AVT/Prosilica GC 1350 test

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Prepared	L. Busoni, M. Bonaglia	2010/09/13
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Change Record

Issue	Date	Section/ Paragraph Affected	Reasons / Remarks	Name
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1 Scope

This technical note describes the tests performed on a Prosilica/AVT GC1350 camera candidate to be used as acquisition camera for ARGOS's WFS.

2 Applicable documents

No.	Title	Number & Issue
AD 1	http://www.ccd.com/pdf/ccd_205.pdf	
AD 2	http://www.arcetri.astro.it/~mauro/Lezioni/Rumore%20nei%20CCD.pdf	

3 Introduction

Prosilica/AVT produces the GC-series of cameras suited for industrial applications characterized by an ultra-compact and light-weight body with Gigabit Ethernet interface.
The GC1350 is a candidate for the WFS patrol camera because of low price (1.5kEuro) and small size and weight. This application doesn't put any strong requirement neither on camera noise nor on camera speed: expected flux is in the order of 300Mph/s and frame rate is supposed to be in the order of Hz, so the use of high-level CCD is not motivated. On the other hand, the small package of the camera is convenient from the mechanical point of view because focal plane shift resulting from flexures of the patrol camera assembly will be reduced.

GC1350 main features [AD1] are:

- Resolution: 1360x1024
- Full frame rate: 20fps
- A/D: 12 bit
- Sensor: ICX 205 square pixels of 4.65um
- Full Well: 10Ke-
- Exposure: 10µs to 60s in µs steps
- ROI and binning
- External trigger and RS232.
- Software SDK available for Windows, Linux, Mac.
- Size 33x46x59mm 100g

A GC1350 camera was received on August 2010. In this documents we report on the software developed to control the camera via IDL and on test done in the lab to measure the camera's main characteristic. A cold test in the freezer will be performed soon to test functionality at low temperatures.

Figure 1 Prosilica/AVT GC1350

All tests, except for cold test, performed at lab temperature using a 632nm laser. Flat field illumination done with a folded paper sheet (very rough!!). Dark measurements done using the camera cover to prevent light from reaching the detector.

4 Bias image

A bias image acquired in the dark with minimum exposure time (10 µs) is shown in Figure 2. The average offset has a median value of 14 ADU and is fairly well following a Gaussian distribution. Some column

