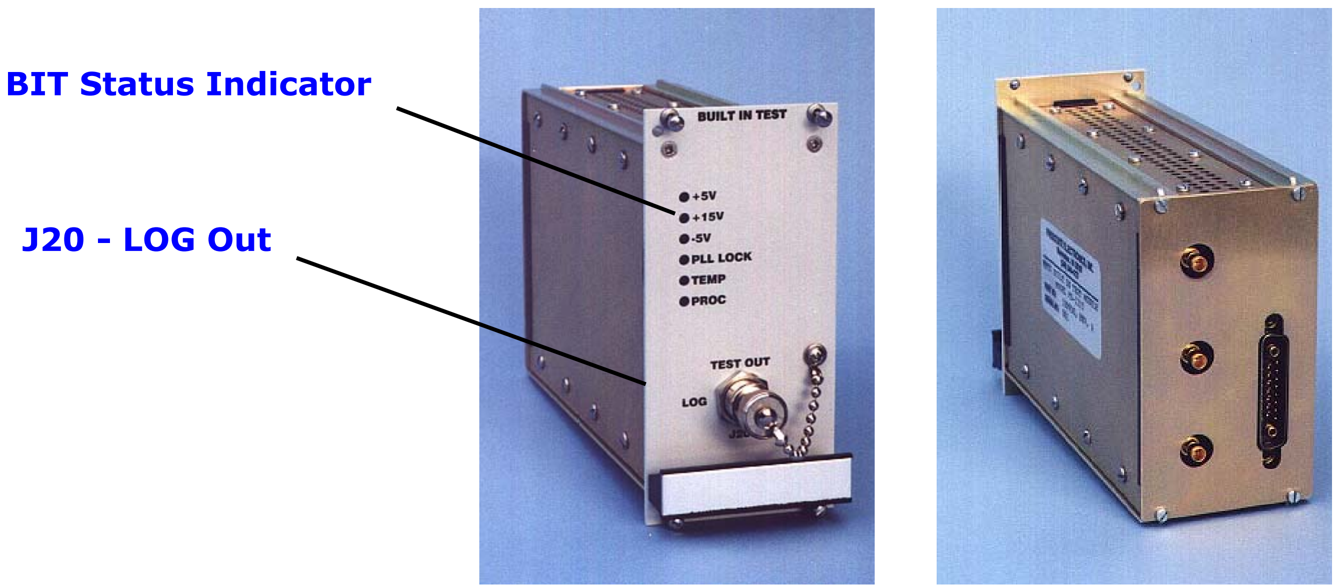
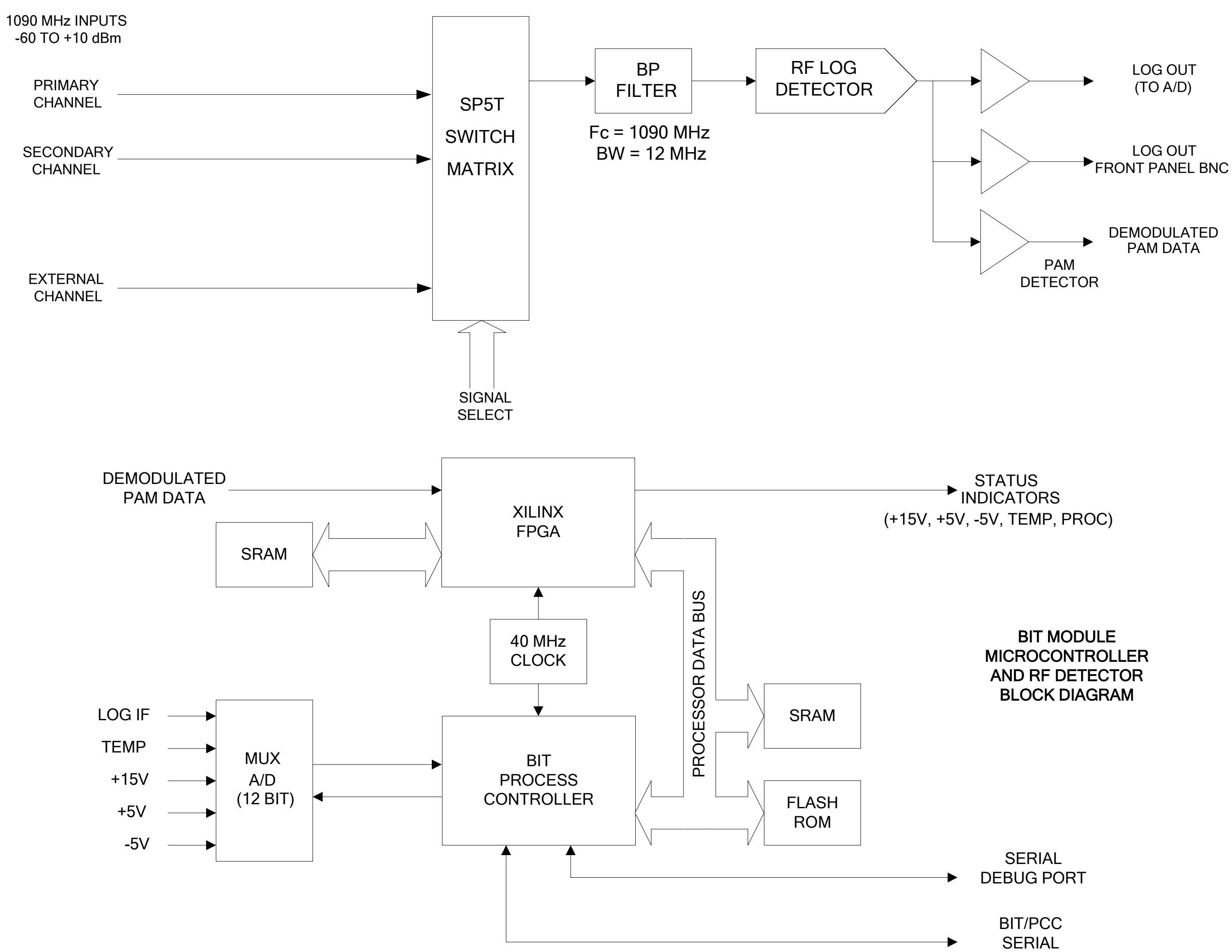


