ECE 615 CMOS mixed-signal circuit design

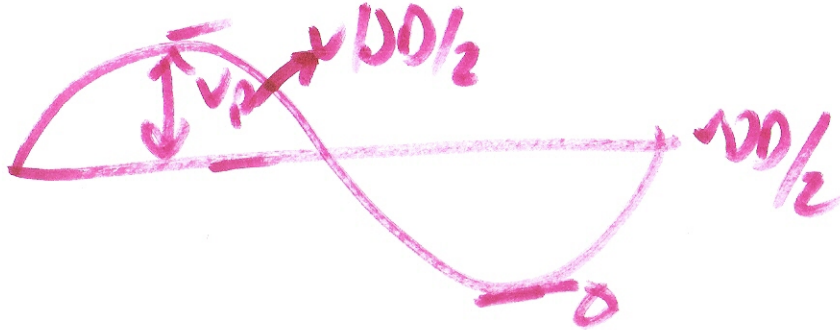
BOISE STATE UNIVERSITY

Lecture 17 OCT. 20, 2010

SNR in data conversions

$$V_{QE,RMS} = \frac{V_{LSB}}{\sqrt{12}} = \frac{V_{REF+} - V_{REF-}}{2^N \cdot \sqrt{12}}$$

$$SNR_{Ideal} = 20 \log \frac{V_P/\sqrt{2}}{\frac{V_{LSB}}{\sqrt{12}}} = 6.02N + 1.76 \text{ dB}$$



$$V_P = \frac{VDD}{2}$$

$$V_{LSB} = \frac{VDD}{2^N}$$

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$$SNR_{ideal} = 6.02N + 1.76$$

