Analog Signal Processor (ASP) Interface Control Document

Version I

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February 2026

Approved:

System Engineering

Date: _____

Approved:

System Architecture

Date: _____

Long Wavelength Array Project

Change Record

Version	Date	Author(s)	Changes
A	2007-11-26	J. Craig	Initial draft
B	2008-7-15	J. Craig	Updated to reflect current hardware
C	2008-9-22	J. Craig	Updated filter table
D	2008-12-5	J. Craig	Updated attenuator interface
E	2010-1-6	J. Craig	Added FEE power control
F	2010-3-3	J. Craig	Updated FIL, AT1, AT2, ATS commands
G	2010-9-15	J. Craig	Added power supply monitoring
H	2015-4-7	J. Craig	Added temperature monitoring, updated MIB entries
I	2026-2-3	J. Dowell	• Updated for Rev I ARX boards and ARX Control Board • Added LOC command, filter codes 6 and 7 • Added FEE current and RF power MIB entries • Added annotations for legacy Rev H differences

Contents

List of Tables

Section 1

Description

1.1 Purpose

This document describes the interface control for the Analog Signal Processor (ASP) subsystem of the Long Wavelength Array (LWA). The ASP is responsible for conditioning the analog signals from the Front End Electronics (FEE) before digitization by the digital processor.

1.2 Scope

This Interface Control Document (ICD) defines:

- Physical interfaces to and from ASP
- Monitor and control (M&C) interfaces
- Safety interfaces
- Command and response message formats
- Management Information Base (MIB) entries

1.3 System Overview

The ASP subsystem performs the following functions:

- Signal filtering (high-pass and low-pass)
- Signal attenuation (three stages)
- FEE power control
- Temperature and power supply monitoring

The standard ASP implementation uses a custom ARX Control Board based on an SAMD21 microcontroller for communication via SPI and I2C buses. Each chassis contains up to 8 Revision I ARX boards that are controlled through this interface. Up to 4 chassis (32 boards) can be controlled. The system also includes RS-485 communication for board-level monitoring.

Rev H System Difference

One legacy system uses the Rev H hardware and software branch with Revision H ARX boards. The Rev H system uses a commercial USB-to-RS485 adapter with RS-485 serial communication as the primary control interface instead of SPI. Temperature monitoring is performed via three sensors per board rather than power supply unit sensors. Where behavior differs, this document notes the Rev H differences.

1.4 Document Organization

This document is organized as follows:

- **Section 1** (this section): General description and scope
- **Section 2**: Abbreviations and definitions
- **Section 3**: Physical interface specifications
- **Section 4**: Monitor and control interface
- **Section 5**: Safety interface
- **Section 6**: References
- **Appendix A**: Exit and status codes

Section 2

Abbreviations and Definitions

2.1 Abbreviations

Abbreviation	Definition
ARX	Analog Receiver
ASP	Analog Signal Processor
AT1	First Attenuator (0–30 dB in 2 dB steps)
AT2	Second Attenuator (0–30 dB in 2 dB steps)
AT3	Third Attenuator (0–15.5 dB in 0.5 dB steps)
dB	Decibel
FEE	Front End Electronics
FIL	Filter selection command
FPW	FEE Power command
HPF	High-Pass Filter
I2C	Inter-Integrated Circuit (communication bus)
ICD	Interface Control Document
LED	Light Emitting Diode
LOC	Locate LED command
LPF	Low-Pass Filter
LWA	Long Wavelength Array
M&C	Monitor and Control
MCS	Monitor and Control System
MIB	Management Information Base
MJD	Modified Julian Date
MPM	Milliseconds Past Midnight
PSU	Power Supply Unit
QMA	Quick Miniature A (RF connector type)
RS-485	Serial communication standard
SAMD21	Microchip SAM D21 ARM Cortex-M0+ microcontroller
SPI	Serial Peripheral Interface
UDP	User Datagram Protocol
USB	Universal Serial Bus

2.2 Definitions

Stand A single antenna structure consisting of two polarizations (X and Y). Each stand is identified by a unique number from 1 to 256.

Board An ARX board that services multiple stands. In the current configuration, each board handles 8 stands.

Chassis An enclosure containing multiple ARX boards and associated power supplies. In the current configuration, a chassis can hold up to 8 boards.

