OSIRIS

Optical, Spectroscopic, and Infrared Remote Imaging System

Shutter parameters for exposure time calculation

RO-RIS-MPAE-TN-073/1a

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D / -	10/07/2014	all	first draft
D / a	11/05/2015	7	added default shutter correction time and counter rollover
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1 General aspects

1.1 Scope

This document describes the method and parameters for calculating the effective exposure time.

1.2 Introduction

The OSIRIS WAC and NAC utilize a mechanical shutter for exposure control. The shutters have two parallel moving blades which move in front of the CCD, allowing illumination (exposure) times from a few milliseconds up to several minutes on the detector. The shutter blades are moved by precisely controlled motors, and their actual position is detected by optical encoders coupled to the motor shafts [RD1]. The shutter drive electronics provide a flexible method to generate arbitrary speed – position profiles for the shutter motion.

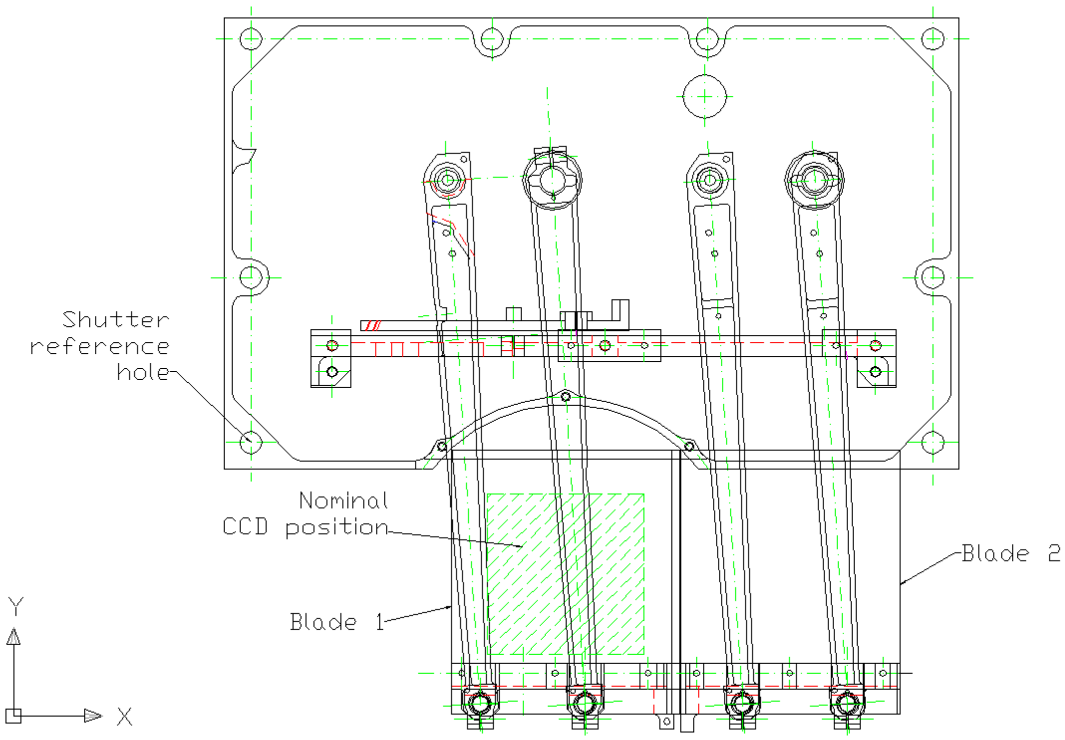

Figure 1 Shutter mechanism

1.3 Reference Documents

no.	document name	document number, Iss./Rev.
RD1	OSIRIS user manual	RO-RIS-MPAE-UM-004, D/s
RD2	Transfer function between the encoder measurement and the blades position of the FM WAC SHM	RO-RIS-UPD-TN-W333-219
RD3	Transfer function between the encoder measurement and the blades position of the FM NAC SHM	RO-RIS-UPD-TN-N333-213
RD4	Interface Plate	RO-RIS-UPD-DM-W331
RD5	OSIRIS calibration pipeline OsiCalliope	RO-RIS-MPAE-MA-007, D/-

2 Exposure time calculation

2.1 Calculation method

The motion of the shutter blades is controlled by the driver electronics, based on a preprogrammed speed profile. Since the velocity is not constant across the CCD surface, and the acceleration profiles of the two blades are different, the actual illumination time can only be calculated from the shutter position function. In order to obtain the position-time function, the shutter system uses encoders on the motor shafts. For the precise time base, the electronics utilize a 2.1 MHz clock signal and two separate 14 bit counters, one for each blade. These counters are sampled each time the encoder sends a pulse.

