

3240AE0002 Issue 1.3: SALT HRS Software Design

Southern African Large Telescope High-Resolution Spectrograph

SALT HRS

3240AE0002 Software Design

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Issue History

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3240AE0002 Software Requirements	MDA	1.0	1 Mar 2005	Shell
	MDA	1.1	5 March 2005	First draft
	MDA	1.2	8 March 2005	Add detectors
	MDA	1.3	14 March 2005	Minor changes

TABLE OF CONTENTS

- 1. SCOPE4**
- 2. ELECTRONIC SYSTEMS.....4**
 - 2.1. ELECTROMECHANICAL SUBSYSTEMS4
 - 2.2. ELECTRONIC NON-MECHANICAL SUBSYSTEMS4
- 3. HIGH-LEVEL OPERATIONS4**
- 4. SERVER STATES.....5**
- 5. OPERATING MODES.....6**
 - 5.1. REGULAR NIGHT TIME OPERATIONS6
 - 5.2. REGULAR DAY TIME OPERATIONS6
 - 5.3. ENGINEERING OPERATIONS7
- 6. OBSERVING MODE SELECTION.....7**
 - 6.1. SELECT SPECTROGRAPH FEED7
 - 6.2. SELECT ILLUMINATION SOURCE7
 - 6.3. SELECT CAMERA8
 - 6.4. SELECT EXPOSURE TERMINATION CRITERION.....8
 - 6.5. BEGIN EXPOSURE8
 - 6.6. TERMINATE EXPOSURE.....8
- 7. SERVER SIDE OPERATIONS9**
 - 7.1. SELECT SPECTROGRAPH FEED9
 - 7.2. SELECT ILLUMINATION SOURCE9
 - 7.3. SLIT VIEWING.....9
 - 7.4. PERFORM AN EXPOSURE.....9
- 8. COMMUNICATION WITH THE TCS/FIF.....10**
- 9. DETECTOR SOFTWARE10**
- 10. DATA REDUCTION SOFTWARE10**
- 11. PROTOTYPE USER INTERFACE.....10**

1. Scope

This document specifies all aspects of the software required to operate SALT HRS.

2. Electronic Systems

SALT HRS has the following electronic subsystems to enable its operations:

2.1. Electromechanical subsystems

- 2.1.1. Fibre selector drive (6 positions, stepper motor)
- 2.1.2. Slit viewing beam splitter drive (2 positions, stepper motor)
- 2.1.3. Fast shutters for both input paths (2 states, COTS)
- 2.1.4. Fold mirror drive to select input path (2 positions, stepper motor)
- 2.1.5. Slow shutters for each camera (2 states, stepper motors)
- 2.1.6. Focus drives for each camera (COTS micrometers)

2.2. Electronic non-mechanical subsystems

- 2.2.1. Slit viewing camera (COTS)
- 2.2.2. Exposure meter (custom)
- 2.2.3. Pressure monitoring sensors (COTS)
- 2.2.4. Temperature monitoring sensors (COTS)
- 2.2.5. Camera illumination lamp (COTS)
- 2.2.6. Spectrograph arc lamp (COTS)
- 2.2.7. Detectors (COTS)

The electronic control of these systems is described in document 3250AE0029 except for the detectors (described in document 3290AE0001 Detector Specification).

The HRS control software must provide the capability to

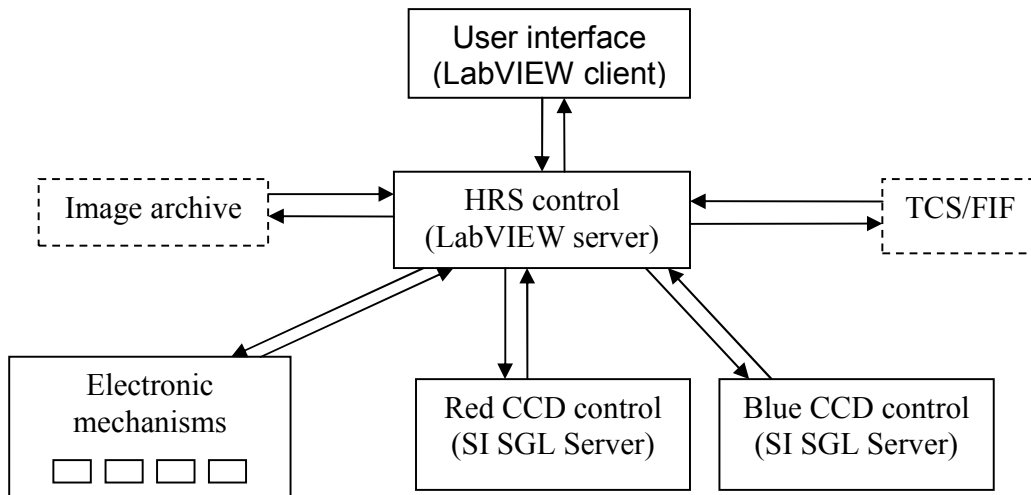
1. Control the electromechanical mechanisms to support observing states.
2. Enforce any lock conditions required by the electronic and electromechanical systems to prevent damage to the instrument.
3. Provide status information for each electronic subsystem.
4. Control the slit viewing camera and exposure meter.
5. Provide data from each temperature and pressure sensor.
6. Provide error recovery operations for each system.

