Southern African Large Telescope
High-Resolution Spectrograph

SALT HRS

3250AE0029 Electronics Design and Control

Ross Ritchie
Geoff Graham
University of Canterbury

Issue 1.3
15 March 2005

Issue History

Number and file name	Person	Issue	Date	Status
3250AE0029 elect	GG	1.0	23 February 2005	CDR Initial draft
	GG	1.1	3 March 2005	Major update
	PLC	1.2	7 March 2005	Formatting
	PLC	1.3	15 March 2005	Final edit

TABLE OF CONTENTS

1 SCOPE 4

2 SYSTEM OVERVIEW 4

3 ELECTRONICS SUBSYSTEMS 4

3.1 SUBSYSTEM DESCRIPTION 7
3.1.1 Fibre selector drive 7
3.1.2 Slit-viewing camera 7
3.1.3 Fast shutters 7
3.1.4 Flip mirror drive-1 7
3.1.5 Flip mirror drive-2 7
3.1.6 Slow shutters 7
3.1.7 Camera focus drives 8
3.1.8 Exposure meter 8
3.1.9 Pressure and temperature monitoring 8
3.1.10 Flat field and ThAr lamp controls 8
3.1.11 Vacuum feed through connectors 8
3.2 GENERAL DESCRIPTION OF THE ELECTRONICS CONTROL SYSTEM 8
3.3 ELECTRICAL SAFETY 8

4 COMMANDS USED WITH THE CONTROL ELECTRONICS 9

4.1 FIBRE SELECTOR 9
4.2 FAST SHUTTER-1 9
4.3 FAST SHUTTER-2 9
4.4 FLIP MIRROR-1 9
4.5 FLIP MIRROR-2 10
4.6 SLOW SHUTTER-1 10
4.7 SLOW SHUTTER-2 10
4.8 FOCUS DRIVE-1 10
4.9 FOCUS DRIVE-2 10
4.10 EXPOSURE METER 11
4.11 INTERNAL & EXTERNAL TEMPERATURE SENSORS AND PRESSURE SENSOR 12
4.12 FLAT FIELD AND THAR LAMPS 13
4.13 COMMS LINK TEST 13

5 ELECTRONICS CABINET LAYOUT 13

6 TOTAL POWER CONSUMPTION FOR HRS ELECTRONICS SYSTEMS 14

7 OTHER 14

1 Scope

This document describes the electronics design and summarises the key elements of electronic control for the operation of the SALT HRS instrument.

2 System overview

The electronics control system enables the control computer to control all of the electro-mechanical functions of the spectrograph. It acts as an interface between the control computer and the actuator devices. The electronics control system performs all the low level tasks associated with positioning actuators and reading temperatures and pressure, allowing the computer to simply issue commands and receive responses. Also associated with the electronics control system is the slit-viewing camera and the exposure meter.

The control of the functions of SALT HRS will be from a stand alone SALT HRS PC with key values passed between the TCS and SALT HRS PC. The telescope and instrument operators will be able to view and alter the status of SALT HRS and its environment.

3 Electronics Subsystems

The electronics control system consists of the following subsystems, where the number in () indicates the number of such systems:

- Fibre selector drive (1)
- Slit-view camera (1)
- Fast shutters (2)
- Flip mirror drives (2)
- Slow shutters (2)
- Camera focus drives (2)
- Exposure meter (1)
- Pressure & Temperature monitoring (8 channels)
- Flat field lamp control (1)
- ThAr lamp control (1)

Figure 1 shows the position of most of the above subsystems, while Figure 2 shows a logical schematic diagram of the control processes.

