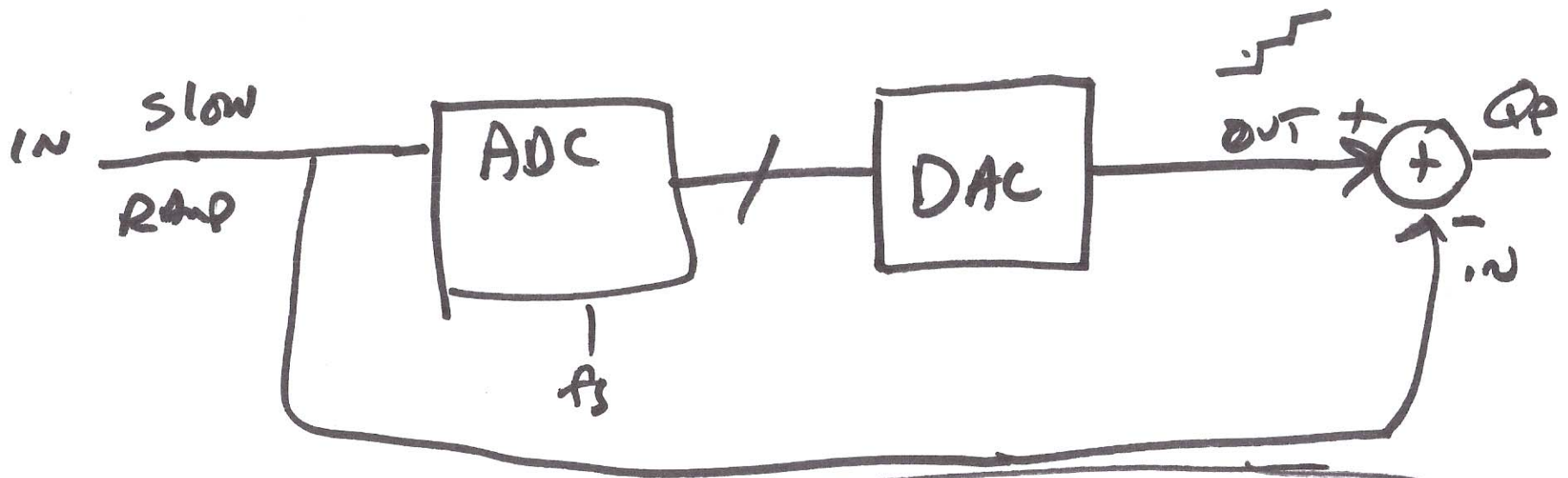


ECG 722

OCT. 1, 2014

Signal-to-noise ratio

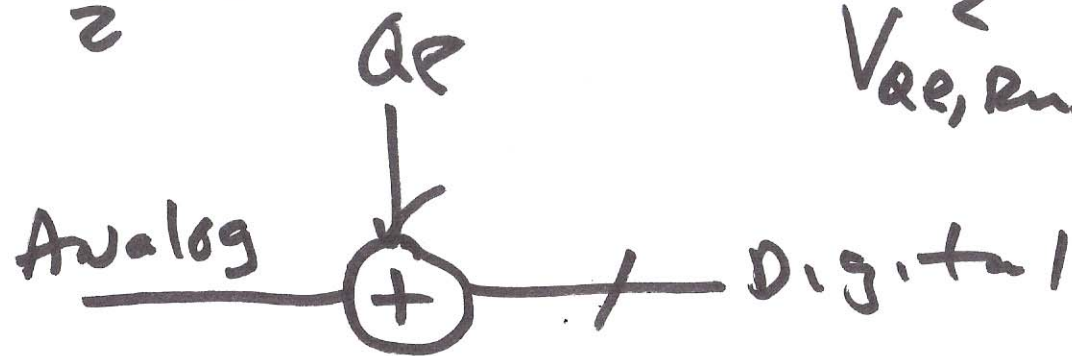
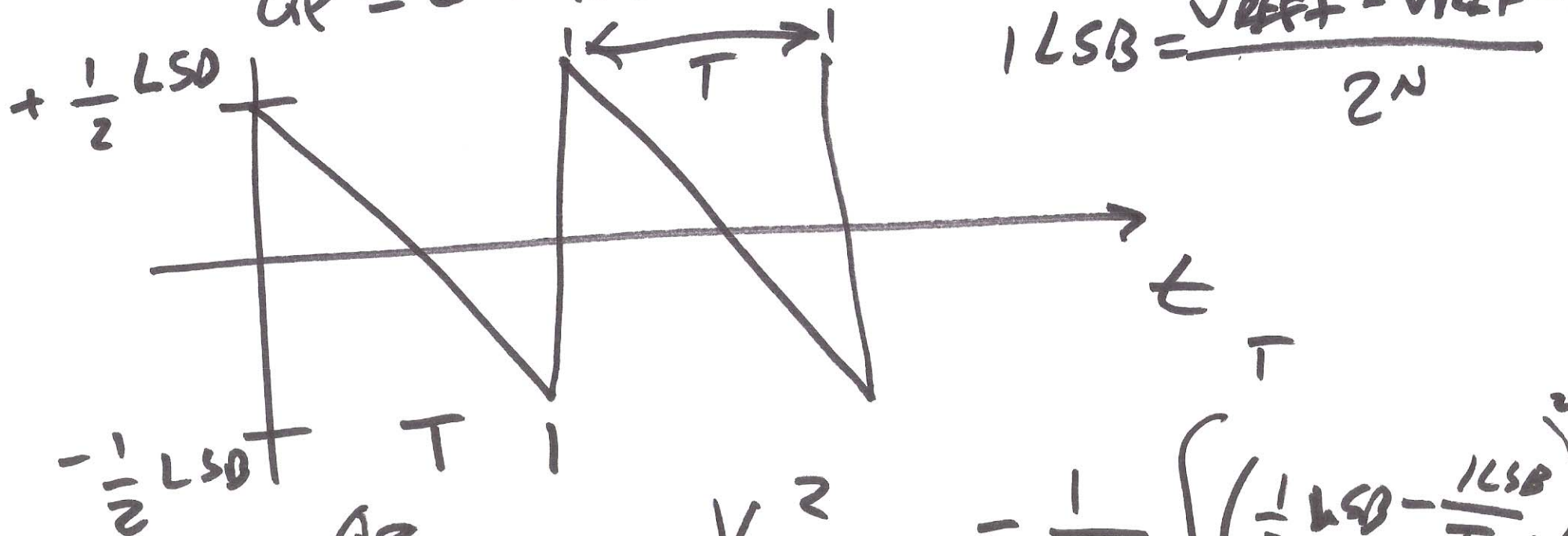


$$V_{Q_P, rms} = \frac{V_{LSB}}{\sqrt{12}}$$

