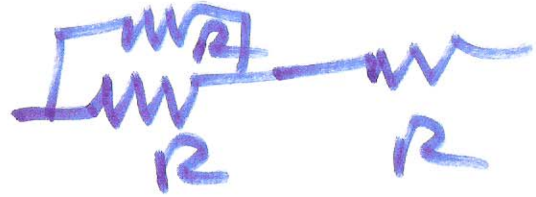
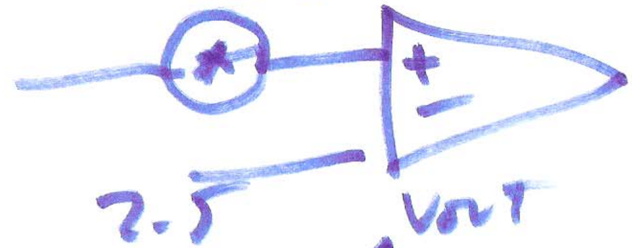
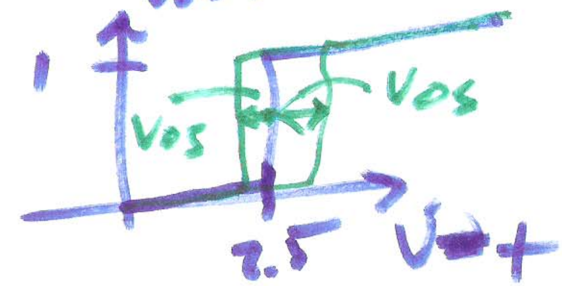
29.2 ADCs



Vos (can be + or -)





