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IMACS MOTION CONTROL SYSTEM MCS MANUAL

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IMACS PC 3

The MCS PC uses a 15-slot ISA back plane along with a Single Board Computer SBC, four Mycom motor Indexer cards and five ComputerBoards digital IO cards. A 16MB silicon disk is used for storage of the auto booting DOS control program. A floppy disk drive is installed but not connected. A hard disk containing all software and development programs is installed but not connected, an inbuilt backup of the system. The contents of the hard disk and the silicon disk, a subset of the hard disk, is also contained in the CD packed with the IMACS MCS 11x17 documentation binder.

The Mycom PPC2410 ISA card is a four axis motor controller with encoder feedback and various IO lines. No interrupts are used, and clock signals are of the "two-clock" variety – one pulse train for clockwise motion and another pulse train for counter-clockwise motion.

DESIGN PHILOSOPHY

BRAKES

All motors with brakes utilize a fail-safe design that requires the brake coil to be energized before the motor can be moved. The computer has to command the brake release and no hard stop may be active before the motor will move.

FAILSAFE HARDSTOP LOGIC

In addition to failsafe brakes, fail-safe circuitry is provided to remove computer control of an individual motion stage if a hard stop limit has been activated. In order to restore normal operation, a technician must go out and remove the fault condition and then reset the hard stop logic. For each motion stage two functions pass through the hard stop logic.

1. The current cutoff to the motor driver and
2. Energization of the brake.

In the event of a hard stop trigger the Altera logic will immediately turn off the associated motor driver current and remove current flow from the brake release coil. To be able to move the stage off the hard stop, the associated hard stop bypass switch must be placed into the up position and will allow the computer to back out of the hard stop. When the fault condition is removed, the bypass switch may be reset and normal operation may once again take place.

COMPONENTS

Off the shelf components used in the MCS are the same as used in the C40, C100, CM1 and CM2

- Opto22 Input Output modules
- Mycom drivers UPS50 and INS50 star connection bi-polar constant current chopper.
- Mycom indexer cards
- Mycom 5phase stepper motors, 0.72 degrees step, 500 pulses rev.
- ComputerBoards Digital IO ISA cards, 48 lines.

HEAT DISSIPATION

A Rittal model SK3218.100 air-water heat exchanger is used to remove the heat generated by the MCS electronics to the telescope cooling fluid. The telescope provides 5 gal/min , 300 gal/hour flow of an ethylene glycol mixture at 2 to 3 degrees C above ambient temperature. The unit is rated at 3500W of cooling at 100 gal/hour; the approximate heat generation of the electronics is 750W, so there is a comfortable margin of heat removal capacity. The air water heat exchanger requires no maintenance. The fan of the air circuit is designed to run continuously. The thermostat for the solenoid valve has been disconnected and the solenoid valve is wired to be on continuously. Because the fluid temperature will never be below ambient temperature, condensation ought not to be a problem.

CHASSIS LED INDICATORS

All rack-mounted chassis are provided with a switch to turn off all LED indicators.

INDICATORS OF CORRECT OPERATION

Most if not all of the motor drivers have an LED that flicker when commands to move are given. The Mycom UPS50 drivers have an LED facing the back of each chassis, which are covered with aluminum tape.

The Renishaw encoders LED will glow green when the read head is a proper distance from and focused on the read tape. When the read head passes the home position, the LED will pulse red. These LEDs are also covered to prevent light pollution and will need to be uncovered in order to precisely reposition soft stops. A less accurate alternative is to take a laptop up to the platform and observe the appropriate GUI to see when a soft stop has been triggered.

Soft stops may be tested by running into the stop and checking the appropriate indicator in the user interface GUI. Manually activating the hard stop and observing the LED indicators on the appropriate chassis may test hard stops. As long as the hard stop LED is on, a fault condition remains.

Disconnected or inappropriately connected cables may be detected by observing two or more soft stops and hardtops on at the same time at the user interface GUI.