Effective # of bits =

$$Neff = \frac{SNR_{meas} - 1.76}{6.02}$$

Example 5.3

$$SNR = 20\log\frac{0.5/\sqrt{2}}{2^{-N}} \simeq 45dB$$

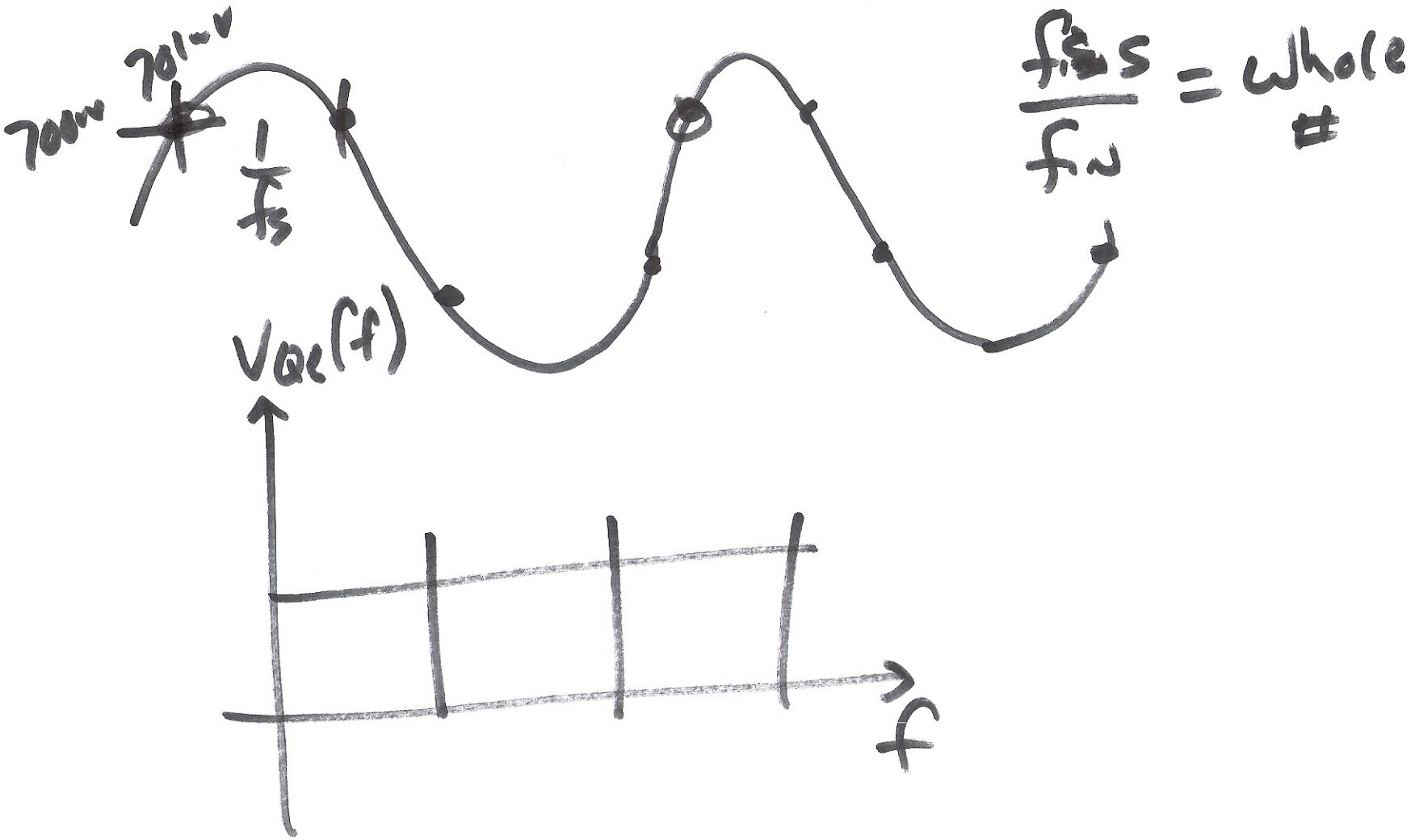
$V_{REF+} = 1$

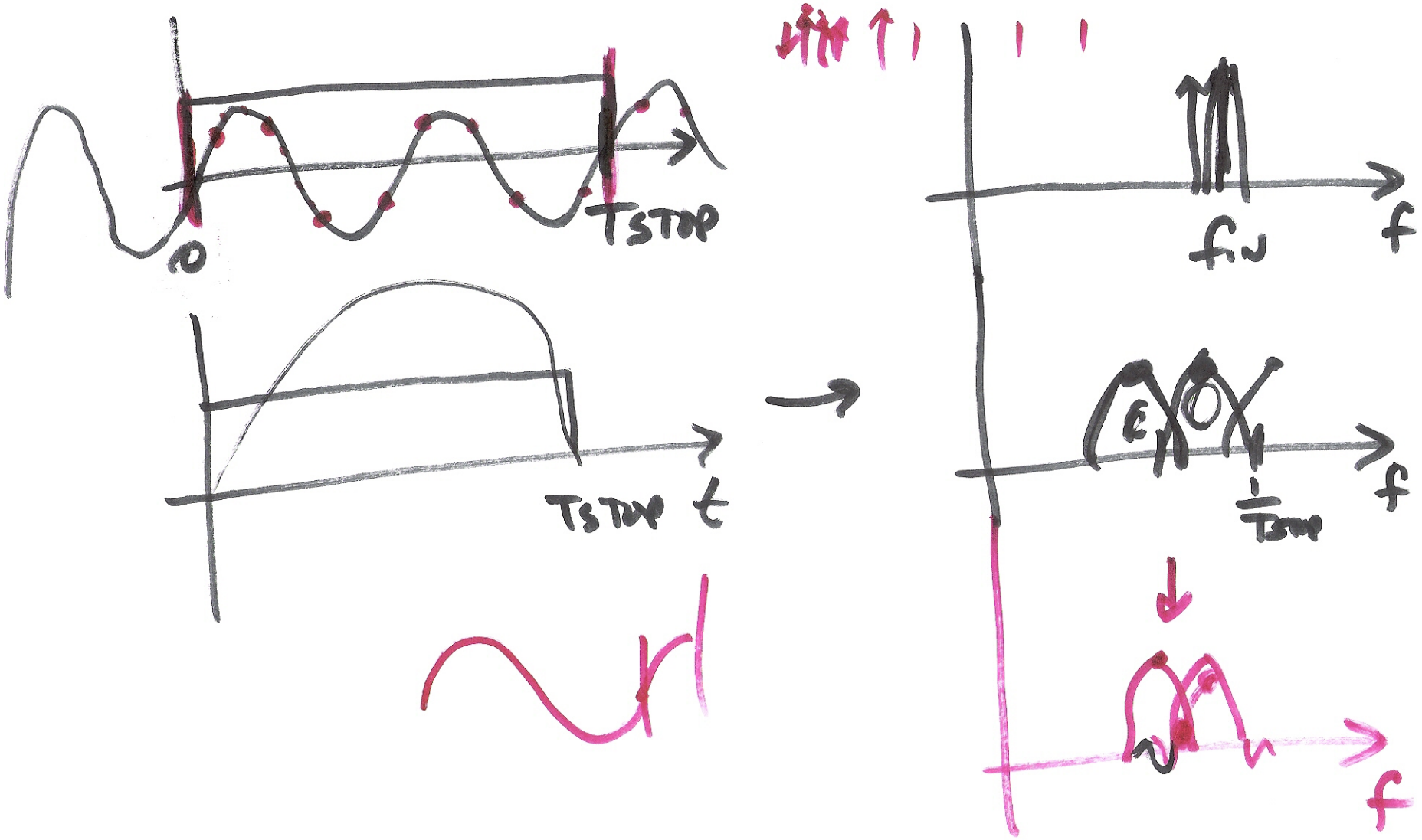
$V_{REF-} = 0$

$V_p = 0.5$

$$Neff = \frac{45 - 1.76}{6.02} = 7.18 \text{ bits}$$

Coherent Sampling



