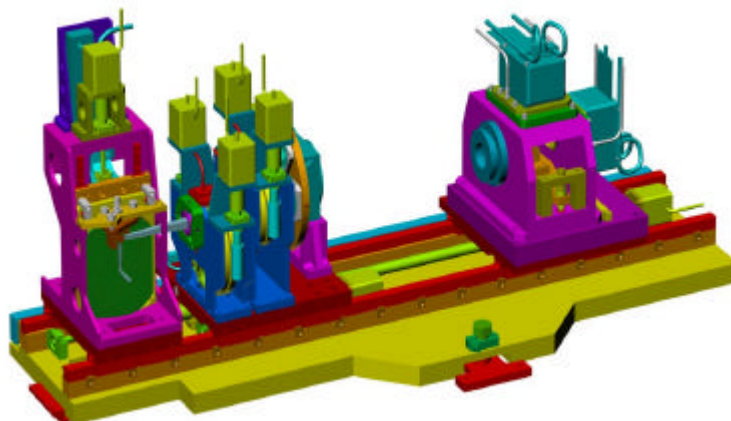


NAOMI Electronic systems Overview

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1: Electronics Rack

The electronics rack houses the power supplies and control for the NAOMI systems. The layout of the rack is illustrated in Fig 1 below and each section will be described.

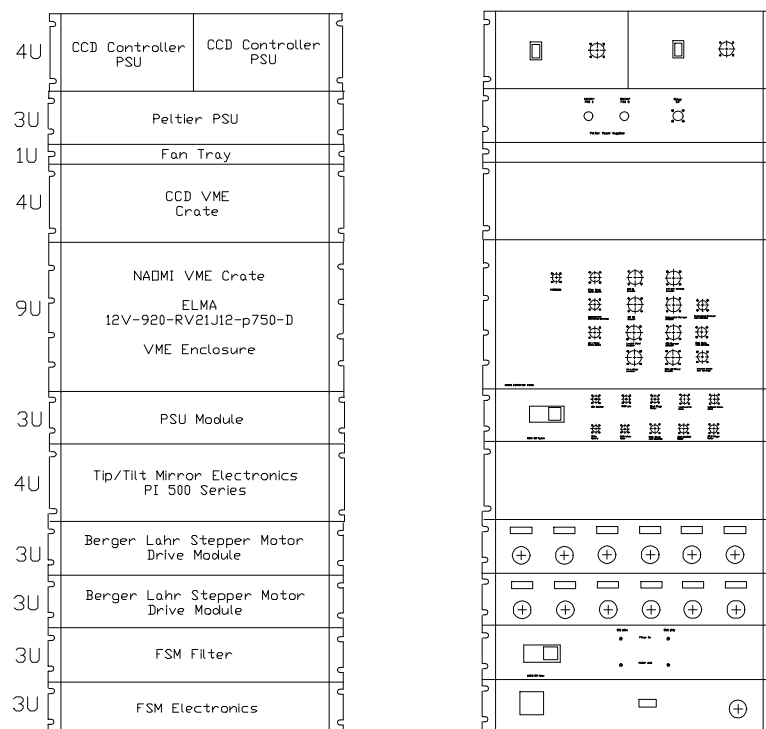


Figure 1 Electronics Rack

1.1: CCD Controller PSU

The CCD Controllers sit on the Optical Bench next to the WFS. The power for the controllers is supplied from two units that sit beside each other on a tray in the electronics rack. The connections from the supplies go directly from each of these units, out the back of the rack and to the associated controller, one for each CCD.

1.2: Peltier PSU : 16-07e4.sch

The Peltier PSU rack provides power to the peltier devices that are attached to the CCD heads. Cooling flows round the heads and controllers. To prevent the power being switched on whilst there is no cooling the power supplies are interlocked with the compressor. A flow meter is attached in line with the cooling lines and provides a signal when there is a flow, where the frequency of the signal is proportional to the flow rate.

The peltier psu rack contains three power supplies, two 12V, one 5v, a solid state relay (SSR), the interlock circuitry and load resistors. When the unit is switched on the 12v supplies, which provide power to the peltiers via the CCD controllers will only be powered up via the SSR if there is coolant flow. The 5v power supply provides the power for the circuitry and the flow meter. The output of the flow meter, which is a square wave, is fed to the interlock circuitry, if the flow is high enough a signal will be sent to the SSR switching on the 12v supplies.

