

MICRO-523: Optical Detectors

Week Seven: CCD Cameras: Electronics & Noise Sources – Exercises

Claudio Bruschini

Institute of Electrical and Micro Engineering (IEM), School of Engineering (STI)
Ecole polytechnique fédérale de Lausanne (EPFL), Neuchâtel, Switzerland

Based on MICRO-523, P.-A. Besse, 2025

TAs: Samuele Bisi, Kodai Kaneyasu

The logo of the École Polytechnique Fédérale de Lausanne (EPFL), consisting of the letters 'EPFL' in a bold, red, sans-serif font.

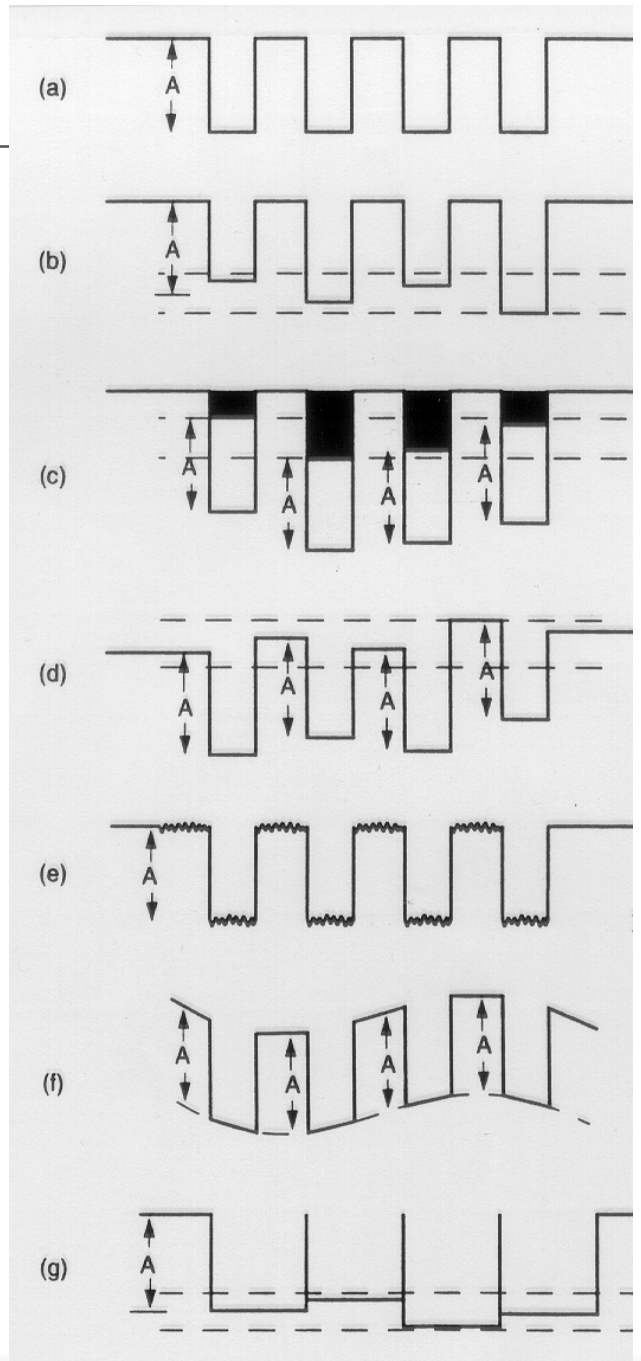
Outline

- 7.1 Noise Sources in Cameras
Calculation of SNR and DR values
- 7.2 Correlated Double Sampling

