CMPE-242
Applied Feedback Control

Gabriel Hugh Elkaim

$$\frac{s+3}{s(s+2)^2}$$

```
sys = tf([1 3],conv([1 0],conv([1 2],[1,2])));

pzmap(sys);
damp(sys);
evalfr(sys,w);

Gjw = evalfr(sys,10);
abs(Gjw);
angle(Gjw);

margin(sys)
sysCL = feedback(K*sys,1);
```

poles & zeros

ω_n, ζ

$G(j\omega)$ — complex #

rad

change to -1 for 0°

Gabriel Hugh Elkaim

Announcements — Midterm coming next week (Friday)

Office Hours → 1-3 pm

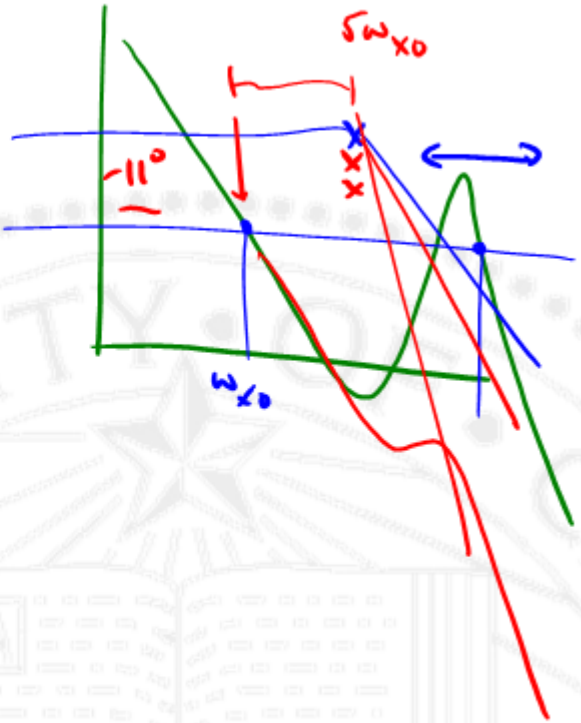
Nyquist

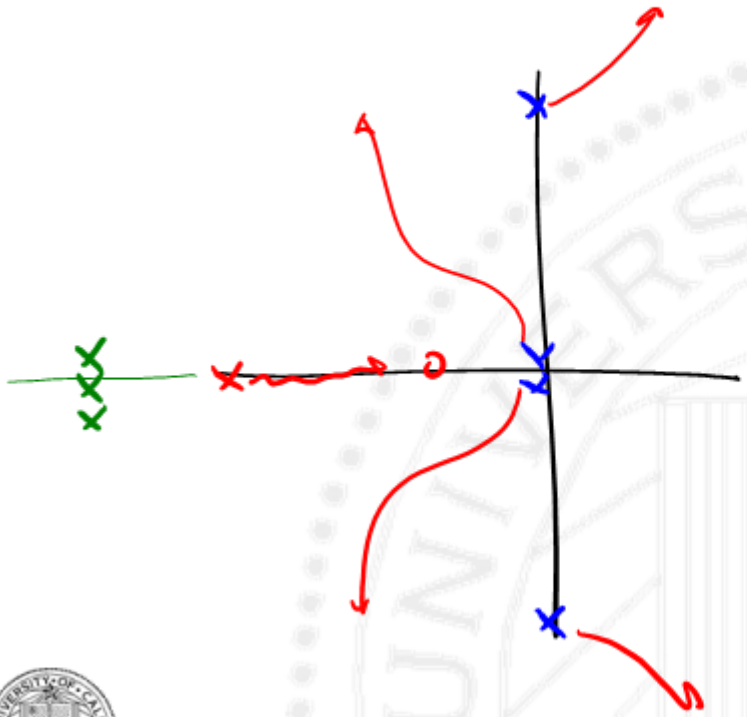
Intro to DigCD

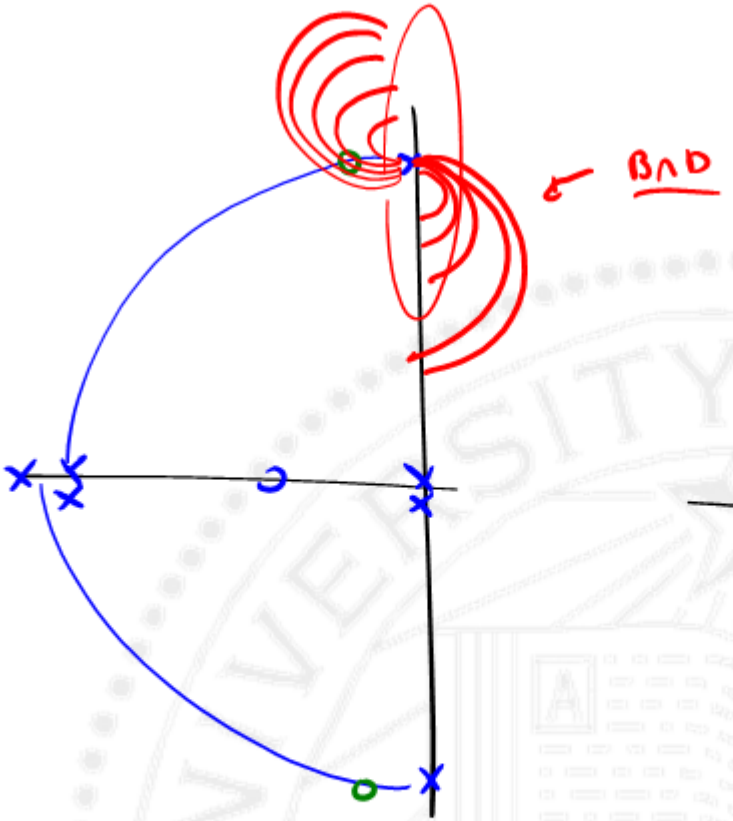
