McLean Sec11 Ex5&11

Misato Fujii

5 Why are CCDs not used as the silicon multiplexers for IR arrays?

CCDs do not respond >1.1um

cutoff wavelength $\lambda_c = \frac{hc}{E_G} = \frac{1.24}{E_G}$

h: Planck's constant

c: speed of light

bandgap energy of Si $E_G = 1.13eV$

Table 5.2. Forbidden energy gaps for some common semiconductors.

Name	*Symbol*	*T* (K)	E_G (eV)	λ_c (µm)
Gallium nitride	GaN	295	3.45	0.36
Silicon carbide	SiC	295	2.86	0.43
Cadmium sulfide	CdS	295	2.4	0.5
Cadmium selenide	CdSe	295	1.8	0.7
Gallium arsenide	GaAs	295	1.35	0.92
Silicon	Si	295	1.12	1.11
Germanium	Ge	295	0.67	1.85
Lead sulfide	PbS	295	0.42	2.95
Indium antimonide	InSb	295 77	0.18 0.23	6.9 5.4
Mercury cadmium telluride	$Hg_xCd_{1-x}Te$	77	0.1 ($x = 0.8$) 0.5 ($x = 0.554$)	12.4 2.5

See: *http://www.semiconductorsdirect.com*

11 Sketch the output signal as a function of time for an infrared array, and use the graph to illustrate what is meant by (a) single-sampling, (b) correlated double-sampling, and (c) multiple-sampling.

Reset
→signal shifts to the pedestal level
→integration (detector begins to discharge due to photocurrent or dark current)

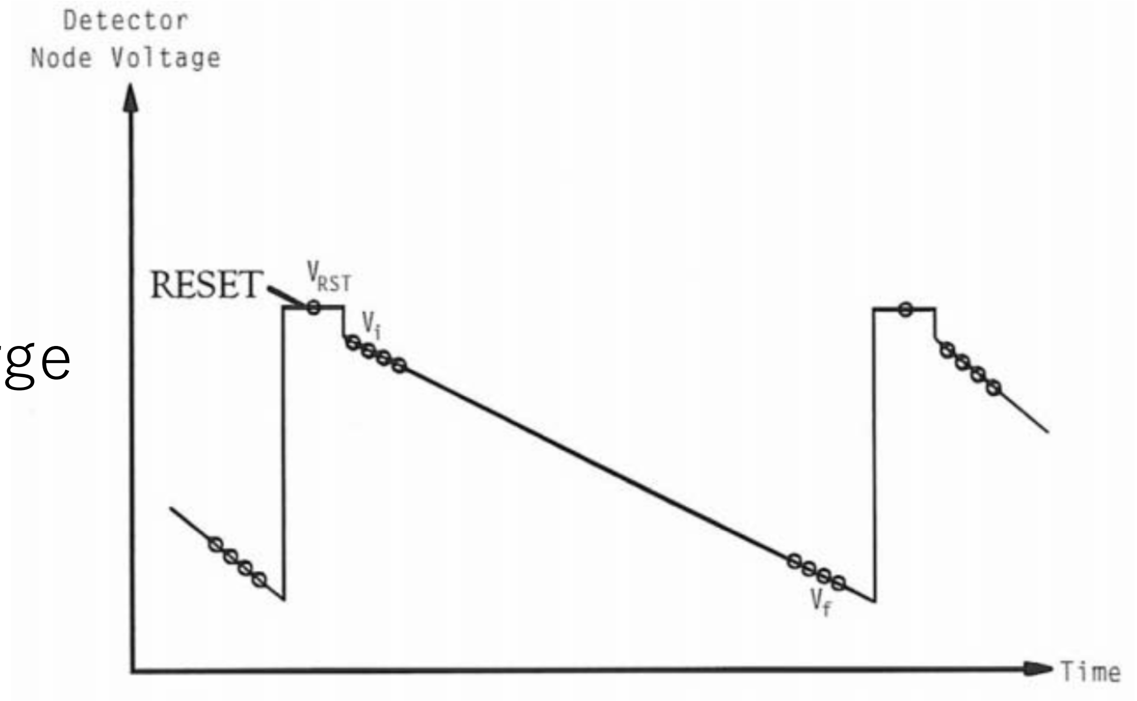

Figure 11.12. The schematic variation of the output voltage as a function of time for a typical pixel in an infrared array detector. Associated readout modes are described in the text.

