Title: Instrument Adapter Subsystem Interface for the WIYN 3.5 Meter Telescope

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Instrument Adapter Subsystem Interface

1. Scope

This document specifies the electrical interface and communications protocol to the Instrument Adapter Subsystem (IAS) Controller, cameras, and the Control System host computer.

2. Configuration

2.1 General

The IAS provides functions (acquisition, guiding, etc.) required for observing on the WIYN port of the WIYN telescope. The IAS consists of an instrument mounting box with calibration sources, control electronics (hereafter referred to as the Controller), and cameras with separate controllers.

The instrument mounting box mounts on the WIYN port Nasmyth Instrument Rotator (NIR) and provides a rigid mounting surface for Science Instruments. The Controller controls the following components:

a. Dark slide for blocking light coming into the IAS.
b. Two Atmospheric dispersion compensator/corrector (ADC) rotating stages.
c. Slide for moving the ADC in and out of the beam.
d. Spectral calibration sources.
e. Two calibration filter wheels.
f. Integrating CCD camera on x-z stages for active optics.
g. Slide for moving the calibration source and integrating camera mirrors into the beam.
h. Two ICCD guide cameras on x-y-z stages.
i. Two filter wheels in front of each guide camera.

The host computer sends commands to the Controller by a serial link. The Controller sends telemetry to the host.

The integrating CCD camera has its own controller that mounts outside the IAS box. The camera controller provides power, shutter timing, integration control and the clocking signals for the CCD. The Image Processing computer is connected to the camera controller with a serial link.

The intensified CCD cameras output standard RS170 that goes directly to the image processing electronics off the IAS. Camera gain is controlled by an analog voltage provided by a remote power supply and potentiometer, operated from the observatory control room.

Power supplies for the Controller are located outside the IAS.

2.2 Address Map and Initial States

Axis Description	Hex Address	Initial States
Dark slide:	00h	In.
ADC slide:	01h	Not moved.
ADC rotate A:	02h	Not moved.
ADC rotate B:	03h	Not moved.
Feed mirror slide:	04h	Out.
Guide x stage:	05h	Home/Index.
Guide y stage:	06h	Home/Index.
Guide z stage:	07h	Not moved.
Guide ND changer:	08h	Closed position.
Guide color changer:	09h	Not moved.
Focus x stage:	0ah	Home/Index.
Focus y stage:	0bh	Home/Index.
Focus z stage:	0ch	Not moved.
Focus ND changer:	0dh	Closed position.
Focus color changer:	0ch	Not moved.
Focus probe pupil splitter slide:	0fh	Out.
Calibration ND changer:	10h	Closed position.
Calibration color changer:	11h	Not moved.
Calibration lamps:		Off.
Integrating camera x stage:	12h	Home/Index
Integrating camera z stage:	13h	Not moved.

3. Controller Interface

The command structure will follow the conventions adopted by UWCG. It provides for high level commands implemented in the host system, using the primitive commands provided by the Controller. The primitive commands will be available to the user for troubleshooting and special operations.

The Controller will accept position, velocity, and acceleration in units of motor steps. The conversion from position on the sky (RA, dec, paralactic angle) to Controller coordinates will be done by the host system. In addition, the host will apply corrections for field distortion and misalignments of the IAS stages.

The Controller will acknowledge all commands immediately, following with requested telemetry when acquired.

3.1 Serial Interface

The serial interface voltage levels used for communication between the control system and the IAS Controller follow the EIA standard RS422 with twisted pairs dedicated to transmission and reception.

3.2 Communications Protocol

A serial communications protocol has been designed as the WIYN standard for the OCS and IAS systems using EIA standard RS422 signal levels. It is designed to be simple and robust following designs used at NOAO and UW. The format is:

Byte	#Function
1&2	Starting field (3232).
3	Address.
4	Command.
5	Data Field Length, 0-255 bytes (not including CRC or stop byte).
6 to n	Data.
n+1	CRC Most Significant Byte(CRC16 for the divisor).
n+2	CRC Least Significant Byte.
n+3	End of Message (03).