Filter Code A numeric code (0–7) that selects the combination of high-pass and low-pass filters applied to the signal.

Attenuator Setting A numeric value that determines the signal attenuation level for each attenuator stage.

Section 3

Physical Interfaces

3.1 Overview

The ASP subsystem interfaces with the following components:

- Front End Electronics (FEE) — signal input
- Next Generation Digital Processor (NDP) — signal output
- Monitor and Control System (MCS) — control interface
- Power supplies — ARX and FEE power

3.2 Signal Input from FEE

The ASP receives analog signals from the FEE via coaxial cables. Each stand provides two polarization signals (X and Y).

3.2.1 Connector Specifications

The FEE signal input connector specifications are listed in Table 3.1.

Table 3.1: FEE Signal Input Connectors

Parameter	Specification	Notes
Connector Type	QMA Female	
Impedance	50 Ω	
Signals per Stand	2 (X and Y polarization)	

3.3 Signal Output to NDP

The conditioned analog signals are output to the Next Generation Digital Processor for digitization.

3.3.1 Connector Specifications

The NDP signal output connector specifications are listed in Table 3.2.

Table 3.2: NDP Signal Output Connectors

Parameter	Specification	Notes
Connector Type	QMA Female	
Impedance	50 Ω	
Signals per Stand	2 (X and Y polarization)	

3.4 Control Interface

The ASP uses a custom ARX Control Board based on an SAMD21 microcontroller for communication. The control board provides:

- SPI bus for ARX board control
- I2C bus for power supply monitoring
- RS-485 for board-level communication

The ARX Control Board design is available at:

`https://github.com/lwa-project/arx_control_board`

Rev H System Difference

The legacy Rev H system uses a commercial USB-to-RS485 adapter instead of the custom ARX Control Board. Board control commands are sent via RS-485 as the primary control interface.

3.4.1 ARX Control Board

The ARX Control Board provides USB connectivity to the control computer and manages communication with all ARX boards. The control board is housed in a Hammond 1590R1 die cast aluminum enclosure with USB-over-Ethernet adapter for connectivity. The control board configuration is summarized in Table 3.3.

Table 3.3: Control Board Configuration

Parameter	Value
Microcontroller	SAMD21
Interface	USB 2.0 (via USB-over-Ethernet)
SPI Clock	Configurable
I2C Address (FEE PSU)	`0x1E` (30)
I2C Address (ARX PSU)	`0x1F` (31)

3.4.2 SPI Bus Connectors

Each ARX board has two SPI connections (in and out) for daisy-chaining (Table 3.4).

Table 3.4: SPI Bus Connectors

Component	Part Number
Connector	TE 826470-4
Housing	TE 926476-4
Terminals	TE 1-141708-1
Alternative:	
Housing	Amphenol 71600-308LF
Cable	8-wire ribbon cable

3.4.3 RS-485 Bus Connectors

Each ARX board has one RS-485 connection with paired A/B terminals for daisy-chaining (Table 3.5).

Table 3.5: RS-485 Bus Connectors

Component	Part Number
Connector	Molex 22-12-4042
Housing	Molex 22-01-2047
Terminals	Molex 08-50-0113

3.5 Power Supply Interfaces

The ASP uses Artesyn iVS series power supplies:

- 15V supply (FEE power): Artesyn IVS1-5N0-3N0-60-A
- 8V supply (ARX power): Artesyn IVS1-5I0-2I0-60-A

Rev H System Difference

The legacy Rev H system uses a single power supply that outputs both 6V (ARX power) and 15V (FEE power).

3.5.1 Power Supply Connectors

The power supply connector part numbers are listed in Table 3.6.

3.5.2 I2C Bus Connectors

The power supplies are monitored via I2C. Each power supply has a 10-pin I2C connector (Table 3.7). The 10-pin cable also sets the I2C address for each power supply.

Rev H System Difference

The legacy Rev H system uses different power supplies that do not support I2C monitoring. The I2C bus is not used in Rev H installations.