Figure 22. BIT RF and Microcontroller Block Diagram



BIT measurements are performed when the ADS-B powers up and upon operator request. The level detector section of the BIT Module verifies the operation of all processor controlled signal generation circuits. The Reply Generator is set to generate CW and pulsed signals. The BIT Module makes CW signal strength measurements as each Reply Generator and Upconverter attenuator control is exercised. Pulsed signals from each signal generation channel are demodulated and analyzed. Both measurements are compared against predetermined pass/fail criteria. Unexpected or improper signal operation results in a fault condition and generates an ADS-B service request.

The BIT Module measures and monitors the three DC power supply voltages (+15V, +5V, and -5V) and the air temperature internal to the chassis. The DC voltages and the voltage from the temperature monitor IC are multiplexed with the detected RF signal at the input to the A/D Converter. The operational status of all monitored signals is communicated to the PCC Module. Other specified BIT functionality, such as PLL status, is handled by the microcontroller within the PCC Module.

Figure 22, the BIT RF and Microcontroller Block Diagram, illustrate the signal processing circuits within the BIT Module. These circuits are described in the following paragraphs.

5.2.4.1 BIT Level Detector

The BIT level detector measure one of the three available 1090 MHz signals at its RF input ports. Signals at these ports derive from the BIT outputs of the Upconverter Modules and from the external transmitter input located on the rear panel of the ADS-B. The selected signal is routed to a precision, monolithic log amplifier that measures the level of the RF signal. The DC signal from the log amplifier IC is digitized in a 12-bit A/D converter. The A/D data outputs are then routed to the onboard microcontroller for analysis or transfer to the PCC Module.

A network of SPDT and SP4T GaAs FET switches, controlled by the BIT microcontroller, selects the RF signal to be processed. The selected RF signal is routed to a four-section 1090 MHz bandpass filter. The filter permits only the selected 1090 MHz signal to pass and be detected. The log amplifier generates an accurate and repeatable DC signal that corresponds to the power level of the selected 1090 MHz signal. The DC signal from the log detector is connected through buffer amps to a 12-bit A/D converter.

The A/D converter has eight multiplexed input signal lines, of which five are used. The A/D circuit measures the DC signal from the RF log detector, the voltage from a temperature measurement IC, and the three DC power supply voltages (+15V, +5V, and –5V). The A/D conversion process is controlled by the BIT microcontroller. Data from the A/D is routed to the microcontroller and then communicated to the PCC Module for analysis. Verification of the performance of each RF amplitude-setting circuit is accomplished by the measurement of detected RF signal levels, routed into the BIT Module from each Upconverter Module, as they are individually set by the PCC Module.

5.2.4.2 BIT Microcontroller

The BIT Microcontroller section interfaces with the PCC Module to control all of the BIT functions. BIT functions include control and monitoring of the BIT RF hardware, verification of the operation of all amplitude controls in each signal generator, temperature monitoring, temperature compensation measurement of transmit signal power levels, and monitoring of power supply voltages.

The core processor components consist of an Intel 80C188EB processor, static RAM and FLASH ROM. A Xilinx FPGA provides the interface between the processor and the BIT RF hardware and also decodes and records the detected pulse RF signals that enter the ADS-B through the external port. The A/D converter measures detected RF signal levels, power supply voltages, and BIT Module ambient temperature. Front panel LEDs display the operational condition of the power supply voltages, module temperature, PLL lock, and of the microprocessor.

Memory includes both RAM and Flash ROM. RAM is static and is configured as an array of 128K words of 8 bits each (128 Kbytes). Flash ROM is configured as an array of 512K words of 8 bits each (512 Kbytes). The Flash ROM may be written to by the CPU to save firmware and FPGA downloads through the serial (RS-232) communications port.

The BIT Module communicates with the PCC Module via a CMOS asynchronous serial port. This serial port uses the same data format as an RS-232 port. For almost all BIT functions, the BIT Module is a slave to the PCC Module (i.e. the BIT Module never initiates any tests). The exceptions are temperature and power supply monitoring. The BIT

Module monitors these conditions continuously, though it reports their status to the PCC only when requested.

The BIT Module also provides a CPU remote RS-232 debug port. This interface allows access to built-in debugging features of the processor. It is used for factory maintenance and repair only.