Exercise 7.1: Noise Sources in Cameras

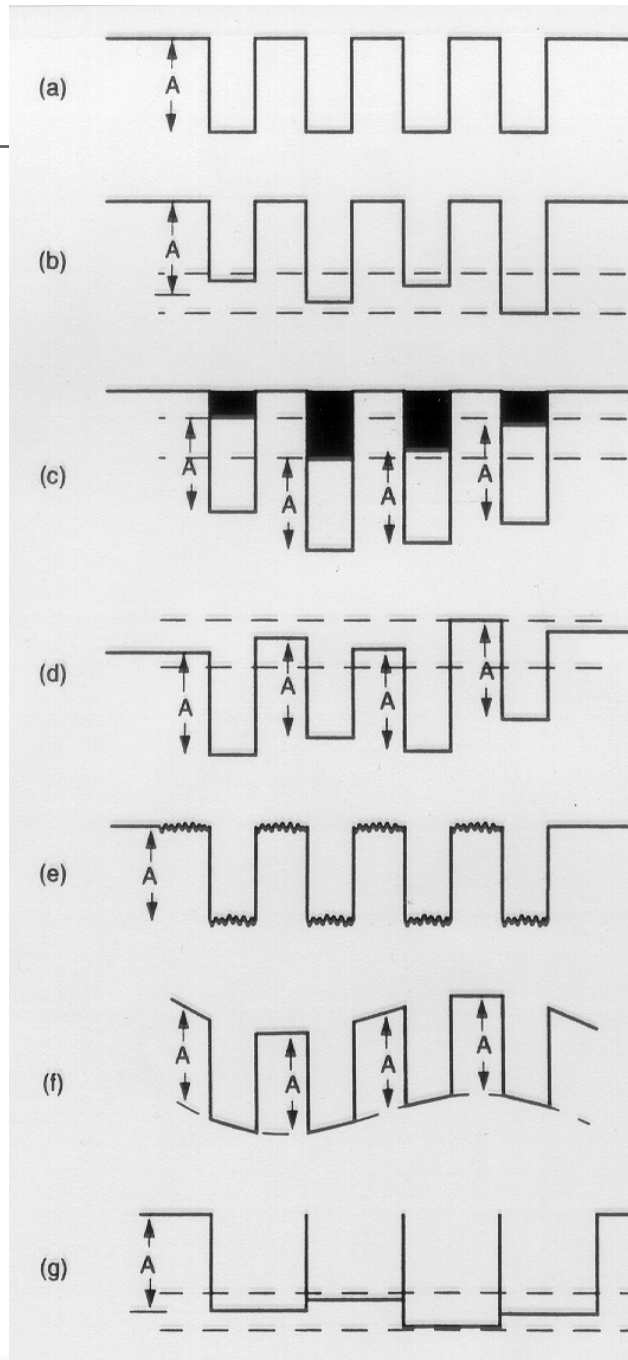
Consider the signal in (a):

1. Name the different noise terms in b,c,d,e,f,g
2. Which noise terms depend on the wavelength of light?
3. Which noise terms depend on temperature, and which depend on capacitance ?