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1)

Q_e = QUANTIZATION ERROR

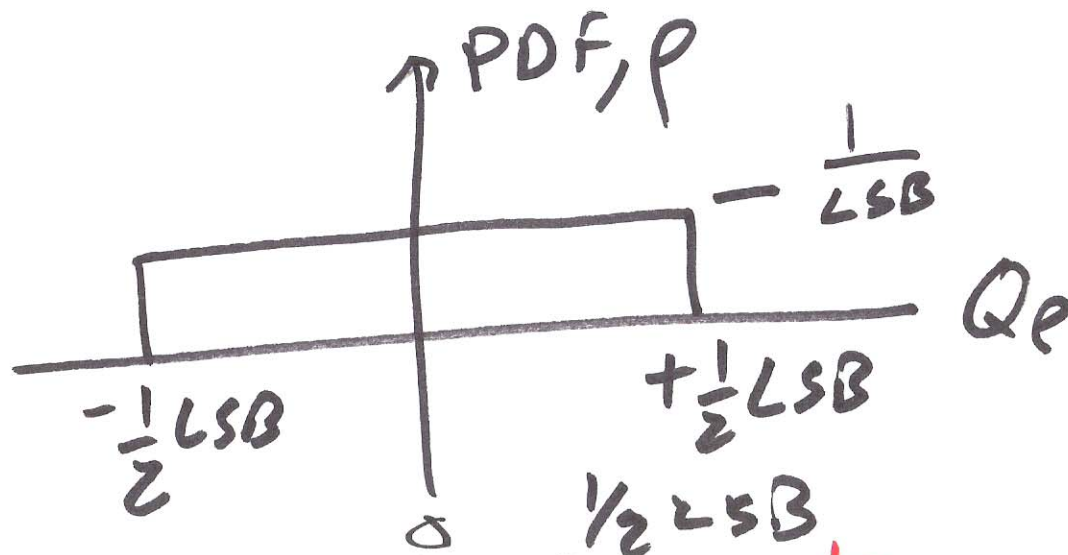


$$V_{oe, rms}^2 = \frac{1}{T} \int_0^{T/2} \left(\frac{1}{2} LSD - \frac{1 LSD}{T} \cdot t \right)^2 dt$$

