SIS Mixer Measurement System

Mixer Bias Supply and
Dewar Interface
Hardware Design Document

2001-02-02

Version 0.53

Revisions

Table 1: Document Revisions

Revision Number	Date	Who	Details
0.1	1999-10-20	Jee	Initial: Requirements for switch sequencer
0.2	1999-10-28	Jee	Added Specifications section, based on comments from Kerr and Pan to “Preliminary Design Concepts for a New Mixer Bias Supply”
0.3	1999-11-04	Jee	Added state change flowchart
0.4	1999-11-19	Jee	Added state table for bias pods
0.5	1999-12-16	Jee	Added Dewar info here.
0.51	1999-12-30 2000-01-06	Jee	Added sequencer description.
0.52	2000-12-21	Jee	Changed front panel to use more pushbuttons and LEDs.
0.53	2001-02-02	Jee	Updated sequencer decriptions.

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1. Introduction

This document provides hardware design and assembly details for the SIS Mixer Bias Supply, which provides the appropriate voltage to the mixers and uses a 4-wire system to monitors the voltage actually supplied to the mixers. Mixer current is also monitored. Also included is design and assembly details for the Dewar system used to test SIS mixers. The Dewar will house a sideband separating, balanced mixer, along with a separate IF amplifier as shown in Figure 1.

The system has the capability to be remotely operated.

2. Changes

2.1 Meeting of 1999-12-08

It was decided to use a single control voltage for both open- and closed-loop operation of each bias card. The switching between open and closed loop will occur on the board using a spare state bit to define the open and closed states.

By using a single control voltage into the bias pod for open and closed-loop operation, three additional pins were freed on each bias pod connector. These were used to add spare state lines. The bias state return line is included as the 9th status line to each pod.

The IF switch on the Dewar would leave one of the SSB Mixer outputs unterminated, which would cause passband ripple. It was decided to simply terminate one output into a load and test one output at a time.

Removal

3. Specifications

3.1 Bias Supply

The new design uses Tucson's concept of locating weak-signal circuits in separate chassis mounted on the Dewar, and enclosing only the control electronics in the rack-mounted chassis.

Design details for the front panel are presented to serve as a visual aid for specifying important features of the bias supply. A more traditional specification table is also shown in Table 3 to describe details that cannot be addressed with the front panel drawings. Finally, a state diagram is included which is useful when designing the state machine to control the supply.

The most significant change from the existing design should simplify switching between states. Each time a new state is requested, the system will automatically cycle through the following states:

1) The op amps controlling the bias voltage are zeroed and the integrating capacitor in the feedback loop is shorted,
2) the bias source and bias monitoring lines are shorted,
3) the state change is performed,
4) shorts are removed from the supply and bias monitoring lines, and
5) the bias voltage control op amps are un-zeroed and the short is removed from the integrating capacitor in the feedback loop,

This is intended to replicate automatically the make-before-break switches in the existing design.

The following points address the major features on the front panel as shown in Figure 2:

1) Each device can be controlled from one of the four subsections on the panel. Kirk recommended naming each section “Device” to differentiate them from the mixer system, which will contain four mixer subsystems.
2) In an attempt to more clearly indicate their function, “Open Loop” and “Closed Loop” have replaced the existing labels “Source” and “Bias”.
3) Ganged bias control is available for two pairs of devices and for all four devices. Polarity for each device is individually settable and is retained during ganged bias operation.
4) To simplify the front panel layout, a single control and single external input are used for both open and closed loop mode.
5) A common sweep oscillator can control each device by switching to “Sweep” on the appropriate subsection. The functions of the sweep oscillator are the same as the existing bias supply, except that the sweep voltage will be *added* to the preset bias voltage. This allows the preset bias voltage to act as an offset adjustment, so its now possible to sweep about a fixed operating point. The sweep voltage will be added to the existing bias voltage using internal circuitry, which eliminates the need for external cables between the sweep oscillator and the “Ext” port for each device. Sweep capability is not available when using external inputs for the bias voltage.
6) Computer control will be provided for most functions. The computer can obtain control of the bias supply when the control switch is in “Remote” or “Local”, but remote access is prevented when the switch is in “Rem Lockout”. When the system requires computer control of the supply, “Remote” should be selected by the operator. “Local” is normally selected for manual control of the supply when the computer program running on the PC is dormant. If the operator must obtain local control while the computer program is controlling the supply, then “Remote Lockout” is selected. The distinction between “Local” and “Remote Lockout” should prevent a common problem that occurs when the computer is prevented from controlling the device because it is switched to “Local”. When the computer actually addresses one of the devices in the bias supply, the LED next to the “Remote” position is illuminated.
7) The Monitor outputs and Ext. inputs are also available on the back of the chassis. The signals from the connectors in the back and front sides of the chassis are connected in parallel.

3.2 Dewar

Table 2 provides details of connector assignments.

