Technical Note – AGC and NUC

AUTO GAIN CONTROL & NON UNIFORMITY CORRECTION

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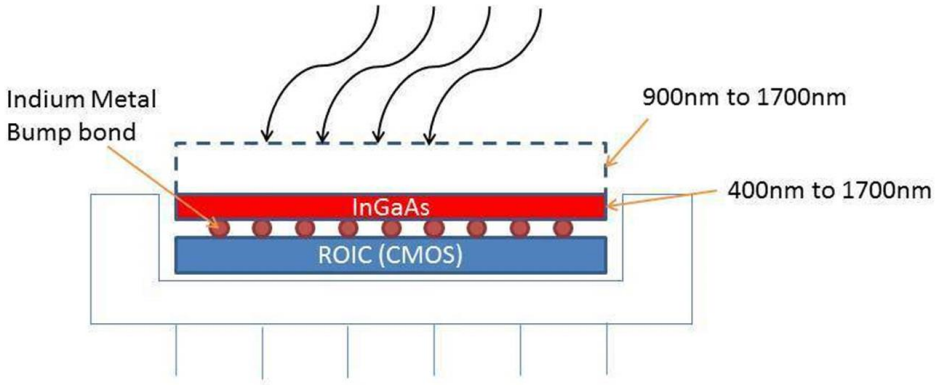
Understanding InGaAs FPA sensors

Short Wavelength Infra-Red (SWIR) cameras use an InGaAs Focal Plan Array (FPA) sensor which is consists of an InGaAs sandwich bonded to a CMOS read out integrated circuit (ROIC) by indium dots. SWIR photons are converted into electrons within the InGaAs layer; these electrons are then channeled via the indium dots to the ROIC which read the corresponding image just like any other standard CMOS.



Non Uniformity Correction

The sandwich architecture described above makes it extremely difficult to manufacture a sensor where all the pixels are fully functional. Issues between the InGaAs layer, the indium dots and the CMOS ROIC are inevitable. Therefore, all SWIR cameras have a pixel operability specification describing how many pixels are operating within normal parameters. Typically the best camera achieves 99% to 99.5% pixel operability. The remaining 1% to 0.5% pixels can be, dead, hot or simply vary too much from the average. These must be compensated for to achieve a good image quality.

This architecture also means that a SWIR camera offers the same benefits as any other CMOS, no charge transfer and fast frame rate. But it also suffers for the same issues, eg. rolling vs global shutter, but most importantly the fact that since each pixel has its own A/D converter, each one will have a slightly different value of offset, gain and dark current.

A scientific CMOS has low readout noise, low dark current and small pixel well depth, so pixel to pixel variations remain small. Whereas, a SWIR camera has larger readout noise because the ROIC is not a scientific CMOS and very large dark current and pixel well depth because of the InGaAs FPA,

Therefore, in order to obtain the same image quality as a single A/D device such as a CCD with a SWIR camera, offset, gain and dark current corrections must be made. These are specified as Non Uniformity Correction (NUC).

Raptor's family of SWIR cameras have an on board FPGA which is capable of not only compensating for the damaged pixel but also to take care of the NUC. This all happens in real time during the acquisition. The user simply has to select the level of correction desired.
See Figure 1 below for examples:

Image	Correction selected	Description of correction
1	NO NUC	Raw Image
2	1 Point NUC	Bad pixel and offset
3	1 Point NUC	Bad pixel, offset and gain
4	1 Point NUC	Bad pixel, offset, gain and dark current

