

# Oversampling (3B)

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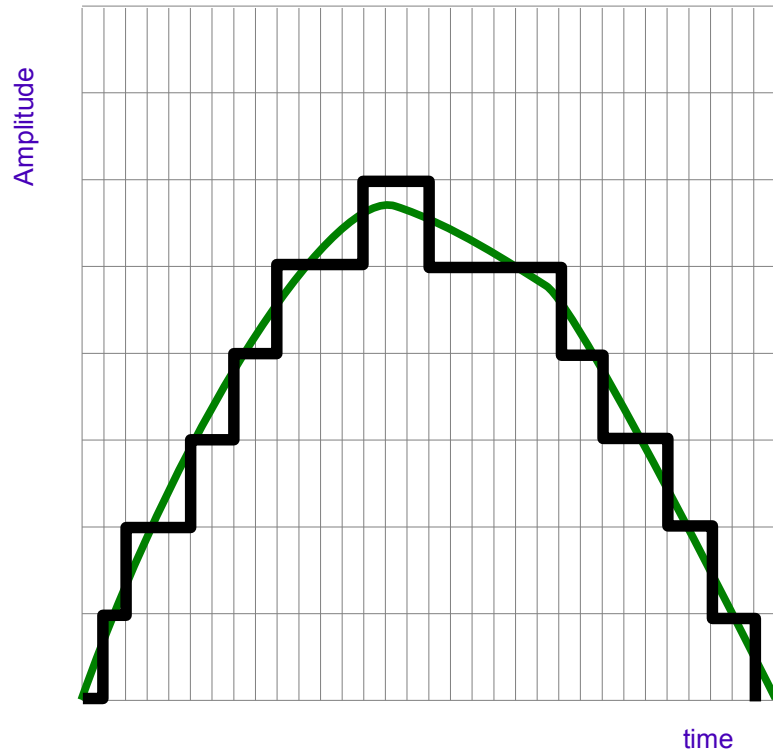
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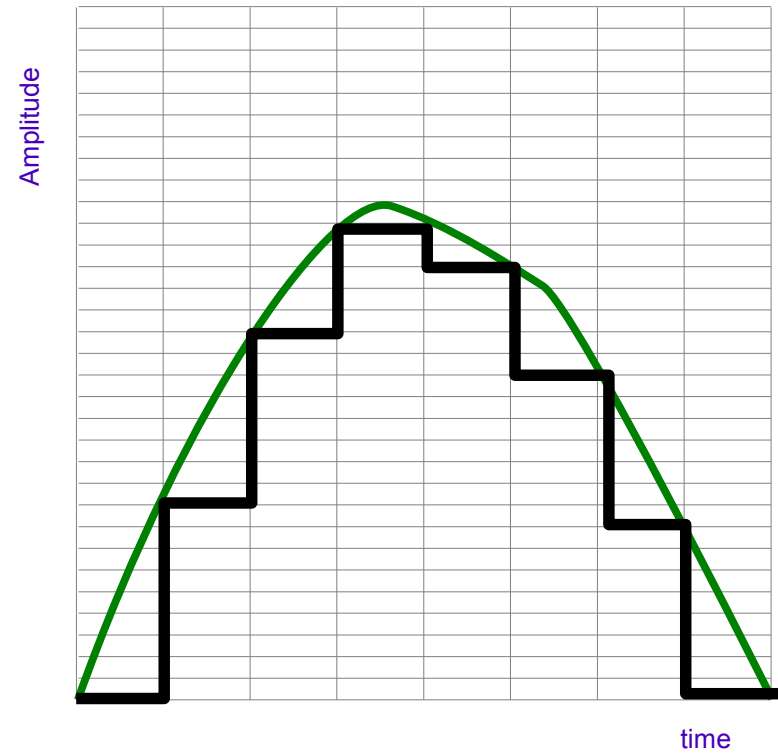
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# Bits and Samples