Table 2 : Dewar Connectors	
Specification	**Notes**
Bias voltage *command* range	-100 to 100 mV
Bias voltage *measurement* range	-100 to 100 mV
Bias current *measurement* range	At least –1450 μA to + 1450 μA[1]
Output impedance manually selectable	A knob will be available at each mixer bias control box (*on the Dewar*) to manually switch the output impedance between: 10 KΩ, 2 KΩ, and 100 Ω
Current and voltage zero and gain	Adjustments will be available on each unit according to the following: <u>Function</u> — <u>Control Unit</u> — <u>Dewar Unit</u> V_{zero} — None[2] — screw driver adjust I_{zero} — None — screw driver adjust V_{gain} — None — screw driver adjust I_{gain} — Pot and meter — screw driver adjust The Gain control for each device allows calibration of the channel gain, which may require changing for each mixer block. When the “Display Gain Adj” button is pressed, the device current meters measure the relevant voltage for each channel, which is adjustable with the Gain control.
Manual voltage adjust	Using knob pots
Polarity change for bias	Either bias voltage can be independently switched from + to – bias. Manual mode only.
Voltage tracking	The following tracking options are available: 1. No tracking – each of four supplies can be independently controlled 2. Paired tracking – Common voltage on the outputs for junctions 1 and 2 and the outputs for junctions 3 and 4. Adjustable with two knobs. 3. All - Common output voltage for all four junction outputs. In all cases, junction outputs polarity is independently switchable. If External input is selected with ganged outputs, the control voltage is obtained from: 1. Ext. inputs 1 and 3 when ganged in pairs 2. Ext. input 1 when all outputs are ganged
Voltage/Current Meters	Two meters for each junction measure bias voltage and current.

[1] The maximum bias current required results from a single junction with 5 Ω junction resistance driven to a maximum bias voltage of 4 times the gap voltage, or approx. 12 mV. The resistance looking toward the junction of the combination of the junction resistance (5 Ω) in series with the current sense resistor (5 Ω) and parrallel to a 50 Ω matching resistor, or 8.3 Ω. Thus, I = 12 mV / 8.3 Ω = 1,446 μA.

[2] Provided by the op-amp

Mixer input line shorting	The bias command voltage as well as current and voltage monitor lines can be shorted: 1. *via* a switch on the front panel 2. programmatically 3. when the control cable is disconnected from the Dewar bias supply block.
Automatic shorting	The following switch changes will cause the bias supply to first short the output the respective device: 1. Switching between open and closed loop 2. Switching internal sweep off/on 3. Internal Level +/- change 4. Switching from internal to external input. 5. Switching any of the ganged output functions

