

Bandpass Sampling (2B)

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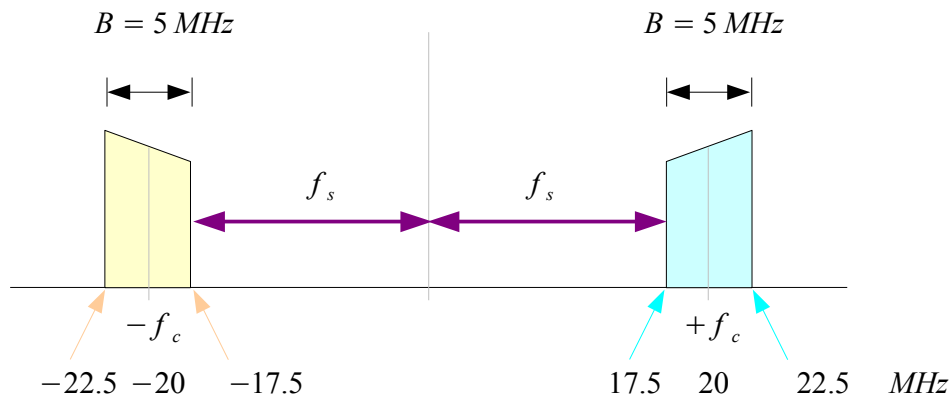
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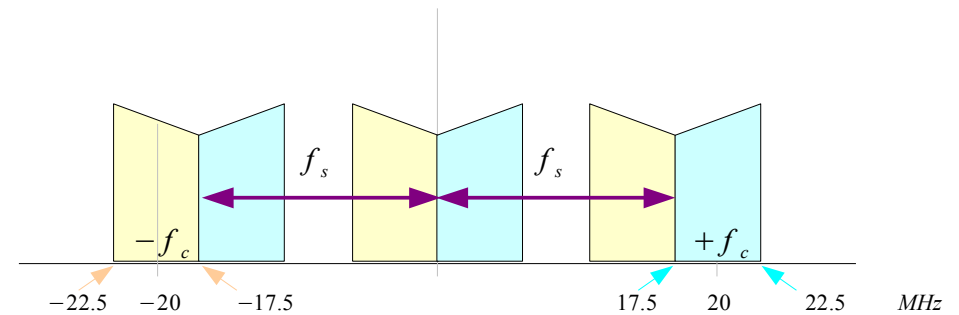
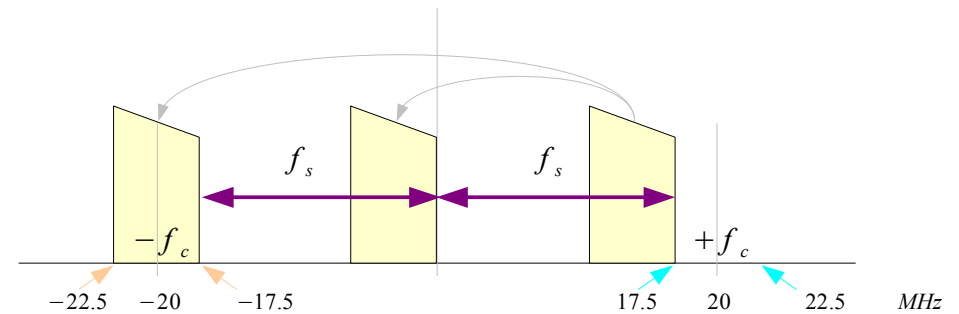
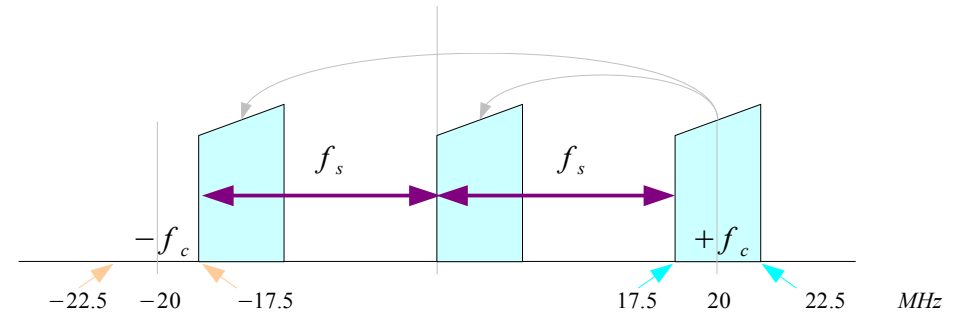
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Band-limited Signal

