

Chapter 4

Serial Control Bus

This chapter describes the installation of the Serial Control Bus (SCB), which is the communications backbone of the SOSS.

Please read this entire chapter before starting. Improper connection of the SCB could have serious consequences. All the information that you need for a basic installation is in this chapter, so please read it before you call PRSS Technical Support for help.

Notice

Before you construct or plug in any cables, read Chapter 2, "Planning & Engineering" to identify and measure all cable runs.

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The Serial Control Bus

The Serial Control Bus (SCB) is the communications backbone of the SOSS. It carries control information from the SOSS computer to the interconnected equipment, and returns status information from those devices back to the SOSS computer. Communication over the SCB is implemented according to the RS-485 protocol, a multidrop serial communication standard. Figure 4-1 shows how the SCB provides communications for the SOSS.

Physical Description

The SCB consists of up to five distinct buses, each of which connects to the ARTIC card installed inside of the SOSS computer. The buses reach the ARTIC card via the ARTIC breakout box.

As a minimum, a bus is a single 6-wire cable (6-pin flat telephone cable for short runs; shielded twisted pair for long or exposed runs) connected to the breakout box at one end, and an ComStream ABR700, DACS Advisory Panel, or GPI at the other end. A single bus can be comprised of a collection of 6-wire cables and bridging adapters needed to interconnect all the equipment on that bus.

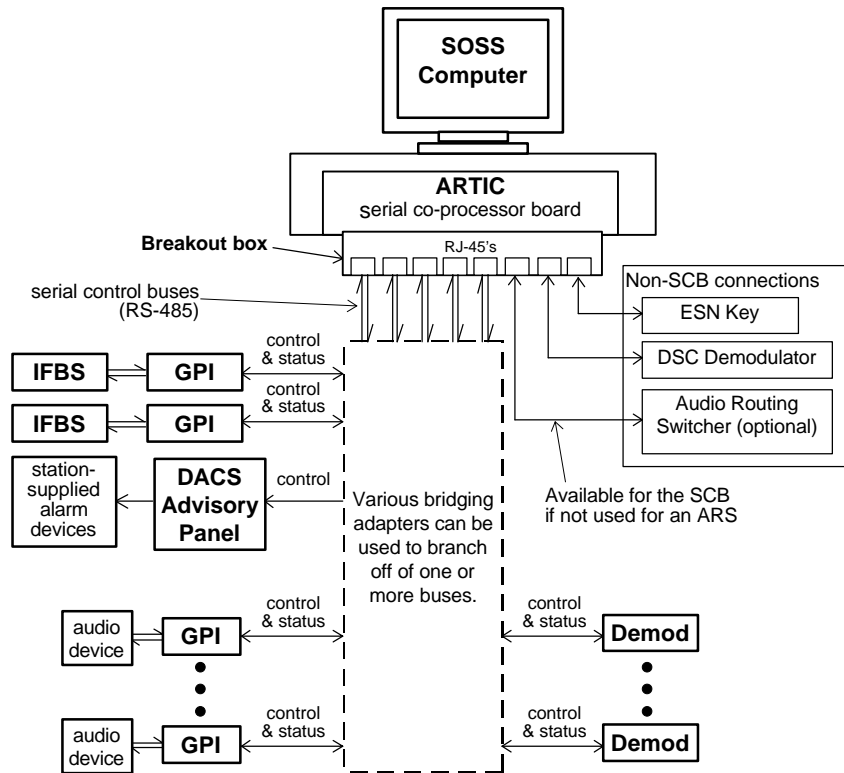


Figure 4-1. Generic SCB Configuration

Planning & Preparation

This section contains information you need to know about planning the installation and preparing your site or equipment.

General Advice

When installing this system, leave yourself enough time to do the job properly. Although the actual installation of the system hardware shouldn't take more than a few hours, planning, site preparation, and cable construction will take a considerable amount of time.