The address byte specifies the Controller address (10h) for commands and the host address for telemetry. The host address is passed to the Controller with the SET HOST ADDRESS command and must be done during initialization. Multi-byte parameters are sent low byte first.

The CRC 16 error checking is chosen to be the same as SDLC format. It is the CCITT-CRC polynomial X16 + X12 + X5 + 1.

3.3 Setup and Configuration Commands

3.3.1 RESET

Initiate a system reset which includes the following actions.

Stop all motion immediately.
Turn off calibration lamps.
Reset all motion parameters to default values.
Clear and enable interrupts.

Opcode: 30h
Data field length:0

3.3.2 INITIALIZE

Initialize the STD bus system includes the following actions. Send ACKNOWLEDGE when done.

RESET.
Initialize hardware.
Initialize interrupts.
Load interrupt mask.
Load modes.
Send all axes home.
Command buffer is cleared and initialized.

Opcode: 31h
Data field length:0

3.3.3 RESET AXIS

Reset the specified axis Controller, clear any axis interrupts, set all previously programmed parameters and settings to their default values, and reset digital outputs.
Opcode: 32h
Data field length: 1 byte
Data byte 1: Address.

3.3.4 SET CURRENT POSITION

Set the absolute position counter to the specified position count.
Opcode: 33h
Data field length: 5 bytes
Data byte 1: Address.
Data byte 2-5: Position in steps.

3.4 Status Commands

3.4.1 SEND CONTROLLER STATUS

Send Controller Status to the host.
Opcode: 40h
Data field length: 0

3.4.2 SEND AXIS STATUS

Send Axis Status to the host.
Opcode: 41h
Data field length: 1 byte
Data byte 1: Address.

3.4.3 SEND CURRENT POSITION AND VELOCITY

Send Current Position and Velocity of the specified axis to the host.
Opcode: 42h
Data field length: 1 byte
Data byte 1: Address.

3.4.4 SEND INDEX POSITION

Send the last captured Index Position of the specified axis to the host.
Opcode: 43h
Data field length: 1 byte
Data byte 1: Address.

3.5 Motor Control Commands

3.5.1 START AXIS MOTION

Initiate a move of the specified axis. The start function is also used to modify the target position during a move. Send ACKNOWLEDGE when done.
Opcode: 50h
Data field length: 1 byte
Data byte 1: Address.

3.5.2 CONTROLLED STOP

Decelerate the specified axis to a controlled stop. Send ACKNOWLEDGE when done.
Opcode: 51h
Data field length: 1 byte
Data byte 1: Address.

3.5.3 IMMEDIATE STOP

Force the motor to zero velocity causing an immediate stop for the specified axis. WARNING: Position count could be lost.
Opcode: 52h
Data field length: 1 byte
Data byte 1: Address.

3.5.4 STANDBY

Enable automatic reduction of motor current on stop.
Opcode: 53h
Data field length: 2 byte
Data byte 1: Address.
Data byte 2: 1=enable, 0=disable.

3.5.5 SEEK HOME

Move to home position. Position counter is not reset on completion. Send ACKNOWLEDGE when done.
Opcode: 54h
Data field length: 1 byte
Data byte 1: Address.

3.6 Profile Setup Commands

3.6.1 SET ACCELERATION

Set the acceleration rate in steps per second^2 for the specified stage. This command can be used to modify the profile on the fly while motion is in progress.
Opcode: 60h
Data field length: 5 bytes
Data byte 1: Address.
Data byte 2-5: 4 byte acceleration in steps/sec.

3.6.2 SET DECELERATION

Set the deceleration rate in steps per second^2 for the specified stage. This command can be used to modify the profile on the fly while motion is in progress.
Opcode: 61h
Data field length: 5 bytes
Data byte 1: Address.
Data byte 2-5: 4 byte deceleration in steps/sec.

