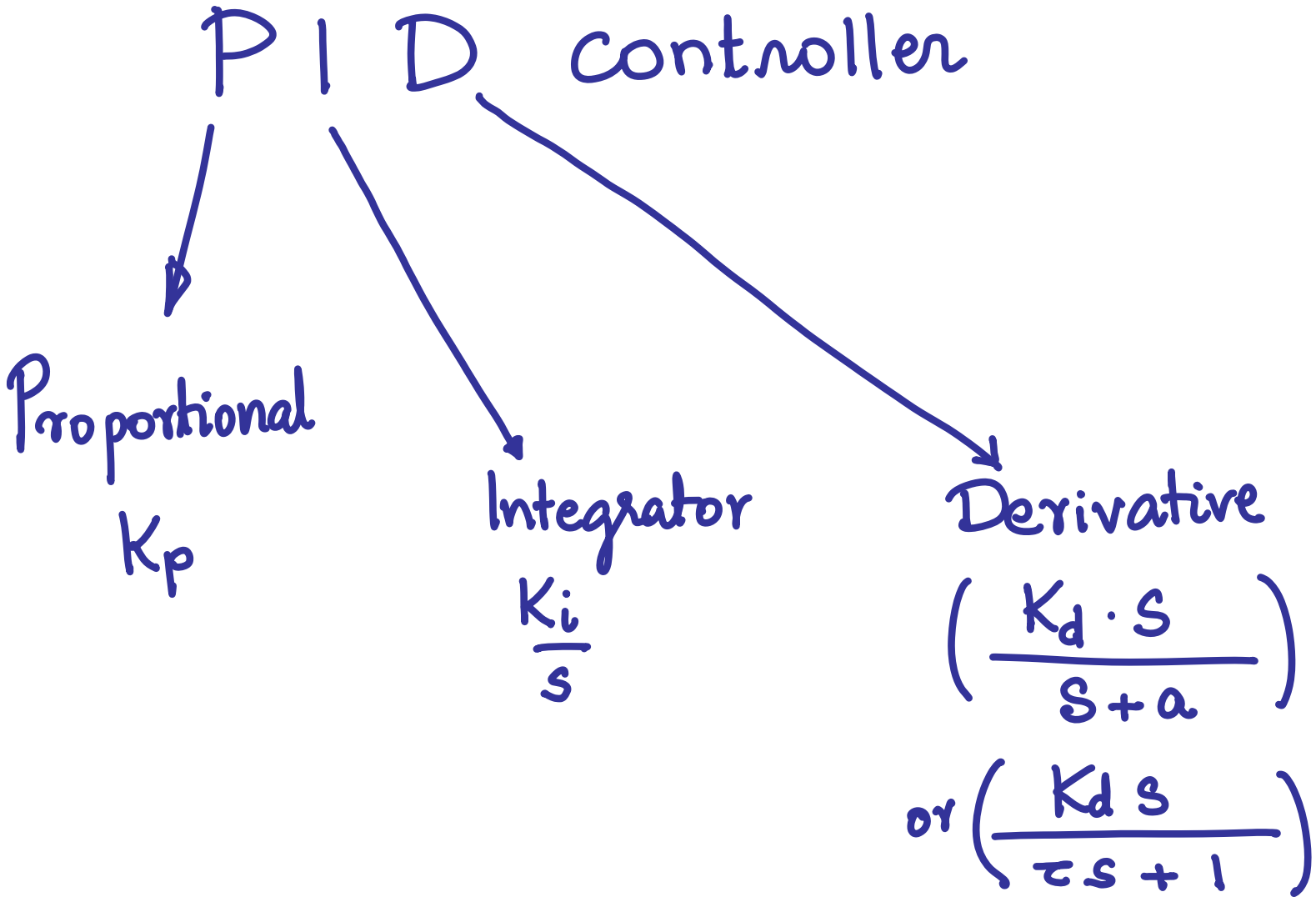
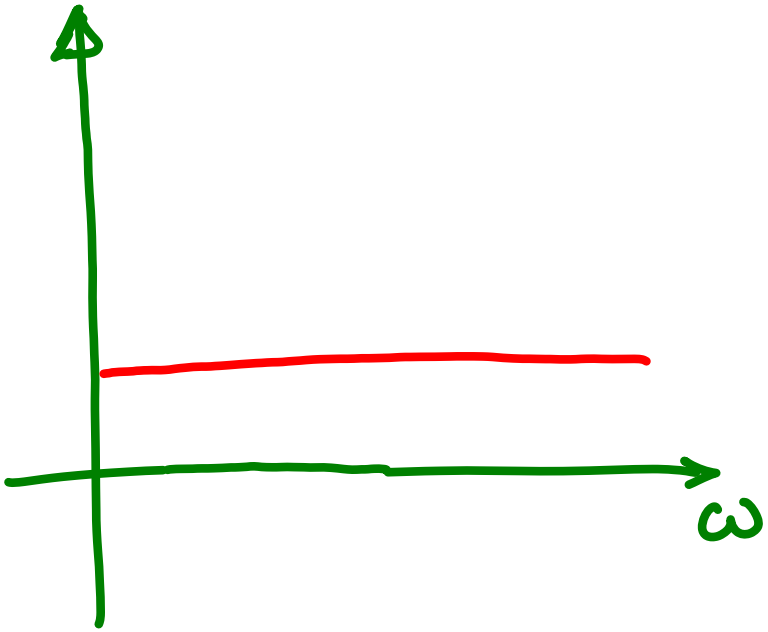