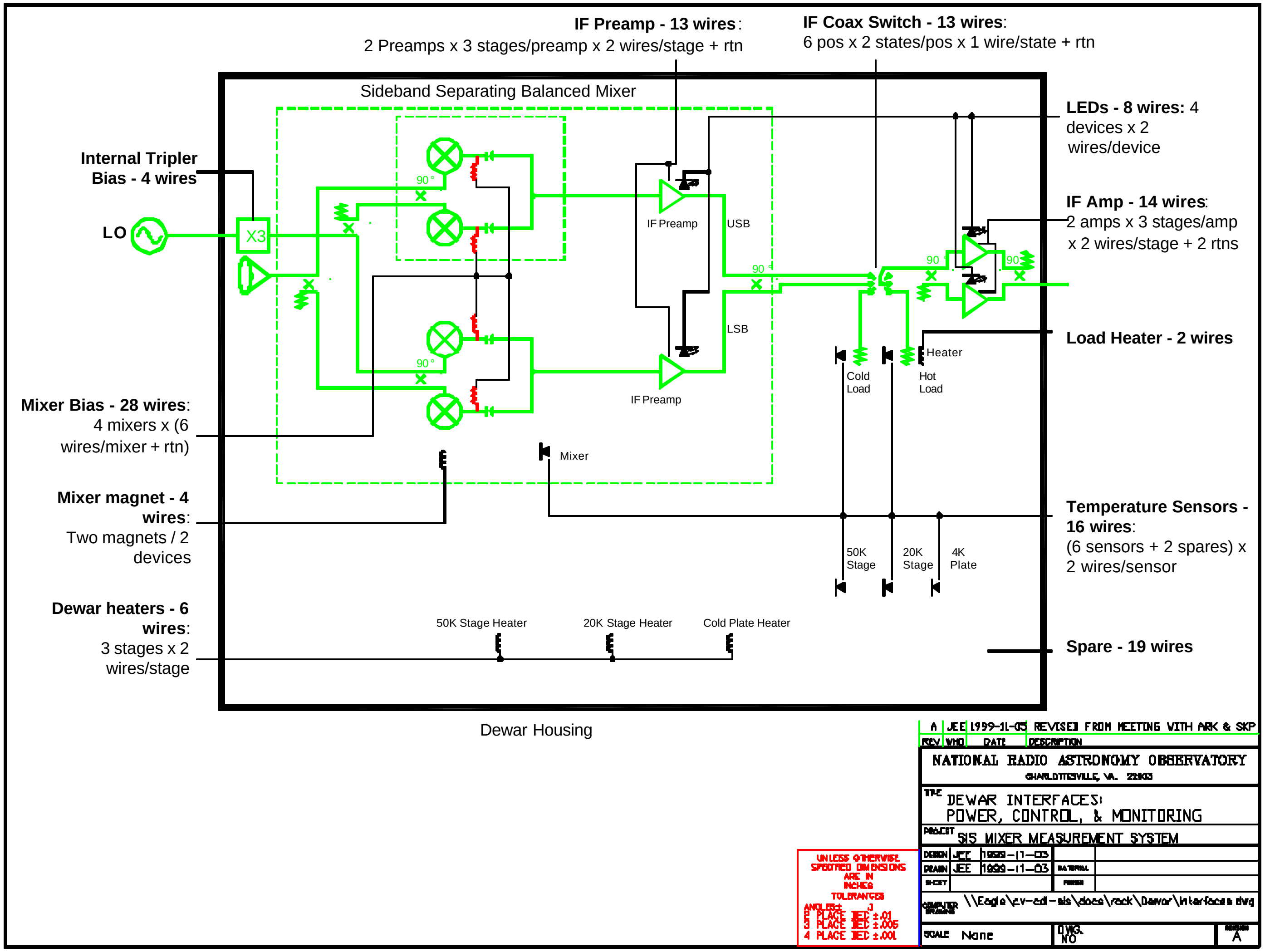

Figure 1: Dewar Control and Monitoring Interfaces

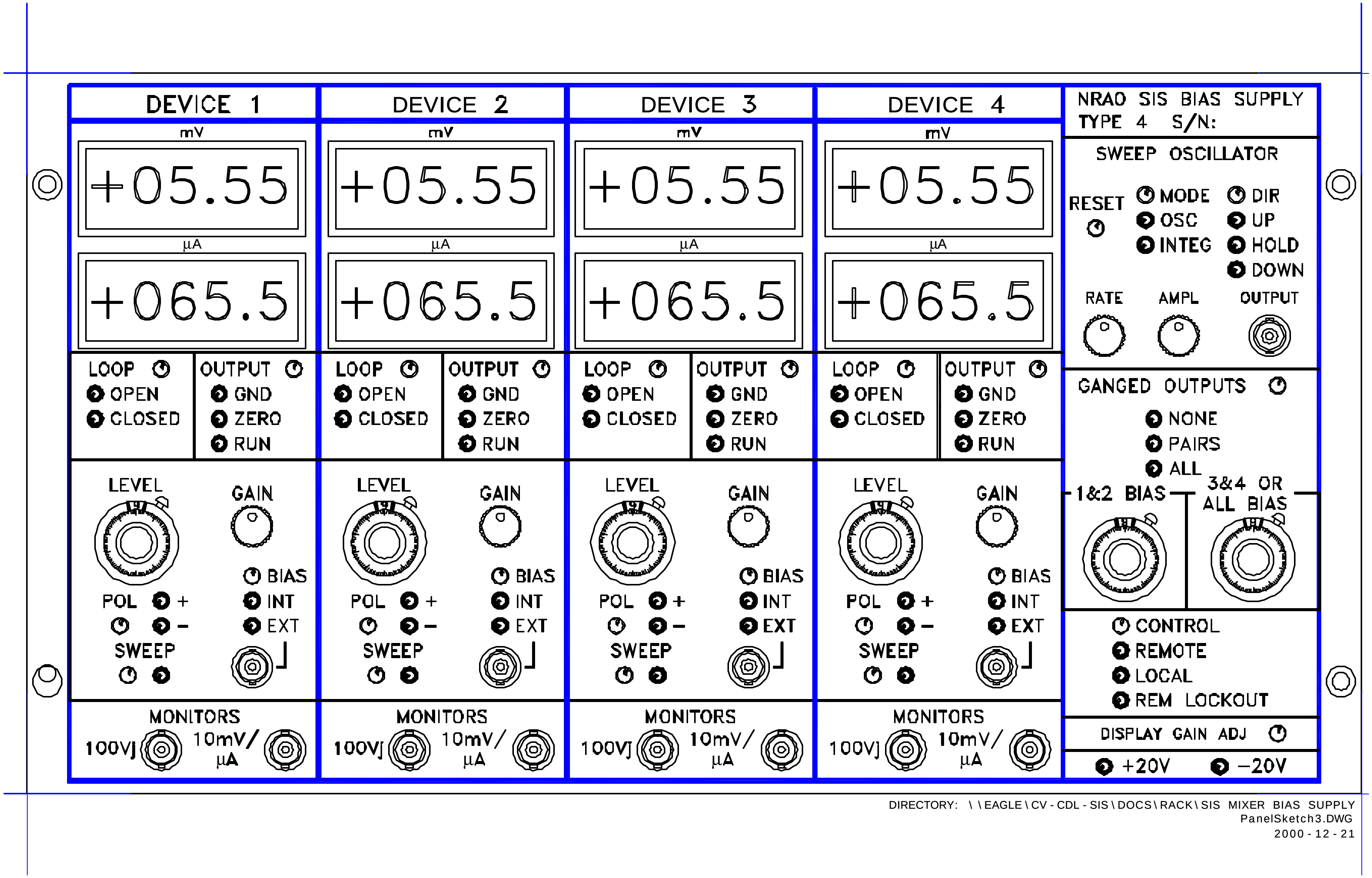

Figure 2: Front Panel Layout

Table 3 provides details that are not apparent from the front panel designs.