3. High-level operations

The high-level (operator level) HRS control software will run on a standard Windows PC. The software will be written in LabVIEW (National Instruments graphical programming language) to facilitate interaction with SALT observatory software. A software model similar to that used for PFIS will be adopted, where the user interface consists of a LabVIEW client. Lower level control of the various electronic systems will be done from the HRS LabVIEW server software, which may reside on a different physical computer. Information will be exchanged between client and server

using simple human readable text strings, facilitating the use of scripting various observing operations from the client side. All LabVIEW code will conform to the SALT LabVIEW programming standards.

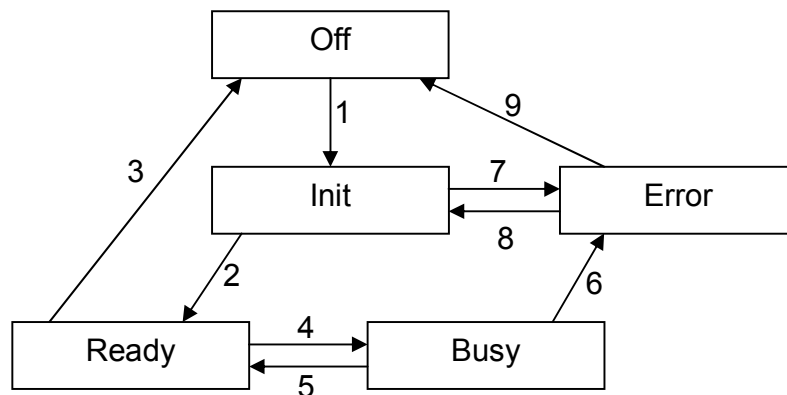
The various software elements and their relationships can be viewed logically in the following diagram.



The user interface may be run on any computer connected to the SALT LAN or on the HRS control PC itself. Each CCD control runs on its own dedicated PC, interfaced to its CCD hardware control box.

4. Server states

The HRS control server can at any time be in any one of 5 states. The relationships between these states is shown in the following diagram.



The transitions between states are

1. Boot HRS control PC.
2. Self checks passed, electronic mechanism states determined.
3. Shut down HRS control server.
4. Command received.
5. Command completed.
6. Hardware or detector failure, broken link.
7. Self check failure, mechanism states not determined.
8. Operator restart.
9. Operator shutdown.

5. Operating modes

A small set of operations are needed to support observing with SALT HRS. The observing mode can be characterised by the selection of input light source and illumination source. Other background operations will be performed as part of the transitions between these modes. The user interface will consist of 3 tabbed LabVIEW GUI screens that allow the following selections.

5.1. Regular night time operations

<i>Spectrograph feed</i>	<i>Illumination source</i>				
	Telescope			Spectrograph	
	Arc	Flat	Sky	Camera flat	Arc
1 High res IS	✓	✓	✓		
2 Med res IS	✓	✓	✓		
3 Low res	✓	✓	✓		
4 High res fibre					
5 Camera flat					

At this level, background operations such as shutter state selection and fold mirror position will not be directly controllable but the state of these mechanisms will be indicated by on screen status lights.

5.2. Regular day time operations

<i>Spectrograph feed</i>	<i>Illumination source</i>				
	Telescope			Spectrograph	
	Arc	Flat	Sky	Camera flat	Arc
1 High res IS	✓	✓			
2 Med res IS	✓	✓			
3 Low res	✓	✓			
4 High res fibre					✓
5 Camera flat				✓	

At this level, background operations such as shutter state selection and fold mirror position will not be directly controllable but the state of these mechanisms will be indicated by on screen status lights.

5.3. Engineering operations

<i>Spectrograph feed</i>	<i>Illumination source</i>				
	Telescope			Spectrograph	
	Arc	Flat	Sky	Camera flat	Arc
1 High res IS	✓	✓	✓		
2 Med res IS	✓	✓	✓		
3 Low res	✓	✓	✓		
4 High res fibre					✓
5 Camera flat				✓	

At this level control will be available for all low level electromechanical operations, including the spectrograph focus controls. The slit viewing camera (used for focussing and alignment of the input optics) will only be available at this level.