5.2.5 Process Control and Communications (PCC)

The primary functions of the PCC Module include:

- Generation of signals to control the timing and amplitude characteristics of RF transmissions
- Performance verification of all ADS-B functions through the implementation of Built In Test processes
- Support of operator functions and settings communicated to the ADS-B from the Operator Control System (OCS) via an IEEE-488 interface

Figure 23. PCC Module Front and Rear Views

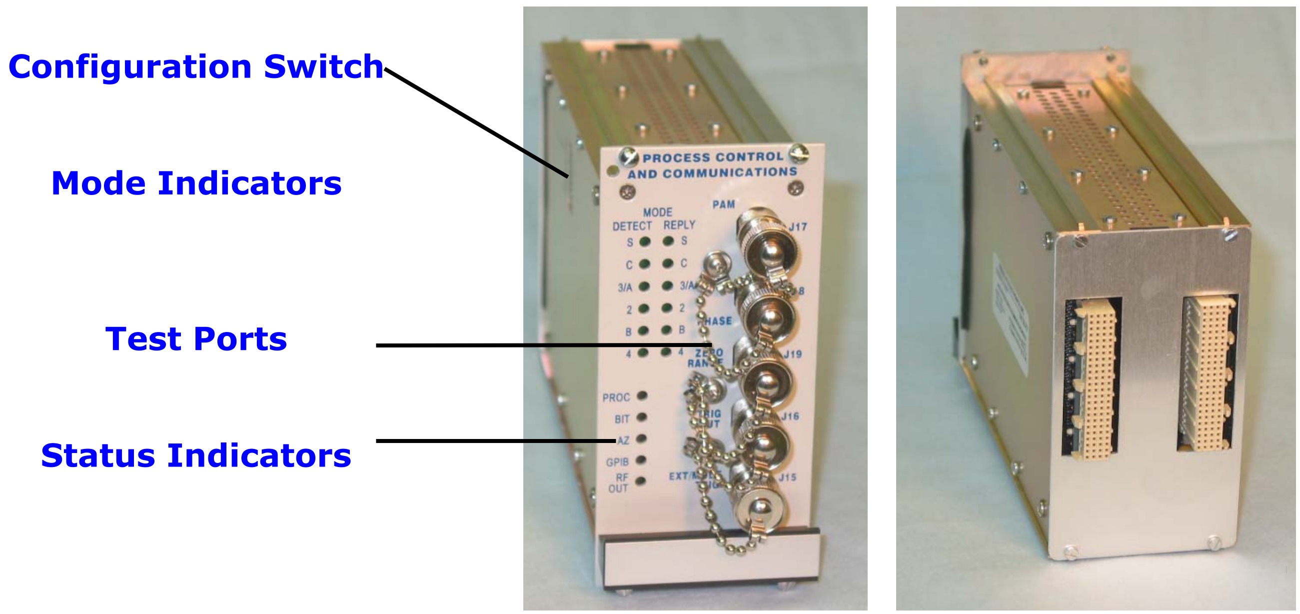
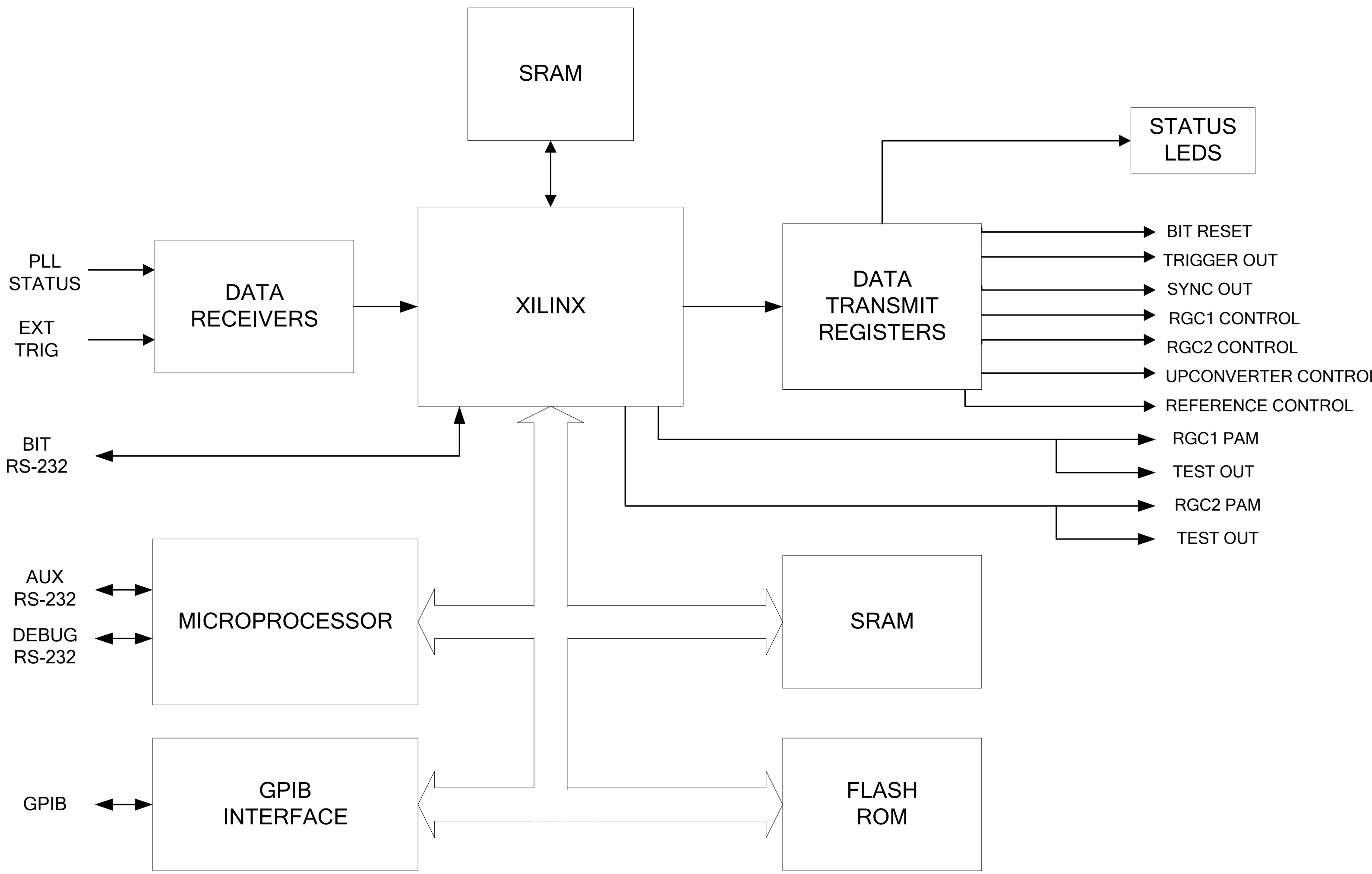