The peltiers require a constant current of about 3A @ 2.5V. This is achieved by regulating the voltage before it goes to the controllers. Due to the high current and the length of cable there is a considerable voltage drop along the lines, this however was not enough to reduce the voltage so resistors were added in the rack adding 1.5V to the line resistance. This then reduces the voltage enough to feed the regulator. The regulator then gives a fixed current of 3A, which is fed into the CCD controllers.

1.2.1: Interlock circuit : 16-07e4.sch

When the coolant flow is high enough to provide sufficient cooling the output from the flow meter is about 60Hz. This is a +/- square wave, which is transferred to a TTL signal (0 to +5v). This is then fed to a frequency to voltage converter, the output of which is compared with a fixed voltage level. The level for the comparator is set to just below the level given by the F-V converter thus allowing for small fluctuations. When there is sufficient flow and the output of the F-V converter is higher than the reference level the output of the comparator will be high closing the SSR, which will switch on the 12V power supplies. If the flow drops the comparator will go low and the supplies will be switched off.

1.3: Fan Tray

The fan tray has six fans to provide cooling for the peltier PSU rack above.

1.4: CCD VME Crate

1.5: NAOMI VME Crate : 00-07e8.dwg

The NAOMI VME crate consists the following cards;

CARD	NAME	DESCRIPTION
MVME 167	Processor Card	
MVME 712	Translation board	
VME 8	8 channel motor controller	Provides signals to control the motor drive cards and has inputs for limit and home switches.
VME 44 # 1	4 channel motor controller with Encoder	As VME-8 but also has inputs for encoders
VME 44 # 2	4 channel motor controller with encoder	As above.
XVME 240	Digital I/O Card	Provides digital output bits to drive relays and control the ADC, Also accepts input bits from the ADC and switches.
VMIVME 4145	Waveform generator	Provides waveform signals to drive the Tip/Tilt controller.
VMIVME 3230	Thermocouple board	Accepts thermocouple inputs.

Table 1; VME rack

1.5.1: Motor Controllers

The outputs of the motor controller cards (VME-8 & 44) are connected to the inputs of the drive cards directly from the VME crate giving the +5V, GND, STEP, DIRECTION and DE-POWER signals. The drive cards then give the 5-phase drive pulses for the motors.

Inputs to the cards from the switches and encoders enter the rack via a connector panel at the back of the rack and are then connected to the VME cards. Decoupling capacitors are attached to the inputs from the limit switches at the connector panel to reduce the noise giving clean high or low levels. When the controllers receive a high level from a limit switch in the direction it is traveling it will stop the motor, the motor can then only be moved in the opposite direction away from the switch. The switch will only affect the motor on the same axes as the drive and in the direction of the switch. The positive limit switch will not stop the motor if it is running in the negative direction. The card and axis used for each of the stages can be seen in table 2 below.

MOTOR	TYPE	ENCODER	DRIVE	CONTROLLER	AXIS	MECHANISM
1	VRDM 545	1	1	VME - 44 # 1	X	Pick-off C
2	VRDM 545	2	2	VME - 44 # 1	Y	Fore-opt C
3	VRDM 566	3	3	VME - 44 # 1	T	CCD C
4	VRDM 545	4	4	VME - 44 # 1	Z	Pick-off M
5	VRDM 545	N/A	7	VME - 8	U	Filter
6	VRDM 545	N/A	8	VME - 44 # 2	X	ADC 1
7	VRDM 545	N/A	9	VME - 44 # 2	Y	ADC 2
8	VRDM 545	N/A	10	VME - 44 # 2	T	Lenslet
9	DC	N/A	PSU	DIGITAL I/O	N/A	Mask
10	Vexta 5 phase	N/A	Vexta	VME - 8	R	Beam Split
11	Newport	5	In house	VME - 44 # 2	Z	X-Stage
12	VRDM 545	N/A	11	VME - 8	T	Y-Stage
13	VRDM 545	N/A	12	VME - 8	Z	Int. Sphere

Table 2 ; Motor Axis

1.5.2: Digital I/O card

The output bits from the digital I/O card are connected from JK1 on the front of the card, through a 50-way ribbon cable to the relay card in the PSU Module. The input bits are connected from JK2 to the ADC Card. Most of the output bits are used to control relays, there are also a couple that control the ADC. Similarly most of the input bits are inputs from the ADC and there are a few inputs from switches. The assignment of the bits are listed below in table 3.

