BODE PLOTS

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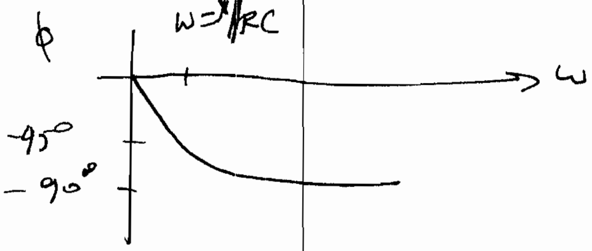
RC filter phase



$H(\omega)$ mathematical properties

$s \equiv j\omega$

So $H(s) \equiv H(j\omega)$

Zero: value of s such that $H(s)=0$

Pole ~~Pole~~: value of s such that $H(s)=\infty$

E.g. $H(s) = \dfrac{s\,(s+2)}{(s+1)(s+1)}$ Pole ~~Poles~~ $s=-2$ ~~s=0~~ ~~Zeros:~~

Poles: $s=-1$ zeros: $s=0,-2$

$\propto$

$$dB \equiv 10\log P_1/P_2 = 10\log \frac{V_1^2/R}{V_2^2/R}$$

$$= 10\log\frac{V_1^2}{V_2^2} = 20\log V_1/V_2$$

table...

~~V_1/V_2~~

dB	P_1/P_2	V_1/V_2
0	1	1
−10	0.1	0.33
−20	0.01	0.1
⋮		
+10	10	3.3
+20	100	10
⋮		
−3	$1/2$	$1/\sqrt{2}$
+3	2	$\sqrt{2}$

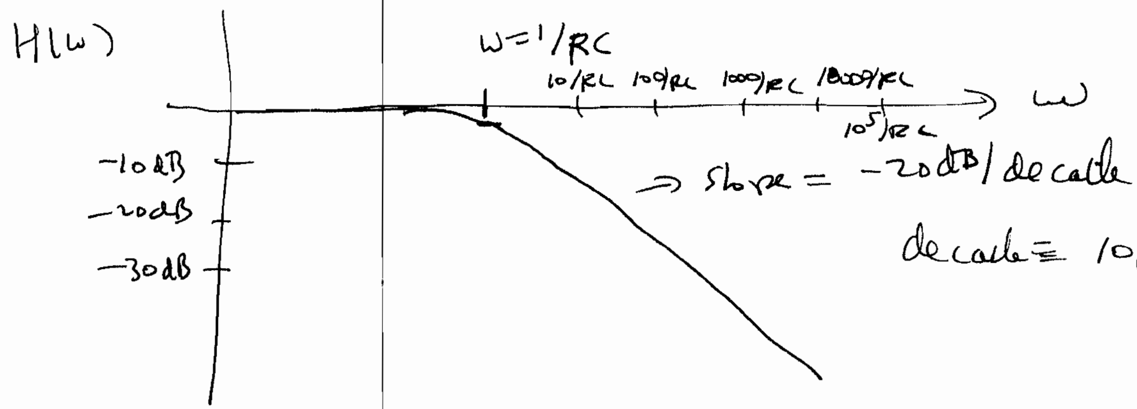
Bode Plot H (dB) vs. ω (log scale)

E.g. RC filter

$$H(\omega) = \frac{1}{1+j\omega RC} \qquad H(s) = \frac{1}{1+sRC}$$

Zero: none

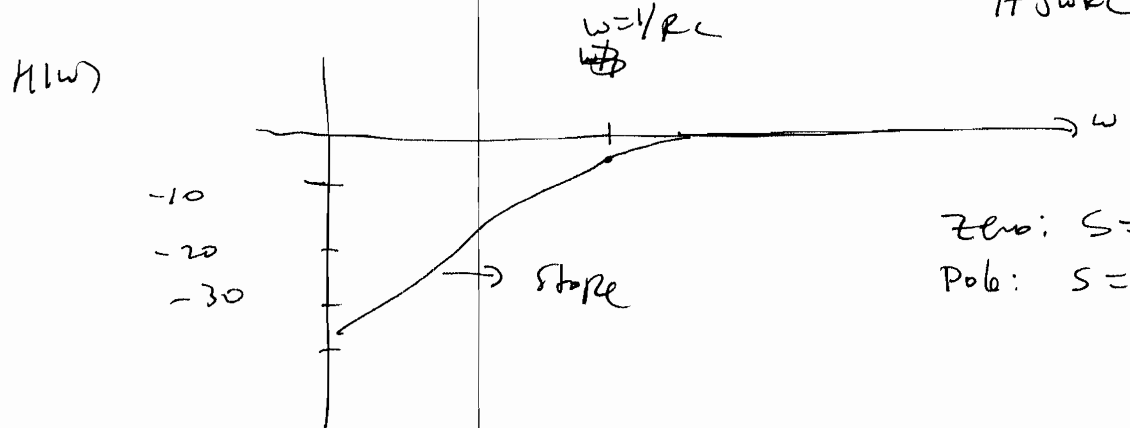
Pole: $s = \frac{-1}{RC}$



decade ≡ 10x change

Eg RC HPF

$$H(\omega) = \frac{j\omega RC}{1+j\omega RC} \qquad H(s) = \frac{sRC}{1+sRC}$$



Zero: $s=0$

Pole: $s = -1/RC$

Can always write $H(s)$ as product of poles, zeros:

