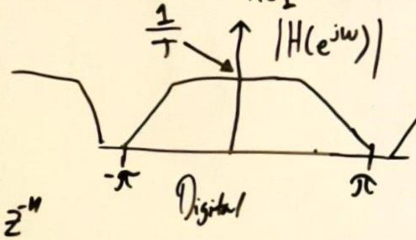
# Lec 2 IIR    IIM = Impulse invariant method    Butterworth LP = BLP

Specs of filter → Analog Proto filter $H(s)$ → Optimus Prime $H(s)$ into $H(z)$

1. Start with $H_c(s)$ get $h_c(t) = \mathcal{L}^{-1}\{H_c(s)\}$ ; Assume BLP for $M=0$, $\beta_0 = A_0$

Rewrite $H_c(s)$ with part frac : $H_c(s) = \sum_{k=1}^{N} \frac{A_k}{s - s_k}$. $h_c(t) = \mathcal{L}^{-1}\{H_c(s)\} = \sum_{k=1}^{N} A_k e^{s_k t}$
(makes it easier)

2. Sample $h_c(t)$: $h[n] = T \cdot h_c(nT)$
$= T \cdot \sum_{k=1}^{N} A_k e^{s_k nT} u[n]$




Multiply with T for sample since in freq it is $\frac{1}{T}$ amp

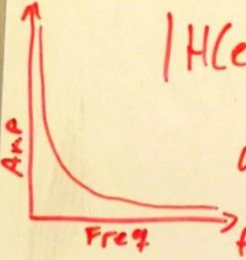
3. Get $H(z)$ of $h[n]$: $H(z) = \mathcal{Z}\{h[n]\} = \sum_{n=0}^{\infty} h[n] z^{-n}$
With the general TF is found using IIM. $= \sum_{k=1}^{N} \frac{T A_k}{1 - e^{s_k T} z^{-1}}$

Indsæt værdier hvis $H_c(s) = \frac{1000}{s+1000}$

$\Longrightarrow H(z) = \frac{\frac{1}{8000} \cdot 1000}{1 - e^{-1000/8000} z^{-1}}$ ; $T = \frac{1}{f_s}$

## generelle vigtige noter om IIM!

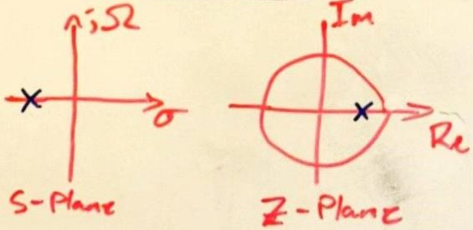
### Sample frekvens




$\omega = T\Omega = 2\pi f \frac{1}{f_s}$
$\Downarrow$
$f = \frac{\omega}{2\pi} \cdot f_s$ ①

hvis $f_s$ bliver større ændre formen på Amplitude Responsen sig ikke. se ①. dermed ændre $f_{3dB}$ sig ikke.
Vi får bare info ved større $f_s$

### Poler S→Z Plan

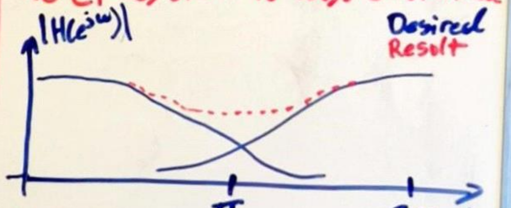



if Stable in S ⇒ Stable in Z
$|z_k| = e^{\sigma_k T} < 1$ for $\sigma_k < 0$

No simple math to map S→Z
Poles and zeros mapped diffrently.
Zeros not that important

### Aliasing

Sample Impuls Respons → Periodic Frequency.
No CT-system is 100% Band limited




Aliasing happens in Digital System when using IIM.

CT = Continous-Time