Equipment, Supplies, & Tools

Material & Supplies

- Six-conductor wire suitable for RJ-11 modular plugs, enough to interconnect to the GPIs, audio demodulators, and the DACS Advisory Panel. Telephone-style (*silver satin*) cable for short distances; shielded, twisted pair cable for long or exposed runs.
- Adequate supply of RJ-11 plugs.
- Multiport bridging adapters.
- Optional. If using Type 'B' breakout box, one (of the three) supplied DB25-to-RJ45 adapters.

Tools Required for This Installation

- Crimp tool for modular connectors
- Wire cutter

Breakout Boxes

The ARTIC breakout box at your installation can be one of two types: 'A' or 'B'. These breakout boxes are functionally identical. Here is a summary of the important differences:

- Type 'A' has RJ-45 jacks, and is more restrictive about the port to which the DSC data line connects (port 01, by default).
- Type 'B' has DB-25 connectors, and comes with three DB25-to-RJ45 adapters, one of which you can use for convenient connection to an SCB. Consider the following issues:
 - If your plan has a single SCB, you can use the supplied DB25-to-RJ45 adapter to connect to a multiport adapter, and use a cable with RJ-45 plugs at both ends (see page 6).
 - If your plan has more than one SCB connecting to the breakout box, or you choose not to use the DB25-to-RJ45 adapter, you will need to construct a cable that connects directly to the breakout box (described on page 7).
 - If you prefer to connect additional SCBs via DB25-to-RJ45 adapters, you will need to construct additional adapters (see Appendix C, "Technical Reference").

The ARTIC breakout box has eight ports (labeled 0 to 7). You can use up to five of these ports to communicate with devices on the SCB. Follow these rules and guidelines for using the ports of the breakout box:

- ❑ You must reserve a distinct port for the Downlink Services Channel (DSC) demod (default port 01), the Electronic Serial Number (ESN) key (default port 0), and an audio switcher (default port 02), if you use one. Each of these devices must be on a different port, and must be the only device connected to that port.
- ❑ You can use any open port for the cables of the SCB. These cables connect directly or indirectly (via multiport adapters) to GPIs, ABR700 demodulators, and the DACS Advisory Panel.

Modular Cables and Connectors

The devices on the SCB are interconnected via RJ style modular connectors. There are two types of RJ modular connectors:

RJ-45

Eight conductors (at a minimum). These are typically found in computer networking applications. The cable used with RJ-45 connectors is usually, but not always, twisted pair, suitable for data rates up to 10 Mb/s (millions of bits per second).

RJ-11

There are two kinds of connectors: 4-conductor and 6-conductor. These are typically found in telephone applications. The cable used with RJ-11 connectors is usually, but not always, *silver satin* flat cable. *Always* use 6-conductor plugs for the SCB.

A useful feature of RJ connectors is that any modular plug will fit properly and function well in a jack that has as many or more conductors. Of course, only the conductors in contact with the cable are active; you cannot use a 6-conductor plug for an application that requires eight conductors, no matter the layout of the conductors in the jacks. This allows a great deal of flexibility in constructing serial control buses.

The connectors on both types of the ARTIC breakout boxes and the DB9-to-RJ45 adapters for ABR700 demodulators will accept either RJ-45 or RJ-11 plugs. The jacks on General Purpose Interfaces (GPIs) will accept only RJ-11 plugs. Many multiport adapters accept only RJ-11 plugs; some can accept either type of modular plug.

Both RJ-45 and RJ-11 plugs can have either flat or oval openings for inserting the cable leads. Cables for the SCB can be one of two types: flat telephone-style (silver satin), or round computer-network style twisted-pair. For the SCB, Category 3 twisted-pair cable is ideal. The twists in each pair act to minimize the effects of electrical noise induced as the cable is routed around the typical equipment found at radio stations. Silver satin cable is adequate for short runs and will work well in many sites. The price difference between twisted pair cable and 6-conductor silver satin is negligible.