Figure 24. PCC Module Block Diagram



5.2.5.1 PCC Module Overview

The PCC Module performs real-time and non real-time functions. Real-time functions include the generation of transmission signals. Non real-time functions include control and monitoring of ADS-B operating frequencies, signal levels, input and output channel selections, BIT functionality, and handling of either GPIB or serial communications.

Figure 24, the PCC Module Block Diagram, indicates the primary connections into the PCC Module and the major signal connections between the functional blocks that make up the PCC Module.

The CPU serves as the central control element for the PCC. It is comprised of an Intel model 80C188EB processor, Flash ROM and RAM memory, remote control ports, and an ADS-B Inter-Module Interface that communicates with and sets the operating parameters of each of the other ADS-B modules. RAM is static and is configured as an array of 64K words of 16 bits each (128 Kbytes). Flash ROM is configured as an array of 1M words of 8 bits each (1 Mbytes). The Flash ROM may be programmed to save firmware and FPGA updates through the use of the RS-232 Control Port.

The transmission generation circuits contained within the Xilinx IC perform all of the real-time processing functions that are required to properly format RF transmissions.

A dedicated IEEE-488 ASIC provides the GPIB communications interface between external devices and the CPU microprocessor. All GPIB communications through this interface follow the transmission protocols listed in the IEEE-488.2 specification. The ADS-B IEEE-488 Command Set (FSE Document No. 200006) lists the commands, responses, and data formats that are required for proper communication with and control of the ADS-B and the PCC Module. The IEEE-488 port is the means by which the OCS communicates with the ADS-B.

Two serial communication ports provide an interface between the PCC CPU and external communication devices. Both ports follow the protocols and guidelines established in the ANSI RS-232C specification. One port is used to upload firmware and FPGA updates and may also be used as a secondary means of controlling the ADS-B. The second RS-232 port provides access to the built-in debug features of the 80C186EB processor. This port is not accessible through any connectors on the exterior of the ADS-B.

A third serial communication port provides an interface between the PCC CPU and the microprocessor located within the BIT Module. The PCC CPU is the system controller of this interface.

5.2.5.2 IEEE-488 Control

An IEEE-488 port (rear panel J12 – IEEE-488 Connector) provides a communication interface between external GPIB devices and the PCC CPU microprocessor. All GPIB communications through this interface follow the transmission protocols listed in the IEEE-488.2 specification. The ADS-B IEEE-488 Command Set (FSE Document No. 200006) lists the commands, responses, and data formats that are required for proper communication with and control of the ADS-B and the PCC Module. A Configuration Switch sets the PCC IEEE-488 bus address. The configuration switch is accessed through a cut-out in the side cover of the PCC Module chassis.

5.2.5.2.1 PCC IEEE-488 Address Configuration and Calibration Setup

The PCC module uses an 8-position Configuration Switch, accessible through the module side cover, to set the GPIB bus address (see Figure 25).

IEEE-488 ADDRESS SWITCH. Switch A1 denotes the Least Significant Bit (LSB), and A5 denotes the Most Significant Bit (MSB) of the GPIB address switch. Bit weighting is 1, 2, 4, 8, and 16 respectively for switch controls A1 through A5. The ADS-B is delivered with a default address 1 (see Figure 50).

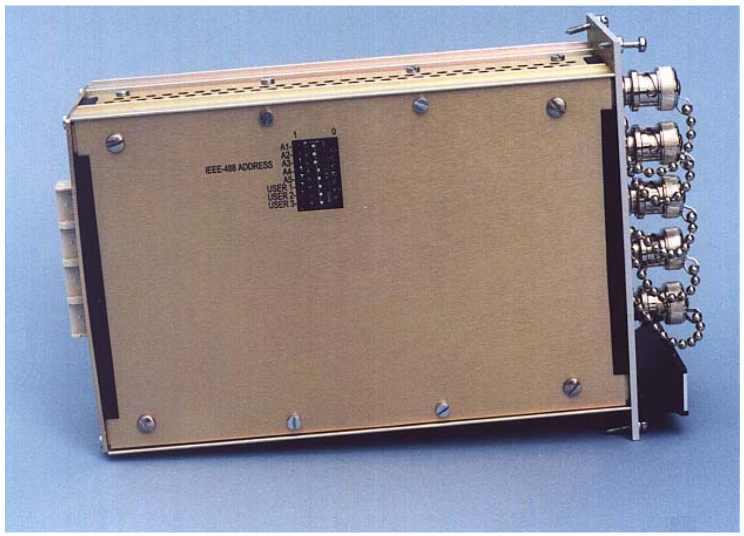
USER SWITCH 1. When switch USER 1 is set to Position 1 overwriting of the internal calibration tables and factors is prevented. When set to position 0, any of the calibration tables internal to the ADS-B can be erased or overwritten.