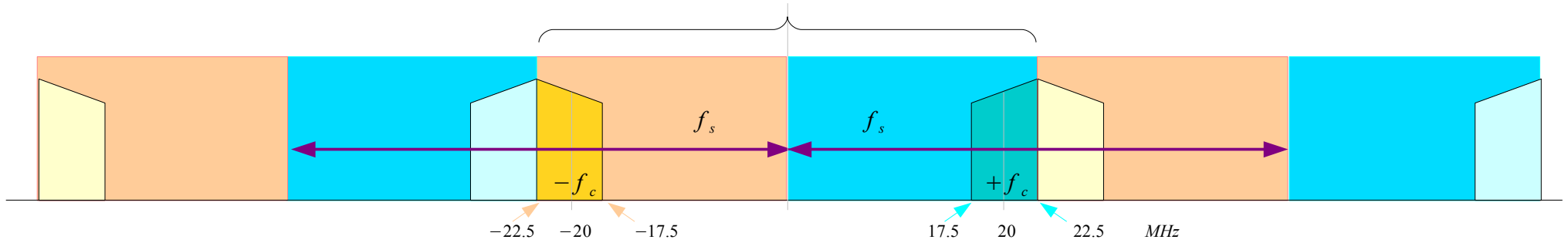


mirror

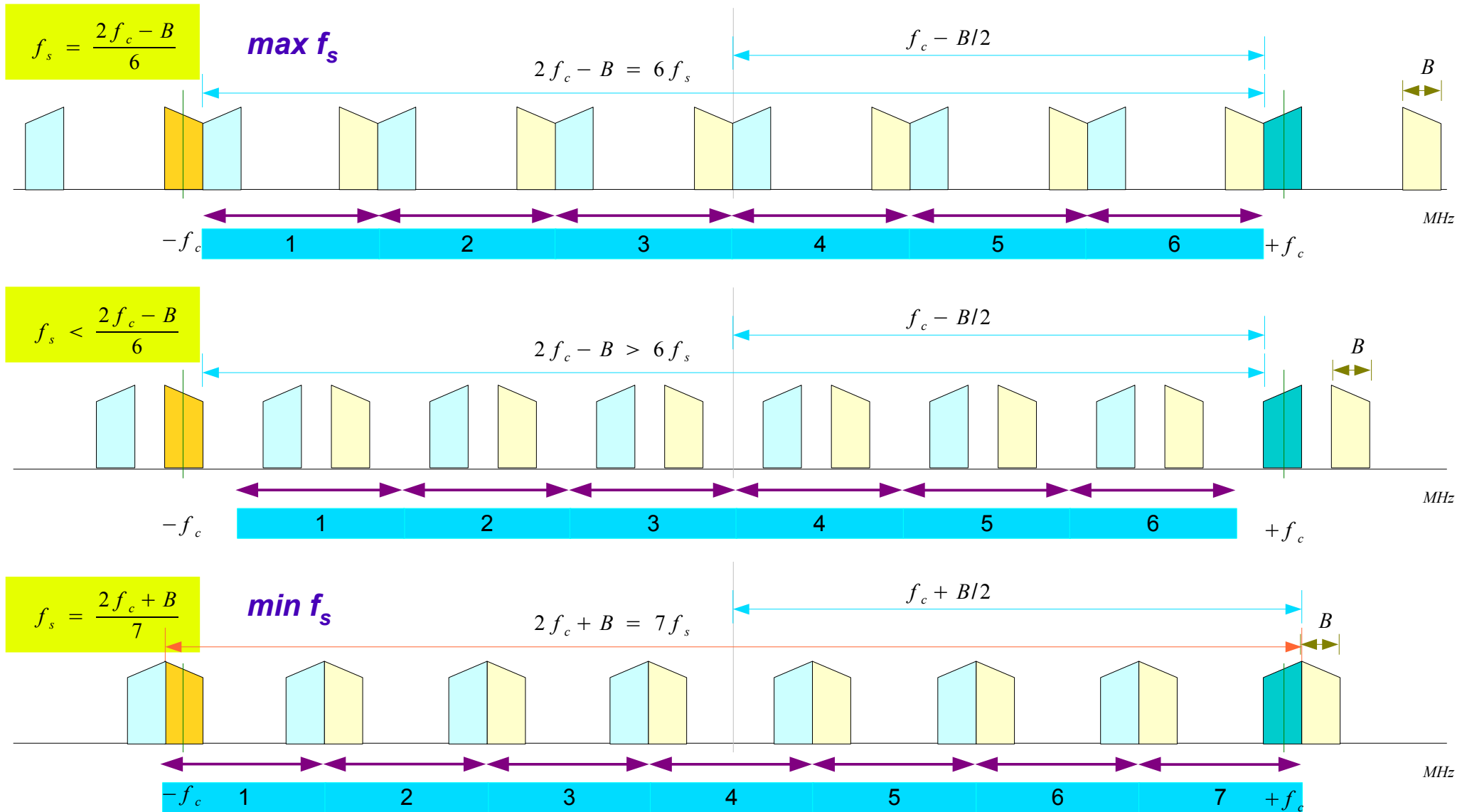
- **Bandpass Sampling**
- **IF filtering**
- **Harmonic Sampling**
- **Sub-Nyquist Sampling**