Table 3.6: Power Connectors

Supply	Component	Part Number
15V (FEE)	Connector	Molex 4316-03104
	Housing	Molex 44441-2004
	Terminals	Molex 43375-10001
8V (ARX)	Connector	Molex 43160-3106
	Housing	Molex 44441-2006
	Terminals	Molex 43375-10001

Table 3.7: I2C Connectors

Component	Part Number
Connector	JST B10B-PHDSS
Housing	JST PHDR-10VS
Pins	JST SPHD-001T-P0.5
Alternative:	
Cable Assembly	Artesyn 70-841-023

3.5.3 ARX Power Supply

The ARX power supply provides power to the ARX boards. It is controlled via I2C commands and monitored for voltage, current, and status. I2C address: `0x1F` (31).

Note

The ARX power supply is nominally rated at 8V but is configured via I2C to output 8.8V.

3.5.4 FEE Power Supply

The FEE power supply (15V) provides power to the Front End Electronics. Individual FEE power can be controlled per stand and polarization. I2C address: `0x1E` (30).

3.6 ARX Boards

The Analog Receiver (ARX) boards condition the signals from the FEE. The current design is Revision I. Design files are available at:

`https://github.com/lwa-project/analog_receiver`

Rev H System Difference

The legacy Rev H system uses Revision H ARX boards, which have a different control interface and temperature sensor configuration.

3.7 Board Configuration

The ASP board configuration is summarized in Table 3.8. The values for maximum boards and maximum stands are site-configurable (see Section 6.3); the defaults shown are for a 256-stand station.

Table 3.8: ASP Board Configuration

Parameter	**Value**
Stands per Board	8
Maximum Boards	32 (configurable)
Maximum Stands	256 (configurable)
Channels per Stand	2 (polarizations)

Section 4

Monitor and Control Interface

4.1 Overview

The ASP subsystem communicates with the Monitor and Control System (MCS) via UDP messages. Commands are received on port 1740 and responses are sent to port 1741.

4.2 Message Format

4.2.1 Command Message Format

Commands from MCS to ASP follow the standard LWA message format, as shown in Table 4.1.

Table 4.1: Command Message Format

Field	Bytes	Position	Description
Destination	3	0–2	Subsystem ID (“ASP”)
Sender	3	3–5	Sender ID (“MCS”)
Command	3	6–8	Command code
Reference	9	9–17	Reference number
Data Length	4	18–21	Length of data section
MJD	6	22–27	Modified Julian Date
MPM	9	28–36	Milliseconds Past Midnight
-	1	37	Space
Data	Variable	38+	Command-specific data

4.2.2 Response Message Format

Responses from ASP to MCS include the command status and any requested data (Table 4.2).

4.3 Management Information Base (MIB)

The following MIB entries can be queried using the `RPT` command. All MIB values are returned as ASCII text strings.

Table 4.2: Response Message Format

Field	Bytes	Position	Description
Destination	3	0–2	Destination ID
Sender	3	3–5	"ASP"
Command	3	6–8	Echo of command
Reference	9	9–17	Echo of reference number
Data Length	4	18–21	Length of data section
MJD	6	22–27	Response MJD
MPM	9	28–36	Response MPM
-	1	37	Space
Status	1	38	"A" (accept) or "R" (reject)
Summary	7	39–45	System status summary
Data	Variable	46+	Response data

4.3.1 General Information

General system information is available via the MIB entries listed in Table 4.3.

Table 4.3: General MIB Entries

MIB Entry	Description
`SUMMARY`	Current system status (7 characters)
`INFO`	Detailed status information (up to 256 characters)
`LASTLOG`	Last log entry (up to 256 characters)
`SUBSYSTEM`	Subsystem identifier ("ASP")
`SERIALNO`	Serial number of the ASP unit
`VERSION`	Software version

4.3.2 Analog Chain State

The current analog chain settings for each stand are available via the MIB entries listed in Table 4.4.

Table 4.4: Analog Chain MIB Entries

MIB Entry	Description
`FILTER_{n}`	Current filter code for stand {n} (0–7)
`AT1_{n}`	First attenuator setting for stand {n} (0–15)
`AT2_{n}`	Second attenuator setting for stand {n} (0–15)
`AT3_{n}`	Third attenuator setting for stand {n} (0–31)

4.3.3 FEE Power State

FEE power state and current draw information is available via the MIB entries listed in Table 4.5.