↳ Discrete Equivalent

↳ Full DigCD — RL / Bode

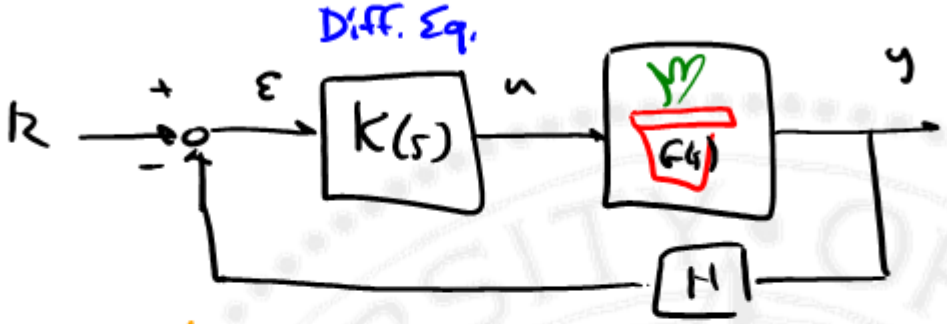
13,1,8

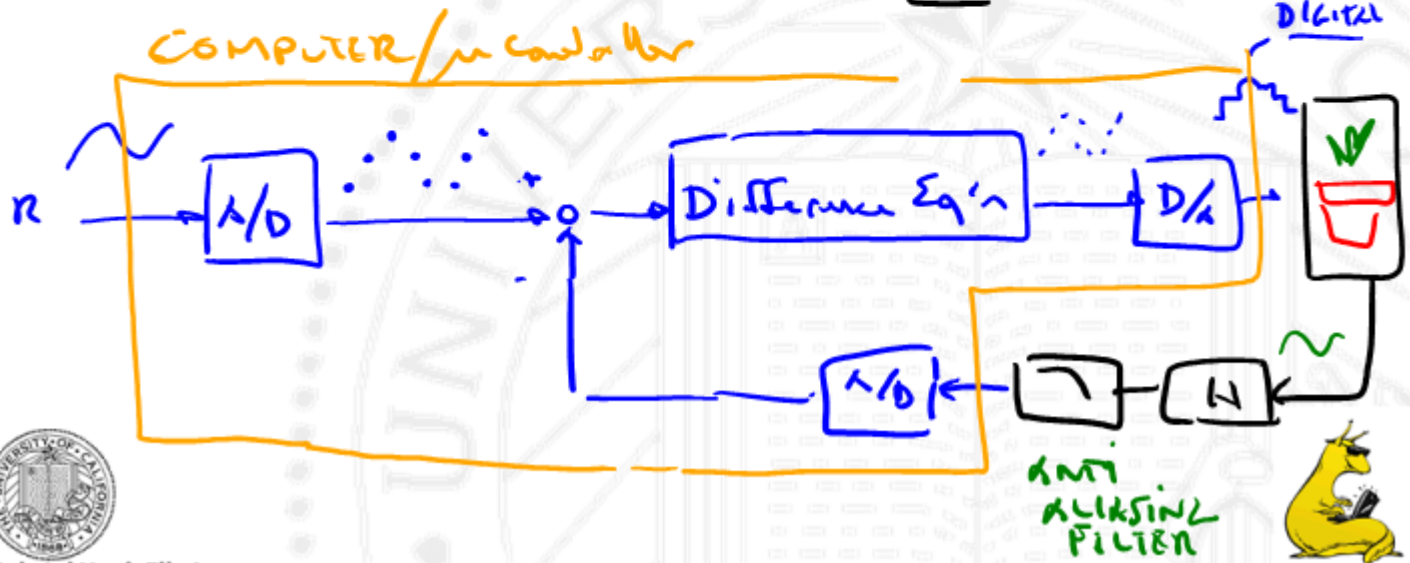


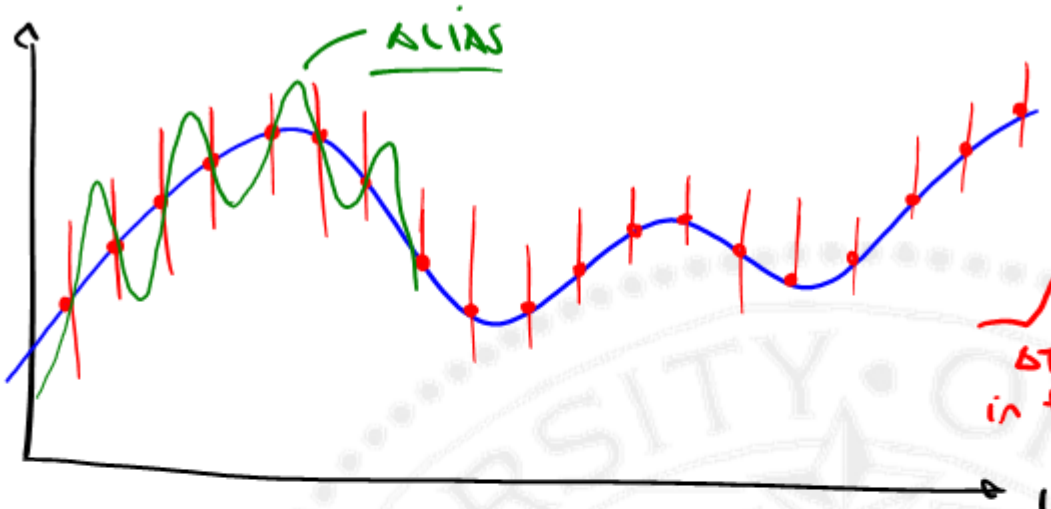


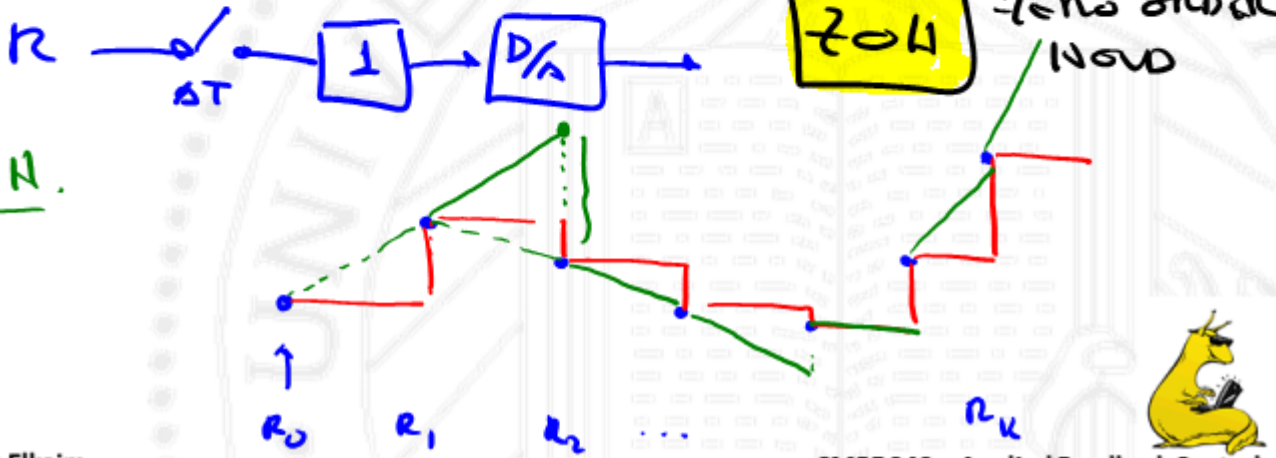

B∧D

DIGITAL CONTROL → FPN Ch. 8