P I D controller
Proportional
K_p
Integrator
$\frac{K_i}{s}$
Derivative
$\left(\frac{K_d \cdot s}{s+a}\right)$
or $\left(\frac{K_d s}{\tau s + 1}\right)$

Proportional

K_p

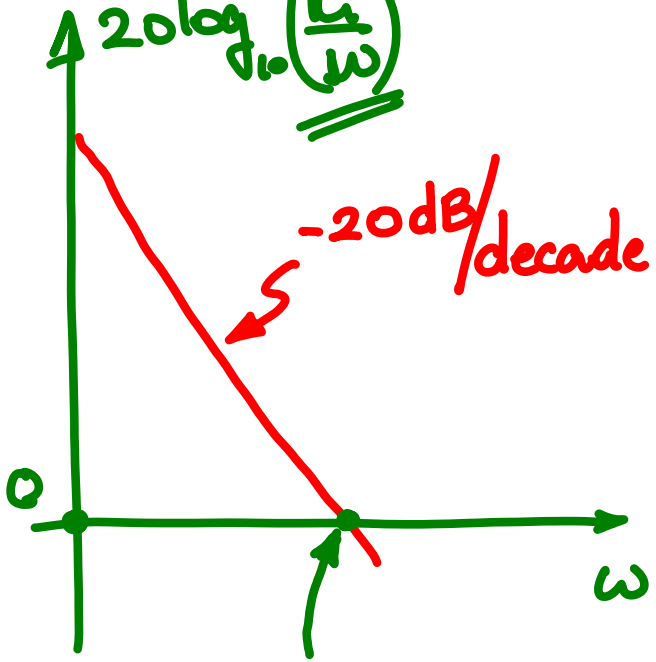
$dB = 20 \log_{10} K_p$



Integrator

$\frac{K_i}{S}$

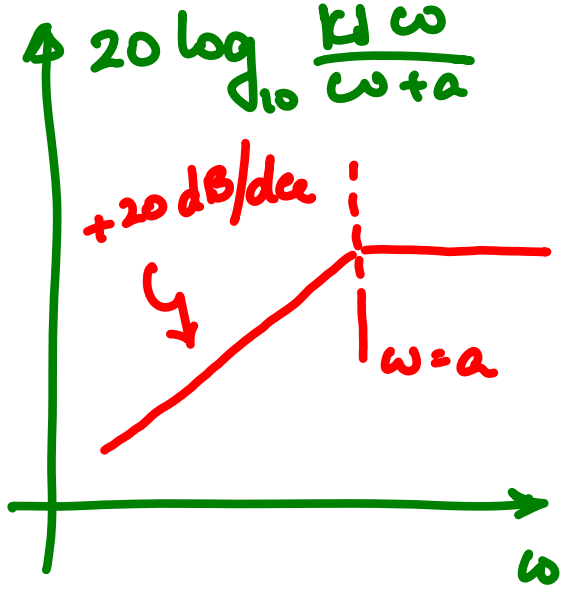
$20 \log_{10}\left(\frac{K_i}{\omega}\right)$