Table 4.5: FEE Power MIB Entries

MIB Entry	Description
FEEPOL1PWR_{n}	FEE power state for stand {n}, pol. 1 (“ON ” or “OFF”)
FEEPOL2PWR_{n}	FEE power state for stand {n}, pol. 2 (“ON ” or “OFF”)
FEEPOL1CUR_{n}	FEE current draw for stand {n}, pol. 1 (mA)
FEEPOL2CUR_{n}	FEE current draw for stand {n}, pol. 2 (mA)

New in Version I

The FEEPOL1CUR_{n} and FEEPOL2CUR_{n} entries are new in Version I. They report the FEE current draw in milliamps for each stand and polarization.

4.3.4 RF Power

RF power measurements are available via the MIB entries listed in Table 4.6.

Table 4.6: RF Power MIB Entries

MIB Entry	Description
RFPWR_{n}	RMS RF power into a 50 Ω load for stand {n}, reported as two space-separated values for pol. 1 and pol. 2 (µW)

New in Version I

The RFPWR_{n} entry is new in Version I. It is only available on systems equipped with square law detector chips. On systems without these chips, the entry returns an error.

Rev H System Difference

All Rev H boards have square law detector chips installed.

4.3.5 ARX Power Supply

ARX power supply status is available via the MIB entries listed in Table 4.7.

4.3.6 FEE Power Supply

FEE power supply status is available via the MIB entries listed in Table 4.8.

The ARXSUPPLY and FEESUPPLY entries report the on/off state of each power supply as a 3-character string: “ON ” (padded), “OFF”, or “UNK” (unknown, when monitoring is not running).

The ARXPWRUNIT_{n} and FEEPWRUNIT_{n} entries return a status string that may include the keywords listed in Table 4.9.

Table 4.7: ARX Power Supply MIB Entries

MIB Entry	Description
ARXSUPPLY	ARX power supply on/off status ("ON " or "OFF" or "UNK")
ARXSUPPLY-NO	Number of ARX power supplies (currently 1)
ARXPWRUNIT_{n}	Info for ARX power supply {n} (name – status)
ARXCURR	ARX total current draw (mA)
ARXVOLT	ARX output voltage (V)

Table 4.8: FEE Power Supply MIB Entries

MIB Entry	Description
FEESUPPLY	FEE power supply on/off status ("ON " or "OFF" or "UNK")
FEESUPPLY-NO	Number of FEE power supplies (currently 1)
FEEPWRUNIT_{n}	Info for FEE power supply {n} (name – status)
FEECURR	FEE total current draw (mA)
FEEVOLT	FEE output voltage (V)

Table 4.9: Power Supply Detailed Status Keywords

Keyword	Description
OK	Power supply operating normally
OverTemperature	Power supply is over temperature
OverCurrent	Power supply is over current
OverVolt	Power supply output voltage is too high
UnderVolt	Power supply output voltage is too low
ModuleFault	Power supply module fault detected

4.3.7 Temperature Monitoring

Temperature sensor data is available via the MIB entries listed in Table 4.10.

Table 4.10: Temperature MIB Entries

MIB Entry	Description
`TEMP-STATUS`	Overall temperature status ("IN_RANGE", "OVER_TEMP", or "UNDER_TEMP")
`TEMP-SENSE-NO`	Number of temperature sensors
`SENSOR-NAME-{n}`	Description of temperature sensor {n}
`SENSOR-DATA-{n}`	Temperature reading from sensor {n} (°C)

Temperature monitoring is performed via sensors associated with the power supply units. The number of sensors depends on the PSU configuration.

Rev H System Difference

On the legacy Rev H system, each ARX board has three dedicated temperature sensors. Temperature monitoring uses the RS-485 bus to query board temperatures directly rather than PSU-based sensors.

4.4 Control Commands

4.4.1 PNG — Ping

The `PNG` command tests connectivity with the ASP subsystem (Table 4.11).

Table 4.11: PNG Command

Field	Value
Command	`PNG`
Data	(none)
Response	Status only

4.4.2 INI — Initialize

The `INI` command initializes the ASP subsystem with the specified number of boards (Table 4.12).

