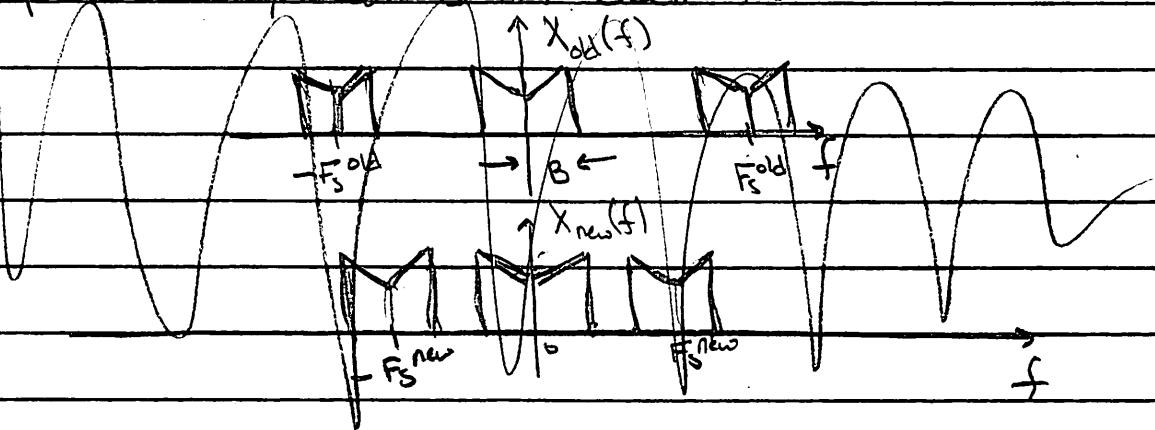
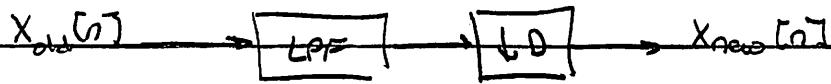


- Spectral Implications of decimation



Decimation is limited by the requirement that $F_s^{new} > 2B$

If application requires $F_s^{new} < 2B$, then low pass filter $X_{old}[n]$.



Q: What if decimation factor, D, is large - $D > 10$
 - Computational savings by doing it in stages.



$$D = D_1 \cdot D_2$$

Q: What should $D_1 \approx D_2$ be to minimize number of taps in low pass FIR filters $LPF_1 \in LPF_2$?

$$D_{1,opt} \approx 2D \frac{1 - \sqrt{DF/(2-F)}}{2-F(D+1)}$$

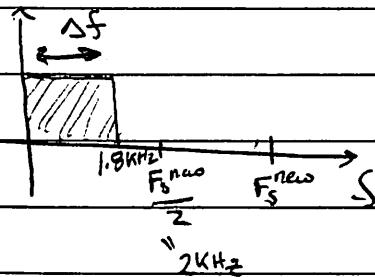
where $F = \frac{\Delta f}{f_{stop}}$

$$\text{Now, } D_2 = D / D_{1,\text{opt}}$$

Example

$$F_s^{\text{old}} = 400 \text{ kHz} \quad D = 100 \quad F_s^{\text{new}} = 4 \text{ kHz}$$

Baseband freqs of interest are: 0 to 1.8 kHz
 "B"



Taps for single stage FIR lowpass filter

$$T = K \frac{F_s^{\text{old}}}{(f_{\text{stop}} - B')} = K \frac{F_s^{\text{old}}}{\Delta f}$$

filter transition band

where $2 < K < 3$ depends on passband ripple?
 stopband atten.

$$\text{So, let } K=2 \Rightarrow T = 2 \left(\frac{400}{0.2} \right) = 4000 \quad \text{ouch!}$$

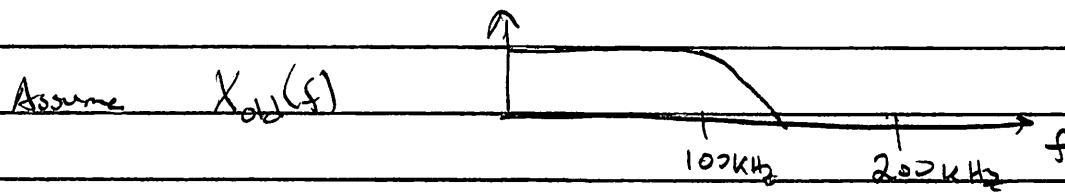
Partition into 2 stages -

$$D_{1,\text{opt}} \approx 31.9 \quad \text{choose submultiple of 100}$$

$$D_{1,\text{opt}} = 25$$

$$\text{So, } D_2 = 4$$





LPF₁ has cutoff of 1.8 kHz w/ f_{stop} = -8 kHz

LPF₂ has cutoff of 1.8 kHz w/ f_{stop} = 2 kHz

$$\text{use } T \approx k \frac{F_s^{\text{old}}}{\Delta f}$$

$$\Rightarrow \bar{T}_{\text{LPF}_1} = 2 \frac{400}{(8-1.8)} =$$

$$\bar{T}_{\text{LPF}_2} = 2 \frac{16}{(2-1.8)} =$$

$$\bar{T}_{\text{Total}} = 289 \text{ taps} \quad \text{Much Better!}$$

Note: If our coeff are symmetrical we can reduce the computations further.

Note: A decimator is not time-invariant

Note: Decimation does not cause time-domain loss, but it does induce magnitude loss by factor of D in Freq. domain.

Q: Why decimate our signals.