3.6.3 SET TARGET POSITION

Set the target absolute position for the specified stage. This command can be used to modify the profile on the fly. Start command 50h is required to initiate a move or activate a new position.
Opcode: 62h
Data field length: 5 bytes
Data byte 1: Address.
Data byte 2-5: 4 byte position in steps from home.

3.6.4 SET OFFSET

Take the target position and add the 32 bit signed offset to obtain the new target position for the specified stage. This command can be used to modify the profile on the fly. Start command 50h is required to initiate a move or activate a new position.
Opcode: 63h
Data field length: 5 bytes
Data byte 1: Address.
Data bytes 2-5: 4 byte position offset in steps.

3.6.5 SET MAXIMUM VELOCITY

Set the target move velocity in steps/second for the specified stage. This command can be used to modify the profile on the fly while motion is in progress.
Opcode: 64h
Data field length: 5 bytes
Data byte 1: Address.
Data byte 2-5: 4 byte maximum velocity in steps/sec.

3.6.6 SET MINIMUM VELOCITY

Set the minimum velocity in steps/second for the specified stage. This command is intended primarily for full or half step motors which may require a minimum starting velocity.
Opcode: 65h
Data field length: 5 bytes
Data byte 1: Address.
Data byte 2-5: 4 byte minimum velocity in steps/sec.

3.7 Filter Control Commands

3.7.1 MOVE FILTER

Move the specified filter changer to the requested filter position. Send ACKNOWLEDGE when done.
Opcode: 70h
Data field length: 2 bytes
Data byte 1: Filter changer Address.
Data byte 2: Filter position.

3.7.2 SEND FILTER POSITION

Send the position of the specified filter to the host.
Opcode: 71h
Data field length: 1 byte
Data byte 1: Filter changer Address.

3.8 Atmospheric Dispersion Compensator/Corrector Control Commands

3.8.1 ROTATE LENS

Rotate the specified lens to the requested absolute position from home. Send ACKNOWLEDGE when done.
Opcode: 80h
Data field length: 5 bytes
Data byte 1: Lens Address.
Data byte 2-5: Absolute position in steps from home (signed 32 bit integer).

3.8.2 OFFSET LENS

Offset the specified lens from the current position. Send ACKNOWLEDGE when done.
Opcode: 81h
Data field length: 5 bytes
Data byte 1: Lens Address.
Data byte 2-5: Relative distance in steps from current position (signed 32 bit integer).

3.8.3 SEND LENS POSITION

Send the position of the specified lens to the host.
Opcode: 82h
Data field length: 1 byte
Data byte 1: Lens Address.

3.9 Slide Control Commands

3.9.1 MOVE SLIDE

Move the specified slide in or out of the beam. Send ACKNOWLEDGE when done.
Opcode: 90h
Data field length: 2 bytes
Data byte 1: Slide Address.
Data byte 2: Slide in/out of beam. (1=in, 0=out)

3.9.2 SEND SLIDE STATUS

Send the status of the specified slide to the host.
Opcode: 91h
Data field length: 1 bytes
Data byte 1: Slide Address.

3.10 Calibration Commands

3.10.1 SET CALIBRATION LAMP

Turn calibration lamps on/off. (1=on, 0=off)
Opcode: a0h
Data field length: 2 bytes
Data byte 1: Address.
Data byte 2: Lamps on or off bit field:
Bit 0-7: Lamp 1-8.

3.10.2 SEND CALIBRATION LAMP STATUS

Send the states of the calibration lamps to the host.
Opcode: a1h
Data field length:0

3.11 Special Commands

3.11.1 SET HOST ADDRESS

Set address of host enabling communication from the Controller. This command must be issued before the Controller can send telemetry to the host.
Opcode: b0h
Data field length:4 bytes
Data byte 1-4: Host address.