Table 4.12: INI Command

Field	Value
Command	`INI`
Data	Number of boards (integer)
Response	Status; on failure: exit code and message

Exit Codes

`0x00` Process accepted without error
`0x01` Invalid number of ARX boards
`0x08` Blocking operation in progress

The initialization sequence:

1. Verify ARX Control Board is present
2. Turn off power supplies
3. Wait 5 seconds
4. Turn on power supplies
5. Count boards via SPI and RS-485
6. Verify board count matches expected
7. Initialize SPI port configuration
8. Start monitoring threads (power, temperature, chassis)

4.4.3 SHT — Shutdown

The `SHT` command shuts down the ASP subsystem (Table 4.13).

Table 4.13: SHT Command

Field	Value
Command	`SHT`
Data	Mode (optional): “SCRAM”, “RESTART”, or “SCRAM RESTART”
Response	Status; on failure: exit code and message

Exit Codes

`0x00` Process accepted without error
`0x07` Invalid command arguments (unknown mode)
`0x08` Blocking operation in progress

4.4.4 FIL — Set Filter

The `FIL` command sets the filter configuration for a specified stand (Table 4.14).

Table 4.14: FIL Command

Field	Value
Command	`FIL`
Data	Stand number + filter code (2 digits)
Response	Status; on failure: exit code and message

Example: `FIL 12305` sets stand 123 to filter code 05.

Exit Codes

`0x00`	Process accepted without error
`0x02`	Invalid stand
`0x04`	Invalid filter code
`0x0A`	Subsystem needs to be initialized

Filter Codes

The available filter codes are defined in Table 4.15.

Table 4.15: Filter Code Definitions

Code	HPF	LPF	Description
0	HPF30	LPF83	Split bandwidth, 10 MHz cutoff
1	HPF10	LPF83	Full bandwidth, 10 MHz cutoff
2	HPF30	LPF73	Reduced bandwidth
3	HPF3	LPF73	Full bandwidth, shifted down
4	HPF20	LPF83	Split bandwidth, 3 MHz cutoff
5	HPF3	LPF83	Full bandwidth, 3 MHz cutoff
6	HPF10	LPF73	Full bandwidth + better FM rejection
7	HPF20	LPF73	Split @ 3 MHz + better FM rejection

New in Version I

Filter codes 6 and 7 are new in Version I. They provide improved FM rejection by using the LPF73 low-pass filter.

4.4.5 AT1 — Set First Attenuator

The `AT1` command sets the first attenuator for a specified stand (Table 4.16).

Table 4.16: AT1 Command

Field	Value
Command	`AT1`
Data	Stand number + attenuator setting (2 digits, 00–15)
Response	Status; on failure: exit code and message

- Setting range: 0–15
- Step size: 2 dB
- Attenuation range: 0–30 dB
- Actual attenuation = setting × 2 dB

Example: `AT1 12308` sets stand 123 AT1 to setting 08 (16 dB attenuation).

Exit Codes

`0x00`	Process accepted without error
`0x02`	Invalid stand
`0x05`	Invalid attenuator setting
`0x0A`	Subsystem needs to be initialized

4.4.6 AT2 — Set Second Attenuator

The `AT2` command sets the second attenuator for a specified stand (Table 4.17).

Table 4.17: AT2 Command

Field	Value
Command	`AT2`
Data	Stand number + attenuator setting (2 digits, 00–15)
Response	Status; on failure: exit code and message

- Setting range: 0–15
- Step size: 2 dB
- Attenuation range: 0–30 dB
- Actual attenuation = setting × 2 dB

Exit Codes

`0x00`	Process accepted without error
`0x02`	Invalid stand
`0x05`	Invalid attenuator setting
`0x0A`	Subsystem needs to be initialized

4.4.7 AT3 — Set Third Attenuator

The `AT3` command sets the third attenuator for a specified stand (Table 4.18).

Table 4.18: AT3 Command

Field	Value
Command	`AT3`
Data	Stand number + attenuator setting (2 digits, 00–31)
Response	Status; on failure: exit code and message

- Setting range: 0–31
- Step size: 0.5 dB
- Attenuation range: 0–15.5 dB
- Actual attenuation = setting × 0.5 dB

Example: `AT3 12320` sets stand 123 AT3 to setting 20 (10.0 dB attenuation).

Exit Codes

`0x00`	Process accepted without error
`0x02`	Invalid stand
`0x05`	Invalid attenuator setting
`0x0A`	Subsystem needs to be initialized

Rev H System Difference

On the legacy Rev H system, this command is named `ATS` and is a no-op (the command is accepted but has no effect).