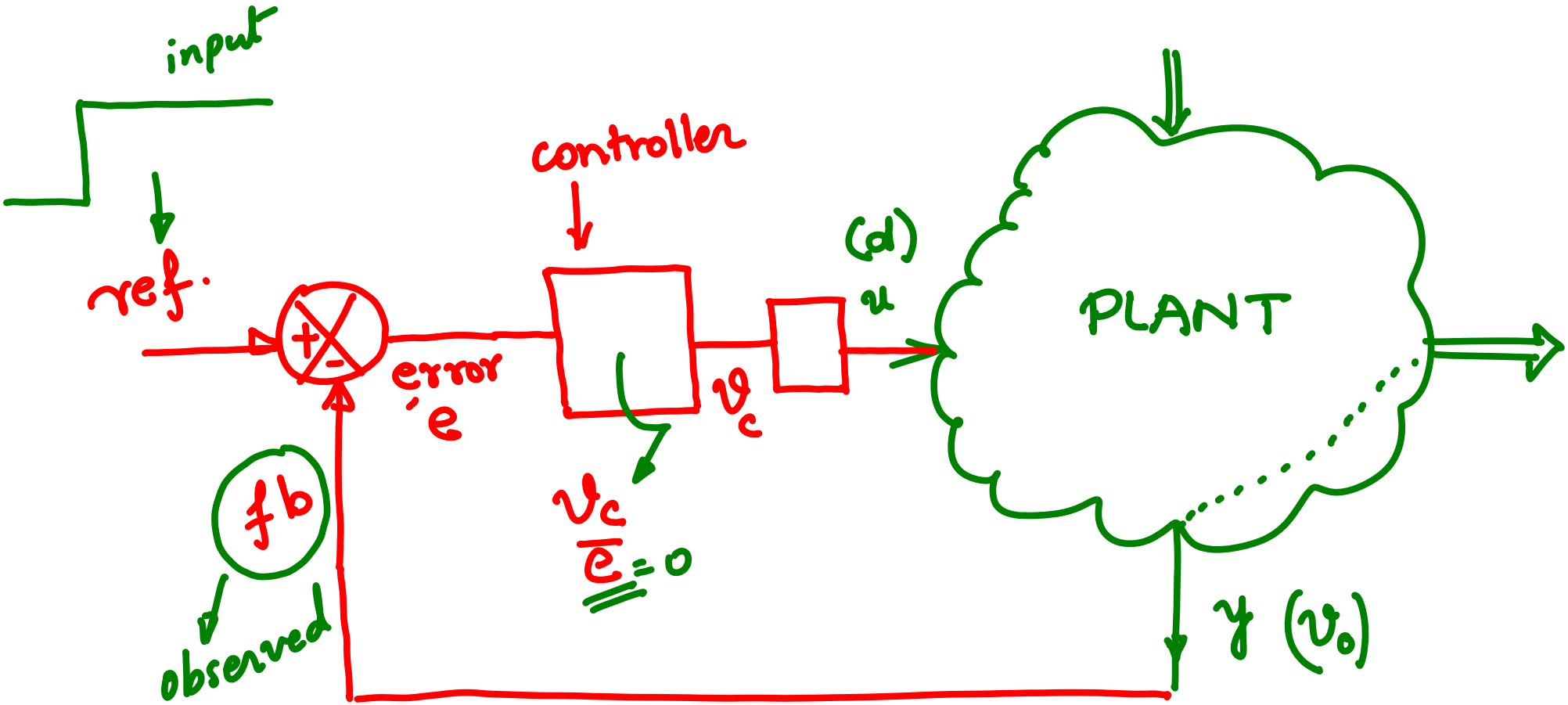


Derivative

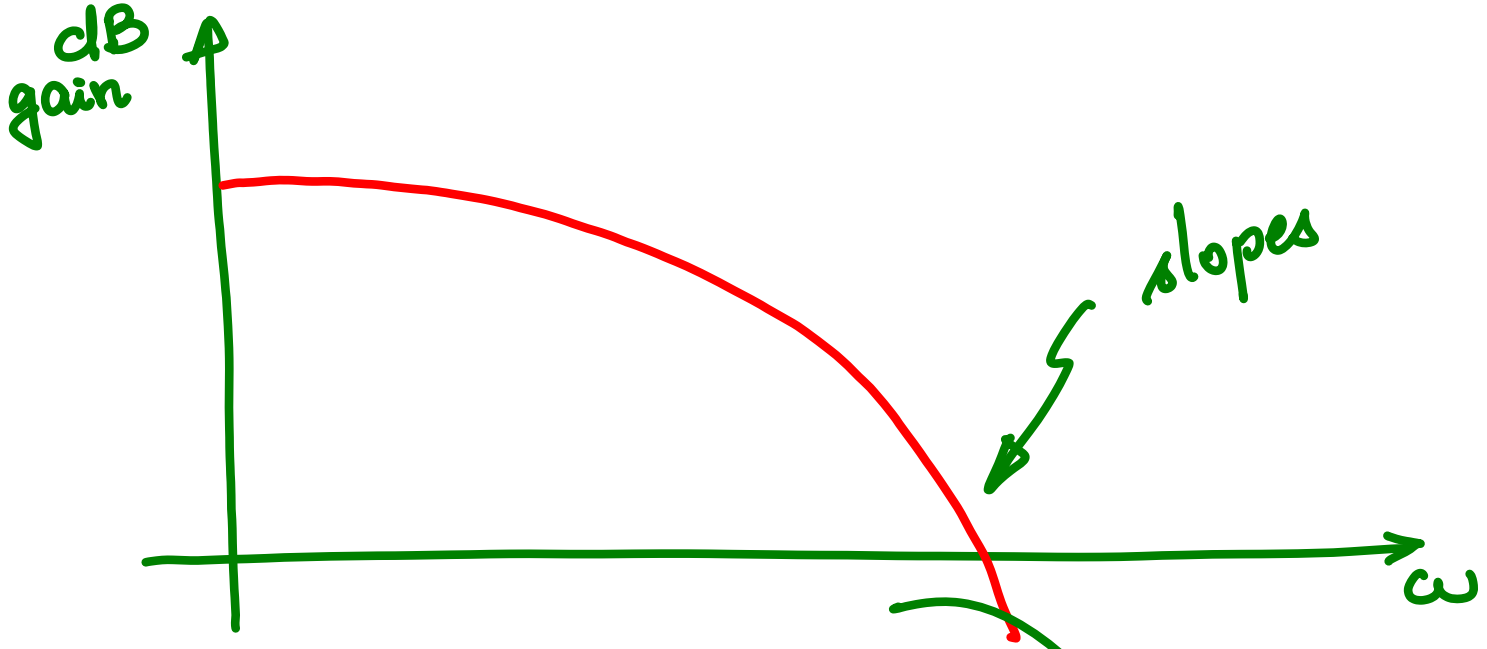
$\frac{K_d S}{S+a}$

$20 \log_{10} \frac{K_d \omega}{\omega + a}$



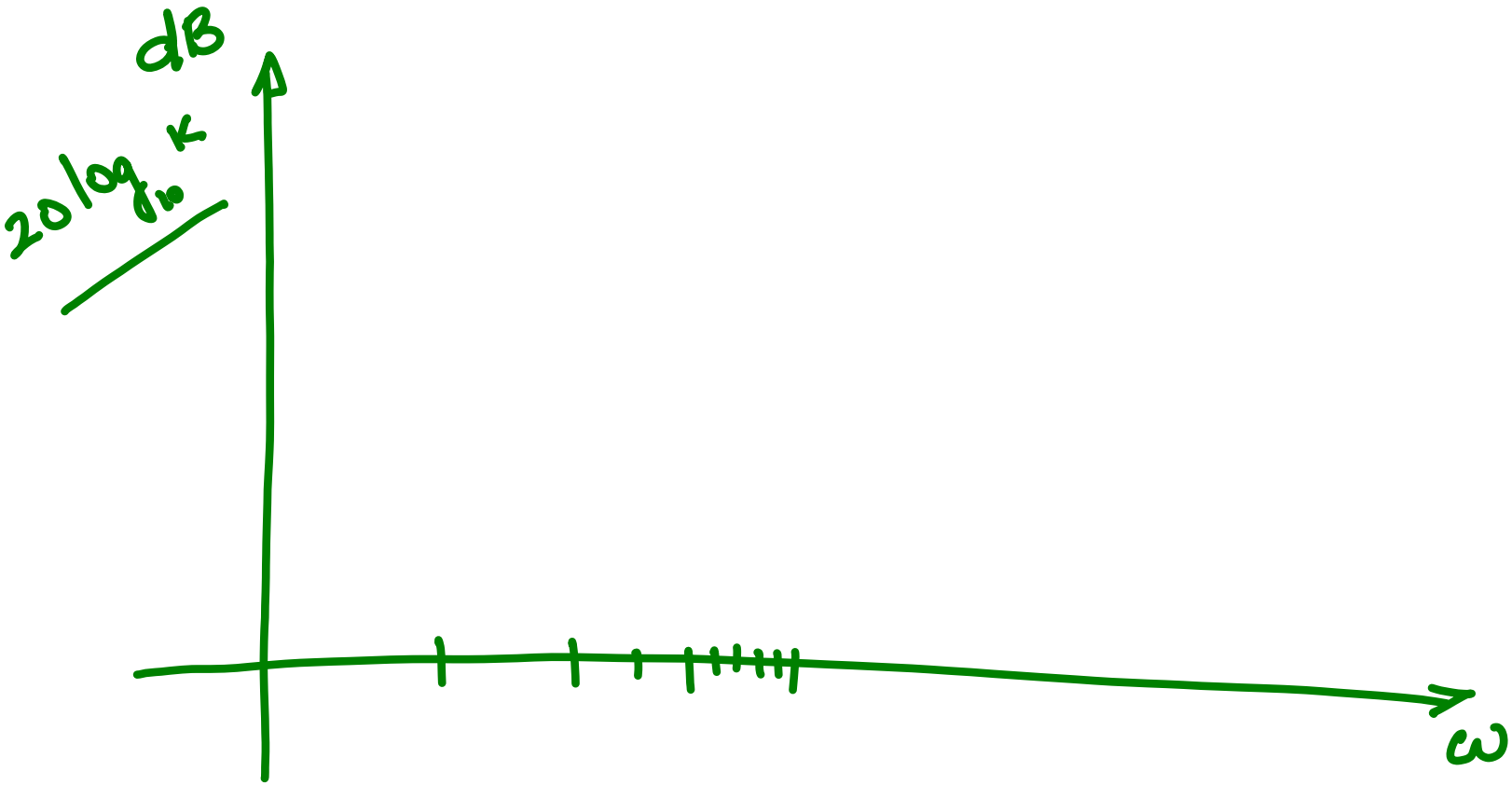


1. noise
2. limited supply voltage at u



PLANT
FREQ Response

P, I, D.