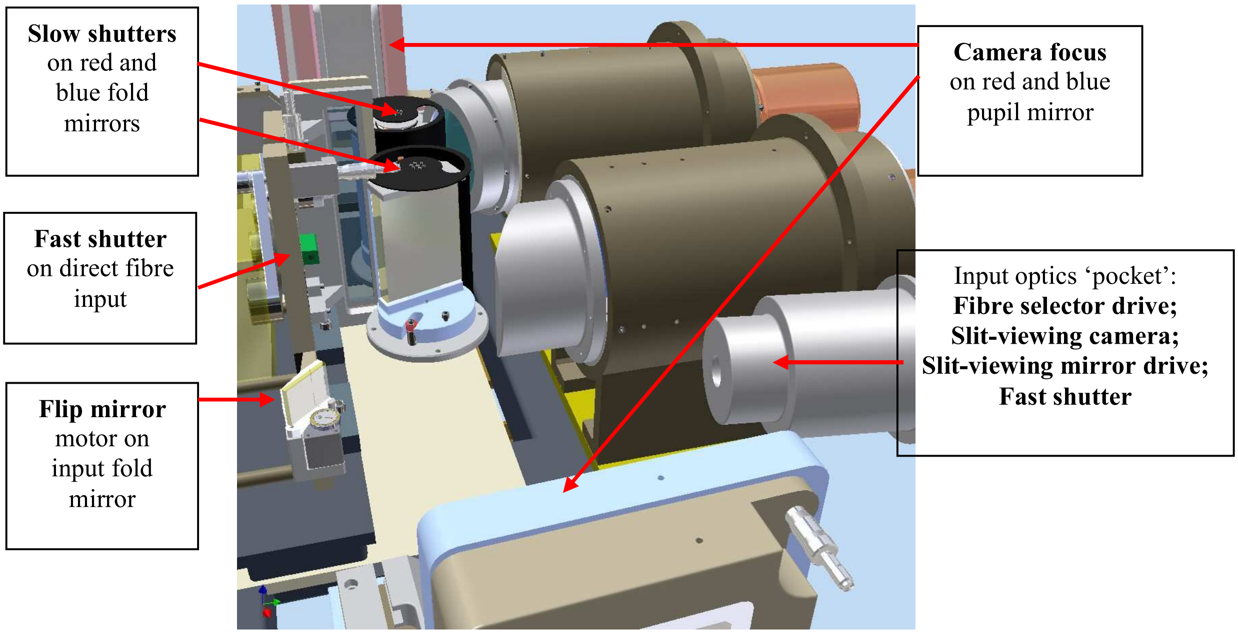

Figure 1: A layout of the SALT HRS showing the position of each of the control subsystems itemised in Section 3, except for the exposure meter, pressure and temperature sensors and flat field lamps.