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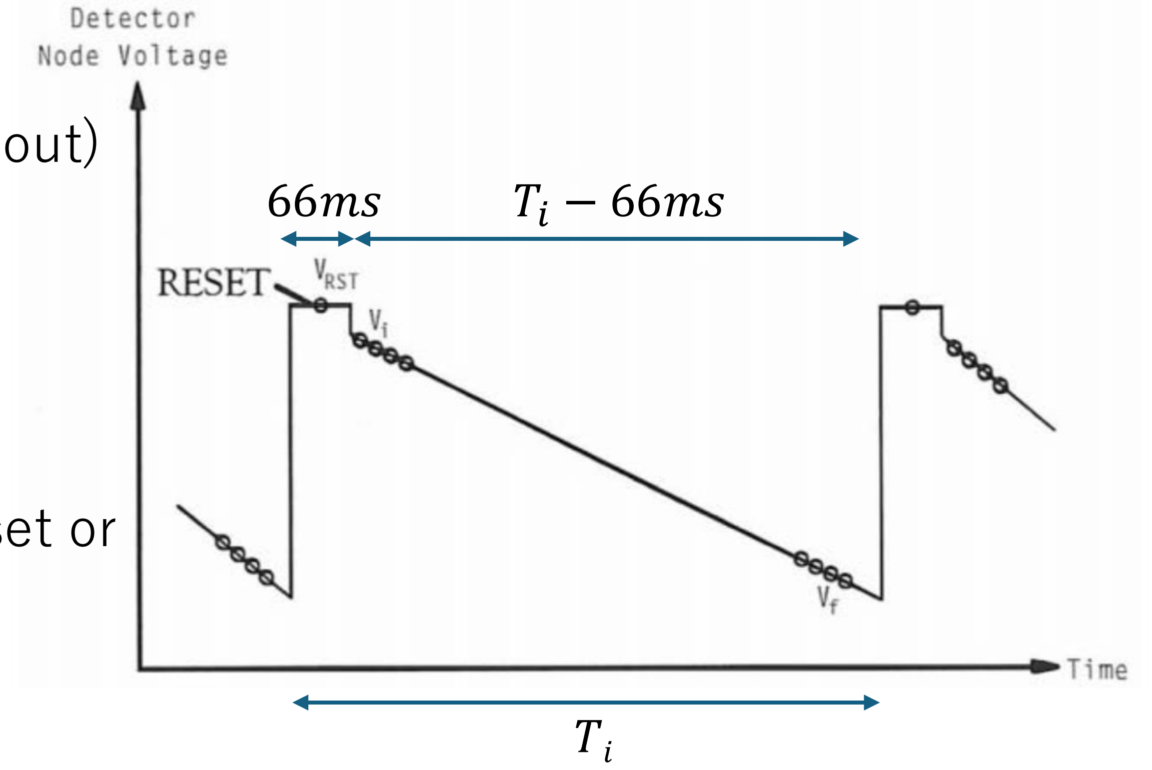
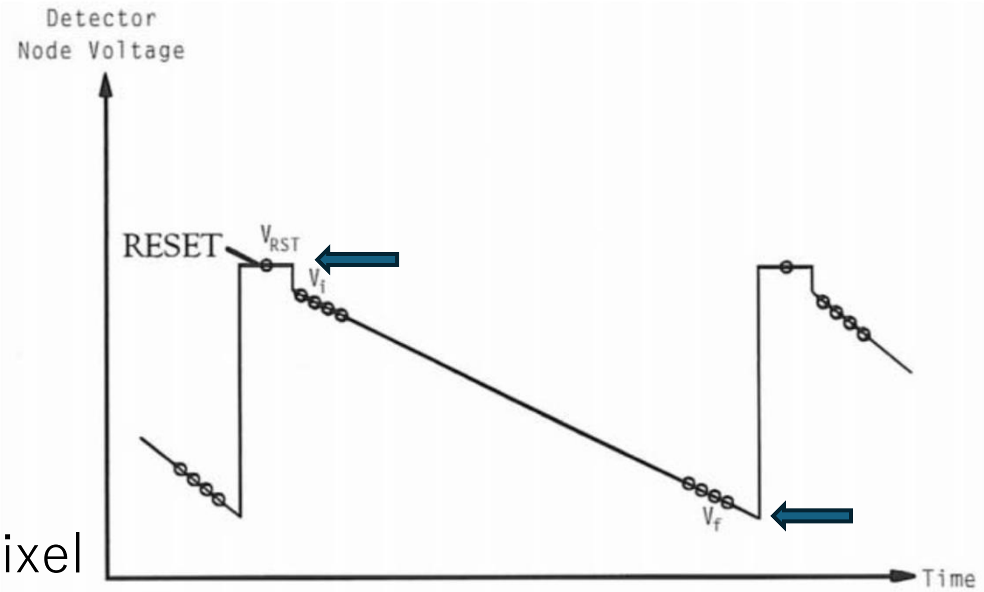
(a) single-sampling