More Samples

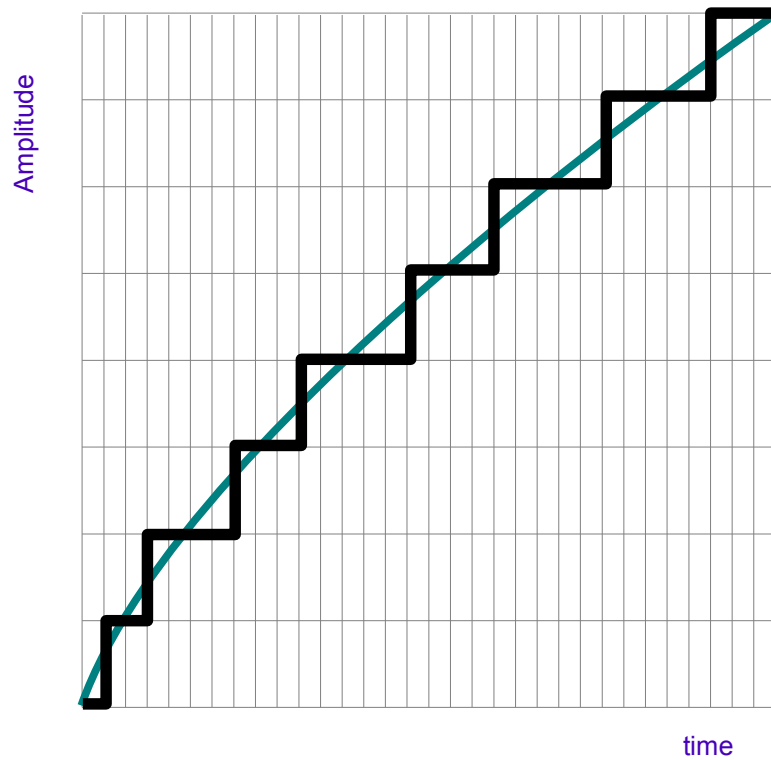


More Bits

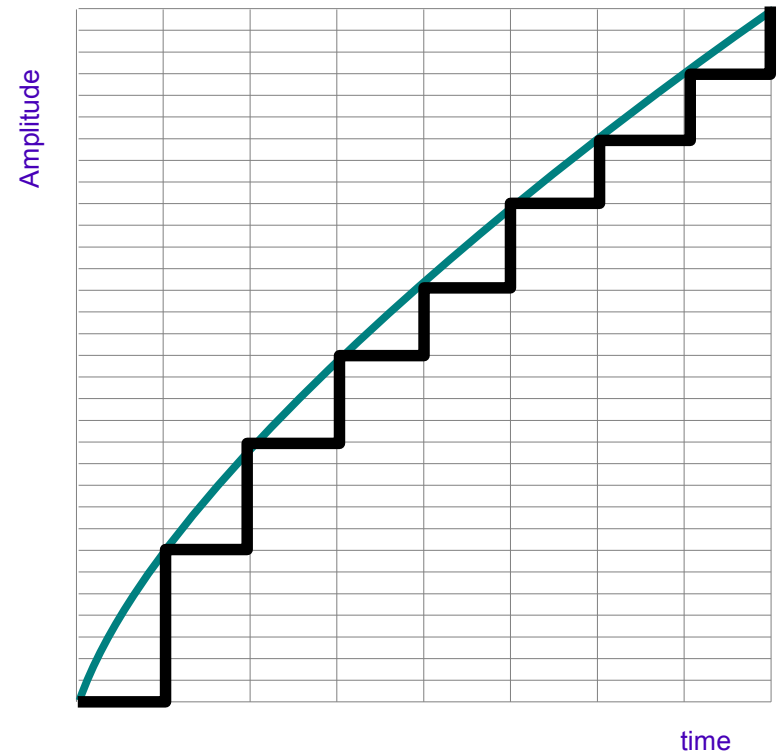


# Bits and Samples

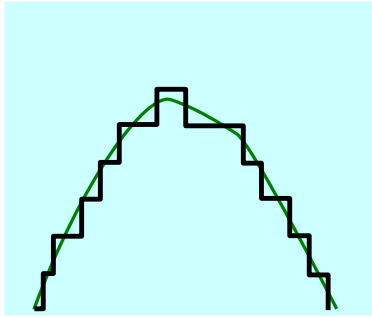
More Samples



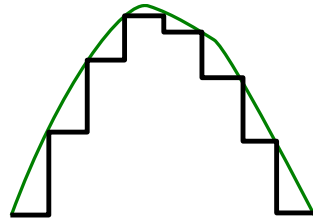
More Bits



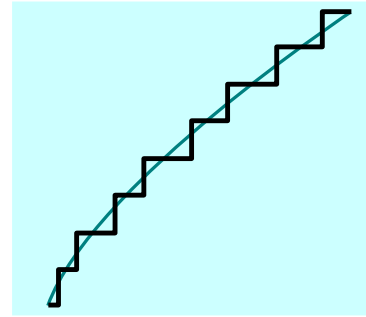
# Over-Sampling



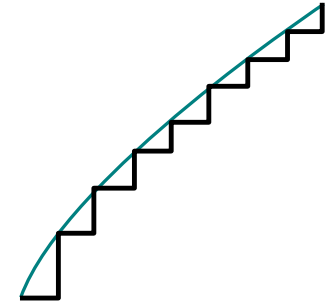
More Samples



More Bits



More Samples



More Bits

