VISION SYSTEMS TECHNOLOGY, LLC

CASE STUDY

Calculate Sensitivity

Calculating the Sensitivity of a Camera

If you need to know the output response of your camera to a givin illumenation level, you can a make mathimatical calculation to solve this question. You will need to have some information about the imaging sensor in the camera and the amount of light that you plan to illuminate a scene. The camera datasheet can provide you this information specific to your camera model. Let's begin with an exdample to illustrate how to make the calculation. The Photron SA1 High Speed camera will be used as an example.

First, lets calculate the case for full resolution of the SA1.1 camera with an exposure of 50 uS. The SA1.1 has an advanced CMOS sensor with a full resolution of 1024 x 1024 pixels. For our example, lets assume the scene we will photography is illuminated with a laser operating at 766 nm. The amount of ilumination from the laser at 766 nm is known either by empericaly measuring the flux density or getting this information from the laser's specification. The flux density for our example will be 10.0 uW/cm^2.

Step 1

The number of electrons, which the array will generate for a given incident light flux and a specific integration time, is given by:

$$Ne = \frac{Pn \times A \times FF \times QE}{NP} \times EXP$$

Where:

A = area or array

NP = number of pixels in the array area

FF = fill factor

QE = Quantum Efficiency in e-/photon

EXP = integration time

Pn = number of photon per unit time

Pn = F x N (photons/sec/cm^2)

N = l / hc

where h = Planck's constant ~ 6.63×10^{-34} J-sec

c = speed of light ~ 3.0×10^{8} m/sec

N = l x 5.0277×10^{15}

Example: PHOTRON FASTCAM SA1.1

sensor resolution: 1024 x 1024 = 1,048,576

pixel size: 20 um (square)

array area: 419.43 mm^2 = 41.943 cm^2

fill factor: 52%

QE @ 766 nm: 17 A/W, ~ 37%

integration time: 50 uS

output conversion: 25 uV/e-

pixel well depth: 45,000 e-

noise floor: 38 e-

Step 2

N = 766 nm x 5.0277×10^{15}

~ 3.851×10^{18} photons/J

and the flux density

F = 10.0 uW/ cm^2 = 10.0 10^{-6} J/sec/ cm^2

Pn = N x F

= 3.851×10^{18} photons/J x 10.0 uJ/sec/ cm^2

= 3.851×10^{13} photons/ sec/ cm^2

To get the number of photons over the full array, multiply the (Pn) x array area

3.851×10^{13} photons/ sec/ cm^2 x 41.93 cm^2 =

161.47243×10^{13} photons/ sec/ array

Step 3

Now we apply the fill factor and divide by the number of pixels and we get the number of photons, which can be generated, at each photosite:

$$\frac{(161.47243 \times 10^{13} \text{ photons/ sec/ array} \times (0.52))}{(1{,}048{,}576 \text{ pixels/array})}$$

= 800.758968×10^{7} photons/ sec/ pixel

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STEP 4

multiply by the QE @ 766 nm

800.758968×10^7 photons/ sec/ pixel x (0.30 e-/photon)

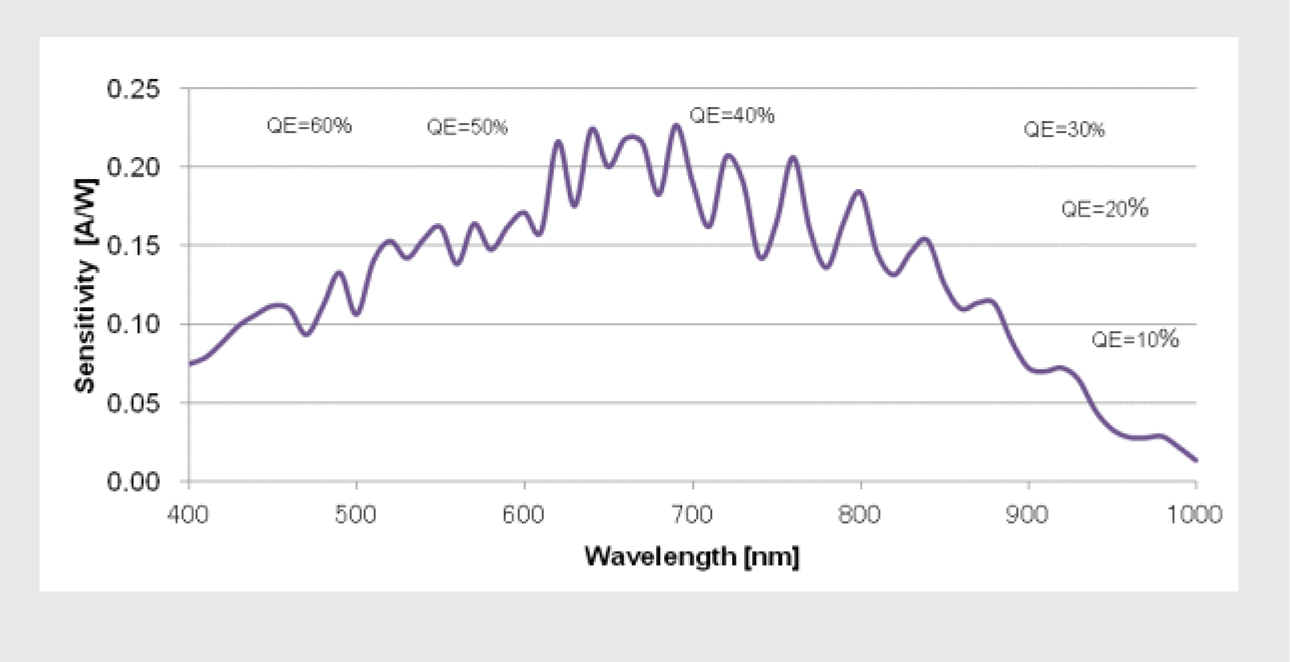
$= 240.23 \times 10^7$ e -/ sec/ pixel

multiply by the integration time

240.23×10^7 e -/ sec/ pixel x 50 uS = 12,011.5 e - / pixel

And the output voltage at the pin:

12,011.5 e - / pixel x 25 uV/e- = 0.3002875 V



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