Homework: Noise Sources in Cameras

4. Suggest ways to reduce the noise
5. In which case decreasing noise leads to decreasing the signal?



Homework: Calculation of SNR and DR values

6. Determine the S/N using the following values (neglect flicker noise):

Power=1 mW

Dark current $I_{dark} = 1 \text{ pA}$

Photosensitive area: $1 \text{ }\mu\text{m}^2$

Integration time: 10 ms

Fill factor: 1

Frequency: 193 THz

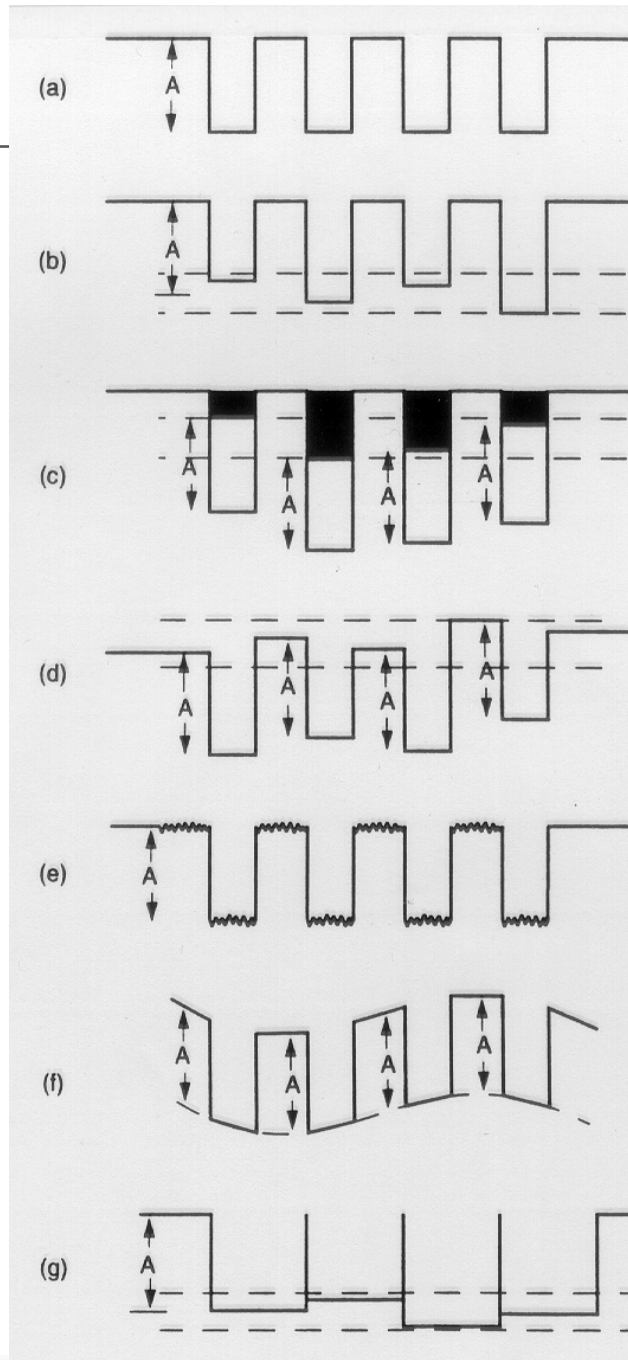
Quantum efficiency: 1

Capacitance: 10 fF

Readout resistance: 1 kOhm