Constructing SCB Cables

This section contains information specific to the actual construction and installation of SCB 4-wire cables. This section describes how to construct two kinds of SCB cables:

- ❑ Cables for interconnecting devices with RJ connectors. Such a cable is used to interconnect multiport RJ-11 adapters, devices that natively have an RJ jack (such as the RJ-11 on a GPI), and DB-to-RJ45 adapters (such as the one you can attach to a Type 'B' breakout box).
- ❑ Cables for interconnecting devices with RJ-45 or RJ-11 jacks directly to a Type 'B' breakout box, which has DB-25 ports.

Before you construct or plug in any cables, read Chapter 2 and use the worksheets supplied there to identify and measure all cable runs. Also, keep in mind the following information.

- ❑ Signals on the SCB follow the RS-485 electrical standard, which describes electrically balanced connections. As such, each signal requires two conductors to function properly, an "A" conductor and a "B" conductor. RS-485 is most effective when carried on twisted pair cable, because external noise affects both conductors of a signal equally, and the signal is measured as the differential voltage.
- ❑ The SCB is designed so that all the modular cables to GPIs, audio demodulators, and the Advisory Panel must be configured as *straight-through* (pin-for-pin).
- ❑ Observe polarity for the respective transmit and receive pairs. It's good practice to record the color code used for each type of wire you use for the SCB.

A cable for RJ-style connectors carries the following signals on its conductors. (Signal names are from the perspective of the ARTIC card.)

Pin on RJ plug	Signal
1	GND
2	RDB
3	RDA
4	SDB
5	SDA
6	GND

For a twisted-pair cable, make sure that the following signals are paired:

Pin on RJ plug	Signal
1 & 6	GND, GND
3 & 4	RDB, RDA
4 & 5	SDB, SDA

SCB Cables with RJ Plugs

Below is a schematic of a completed cable. The procedure for constructing this cable follows.

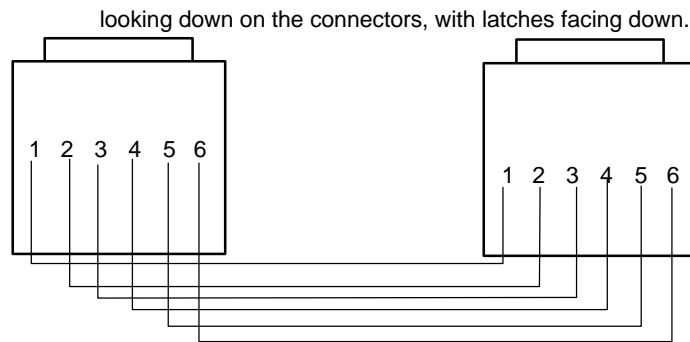


Figure 4-2. SCB Cable with RJ-45 Plugs

1. Allowing for some slack, cut a cable of the appropriate length.
2. Strip the cable jacket at both ends.
3. Insert the wires according to the pin assignments listed above, and the color code you are using.
4. Crimp the modular connector onto the cable.
5. Repeat steps 2 through 4 for the other end.

SCB Connections to Type 'B' Breakout Box

If your station received a Type 'B' breakout box, and you need to connect an SCB cable directly to a DB-25 connector of the breakout box, construct a cable according to the following pinout table.

Table 4-1. Pinouts for DB-25 SCB Cables

ARTIC Breakout Box, Type B	Cable: ARTIC End		Cable: Device End		GPI	ABR700 M&C Port
	DB-25	RJ-11	RJ-11	DB-9	Signal	Signal
GND	7	1	1	5	GND	GND
RDB	17	2	2	8	TD+	RD+
RDA	3	3	3	9	TD-	RD-
SDB	24	4	4	1	RD+	TD+
SDA	2	5	5	7	RD-	TD-
GND	1	6	6		GND	

Installing the Buses

You should already have your cables constructed, know exactly which equipment will be connected to the SCB, and know which ports of the ARTIC breakout box are assigned to handle particular SCB traffic.

1. Following the SCB scheme you developed in the "Planning & Engineering" chapter, interconnect the GPIs, audio demodulators, and DACS Advisory Panel to the multiport bridging adapters employed in your system.
2. Locate the cables that you intend to connect to the SOSS computer.
3. For each bus, plug one end of the cable into the designated port of the ARTIC breakout box (connected to your SOSS computer).