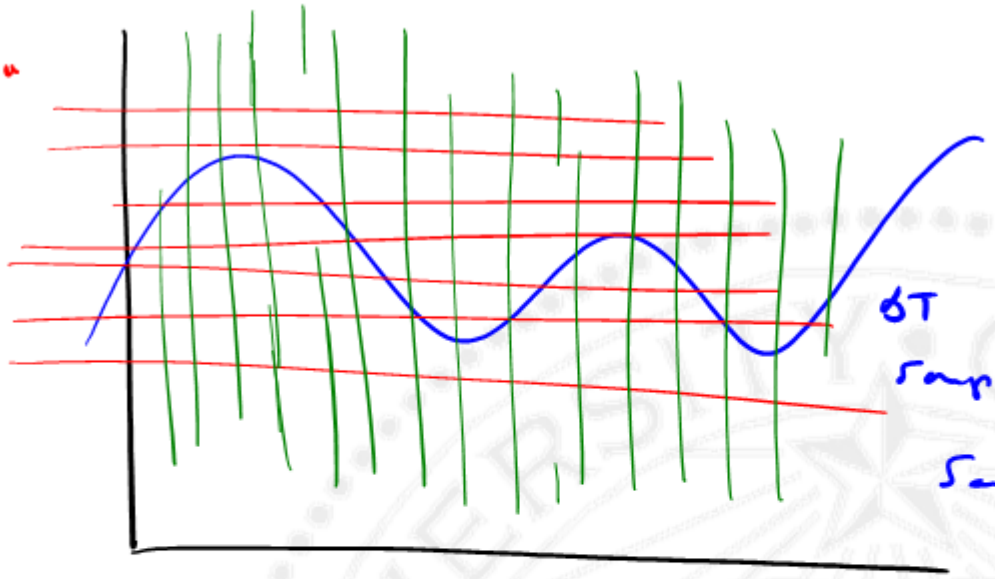




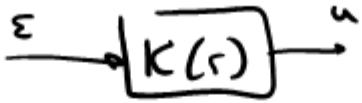

ALIAS
ΔT
in time
t


R
ΔT
1
D/A
ZOH
ZERO ORDER HOLD
F.O.H.
R0
R1
R2
...
RK

A/D
"bits"



$$K(s) = \frac{K}{s+a}$$



$$\frac{u}{\varepsilon}(s) = \frac{K}{s+a} \quad \rightarrow \quad u(s+a) = K\varepsilon$$