6. Observing mode selection

The following client side parameter selections are required to select an observing mode from the tables above. Prototype user interface screenshots are shown in Section 10.

6.1. Select spectrograph feed

6.1.1. High resolving power image slicer

6.1.2. Medium resolving power image slicer

6.1.3. Low resolving power fibre

- 6.1.3.1. Select either *fixed position* or *nod & shuffle* exposure.
For *nod & shuffle* exposure, select *nod interval* (in seconds).

6.1.4. High resolving power fibre

6.1.5. Camera flat

6.2. Select illumination source

6.2.1. Telescope arc

Available for spectrograph feeds 1, 2, 3.

6.2.2. Telescope flat

Available for **spectrograph feeds 1, 2, 3.**

6.2.3. Sky

Available for **spectrograph feeds 1, 2, 3.**

6.2.4. Camera flat

Available only for **spectrograph feed 5.**

6.2.5. Spectrograph ThAr lamp

Available only for **spectrograph feed 4.**

6.3. Select camera

6.3.1. Blue camera

6.3.2. Red camera

6.3.3. Both cameras

6.4. Select exposure termination criterion

Cannot select different termination type for each camera. Select either

6.4.1. Exposure time termination

Exposure time must be set for each camera.

6.4.2. Signal to noise termination

Maximum exposure time must also be set.

B-R for target needs to be specified.

Both minimum and maximum S/N must be specified for each camera.

Exposures will terminate if any of the following are true:

- a. Maximum exposure time has been reached.
- b. Minimum S/N has been reached in both cameras. In this case, both camera exposures will be terminated by closing a fast shutter.
- c. Maximum S/N has been reached in one camera before minimum S/N has been reached in the other. In this case, the exposure that has reached maximum S/N will be terminated with a slow shutter. The remaining exposure will continue until condition a. or b. is reached.

6.5. Begin exposure

6.6. Terminate exposure

Override the preset termination conditions for an in-progress exposure.

7. Server side operations

The following background electromechanical operations will be implemented by the HRS control server software when transitioning between observing modes. Each operation will be implemented using one or more LabVIEW Virtual Instruments (VIs).

7.1. Select spectrograph feed

- 7.1.1. Change state of slow shutter 1 if required.
- 7.1.2. Change state of slow shutter 2 if required.
- 7.1.3. Move fibre selection wheel if required.
- 7.1.4. Notify TCS of FIF fibre selection.

7.2. Select illumination source

- 7.2.1. Switch spectrograph flat field lamp off or on if required.
- 7.2.2. Switch spectrograph arc lamp off or on if required.
- 7.2.3. Notify TCS to deploy/stow and switch on/off flat field lamp if required.
- 7.2.4. Notify TCS to deploy/stow and switch on/off arc lamp if required.
- 7.2.5. Interrogate TCS to confirm FIF ready for observation.

7.3. Slit viewing

- 7.3.1. Move beamsplitter into/out of beam.
- 7.3.2. Turn on or off slit view camera.
- 7.3.3. Receive slit view camera images and pass to client.

7.4. Perform an exposure

To perform an exposure, the HRS control server may be required to perform the following operations.

- 7.4.1. Reset exposure meter
- 7.4.2. Interrogate TCS for initial telescope data for image headers.
- 7.4.3. Signal CCD computer(s) to begin a timed or open-length exposure.
- 7.4.4. Monitor and pass to client exposure meter data.
- 7.4.5. Monitor client for early termination signal.
- 7.4.6. Signal CCD computer(s) to terminate exposure.
- 7.4.7. Receive FITS image(s) from CCD computer(s).
- 7.4.8. Interrogate TCS for final telescope data.
- 7.4.9. Modify image headers.
- 7.4.10. Pass images to data storage.
- 7.4.11. Instruct TCS to nod telescope.
- 7.4.12. Instruct CCD computer(s) to shuffle charges on CCD.

8. Communication with the TCS/FIF

The server software will be required to interact with the SALT telescope control system / fibre instrument feed to:

- 8.1. manage telescope nods during nod and shuffle exposures
- 8.2. perform image centering peak ups

These interactions will be via the exchange of text strings following the protocols developed for PFIS interactions with the TCS.

9. Detector software

Each detector is controlled via the Spectral Instruments SGL Server application which operates the Spectral Instruments cameras through a PCI card interface. The SGL server will be accessed through the exchange of TCP/IP packets with the HRS control server. A custom set of LabVIEW VIs to perform the necessary camera operations are provided by Spectral Instruments and will be integrated into the HRS control server.

10. Data reduction software

A data pipeline will be produced that uses well-established standard CCD preprocessing and echelle reduction routines. Most likely this will comprise standard IRAF tasks, scripted in PyRAF.

11. Prototype user interface

Shown below are screenshots of the prototype LabVIEW user interface.