Eg $$H(s) = \frac{s\ (s+2)}{(s+1)(s+1)}$$

$$= 2 \times s \times \left[1 - \left(-\tfrac{s}{2}\right)\right] \times \frac{1}{[1-(-s)]} \times \frac{1}{[1-(-s)]}$$

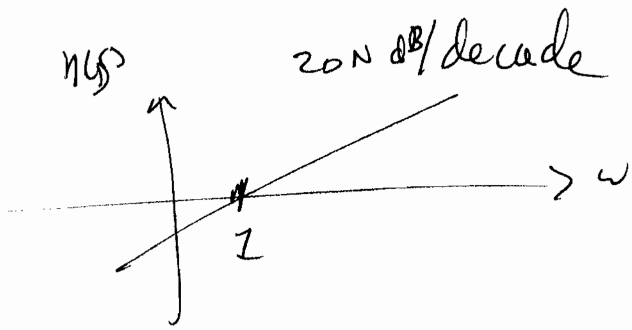
But in dB $$\log H(s) = \log \left\{ 2 \times s \times \left[1 - \left(-\tfrac{s}{2}\right)\right] \times \left[\frac{1}{1-(-s)}\right] \times \left[\frac{1}{1-(-s)}\right] \right\}$$

$$= \log 2 + \log(s) + \log\left[1 - \left(-\tfrac{s}{2}\right)\right] + \log\left[\frac{1}{1-(-s)}\right] + \log\left[\frac{1}{1-(-s)}\right]$$

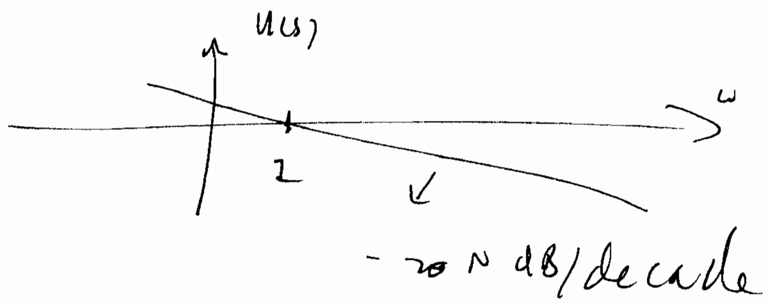
So to sketch $H(s)$ Bode plot, easy to do if you know behavior of some simple cases: poles, zeros.