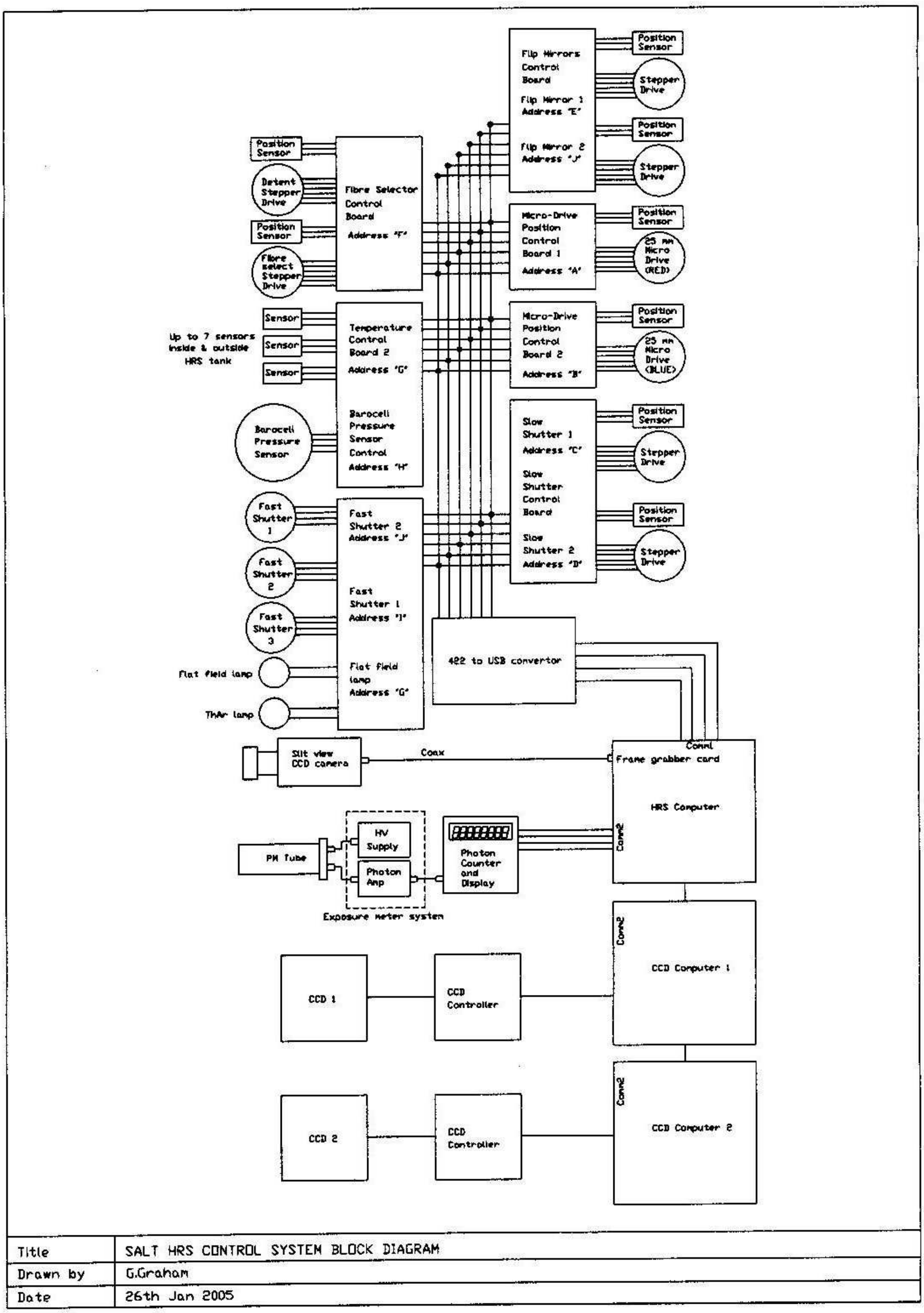

Figure 2: Schematic layout of the SALT HRS control system.

3.1 Subsystem description

The following sub-sections contain a description of each of the subsystems noted above. Specification sheets for each of the following commercial off the shelf (COTS) equipment are provided in 3250AD00033.

Pulnix TM-300 CCD camera	Appendix I
National Instruments PCI-1407 image acquisition card	Appendix II
Hamamatsu R943-02 photomultiplier tube	Appendix III
Hamamatsu C6465 photon amplifier	Appendix III
Hamamatsu C4877 thermo electric cooler	Appendix III
Hamamatsu C6438 preamplifier	Appendix III
Spellman model MP2N high voltage supply	Appendix III
Thorlabs Z625BV motorized actuator	Appendix IV
Empire Magnetics VC-U17-X	Appendix V
Fast shutters Uniblitx VS25	Appendix VI
MKS baratron model 722A-100 pressure sensor	Appendix VII
ACCU-GLASS PRODUCTS vacuum feed-throughs	Appendix VIII
Data Loggers	Appendix IX
Flat field lamps	Appendix X
USB to 422 Convertors	Appendix XI

3.1.1 Fibre selector drive

This is a M23 frame size stepper motor driven rotary turret with 6 electronically sensed positions. The turret is locked in position by an M17 frame size stepper motor driven detent mechanism and power is removed from the stepper motor when not in use.

3.1.2 Slit-viewing camera

This is a standard off the shelf CCD camera and frame grabber card system. The frame grabber card is in the spectrograph control computer. The Slit view CCD camera is a Pacom model MCT5C05N2 half inch monochrome CCIR camera. The frame grabber card is a National Instruments PCI-1407 single analog monochrome image acquisition card.

3.1.3 Fast shutters

These are commercial shutters (one for direct fibre injection inside the vacuum, the other for the image slicer options outside the vacuum) vacuum rated (Uniblitz VS25) controlled by the CCD camera systems. They are interlocked with the movement of the flip mirror drive-1.

3.1.4 Flip mirror drive-1

This is a custom built assembly consisting of a mirror (for transfer between direct injection and image slicer modes) driven by an Empire Magnetics VC-U17-X vacuum rated stepper motor and cam assembly. Power is removed from the stepper motor when not in use. Electronic positioning sensors detect the resting positions.