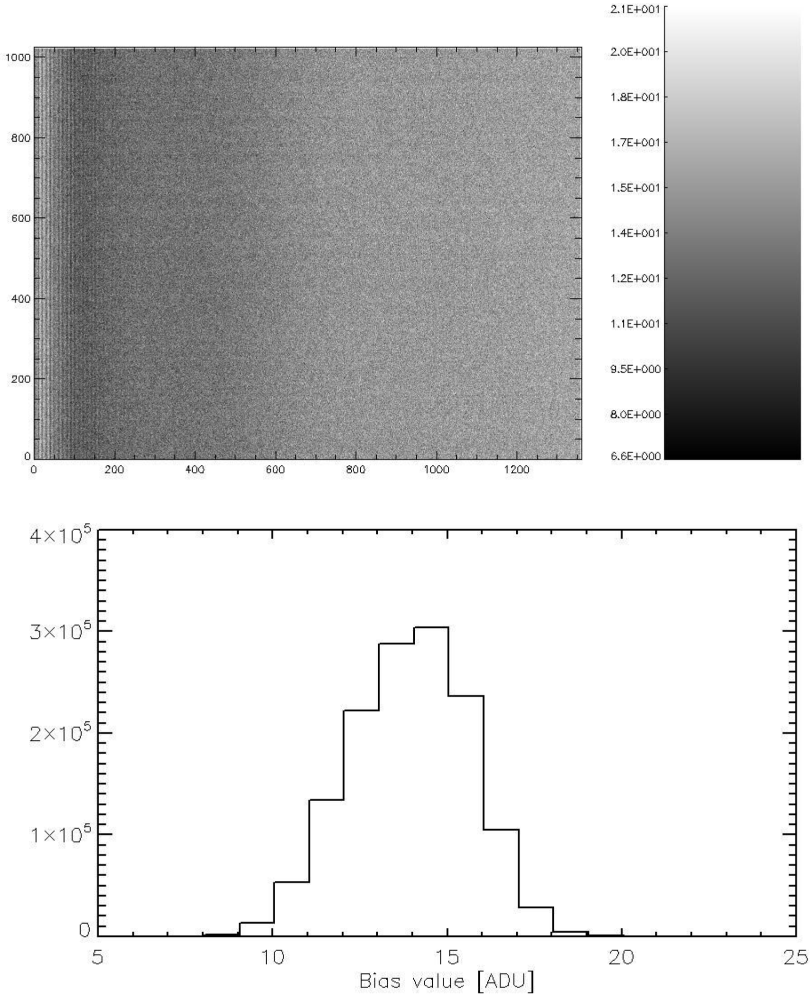

Figure 2 Bias image and histogram of bias level. Some column noise is visible on the left of the image.

noise is visible especially in the first 50 columns on the left of the image.

5 Gain

The gain of the camera has been measured taking images of a flat field at different exposure values ranging from 200us to 10ms giving average counts from 45 to 1400 ADU (bias is 15 ADU).

For every exposure time, 20 images at 4 Hz were acquired, and time-average and variance of each pixel were computed.
The gain was computed by linear fitting of variance vs. time-average for each pixel in the range of counts between 50 and 1400 ADU where sensor linearity is very good.
A histogram of the gain value is shown in Figure 3 (bottom): bad pixels (defined as pixels having a gain value outside the 6-sigma confidence interval) have been excluded from the plot. The number of bad pixels amounts to 0.1% of the total, without any peculiar pattern (as shown in Figure 3, top).
The median value of the gain is 3.9±1.6 e-/ADU.

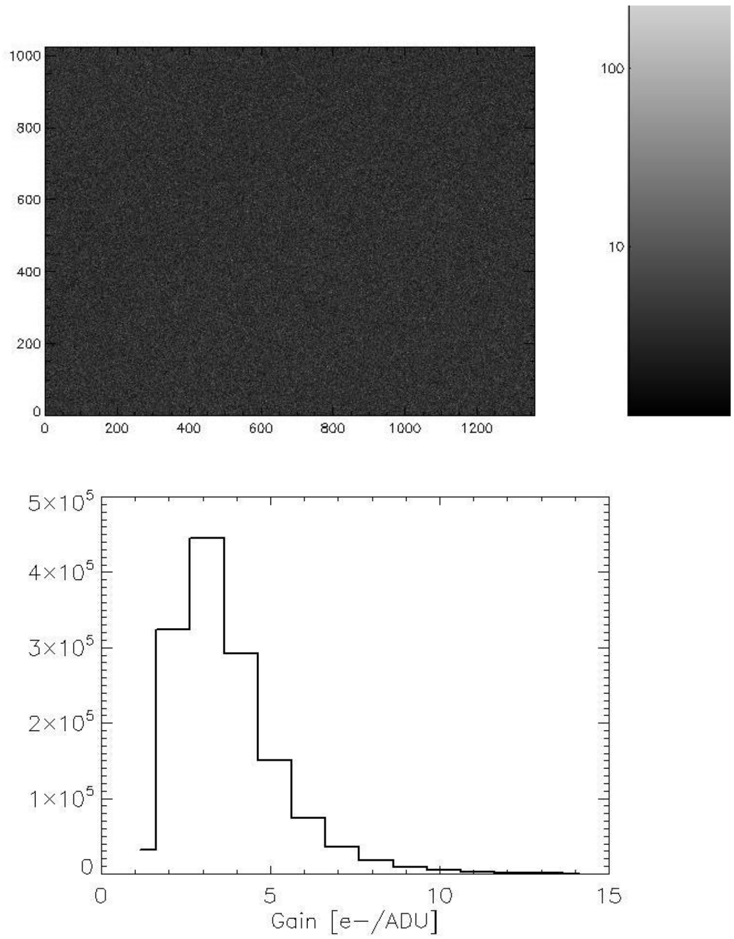

Figure 3 Gain map (log scale) and histogram of gain. Only "good" pixel have been used for the histogram (see text).

6 Read out noise

Readout noise has been measured from the variance of the bias image, taken at minimum exposure time (10 us) in the dark. The median value of the variance of the bias image is 27 ADU^2 corresponding to a RON noise of $20e^-$.