Table 3 : Mixer Bias Supply Specifications	
Specification	**Notes**
Bias voltage *command* range	-100 to 100 mV
Bias voltage *measurement* range	-100 to 100 mV
Bias current *measurement* range	At least –1450 µA to + 1450 µA[3]
Output impedance manually selectable	A knob will be available at each mixer bias control box (*on the Dewar*) to manually switch the output impedance between: 10 KΩ, 2 KΩ, and 100 Ω
Current and voltage zero and gain	Adjustments will be available on each unit according to the following: Function / Control Unit / Dewar Unit V_{zero} / None[4] / screw driver adjust I_{zero} / None / screw driver adjust V_{gain} / None / screw driver adjust I_{gain} / Pot and meter / screw driver adjust The Gain control for each device allows calibration of the channel gain, which may require changing for each mixer block. When the "Display Gain Adj" button is pressed, the device current meters measure the relevant voltage for each channel, which is adjustable with the Gain control.
Manual voltage adjust	Using knob pots
Polarity change for bias	Either bias voltage can be independently switched from + to – bias. Manual mode only.

[3] The maximum bias current required results from a single junction with 5 Ω junction resistance driven to a maximum bias voltage of 4 times the gap voltage, or approx. 12 mV. The resistance looking toward the junction of the combination of the junction resistance (5 Ω) in series with the current sense resistor (5 Ω) and parrallel to a 50 Ω matching resistor, or 8.3 Ω. Thus, I = 12 mV / 8.3 Ω = 1,446 µA.

[4] Provided by the op-amp

Voltage tracking	The following tracking options are available: 4. No tracking – each of four supplies can be independently controlled 5. Paired tracking – Common voltage on the outputs for junctions 1 and 2 and the outputs for junctions 3 and 4. Adjustable with two knobs. 6. All - Common output voltage for all four junction outputs. In all cases, junction outputs polarity is independently switchable. If External input is selected with ganged outputs, the control voltage is obtained from: 3. Ext. inputs 1 and 3 when ganged in pairs 4. Ext. input 1 when all outputs are ganged
Voltage/Current Meters	Two meters for each junction measure bias voltage and current.
Mixer input line shorting	The bias command voltage as well as current and voltage monitor lines can be shorted: 4. *via* a switch on the front panel 5. programmatically 6. when the control cable is disconnected from the Dewar bias supply block.
Automatic shorting	The following switch changes will cause the bias supply to first short the output the respective device: 6. Switching between open and closed loop 7. Switching internal sweep off/on 8. Internal Level +/- change 9. Switching from internal to external input. 10. Switching any of the ganged output functions

3.3 Sequencer Operation

The sequencer is responsible for changing the bias supply from one state to another while protecting the mixer by shorting all bias source and monitoring lines during state changes. One sequencer will be used for each mixer device, or a total of four. Figure 3 is a diagram of the sequencer states. Each arrow in the top two diagrams depicts a change in state, and will initiate the protection sequence shown in the bottom diagram.

The flow diagram for the sequencer is shown in Figure 4 and operates according to these steps:

1. When one of the relevant controls on the front panel (Figure 2) is changed, the system identifies a request for state change.
2. The desired state is stored for later recall. A single bit can describe each state. For example, each stage's internal sweep mode is controlled with a line where a high corresponds to internal sweep on, and low to internal sweep off.

3. After storing the desired state, the sequence clock is started. To prevent this clock signal from interfering with the analog signal lines, the clock only outputs a predetermined number pulses while the state is being changed. Upon completion of the state change, the clock output goes quiescent.
4. The mixer bias voltage source lines, voltage monitor lines, and current monitor lines are zeroed for the appropriate mixer. In addition, when the ganged output switch is changed, all four of the mixer devices are simultaneously sequenced as described here.
5. Sending a pulse to the appropriate reed relay control circuit shorts the mixer source and monitor lines.
6. The system is commanded to change to the desired state that was stored in Step 2 above.
7. The short is removed from the mixer source and monitoring lines.
8. The command voltage for the appropriate bias lines is returned to nominal. Command voltages set manually are retained by the position of the front panel potentiometer. Command voltages set using computer control are available from the external bias inputs.
9. Lastly, the sequence clock is halted.

The block diagram of the state controller is shown in Figure 5. This diagram shows that all excitations can be described using single bit lines except for the Ganged Outputs, which require two lines for the three states. The state controller enables the clock and then drives the state controller. The outputs of the state controller consist of the same states as the excitation lines but additionally include commands to zero the bias voltages and short mixer device lines.

