



# MULTIPLE MIRROR TELESCOPE OBSERVATORY

Smithsonian Astrophysical Observatory and Steward Observatory, University of Arizona

MMTO Technical Memorandum 85-2

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Subject: THE IRIS SYSTEM FOR THE MULTIPLE MIRROR TELESCOPE

## I. INTRODUCTION

The Iris System for the MMT consists of six iris diaphragms, one for each telescope, mounted on the Optical Support Structure (OSS) between the tertiary mirrors and the beamcombiner. The irises can be fully opened, fully closed or stepped to intermediate positions to independently reduce or eliminate the beam from each telescope. During phasing experiments, the Iris System can block the images from all of the telescopes except for the two that are being phased; and for engineering experiments, it can allow the viewing of the image from one telescope when all six telescopes are coaligned on a star in the center of the field. The irises can also provide sky masking in addition to or instead of the light baffles around the secondary mirrors. The operator uses a remote hand paddle to control the stepper motors that drive the irises open and closed. This memo will describe in detail the electronics and the mechanics of the Iris System, including a discussion of problems encountered, their solutions, maintenance recommendations and possible improvements.

## II. ELECTRONIC SYSTEM

Under control of a remote hand paddle, the electronics for the Iris System generate drive pulses for the stepper motors that open and close the iris diaphragms. The electronics is comprised of two sections: the controller and the set of drivers.

### A. Controller

The controller interfaces the operator's hand paddle to the drivers and the iris assemblies. Switch settings on the hand paddle determine how many steps to issue to the stepper motors, which stepper motors will be enabled to drive the irises and whether the irises will open or close. The controller reads the switch setting and produces the appropriate number of pulses (four step increments are available: 4608, 1024, 256 and 64). Again utilizing switch settings, the controller directs the pulses to the drivers associated with the enabled irises. Two momentary contact switches on the hand paddle, one for open and one for close, initiate the pulse generation and supply the drivers with the direction of travel. The controller arbitrates between the open command and the close command with close being given higher priority if both should occur simultaneously and with both being ignored while a previous command is in progress. Travelling from fully open to fully closed, or vice versa, requires 4608 steps. The other step numbers enable a rough setting of the iris aperture in intermediate positions. The controller disables an iris when that iris' mechanism contacts a microswitch located at the limit of travel for the open command. No microswitch disables the driver at the limit of travel for the close command; instead the excess pulses are essentially ignored since motion stops when the stepper motor stalls at the iris' fully closed position. To avoid needless heat

dissipation that could degrade seeing, the controller turns off the power to a stepper motor when at least one of three conditions is met: no commands are in progress, the associated iris is disabled or the iris is fully open.

#### B. Set of Drivers

The six drivers utilize direction, step and power-on signals from the controller to enable an SAA1027 Stepper Motor Driver IC, the central component of each driver, to drive the stepper motors. The direction signal determines the sequence in which the stepper motor windings are pulsed, thus opening or closing the irises; the step signal clocks the SAA1027 through this sequence; and the power-on signal enables the steps to be applied to the motor windings by supplying bias current for the SAA1027's output transistors. The SAA1027's internal counter determines which two of the four windings will be energized, with each drawing about 300mA. All six drivers receive the same direction signal from the controller; however, the step and power-on signals differ between drivers. The controller sends these signals only to enabled drivers. When an iris has fully opened during an open command or has completed the specified step increment for an open or close command, the controller will disable the power-on and step signals.

### III. MECHANICAL SYSTEM

#### A. Motor to Iris Linkage

A three bar linkage allows the stepper motor to open and close the iris. The motor turns the driver bar at a constant angular velocity with a constant maximum torque available. The coupler bar transfers this power to the follower bar, whose motion opens and closes the iris. The follower bar always turns at an angular velocity less than that of the driver bar; and ideally, the mechanical advantage of the linkage increases the torque available for opening and closing the iris.

The iris diaphragms cannot fully close, so a flat paddle attached to the linkage moves over the small aperture that remains when an iris is fully stopped down.

### IV. PROBLEMS AND SOLUTIONS

Initial testing of the completed Iris System exposed electronic and mechanical problems. Irises E and F opened erratically under some circumstances and Irises B, C and D failed to completely close (Note: the labels given to the irises in this report happen to only be relative labels -- they do not correspond to telescope positions). The former appeared to have an electronic cause, and the mechanical design resulted in the latter.