・readout time ~66ms (same rate as the normal readout)
・exposure time T_i
→readout begin $T_i - 66ms$ after the last pixel reset

・only one sample is taken
⇨incapable of removing kTC noise and drift
・direct measurement of the signal relative to the reset or bias levels and detect saturation

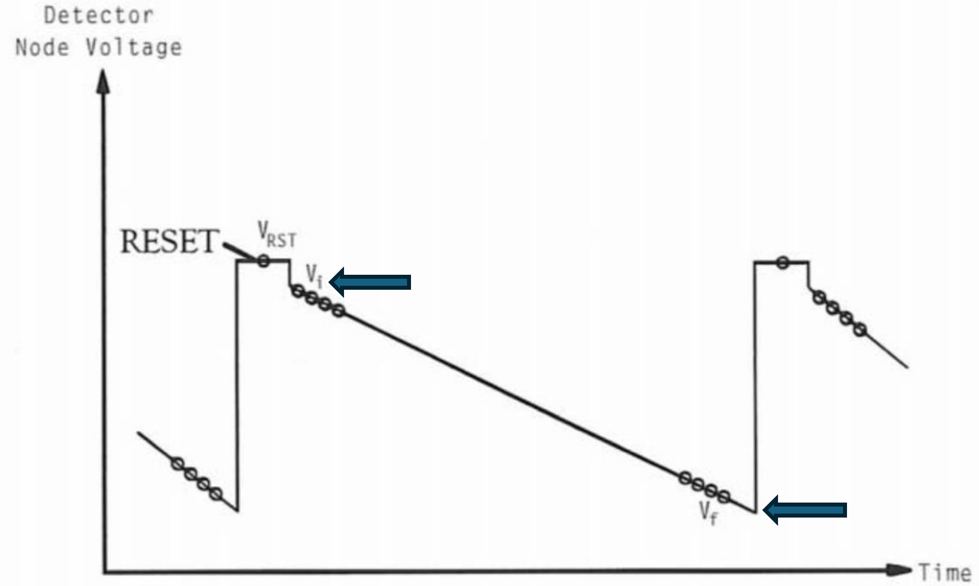


11 Sketch the output signal as a function of time for an infrared array, and use the graph to illustrate what is meant by (a) single-sampling, (b) correlated double-sampling, and (c) multiple-sampling.