Another sequencer is required for the sweep circuit. When the sweep circuit is either activated or deactivated using the front panel or the remote sweep control, the circuit automatically holds the sweep and resets the command voltage, which zeros it.

3.3.1 Sequencer Circuit Description

3.3.1.1 Intial Design (Kiriaki Xiluris):

Note: The Xiluris *design is now obsolete. Section 3.3.1.3 describes the active design.*

Function	Device	Description
Monostable Clock	½ NE556	Provides clock pulses only during operation of sequencer
Command Decoders	74148's and 74ls00's	Decodes the 16 possible inputs into 4 output lines
State Sequencer	74LS163 and PROM - AM27S19	Counter used to sequence to the next state and PROM that holds the current and next state
State Memory	74LS163	D-type 4 to 16 line decoder.

Any of the inputs to the encoders force their EON lines true, which should start the astable multivibrator (NE556). Note that the current schematic was modified to use an enable button on the front panel, so that function must be added again. The astable multivibrator provides a clock to the 74163 counter, which sequences the AM27S19 ROM. The ROM is used to determine the state sequence, which is generally:

1) Start the clock
2) Set bias to zero
3) Ground mixer lines
4) Do something, *e.g.*, change polarity of bias.
5) Un-ground mixer lines
6) Unzero mixer bias

3.3.1.2 Future Work for Xiluris' Design:

1) If more than one command input is changed before the previous command input has completed cycling through its required states, the states will become indeterminate. I FIFO buffer or push buttons with state lights are required.
2) The outputs of the 74LS154 persist only for a few clock pulses. Since these reflect the actual states of the system, they need to persist until the state is changed.
3) The monostable multivibrator was included to provide sufficient time for the reed relays on the bias card to switch. This needs to be integrated into the design. As a better alternative, the PROM could be programmed to stay in the required state for multiple clock pulses.

3.3.1.3 Enhanced Design (PLDs)

An alternative to Xiluris' design is to use programmable logic devices (PLD's). A 22V10 type of PLD can be programmed to generate the sequencer operation and function as a state machine as well as prevent problems with simultaneous state changes that can occur with Xiluris' design. Each of the 10 D-type flip-flops in the 22V10 will hold the state information, and the input combinatorial logic indicates when one of the input states differs from the output states.

A difference between the inputs and outputs of the PLD commences the sequence clock which, in turn, cycles the zero–ground–zero states. The state difference is readily obtained in the PLD using one of the outputs of the 22V10 in a combinatorial mode configured as the sum (OR) of exclusive OR (XOR) terms. Each XOR term provides the proper functionality: The output is `TRUE` if the inputs do not equal each other:

$$\mathtt{Input}_0 \ \mathtt{XOR} \ \mathtt{Output}_0 \ \mathtt{OR} \ \mathtt{Input}_1 \ \mathtt{XOR} \ \mathtt{Output}_1 \ \mathtt{OR} \ \ldots \ \mathtt{OR} \ \mathtt{Input}_N \ \mathtt{XOR} \ \mathtt{Output}_N$$

This product term is `TRUE` if any of the inputs don't equal the outputs.

Remote/local control can be obtained using either standard multiplexers or implemented with another PLD, such as the 22V10, configured for asynchronous operation. Using the PLD provides flexible mapping from N computer words to 2^N states, thus saving computer I/O lines.

