**ADVENTAGES OF DIGITAL CDS**

- Simplicity, compactness: see circuit below.
- Faster than normal rates possible, albeit with higher noise. Maximum is set by antialiasing filter corner.
- Slower pixel rates use same analog gain and BW. Just do more coadds → noise and dynamic range improve automatically. Contrast with:
  - Clamp samples need different filter BW.
  - Dual slope needs gain (integrator capacitor) change.
- Dynamic range exceeds ADC's, thanks to averaging.
- No tuning to match true and inverse gains: only one path.
- True zero: offsets are removed perfectly by subtraction.
- Digital oscilloscope mode: can transmit all samples to show raw video waveform instead of coadding (usually on subset of video channels to avoid overwhelming data link).

The digital equivalent of dual slope integration is to subtract $N$ samples after the CCD reset from the sum of $N$ samples after the charge dump. For sufficient sample density, and with a suitable antialiasing filter, the transfer function for digital CDS approaches the dual slope integrator. The key question is how low can the sample density be without significantly compromising read noise.

Zwicky Transient Facility (ZTF) camera’s pixel rate is 1 MHz. We would like to use the AD7626 charge division ADC since it delivers excellent DNL ($\pm 0.35$ ADU), low noise (<0.5 ADU) with 16 bit resolution at low power (136 mW) in a compact (25 mm$^2$) package, however its conversion rate is only 10 MHz.

We present the transfer functions at low sample density to show that averaging only 5+5 samples at 10 MHz comes within 1% of the dual slope integrator’s read noise when a 2 pole anti-alias filter with 4 MHz corner frequency is used. This moderate-sample-rate CDS processor with uncompromised ADC performance is very simple and compact with low power consumption, as needed in high channel count cameras. At the same time it will deliver greater than 16 bit dynamic range with superb DNL.

**CONCLUSION:** 10 MHz ADC is sufficient for 1 MHz pixel rate.

Digital CDS requires no parameter changes to work at lower pixel rates, other than number of samples to average. Main alias moves to slightly higher frequency as passband moves to lower frequency.