DIG Signal	Type	CONTROL	FUNCTION	PORT #	PIN #
BIT 0	Output	Rel 1	DC Motor - Forward	0	JK 2, 1
BIT 1	Output	Rel 2 & Rel 7	DC Motor - Reverse	0	JK 2, 2
BIT 2	Output	Rel 3	Calibration Lamp	0	JK 2, 3
BIT 3	Output	Rel 6	WFS Lamp	0	JK 2, 4
BIT 4	Output	Rel 8	CCD Shutter	0	JK 2, 5
BIT 5	Output	Rel 4	Video Camera	0	JK 2, 6
BIT 6	Output	Rel 5	CCD Shutter	0	JK 2, 7
Bit 7	Output	ADC	Start Conversion	0	JK2,8
Bit 0	Output	ADC	Set ADC	1	JK2,13
Bit 0	Input	Switch 9	DC Motor In	4	JK1,1
Bit 1	Input	Switch 10	DC Motor out	4	JK1,2
Bit 2	Input	Switch	Shutter Open	4	JK1,3
Bit 3	Input	ADC	Ready	4	JK1,4
Bit 0	Input	ADC	ADC Bit 0	5	JK1,13
Bit 1	Input	ADC	ADC Bit 1	5	JK1,14
Bit 2	Input	ADC	ADC Bit 2	5	JK1,15
Bit 3	Input	ADC	ADC Bit 3	5	JK1,16
Bit 4	Input	ADC	ADC Bit 4	5	JK1,17
Bit 5	Input	ADC	ADC Bit 5	5	JK1,18
Bit 6	Input	ADC	ADC Bit 6	5	JK1,19
Bit 7	Input	ADC	ADC Bit 7	5	JK1,20

Table 3 ; Digital input / output bits

1.5.3: Waveform Generator card

This card will produce signals on three channels that will be connected to the PI driver for the PI Tip/Tilt mirror in the calibration unit. The signals are connected via a filter box, which contains a low pass filter of 300Hz for each of the three channels. The connections come directly from BNC connectors on the front of the VME card. No EPICS driver has been written for this card as yet, therefore the tip/tilt injection must be done via a signal generator.

1.5.4: Thermocouple Board

The thermocouple board accepts most types of thermocouples connected to the front of the card.

1.6: PSU Module : 00-07e7.dwg

The PSU module is a sub-rack of the main electronics rack. It is used to house power supplies, a relay card to switch the power supplies, an ADC Card and two further drive cards as detailed below in Table 4.

Supply	Use
+24Vdc	Calibration lamps for WFS
24Vac	Video camera
+/- 12Vdc	DC Motor, forwards and reverse.
+5Vdc	Power for Relay and ADC Cards
+24Vdc	Power for the Newport and Vexta motor drives
Relay Card	Switch the above power supplies on and off under software control.
ADC Card	Converts the analogue inputs from the photodiode in the calibration unit to digital to be read by software.
Vexta Drive card	5-Phase drive card to provide the drive signals for the Vexta motor on the beam splitter stage in the calibration unit.
Newport Drive	2-Phase drive card built in house to give the drive signals for the Newport motor on the Deformable Mirror X-Stage.

Table 4 ; PSU Module.

1.6.1: Relay Card 16-07e7.sch

The relay card consists of six single pole double throw relays and two cross over relays, which switch the various power supplies. One side of the relay coils are attached to the +5V and the other is connected to an output from the Digital I/O card in the VME rack, as shown above in table 3. A pull up resistor is connected +5V at the control side preventing the relay from being active when there are no control signals. This then

implies that a low level signal from the Digital I/O card is required to activate or close the relay. (Normally open contacts are used.)

The control for the DC motor and Shutter is described below. All of the other relays simply close when a low signal is applied switching on the appropriate voltage feeding it through to connectors on the back of the PSU module and out to the respective mechanism.