L05 focus motors are best tested by putting an ear near the collimator inside the instrument and listening to each motor move. Otherwise you will have to rely upon the encoder counts observed in the user interface GUI.

The science camera dewar focus mechanism has a shaft that can be seen turning at the back of the camera. As well, the GUI can be observed for proper encoder counts.

Most digital input or output signal or command status may be observed by looking at the LED indicators on the Opto22 units inside chassis 1 through 4. Some of these signals go straight to the motor indexer cards and may be probed at the high density 80 pin to Phoenix contact breakout boards located in the inside front of each chassis.

Heat exchanger operation may be confirmed by observing the internal rack temperature as monitored by the data acquisition unit, as well as by fan noise.

PROTOCOLS and CONVENTIONS

The long camera subsystems are designated as 1 because they were designed and built first. Example: Filter Server 1, DSP1 TRIG. DSP1 TRIG refers to the Long Camera begin integration signal provided by the Long Science Camera saddlebag DSP board to initiate the opening and closing of the Long Camera shutter.

The short camera subsystems are designated as 2, example: Filter Server 2, DSP2 TRIG.

Except for the science camera dewar focus motor drivers, all motor drivers run in "two-clock""bi-clock" mode where a separate pulse waveform is required to move CW and to move CCW.

Brakes are run in fail-safe mode, where a current must be supplied before the brake will turn off.

Hard stops are operated in fail-safe mode, where a disconnect anywhere in-line will trigger the hard stop.

SAFETY

The AC power input to the system first enters a rack mounted TriPLite noise and surge suppressor. Each chassis has three metal oxide varistors MOV that protect hot to chassis ground, neutral to chassis ground and hot to neutral. Note that their failure mode is a dead short. Circuit breakers and-or fuses are incorporated into each chassis.

Lamp 6 has a fuse located on the digital phase control board located in the back of chassis 3.

Appropriate Opto22 modules are fused and accessed through the top of the module.

Each solenoid in the instrument has a back EMF diode installed. Three switched inductors in the MCS have back EMF diode protection.

The power supply chassis has a ground fault circuit breaker mounted inside. It tripped whenever a chassis 3 disperser grating tilt cable was plugged in so was bypassed. It is not known if this fault has been removed.

AC power is sent through the Lamps Fans wrap cable to the black ABS box. This AC power is controlled by a heavy duty milspec switch on the front panel of Chassis 3 and is used to turn off power to the black ABS box when switching the high voltage piezo control lines plugged into the PI chassis contained within the black ABS box. **Turn this switch off when you work inside the black ABS box if you want to avoid receiving an electrical shock! The air pressurization and air circulation fans are also powered by 117VAC.**

IMACS Chassis I

Chassis 1 controls Filter Server 1 and Filter Server 2, as well as the Mask Server and the Center Field Guide Camera.

IMACS DIO MR1A

IMACS Filter 1 Driver

- IMACS Filter 1 Motion
- Filter Server 1 uses
 - 1 Mycom UPS50 5 phase stepper motor driver
 - 1 Mycom PS596AM motor with a brake
 - 1 Renishaw RGH22 encoder
 - 2 soft limit switches
 - 1 near switch
 - 2 hard limit switches
 - 2 air cylinder retract limit switches
 - 2 air cylinder extend limit switches
 - 1 air solenoid
 - 2 air cylinders

IMACS DIO MR1B

Digital IO Rack MR1B uses

- 5 SNAP IDC5 Opto22 input modules
- 1 SNAP ODC5SRC Opto22 source output module

IMACS Mask Driver

IMACS Mask Motion

The Slit Mask Server uses

- 1 Mycom UPS50 5 phase stepper motor driver
- 1 Mycom PS596AM motor with a brake
- 1 Dynamic Research Corp DRC LB4A 0320 EL L03XXB0 encoder
- 2 soft limit switches
- 1 near switch
- 2 hard limit switches
- 2 air cylinder retract limit switches
- 2 air cylinder extend limit switches
- 2 air solenoids
- 2 air cylinders
- 1 mask installed sensor Turck Bi2 K11 AN6 inductive
- 8 mask position open sensors Turck Bi2 K11 AN6 inductive

