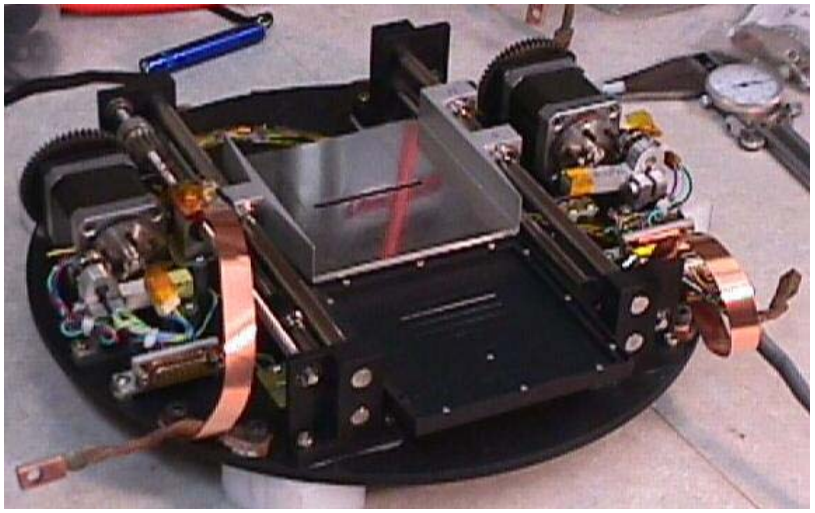
Mimir Unit	Version	Date	Author	Notes
Decker	1.0	5/12/2004	D. Clemens	Initial Writeup
	1.1	5/26/2004	D. Clemens	Format cleanup



1. Overall Operation Description

The decker unit consists of two cars that run on parallel rails and are driven to positions by screws, gears, and stepper motors. The two car drive units are identical. The car carrying the removable slit mask is the “Slits” car and resides closer to the
first lens and to the first focus. The upper car carries the “Decker” or selector.

The Decker drive unit is currently identified with connector M1 (“Decker”) on the warm bulkhead. When queried by the I/O boards, the decker drive unit returns a voltage decoded as device “9” to the I/O board front panel.

The Slits drive unit is on warm bulkhead connector M8 (“Slits”). Its I/O return voltage code is “c” (lower case c) on the I/O panel.

Both drive units have left and right software and hardware limit sensing as well as stepper motor detent sensing.

The cars are normally homed prior to moving to a known position. This is necessary because the stepper motor detent action causes some steps to be lost. By resetting position and step count at the home location each time, repeatability is enhanced.

After homing, the cars are driven fixed numbers of steps to place either the decker opening or one of the slit openings along the optical axis. The step numbers are chosen to ensure the detent is engaged when the desired slit or opening is in place. Both slit and decker home positions were also tuned to be detent falls, to make this all easier.

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

1.1. Stepper motors, gears, drive gear details

The Vextra stepper motors (with nominal 400 steps per revolution) are operated in a half-step mode by the STP100 stepper motor boards to achieve 800 steps per motor revolution. Each stepper has a 56-tooth gear on the stepper shaft. These engage 14-tooth gears mounted on the drive screws. This 4:1 gear ratio means that one motor revolution becomes four drive screw revolutions. The drive screw pitch is a metric 1mm per revolution, and is made from stainless steel. The stepper motor 56-tooth gears also have 6 pins that pairwise engage the detent system, producing 6 detents per motor revolution. This gives 133.333 steps per detent (probably not a great choice, in hindsight – integer numbers, ala 8-detents per rev, would have been wiser).

So, warm, one motor step moves its car 5 microns, or 1.9685039×10^{-4} inches.

1.2. Slit Plate

The slit plate is a thin CuBe plate with Ni electroformed slits. One of the five plates we had made was also laser-shot to create a 16x16 grid of 0.3 mil dia pinholes for optics evaluation.

The 13 slit locations are occupied by slits, darks, opens, and such of various heights and widths. They generally fall into Tall or Short designations, and span a range of widths.

The slit locations were designed to be 10 detents apart, so one could go from slit to slit accurately and repeatably.