4.4.8 LOC — Locate LED

The `LOC` command controls the locate LED on a specified stand (Table 4.19).

Table 4.19: LOC Command

Field	Value
Command	`LOC`
Data	Stand number + locate setting (2 digits, 00 or 11)
Response	Status; on failure: exit code and message

- Setting 00: LED off
- Setting 11: LED on

Example: `LOC 12311` turns on the locate LED for stand 123.

Exit Codes

`0x00`	Process accepted without error
`0x02`	Invalid stand
`0x05`	Invalid locate setting
`0x0A`	Subsystem needs to be initialized

New in Version I

The `LOC` command is new in Version I. It allows field personnel to identify specific stands by illuminating a locate LED on the ARX board.

Rev H System Difference

The `LOC` command is not available on the legacy Rev H system.

4.4.9 FPW — FEE Power

The `FPW` command controls the FEE power for a specified stand and polarization (Table 4.20).

- Polarization: 1 (X) or 2 (Y)

Table 4.20: FPW Command

Field	Value
Command	`FPW`
Data	Stand number + polarization (1 or 2) + state (2 digits)
Response	Status; on failure: exit code and message

- State 00: Power off
- State 11: Power on

Example: `FPW 123111` turns on FEE power for stand 123, polarization 1.

Exit Codes

`0x00`	Process accepted without error
`0x02`	Invalid stand
`0x03`	Invalid polarization
`0x06`	Invalid power setting
`0x0A`	Subsystem needs to be initialized

4.4.10 RXP — ARX Power Supply Control

The `RXP` command controls the ARX power supply (Table 4.21).

Table 4.21: RXP Command

Field	Value
Command	`RXP`
Data	State (00 or 11)
Response	Status; on failure: exit code and message

- State 00: Power off (system enters ERROR state)
- State 11: Power on

Exit Codes

`0x00`	Process accepted without error
`0x06`	Invalid power setting
`0x08`	Blocking operation in progress

4.4.11 FEP — FEE Power Supply Control

The `FEP` command controls the FEE power supply (Table 4.22).

- State 00: Power off (system enters ERROR state)
- State 11: Power on

Table 4.22: FEP Command

Field	Value
Command	`FEP`
Data	State (00 or 11)
Response	Status; on failure: exit code and message

Exit Codes

`0x00` Process accepted without error
`0x06` Invalid power setting
`0x08` Blocking operation in progress

4.4.12 RPT — Report MIB Entry

The `RPT` command queries a MIB entry (Table 4.23).

Table 4.23: RPT Command

Field	Value
Command	`RPT`
Data	MIB entry name
Response	MIB value; on failure: error message

Example: `RPT FILTER_123` returns the filter code for stand 123.

4.5 System States

The ASP subsystem reports one of the status values listed in Table 4.24.

Table 4.24: System Status Values

Status	Description
`SHUTDWN`	System is shut down or not initialized
`BOOTING`	System is initializing
`NORMAL`	System is operating normally
`WARNING`	Warning condition (e.g., temperature approaching limit)
`ERROR`	Error condition requiring attention

Section 5

Safety Interface

5.1 Overview

The ASP subsystem includes several safety features to protect equipment from damage due to temperature or power supply anomalies.

5.2 Temperature Monitoring

The ASP continuously monitors temperature via sensors associated with the power supply units.

5.2.1 Temperature Thresholds

The temperature thresholds and associated actions are listed in Table 5.1.

Table 5.1: Temperature Thresholds

Threshold	**Value**	**Action**
Minimum	0.0 °C	Under-temperature warning/error
Warning	40.0 °C	System enters WARNING state
Maximum	45.0 °C	System enters ERROR state; power supplies turned off

5.2.2 Temperature Response

1. **Warning Condition**: When any temperature sensor exceeds the warning threshold (40 °C), the system enters WARNING state. This is a cautionary indicator.
2. **Over-Temperature**: If temperatures exceed the maximum threshold (45 °C) for three consecutive monitoring cycles, the system:
    - Enters ERROR state
    - Turns off ARX power supply
    - Turns off FEE power supply
    - Sets the ready flag to false

3. **Under-Temperature**: If temperatures drop below the minimum threshold (0 °C) for three consecutive monitoring cycles, the system enters ERROR state but does not turn off power supplies.

