HIGH PRECISION SHUTTER FOR THE T.N.G. CCD CAMERA

F. PEDICHINI[1], M. COMARI[2], R. COSENTINO[3] G. FARISATO[4], W. DE BACO[5], G. SANDRE[5]

ABSTRACT

The requirement to have detectors able to cover large fields of view on the focal plane of telescopes, demands the use of new generation CCDs with large dimensions or the combination of CCDs to form mosaics. The TNG optical imager, for example, will use a 6 cm squared CCD detector (2 X 2 Loral chips). Furthermore, modern fast optics telescopes, such as the NTT or the TNG, use, for standard star calibration, exposure times of the order of 1 s.

These requirements make the design and realization of the shutter for the CCD camera a very delicate and important task. Large linear dimensions, to allow a proper illumination of the whole detector, and high accuracy in exposition time, to avoid systematic photometric errors during short exposures, are the fundamental characteristics that the shutter has to comply with.

We present the main characteristics of the shutter built for the TNG CCD camera. Its working area is 8 × 8 cm. Thanks to a peculiar double blade mechanics and a two step-motors driving system, the shutter assures a uniformity of exposure time of ± 0.8 ms over the whole field when exposed for 1 s. Finally, the control electronics provides a simple interface to any type of CCD controller and a telemetry read-out feedback of the 'real exposed time' to avoid problems when using non real-time control software.

1. TECHNICAL SPECIFICATIONS

Shutter working area: 80 x 80 mm
Dimensions: 220 x 150 x 35 mm
Weight: 800 gm - (control electronic 300 gm)
Control cable: 2 meters of flat cable between shutter and control electronics
Power supply requirements: 18V, standby 0.25 A, working 1.2 A
Minimum exposure time: 10 ms
Blades driving: two step motors
Position and state feedback: two on-axis custom optical encoders.
Host interface:

- opto-coupled parallel TTL input control signals: open/close, reset, arm
- opto-coupled parallel TTL output control signal: readout of real exposed time

[1] Osservatorio Astronomico di Monte Porzio, Roma (Italy); Email: **pedik@coma.mporzio.astro.it**
[2] Osservatorio Astronomico di Trieste, Trieste (Italy)
[3] Osservatorio Astrofisico di Catania,Catania (Italy)
[4] Osservatorio Astronomico di Padova, Padova (Italy)
[5] C.F.R. Padova (Italy)

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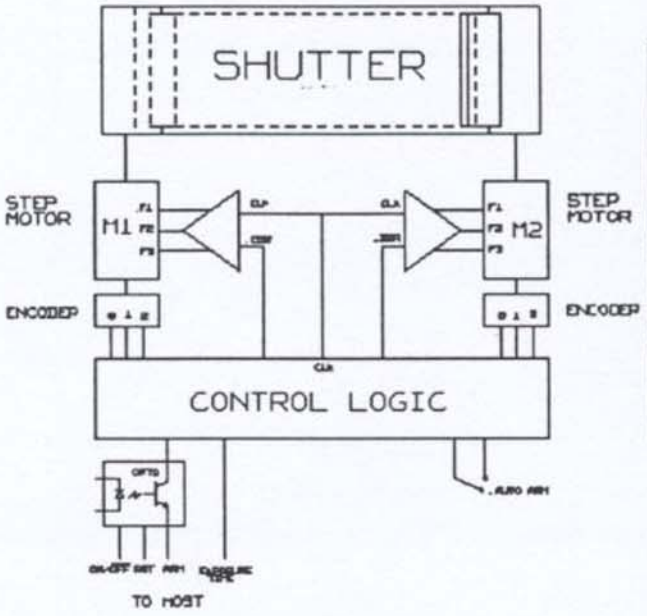
Reset and loading: automatic on power-up (it is possible to configure the control electronics for auto loading after the last exposure).



CLK	CLOCK FOR THE STEP MOTORS
F1, F2, F3	PHASES FOR THE STEP MOTORS
DIR	STEP MOTOR DIRECTION
ON/OFF	H=SHUTTER OPEN, L=SHUTTER CLOSED
RST	RESET THE ELECTRONICS
ARM	LOAD THE SHUTTER
AUTO ARM	IF CLOSED THE SHUTTER IS LOADED AUTOMATICALLY AFTER EXPOSURE
EXPOSURE	IF OPEN THE CONTROL LOGIC WAIT THE ARM SIGNAL TO LOAD THE SHUTTER
TIME	THE EXPOSURE TIME IS THE ELAPSED TIME BETWEEN ''UPPER BLADE HALF OPEN'' TO ''LOWER BLADE HALF OPEN''

Figure 1: TNG shutter block diagram

2. TEST RESULTS

2.1. Exposure uniformity

Exposure uniformity measurements on the 8x8 cm field has given the following result: ± 0.5 ms during 1 second exposure mean time.