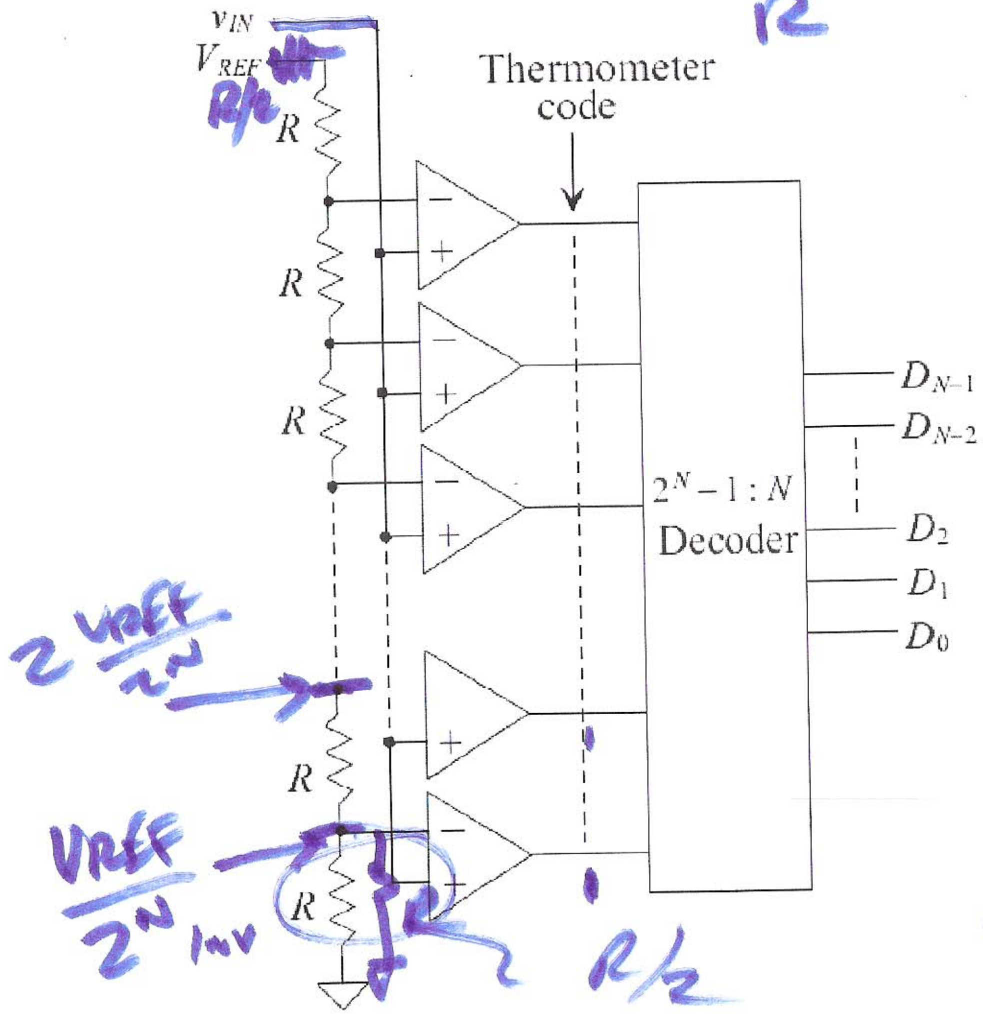


Figure 29.21 Block diagram of a Flash ADC.

0 → 1LSB → 0000

$\frac{V_{REF}}{2^N}/2$ $\frac{1}{2}$ LSB

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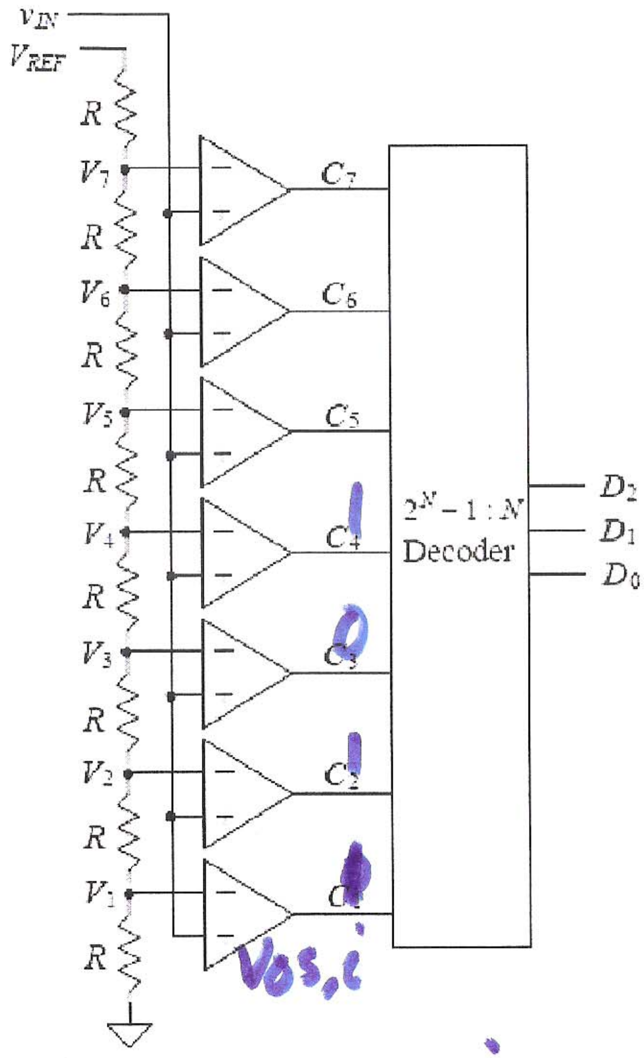
3)

$$V_i = V_{i,ideal} + \frac{V_{REF}}{2^N}\sum_{K=1}^{i}\frac{\Delta R_K}{R}$$

$$V_{SW,i} = V_i + V_{OS,i}$$

$$INL = V_{SW,i} - V_{i,ideal}$$



$$= \frac{V_{REF}}{2^N}\sum_{K=1}^{i}\frac{\Delta R_K}{R} + V_{OS,i}$$

WORST CASE mismatch in middle

As before

$$i = \frac{2^N}{2} = 2^{N-1}$$

$R_1 = R_2 = R_3$ LSBs

Figure 29.22 Three-bit Flash A/D converter to be used in Ex. 29.10.