{ Sampling → Quantization in time axis  
Quantization → Quantization in amplitude axis

OverSampling → trade off bits for samples

→ alleviate the need for high quality prefilters and postfilters

# Band-limited Signal

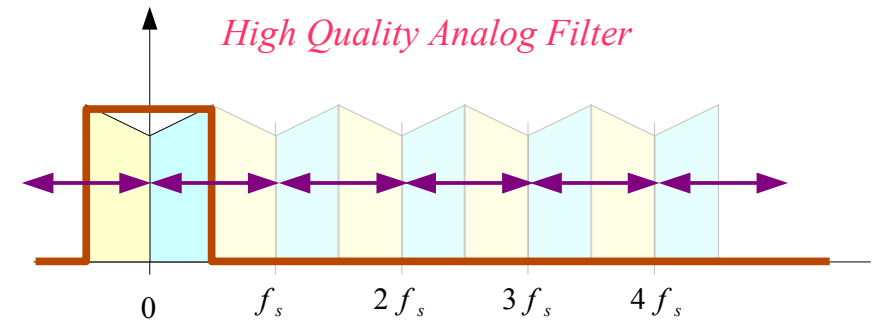
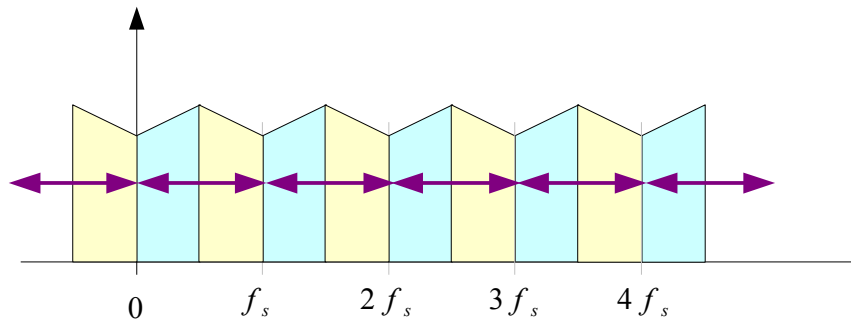
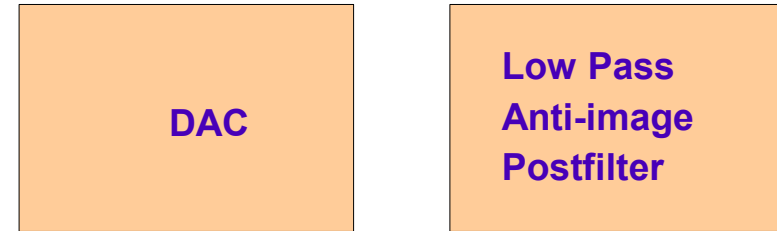
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# Band-limited Signal