1.6.1.1: DC Motor (Mask Stage)

The DC motor requires either + or – 12V depending on the direction it is to be driven. Each of the +/- voltages are switched using relays 1 and 2. They are then fed to a cross over relay (7) which prevents the +12v being connected to the –12V as illustrated in figure 2 below.

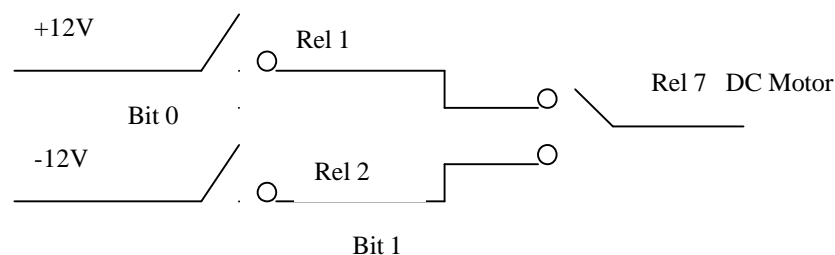


Figure 2 ; DC Motor control

Relay 1 is closed for the motor to be driven in the forward direction. For this to happen relay 7 has to be inactive so that the +12v can be connected through the normal closed contact to the motor. To drive the motor in reverse relay 1 should be open and relays 2 and 7 closed allowing the –12V through the normally open contacts of relay 7. Relays 2 and 7 are controlled by the same bit giving a complete path for the –12V when the motor is requested to be driven in reverse. If the request is made whilst the motor is travelling in a forward direction the motor will change direction. If it is then stopped in reverse whilst control bit 0 is active the motor will then drive forward again. Each motion should therefore be stopped prior to the next one starting. The motor will be stopped in the direction it is travelling when the associated limit switch is hit and a low level signal is applied to the input of the digital I/O card via the ADC card. When this is read the software toggles the control bit high opening the relay and thus stopping the motor.

1.6.1.2: Shutter Control

The shutter on the CCD module requires 24V volts to open it then 5V to hold it open and closes when this holding voltage is removed. Relay 5 is initially closed presenting 5V to

the normally closed contacts of relay 8, which is connected to the shutter. This however is not enough to open the shutter. 24V is applied to the normally open contacts and the relay is momentarily opened presenting 24V to the shutter allowing it to open. Relay 8 is then closed again leaving the 5V holding voltage at the shutter. A capacitor is also connected to the shutter line to hold a charge whilst relay 8 closes preventing the shutter from closing before the holding voltage is connected as illustrated below in figure 3. The shutter is closed by opening relay 5. When the shutter opens a switch at the shutter closes, sending a low level input to the Digital I/O letting the software know that the shutter has opened. If this signal is not received relay 5 will be opened and the user will be informed that the shutter failed to open.

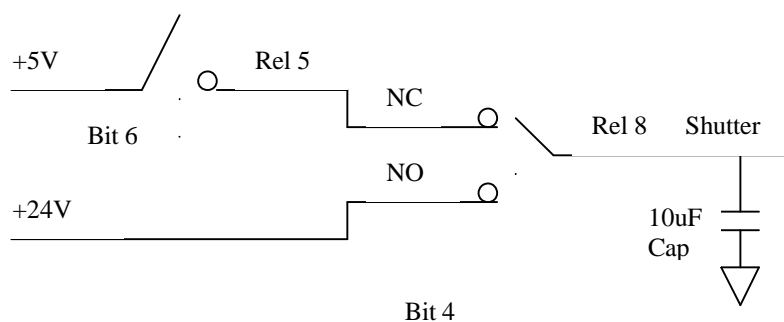


Figure 3 Shutter Control

1.6.2: Vexta Drive card

The Vexta drive card is a bought in card to drive the Vexta 5-phase motor on the beam splitter stage in the calibration unit. It requires 24V to drive the motor and 5V for the logic circuitry. The card receives the 24V from the power supply in the PSU module and the 5V from the VME crate along with the drive signals from the VME-8 card. The drive card will then output 5-phase signals to the motor in the required sequence to give the correct stepping.

1.6.3: Newport Drive card 16-07e6.sch

The Newport drive card is an in house built card to drive the 2-phase stepping motor attached to the Newport stage for the Deformable Mirror X travel. This card also requires 24 and 5V supplies and produces 2-phase signals in the correct sequence to drive the 2-phase stepping motor.