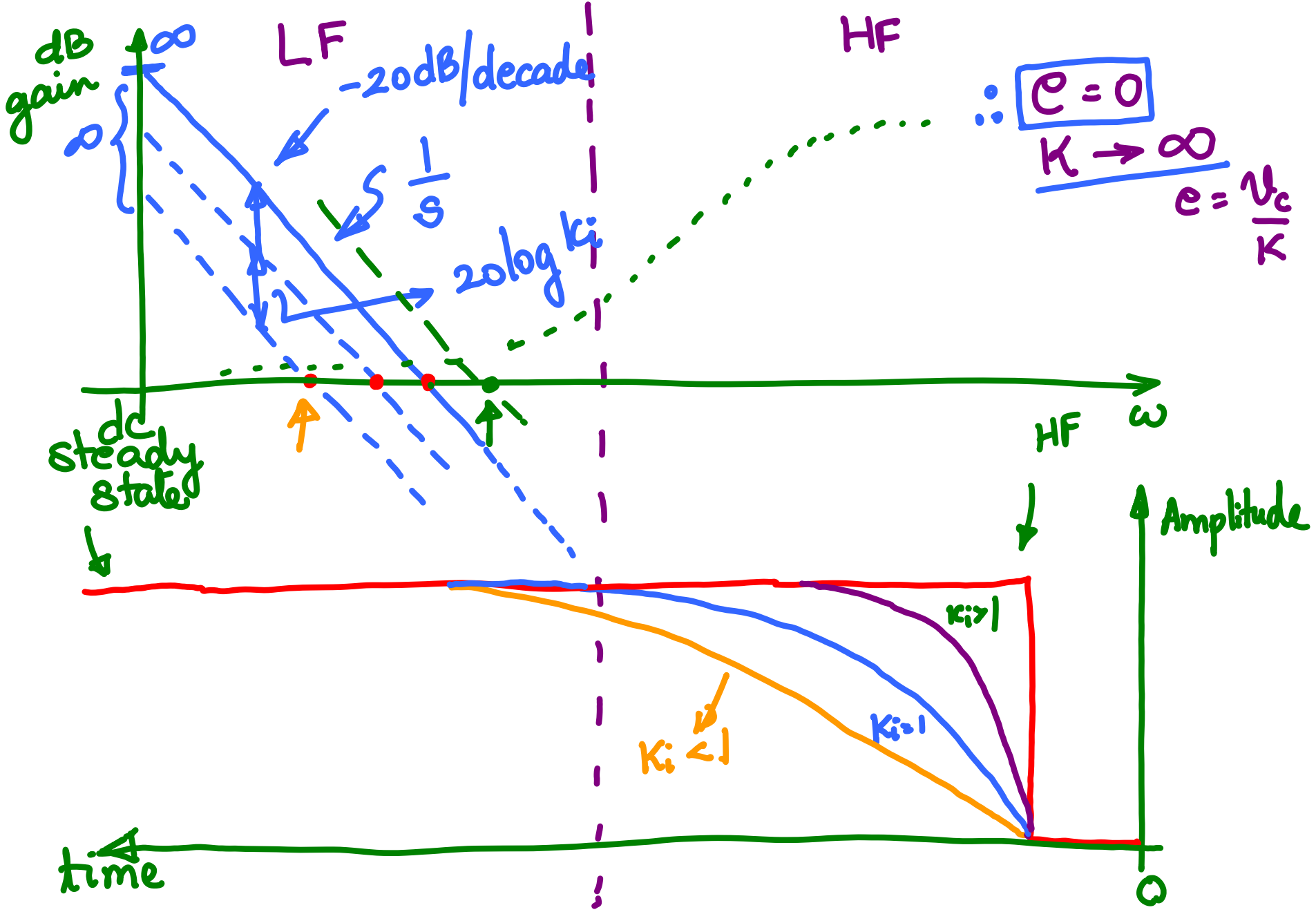

dB
$20\log_{10} K$
ω

Integrator $= \frac{1}{s}$

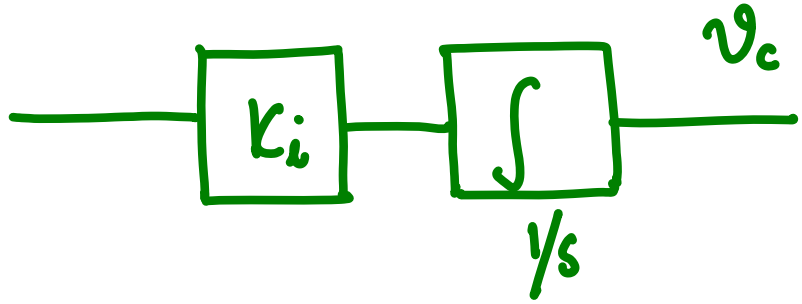
$$\frac{1}{s} = \frac{num}{den} = \frac{1.s^0}{1.s^1 + 0.s^0} = \frac{[1]}{[1 \quad 0]}$$