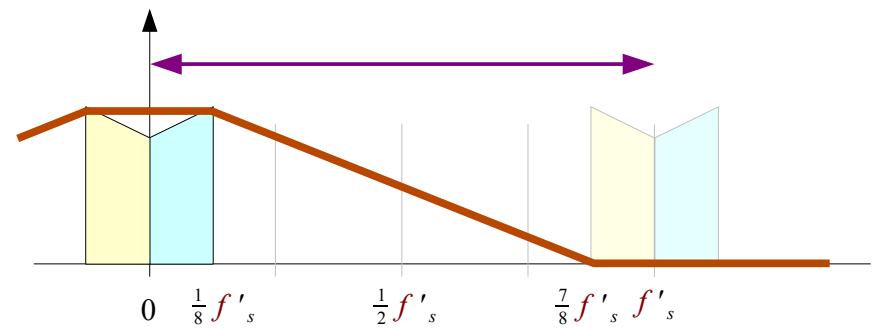
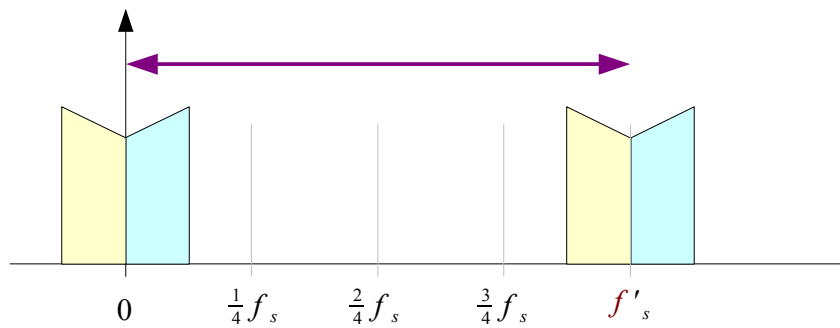
*Analog Filter*