$$= \frac{1}{T} \left(\frac{1}{2} LSD \cdot \frac{1}{2} LSD \cdot \frac{T}{2} - \frac{1 LSD}{T} \cdot \frac{1}{2} LSD \cdot \frac{T^2}{4} \right)$$

$$= \frac{1 LSD^2}{12}$$

go back to 1)



$$R_{MS} = \frac{1 \text{ LSB}}{\sqrt{12}}$$

$$\frac{(1 \text{ LSB})^2}{12}$$

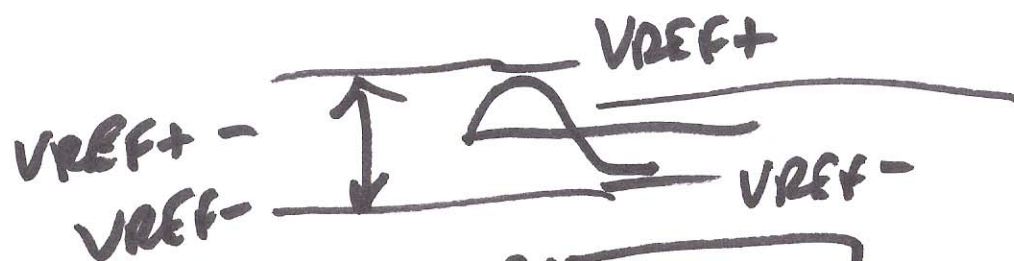
$$P_{oe} = \int_{-1/2 \text{ LSB}}^{+1/2 \text{ LSB}} P \cdot (Q_e)^2 \cdot dQ_e$$

↑
 VARIANCE
 (MEAN-SQUARED)

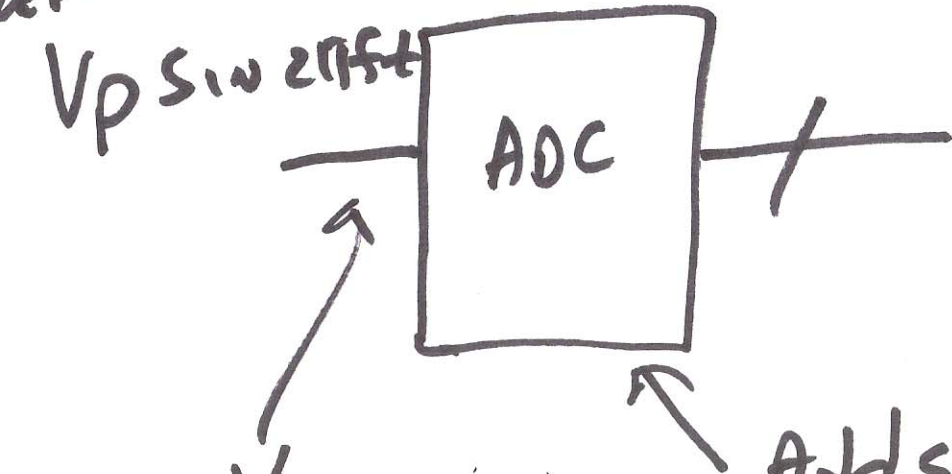
$$= \frac{1}{\text{LSB}} \frac{1}{3} x^3 \Big|_{-1/2 \text{ LSB}}^{+1/2 \text{ LSB}}$$

$$\text{Standard deviation} = \sqrt{\text{Variance}} = R_{MS}$$

3)



$$V_p = \frac{V_{REF+} - V_{REF-}}{2}$$



$$R_{ms,IN} = \frac{V_{REF+} - V_{REF-}}{2 \cdot \sqrt{2}}$$

$$R_{ms} \leftarrow \frac{V_p}{\sqrt{2}}$$

Adds R_{ms} NOISE

$$\frac{1 \text{ LSB}}{\sqrt{12}} = \frac{V_{REF+} - V_{REF-}}{\sqrt{12} \cdot 2^N}$$

$$SNR = 20 \log$$

$$\frac{\frac{V_{REF+} - V_{REF-}}{2 \sqrt{2}}}{\frac{V_{REF+} - V_{REF-}}{2^N \cdot \sqrt{12}}}$$