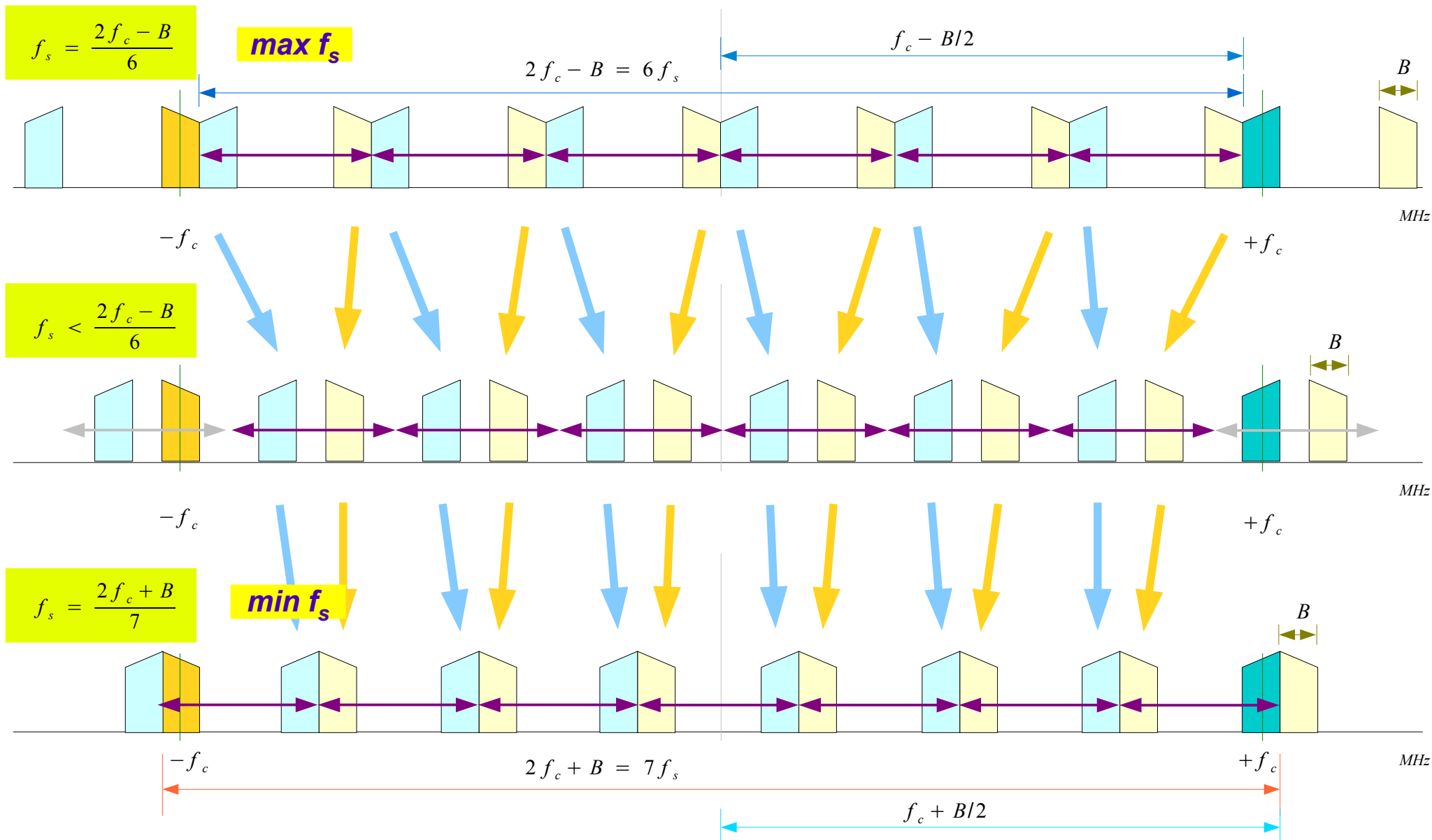
Low-pass Signal Sampling



Band-pass Signal Sampling



Band-pass Signal Sampling



$$\frac{2f_c + B}{m + 1} \leq f_s \leq \frac{2f_c - B}{m}$$

$$f_c = 20 \text{ MHz}$$

$$B = 5 \text{ MHz}$$

$$2B \leq f_s$$

$$\frac{2 \cdot 20 + 5}{1 + 1} = 22.5 \leq f_s \leq \frac{2 \cdot 20 - 5}{1} = 35 \quad \Rightarrow \quad f_s = 22.5 \text{ MHz} \quad (10 \leq f_s)$$

$$\frac{2 \cdot 20 + 5}{2 + 1} = 15 \leq f_s \leq \frac{2 \cdot 20 - 5}{2} = 17.5 \quad \Rightarrow \quad f_s = 17.5 \text{ MHz} \quad (10 \leq f_s)$$

$$\frac{2 \cdot 20 + 5}{3 + 1} = 11.25 \leq f_s \leq \frac{2 \cdot 20 - 5}{3} = 11.67 \quad \Rightarrow \quad f_s = 11.25 \text{ MHz} \quad (10 \leq f_s)$$

$$\frac{2 \cdot 20 + 5}{4 + 1} = 9 \geq \frac{2 \cdot 20 - 5}{4} = 8.75 \quad \Rightarrow \quad \text{X}$$

$$\frac{2 \cdot 20 + 5}{5 + 1} = 7.5 \geq \frac{2 \cdot 20 - 5}{5} = 7.0 \quad \Rightarrow \quad \text{X}$$

