Mimir Operations Notes

Mimir Unit	Version	Date	Author	Notes
Camera	1.0	5/19/2004	D. Clemens	Initial Writeup
	1.1	5/26/2004	D. Clemens	Motion direction corrected

1. Overall Operation Description

The camera unit consists of the camera block, which contains four “cameras” and which is kinematically mounted to one carrier that runs on a THK ball-and-lead-screw rail and is driven to positions by a stepper motor. While there is no formal detent action, there is an electromechanical brake (action=brake when not energized) and a zero-phase sensor for the lead screw (one reed switch closure per lead screw revolution).

The Camera drive unit is currently identified with connector M7 (“Camera”) on the warm bulkhead. When queried by the I/O boards, the camera drive unit returns a voltage decoded as device “8” to the I/O board front panel. The current I/O board assigned to the camera is BD6.

The camera drive unit has left and right software and hardware limit sensing as well as lead screw zero-phase sensing (fed through the normal “detent” signal line).

The camera carrier is normally homed at the beginning of a run and again as necessary if there have been a large number of camera position changes.

After homing, the camera carrier is driven fixed numbers of steps to place one of the four “cameras” (f/5, f/17, TT, or PV) boresights along the optical axis. The step numbers were chosen to place the desired camera in position to within 5 mils, either warm or cold (see table below).

The zero-phase sensing is used only to verify that move commands to the camera unit are being executed. There is no positioning information derived from the zero-phase sensor.

In the following, details of the design and operations are explained so that robust and repeatable operation can be achieved.

1.1. Stepper motor and brake details

A single Vexta stepper motor (with nominal 400 steps per revolution) is operated in a half-step mode by the STP100 stepper motor boards to achieve 800 steps per motor revolution. The THK lead screw pitch is a metric 6mm per revolution, and is made from stainless steel. This gives 800 steps per revolution, and zero-phase condition So, warm, one motor step moves the camera carrier 7.5 microns, or 2.95276×10^{-4} inches. When cold, the step size is reduced to 7.5 / 1.00205 microns (due to the steel CTE). Positioning is more complex, however, as the reference location and the software limit locations change when going from warm to cold.

The electromechanical brake is mounted coaxially on the opposite shaft end from the Vexta motor. The brake is energized to release its load by about 7 V of DC power. It consists of an electromagnet and a clutch plate. When no power is supplied, the clutch plate is pressed by springs against its fixed twin, allowing no revolutions and thus holding the camera block in place.

During normal observing, the motor and brake are both without power and the camera position is fixed. When moving the camera unit, however, the procedure should be (1) force stepper motor power to be always on (via the “SP” command), (2) command I/O board to MOVE mode (“PC6 PS5”) – which causes the brake to release, (3) move the stepper motor, (4) command the I/O board to leave MOVE mode (“PS6”), and (5) depower the stepper motor (“SO”).

Unfortunately, the direction of stepper motion is opposite to that of the decker/slit system. That is, to move the camera unit from SR to SL, the desired step direction is negative (“-“ steps).

1.2. Cameras

The four cameras in the camera block are the f/5 wide field camera, the f/17 narrow field camera, the pupil viewer (PV), and the LED illuminator (the TT or Tollestrup Telescope, so named by Domenic).

1.3. Home Position

The camera carrier is home when it has tripped the SR (Software Right) encoder. In this position, the f/5 camera is about 0.210” away from the optical axis (when warm) and the camera block is about 0.881” away from the righthand (non-motor side) interior wall.

1.4. Cold vs. Warm Operations

The configuration of the camera rail and carrier system is complex and exhibits a larger than usual operations change when going from warm to cold. The THK rail system is made of steel, with a different CTE than the aluminum 6061 box it is mounted within. Further, kinematic mounts (cone-cone, cone-slot, cone-flat) were used to mount the THK rail to the box bottom and to mount the camera block to the THK carrier. The net effect is that the cone-cone locations define two reference positions that are connected by steel, but which are linked to two aluminum structures. Further, the location of the SR (software right = home) reed switch sensor is far from the fixed cone-cone location. Thus the SR location moves, relative to the THK rail position, during cooldown. As the home position determination is dynamic (it is done when cold as well as when warm), this movement of the SR sensor location needed to be taken into account when deriving the motor motion table below. The warm design drawings were confirmed by lab measurements, probably to an accuracy of 2-3 mils (about 7-10 motor steps). Location calibration to higher accuracy will have to await telescope operations.

1.5. Camera Positions and Step Numbers

Camera Location	Warm Step Number	Cold Step Number	Notes
R Limit	700	**701**	Hardware Right Limit
Home	0	**0**	SR
f/5	-728	**-675**	Wide-field camera
f/17	-11,914	**-11,837**	Narrow-field camera
TT	-18,786	**-18,699**	LED Illuminator
PV	-22,159	**-22,271**	Pupil Viewer
SL Limit	-22,225	**-22,271**	Software Left Limit
L Limit	-22,995	**-22997**	Hardware Left Limit

1.6. Motor Commands

1.6.1. Initialization

Initialization consists of the I/O boards recognizing the camera unit, autoconfiguring the I/O board, and issuing a set of commands to the I/O board to cause the camera unit to find the SR reed switch sensor.