IMACS Filter 2 Driver

IMACS Filter 2 Motion

Filter Server 2 uses

- 1 Mycom UPS50 5 phase stepper motor driver
- 1 Mycom PS596AM motor with a brake
- 1 Renishaw RGH22 encoder
- 2 soft limit switches
- 1 near switch
- 2 hard limit switches
- 2 air cylinder retract limit switches
- 2 air cylinder extend limit switches
- 1 air solenoid

4

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7

8

9

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12

2 air cylinders	
IMACS CFGC Driver	13
IMACS CFG Camera Rev. A	14
The Center Field Guider uses	
1 Mycom UPS50 5 phase stepper motor driver	
1 Mycom PS569AM motor with a brake	
2 soft limit switches	
1 near switch	
2 hard limit switches	
2 filter and lens shuttle retract limit switches	
2 filter and lens shuttle extend limit switches	
2 air solenoids	
2 air cylinders	
IMACS DIO MRIC	15
Digital IO Rack MR1C uses	
1 SNAP IDC5 Opto22 input module	
1 SNAP ODC5R Opto22 relay output module	
IMACS CHASSIS 1 ALTERA Logic Board	16
Protected subsystems are	
Filter Server 1	
Filter Server 2	
Mask Server	
Center Field Guider Camera no brake function not used	
IMACS Power Supply Chassis	17
One power supply chassis supplies 24VDC, 5VDC and 117VAC power to all 4 motion control system chassis. The capability exists to isolate the 5VDC supply from the 24VDC and 117VAC supplies if additional noise filtering is needed. Chassis 2 also includes a separate 5.6VDC supply to operate the guide camera encoders and chassis 4 includes a 48VDC supply for the science camera focus motor.	
The big red mushroom emergency off button turns off the 117VAC and 24VDC power only. The 5VDC is left on so that all the digital logic states do not get reinitialized	
IMACS Long Camera Power Supply Chassis	18
Contains 2 48VDC center tapped supplies. One switch is used to switch AC on and must be switched on first; the second switch is to transfer the DC across once the supply has stabilized.	
IMACS Short Camera Power Supply Chassis	19
Contains 2 48VDC center tapped supplies. One switch is used to switch AC on and must be switched on first; the second switch is to transfer the DC across once the supply has stabilized.	
IMACS Guider Cameras Power Supply Chassis	20
Contains 2 48VDC center tapped supplies, one of which is an installed spare. There is no need to sequence the turn on of this supply.	
IMACS Guider & Science Camera Power Cables	21
IMACS PI Motor Driver Power Supply Chassis	22
IMACS Chassis 2	23
Chassis 2 controls the Shack Hartmann theta and radial guide cameras as well as the Principal Guide Camera. The Shack Hartmann radial Renishaw encoder power is controlled by an OPTO22 relay contact module under computer control. An inductor is wired in series to the supply line to eliminate glitch-causing noise spikes caused by current surge through the relay contacts at initial turn on. The power to the encoder is turned off in between moves to eliminate light leakage from the LED indicator and read head, which is quite a light polluter during CCD integration time. The power supply for the SH radial and theta encoders and the Principal Guider encoder is set at 5.6VDC in chassis 2, to compensate for the line loss in the cable wrap.	
IMACS DIO MR2A	24
Digital IO Rack MR1B uses	
3 SNAP IDC5 Opto22 input modules	
1 SNAP ODC5SNK Opto22 sink output module	
2 SNAP ODC5SRC Opto22 source output modules	
IMACS DIO MR2B	25
Digital IO Rack MR2B uses	
1 SNAP ODC5R Opto22 relay output module	
IMACS SHGC Drivers	26
IMACS SHG Camera	27
The Shack Hartmann Guider uses	
1 Mycom UPS50 131 5 phase stepper motor driver theta	
1 Mycom UPS50 030 5 phase stepper motor driver radial	
1 Mycom PS569ACM motor with a brake theta	
1 Mycom PS566AM motor with a brake radial	
2 Renishaw RGH 24D encoders	
4 soft limit switches	
2 near switches	
2 hard limit switches theta only	
2 filter and lens shuttle retract limit switches	
2 filter and lens shuttle extend limit switches	
2 air solenoids	
IMACS PGC Driver	28
IMACS PG Camera	29
The Principle Guide Camera uses	