3.11.2 SEND VOLTAGE

Send the voltage of the specified A/D channel.
Opcode: b1h
Data field length: 1 byte
Data byte 1: A/D multiplexer channel address.

3.12 Telemetry

The general format for the ACKNOWLEDGE response is:
Opcode: Echos issued command.
Data field length:3 or 4 bytes for commands without telemetry, 3+n or 4+n for commands with telemetry.
Data byte 1: ACK Bitfield defined by UWCG is reproduced here. (1=true, 0= not true)
Bit 0-4 Not used.
Bit 5 Error detected.
Bit 6 Command complete.
Bit 7 New command.
Data byte 2: Error code. Least significant byte.
Data byte 3: Error code. Most significant byte.
Data byte 4: For Multi-axis commands, byte 4 is the axis address.
Data byte 4: For telemetry, data is returned in bytes 4-n as defined in the following sections.

3.12.1 Controller Status.

Content: Controller status. (1=true, 0= not true)
Opcode: 40h
Data field length:9 bytes
Data byte 1: ACK Bitfield.
Data byte 2-3: Error code.
Data byte 4-5:
Bit 0-15 Axis 0-15 Axis ready.
Data byte 6-7:
Bit 0-15 Axis 0-15 Axis Look-At-Me.
Data byte 8-9:
Bit 0 Dark slide inserted.
Bit 1 ADC slide inserted.
Bit 2 Calibration slide inserted.
Bit 3 Focus pupil slide inserted.
Bit 4 All calibration lamps off.

Bit 5 Task overflow.
Bit 6 Not used.
Bit 7 Not used.
Bit 8 +5 VDC ok.
Bit 9 +12 VDC ok.
Bit 10 -12 VDC ok.
Bit 11 +24 VDC ok.
Bit 12-15 Not used.

Look-At-Me bits flag the host that a condition was detected that requires control system attention.

3.12.2 Axis Status.

Content: Axis status.
Opcode: 41h
Data field length: 6 bytes
Data byte 1: ACK Bitfield.
Data byte 2-3: Error code.
Data byte 4: Address.
Data byte 5-6:

Bit 0 On position; set while programmed position is equal to current position.
Bit 1 On velocity; set while programmed velocity is equal to current velocity.
Bit 2 Acceleration in progress; set while motor is accelerating.
Bit 3 Deceleration in progress; set while motor is decelerating.
Bit 4 In motion; set while motor is moving.
Bit 5-6 Not used.
Bit 7 External input 1; level of limit switch 1 status.
Bit 8 External input 2; level of limit switch 2 status.
Bit 9 External input 3; level of home limit switch 3 status.
Bit 10 Disable line; level of disable input.
Bit 11 Direction out; level of direction output.
Bit 12 Step out; level of step output.
Bit 13 Encoder index; level of encoder index or Z input.
Bit 14 Encoder direction in; level of encode direction on closed loop, same as direction out on open loop.
Bit 15 Encoder step in; level of encoder step pulse on closed loop, invalid on open loop.

3.12.3 Current Position and Velocity.

Content: Current position and velocity of the specified stage.
Opcode: 42h
Data field length: 12 bytes
Data byte 1: ACK Bitfield.
Data byte 2-3: Error code.
Data byte 4: Address.
Data byte 5-8: Current position in steps from home.
Data byte 9-12: Current velocity in steps/second.

3.12.4 Index Position.

Content: Last position captured when the index occurred from the specified stage.
Opcode: 43h
Data field length: 8 bytes
Data byte 1: ACK Bitfield.
Data byte 2-3: Error code.
Data byte 4: Address.
Data byte 5-8: Last captured index position.

3.12.5 Filter Position.

Content: Position of the specified filter.
Opcode: 71h
Data field length: 5 bytes
Data byte 1: ACK Bitfield.
Data byte 2-3: Error code.
Data byte 4: Filter changer number.
Data byte 5: Filter position.