$$\frac{2f_c + B}{m + 1} \leq f_s \leq \frac{2f_c - B}{m}$$

$$f_c = 20 \text{ MHz}$$

$$B = 5 \text{ MHz}$$

$$2B \leq f_s$$

$$\frac{f_c + B/2}{B} = R$$

highest signal frequency
bandwidth

$$\frac{2f_c + B}{(m + 1)B} = f(m, R)$$

minimum sampling rate
bandwidth

$$\frac{2(f_c + B/2)}{(m + 1)B} = \frac{2R}{m + 1} = f(m, R)$$

$m = 1$	$f(1, R) = R$	$m = 5$	$f(5, R) = \frac{1}{3}R$
$m = 2$	$f(2, R) = \frac{2}{3}R$	$m = 6$	$f(6, R) = \frac{2}{7}R$
$m = 3$	$f(3, R) = \frac{1}{2}R$	$m = 7$	$f(7, R) = \frac{1}{4}R$
$m = 4$	$f(4, R) = \frac{2}{5}R$	$m = 8$	$f(8, R) = \frac{2}{9}R$

References

- [1] <http://en.wikipedia.org/>
- [2] J.H. McClellan, et al., Signal Processing First, Pearson Prentice Hall, 2003
- [3] A "graphical interpretation" of the DFT and FFT, by Steve Mann
- [4] R. G. Lyons, Understanding Digital Signal Processing, 1997