$\omega = logspace(-3, 3)$

10^{-3} to 10^{3}

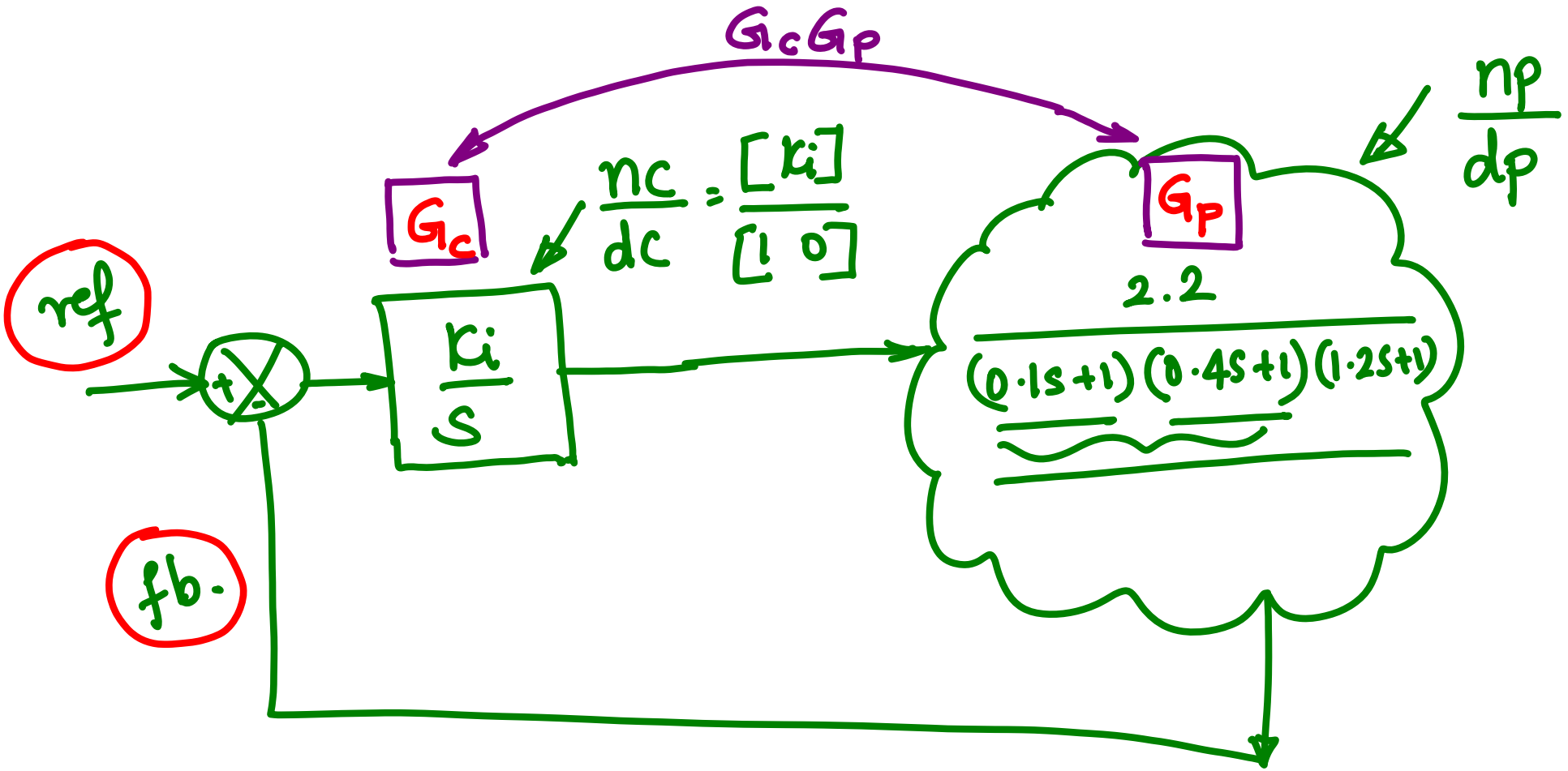

dB gain
∞
0
LF
-20dB/decade
HF
1/s
20log Ki
2
dc steady state
ω
HF
Amplitude
Ki>1
Ki=1
Ki<1
time
0
e = 0
K → ∞
e = Vc/K