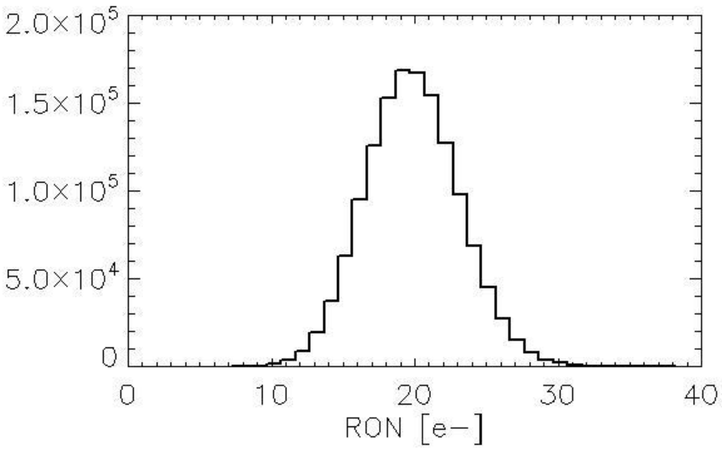

Figure 4 Read out noise distribution

7 Linearity

The linearity of the sensor is shown in Figure 5. A constant intensity with varying exposure time has been used. Each point is the median value of a long-exposure image made of 10 frames, bias subtracted. The solid line is a linear fit of the measurements from 10µs to 3ms corresponding to 1200 ADUs.

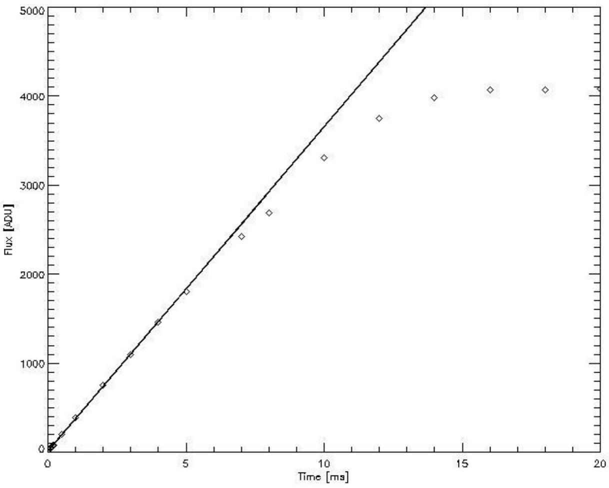

Figure 5 Linearity of the sensor

8 Dark current

To measure the dark current several sets of 10 dark frames have been acquired with exposure times in the range 10µs – 60s. Note that the camera is not cooled, and at the time of the test it was powered on and used for 3h. When used (expecially in case of intense Ethernet communication) the camera body and the circular connector becames warm. This may be an issue at the telescope because of the constrain about the allowed delta-temperatures with respect to the dome temperature.
The histogram in Figure 6 has been obtained removing hot pixels (defined as pixels having a dark current value outside the 6-sigma confidence interval). The median value is 0.9 e/s/px; the number of hot pixels is 0.3% of the total and is distributed quite uniformly has shown in Figure 7. The glow at the frame bottom visible in the dark current map (Figure 6, right) has been reported to be due to the diode protection glow [AD 2].