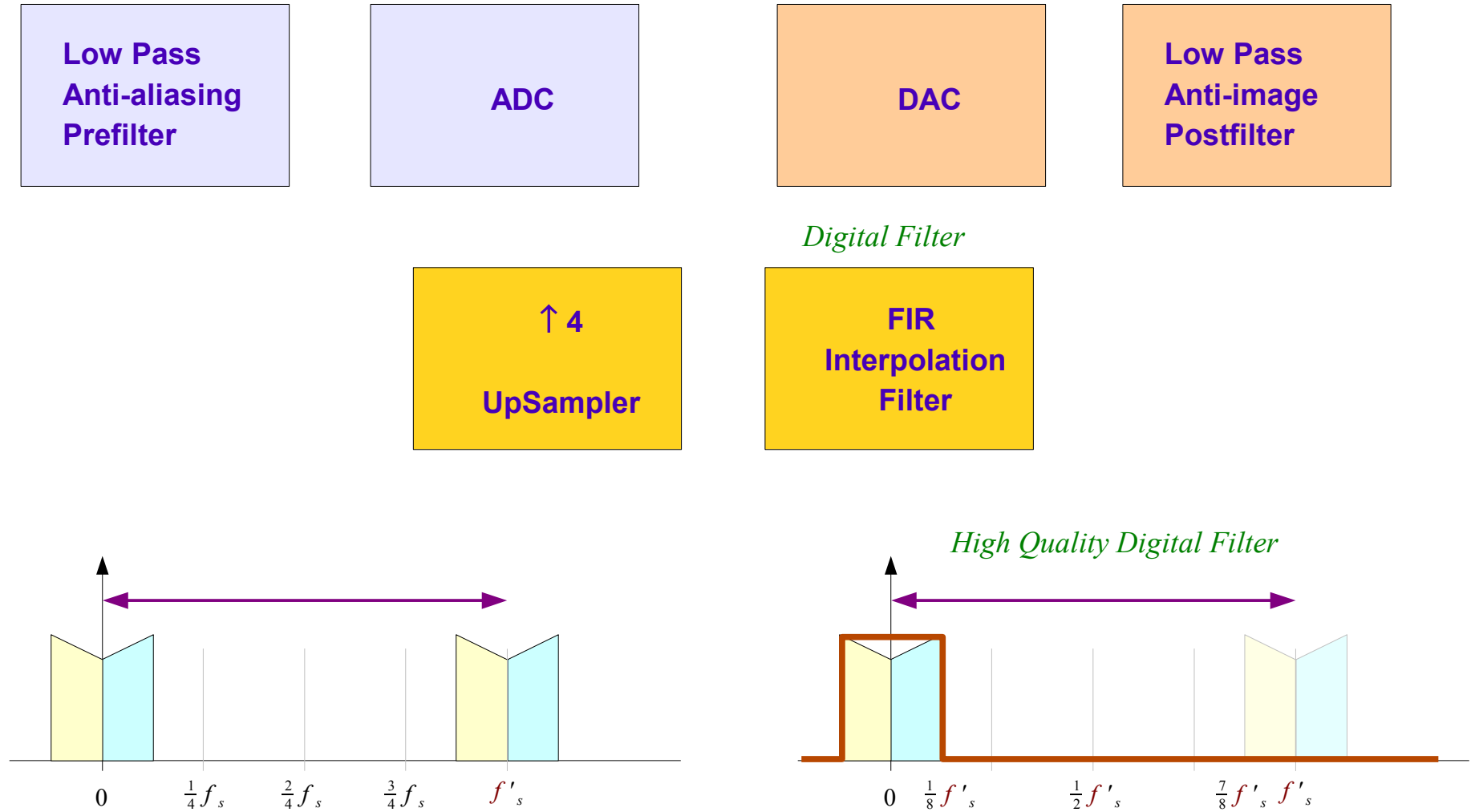
*Analog Filter*



*High Quality Analog Filter*



# Band-limited Signal

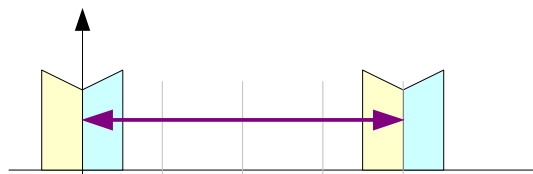
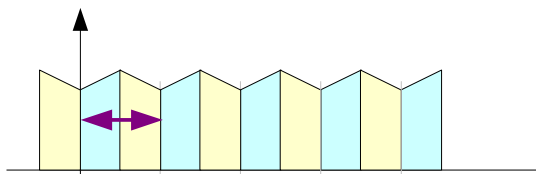
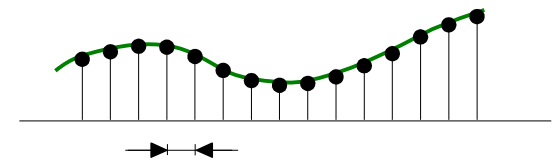
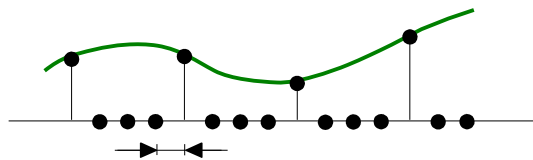
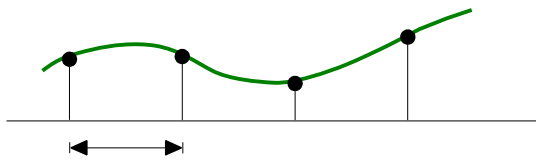