1 Mycom UPS50 5 phase stepper motor driver	
1 Mycom PS569AM motor with a brake	
1 Renishaw RGH 24D encoder	
2 soft limit switches	
1 near switch	
2 hard limit switches	
1 retract limit switch	
1 extend limit switch	
1 air solenoid	
IMACS CHASSIS 2 ALTERA Logic Board	30
Protected subsystems are	
Principal Guide Camera	
Shack Hartmann Theta Camera	
Shack Hartmann Radial Guide Camera is not protected.	
IMACS Chassis 3	31
Chassis 3 controls the disperser carousel wheel motion and the tilt for three grating tilt stages. Control of the calibration lamps, lamp 6 intensity level, hatch control and AC power to the black ABS box is also located in Chassis 3.	
IMACS DIO MR3A	32
Digital IO Rack MR3A uses	
2 SNAP OAC5 Opto22 AC Output modules	
1 SNAP ODC5R Opto22 relay output module	
1 SNAP ODC5SRC Opto22 source output module	
2 SNAP IDC5 Opto22 input modules	
IMACS DIO MR3B	33
Digital IO Rack MR3B uses	
4 SNAP IDC5 Opto22 input modules	
1 SNAP ODC5SNK Opto22 sink output module	
1 SNAP ODC5SRC Opto22 source output module	
IMACS Lamps/Fans	34
The high level GUI computer switches on and off 5 rare gas calibration lamps. Two different models of power supply are used for the lamps, as shown in the schematic.	
AC power is also sent through the Lamps Fans wrap cable to the black ABS box. This AC power is controlled by a heavy duty milspec switch on the front panel of Chassis 3 and is used to turn off power to the black ABS box when switching the high voltage piezo control lines plugged into the PI chassis contained within the black ABS box. Turn this switch off when you work inside the black ABS box if you want to avoid receiving an electrical shock!	
IMACS Lamp6 Digital Phase Control	35
The discrete illumination levels of the Lamp6 halogen bulb is created by splitting each quadrant of the applied 117VAC into 16 time intervals, starting the count on the zero crossing of the AC waveform and shutting off current flow at the end of the count loaded by the GUI computer.	
IMACS DT Drivers	36
IMACS DT	37
The Disperser Grating Tilt mechanisms use	
3 Mycom INS50 110 Hi Resolution 5 phase stepper motor drivers	
3 Mycom PF566AM hi resolution stepper motors with no brake	
3 Renishaw RGB25Y00R00 0.1 micron encoders	
6 soft limit SUNX GXL H12F proximity switches	
3 near SUNX GXL H12F proximity switches	
6 hard limit switches Honeywell 311SM5 T	
The INS50 driver is set to divide the 0.72 degree basic step by 25, so there are 125,000 steps per revolution. Two-clock (CW , CCW) input pulses are used. An OPTO22 relay contact module under computer control controls the disperser grating tilt mechanisms Renishaw encoder power. The power to the three encoders is turned off in between moves to eliminate light leakage from the LED indicator and read head. An inductor is wired in series to the supply line to eliminate glitch-causing noise spikes caused by current surge through the relay contacts at initial turn on.	
IMACS DC Driver	38
IMACS DC	39
The Disperser Carousel uses	
1 Mycom UPS50 5 phase stepper motor driver	
1 Mycom PS596 AM motor with a brake	
1 Renishaw RGH 24D 5 micron encoder	
2 soft limit switches	
2 brake extend retract limit switches OSIN 014	
1 near switch	
2 hard limit switches Honeywell 311SM5 T	
4 retract limit switch Bimba MSK X NPN Sink Normally Open	
4 extend limit switch Bimba MSK X NPN Sink Normally Open	
2 air solenoids Disperser clamp actuator and Disperser carousel clamp brake	
24 DSS load switches Honeywell 311SM5 T	
IMACS Hatch	40
The hatch uses one control line to open the hatch and another control line to close the hatch. Limit switches are internal to the hatch.	