1.3. Home Positions

The decker car is home when it has tripped the SR (Software Right) encoder. This should correspond with a detent fall, as well. In this position, the decker should be some 20 mils (5 arcsec) or more out of the full FOV.

The same is true of the slits car.

1.4. Cold vs. Warm Operations

When cold, the aluminum in the decker unit will have contracted by about 0.4%, symmetrically about the optical axis. However, the drive screws, in being made of SS, will have contracted only about half that amount and not symmetrically about the optical axis. The SS screws have one end hard referenced (via a ball bearing race) to the "Left" pillar – the one closest to the home positions of the cars. Because the SS contracts less than the aluminum, the effect is to shrink the step size (to 4.989771 microns per step, or $1.96447676 \times 10^{-4}$ inches per step), though not as much as if the screws were made of aluminum. At the same time, the distances the cars have to travel to get to optical axis has been reduced by the CTE of the aluminum. These differential factors were taken into account to produce the following operations tables for the two drive units.

1.5. Unit Positions and Step Numbers – see web page for current step values

Decker Location	Cold Step Number	Detent Number	Detector Offset from Center	Notes
R-Limit				Hardware Right Limit
Home				SR+Detent
Center				"beyond", or L of detector center
SL-Limit				Software Left Limit
L-Limit				Hardware Left Limit

Slits Location	Cold Step Number	Detent Number	Detector Offset from Center	Notes/Name
R-Limit				Hardware Right Limit
Home				SR+Detent
S0				20" clear of center; Buie "Pluto photometry position"
S1				Tall-Narrow ("Buie Slit")
S2				Dark-1
S3				Tall-Medium
S4				Fat+Ears
S5				Tall-Super-Wide
S6				Tall-Wide
S7				Tall-Super-Narrow; Optical Center of slits plate
S8				Dark-2
S9				Short-Medium
S10				Open Circle (20" dia)
S11				Short-Narrow
S12				Short-Wide
S13				Short-Super-Wide
SL Limit				Software Left Limit
L-Limit				Hardware Left Limit

1.6. Motor Commands

1.6.1. Initialization

Initialization of the decker unit consists of the I/O boards recognizing a legitimate decker unit (slit or decker), autoconfiguring of the I/O board, and issuing a MOVE command to the I/O board.

1.6.2. I/O Board Assignments

The decker motor unit is currently assigned to I/O board 7 (BD7) and the slit motor unit is assigned to I/O board 8 (BD8). When in raw RS232 communication with the STP100 chain of boards, one needs to issue the following commands to access these boards:

```
BD7        (selects board 7, the decker motor unit I/O board)

or

BD8        (selects board 8, the slits motor 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 slit unit should return a "c" and the decker should return a "9". 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).

To move a unit, start by issuing a PS6 ("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.

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

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 slit locations after homing has been done.

For example, after homing, I wish to move the slit car to position S7 on the optical axis. To do so, I issue a:

```
MI-20267
```

command to move the car -20,267 steps (152 detents) to the Left, away from the Right, home, limit.

1.6.5. Finding a Detent

Generally, we will try to move from detent to detent, but sometimes that is not possible (say at power-loss startup). To find a detent:

```
PC6        (to go to MOVE mode in the I/O board)
TC3        (test for "clear" on "Pin 3" – the detent sensor)
II2000     (an arbitrarily large move guaranteed to find a detent)
```

Detents should be 133 steps apart (actually 133.3333 – important to remember for large moves), so you should end up in a detent quickly.

1.6.6. Homing

Assuming you are completely lost and not in a detent or a software limit, do the following to find home:

```
PC6
TC3
II2000          (should be in a detent, now)

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+Detent lites lit on I/O board.

```
HM0             (reset step counter to 0)
```

then do moves to slits as needed

PS6 (put I/O board back into READ-A mode)

1.6.7. Motor Speed Settings

Both the decker and slit unit I/O boards have been set to identical 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**	**800**		**0**	**2000**

The units of the step delay are 1.6 microseconds. Limits were established when warm and should be redone 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)

A “fast” set, if needed for Buie-switching would be:

SA5
SM800
SD300

This has a longer acceleration time, but reaches a faster speed.