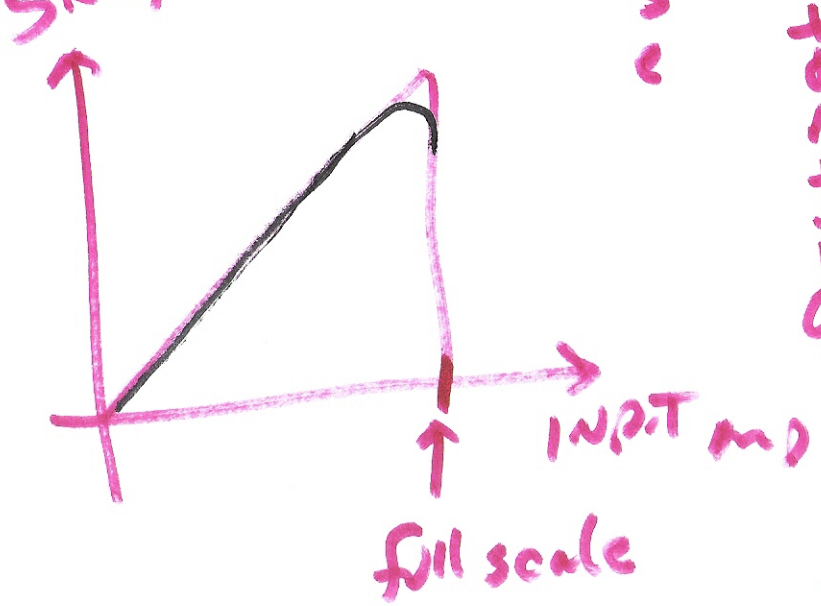

0
TSTOP
t
TSTOP
f
fM
f
1/TSTOP
f

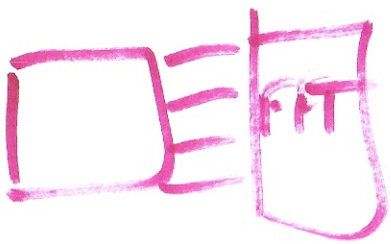
$$SNDR = 20\log \frac{0.5/\sqrt{2}}{29.7mV} = 24dB$$

$$Neff = \frac{24 - 1.7}{6} = \underline{3.7\ b.t.s.}$$

$$SINAD = SNDR$$

SINAD = NOISE AND Distortion





SNDR
SNRmeas.

$$SNR = 6.02N + 1.76$$

5)