3.12.6 Lens Position.

Content: Position of the specified ADC lens.
Opcode: 82h
Data field length: 8 bytes
Data byte 1: ACK Bitfield.
Data byte 2-3: Error code.
Data byte 4: Lens Address.
Data byte 5-8: Lens position in steps from home.

3.12.7 Slide Status.

Content: Status of the specified slide.
Opcode: 91h
Data field length: 5 bytes
Data byte 1: ACK Bitfield.
Data byte 2-3: Error code.
Data byte 4: Slide Address.
Data byte 5:
Bit 0 Out.
Bit 1 In.
Bit 2 Moving.
Bit 3 Direction.
Bit 4 Undetermined.
Bit 5-7 Not used.

3.12.8 Calibration Lamp Status.

Content: Calibration lamps state. (1=on, 0=off)
Opcode: a1h
Data field length: 4 bytes
Data byte 1: ACK Bitfield.
Data byte 2-3: Error code.
Data byte 4:
Bit 0-7 Lamp 1-8.

3.12.9 A/D Voltage.

Content: Digitized value of the specified channel input to 12 bits.
Opcode: b1h
Data field length: 6 bytes
Data byte 1: ACK Bitfield.
Data byte 2-3: Error code.
Data byte 4: Channel number.
Data byte 5-6:
Bits 0-11 12 bit data.
Bit 12-15 Not used.

3.13 Power and Utilities

The cameras are powered by their respective controllers. The integrating camera requires active cooling by water. The camera cooler produces TBD watts. The intensified cameras produce TBD watts.

Power for the Controller will be supplied by power supplies located under the skirt. Voltages and power requirements are located below.

Electronic Card Cage	+5 VDC	25 watts.
	+12 VDC	10 watts.
	-12 VDC	0.2 watts.
Stepper Motor Driver	+5 VDC	4 watts.
	+24 VDC	0.1 to 2.0 Amp/phase.
DC Motor Drive	+5 VDC	2 watts.
	+24 VDC	0 to 2.5 Amp/phase.

Utilities include air pulled thru the mounting box, removing heat. The integrating camera requires cooling water at TBD·GPM.

4. Guide Cameras

4.1 Video Signal

The video signal from the guide and focus cameras will be EIA standard RS170. The video signal will be routed to an input video multiplexer which routes the video signal to monitors or the image processor.

4.2 Camera Control

Camera control is TBD.
A remote control box in the control room provides camera power and control for intensifier gain.

4.3 Power Requirements

Power requirements are TBD.

5. Wavefront Sensor Camera

5.1 Digital Interface

TBD.

5.2 Commands and Data

TBD.