5.3 Power Supply Monitoring

The ASP monitors power supply status for fault conditions.

5.3.1 Monitored Conditions

The power supply fault conditions and their responses are listed in Table 5.2.

Table 5.2: Power Supply Fault Conditions

Condition	Response
Over Temperature	Shut down affected power supply; enter ERROR state
Over Current	Shut down affected power supply; enter ERROR state
Over Voltage	Shut down affected power supply; enter ERROR state
Under Voltage	Shut down affected power supply; enter ERROR state
Module Fault	Shut down affected power supply; enter ERROR state

5.4 Control Board Monitoring

The system periodically verifies that the ARX Control Board USB device is present and responding. If the control board disappears:

- System enters ERROR state
- INFO field reports device not found
- Ready flag is set to false

5.5 Board Configuration Monitoring

The chassis status monitoring thread periodically verifies that ARX boards maintain their SPI port configuration. The thread reads a known configuration register from the RS485 bus and checks that its value matches the expected configuration pattern. If the bus has lost its SPI port setup (e.g., from a USB reset or power glitch), the register value will differ, indicating that communication with the boards is no longer possible. If a board loses configuration:

- System enters ERROR state
- INFO field reports which antennas are affected

- Ready flag is set to false

Rev H System Difference

On the legacy Rev H system, board configuration monitoring uses a timestamp-based mechanism rather than SPI register checks. During initialization, a reference timestamp is written to all boards via the RS-485 `STIM` command. The monitoring thread periodically queries each board for its stored time using the `GTIM` command. If any board has reset or lost power, its stored time will differ from the reference. This approach can identify exactly which individual board(s) have failed, rather than detecting a whole RS485 bus failure.

5.6 Error Recovery

To recover from most error conditions, the system must be re-initialized using the `INI` command. The operator should:

1. Address the underlying cause of the error (temperature, power supply fault, etc.)
2. Issue a `SHT` command if the system is not already shut down
3. Issue an `INI` command with the appropriate board count

Section 6

References

1. MCS Common ICD — Monitor and Control System Common Interface Control Document
2. NDP ICD — Next Generation Digital Processor Interface Control Document
3. ASP Preliminary Design Document
4. LWA Memo #222 — LWA ARX Requirements - On Beyond Rev H
5. LWA Memo #229 — Collected LWA Engineering Memos from the Development of the Analog Receiver (ARX) Rev. I, 2023 August 28 - 2024 October 21
6. LWA Station Architecture Document

6.1 Hardware Design Repositories

- ARX Control Board: `https://github.com/lwa-project/arx_control_board`
- Analog Receiver (Rev I): `https://github.com/lwa-project/analog_receiver`

6.2 Related Software

The following Python modules implement the ASP control software (Table 6.1).

6.3 Configuration Files

ASP configuration is stored in JSON format in site-specific files (`defaults.json.`*`site`*). The top-level keys and their nested structure are described below.

6.3.1 Global Parameters

The top-level scalar parameter identifies the ASP instance (Table 6.2).

6.3.2 `mcs` — MCS Communication

The `mcs` object configures the UDP interface between ASP and MCS. Table 6.3 lists the available parameters.

Table 6.1: ASP Software Modules

Module	Description
`asp_cmnd.py`	Main ASP control daemon; MCS command interface
`aspFunctions.py`	Core ASP functions; command processing
`aspSUB20.py`	Communication functions; SPI/I2C/RS-485
`aspThreads.py`	Monitoring threads (temperature, power, chassis)
`MCS.py`	MCS message protocol implementation
`arx_control/`	Low-level ARX hardware control; C++/Python SPI register definitions, board configuration, and power supply utilities

Table 6.2: Top-level Configuration Parameters

Key	Type	Description
`serial_number`	string	ASP unit serial number (e.g., "ASP01")

Table 6.3: `mcs` Configuration Parameters

Key	Type	Description
`message_host`	string	MCS host IP address
`message_out_port`	int	UDP port for sending responses to MCS
`message_in_port`	int	UDP port for receiving commands from MCS

6.3.3 Temperature and Monitoring

Several top-level keys control temperature thresholds and monitoring intervals. Table 6.4 lists these parameters.