1.7: Berger Lahr Stepper Motor Drive modules.

There are two Stepper drive modules each containing six drive cards made by Cortex Controllers used to drive all of the Berger Lahr 5-phase stepping motors. Drives 1-6 are in the top module and drives 7-12 are in the bottom module as they sit in the electronics rack. Table 2 above in the Motor controllers section (1.5.1) shows which drive controls which motor and hence which stage. The drive signals are supplied to the modules from the VME-8 and 44 cards and the modules then supply the motor phases with the correct stepping sequences.

1.8: FSM Filter : 16-07e1 to 3.sch

The Fast Steering Mirror (FSM) filter, filters the input signals to the FSM electronics from the Electra system. Its function is to protect the FSM from receiving demand voltages that are too high at the relevant frequency. The filter is made up of four LMF100 filters, each of which are dual 4-stage filters. A block diagram of the filter is illustrated below in figure 4.

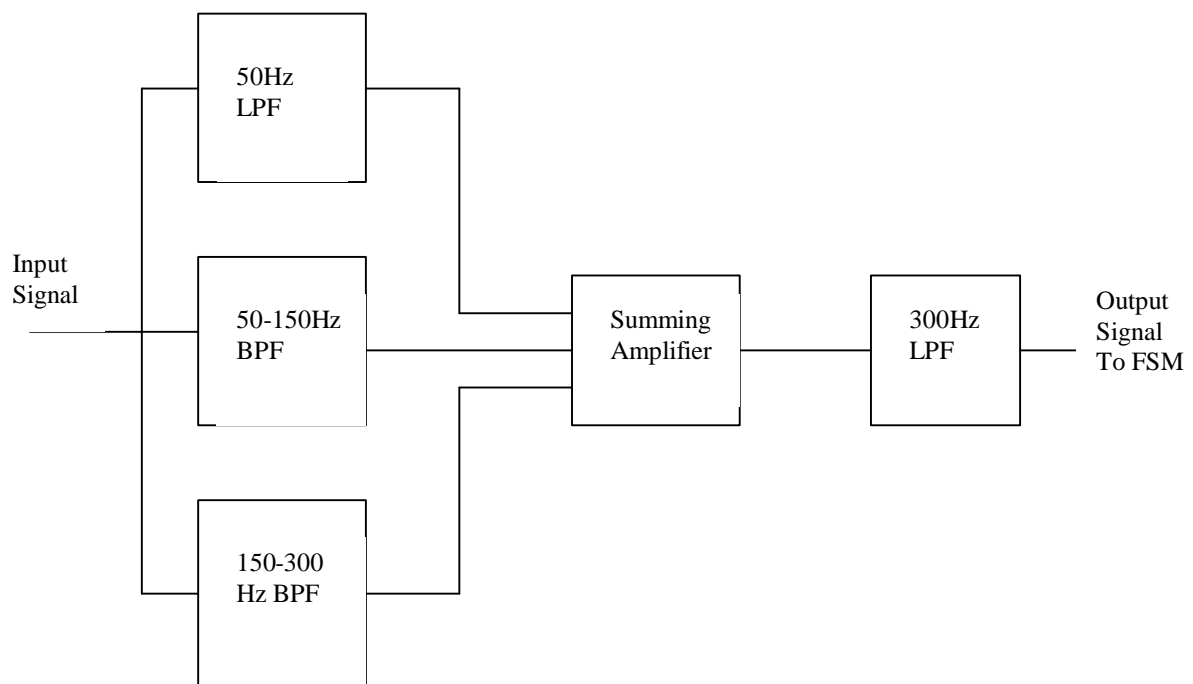


Figure 4 ; FSM Filter Block Diagram

Each of the individual filters use both parts of the LMF100 giving 8-stage filters. The cut-off frequencies are obtained by the resistor values in the circuits. The output voltage of

each filter is limited to different values. There is no limitation on the 50Hz low pass filter, the 50-150Hz is limited to 4V and the 150-350Hz is limited to 1V. These three filters were used to separate the frequency bands in order that they can be limited in this way. The outputs of the filters are then summed together. The output of the summing amplifier is effectively the output of the filter that corresponds to the frequency being applied, hence if a signal of 30Hz is applied to the input it will be allowed to pass through the 50Hz LPF but will be blocked by the other two. The output of the summing amplifier will then be the same as the output of the 50Hz LPF, which will be 30Hz, at whatever voltage was applied (limited to +/- 6V due to the supplies). The output of the summing amplifier then goes to another filter (300Hz LPF) which is the overall bandwidth of the FSM giving additional protection from signals out with this range.