The label on the top of the breakout box identifies each port.

Follow the port assignments defined by the Setup program, which should match Worksheet 1 from Chapter 2. To learn how to set port addresses, see Part III, "ARA Operation."

IMPORTANT: Make sure that the ESN key is plugged into the correct port. If the SOSS computer cannot verify the presence of the ESN key for a duration of 10 minutes, it will not send commands over the SCB. In such a case, plug the unit into the correct port. Then, shut down and restart the ARA applications as described in Chapter 8. If the problem persists, the ESN key or other hardware component might be damaged.

Optional Installation Issues

This section describes the installation of equipment that you might include in your SOSS system.

Non-polled Devices

Several devices that can be attached to an SCB are not polled, including DACS Advisory panels and several third-party clock systems. These devices only display information that the SOSS computer sends to them; they are not automated devices in the same sense as an ABR700 demodulator or a General Purpose Interface (GPI), in which the status from the device is necessary for the proper execution of programmed events. Because status from a DACS Advisory or clock system has no effect on executing events, the communication protocol for an SCB does not generate status requests (polls) for those devices, saving time for status requests and commands for real-time devices.

Based on the layout of your station, you might want to attach one of these non-polled devices to the SOSS computer on a SCB that isn't used to control demodulators or GPIs. To do that, you need to turn on the desired ARTIC port so that it sends data to the non-polled devices.

To turn on an ARTIC port:

1. Create a *starter* resource in the Setup program.
Define it as a General Resource, with an SCB address on that port.
2. Attach a GPI, configured to match the address in the Setup program to the ARTIC port, along with the DACS Advisory panel or clock system.
3. Restart the SOSS software, starting with Load ARTIC Tasks.
The SOSS software will send status data down the newly defined SCB.

The best way to check to see if the SOSS software recognizes the additional SCB is to look at the Audio Recording Automation window. At the bottom, in the section labeled "ARTIC Task Versions", one instance of CONBUS will be present for each functional SCB.

Terminating Resistors and Bias Resistors

For high data rates (9600 baud and faster) and long transmission lines, it is recommended that the transmission line be terminated with a resistor across the transmit leads (across pins 4 and 5). Twisted pair usually has an impedance of about 100 ohms; therefore, a 100 ohm resistor is normally used for termination. The terminating resistor may be greater, but never less than 100 ohms. The terminating resistor must be located at the far end of the SCB.

Some installations with Type 'A' ARTIC breakout boxes and 6-wire SCB cables might benefit from installing an idle bias resistor between conductors 1 and 3 (240 to 270 ohms) of the cable. See Appendix C, "Technical Reference" for details. Note that installations with Type 'B' breakout boxes do not require additional bias resistors, because the supplied DB25-to-RJ45 adapters contain them.

Transient Suppression

RS-485 networks with cables that are long or exposed to the outdoors are susceptible to damage from transients induced by nearby lightning strikes. An effective way to reduce the risk of transient damage is to install a transient suppresser at the SOSS computer. When devices are at separate locations, such as a separate building, a single transient suppresser may be installed at the entrance to each location.

Repeaters

As many as 64 devices can be multidropped in a RS-485 four-wire mode. Beyond this, it is advisable to isolate sections of the network using a multidrop repeater, such as OPTO22 model AC30A. A repeater may also be used to extend the 4,000 feet limit of RS-485, and to implement star arrangements or long branches from the standard RS-485 multidrop wiring mode.

Troubleshooting the SCB

The performance of your SOSS depends on good, reliable communications between the ARTIC card and the devices on the SCB. When the SCBs connected to your SOSS computer are running well, you will get fewer alarms, your events will execute faster and more reliably, and you will have fewer overall problems with the SOSS.

While the RS-485 protocol used for the SCB is tolerant of noise and differences in ground voltage, the time that the ARTIC takes to process even infrequent communication problems could affect the SOSS computer's ability to properly execute an event. In some cases, poor communications on a bus can cause the ARTIC to stop working.