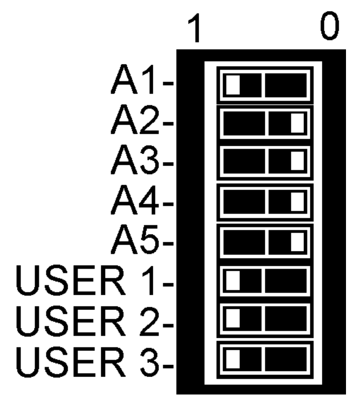
USER SWITCH 2 and 3. Switches USER 2 and USER 3 are for special factory procedures only. For normal ADS-B operation these should remain in position 0. Both switches need to be set to Position 1 to enable the use of software and firmware field upgrades.

CAUTION

Keep the USER 1 switch set to position 1 to prevent overwriting of factory set calibration tables and factors.

Figure 25. PCC Module Side View Showing Setup Switches and Detail





Switches A1 through A5 are used for setting the IEEE-488 bus address to a binary value between decimal 0 and 31. User 1 enables/disables overwriting factory calibration settings. User 2 and User 3 are for factory use only.

6 STANDARDS AND TOLERANCES

6.1 ADS-B General Operating Characteristics

The ADS-B mounts in a 7-inch (4U) high opening of a standard 19-inch rack or equipment cabinet. It is designed for indoor operation only. Table 2 lists the General Operating Characteristics of the ADS-B.

Table 1. ADS-B General Operating Characteristics

Characteristic	Specification
Weight	35 pounds
Size	Front Panel - 7 x 19 (H X W) inches Rear Panel - 7 x 17.625 (H x W) inches Depth - 14 inches
Power	115 to 230 VAC, 50-60 Hz, 50 Watts, typical
Temperature	Operating: +10°C to 50°C Storage: -20°C to +70°C
Relative Humidity	0% to 90%, non-condensing
Altitude	Operating: 10,000 feet Storage/Shipping: 20,000 feet
Shock and Vibration	Normal bench handling

6.2 ADS-B Signal Interfaces

Signal interfaces are located on the front and rear panels of the ADS-B. The primary signal output interfaces are located on the ADS-B chassis rear panel. The IEEE-488 control, the RS-232 control, and the AC power input are also located on the chassis rear panel. Video, IF, and RF test inputs and outputs are located on the front panels of the various plug-in modules.

6.2.1 Rear Panel Signal Interfaces

Refer to Figure 2 for rear panel connector locations.

6.2.1.1.1 J1 and J4 - 1090 MHz Signal Outputs

The 1090 MHz Channel A and Channel B signal connectors are located on the ADS-B rear panel. Type N female connectors are used. Connector reference designators are:

J1 - Channel A Output

J4 - Channel B Output

Table 2. J1 - Channel A Output

Connector Reference Designator	J1
Connector Name	1090 MHz Output, Channel A
Connector Location	ADS-B Rear Panel
Connector Type	"N"
VSWR/Impedance	1.5:1 maximum, 50 Ohms
Output Level	Adjustable, -95 dBm to 0 dBm
Output Signal Frequency	1090 MHz nominal, 1080 MHz to 1100 MHz, adjustable in 200 kHz increments

To: Section 6.2.1, Rear Panel

Table 3. J4 - Channel B Output

Connector Reference Designator	J4
Connector Name	1090 MHz Output, Channel B
Connector Location	ADS-B Rear Panel
Connector Type	“N”
VSWR/Impedance	1.5:1 maximum, 50 Ohms
Output Level	Adjustable, -95 dBm to 0 dBm
Signal Frequency	1090 MHz nominal, 1080 MHz to 1100 MHz, adjustable in 200 kHz increments

To: 6.2.1 Rear Panel

6.2.1.2 J12 – IEEE-488 Connector

The IEEE-488 interface, J12, is located on the rear panel of the ADS-B. All pin name and numbering assignments are per IEEE-488 standards as shown in Table 12. Refer to Figure 2 for rear panel connector locations.

Table 4. J12 - IEEE-488 Connector Pin Designations

Pin Number	Designation	Pin Number	Designation
pin 1 -	DIO1	pin 13 -	DIO5
pin 2 -	DIO2	pin 14 -	DIO6
pin 3 -	DIO3	pin 15 -	DIO7
pin 4 -	DIO4	pin 16 -	DIO8
pin 5 -	EIO	pin 17 -	REN
pin 6 -	DAV	pin 18 -	GND
pin 7 -	NRFD	pin 19 -	GND
pin 8 -	NDAC	pin 20 -	GND
pin 9 -	IFC	pin 21 -	GND
pin 10 -	SRQ	pin 22 -	GND
pin 11 -	ATN	pin 23 -	GND
pin 12 -	SHIELD	pin 24 -	LOGIC GND

6.2.1.3 J13 – Auxiliary RS-232 Control Port

The Auxiliary RS-232 serial communications interface, J13, is located on the rear panel of the ADS-B. The serial interface conforms to the protocols listed in ANSI/TIA/EIA-232F. The Auxiliary RS-232 Control Port uses the same command structure as the IEEE-488 interface. The interface operates at 9600 baud, 8 data bits, 1 stop bit and no parity bit. Handshaking should be turned off. Refer to Figure 2 for rear panel connector locations.