HR5 Night time operations | HR5 Day time operations | HR5 Engineering operations

Exposure meter controls

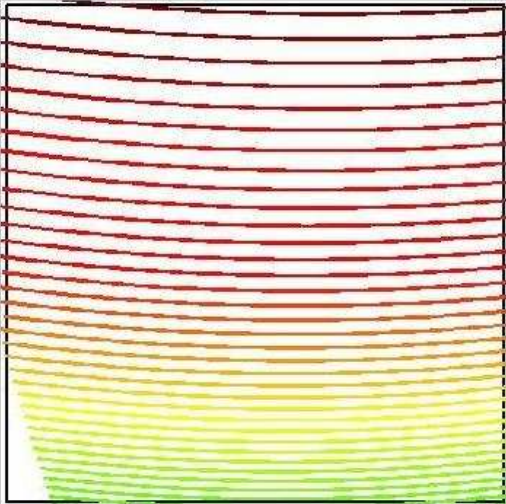
RED Min S/N Max S/N S/N Ratio Max exp time

BLUE Min S/N 2 Max S/N 2 S/N Ratio 2 Reset Exposure Meter

Min RED S/N Reached Max RED S/N Reached Use exposure timer Use exposure meter

Min BLUE S/N Reached Max BLUE S/N Reached

Red camera display



Rate meter counts per second (log scale)

Counts per second

Accumulated photon count

Exposure timer

RED elapsed time (secs) Red exposure time (secs) Exposure started at

BLUE elapsed time (secs) Reset timer Blue exposure time (secs) RED exposure stopped at

BLUE exposure stopped at

Spectrograph control

Spectrograph operating mode selection High res IS (flat field calibration lamp) Click to set up spectrograph Perform setup

Moving to position Ready

Camera selection

- Use RED camera only
- Use BLUE camera only
- Use RED & BLUE cameras

Calibration lamps from telescope

Flat field lamp Argon lamp

On Off On Off

Start exposure Exposing Stop exposure

Nod and shuffle setup Nod interval (secs) Nod counter

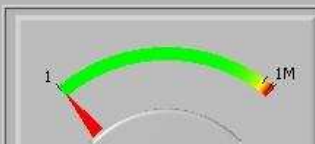
Create new filename Filename 2

HRS Night time operations | HRS Day time operations | HRS Engineering operations

Exposure meter controls

RED: Min S/N 3, Max S/N 3, S/N Ratio 3, Max exp time 2
 BLUE: Min S/N 4, Max S/N 4, S/N Ratio 4, Reset Exposure Meter

Min RED S/N Reached Max RED S/N Reached Use exposure timer Use exposure meter
 Min BLUE S/N Reached Max BLUE S/N Reached



Rate meter counts per second (log scale)
 Counts per second:
 Accumulated photon count 2:

Exposure timer

RED elapsed time (secs): Red exposure time (secs): Exposure started at:
 BLUE elapsed time (secs): Blue exposure time (secs): RED exposure stopped at:
 BLUE exposure stopped at:

Spectrograph control

Spectrograph operating mode selection: Click to set up spectrograph
 Moving to position Ready

Camera selection:
 Use RED camera only
 Use BLUE camera only
 Use RED & BLUE cameras

Calibration lamps from telescope:
 Flat field lamp: On Off ThAr lamp: On Off
 Calibration lamps from spectrograph:
 White Intensity: ThAr lamp: On Off

Start exposure
 Exposing
 Stop exposure

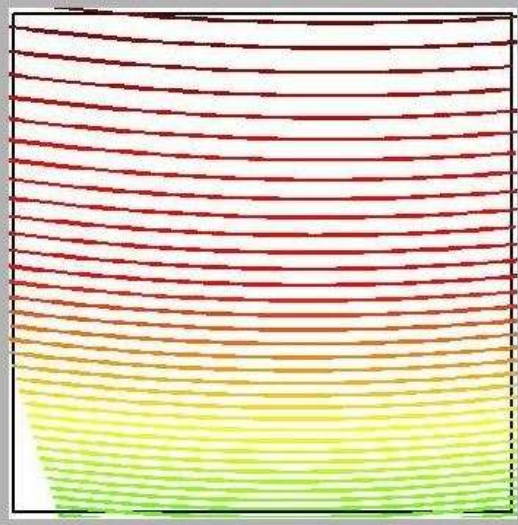
Nod and shuffle setup: Nod interval (secs): Nod counter:

Focus drive

Current position: Drive to position: GO Focus drive RED
 Position in microns (max: 25000 microns): Driving
 Go forward by: GO Go back by: GO

Current position: Drive to position: GO Focus drive BLUE
 Position in microns (max: 25000 microns): Driving
 Go forward by: GO Go back by: GO

Red camera display



Blue camera display