2.2. Stress tests

The stress tests have been performed at a temperature of 22°C and at an altitude of 200 m above sea level.

The tests consist in:

- 2 series of 2000 exposures of 2 sec with a frequency of 0.1 Hz: the test has shown an increase in the device temperature less than 1°C.
- 1 series of 2000 exposures of 1 sec with a frequency of 0.2 Hz: the test has shown an increase in the device temperature of 1°C.
- 1 series of 1000 exposures of 0.4 sec with a frequency of 0.5 Hz: the test has shown an increase in the device temperature of 2°C.
- 2 series of 500 exposures of 0.2 sec with a frequency of 1 Hz: the test has shown an increase in the device temperature of 4°C.
- The control electronic working temperature was in the 30 - 35°C range. All the tests have not shown any significant stress.

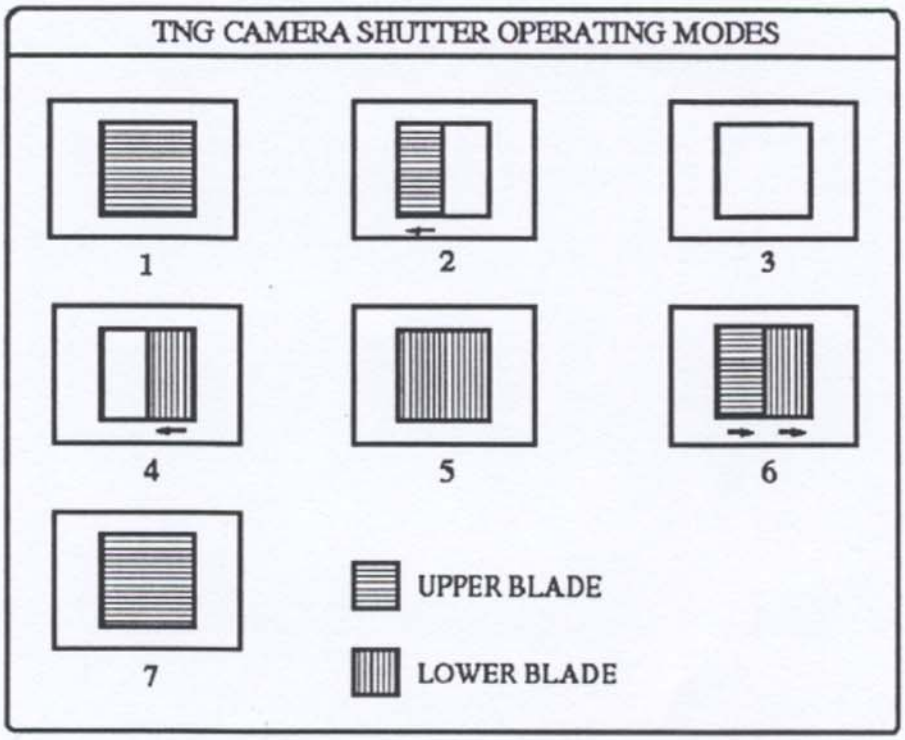


Figure 2: Operating modes

1. THE SHUTTER IS READY TO OPEN [both blades are loaded]
2. THE SHUTTER IS OPENING [upper blade is moving while lower blade is loaded]
3. THE SHUTTER IS OPEN [upper blade is open while lower blade is loaded]
4. THE SHUTTER IS CLOSING [upper blade is open and lower blade is moving]
5. THE SHUTTER IS CLOSED [both blades are open]
6. THE SHUTTER IS CLOSED [both blades are loaded]
7. THE SHUTTER IS READY TO OPEN [both blades are loaded]

3. CONCLUSIONS

The shutter has shown a very good reproducibility and uniformity of exposure with opening times of the order of ten milliseconds and is useful as a shutter for CCD cameras that mount large area detectors or CCD mosaics. No failure or malfunctions have been detected during test session of 8000 cicles. A final inspection revealed no degradation in the mechanic assembly and the moving parts. Future tests at 2200 m above sea level and at a temperature of -20° C are foreseen.

At the time of publishing three shutters have been produced by the C.F.R. in collaboration with ESO and the Osservatorio Astronomico di Roma for the SUSI 2 imager of ESO. Several improvements in the mechanics and the control electronics enhance the performances and the reliability of the system.

A black anti reflection painting (reflectivity < 0.3% from 300 nm to 1100 nm)has been applied o both blades and the body of the shutter is black anodized.

The 5 volt linear regulator has been substituted by means of a switching device to reduce the dissipated power.

All the mechanical parts have been machined with CNC tools and laser cutting to achieve a high production standard.

Simple self regulating springs have been added on the link between the blades and the pulling cables to reduce backlash.

The three shutters are now under intensive testing at ESO, C.F.R. (Padova) and in Rome to acquire detailed statistical performance.