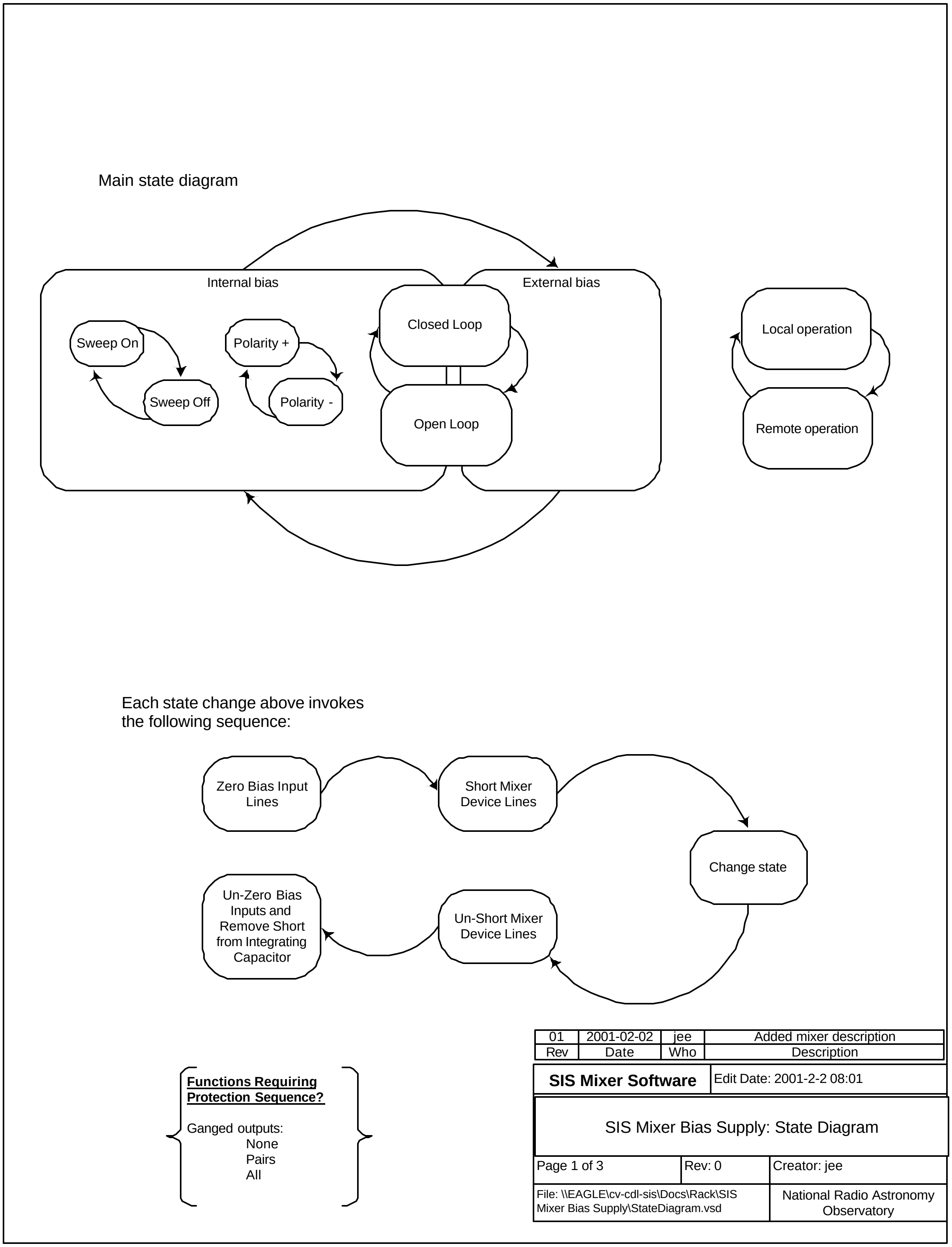

Figure 3: Sequencer State Diagram

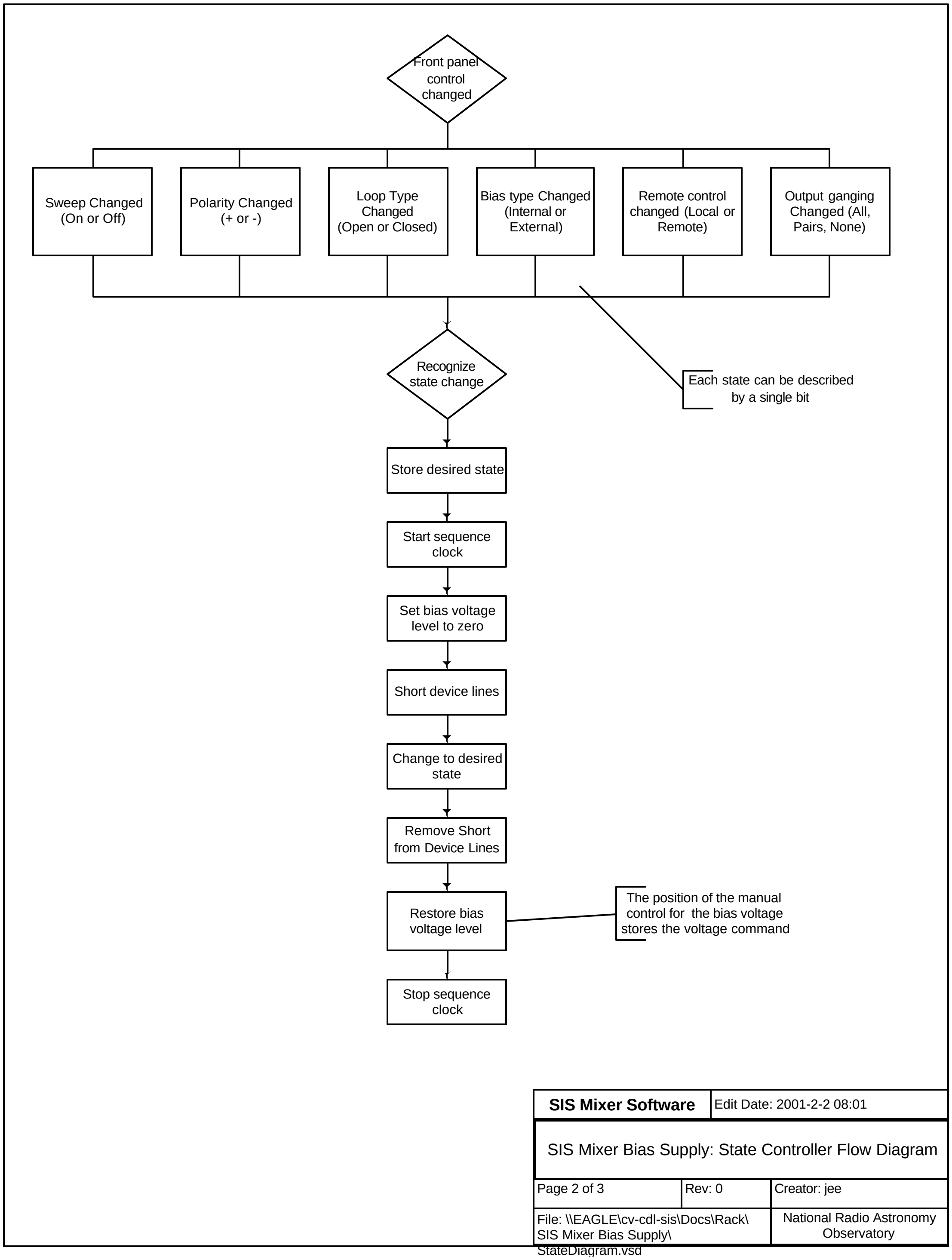

Figure 4: Sequencer Program Flow

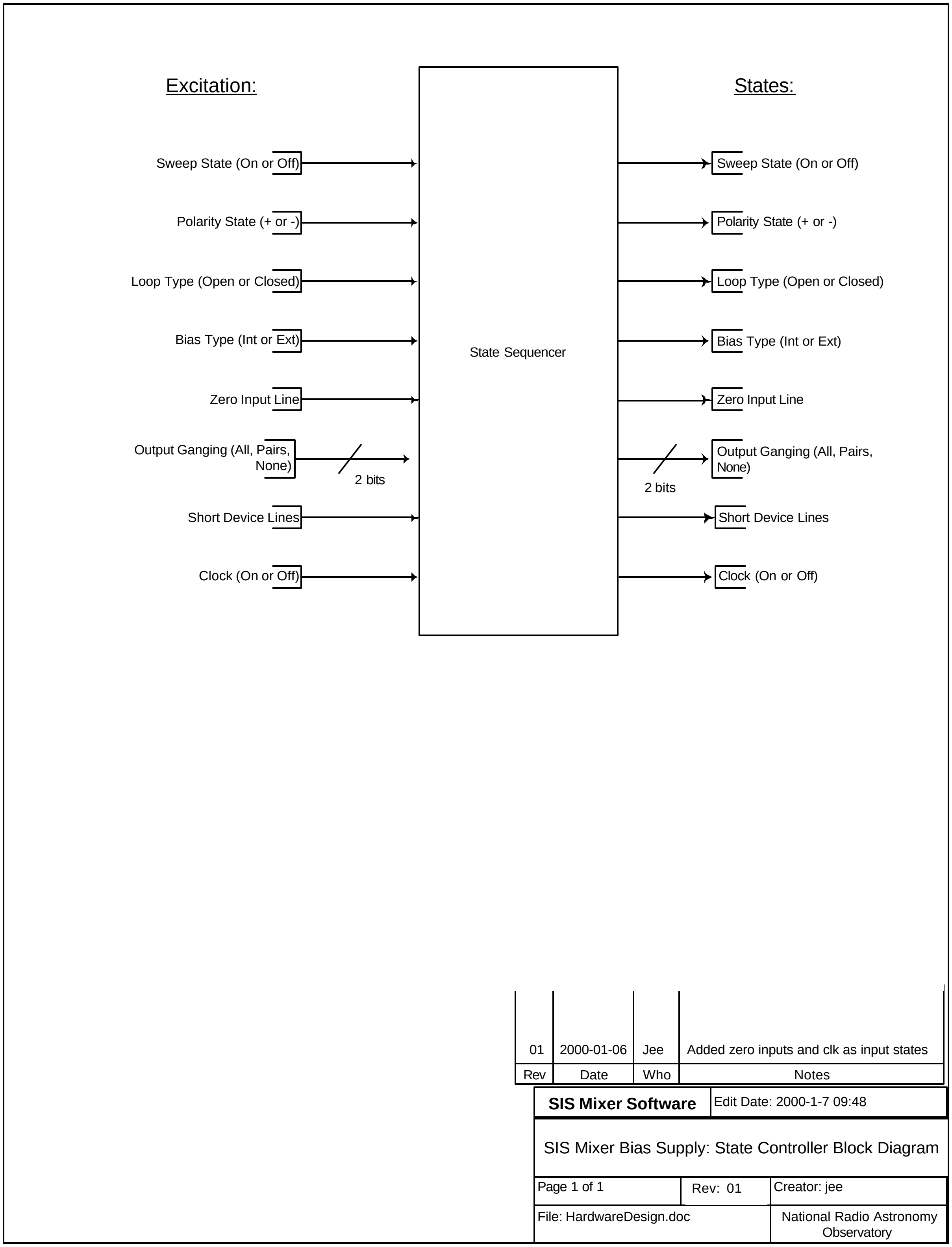

Figure 5: State Controller Block Diagram

3.4 Programmable Functions

Table 4 provides details for the functions in the bias supply that can be controlled by computer. Control and measurement of bias voltage and current measurement by the computer is only possible through the analog input and output connectors on the supply. This relaxes the speed requirements for the supply's computer interface.