As stated above, it is important to be aware that the camera block is very heavy and the stepper motor is usually unpowered. If the brake is not engaged, the entire unit will slide to one hard limit or the other, depending on instrument orientation.

The preferred movement sequence is: motor powered, brake released, move, brake set, motor depowered. See below for a detailed listing of the STP100 commands.

1.6.2. I/O Board Assignments

The camera unit is currently assigned to I/O board 6 (BD6). When in raw RS232 communication with the STP100 chain of boards, one needs to issue the following commands to access these boards:

BD6 (selects board 6, the camera unit I/O board)

1.6.3. I/O Board Configuration

When powered up, the I/O boards should test for the voltage divider encoder resistor and return the encoded voltage to the I/O board front panel in the 7-segment LED numeral. The camera unit should return an “8.” If either of these is not true, press the black buttons on the front of the I/O boards to force a retest of the resistors. If this fails, stop and get help.

When in idle, the I/O boards should show both “Bit 5” and “Bit 6” lit on the 10-LED bar on the I/O board. Bit 5 is the fourth LED from the top and should be yellow when lit. Bit 6 is the red LED just above it. If both are lit, the I/O board is in the “READ A” mode (a safe way to start since the brake is set in both READ modes).

To move the camera unit, start by issuing a SP (“Stepper Powered”) command to force current into the stepper motor. Once in this condition, the stepper motor can prevent the camera block from moving, thus the brake may be safely released.

To release the brake, issue a PC6 (“Pin Set 6”) command to the STP100. This causes the I/O board to change from READ-A to MOVE mode. This is critical, because although the motor can be moved outside of MOVE mode, the limit sensors will not work properly, possibly leading to damage of the unit. For the camera unit, the brake is released only when in the MOVE mode.

Once in MOVE mode, the limit reed switches are continuously monitored and the unit is self-protecting.

After the move has been completed, issue a PS6 (“Pin Clear 6”) command to return the I/O board to READ A mode, which sets the brake. Then, issue a SO (“Stepper Unpowered”) command to the I/O board to remove power from the stepper motor. At this point, the camera unit is held in place by the brake only.

1.6.4. Moves

There are several ways of moving the stepper motor with the STP100 commands. These include immediate moves (II-type), absolute moves (MI-type), and others. Use II-type moves to find the home sensor and MI-type moves to go to the camera locations after homing has been done.

For example, after homing, I wish to move the camera carrier to position the f/17 camera on the optical axis. To do so, I issue a:

MI-11837

command to move the carrier 11,837 steps to the Left, away from the Right, home, limit.

1.6.5. Zero-Phase Sensing

Generally, the camera unit will perform absolute moves to its camera positions. However, we will likely test for closures of the zero-phase sensor to verify that the THK drive screw is turning. Software currently drives the camera in units of 400 steps (one half of a revolution) and looks for the on-off modulation of the zero-phase sensor to verify motion. To position the drive screw onto a closure of the zero-phase sensor, we let the STP100 monitor the detent signal:

PC6	(to go to MOVE mode in the I/O board)
TC3	(test for “clear” on “Pin 3” – the zero-phase sensor)
II-2000	(an arbitrarily large move guaranteed to find a “clear”)

1.6.6. Homing

Assuming the camera positioning is completely lost and not in a software limit, do the following to find home:

BD6	
PS6	
PS5	(force READ A mode – brake set)
SP	(power up stepper motor)
PC6	(change to MOVE mode –brake released)
TC3	
II-2000	(should find zero-phase)
TC8	(look for a “Pin 8” clear condition = any limit)
II30000	(ie, off the end, but SR will be found first)

after move ends, should see SR LED lit on the I/O board.

HM0	(reset step counter to 0)

then do moves to slits as needed

PS6	(put I/O board into READ-A mode – brake set)
SO	(remove stepper power)

1.6.7. Motor Speed Settings

The camera unit I/O board has been set to some default motor speed settings. The settings consist of:

Motor Speed Parameter	STP100 Command	Default Value	Current Value	Low Limit	High Limit
Step Type	**SH**	**Half**		**SF (Full)**	
Step Delay	**SD, RSD**	**600**		**275**	**2000**
Step Acceleration	**SA, RSA**	**10**		**0**	**100**
Step Min Delay	**SM, RSM**	**600**		**0**	**2000**

The units of the step delay are 1.6 microseconds.

Limits were established without the camera block in place when warm and should be redone with the camera block when cold.

Current value column left blank for future tuning.

These are changed by issuing an STP command, for example:

SD550	(sets step delay to 550)
RSA	(returns current step acceleration value)
WSS	(saves the current settings in EEPROM)