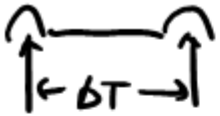
$$\dot{u} + au = K\varepsilon$$

$$\frac{u_k - u_{k-1}}{\Delta T} + a u_k = K\varepsilon_k$$

$$u_k - u_{k-1} + a\Delta T\, u_k = K\Delta T\, \varepsilon_k$$

$$[1 + a\Delta T]\, u_k = u_{k-1} + K\Delta T\, \varepsilon_k$$

$$u_k = \left[\frac{1}{1+a\Delta T}\right] u_{k-1} + \left[\frac{K\Delta T}{1+a\Delta T}\right] \varepsilon_k$$



Init $u_0 = \phi$.

WAIT
ΔT

Read R_k

Read Y_k

For $\varepsilon_k = R_k - Y_k$

$$u_k = \left(\frac{1}{1+a\Delta T}\right) u_{k-1} + \left(\frac{K\Delta T}{1+a\Delta T}\right) \varepsilon_k$$

write u_k

$u_{k-1} = u_k$

Gabriel Hugh Elkaim

CMPE 242 – Applied Feedback Control

Why go digital

(1) Easy to change (NOT)

(2) LOGIC — "if, then, else" (KG) ~ 10%

(3) Non-linearity

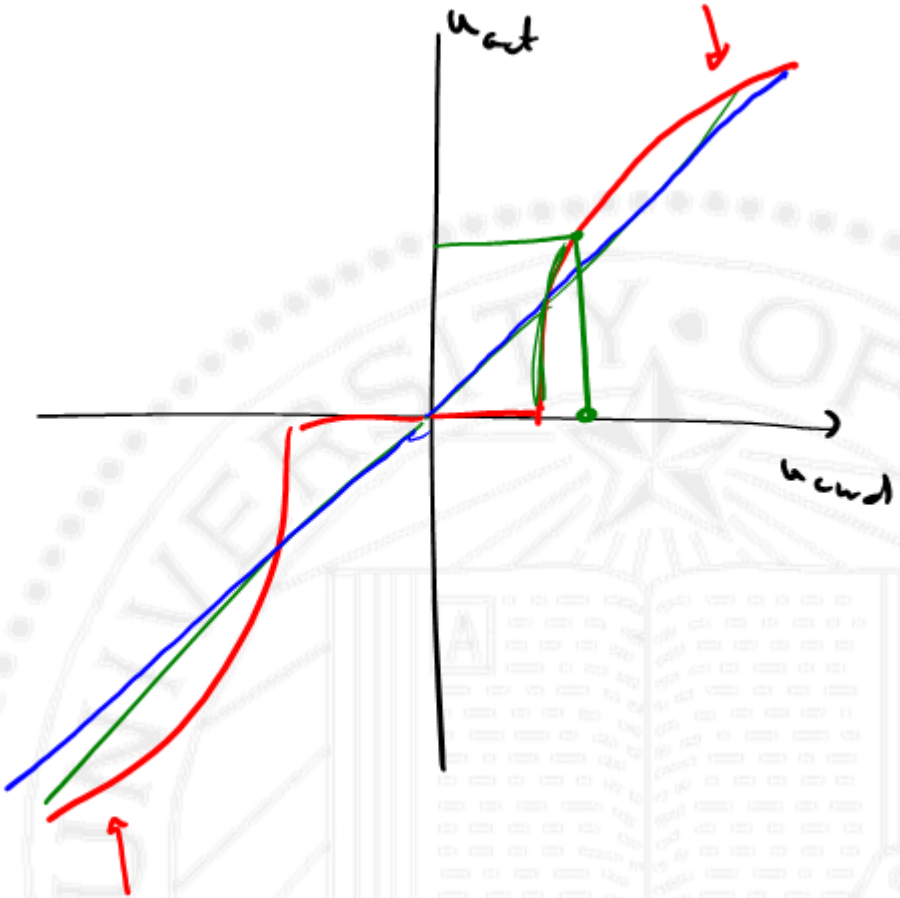
(4) Cheaper — already have a microcontroller (only if you don't account for debugging time).