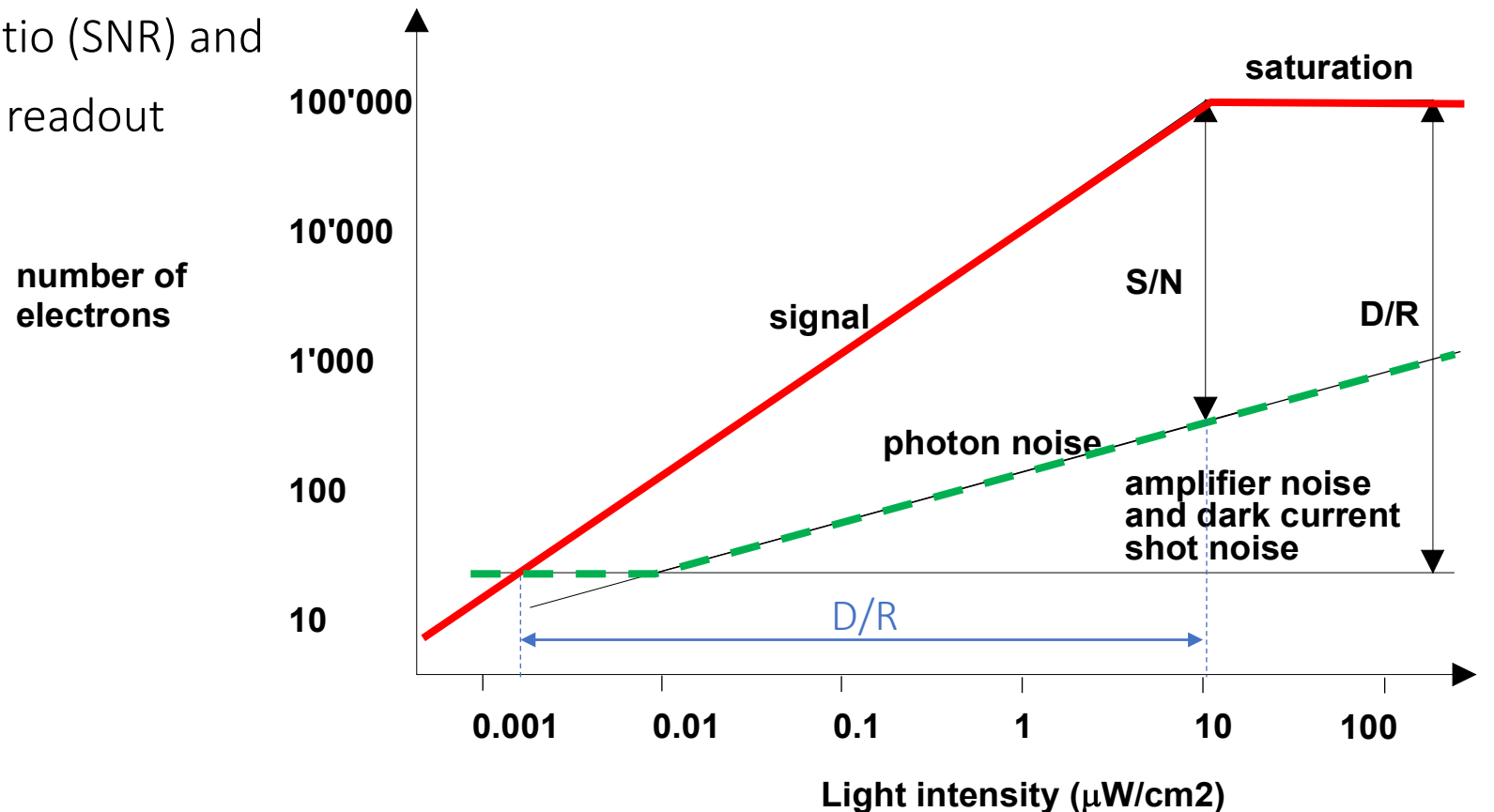
$\Delta f=1 \text{ MHz}$

$T=25^\circ\text{C}$

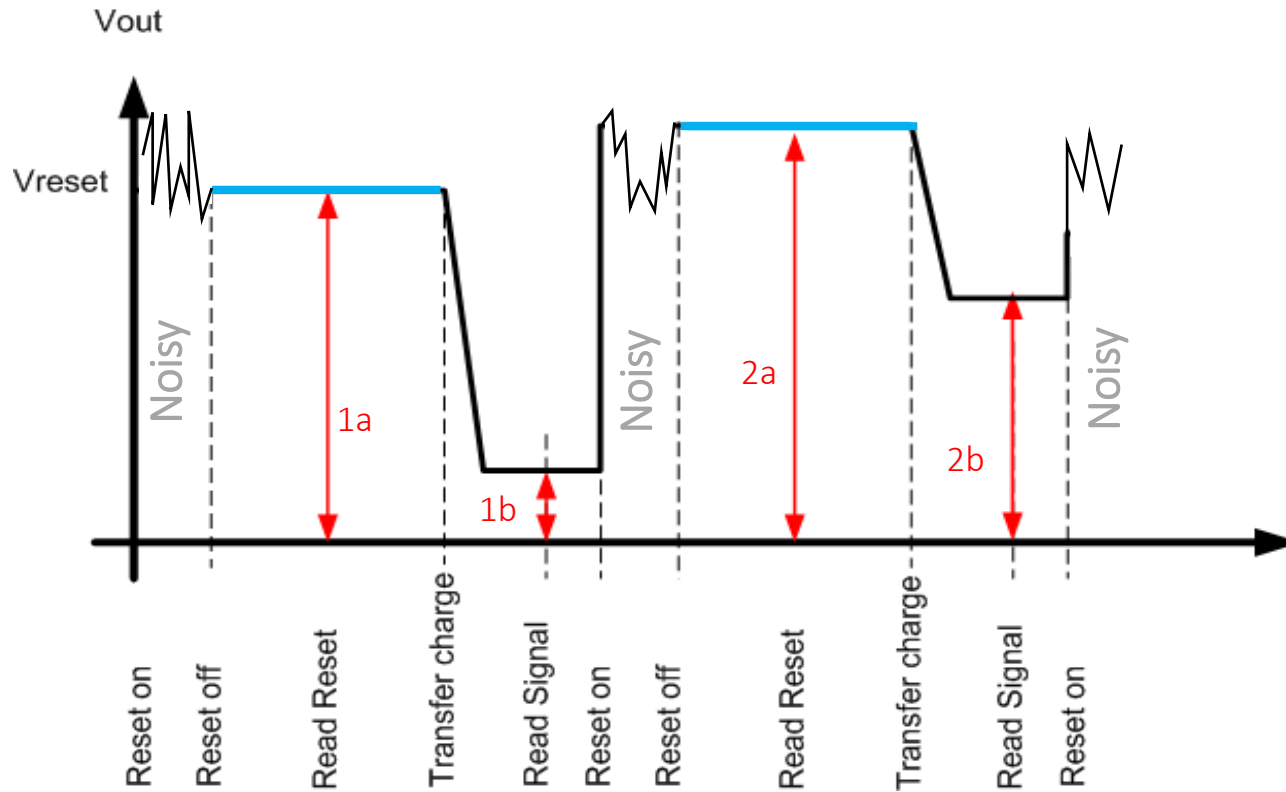


Exercise 7.1: Dynamic range

- Consider a camera with a full well capacity of 62'500 electrons
 - Read noise: 25 electrons per pixel/readout
 - Dark current: negligible
1. Calculate signal-to-noise ratio (SNR) and dynamic range (DR) for a single readout at full well capacity



Exercise 7.2: Correlated Double Sampling



How does CDS work?

What are its main advantages?

Can we improve on CDS?