Table 6.4: Temperature and Monitoring Configuration Parameters

Key	Type	Description
`temp_min`	float	Minimum (cold) temperature threshold (°C)
`temp_warn`	float	Warning temperature threshold (°C)
`temp_max`	float	Critical (shutdown) temperature threshold (°C)
`temp_period`	int	Temperature monitoring interval (seconds)
`power_period`	int	Power supply monitoring interval (seconds)
`chassis_period`	int	Chassis status monitoring interval (seconds)

6.3.4 Board and Stand Configuration

These parameters define the physical board and stand layout. Table 6.5 lists the available parameters. The values of `max_boards` and `max_stands` are site-specific.

Table 6.5: Board and Stand Configuration Parameters

Key	Type	Description
`stands_per_board`	int	Number of stands per ARX board
`max_boards`	int	Maximum number of ARX boards
`max_stands`	int	Maximum number of stands
`max_atten`	array of int	Maximum attenuator values `[AT1, AT2, AT3]`

6.3.5 SPI Bus Configuration

These parameters control SPI communication retry behavior. Table 6.6 lists the available parameters.

Table 6.6: SPI Bus Configuration Parameters

Key	Type	Description
`max_spi_retry`	int	Maximum number of SPI transaction retries
`wait_spi_retry`	float	Delay between SPI retries (seconds)

6.3.6 Power Supply I2C Addresses

These parameters specify the I2C bus addresses for the power supplies. Table 6.7 lists the available parameters.

Table 6.7: Power Supply I2C Address Parameters

Key	Type	Description
`arx_ps_address`	int	I2C address of ARX power supply (decimal)
`fee_ps_address`	int	I2C address of FEE power supply (decimal)

6.3.7 Control Board Mapping

These parameters map the ARX Control Board to the physical hardware. Table 6.8 describes the mapping structure. The `sub20_antenna_mapping` and `sub20_rs485_mapping` objects are keyed by control board serial number; the RS-485 mapping is further nested by board address.

Table 6.8: Control Board Mapping Parameters

Key	Type	Description
`sub20_i2c_mapping`	string	Serial number of the control board used for I2C communication
`sub20_antenna_mapping`	object	Maps control board serial number to antenna stand range `[start, end]`
`sub20_rs485_mapping`	object	Maps control board serial number to an object of RS-485 board addresses, each mapping to a stand range `[start, end]`

Appendix A

Exit and Status Codes

A.1 Command Exit Codes

The following exit codes (Table A.1) are returned in response to control commands when an error occurs.

Table A.1: Command Exit Codes

Code	Description
0x00	Process accepted without error
0x01	Invalid number of ARX boards
0x02	Invalid stand
0x03	Invalid polarization
0x04	Invalid filter code
0x05	Invalid attenuator setting
0x06	Invalid power setting
0x07	Invalid command arguments
0x08	Blocking operation in progress
0x09	Subsystem already initialized (reserved; not currently returned)
0x0A	Subsystem needs to be initialized
0x0B	Command not implemented

A.2 Subsystem Error Codes

The following error codes (Table A.2) are used in the INFO field to describe error conditions.

Table A.2: Subsystem Error Codes

Code	Description
0x00	Subsystem operating normally
0x01	PS over temperature

Code	Description
0x02	PS under temperature
0x03	PS over voltage
0x04	PS under voltage
0x05	PS over current
0x06	PS module fault error
0x07	Failed to process SPI commands
0x08	Failed to process I2C commands
0x09	Board count mis-match
0x0A	Temperature over TempMax
0x0B	Temperature under TempMin
0x0C	Power supplies off
0x0D	Temperature warning

A.3 System Status Values

The SUMMARY field in MCS responses contains one of the status values listed in Table A.3.

Table A.3: System Status Values

Status	Description
SHUTDWN	System is shut down or not yet initialized. No commands except INI will be processed.
BOOTING	System is in the process of initializing. Commands will be rejected with exit code 0x08.
NORMAL	System is operating normally. All commands are accepted.
WARNING	System is operating but a warning condition exists (e.g., temperature approaching limit). Commands are accepted.
ERROR	An error condition exists. The system may need to be re-initialized.