3.1.5 Flip mirror drive-2

This is a custom built assembly consisting of a beam-splitter (for slit viewing) driven by a B17.1 stepper motor. Power is removed from the stepper motor when not in use. Electronic positioning sensors detect the resting positions.

3.1.6 Slow shutters

These are custom-made shutters (in front of each camera system) consisting of a Empire Magnetics VC-U17-X vacuum rated stepper motor driven disc and position sensing electronics. Power is removed from the stepper motor when not in use. This is a vacuum rated actuator.

3.1.7 Camera focus drives

These are Z625BV vacuum rated micrometer type servo actuators made by Thorlabs. The servo-drive electronics are custom-made microprocessor controlled servo amplifier systems. This is a vacuum rated actuator.

3.1.8 Exposure meter

This system consists of a fibre fed photomultiplier tube housed in a cooler unit, a high voltage power supply unit, a preamp, a photon amplifier unit and a photon counting unit. The PM tube is a Hamamatsu R943-02. The photon amplifier is a Hamamatsu C6465. The cooler is a Hamamatsu C4877. The preamp is a Hamamatsu C6438 preamplifier. The high voltage supply is a Spellman model MP2N.

The photon counter is a custom designed counter and display unit. The counter is connected to a serial comm port of the spectrograph control PC. The exposure meter will be started and reset by the PC and the count can be sent on command to the PC at any time.

3.1.9 Pressure and temperature monitoring

The chamber pressure is sensed using an MKS baratron model 722A-100 pressure sensor and temperatures are sensed using up to seven 100k ohm RT curve matched thermistor bead sensors placed at various positions around the spectrograph, both inside the chamber and outside of it. Pressure readings have a resolution of 0.1mm. Temperature readings have a resolution of 0.1ºC.

3.1.10 Flat field and ThAr lamp controls

These turn on or off the flat field lamps. They are controlled by the same module that controls the fast shutters.

3.1.11 Vacuum feed through connectors

These will be from the ACCU-GLASS PRODUCTS range of D connectors.

3.2 General description of the electronics control system

The HRS control computer will control the movement of the actuators in the spectrograph by sending commands and receiving responses from peripheral custom built electronics using serial commands. The electronic system that controls the actuators is divided into modules, each with its own micro-controller. Each module has an individual address identifier so that all the modules can be linked serially on a common RS422 serial bus, which goes back to the PC. At the computer a 422 to USB converter (a USB-COMi from easysync.co) is attached to a USB port. This allows direct serial to 422 without going through RS232.

The exposure meter is also linked to the computer by serial RS232, but uses a separate comm port.

All motors will have power removed when not in use. All optical position sensors will have power removed from their LEDs once the motor has located its position. This eliminates any unwanted heat and stray light and it keeps the average power dissipation down to a very low level.

3.3 Electrical safety

All mains operated equipment will comply with South African electrical safety standards for portable appliances.

4 Commands used with the control electronics

The following information applies to the detailed descriptions in the followings sub-sections:

All commands are sent in ASCII format, 8 bit no parity, 9600 baud.
All commands are terminated with either carriage-return (CR) or carriage-return line feed (CRLF).

All responses from the modules are in ASCII format, 8 bit no parity, 9600 baud.
All responses are followed by carriage-return line feed (CRLF).

All commands must start with the address character for the module being accessed.

NOTE: “ ” denotes an ASCII string.

4.1 Fibre selector

Address character “F”

Commands:

FaX This command will drive the fibre selector to position X where X is a fibre selector number between 1 and 6. The response sent to the PC is “FaX” followed by (crlf) when the fibre selector is in position, where X is the position of the fibre selector.

4.2 Fast shutter-1

Address character “I”

The fast shutters are controlled by the HRS control computer.

Commands:

Ia This command will cause the fast shutter-1 to open . The response sent to the PC is “Ia” followed by (crlf).

Ib This command will cause the fast shutter-1 to close . The response sent to the PC is “Ib” followed by (crlf).

4.3 Fast shutter-2

Address character “J”

The fast shutters are controlled by the HRS control computer.