Table 5. J13 – Auxiliary RS-232 Control Port

Connector Reference Designator	J13
Connector Name	Auxiliary RS-232 Control Port
Connector Location	ADS-B Rear Panel
Connector Type	DB-9 Female
Signals	pin 2 - TX Data pin 3 - RX Data pin 5 - Ground

6.2.1.4 J14 – AC Power

AC power is applied to the ADS-B through rear panel connector J14. Refer to Figure 2 for rear panel connector locations.

Table 6. J14 - AC Power Input Connector

Connector Reference Designator	J14
Connector Name	AC Power
Connector Location	ADS-B Rear Panel
Connector Type	3 Prong IEC
Input Level	105 to 265 Volts AC
Maximum Current Draw	0.8 Amperes
Signal Frequency	50 to 60 Hz
Fuse Type	3AG Type, 1 Amp, 250 VAC

6.2.1.5 Fuse

The ADS-B is protected from current overload by Fuse F1, which is a 3AG Type, rated at 1 Ampere, 250 VAC. The fuse holder is located on the ADS-B rear panel.

6.2.2 Front Panel Connectors

6.2.2.1 J15 through J19 – Data Interfaces

There are five ADS-B data signal interface connections. These include the External Trigger Input (J15), the Trigger Output (J16), the PAM Primary Output (J17), the PAM Secondary Output (J18), and Sync Output (J19). These connections are located on the front panel of the Process Control and Communications (PCC) Module. All connectors are type BNC.

Refer to Figure 1 for the front panel module locations.

Refer also to Section 2.3.2.4.2, PCC Module Test Ports and Status Indicators, for a description of the use of these test ports.

Specifications for each of the connectors can be found in the following tables:

Table 7. J15 –External Trigger In

Table 8. J16 – Trigger Out

Table 9. J17 – PAM

Table 10. J18 –

Table 11. J19 – Sync Out

Table 7. J15 –External Trigger

Connector Name	External Trigger
Connector Reference Designator	J15
Connector Location	PCC Module Front Panel
Connector Type	BNC
Signal Description	Trigger signal input for signal generation
VSWR/Impedance	75 Ohm
Input Level	TTL Compatible, Trigger occurs on rising edge of input pulse.
Pulse Width/Timing	Pulse width = 0.1 μSec
Signal Frequency	Up to 8,000 trigger signals per second

Table 8. J16 – Trigger Out

Connector Name	Trigger Out
Connector Reference Designator	J16
Connector Location	PCC Module Front Panel
Connector Type	BNC
Signal Description	Trigger output pulse created by ADS-B in response to every valid trigger signal
VSWR/Impedance	75 Ohm
Output Level	TTL Compatible
Signal Frequency	At the rate of detected triggers, pulse width user variable from 0.1 to 5.0 μSec

Table 9. J17 – PAM Primary

Connector Name	PAM Reply Data
Connector Reference Designator	J17
Connector Location	PCC Module Front Panel
Connector Type	BNC
Signal Description	Pulse amplitude modulating sequence applied to the primary channel signal generation circuits of the ADS-B
VSWR/Impedance	75 Ohm
Output Level	TTL Compatible, low enable
Pulse Width/Timing	Set by ATCRBS and Mode S data specifications, operator variable pulse width and pulse timing

Table 10. J18 – PAM Secondary

Connector Name	Phase Reply Data
Connector Reference Designator	J18
Connector Location	PCC Module Front Panel
Connector Type	BNC
Signal Description	Pulse amplitude modulating sequence applied to the secondary channel signal generation circuits of the ADS-B
VSWR/Impedance	75 Ohm
Input Level	Not Applicable
Output Level	TTL Compatible, low enable
Pulse Width/Timing	Set by ATCRBS and Mode S data specifications, operator variable pulse width and pulse timing

Table 11. J19 –SYNC Out

Connector Name	Zero Range Data
Connector Reference Designator	J19
Connector Location	PCC Module Front Panel
Connector Type	BNC
Signal Description	Pulse signal from Master ADS-B unit used to synchronize triggering and event timing of Slave ADS-B units
VSWR/Impedance	75 Ohm
Input Level	Not Applicable
Output Level	TTL Compatible
Signal Frequency	Data rate and signal timing dependent upon trigger requirements

Table 12. J20 – Log Video Test Output

Connector Name	Log Video Test Out
Connector Reference Designator	J20
Connector Location	BIT Module Front Panel
Connector Type	BNC
VSWR/Impedance	1.5:1, 50 Ohm
Output Level	Log video representation of the level of the selected RF signal (RF primary or secondary channels, or External signal input), 0.6 Volts to 1.7 Volts into 50 Ohms
Signal Frequency	At the rate of the detected BIT test pattern

6.2.2.2 J25 – 1060 MHz Test Output

1060 MHz test signal are available at the Reference Source Module TEST OUT CW connector (J25). J25 is a type N connector.