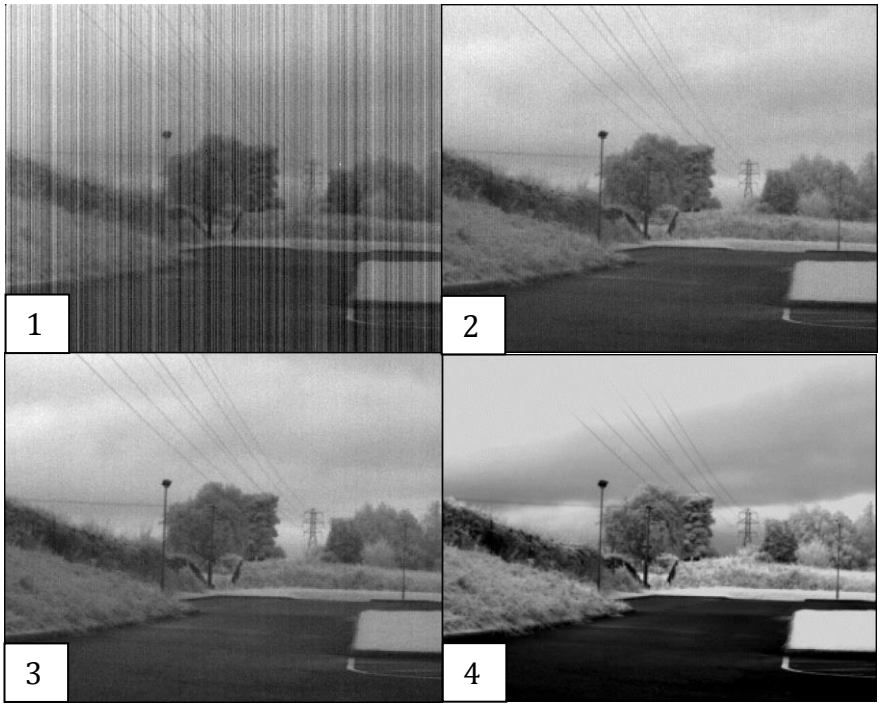


Figure 1: NUC states from RAW image to Offset, Offset+Gain, Offset+Gain+Dark Current

Auto Gain Control

As well as offering NUC in real-time, Raptor's family of SWIR cameras are also capable of continuously performing the Auto Gain Control (AGC) on the onboard FPGA. The AGC constantly checks the signal level and automatically adapts the exposure time and the digital gain accordingly. Like the NUC, the AGC can be simply switched on or off by a simple serial command allowing the user to fix the exposure time and gain manually if he / she so choses.

Active Image Enhancement

SWIR cameras sensors are limited to low resolution, 320x256 and 640x512. In order to further increase the image quality, the Owl 640 FPGA also includes a proprietary Active Image Enhancement (AIE) algorithm which extrapolates the resolution to an equivalent of 1024x800. Figure 2: Owl 640 without and with Active Image Enhancement (Image B). You can see this more clearly in this example video.

Again like the AGC, this feature can be engaged with a simple serial command.

Figure 2: Owl 640 without and with Active Image Enhancement

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Raptor Owl specifications and features

	Owl High Speed	Owl 320	Owl 640
Sensor	3-5 lab		SCD
Resolution	320x256		640x512
Pixel Size	30x30µm		15x15µm
Frame Rate	350 Hz	60 Hz	120 Hz
ROI readout	YES (up to 40 kHz)	NO (only for AGC)	
AGC	NO (all manual)	YES	
NUC	2 points	3 points	
AIE	No		Yes
Readout noise (High Gain)	<150 e^-		<50 e^-
Readout noise (Low Gain)	<700 e^-		<180 e^-
Pixel Well Depth (High Gain)	170,000 e^-		12,000 e^-
Pixel Well Depth (Low Gain)	3,500,000 e^-		650,000 e^-
Spectral Range	SWIR or Vis-SWIR		Vis-SWIR only
Peak QE	75% or 93%		85%

Figure 3: Owl 320 and 640

- **SWIR technology.** Enables high sensitivity imaging from 0.9mm to 1.7mm
- **High quality sensors,** 99% operability, 320x256 30µm or 640x512 15µm
- **Optional Visible extension.** Enables high sensitivity imaging from 0.4mm to 1.7mm
- **14 bit CameraLink output.** Enables high speed digital video with intelligent auto AGC
- **On-board Automated Gain Control (AGC).** Enables clear video in all light conditions
- **On-board intelligent 3 point NUC.** Enables highest quality images
- **Active Image Enhancement.** Further increases the image resolution of the 640x512 sensor
- **Easy control of camera parameters.** Control of Exposure, Gamma and intelligent AGC
- **500ns minimum exposure.** Ideal for active imaging applications
- **Ultra compact,** 50x50x82mm/282g
- **Low power (< 5W).** Ideal for hand-held, mobile or airborne systems
- **Rugged, fanless.** Operation tested up to 2.3 Teslas.

The live 3 point Non Uniformity Correction without user calibration, combined to the Auto Gain Control and Active Image Enhancement are unique features in the industry which combined to the best quality sensors available on the market allows the Owl to achieve excellent image quality without any action from the user.

About Raptor Photonics

Raptor Photonics Limited is a global leader and manufacturer of high performance, industrial-grade and extremely rugged ultra-low light digital & analogue cameras. Raptor specializes in complete cameras and core engine solutions using CCD, EMCCD, Scientific CMOS and SWIR sensor technology. The extreme low light capability of Raptor's cameras makes them ideal for day/night surveillance, homeland security and scientific markets. Raptor Photonics Ltd is a registered ISO 9001:2008 company and is headquartered in Larne, Northern Ireland.

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