Each SOSS installation is unique. A particular solution or wiring strategy might work at one site, but not another. We encourage stations to share their troubleshooting solutions. To do so, please contact the PRSS Technical Support office.

Tools for Troubleshooting

Below is a summary of software and hardware tools used to troubleshoot the SCB. Each tool has its value, and the combined information you gather from using two or three allows you to locate problems.

Direct Control Program (DCP)

The quickest way to check the general health of the SCB. This shows the general health of communications between a particular device and the ARTIC.

Quadron ANLZ program (qCF)

Displays detailed real time status of all the communications between the ARTIC card in the SOSS computer and devices connected on the SCB. ANLZ shows that status of the SCB as a whole.

Setup Program

As you troubleshoot the SCB, you will need to enable and disable communications with configured resources.

Hardware Activity Monitor

PRSS Technical Support recommends that you construct an activity monitor that you can attach to an SCB. You can place an activity monitor on an individual SCB to see the signaling status of that SCB.

Using the Direct Control Program

The Direct Control Program (DCP), which is part of the ARA software suite, enables you to remotely control and monitor any *resource* in real time, without regard to a schedule of events. (See Chapter 12 for details.) Aside from its control and monitor functions, the DCP is the quickest way to check the general health of the SCB.

The Comm Stat column of the DCP (shown in Figure 4-3) lists the current status of each resource. Of the possible values for this column, three in particular indicate the status of the connections between the ARTIC card and resources over the SCB:

OK

The resource and its connections to the SOSS computer are operating normally.

TOUT

Timeout. The resource did not respond to three consecutive polls or commands from the ARTIC card. The device is either connected poorly or is not connected to the SCB.

CRC

Cyclic Redundancy Check failure. The response from the resource, while formatted properly, failed an error checking procedure. The response was discarded by the ARTIC.

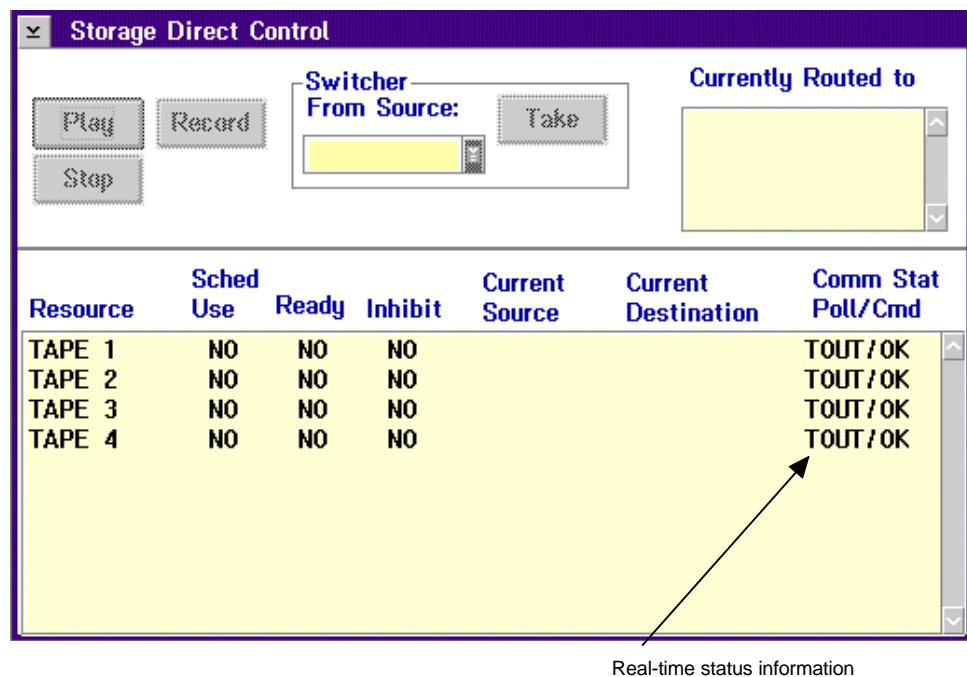


Figure 4-3. Direct Control Panel

This indication of status is a useful tool when you are setting up a SCB, and it gives a good idea of the general health of your system. However, DCP does not have the resolution to display SCB problems in fine detail. The SCB can perform relatively poorly (for example, due to dropped packets to and from the devices that can cause delays in polling and command execution), but the DCP will not show that anything is wrong.