# Band-limited Signal

↑ 4  
UpSampler

*Digital Filter*  
FIR  
Interpolation  
Filter



# Band-limited Signal

Low Pass  
Anti-aliasing  
Prefilter

ADC

DAC

Low Pass  
Anti-image  
Postfilter



↑ 4

$$f_{oversampling} = 4^n \cdot f_s$$

UpSampler

FIR  
Interpolation  
Filter

$$f_s > 2 \cdot f_H$$

# Band-limited Signal

$$f_{\text{oversampling}} = 4^n \cdot f_s$$

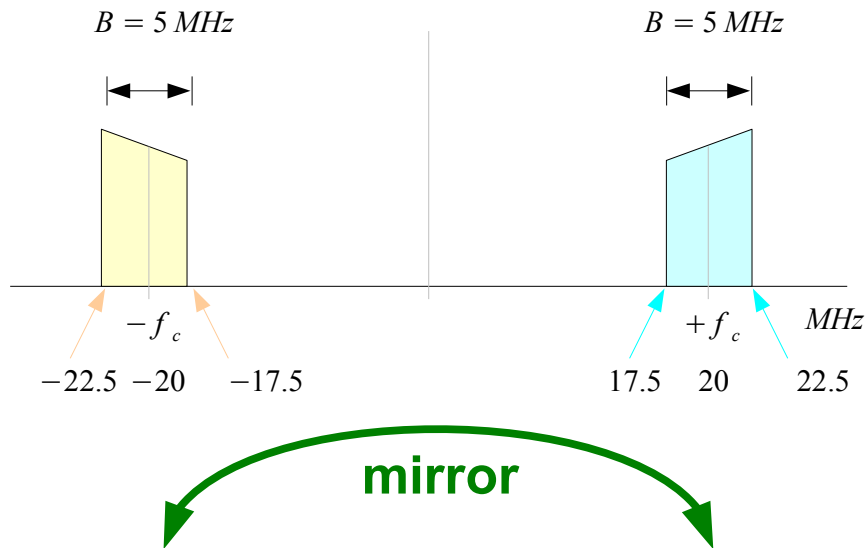
**Oversampling and Decimation**  
**Oversample and Lowpass Filter**