#### A. Electronic Difficulties

Irises E and F opened erratically when any of Irises A through D were enabled and had been only partially closed. Since the drivers for E and F reside on a different circuit board than those for A through D, an electronic difference was thought to be the cause of the problem. All inputs to the SAA1027s in the drivers for E and F appeared correct when observed during the failure. The trigger input was fine; the direction

input was fine; the set input was fine; the bias current was turned on; and according to the schematic and from quick probing with a DMM, the supply voltage and decoupling seemed fine. That was not the case. Some miswiring and incorrect specification of a decoupling point created problems that occurred on two separate occasions and were finally corrected.

A thorough inspection of the actual wiring around the SAA1027s on each of the boards revealed supply voltage and decoupling differences. The probing with the DMM didn't differentiate between the filtered and the unfiltered versions of the supply. The specification sheet for the SAA1027 cautions against improper decoupling that could lead to faulty switching sequences inside the IC due to supply noise. After rewiring all of the power inputs and grounds associated with the SAA1027s to be those of the unfiltered supply, the irises properly cycled open independent of which were enabled and independent of their initial positions. This configuration worked fine with the short test power cable.

When using the 200 foot power cable as specified for the system, the decoupling and supply problems appeared again. An oscilloscope trace of the power input for the logic portion of the SAA1027s revealed a high frequency ringing that occurred after the beginning of the step pulse. The RC filter on the supply line couldn't contend with the transients imposed on the supply by the switching of the motor windings. The power input needed the filtered version of the supply, although all of the grounds remained unfiltered to keep an identical decoupling point. The choke separating the filtered supply from the unfiltered supply sufficiently suppresses the high frequency ringing to allow the SAA1027s to properly sequence the motor winding switching.

#### B. Mechanical Difficulties

A mechanical problem surfaced simultaneously with the electronic problem -- some of the stepper motors would stall when closing the irises. Swapping the drivers and measuring the drive currents indicated that all of the stepper motors were being driven in the same manner. The stalling while closing must be related to the individual iris' mechanics (assuming reasonably similar motors), with some of the mechanisms requiring more torque than the motors could supply. Decreasing the step rate in order to increase the motor output torque resulted in improved, although not yet perfect, performance from the stalled irises. Some of the mechanisms still needed more torque. The same basic stepper motor, but with more torque because of a 150:1 gear ratio (GR) instead of a 30:1 GR was installed on the iris having the most difficulty closing. The iris functioned properly. 150:1 GR motors have been ordered for all of the irises; however, because of the necessity to use the Iris System before the new motors arrive (four month delivery dates, P.O.# 038006), all of the irises have been cleaned and lubricated so that they operate with the 30:1 GR motors.

#### V. FINAL TESTS AND INSTALLATION

Prior to installation on the telescope, two of the irises, one with a 30:1 GR motor and one with a 150:1 GR motor, were placed in the MMT0 "environmental chamber" for an operational test under simulated temperature conditions. Both cycled open and closed at 15°F with no noticeable degradation in performance over that at room temperature.

The irises were installed and tested on the telescope on February 28, 1985. Although they passed the basic operational test, they need to be refitted with the 150:1 GR motors since they presently have an insufficient torque error margin to operate reliably.

One problem noted was that the paddle which covers the small aperture that remains at the end of the closing motion of the diaphragm overshoots the center of the aperture and allows a noticeable amount of light to pass through the closed iris. This problem results from the electronics being unable to issue the exact number of steps to center the paddle over the remaining aperture. There are three solutions to this problem: use a microswitch to limit the travel of the paddle at the closed position, modify the pulse generation to issue only enough steps to center the paddle or increase the size of the paddle. Increasing the paddle size is an immediate, although temporary, solution. A limit switch should be installed, since the linkage could eventually be damaged by the stresses exerted upon it when the motors are forced to stall -- the higher torque 150:1 GR motors will necessitate this modification.

The center of each aperture must lie on the optical axis of its telescope so that field reduction will occur concentrically between the telescopes. Currently, this alignment has not been performed on the remounted irises.

## VI. OPERATIONAL CONSIDERATIONS

The normal operational procedure for the Iris System:

1. Turn on the power supply for the system -- +13 volts and four amps are necessary. Power-on will be indicated by a green LED lighting on the operator's hand paddle.
2. Set the toggle switches to enable only the selected irises to move.
3. Set the four position switch to the step increment wanted. Currently, 1024 is the maximum usable step size for the 30:1 GR motors -- 4608 is only for the 150:1 GR motors.
4. Press the appropriate push button switch to initiate the opening or closing of the irises. A red LED, the busy signal, will light to indicate that a move is in progress.