**Understanding
Timeouts**

When the ARA software is active, the ARTIC card constantly sends out polling messages and commands to the devices (called resources) connected to the SCB. For both polling messages and commands, the ARTIC card waits 300 milliseconds (msec.) for a response. If three successive polls or three successive commands receive no response, then the ARTIC card declares a timeout error for that resource.

Polling The ARTIC card inside the SOSS computer is continuously checking the status of resources defined for your station. It polls each defined resource in turn, and waits 300 msec. for a response. If it does not get a response within 300 msec., it polls the next device. If a resource does not respond after the third polling pass, the ARTIC card declares a timeout error for that resource, and displays "TOUT".

Given that response times are often significantly less than 300 msec. (GPI/tape deck typically responds in 10 msec.; ABR700s typically respond in 250 msec.), the amount of time that the ARTIC must wait for three timeouts from a single device is significant. As a result of polling delays, status of resources might not be updated fast enough to accommodate both the needs of the system and the needs of the users. At the very least, the SOSS will generate many alarms.

For example, if your SOSS has one ABR700 demod and two GPIs (each with a tape deck), the total response time for three polling passes might be 810 msec. (270x3). But, if one of the GPIs is unplugged, it alone consumes 900 msec., raising the total time for three polling passes to 1680 msec. ((260x3)+900); that's over twice as much time to poll devices.

Commands Similarly, when the ARTIC card sends a command to a resource, it waits 300 msec. for an acknowledgment (ACK). If an ACK is not received, the ARTIC immediately resends the command, instead of moving on to the next command. Three successive command failures result in a "TOUT" on the DCP display.

For example, a particular event involves starting a tape deck, tuning a demodulator, and switching an IFBS. If you unplugged the GPI for the tape deck, the ARTIC sends a total of five commands that take 1600 milliseconds; that's about 1 1/2 seconds to execute the event.

Compounding delays can greatly affect the execution of your program schedule, especially when the system needs to send commands to several devices in rapid succession (such as a top-of-hour program break).

Quadron Analyzer

The Quadron Communications Facility (known as qCF) is the device driver software for the ARTIC card within the SOSS computer. It includes a communications analyzer called ANLZ. ANLZ displays detailed real time status of all the communications between the SOSS computer and devices connected on the SCB, the ESN key, and the DSC data stream.

ANLZ is most useful for tweaking the performance of the SCB, and for troubleshooting intermittent errors. It shows the status of individual packets that are corrupted or dropped.

To start ANLZ:

- 1.** On the SOSS computer, open an OS/2 terminal window.
You see a command prompt.
- 2.** At the C:\ prompt, type `ANLZ`, and then press `ENTER`.
ANLZ starts, and displays its own command prompt:
`cmd :`
- 3.** At the ANLZ prompt, type `mon`, and then press `ENTER`.

The SOSS computer displays the Quadron Diagnostic Monitor screen (shown below). This figure shows a typical ARTIC task list.