$$V_{i,ideal} = V_{REF}\frac{\sum_{K=1}^{i} R_K \cancel{+\Delta R_K}}{2^N \cdot R} = \frac{V_{IN}}{2^N}\cdot i \cdot \frac{R}{R}$$

2)

$$INL_{WORST} = 1LSB \cdot \sum_{K=1}^{2^{N-1}} \frac{\Delta R_K}{R} + V_{OS,i}$$

$$= \frac{V_{REF}}{\cancel{2^N}} \cdot 2^{N-1} \frac{\Delta R_{K,MAX}}{R} + V_{OS,MAX}$$

$$= \frac{V_{REF}}{2} \cdot \left| \frac{\Delta R_{K,MAX}}{R} \right| + |V_{OS,i}|_{MAX}$$

if $V_{REF} = 2$

$$= \frac{2}{2} \cdot \underbrace{|0.005|}_{5mV} + \underbrace{10mV}_{10mV}$$

Voffset biggest influence

8-bits

256 comparators in general

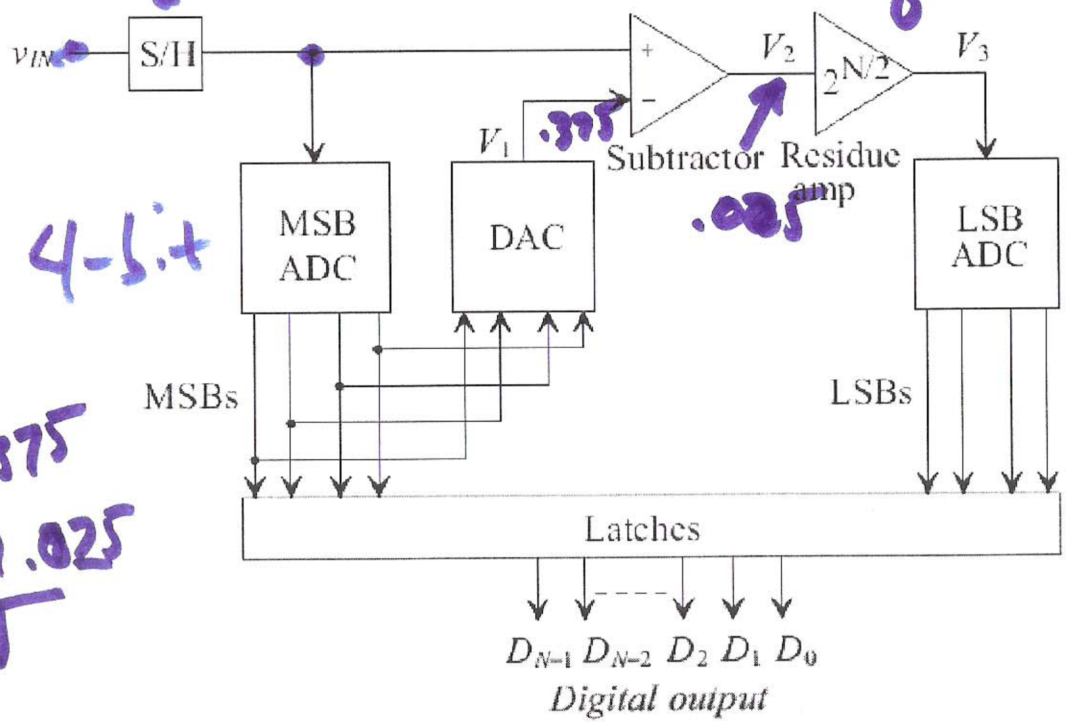
6-bits without Calibration

$$DNL_{max} = \underbrace{V_{i,ideal} - V_{i-1,ideal}}_{1LSB} + \frac{V_{REF}}{2^N} \cdot \frac{\Delta R_i}{R} + V_{os,i} - V_{os,i-1} - \cancel{1LSB}$$

$$DNL_{max} = \frac{V_{REF}}{2^N} \cdot \frac{\Delta R_i}{R} + \left| 2 V_{os,max} \right|$$

$$V_{os,max} = |V_{os,min}|$$

8 .025 ⇒ 200mV



4-bit

4-bit

32 cap. for 8-bits

$\frac{5}{16} = .375$

1.025

.65

.375 .4

0

Figure 29.26 Block diagram of a two-step Flash ADC.