The program word is used to input the program function into the bias controller from the computer. For example, to set Mixer 2 for open loop, internal bias, sweep off, output state run, no ganged outputs, the program word is

```
01 000 1011
```

Table 4 : Programmable Functions for Mixer Bias Supply

Program Word	Function	Notes
 XX XXX XXX1 XX XXX XXX0	Loop Type: Open Closed	Programmable for each device
 XX XXX XX1X XX XXX XX0X	Bias source: Internal External	Programmable for each device
 XX XXX X1XX XX XXX X0XX	Sweep Control: On Off	Programmable for each device, but you cannot remotely control any of the sweep setup parameters, such as sweep rate and amplitude. When the sweep control is switched from On to Off, the sweep is automatically halted and the sweep voltage output is zeroed.
 XX XX0 0XXX XX XX0 1XXX XX XX1 0XXX XX XX1 1XXX	Output state: Run Zero Gnd Spare	Programmable for each device
 XX 00X XXXX XX 01X XXXX XX 10X XXXX XX 11X XXXX	Ganged Outputs: None Pairs All Spare	Programmable. When External input is selected with ganged outputs, the control voltage is obtained from: Ext. inputs 1 and 3 when ganged in pairs Ext. input 1 when all outputs are ganged
	Bias + or -	Always + in remote mode: External input accepts both voltage polarities which eliminates programmable requirement
00XXXX	Control Mixer 1	
01XXXX	Control Mixer 2	
10XXXX	Control Mixer 3	
11XXXX	Control Mixer 4	
	Control of bias voltage	*Not* programmable: Available only using the Ext. Input on the rack-mounted chassis. Each bias supply can be independently controlled.
	Reading of bias voltage	*Not* programmable: Available only using Monitor outputs on front or back of the rack-mounted chassis
	Reading of bias current	*Not* programmable: Available only using Monitor outputs on

		front or back of the rack-mounted chassis

3.5 Bias Pod States

The bias pods are the printed circuit boards located adjacent to the Dewar that control junction voltages and measure junction voltage and current fed back from the 6-wire bias system. Each state is set by controlling individual lines into the bias pod board.

Although these states could be defined by three bits[5] and applied using a decoder and latch, it has been decided to send eight individual bits to the bias pods on the Dewar. This reduces the chance of noise pickup by removing the decoder and latch from the bias pod PCB.

Table 5 : Mixer Bias Pod States

Address bits	Function	Notes
000	Ground all outputs	
001	Output State - Zero	
010	Open loop	
011	Closed loop	
100	Spare	
101	Spare	
110	Spare	
111	Spare	

4. Bias Supply PCB

The Bias supply PCB is located on the Dewar to minimize the cable lengths between the mixer and bias supply that carry low bias levels.

4.1 Reed Relay Sequencer

Reed relays short all bias lines and voltage/current monitor outputs upon command from the system or if the cable is disconnected from the bias assembly housing. To minimize voltage transients presented to the mixers, either from the bias lines or the monitor outputs, the reed relays are sequenced so that the input to the voltage control op amp is shorted prior to shorting the bias supply lines. When the short command goes false, the op-amp inputs remain shorted until after the mixer bias lines are unshorted.

Figure 6 shows the timing sequence for the TTL lines that command the reed relays. After the short command is produced by the system, the op-amp inputs are first shorted, then the mixer input lines are shorted. When the system short command goes low, first the mixer inputs are unshorted, then the op-amp inputs are unshorted.

[5] Three-bit operation was specified in V0.4 (1999-11-19) of this document, but removed in V0.5 (1999-12-16).

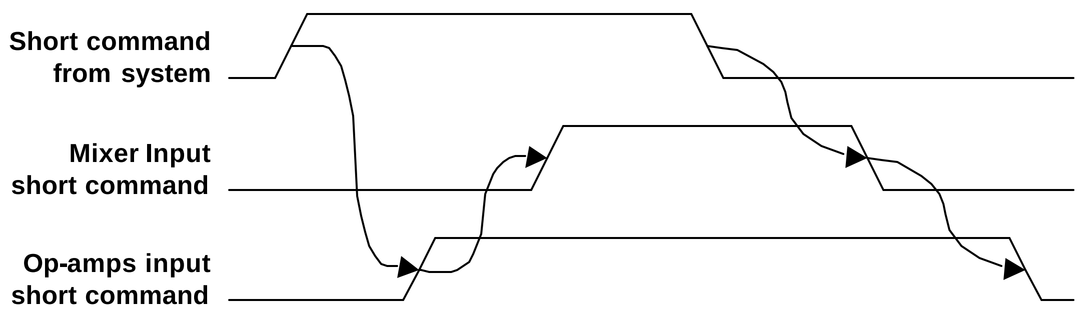

Figure 6: Timing Sequence for Reed Relay Switching