1.9: FSM Electronics

The FSM Electronics is the control unit for the fast steering mirror supplied from Zeiss with the mirror. The signals from Electra go through the above filter to this unit which then supplies high voltage signals to the mirror.

1.10: NCU Lamp PSU : 16-07e8.sch

The NCU lamp requires an igniter to start it, this is mounted in the calibration unit however the associated circuitry is in a box in the electronics rack. The power is switched on using a solid state relay which is controlled from output bit 2 of digital I/O card. When the relay is energised 240Vac is switched through a ballast and out to the igniter. The igniter then supplies a 4.5kV starting voltage to the lamp.

2: Calibration Unit : 00-07e5.dwg

The calibration unit consists of the following parts;

- Mask stage
- Beam Splitter Stage
- Shutter
- Lamp
- Photodiode
- Tip/Tilt Mirror

2.1 Mask Stage

The Mask stage is driven by the DC Motor controlled by the digital I/O card via the relay card as previously described in section 1.6.1.1. Connections go from motor and switches on the stage out to the connector panel on the side of the calibration unit.

2.2: Beam Splitter stage

The Beam Splitter stage is a bought in unit driven by a Vexta 5-phase stepping motor. It is controlled by the VME-8 card and driven by the Vexta drive card in the PSU Module. There are three switches on this stage, two limits (+/- direction) and a home switch, which are all connected to the inputs of axis R of the VME-8 card.

2.3 Calibration shutter

The Shutter is driven by one of the Berger Lahr 5-phase motors to control the intensity output from the NCU. The motor is controlled by the VME-8 card. There are no switches on this stage however a photodiode measures the light from the lamp, which is controlled by the digital I/O card via the relay card. The output from the photodiode is then connected via the BNC connector at the side of the unit to the ADC card, where the analogue signal is converted to digital and read by the Digital I/O card giving a reading of the light level. From this the position of the shutter can be determined.

2.4 Tip/Tilt Mirror

The Tip/Tilt mirror is a small bought mirror with it's own dedicated controller situated in the electronics rack. It's function is to allow testing of the AO system by injecting a tip/tilt motion into the calibration image. Not to be used in normal operation. The connections to the mirror are made from the front of the controller to the connector panel

of the calibration unit and mirror. The unit was calibrated with these particular cables of the required length.