Commands:

Ja This command will cause the fast shutter-2 to open . The response sent to the PC is “Ja” followed by (crlf).

Jb This command will cause the fast shutter-2 to close . The response sent to the PC is “Jb” followed by (crlf).

4.4 Flip mirror-1

Address character “E”

Commands:

Ea This command will drive the flip mirror into the “use” position. The response sent to the PC is “Ea” followed by (crlf) when the flip mirror is in position.

Eb This command will drive the flip mirror into the “closed” position. The response sent to the PC is “Eb” followed by (crlf) when the flip mirror is in position.

4.5 Flip mirror-2

Address character "J"

Commands:

Same as for Flip mirror-1 except "E" is replaced with "J".

4.6 Slow shutter-1

Address character "C"

Commands:

Ca This command will drive the slow shutter into the "open" position. The response sent to the PC is "Ca" followed by (crlf) when the shutter is open.

Cb This command will drive the slow shutter into the "closed" position. The response sent to the PC is "Cb" followed by (crlf) when the shutter is in closed.

4.7 Slow shutter-2

Address character "D"

Commands:

The commands for the slow shutter 2 are the same as the commands for the slow shutter 1 except that you use the character "D" in place of the character "C".

4.8 Focus drive-1

Address character "A"

Commands:

Aa12345 This is the command to drive to position 12345 where 12345 represents any number in the range 0 to 25000 (microns). The drive initializes to position 0 (microns) which is where the micrometer shaft is fully withdrawn. The fully extended position is 25000 (microns).

Example: To drive to position 7500 microns send the serial string "Aa7500" followed by character (13) which is carriage return (cr).
All positions are relative to the fully withdrawn 0 position.
When the drive has moved to position, it will respond by sending the new position.
The response will be "A12345" followed by crlf (carriage-return line feed) where 12345 represents a number on the range 0 to 25000 (microns) This is a fixed length string.

Ab This command requests the current position of the drive.
The response will be "A12345" followed by crlf (carriage-return line feed) where 12345 represents a number on the range 0 to 25000 (microns). This is a fixed length string.

Az This command will abort the current action. The response sent to the PC is "Az" followed by (crlf)

4.9 Focus drive-2

Address character "B"

Commands:

The commands for this module are the same as those for Focus drive 1 except that you use the character "B" in place of the character "A".

4.10 Exposure meter

The exposure meter is connected to comm2 of the HRS control computer.

The exposure meter can be started, stopped or cleared by commands from the HRS control computer.

There are two threshold settings that can be programmed into the exposure meter so that the exposure can be stopped. Two settings allow for different exposures on each CCD system.

The CCD computers receive the exposure status from the HRS control computer.

Commands:

"Xa" followed by (cr or crlf)
This command will cause the exposure meter to clear its counters (set the counters to zero).
The exposure meter responds with "Xa" (crlf) when the counters are cleared.

"Xb" followed by (cr or crlf)
This command will cause the exposure meter to start counting photon events.
The exposure meter responds with "Xb" (crlf) when the count starts.

"Xc" followed by (cr or crlf)
This command will cause the exposure meter to clear its counters and start counting.
The exposure meter responds with "Xc" (crlf).

"Xd" followed by (cr or crlf)
This command will cause the exposure meter to stop counting.
The exposure meter responds with "Xd" (crlf) when the count stops.

"Xe" followed by (cr or crlf)
This command will cause the exposure meter to stop counting and send the accumulated count and the count rate in counts per second to the HRS control computer.

The exposure meter responds with "Xe12345678r12345678" (crlf) where e12345678 represents the accumulated count which will be a number between 0 and 99999999, and r12345678 represents the count rate in counts per second. This is a fixed length string.

"Xf" followed by (cr or crlf)
This command will cause the exposure meter to send the latest accumulated count and the count rate in counts per second. This command can be repeated continuously to give a continuous update of the exposure progress.

The exposure meter responds with "Xe12345678r12345678" (crlf) where e12345678 represents the accumulated count which will be a number between 0 and 99999999, and r12345678 represents the count rate in counts per second. (This is a fixed length string)

"Xi12345678" followed by (cr or crlf)
This command will cause the exposure meter to receive the threshold setting for threshold-1.