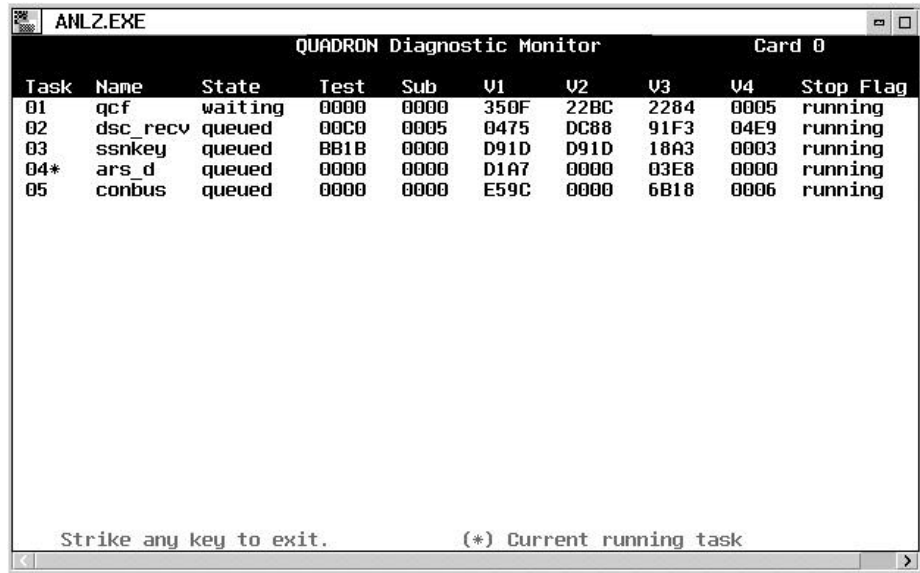


Figure 4-4. Quadron Diagnostic Monitor Screen

The data columns are described in Table 4-2, below.

Table 4-2. Information on the Quadron Diagnostic Monitor

Column	Displays
Task	ARTIC task number. The green asterisk (*) indicates the active task being performed by the ARTIC card.
Name	Name of the ARTIC task. The names match the task names in the ARA window (except "qcf", which is the ARTIC device driver). Your computer might show two or more conbus tasks.
State	Current status of the ARTIC task. "queued" is normal for the ARTIC tasks. "waiting" is normal for the qCF task.
Test, Sub, V1, V2, V3, V4	Counters for ARTIC tasks These show packet counts for various ARTIC tasks. These are the primary indicators for troubleshooting the SCB. See Table 4-3, below.
Stop Flag	Not used for troubleshooting.

ANLZ keeps track of the packets sent from and received by the various ARTIC tasks, including any packets that are corrupted or re-sent by the ARTIC card. The useful statistics for troubleshooting the SCB are the counters (V1, V2, V3, V4) for the conbus task. The packet counts for the conbus task are summarized by the following table.

Table 4-3. ANLZ - Conbus Counters

Test	Sub	V1	V2	V3	V4
not used	not used	Loop counter: indicates task is running	not used	Retry Counter: counts status request packets from ARTIC without responses	Response Counter: counts command packets from ARTIC without responses.

If the bus is running well, only the V1 counter is incrementing; the V3 and V4 counters should not be incrementing. If the V3 or V4 counters are incrementing at all, the ARTIC card is resending packets to devices.

If the V3 and V4 counters are incrementing, follow this procedure:

1. In the Setup program, make certain that your SOSS computer is polling only the devices that are actually connected to the SCB.

To do so, check your the configuration of resources in the Setup program. Remove any resources that are not currently connected to the SCB or are not being used.

To add or remove a resource, open the Setup program, and choose Schedule Resource command from the Edit menu. Then change and delete resources one at a time.

2. Also, in the Setup program, check these three GPI outputs: Time Sync, Alarm, and DACS Alarm.

If you are *not* using these outputs, set them to address 0. (The Time Sync and Alarm outputs are set in General Parameters. The DACS Alarm output is set in Communications.) Address 0 on a SCB is a special address that tells the SOSS software not to poll the device.

3. If the V3 and V4 counters are still incrementing, check for one or more of the following hardware problems:

- A wiring problem on the SCB. Most SCB problems can be traced to wiring problems, including bad crimps on modular plugs, damaged wiring, or bad adapters on demods.
- A device on the SCB is not communicating properly. The Technical Support office has seen cases where the data transmitters in GPIs and demods send corrupted responses to polls, or issue signals on their own, not in response to a command or poll.
- One of the ports of the ARTIC breakout box is operating improperly.

To find such a hardware problem, you will need to swap cables, re-addressing devices in Setup, and changing out adapters.