IMACS CHASSIS 3 ALTERA Logic Board	41
Protected subsystems are	
Disperser Carousel	
Disperser Grating Tilt A	
Disperser Grating Tilt B	
Disperser Grating Tilt C	
The Disperser Grating Tilt mechanisms originally used motors that had brakes but have since been replaced with high-resolution motors with no brakes. The old brake connections to the Altera hard stop logic were removed and have been left dangling.	
IMACS Chassis 4	42
Chassis 4 contains the drive circuitry and feedback control for the long and short science camera focus stages. A motor driver to rotate the structure during integration and test is also located in Chassis 4. In normal use this driver and connector on the front panel of Chassis 4 will not be used.	
IMACS DIO MR4A	43
Digital IO Rack MR4A uses	
1 SNAP IDC5 Opto22 input module	
IMACS DIO MR4B	44
Digital IO Rack MR4B uses	
No installed modules	
IMACS LDF Driver	45
IMACS LDF	46
The Long Detector Science Camera Focus mechanism uses	
1 Gecko G210 stepper motor driver	
1 Phytron ZSS32 200 1,2 stepper motor with an integral HEDL 5540 encoder	
2 soft limit switches Honeywell 311SM5 T	
2 hard limit switches Honeywell 311SM5 T	
IMACS STRUCTURE Driver	47
IMACS Structure Rotator	48
The structure rotator uses	
1 Mycom PSU50 stepper motor driver	
1 Mycom PF6913BC stepper motor	
After delivery and instrument integration at the Baade telescope this rotator will no longer be used.	
IMACS SDF Driver	49
IMACS SDF	50
The Short Detector Science Camera Focus mechanism uses	
1 Gecko G210 stepper motor driver	
1 Phytron ZSS32 200 1,2 stepper motor with an integral HEDL 5540 encoder	
2 soft limit switches Honeywell 311SM5 T	
2 hard limit switches Honeywell 311SM5 T	
The Phytron motor is a NEMA size 42, 200 steps per revolution, 1.2 amp motor winding with the windings connected in series.	
IMACS CHASSIS 4 ALTERA Logic Board	51
Protected subsystems are	
Long Science Camera Dewar focus mechanism	
Short Science Camera Dewar focus mechanism	
IMACS Shutter Controller	52
The shutter controller uses	
1 four-channel Model E 4000 LINMOT driver	
1 "Jackrabbit BL1810" PC104 single board microprocessor to communicate between the driver and the GUI interface.	
IMACS Shutter	53
IMACS Shutter Trigger Cable	54
Shutter trigger inputs from the science camera CCD DSP trigger saddlebag are optoisolated before entry to the Jackrabbit microprocessor.	
Each of the shutter blade linear motors has the same type keyed connector, so they can be swapped with each other for testing purposes. Note that the timing response of each blade is slightly different from each other.	
IMACS Shutter Test	55
IMACS Data Acquisition Unit A	56
The data acquisition system uses	
1 Agilent Technologies 34970A base unit with included DMM	
3 HP34901A 20 channel MUX input modules	
The unit monitors twenty-two temperatures, air pressure, two coolant pressures and fourteen power supply voltages of the DOS control computer, MCS, and guide and science camera power supplies.	
IMACS RTD Thermal Sensors A	57
Module A measures ten 4 wire RTD temperatures and two current loop pressures	