Table 13. J25 – 1060 MHz Test Output

Connector Name	1060 MHz Test Out
Connector Reference Designator	J25
Connector Location	Reference Source Module Front Panel
Connector Type	N
VSWR/Impedance	1.5:1, 50 Ohm
Input Level	Not Applicable
Output Level	Normally disabled. Controllable, -22 to +8 dBm
Signal Frequency	1060 MHz

6.2.2.3 J26 - 70 MHz Test Output

70 MHz IF test signals are available at the front panel of both Upconverter Modules. ***It is important to terminate this port with the included 50 Ohm load when it is not otherwise in use***.

Table 14. J26 – 70 MHz Test Output Connector

Connector Name	70 MHz Test Out
Connector Reference Designator	J26
Connector Location	On each Upconverter Module front panel
Connector Type	BNC
VSWR/Impedance	1.5:1, 50 Ohm
Output Level	Approximately 23 dB below the level of signals at the applicable rear panel output
Signal Frequency	70 MHz, nominal

6.2.2.4 J27 & J28 – 1090 MHz Test Outputs

1090 MHz, Channel A and Channel B test signals may be monitored at the front panel of both Upconverter Modules. The Output Select control determines which of the two test ports is active. Terminate these ports, using the attached 50 Ohm loads, when they are not in use.

Table 15. J27 & J28 – 1090 MHz Test Outputs

Connector Name	1090 MHz Test Out
Connector Reference Designator	J27, Channel A J28, Channel B
Connector Location	On both of the Upconverter Module front panels
Connector Type	BNC
VSWR/Impedance	1.5:1, 50 Ohm
Output Level	Approximately 20 dB below the level of signals at the rear panel output
Signal Frequency	1090 MHz nominal, Operator selectable, 1080 to 1100 MHz in 200 kHz steps

6.2.2.5 J30 –1090 MHz Transmission Input

Transmitter signals enter the ADS-B through this interface.

Table 16. J30 - 1090 MHz Transmission Input

Connector Reference Designator	J1
Connector Name	1090 MHz Transmission Input
Connector Location	ADS-B Rear Panel
Connector Type	"N"
VSWR/Impedance	1.5:1 maximum, 50 Ohms
Transmission Input Level	+30 dBm to +50 dBm nominal, +50 dBm maximum

To: Section 6.2.1, Rear Panel

7 MAINTENANCE AND REPAIR

7.1 Periodic Maintenance

Periodically the physical condition and the electrical performance of the ADS-B should be verified. Maintenance schedules should be based upon the environment in which the ADS-B operates. If the ADS-B is used in hot and dusty environments maintenance should occur more frequently than suggested below.

7.1.1 ADS-B Cleaning

The physical condition of the ADS-B should be inspected at a minimum of every six months for the accumulation of dust or dirt in the ventilation holes on the bottom and top panels of the chassis.

If it is found that the top or bottom panels have an accumulation of dust, it is recommended that they be cleaned with a clean, soft bristle brush, and a vacuum cleaner.

Each Upconverter Module should also be pulled out at this time to check for the accumulation of dust on their top and bottom panels. Module removal requires the use of a small flat-blade screwdriver. Each module is held in place with either two or four captive screws. Loosen the screws and pull the module away from the chassis through the use of the front panel handle. All modules should be removed if the Upconverter modules are found to be dirty. Clean these with a soft brush and vacuum cleaner, as required.

NOTE

> The location of each Reply Generator and Upconverter Module in the chassis should be noted prior to removal. Insert each Upconverter Module back into the slot from which it was extracted. Failure to do so will require realignment and possibly recalibration of the ADS-B.

The chassis interior should be thoroughly cleaned using a soft brush and vacuum cleaner.

When replacing a module use caution not to over tighten the screws that hold the module to the chassis.

If the exterior of the ADS-B should require additional cleaning, it can be wiped with a clean cloth that has been moistened with a spray type of household cleaner. Do not spray the cleaner directly onto the ADS-B surfaces.

7.1.2 Equipment Calibration

It is recommended that the operation of the ADS-B be evaluated at least once a year. Contact Freestate Electronics for more information.

7.2 Repair

The ADS-B includes extensive Built In Test features that can often, through proper analysis, pinpoint a performance issue to a particular circuit within a particular module. Some ADS-B performance parameters are continuously monitored. These are displayed on the OCS control panel as described in the System Status section of this manual. Other performance parameters are checked only when the ADS-B Self Test/Diagnostics Mode has been selected. If the ADS-B has operational issues, use the Standby/Diagnostics Mode to evaluate the problem. Once the results of the tests performed in the Standby/Diagnostics Mode are available they can be analyzed using the outline provided in the following section.

The BIT process assumes that the BIT Module functions properly. The BIT Module measures the performance of all Reply Generator and Upconverter RF control circuits. BIT testing insures the functionality, not the absolute accuracy, of each RF control. For the ADS-B design, soft failures, in which a circuit partially works, are not a likely event.

Always verify the results of the BIT process, by repeating the test sequence or through the use of external test equipment, before proceeding with module or unit replacement.

7.2.1 Trouble Diagnostics

Use the table below and the test results of the Standby/Diagnostics Mode to determine the most likely source of any problem. The Self Test/Diagnostics Mode Status Indicators section of this manual defines all of the trouble conditions listed below.

Refer to Section 7.3, below, for information regarding replacement of ADS-B modules.

A thorough understanding of the ADS-B theory of operation, Section 5.1, will provide insight into the trouble shooting process. This should be reviewed as necessary.