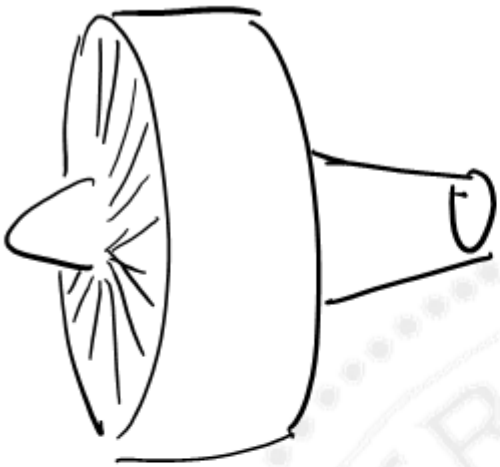
(5) Repeatable

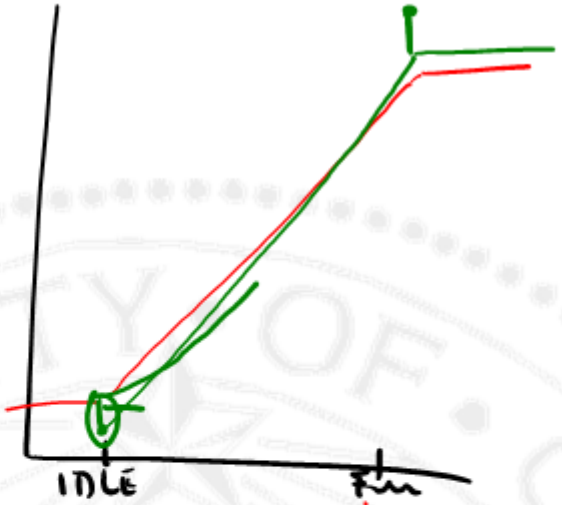
(6) X adaptable

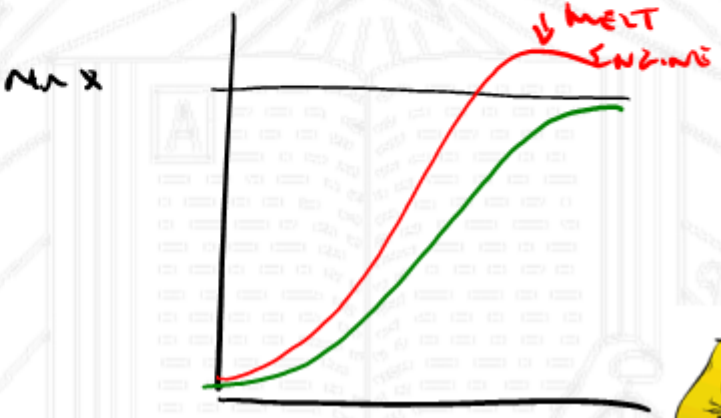
(7) Performance / Speed (NOT IT)