8-bit Flash 255 cap

FLASH $2^N - 1$ COMPARATORS

5)

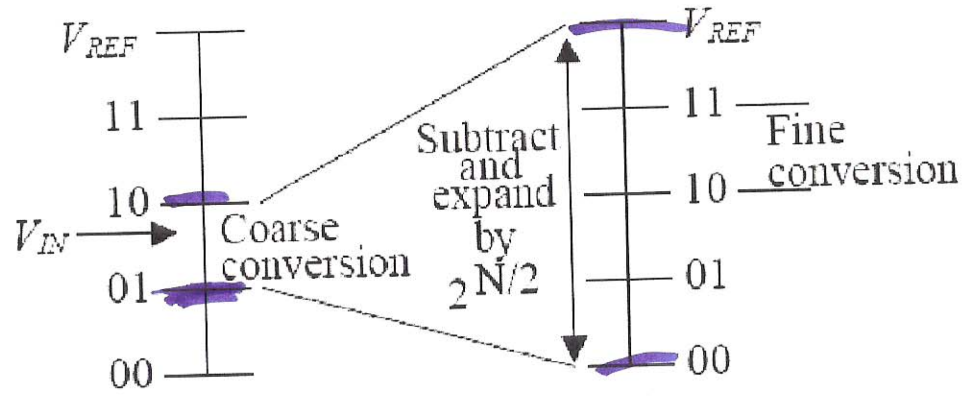


Figure 29.27 Coarse and fine conversions using a two-step ADC.

6)