Table 17. Trouble Diagnostics - ADS-B Operation

Indicated Problem	Problem Area	Suggestions
REF PLL alone or if any other PLL indicators active	Reference Source Module If no other PLL issues indicated, the LO circuit is problematic. If multiple PLL faults indicated, the crystal oscillator or output buffer is problematic.	Replace Reference Source Module
RGC PLL	Reply Generator Module PLL circuit If no other PLL issues indicated This condition may cause many other fault conditions	Replace Reply Generator Module Check Reference Signal into the module
1100BIT PLL	BIT Module 1100 MHz PLL circuit If no other PLL issues indicated	Replace BIT Module Check Reference Signal into the module
70BIT PLL	BIT Module 70 MHz PLL circuit If no other PLL issues indicated	Replace BIT Module Check Reference Signal into the module
Power Alarm	One of the three power supply voltages is non-compliant This condition may cause many other fault conditions	Check displayed power supply voltage measurements Replace appropriate Power Supply

Indicated Problem	Problem Area	Suggestions
Temperature Alarm	Internal temperature of ADS-B is out-of-specification	Turn off ADS-B. Do not operate until ambient conditions are within +10ºC and +50ºC.
Calibration Alarm	ADS-B output level could not be properly calibrated ADS-B may operate but not with specified output level accuracy	Check ambient temperature Check ADS-B Calibration
TGT Atten	Target Level Attenuator circuit within the Reply Generator This condition may cause many other fault conditions	A) Verify attenuator performance at the Upconverter 70 MHz test port Replace the Reply Generator Module B) Verify 32 dB gain step in the Upconverter Replace the Reply Generator Module
SUP Atten	Upconverter calibration attenuator circuit within the Reply Generator This condition may cause many other fault conditions	Verify attenuator performance at the Upconverter 70 MHz test port Replace the Reply Generator Module

Indicated Problem	Problem Area	Suggestions
PAM Atten	Pulse Amplitude Modulator circuit within the Reply Generator Module	Check operation of circuit at rear panel of ADS-B Replace the Reply Generator Module
XILINX Load	Xilinx or Flash ROM of PCC Module	Reprogram Flash ROM of PCC Module Replace PCC Module
Factory Config	Flash ROM of PCC Module	Reprogram Flash ROM of PCC Module Replace PCC Module
BER Reply	Reply Generation Circuits	Check Reply Generator output levels Check Upconverter output levels Check BIT detection circuits
User XILINX	Xilinx used in PCC Module	Replace PCC Module
User Prog	Flash ROM of PCC Module	Retest Reprogram Flash ROM Replace PCC Module

7.3 Module Replacement

Replacing, instead of repairing, a faulty module is a valid maintenance strategy if the following limitations are understood and can be overcome.

The performance of every production module is slightly different. Gain variations within Reply Generator Modules and Upconverter Modules, in particular, are of major importance. These differences are equalized, at the factory, through the use of calibration constants stored in the PCC Module. Therefore the replacement of any of these three modules, the Reply Generator, the Upconverter, or the PCC, may result in less than specified performance. It is recommended that the ADS-B unit be returned to the factory, in its original configuration, if diagnostics indicate that any of these three modules, or the BIT Module, is found to be faulty. The Reference Source Module may be replaced without concern for the above issues.

Module removal requires the use of a small flat-blade screwdriver. Each module is held in place with either two or four captive screws. Loosen the screws and pull the module away from the chassis through the use of the front panel handle. When replacing the module use caution not to over torque the screws that hold the module to the chassis.

8 INSTALLATION, INTEGRATION, AND CHECKOUT

8.1 Installation

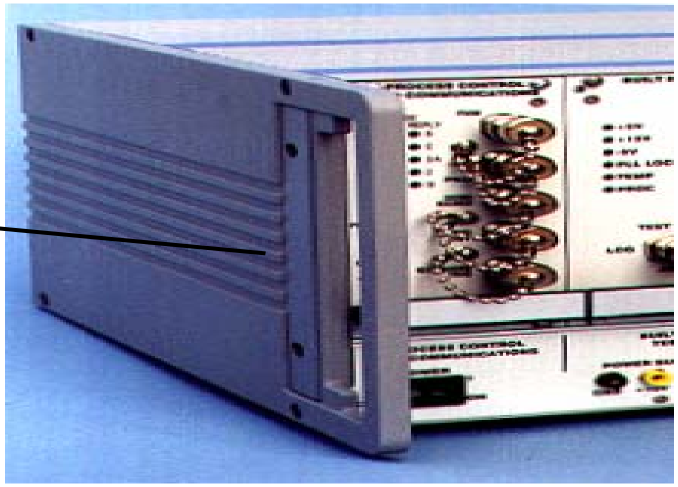
The ADS-B can be operated from a tabletop or it can be installed in a standard 19-inch equipment rack.

If operated on a tabletop, the chassis bottom and top must be clear of any obstructions so as to allow proper ventilation.

Hinged brackets for mounting in a standard EIA/RETMA 19-inch equipment rack or cabinet are included as part of the chassis as shown below in Figure 26. The brackets are shown in the retracted position. They can be easily extended to a right angle from the chassis.

Figure 26. ADS-B Chassis Rack Mount Brackets

Fold-Out Rack Mount Bracket



The ADS-B front panel is 7.5 inches high, but a minimum opening of 10.5 inches is recommended for mounting it within an equipment rack or cabinet. As shown in Figure 27 below, 1.75 inch high blank panels should be mounted above and below the chassis to allow adequate air flow through the ADS-B.

Figure 27. Recommended Rack Mount Configuration