The number 12345678 represents a string which is the threshold setting which can be any number between 0 and 99999999. A number of 0 will disable the threshold-1 detection. When the count exceeds the threshold value, the exposure meter will send the string "Xi-1" (crlf). It also raises the control line DTR and raises an extra DTR line which goes to CCD computer-1 which remains high until the counter is zeroed.

When this command is issued, the exposure meter responds by returning the string it received.

The default setting is 0, which disables the threshold-1 response.

The threshold detector can be used to terminate the exposure of each camera asynchronously.

"Xj12345678" followed by (cr or crlf)
This command will cause the exposure meter to receive the threshold setting for threshold-2.

The number 12345678 represents a string which is the threshold setting which can be any number between 0 and 99999999. A number of 0 will disable the threshold-2 detection. When the count exceeds the threshold value, the exposure meter will send the string "Xj-2" (crlf). It also raises the control line DTR and raises an extra DTR line which goes to CCD computer-2 which remains high until the counter is zeroed.

When this command is issued, the exposure meter responds by returning the string it received.

The default setting is 0, which disables the threshold-2 response.

The threshold detector can be used to terminate the exposure of each camera asynchronously.

"Xk" followed by (cr or crlf)
This command will cause the exposure meter to send its settings to the PC.

The exposure meter responds with:
"Threshold-1 value 12345678" (crlf) or "Threshold-1 value 0 (disabled)" (crlf).
"Threshold-2 value 12345678" (crlf) or "Threshold-2 value 0 (disabled)" (crlf).

The number 12345678 represents any number between 1 and 99999999.

4.11 Internal & external temperature sensors and pressure sensor

Address character "H"
Commands:
Ha This command will cause the temperature module to send the temperature readings from all sensors (a to g) . The response sent to the PC is "HaXX.X" followed by (crlf) for sensor (a) where X is the temperature in degrees C. This is a fixed length string. This is repeated for all sensors.

Hb This command will cause the internal pressure module to send the pressure readings from the sensor. The response sent to the PC is "HbXXXX.X" followed by (crlf) where X is the pressure in mm Hg. This is a fixed length string.

4.12 Flat field and ThAr lamps

Address character “G”

Commands:

Ga This command will turn on flat field 1. The response sent to the PC is “Ga”.
Gb This command will turn off flat field 1. The response sent to the PC is “Gb”.

Gc This command will turn on the ThAr lamp. The response sent to the PC is “Gc”.
Gd This command will turn off the ThAr lamp. The response sent to the PC is “Gd”.

4.13 Comms link test

The comms link can be tested by sending “T” and (crlf) or (cr).

This is a general address that is recognized by all modules. When each module receives this address it will respond by sending its own module address followed by (crlf).

The modules are all linked with a common handshake line that is used for bus arbitration so that only one module will try to transmit at a time.

5 Electronics cabinet layout

The electronics control system is housed in a 19-inch rack mounted chassis. The exposure meter system occupies one chassis. The temperature sensor and pressure sensor systems occupy one chassis. The motor drives occupy one chassis. The flat field and ThAr lamps and shutter controllers occupy chassis. This makes four chassis in total in one 19-inch rack.

All cables in and out of the chassis are plugged and socketed. All mains input sockets are filtered. All mains power is derived from a UPS.

6 Total power consumption for HRS electronics systems

Equipment	Power consumption (Watts)
HRS control computer	460
Red CCD computer	460
Blue CCD computer	460
Photo multiplier cooler	270
HV power supply	20
Red CCD controller	150
Blue CCD controller	150
Red CCD cooler	500
Blue CCD cooler	500
Photon counter	5
Photon amplifier	1
Slit viewing camera	2.5
Fast shutter 1	2.5
Fast shutter 2	2.5
Flat field lamp	150
Circuit board chassis (total)	5
Stepper motors (average power)	2
ThAr lamp supply	15
Total power consumption =	**3156.5**

7 Other

As currently designed the photomultiplier cooler requires a cold water supply of 3 litres per minute at 20 ºC. A closed cycle system refrigerator system should be investigated.