3: Wave Front Sensor (WFS) : 00-07e2 to 4.dwg

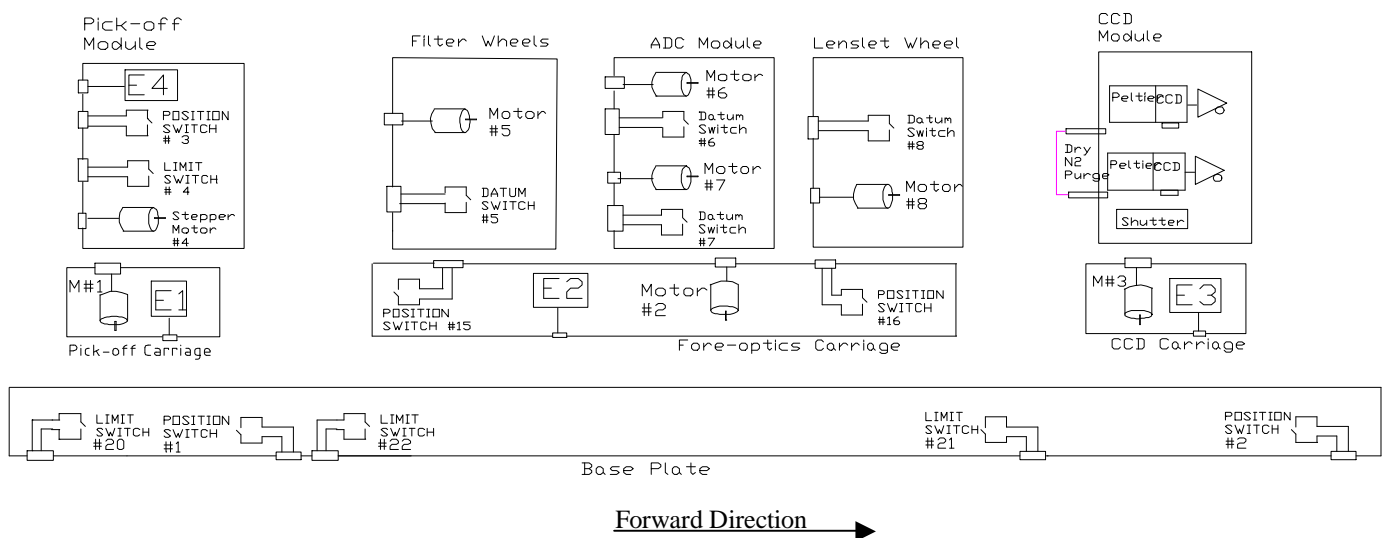


Figure 5; WFS Block Diagram

The WFS, shown above in a simplified block diagram, contains a number of stages that are driven by the Berger Lahr 5-phase stepping motors. Some of the stages have encoders associated with them as detailed in table 2 (Motor Controllers). All of the stages have Home or Limit switches associated with them. All of the connections for the stages go to the connector panel at the end of the WFS.

In the above diagram it can be seen that there are position, limit and datum switches. The position switches are high precision switches used to Datum the stages as well as act as a limit. The Datum switches are the same high precision switches but are only used as a datum with the contacts connected to the HOME input on the VME 8/44 cards. The limit switches are standard micro-switches, the function of each of the switches are detailed below in Table 5. The encoder heads are indicated by an "E". There are three on the base plate for each of the carriages and one for the Pick-off Y-stage. Each of the encoder heads are connected to the associated encoder inputs on the VME 44 card, as shown in table 2.

Switch	Purpose
Position # 1	Acts as the datum for the Pick-off carriage and prevents the carriage from hitting the end stop when travelling in the forward direction.
Position # 2	Prevents the CCD Carriage hitting its end stop when in the Forward direction.
Position # 3	Acts as the datum for the Pick-off Y-stage and prevents the stage hitting its end stop when travelling up (Forward)
Limit # 4	Prevents the Y-stage hitting the lower limit (Reverse)
Datum # 5	This switch is connected to the HOME inputs of the VME 8 card and acts as a Datum for the filter wheel rotational stage. This has no affect other than when there is a request to datum the stage. Hence there are no limits.
Datum # 6	The datum for the ADC # 1 rotation stage.
Datum # 7	The Datum for the ADC # 2 rotation stage.
Datum # 8	The Datum for the lenslet wheel rotation stage.
Position # 15	Prevents the Fore-optics carriage hitting the pick-off carriage when traveling in the reverse direction or similarly the if the pick-off is travelling in the forward direction. If this switch is hit it will stop both of these carriages. It also acts as the datum for the fore-optics carriage, once the pick-off carriage has datumed the fore-optics carriage datum's on the pick-off carriage.
Position # 16	Prevents the Fore-optics and CCD carriages from colliding. It will stop both carriages, the Fore-optics when traveling forward and CCD when in reverse. It also gives the datum for the CCD carriage.
Limit # 20	Prevents the Pick-off carriage hitting its end stop when traveling in the reverse direction.
Limit # 21	Prevents the Fore-optics carriage from hitting its end stop when in the forward direction.
Limit # 22	Prevents the Fore-optics carriage hitting its hard stop when traveling in the reverse direction.