- **Normal Averaging**
- **Decimation / Interpolation**

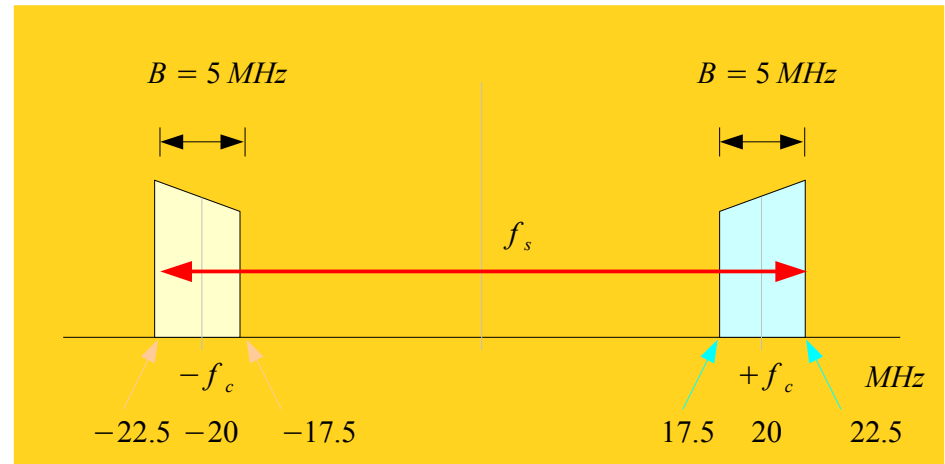


$$f_s > 2 \cdot f_H$$

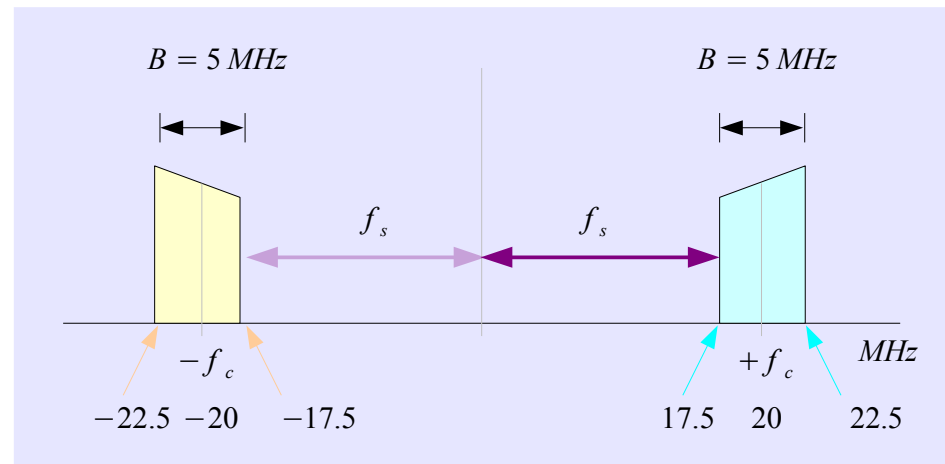
# Band-limited Signal



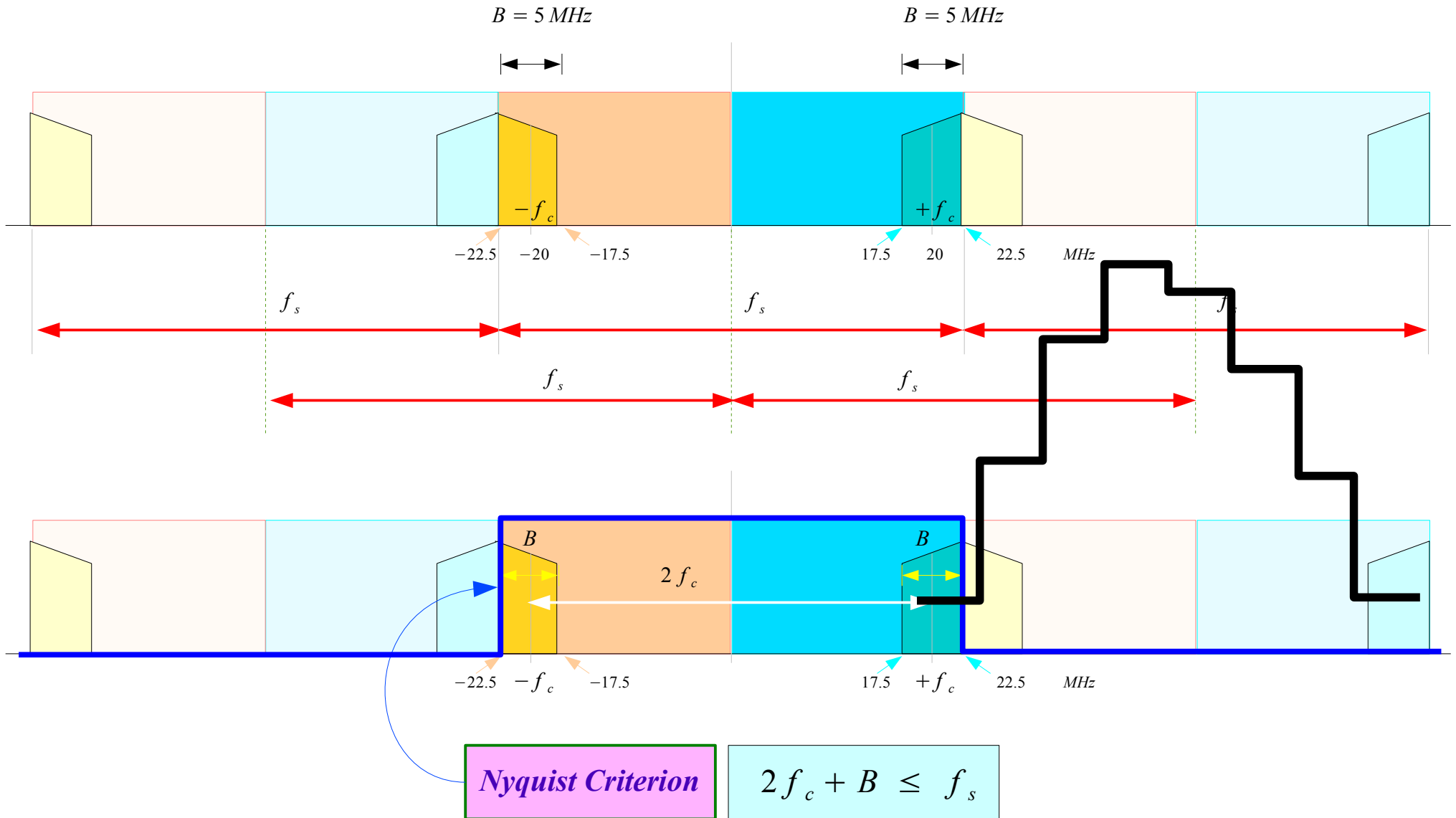
- Bandpass Sampling
- IF filtering
- Harmonic Sampling
- Sub-Nyquist Sampling



- Lowpass Sampling



# Low-pass Signal Sampling



## 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
- [5] AVR121: Enhancing ADC resolution by oversampling
- [6] S.J. Orfanidis, Introduction to Signal Processing  
[www.ece.rutgers.edu/~orfanidi/intro2sp](http://www.ece.rutgers.edu/~orfanidi/intro2sp)