4. If, after a thorough checkout, you still don't see clean communications between a device and the SOSS computer, move the associated SCB to another port on the ARTIC, and then restart the SOSS computer.

Besides physically moving the cable on the ARTIC breakout box to another port, you will have to reassign all resources in the Setup application to the new ARTIC port. Typically, Port 4 or Port 5 on the ARTIC breakout box works as well or better than port 3.

Building and Using an SCB Tester

A home made SCB activity monitor is another useful tool.** You can build this device from spare parts lying around your shop or at our local Radio Shack™.

NPR Satellite Facilities has built several of these monitors into the cases of salvaged surface-mount RJ-11 blocks. (The device resembles an ESN key with LEDs on top.) Building the monitor with an RJ-11 jack makes it easy to add to an SCB.

Below is a schematic of a basic SCB tester. You will need to select resistor values that give acceptable brightness to the LEDs that you use.

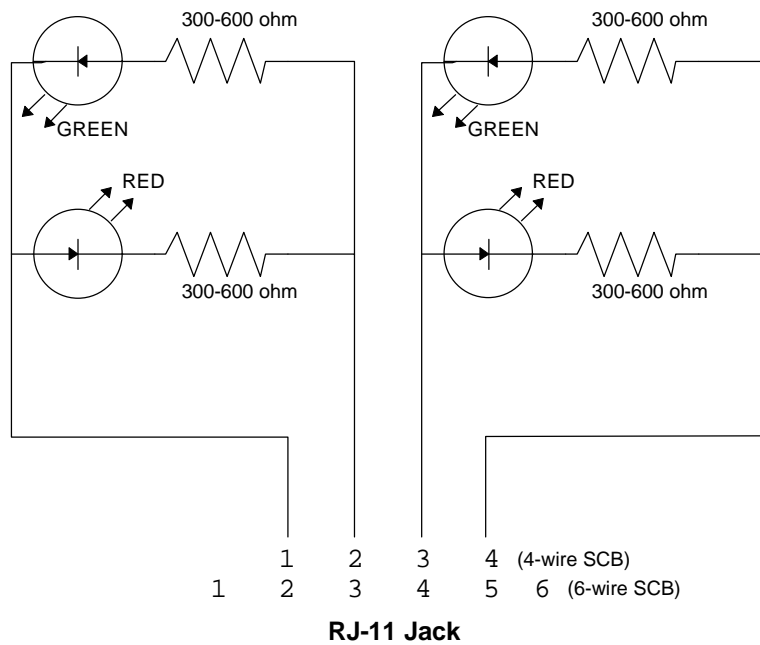


Figure 4-5. Schematic of Basic SCB Activity Monitor

** Thanks to Paul Litwinovich at WSHU-FM for the basic idea behind the SCB activity monitor.

An SCB has four signal wires; the two outside wires are grounds. The 4&5 pair carries commands and status requests from the ARTIC. The 2&3 pair carries responses from all devices on that SCB. Following the RS-485 protocol, each pair is balanced to ground, and can have one of three states: the A line is positive with respect to B, the B line is positive with respect to A, or both lines are in a high-impedance state in which there is very little potential difference between lines A and B. Because the LEDs for lines A and B are wired in opposite directions, the LEDs will correspondingly indicate red, green, or both off.

When the transmit lines are operating normally, one of the LEDs of the transmit lines will appear to be steady illuminated, with the other one flickering as data passes.

The LED indications on the response lines depend on the activity of the devices on that SCB. The devices on an SCB have tri-state data transmitters that output a high-impedance state when there is no activity. When a device on an SCB is responding, both the LEDs on the response line should flicker with equal brightness. When there is no activity, both LEDs should be dark.

On a properly operating SCB, the flickering of data on both lines appears to be continuous. If a device does not respond to a poll or command, the reply line will go dark for about 300 msec. ($\frac{1}{3}$ of a second).

With an activity monitor connected to an SCB, you can more effectively use the Setup program to add and remove devices while watching the effect of the data. Leaving a well-built activity monitor connected to an SCB is generally a good idea, and introduces no significant risks.