(8) DOES NOT DRIFT W/TEMP. or TIME

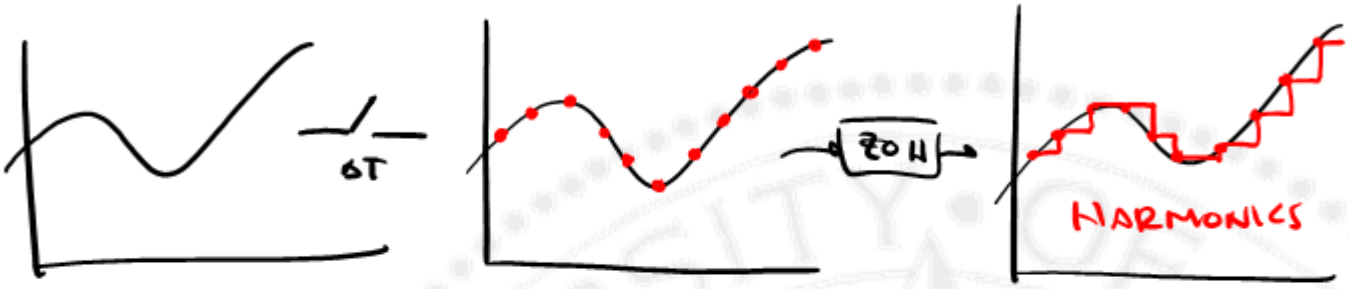

u_{act}
u_{cmd}




IDLE
MELT
ENGINE



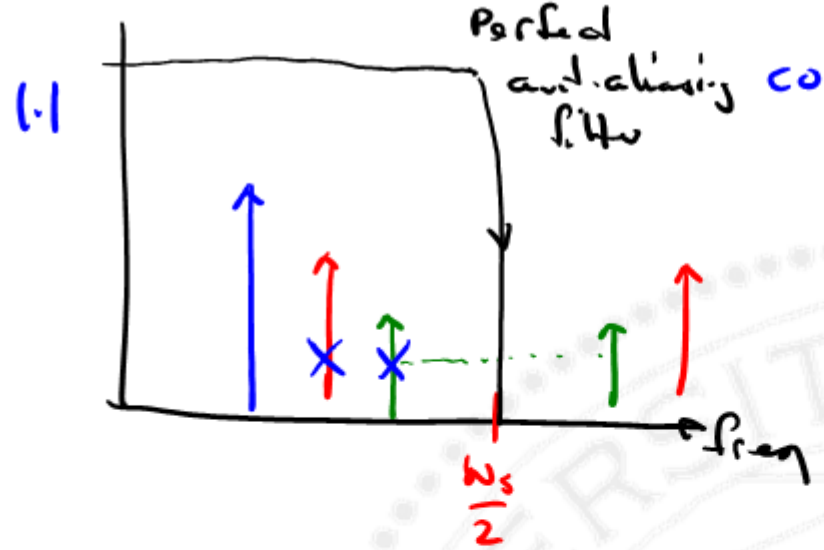
PROBLEMS W/ DIGITAL CONTROL



$\left(\frac{\Delta T}{2}\right)$ delay

QUANTIZATION NOISE $\propto \frac{LSB}{B}$

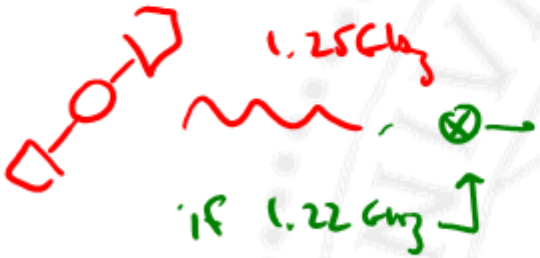
SMALL AMPLITUDE REDUCTION

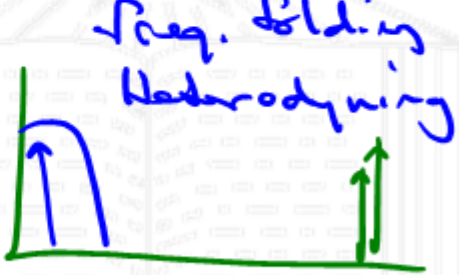


$\cos(a)\cos(b) =$

$\cos(a+b)$

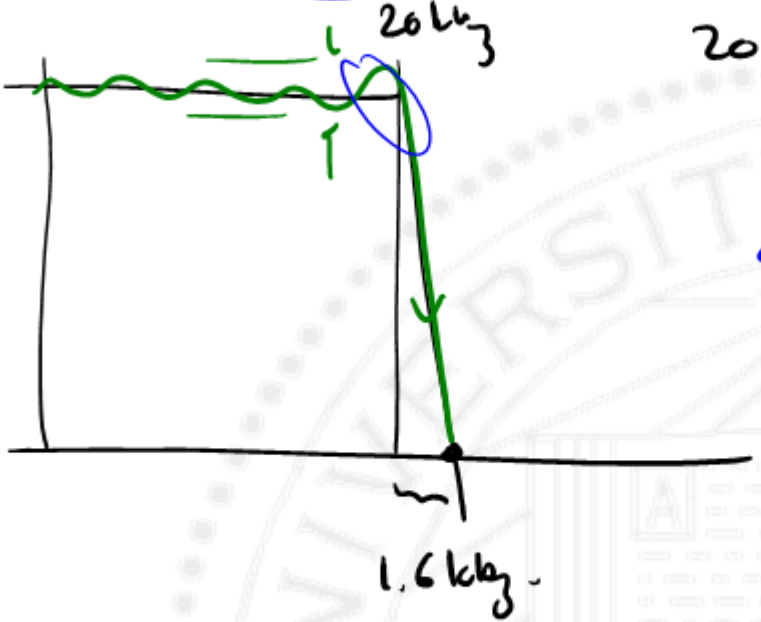
$\cos(a-b)$





CD → 44.1 → $\frac{1}{2}$ → 21.6 kHz