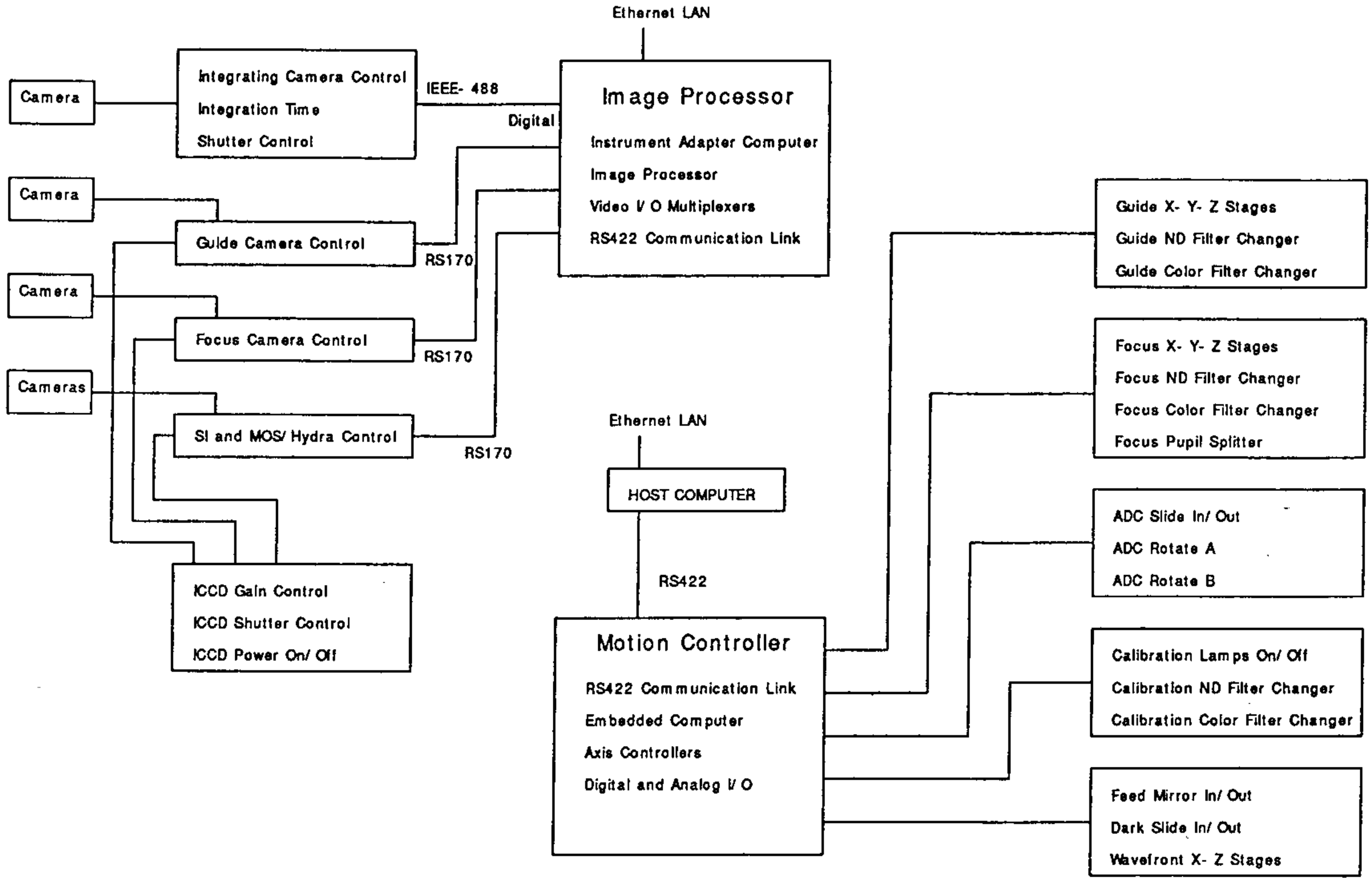
5.3 Power Requirements

TBD.

Appendix A

Command opcodes

Command	Opcode
RESET	30h
INITIALIZE	31h
RESET AXIS	32h
SET CURRENT POSITION	33h
SEND CONTROLLER STATUS	40h
SEND AXIS STATUS	41h
SEND CURRENT POSITION AND VELOCITY	42h
SEND INDEX POSITION	43h
START AXIS MOTION	50h
CONTROLLED STOP	51h
IMMEDIATE STOP	52h
STANDBY	53h
SEEK HOME	54h
SET ACCELERATION	60h
SET DECELERATION	61h
SET TARGET POSITION	62h
SET OFFSET	63h
SET MAXIMUM VELOCITY	64h
SET MINIMUM VELOCITY	65h
MOVE FILTER	70h
SEND FILTER POSITION	71h
ROTATE LENS	80h
OFFSET LENS	81h
SEND LENS POSITION	82h
MOVE SLIDE	90h
SEND SLIDE STATUS	91h
SET CALIBRATION LAMP	a0h
SEND CALIBRATION LAMP STATUS	a1h
SET HOST ADDRESS	b0h
SEND VOLTAGE	b1h



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