Table 5; WFS Switches

From the above table it can be seen that switch 15 will stop both the Pick-off and Fore-optics carriage, however switch 1 will only stop the Pick-off carriage in the same direction and switch 22 the Fore-optics carriage. Similarly Switch 16 stops both the Fore-optics and CCD carriages but switch 21 will only stop the Fore-optics carriage. Additional logic circuitry, shown below in Figure 6, has been added before the VME 8/44 cards to allow the following functions;

Pick-off carriage stopped in Forward direction by switch 1 OR 15
 Fore-optics carriage stopped in reverse direction by switch 15 OR 22
 Fore optics carriage stopped in Forward direction by switch 16 OR 21

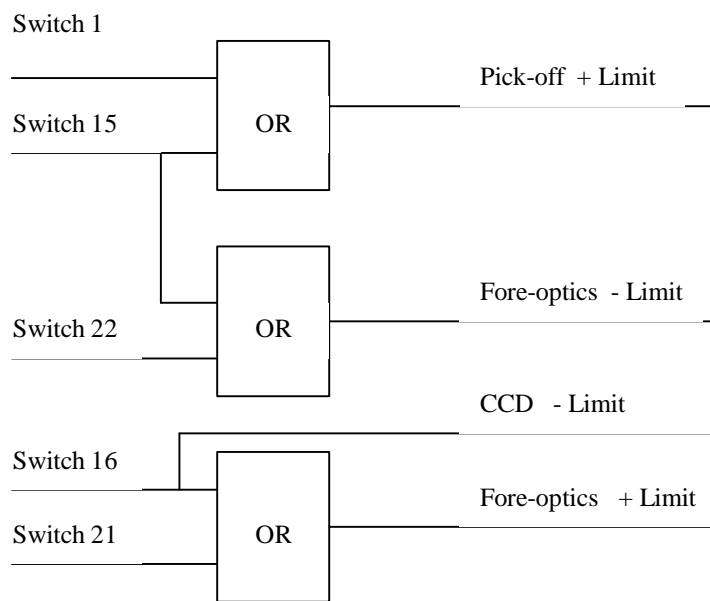


Figure 6; Switch Logic for WFS

With the above circuit each discrete fault condition due to switches being hit will be the result of one single switch. For example;

The fore-optics stage can be stopped in the negative direction if switches 15 or 22 are hit and switch 1 or 15 will stop the Pick-off in the forwards direction thus giving three possibilities that could stop these movements.

If the pick-off and fore-optics carriages both stop then switch 15 was hit and the two carriages collided. If the pick-off stopped but not the fore-optics then switch 1 was hit at the end of travel for the Pick-off, similarly switch 22 will be hit if only the fore-optics carriage stops.

The CCD module consists of two CCD heads and two Peltier devices, which are controlled by the CCD controllers. The connections for these are through the side of the WFS. The connections for the shutter, which is also on the CCD module is through the connector panel at the end of the WFS and is controlled as previously described.

4: Optical Mechanical Chassis (OMC) 00-07e6.dwg

The OMC sits on the optical bench and has the fast steering mirror, which is connected to its dedicated controller in the electronics rack. The deformable mirror also sits on a stage, which can be moved in the X and Y directions. The stage is driven in the X direction by the Newport stage, which includes two limit switches and an encoder. The Y direction is driven by one of the Berger Lahr 5-phase motors controlled by the VME-8 card.

Appendix I

Spares List

2 x Berger Lahr Motors VRDM545
1 x Berger Lahr Motor VRDM566
1 x Position Switch
2 x Cortex motor drive cards. Drives 5 and 6 in the rack.
2 x NCU Lamps
1 x Igniter for NCU Lamp
1 x NCU Lamp holder
2 x Capacitors for NCU lamp PSU

To be Delivered;

1 x VME 44 Motor controller (With encoder inputs)
1 x VME 8 Motor controller
1 x MVME 167 Processor card
1 x MVME 712 Transition Card
1 x XVME 240 Digital I/O Card

Appendix II

Temporary setup of Electronics rack

At present the rack is set up different from the layout described in section 1, figure 1. The actual layout is illustrated below.

Tip/Tilt Amp (FSM)	
Peltier PSU	
Fan Tray	
FSM Filter	
VME Crate	
PSU Unit	
Tip/Tilt	Lamp PSU
Motor Drive rack	
Motor Drive rack	
CCD VME	
CCD Control	CCD Control

The EPICS record for the waveform generator card that would drive the Tip/Tilt mirror has not been written therefore a signal generator is required to apply a signal to the Tip/tilt unit so that the tip/tilt mirror in the calibration unit can be driven. This however this mirror is not required for normal operation.

The FSM has been sent back to Zeiss for repair so there is a substitute FSM in the system at present controlled by the Tip/Tilt Amp at the top of the electronics rack.