4)

$$\text{SNR} = 20 \log \frac{2^N \cdot \sqrt{12}}{2 \sqrt{2}}$$

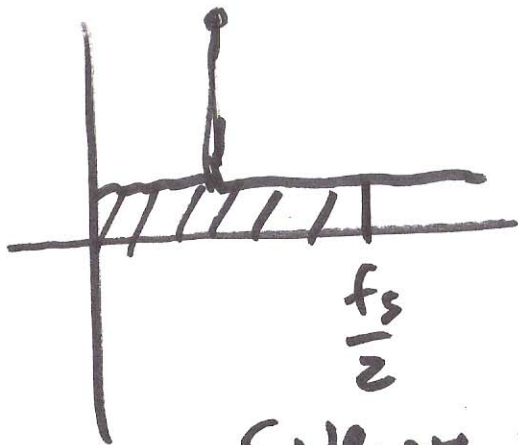
$$= 20 \log(2^{N-1} \cdot \sqrt{6})$$

$$= 20 \log 2^{N-1} + 20 \log \sqrt{6}$$

$$= (N-1) \cancel{20 \log 2}^{6.02} + 20 \log \sqrt{6}$$

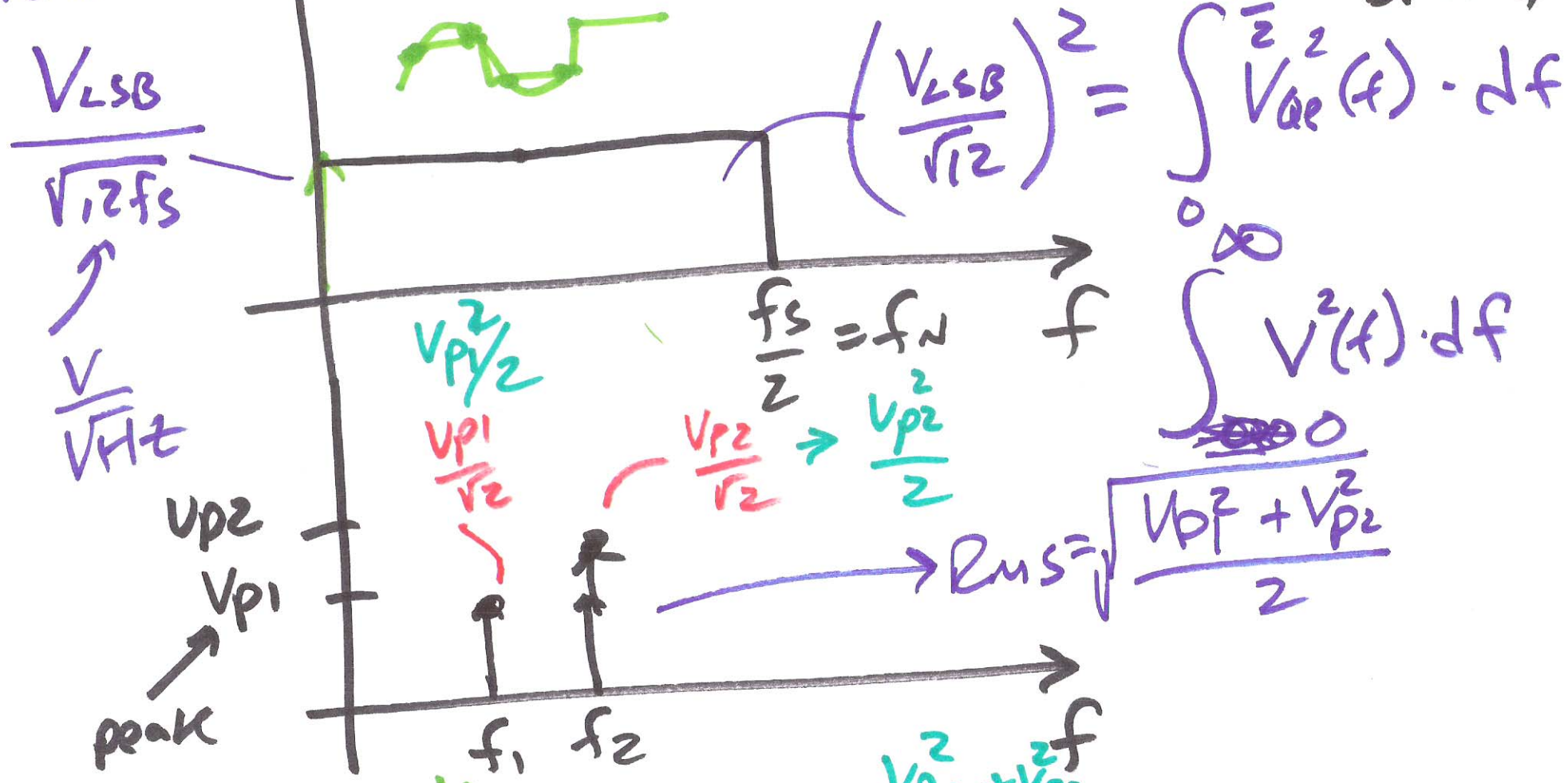
$$\text{Neff} = \frac{\text{SNR}_{\text{max}} - 1.76}{6.02} = 6.02N - 6.02 + 7.78$$

