up sampling summary

$$x[n] \longrightarrow \boxed{\uparrow N} \xrightarrow{\;w[n]\;} \boxed{\text{LPF}} \longrightarrow y[n]$$

$$
\begin{array}{c} x[n] \\ X(f) \end{array} \longrightarrow \boxed{\begin{array}{c}\text{sequence to}\\ \text{impulse train}\end{array}} \begin{array}{c} w[n] \\ \hline W(f) \end{array} \longrightarrow \boxed{\begin{array}{c}\text{low pass filter}\\ h[n] \leftrightarrow H(f)\end{array}} \begin{array}{c} y[n] \\ Y(f) \end{array}
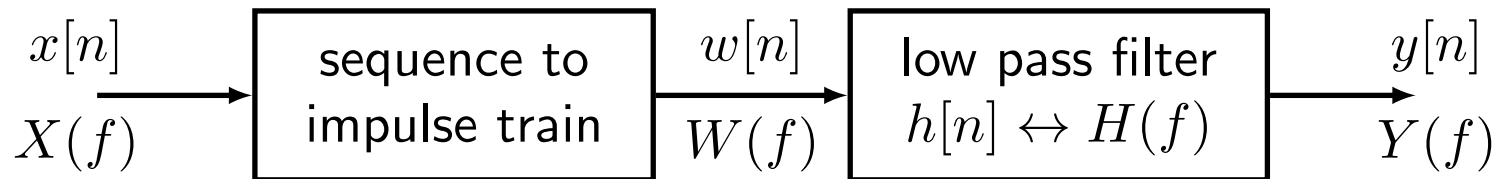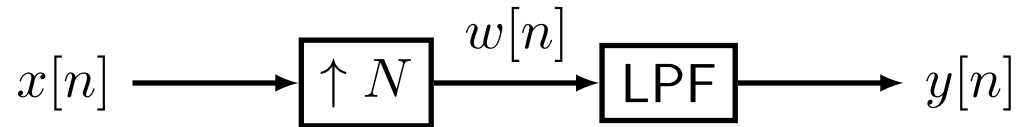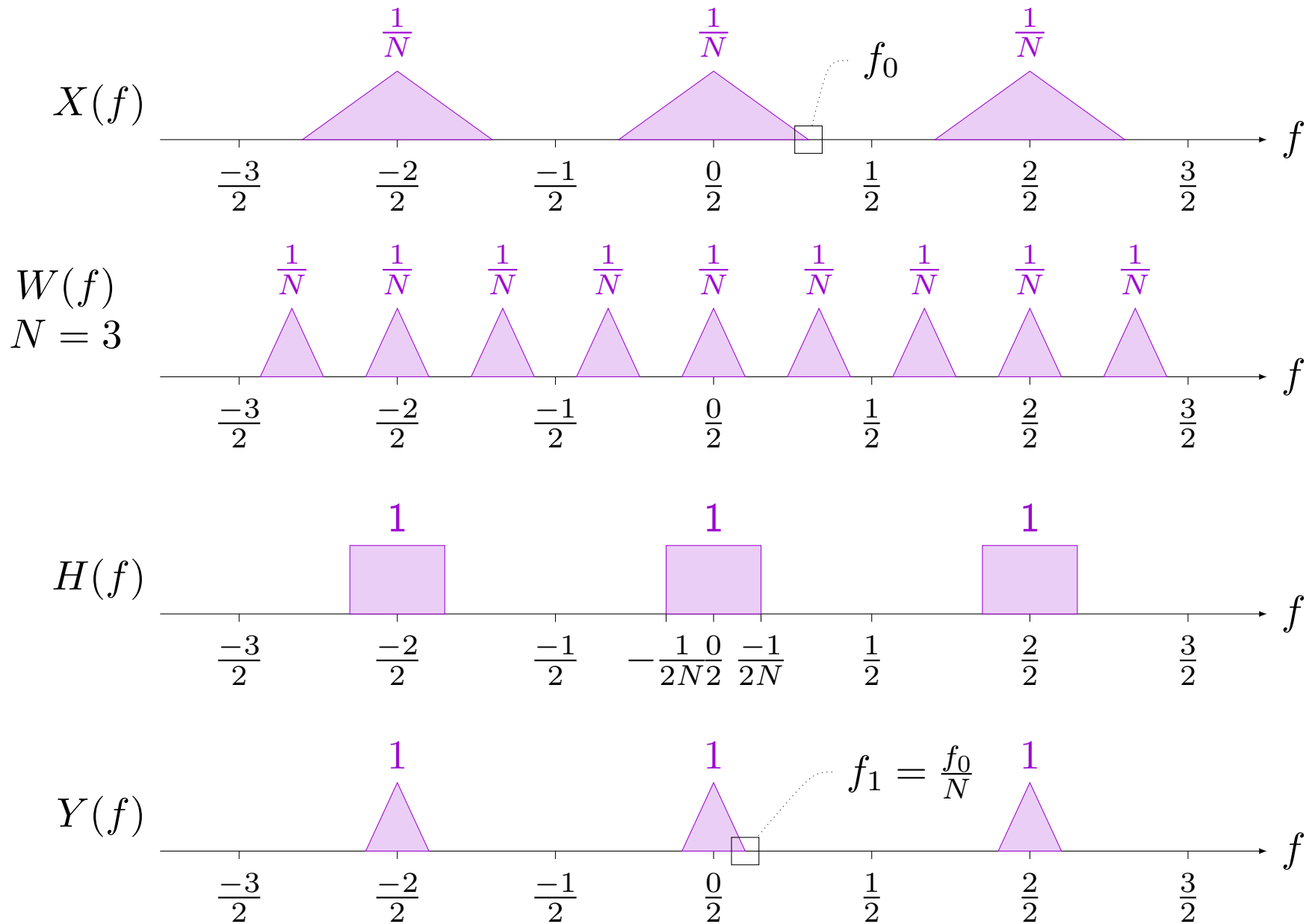$$

imaging formula: $W(f) = X(fN) = X\left(\dfrac{f}{f_s}\right)$

LPF to remove images: $Y(f) = \begin{cases} X(fN) = X\left(\frac{f}{f_s}\right), & |f| \leq \frac{1}{2N} = \frac{f_s}{2}, \\ 0, & \text{otherwise} \end{cases}$

graphical approach to up sampling

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