Simple cases

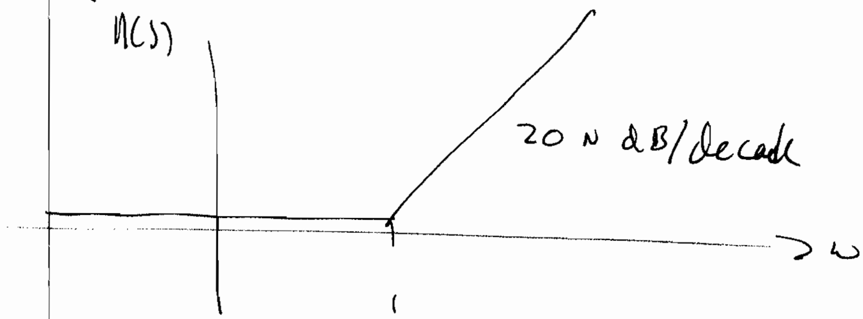
$H(s) = s^N$



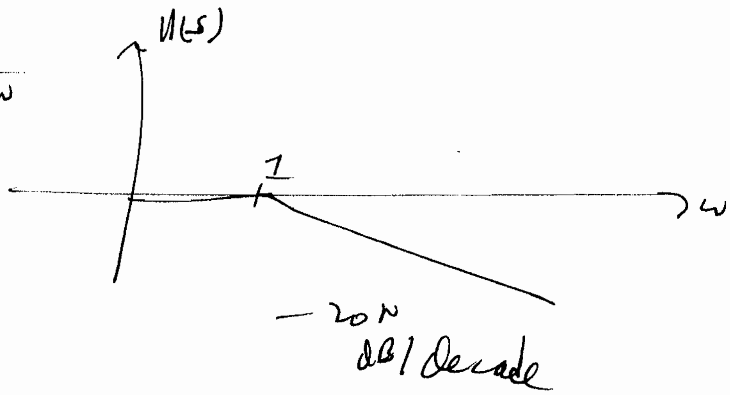
$H(s) = s^{-N}$



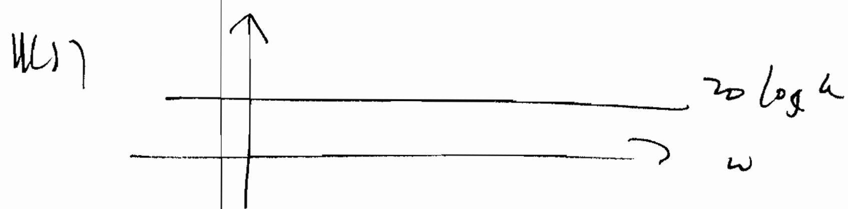
$$H(s) = (1+s)^N$$



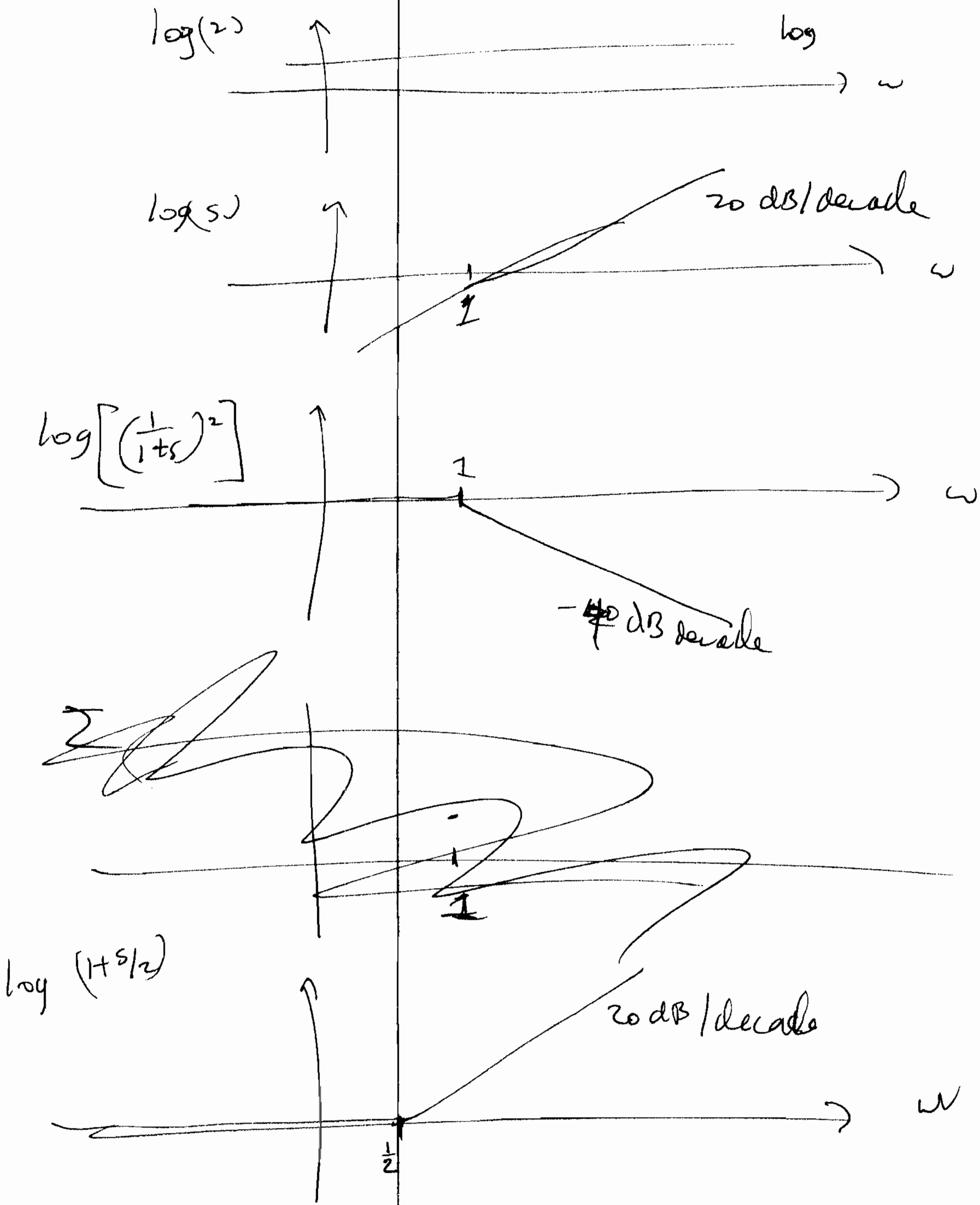
$$H(s) = \frac{1}{(1+s)^N}$$



$H(s) = K$ (constant)



$$\text{Ep } H(s) = \frac{s\,(s+2)}{(s+1)\,(s+1)} = \frac{2\;s\,(1+s/2)}{(1+s)(1+s)}$$



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