$\frac{K_i}{s}$ =



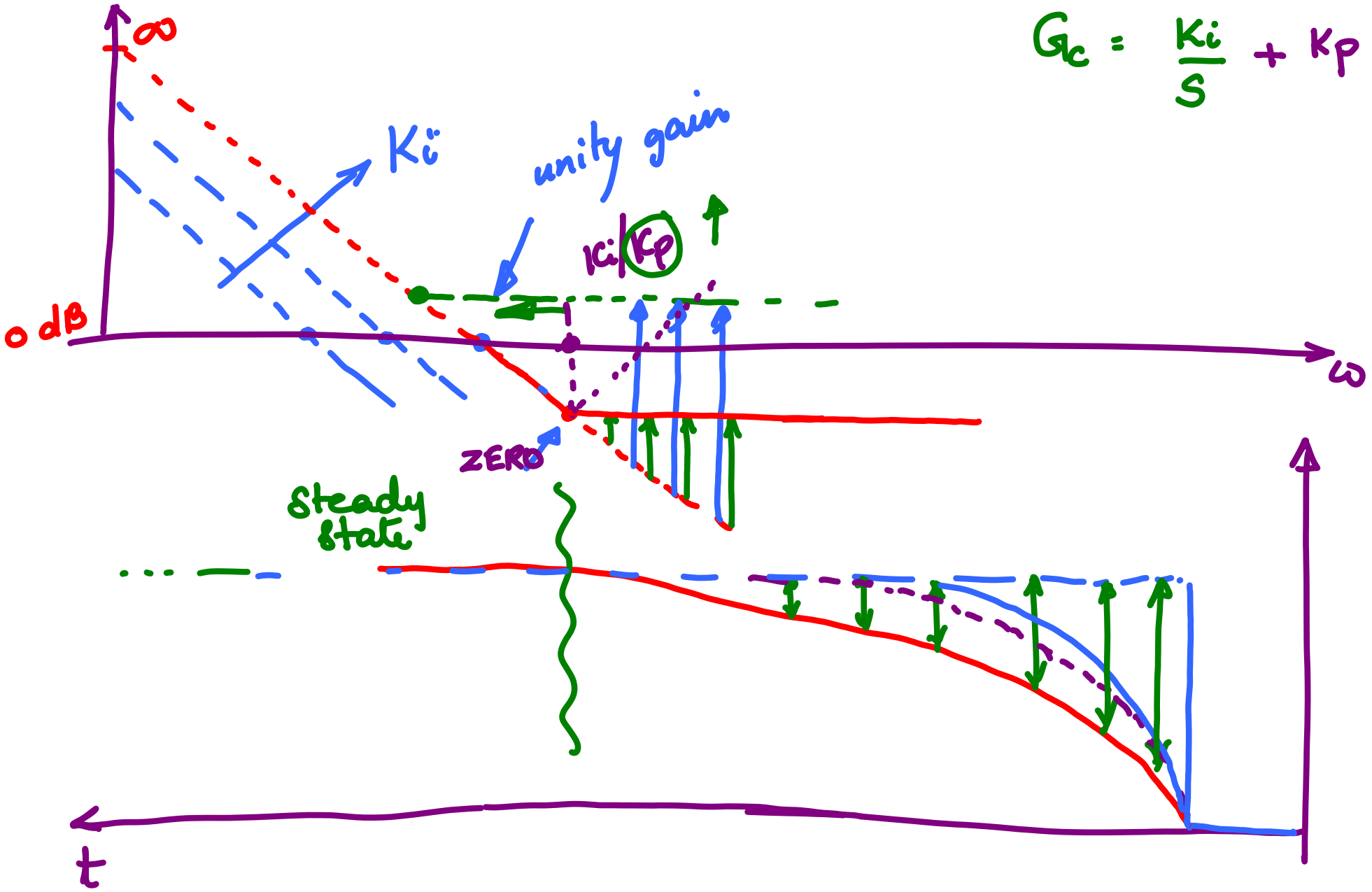
$$20 \log_{10} \frac{K_i}{\omega}$$

$$= 20\log_{10} K_i - 20\log_{10} \omega$$

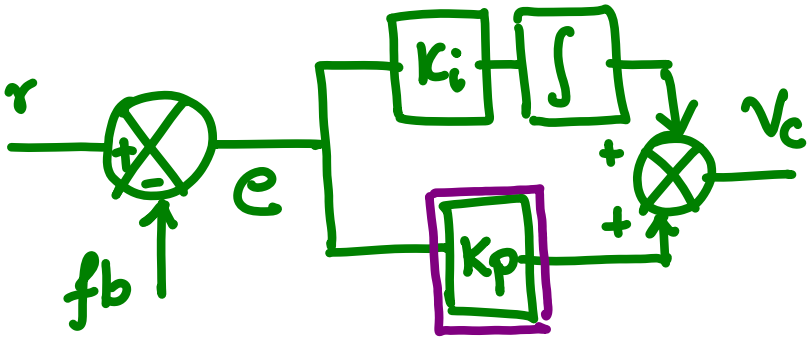


$$G_s = \frac{G_c G_p}{1 + G_c G_p} = \frac{ns}{ds}$$

P I D controller


$G_c = \frac{K_i}{s} + K_p$
∞
Ki
unity gain
Ki/Kp
0 dB
ω
ZERO
steady state
t

$$G_c = \underbrace{\frac{K_i}{s} + K_p}$$

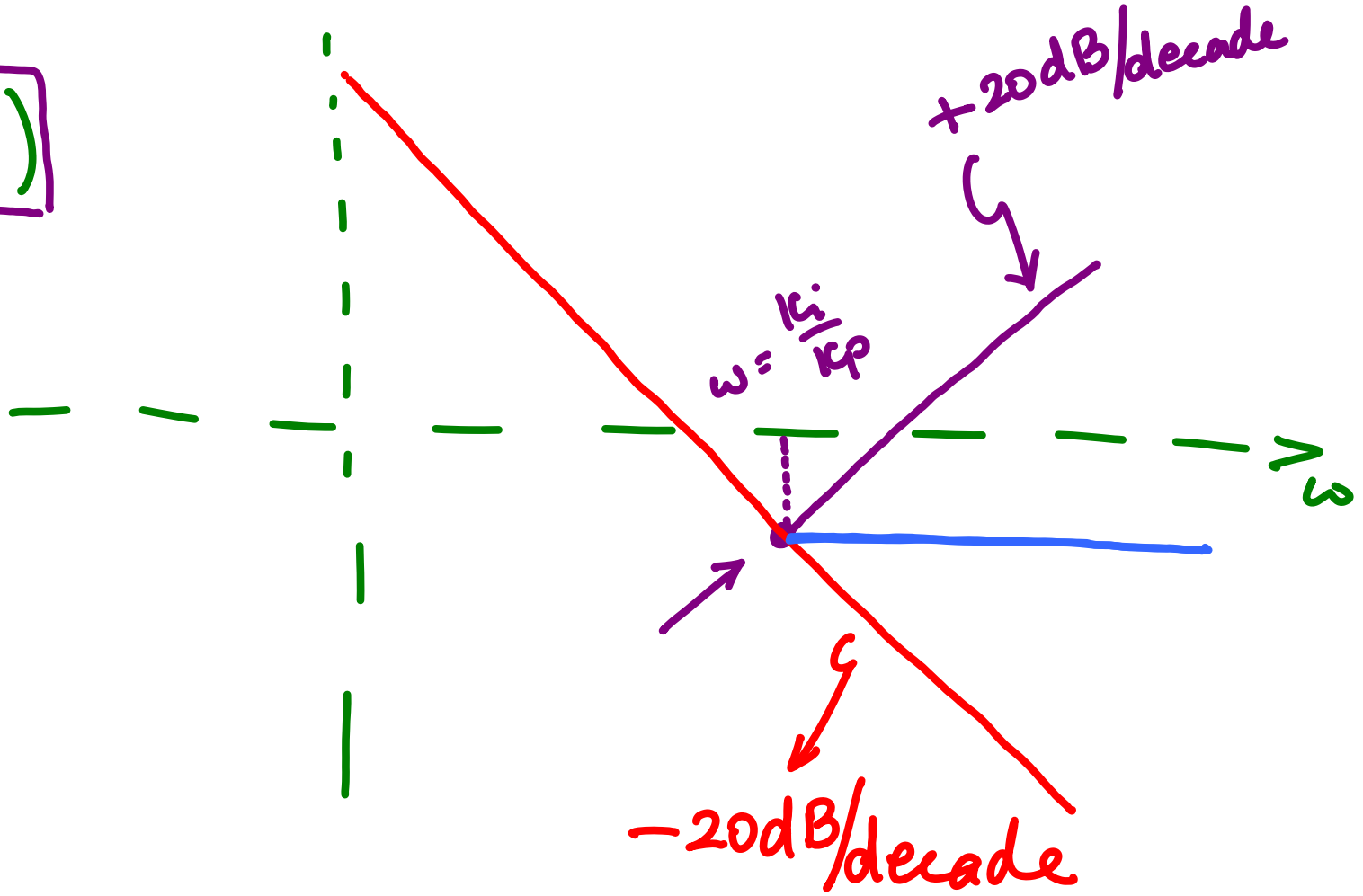


$$= \frac{K_i + K_p s}{s}$$

$$= K_p \boxed{\frac{(s + K_i/K_p)}{s}}$$