Dynamic Range

$$DR = \frac{V_{REF+} - \left((V_{REF+} - V_{REF-})/2^N\right) - V_{REF-}}{V_{REF+} - V_{REF-}}$$

$$= \frac{1 - \frac{1}{2^N}}{\frac{1}{2^N}} = (2^N - 1) \simeq 2^N$$

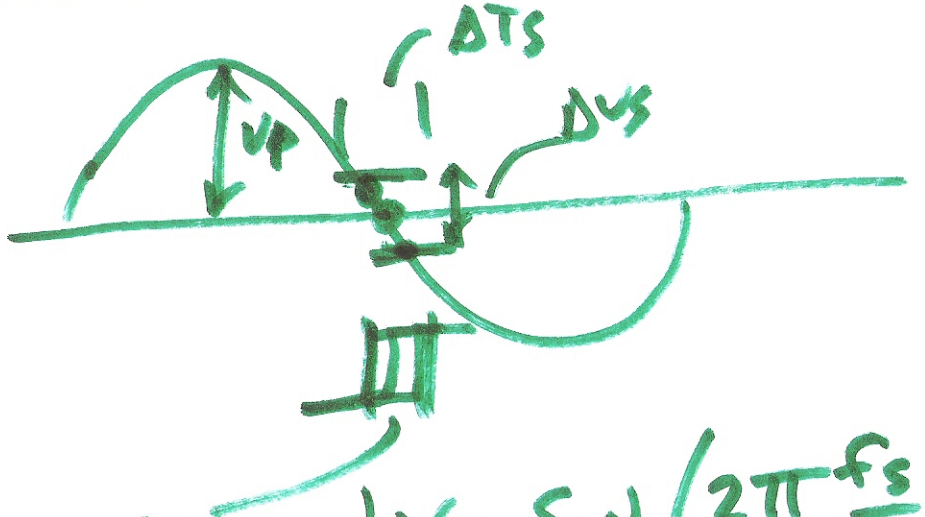
$20 \log 2^N$

$$DR = 20 \log 2^N = 6.02\,N$$

Another is to say when does SNR → dB

DR → SNDR 60dB

Clock jitter



$$\text{stability} = \frac{\Delta T_s}{T_s}$$

10 ppm $\rightarrow 10^{-6}$

$$\Delta T_s \quad \frac{dV_p}{dt} \sin\left(2\pi \frac{f_s}{2} \cdot t\right)$$

$$= V_p \cdot \pi f_s \cdot \cos(\pi f_s \cdot t)$$

$$\frac{x}{V_{DD}} \cdot \frac{V_{DD}}{2^N} = V_p \cdot \pi f_s \cdot 1$$

$$V_p \cdot \pi \cdot f_s = \frac{\Delta V_s}{\Delta T_s}$$

ΔV_s: $\frac{1}{2}$ LSB

$\frac{1}{2} V_p = \frac{V_{DD}}{2}$

$1\ \text{LSB} = \frac{V_{DD}}{2^N}$

ΔT_s: peak to peak jitter

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

7)

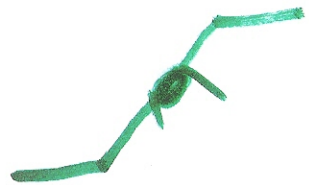
$$\Delta T_s \geq \frac{1}{2^N} \cdot \frac{1}{\pi f_{in}}$$

reduces SNR > 0.5 bits

$$\Delta T_s = \frac{1}{2^{N-N_{loss}}} \cdot \frac{1}{2\pi f_{in}}$$

$$SNR = 6.02\underbrace{(N - N_{loss} - 0.5)}_{N_{eff}} + 1.76\ dB$$

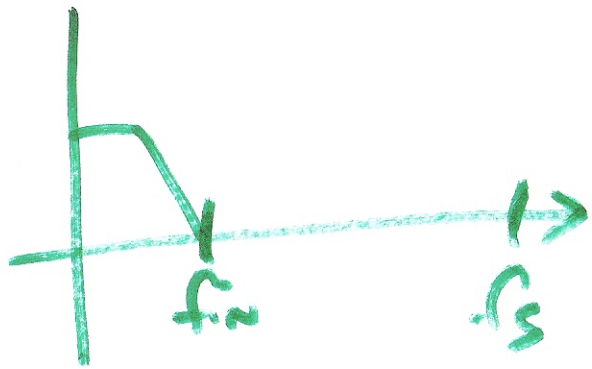
N_{eff} → due to clock jitter

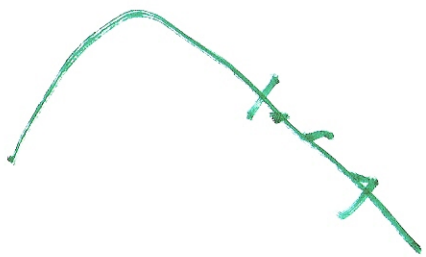


8)