For the duration of the busy signal, the controller ignores any further open or close commands originating from the hand paddle; however, the enable switches and the step increment switch can disturb the normal operation of the system if they are changed at this time. The enable switches will enable or disable their respective drivers dynamically during a move if they are not left in one position. Turning the step increment switch will either decrease or increase the number of pulses issued by the controller depending upon which direction it is turned. A move can be aborted by two means. First, by disabling all of the irises or by setting the step increment switch to 64 steps. The latter prematurely terminates a lengthy move, and the former allows the controller to finish its pulse counting, with all of the generated pulses having no effect on the irises since all of the drivers have been disabled.

## VII. MAINTENANCE

### A. Electronic Maintenance

The electronic system is maintenance free.

### B. Mechanical Maintenance

The irises require periodic cleaning and lubrication. They should be inspected monthly for dust accumulation and cleaned when it becomes excessive. Both sides of the diaphragms need to be cleaned. Any accumulated dust should be wiped from the diaphragms with a dry, relatively lint-free wiper such as a Kim-wipe or a Micro-wipe. Next, they should be relubricated with a high viscosity silicone based fluid such as Dow Corning FS-1265 Fluid of 1000 cs. viscosity. Sparingly apply the lubricant with a clean wiper, taking care that tissue shreds don't imbed themselves in the cracks between the leaves of the diaphragms. Some fluid should also be forced into the crack between the rotating ring of the diaphragm and its body.

If any of the irises fail to fully close and the electronics function properly, dust build-up either in the leaves or in the large retaining ring on the edge of the diaphragm could be responsible for the mechanical failure. In this case (a mechanical failure), the irises should be removed from their assemblies and soaked in a solvent bath to remove the dust contaminated lubricant. They should then be relubricated and reinstalled.

The irises should be kept fully open when not in use. This will slow the rate of dust accumulation.

## VIII. POSSIBLE IMPROVEMENTS

Although the Iris System functions in its current state, its performance could be improved if necessary. Improvement could occur in three categories: speed of operation, iris position detection and control refinement.

### A. Speed of Operation

With the current drive configuration, the irises require 45 seconds to travel from fully open to fully closed, or vice versa. This time could be at least halved if the stepper motors were driven in an L/4R configuration instead of with the SAA1027. At 260 steps per second with an L/4R drive, the stepper motor produces the same torque as at 100 steps per second with the current SAA1027 drive. Drawbacks are that more heat would be produced in the drivers and in the motors with the L/4R drive, and also a second supply would be necessary for the motors. Additional speed could be gained by ramping of the stepper motor drives. Both of these speed improvements would require major redesigning of the electronic system.

### B. Position Detection and Display

The electronics could be modified to display the size of the iris' aperture. Since the number of steps needed to close the iris from its fully open position determines the aperture, this number could be displayed and to simplify its relationship with the aperture, the linkage could be reconfigured so that the driver link and the follower link traverse the same

angle for each motor step. Instead of utilizing the step count, a rough approximation of the aperture could be obtained by attaching a potentiometer to the motor shaft and displaying the voltage at its wiper when a fixed voltage is applied across its resistor.

In addition to the position display, a microswitch could be placed at the limit of the closing motion so that the motor doesn't stall and subject the linkage to unnecessary stress. Any of these improvements would require major changes to the circuitry.

### C. Control Refinement

By redesigning the circuitry, the following features could be added:

- Move to the closing limit.

- Move to the open limit.

- Move to position xxx.

- Move xxx steps closed.

- Move xxx steps open.

- Close while a switch is depressed, stop when it is released.

- Open while a switch is depressed, stop when it is released.

- Cancel switch to abort a move that is in progress.

- Abort step generation when all irises have reached their specified positions or limits.

- Open LED turns on when fully open, flashes when opening.

- Closed LED turns on when fully closed, flashes when closing.

- All paddle switch positions, except cancel move, are latched when a move command is issued.

- A digital interface for computer control of the irises.

## IX. CONCLUSION

After alignment, and with a temporarily enlarged paddle, the Iris System can be experimentally utilized to determine the necessary modifications other than the refitting with the higher torque motors. Installation of a closing limit switch is recommended to center the paddle and prevent damage to the linkage. Since the extra limit switch will require some redesign of the electronics, the termination of step generation when all irises have reached their limits can also be included in the redesign. Careful consideration should be given to other refinements of the Iris System that can occur when the new motors are installed in the iris assemblies.