ZERO

$$G_c = \frac{(K_i + K_p s)}{s}$$



$$G_c = \frac{K_i + K_p s}{s} = \frac{nc}{dc}$$

$$nc = \begin{matrix} s^1 & s^0 \\ \begin{bmatrix} K_p & K_i \end{bmatrix} \end{matrix}$$

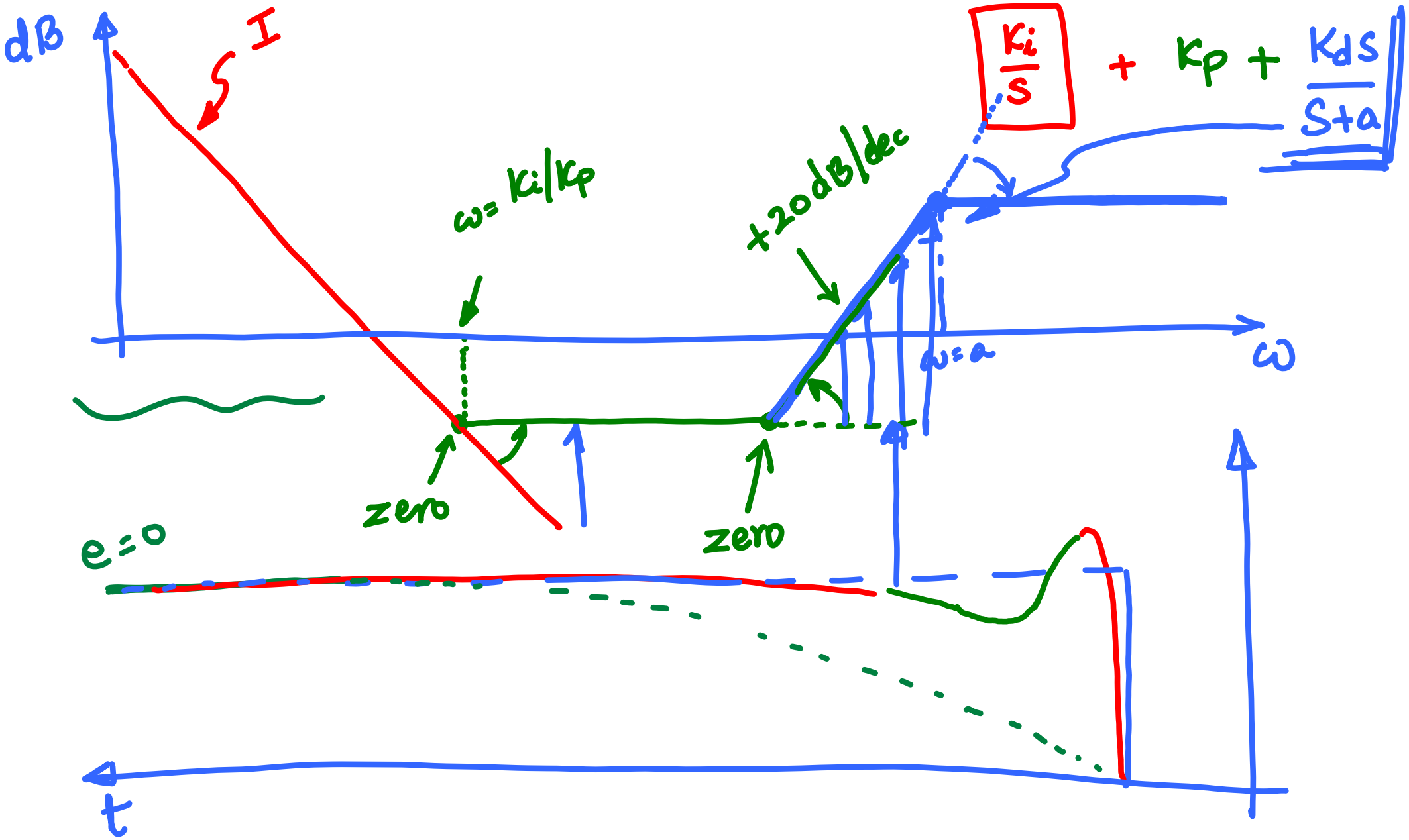
$$dc = \begin{matrix} s^1 & s^0 \\ \begin{bmatrix} 1 & 0 \end{bmatrix} \end{matrix}$$

Proportional + Integral

PI controller

K_i

K_p


dB
I
$\frac{K_i}{S}$ + K_p + $\frac{K_d s}{S+a}$
$\omega = K_i/K_p$
+20dB/dec
$\omega = a$
ω
zero
zero
e=0
t