(b)correlated double-sampling

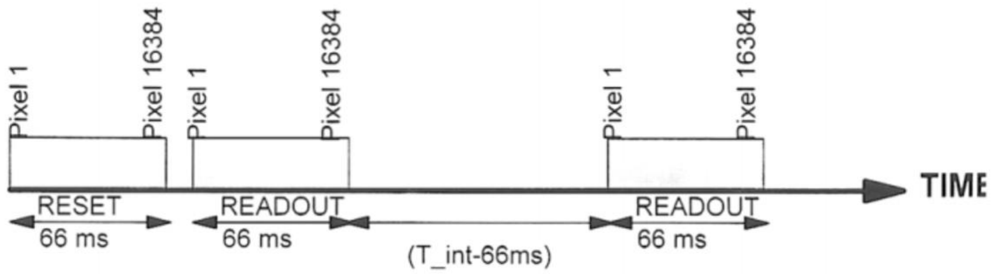
・several ways
  ・digitize the reset level
    →subtract the two results
  ・reset the pixel
    →digitize the pedestal level before moving to the next pixel
⇨eliminate kTC noise

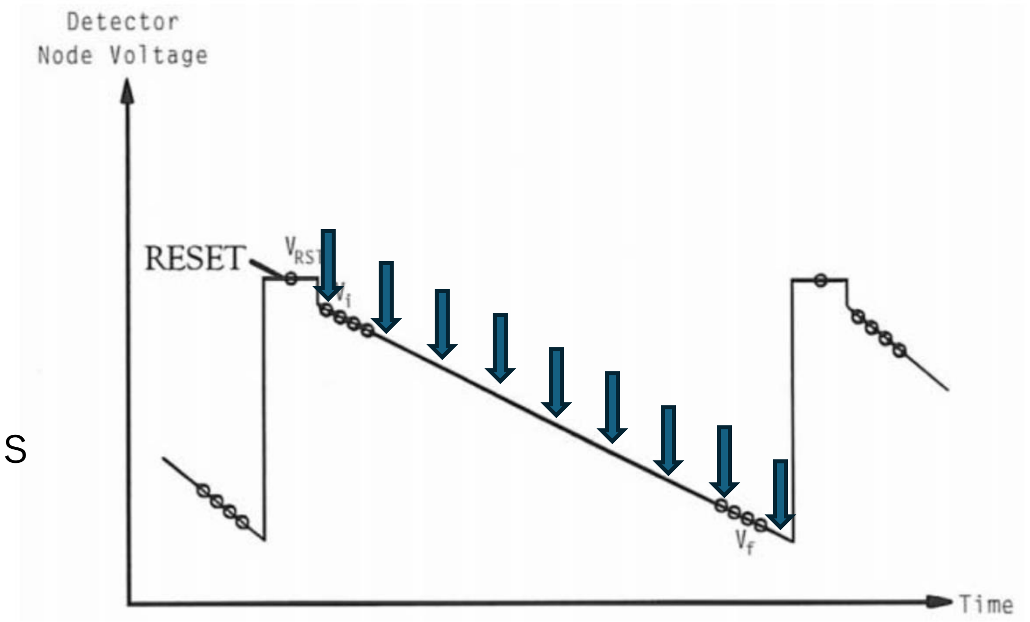


・common with the first IR arrays
↔ ・the reset action requires milliseconds
  ・act of de-addressing the current pixel adds noise

11 Sketch the output signal as a function of time for an infrared array, and use the graph to illustrate what is meant by (a) single-sampling, (b) correlated double-sampling, and (c) multiple-sampling.

(c) multiple-sampling





- multiple Fowler sampling (or reset-read-read)
  - reset the entire array pixel
    →read out the entire array (multiple times)
    →digitize the signal in each pixel
  - eliminate kTC noise
  - hard to know when the array saturate

- up-the-ramp (UTR)
  - sample the signal many times at regular intervals throughout the exposure
  - useful for saturated objects and space applications

- number of samples (readout): n
  →signal: $\times\ n$
  readout noise: $\times \sqrt{n}$
  effective readout noise in the final integrated flux: $\times\, 1/\sqrt{n}$