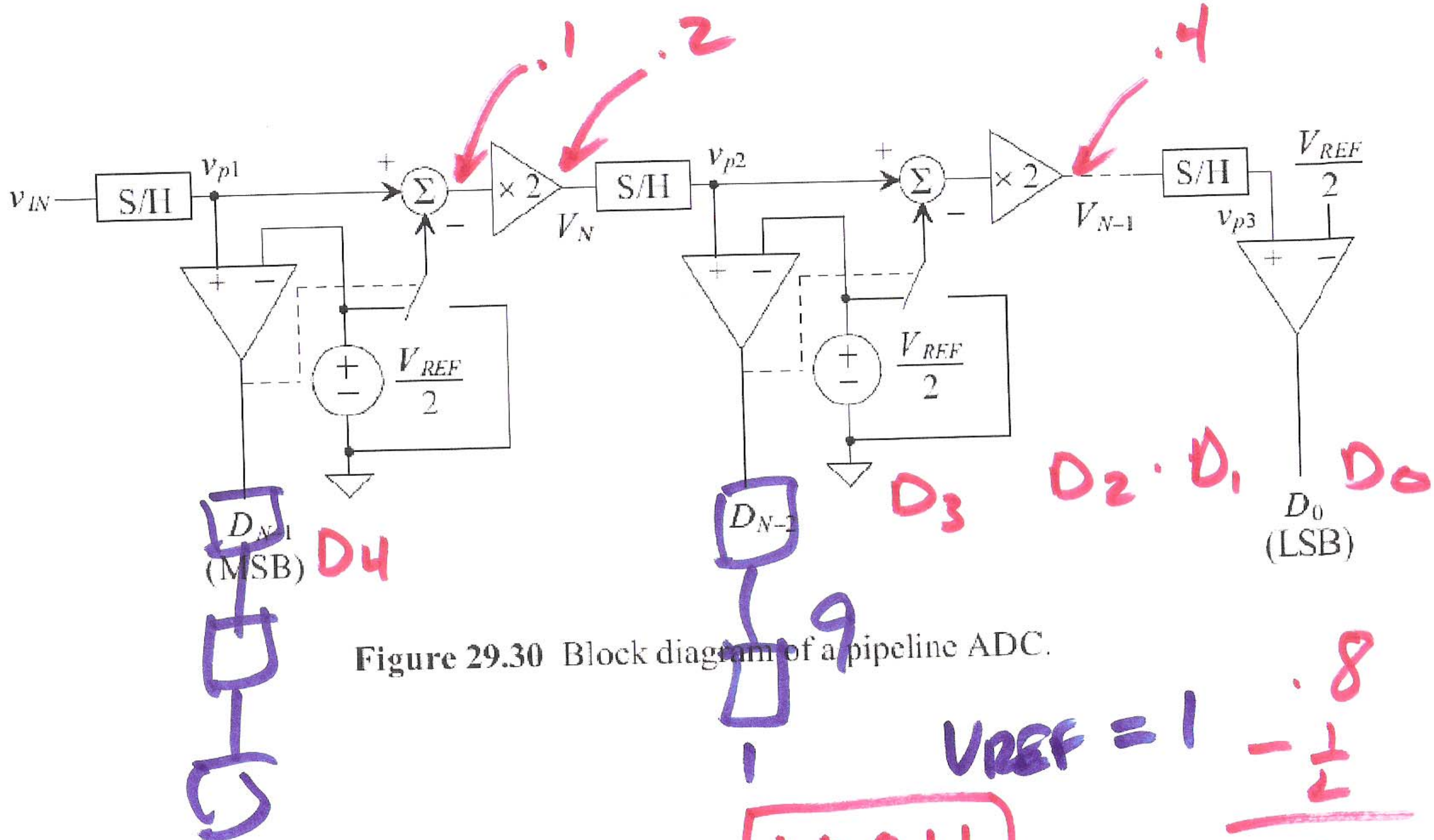


Figure 29.30 Block diagram of a pipeline ADC.

VREF = 1

$.8 - \frac{1}{2} = .3$

$\boxed{10011}$

$\frac{V_{IN}}{.6}$

D4 = 1

D3 = 0

D2 = 0

D1 = 1

D0 = 1

$\frac{V_{REF}}{2^n} = \frac{1}{32} = 0.03125$ .6

1 + 2 + 16

$\boxed{19 \cdot .03125}$

7)

$$A_{CL} = \frac{A_{OL}}{1+\beta A_{OL}} = \frac{1}{\beta} - \Delta A$$

Accuracy issues in op-Amps, ideally $\Delta A = 0$ & $A_{OL} = \infty$

$\frac{1}{\beta} = 2^N$ error to $< \frac{1}{2} V_{LSB}$

$< \frac{V_{REF}}{2^{N+1}}$

$$\cancel{A_{OL}} = \frac{1}{\beta}(1+\beta A_{OL}) - \Delta A(1+\beta A_{OL})$$

$$= \frac{1}{\beta} + \cancel{A_{OL}} - \Delta A - \beta A_{OL} \cdot \Delta A$$

$\beta A_{OL} \cdot \Delta A$

$$= 2^N \cancel{\tfrac{1}{\beta}} - \Delta A$$

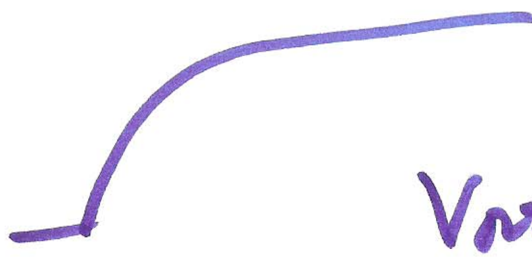
$$A_{OL} = \frac{2^{N+1}}{\beta} - \frac{1}{\beta} = \frac{1}{\beta}(2^N - 1)$$

8)

$$\boxed{A_{OL} \simeq \frac{2^{N+1}}{\beta}}$$ for a $\frac{1}{2}$ LSB error

for pipeline $\beta = \frac{1}{2}$

$A_{CL}\Big|_{ideally} = \frac{1}{\beta}$



$V_{OUTfinal}\left(1 - \frac{1}{2^{N+1}}\right)$

$$\boxed{f_{UN} \geq \frac{f_{CLK} \cdot \ln 2^{N+1}}{\pi \cdot \beta}}$$

unity gain freq.