IMACS RTD Thermal Sensors B	58
Module B measures ten 4 wire RTD temperatures and two current loop pressures. One current loop pressure measurement channel is a spare.	
IMACS Voltages Sensors C	59
Module A measures two 4 wire RTD temperatures, fourteen voltage measurements and two spare current loop pressure channels. There are two spare 2-wire measurement channels available.	
The pressure transducers are rated at 100 psi 4-20 mA with a 1/8 inch NPT fitting. Overpressure rating is 200 psi.	
IMACS Serial Ports	60
Six devices have serial ports in the IMACS MCS. A 16 channel Lantronix TC-IP to RS232 converter is used to provide the interface between the high level GUI control computer and the six serial devices of the IMACS MCS. The six serial devices consist of the MCS DOS control computer, two science camera vacuum gauges, the Agilent Technologies data acquisition unit, the Physik Instrumente flexure controller and the PI L05 focus controller.	
IMACS Serial Ports Simplified	61
RS-422 & Pressure & Transducer Excitation Chassis	62
This chassis contains two separate functions. A 24DC supply is used as an excitation source for the pressure gauges and three RS232 to RS422 converters that are used to communicate with the black ABS box.	
CCD Vacuum Gauges	63
IMACS Black ABS Box Rack	64
The black ABS box is located within the instrument and is provided with it's own heat exchanger and fluid coolant lines. Located within this 19 inch rack mount case are the Physik Instrument PZT controller, used as flexure control, two vacuum gauge display-controllers used to monitor the vacuum in the science dewars, and three variacs used to control the speed of the fans in the black ABS box heat exchanger, air pressurization fan and air circulation fans. Power for the microphone amplifiers are provided within this box as well. The case is lined with high R value thermal insulation. Three differential RS422 lines are used to communicate between the RS-422 & Pressure & Transducer Excitation Chassis and the black ABS box PI controller and two vacuum gauges.	
IMACS L05 Focus Motor Chassis	65
L05 focus is performed by three DC linear motors with feedback control. The controller-drivers are located within their own chassis located in Rack 2.	
IMACS PI Motion Stage Controller	66
The PI Motion Stage Controller is located in the black ABS box inside the instrument and controls the flexure motion of the CCD science camera using high voltage piezo transducers.	
IMACS PI Encoder Repeater	67
Three linear motor driver repeaters plus spares are located in the spare parts for the PI Motion Stage Controller. If any flakiness develops in motor motion or feedback these self-powered units may be inserted inline to reamplify and buffer the signals for two-way transmission over the cable wrap.	
IMACS Audio Monitor Block Diagram	68
A dual channel audio microphone system is included to provide aural confirmation of the operation of IMACS. One microphone pickup is located next to the disperser server on the Main Optical Support Structure (MOSS), the other on the Front Optical Support Structure disk (FOSS disk) The FOSS disk carries the three guide cameras, the slit-mask shuttle and transfer mechanisms. These differential signals are sent down to a pair of amplified speakers in the control room.	
IMACS Microphone Preamp/Driver	69
The Microphone preamp has inputs for both dynamic and condenser microphones. Microphone gain is adjusted via potentiometer R3. The amplified output of the preamp is a differential signal for transmission over long distances with a high common mode rejection ratio.	
IMACS Audio Differential Receiver	70
The differential receiver has two input channels and two single ended outputs. Output gain is adjusted via potentiometers R1 and R2. Any self-powered PC speaker system may be plugged into the standard stereo mini jack.	
IMACS Mic Cable Layout	71
IMACS MYCOM PPC-2410 mods	72
The motor indexer cards had to be modified as shown in this schematic. The four spare indexers have already been modified. Each indexer controls four motors and includes feedback and digital I-O.	
IMACS OPTO 22 I/O Mapping	
Memory mapped addressing is used to control OPTO22 devices within the IMACS MCS.	
Card 1	73
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