The first counter resets at the exposure start signal, when the first blade motor is activated. The second counter resets at the end of the commanded exposure time, when the second blade is activated. In this way the counters deliver a relative time value for each encoder position. Based on the shutter transfer functions [RD2, RD3], the actual positions of the shutter cutting edges are calculated. The time difference between the two shutter functions at the same location over the CCD gives the actual exposure time.

2.1.1 Counter rollover

Each counter holds the number of clock pulses since its reset. Considering that these units are 14 bit counters, the number will roll over after 16384 pulses. This rollover is partially handled by the on-board software. Partially means, that the spacecraft software examines the sampled values of the counter, and supposing a continuously increasing time, if the value is smaller than the previous one, the rollover number n is incremented and the pulse count is calculated by increasing its value by $n \cdot 16384$. This method should be corrected when the sampling time interval is larger than *16384/2.1MHz*.

2.1.2 The "ZEROPULSE_FLAG"

To ensure a stable reference point for the blades, the encoders provide an additional signal, a "ZERO_PULSE" to the electronics. This is a reference point of the encoder, thus not affected by the mechanical elasticity, or wear out. The position of this pulse is not coincident with the shutter nominal (home) position. During the image acquisition the "ZEROPULSE_FLAG" determines the first sampling position of the pulse count:

- ZEROPULSE_FLAG = FALSE: the first sample in the pulse array is the time count at the first encoder pulse (practically the start of the blade motion).
- ZEROPULSE_FLAG = TRUE: the first sample in the pulse array is the time count at the zero pulse position. This gives a more accurate positioning; however the counter rollover during the first time slot must be handled separately.

2.2 Shutter parameters

The shutter parameters are used to calculate the blade cutting edge position, as a function of the encoder position. They are derived from the mechanical dimensions, measurements during system integration [RD2, RD3], and operational tests.

The shutter transfer function is:

$$x = L \cdot [\sin(\Theta_0) + \sin(n \cdot 0.05° + \Theta_z - \Theta_0)] - x_0$$

Where:
- x : cutting edge position of the blade, relative to the CCD edge
- L : shutter arm length (100.00 mm)
- θ_0 : rotation angle of the shutter arm in nominal (home) position
- n : the number of encoder pulses
- θ_Z : rotation angle of the shutter arm from nominal (home) position, to the zero encoder pulse position
- x_0 : distance between the blade cutting edge and the CCD edge, in the nominal (home) position

Parameter	NAC FM		WAC FM		Source
	Blade1	Blade2	Blade1	Blade2	
L	100.00 mm	100.00 mm	100.00	100.00	RD2, RD3
θ_0	3.56 °	3.77 °	4.95 °	4.16 °	RD2, RD3
θ_Z	1.025 °	1.95 °	1.9 °	1.2 °	Calculations*
x_0	8.796 mm	6.956 mm	9.136 mm	7.146 mm	RD2, RD3, RD4
Counter rollover	0	1	1	0	Calculations*
Default exposure time correction	-0.0027 s		-0.0025 s		Calculations*

* Calculations are based on matching full shutter data of images (ZEROPULSE_FLAG = FALSE) with (ZEROPULSE_FLAG = TRUE) :

- WAC_2008-03-19T21.48.40.651Z_ID10_0000000150_F12.IMG
- NAC_2008-02-13T23.05.57.436Z_ID10_0000000200_F21.IMG

3 Ballistic mode

Description pending.

4 Calibration files used by OsiCalliope

The calibration files used by OsiCalliope to calibrate OSIRIS images are:

for “Regular” mode: described in RO-RIS-MPAE-MA-007_1_a.docx

for “Ballistic” mode:

- NAC_FM_EXP_BAL_V01.TXT
- WAC_FM_EXP_BAL_V01.TXT
- WAC_FM_EXP_20160323_V01.TXT
- WAC_FM_EXP_20160405_V01.TXT

Previous versions:

for “Ballistic” mode:

- NAC_FM_EXPOSURE_BAL.LBL
- WAC_FM_EXPOSURE_BAL.LBL
- WAC_FM_EXPOSURE_20160323.LBL
- WAC_FM_EXPOSURE_20160405.LBL