20 kHz — HUMAN



44 kHz.

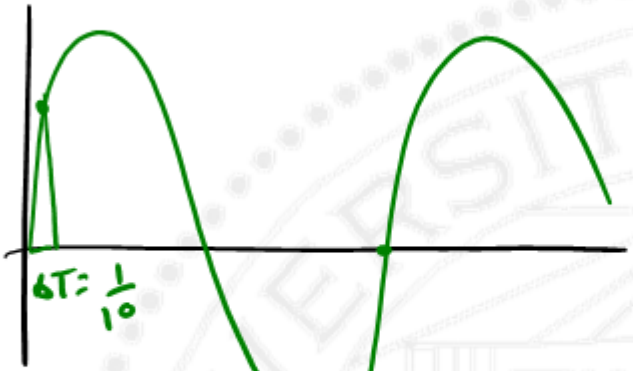
|

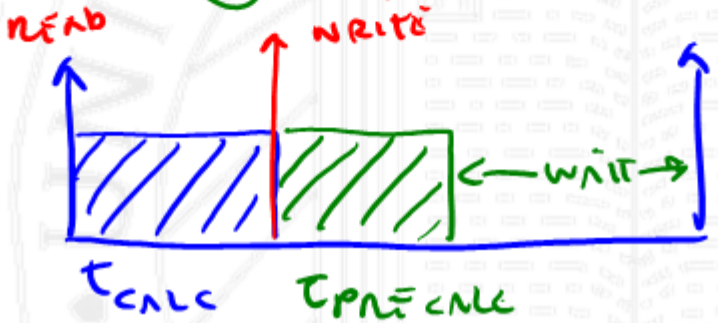
-20 kHz

4 kHz

Sample @ 10 ω_{x0} → $\frac{1}{20}(360)$ → 18° phase lag

5 ω_{x0} $\frac{1}{10}(360)$ → 36° phase lag



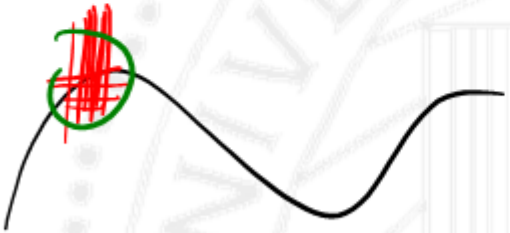


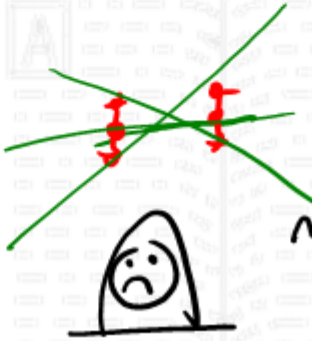
$$\dot{e} \simeq \frac{e_k - e_{k-1}}{\Delta T}$$

first order difference

# of bits in my ADC ← QUANTIZATION ERROR

~ WHITE NOISE $\frac{LSB}{2}$





ROUND OFF ERRORS

AMPLIFY NOISE