oversampling

$\frac{f_s}{2} = K \cdot f_{in}$ ← max



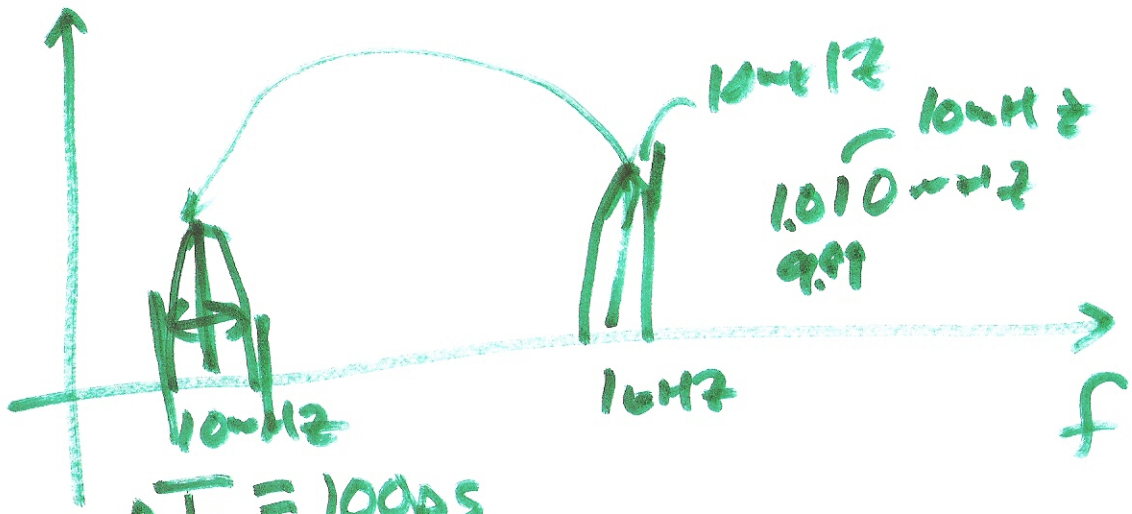


Ex.

new stability, pm =

old, pm · K

Clock signal



$\Delta T_s = 100ps$

100NS

10 99.9NS

100.1

10. 10.01MHz

9.99 MHz

1 1

1NS

$\Delta T_s = 1ps$

1,000 ppm

= 0.1%

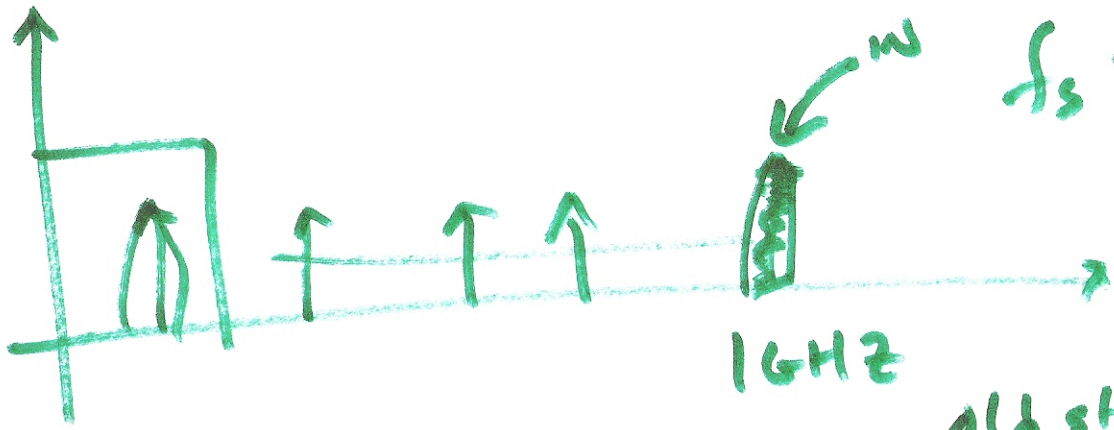
= 0.001

|100ps|

1NS ± 1ps

10MHz ± 100ps

10)



$f_s = 100\text{-Hz}$

$$\frac{\text{old stability}}{K} = \text{new stability}$$

$$\frac{8}{\frac{1000\text{ppm}}{8}}$$

$$125\,f_s$$