$$\boxed{\text{SNR} = 6.02 \cdot N + 1.76 \text{ dB}}$$



5)

$\frac{V_{LSB}^2}{12f_s} \Rightarrow P_{LSB}$ $V_{RMS}(f) \rightarrow \frac{V}{\sqrt{Hz}}$ Voltage Spectral Density $\frac{V^2}{Hz}$ $\frac{V^2}{Hz} \rightarrow$ Power Spectral Density



$.45 \mu V = \frac{V_{LSB}}{\sqrt{12}}$

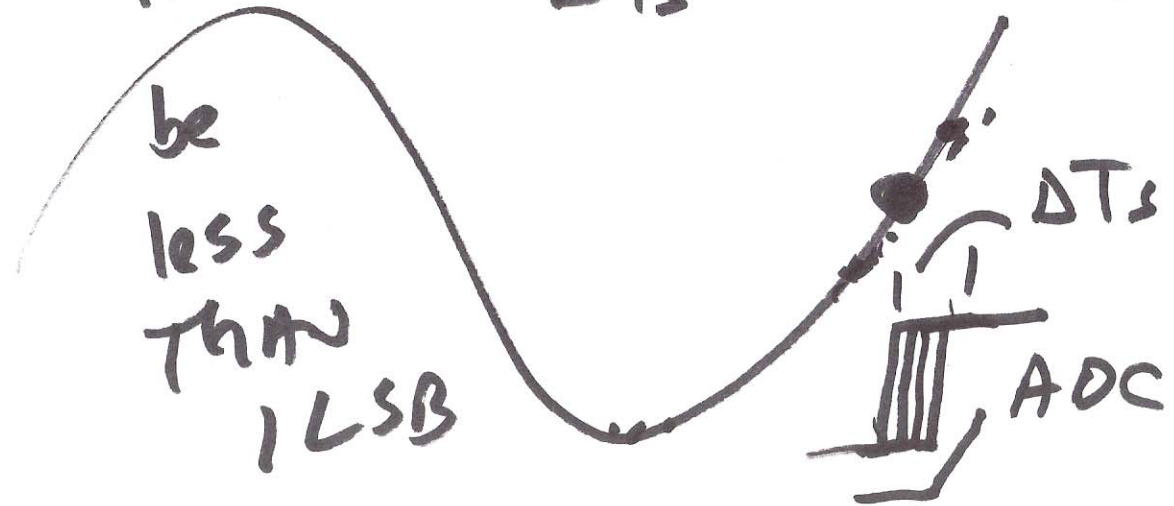
$P_T = \frac{V_{p1}^2 + V_{p2}^2}{2}$

$V_{LSB} = 1.55 \mu V$
 $4 \Rightarrow mV$

$\frac{1}{28} = \frac{1V}{28} = 1LSB$

6)

error to $\rightarrow \frac{\Delta V_S}{\Delta T_S} = \frac{V_{REF+} - V_{REF-}}{2^n \cdot \Delta T_S} \leq V_P \pi f_s$



$\frac{V_{REF+} - V_{REF-}}{2}$

error in sampling $V_P \sin 2\pi f_N \cdot t$
 $\frac{f_s}{2}$

$\frac{\Delta V_S}{\Delta T_S} = \frac{d}{dt} (V_P \sin \pi f_s \cdot t) = \pi f_s \cos \pi f_s T$
 $= \frac{V_P \pi f_s}{1}$

7)

$$\frac{1}{2^N \Delta T_s} \approx \frac{\pi f_s}{2}$$

$$1 - z^{-k} \quad \Delta T_s \leq \frac{1}{2^{N-1}} \cdot \frac{1}{\pi f_s}$$

$\sigma = \text{S.D.}$
 $\sigma^2 = \text{M.S.}$
 $\sigma = \frac{\Delta T_s}{\sqrt{k}}$ for 1 LSB (error)

book used
 $\leq 1 \text{ LSB}$