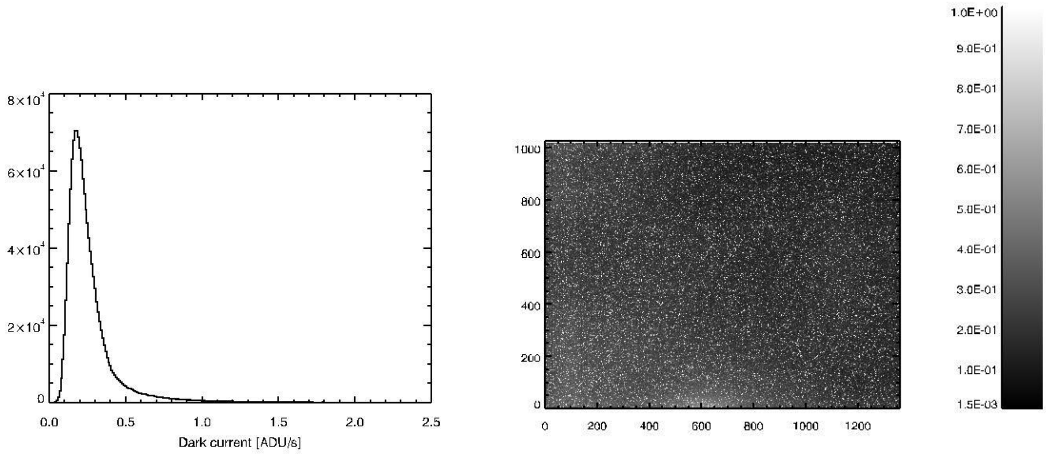

Figure 6 Dark current histogram (left) and map (right).

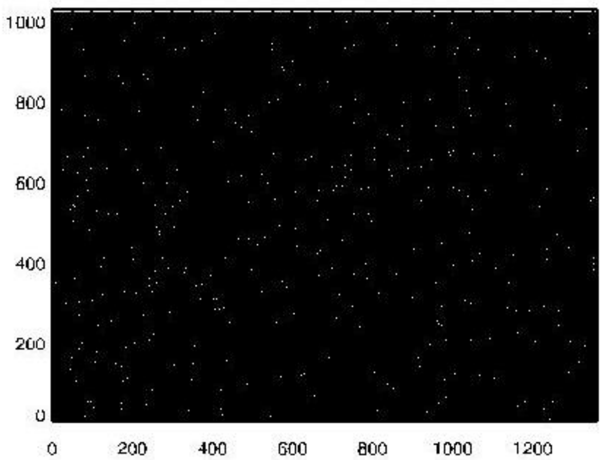

Figure 7 Hot pixel map

9 Cold test

Cold test has been done to check the functionality of the camera at low temperatures. The camera is placed in a transparent plastic box with silica packs and a pipe to flux nitrogen at very low rate. A pattern to be imaged is placed inside the freezer and a light bulb is used as heat and light source . Every devices can be switch on and off remotely. The temperature is measured with a thermo-couple. Relative humidity is not measured.
In a first run a cycle 20°C to -30°C and back has been done, keeping the camera always powered on and acquiring images every 5°C step.
In a second run, the camera was kept switched off and thermalized at -30°C. Then, it was switched on and off several times to check cold-start.
All these functionality tests were successful without any error to be reported.

Figure 8 Cold test setup

10 Flexure test of Patrol Camera assembly

The patrol camera assembly is composed of a tube, 3 commercial lenses and the patrol camera. The telescope focal plane (on one side of the tube) is imaged on the detector (at the other side of the tube).
We want to check the co-alignemnt of these conjugated planes under gravity changes to assess the accuracy of the patrol camera measurements of the laser pointing direction. The goal is to have a shift of <1 arcsec on sky, to be capable of repointing the laser inside the WFS field stop.
To be done

11 Software

The camera's vendor provides an SDK comprehensive of examples and shared libraries. SDKs are available for Linux, Windows and MacOS.
To control the camera from IDL, a Dynamic Loadable Module (DLM) was developed. A DLM is a library written in C using IDL's internal API that is dynamically loaded at run time. A set of functions in the DLM can be exported as function/procedures into IDL.
In this case the DLM was linked against both IDL and AVT shared library to provide IDL access to AVT API.
A simplified functionality was implemented:

- a list of the cameras present on the network can be retrieved including camera name and IP address
- a camera can be open using its IP address
- Camera's attributes can be set or read (e.g. ROI, Binning, FrameRate, ExposureTime)
- A set of frames can be acquired
- The full list of attributes of the camera can be read and added to the frames as header in a FITS file.

The software sets the camera in Continuos acquisition mode at Fixed frame rate, without triggering capabilities.

An example of code (self-explaining, of course):

```
cam = obj_new('AVT', '192.168.18.10')
cam->setROI,[0,0,1360,1024]
cam->setFrameRate, 4
n_samples = 20
cam->setExposure,5d-3
frames = cam->getFrames(n_samples, info=info5000, file='dark_5000us.fits')
```

The DLM has been tested under Windows XP / 7 with IDL 7.0/8.0 and under Linux Ubuntu with IDL 8.0.

End of document