Analog to Digital Conversion

Sampling Theory

- Nyquist – Shannon sampling theory:
  - If a function x(t) contains no frequencies higher than [or equal to] B Hertz, it is completely determined by giving its ordinates at a series of points spaced 1/(2B) seconds apart.

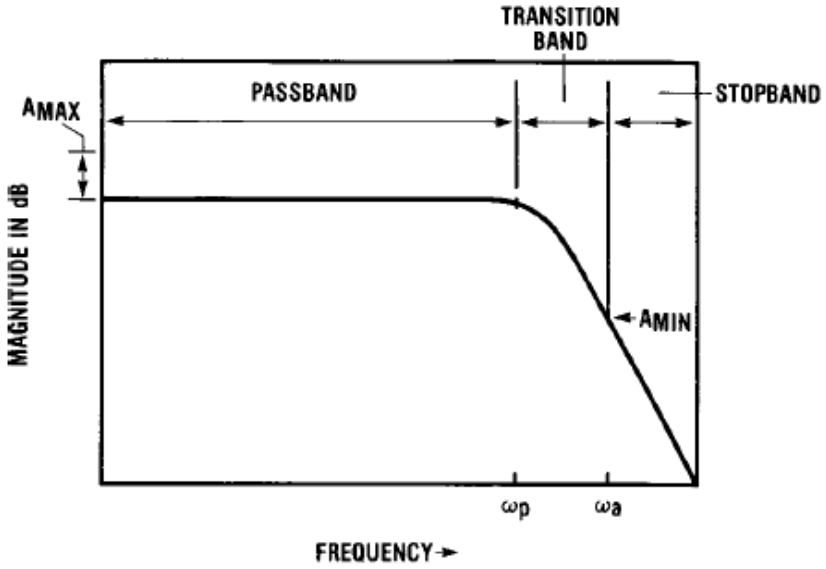
Demonstration

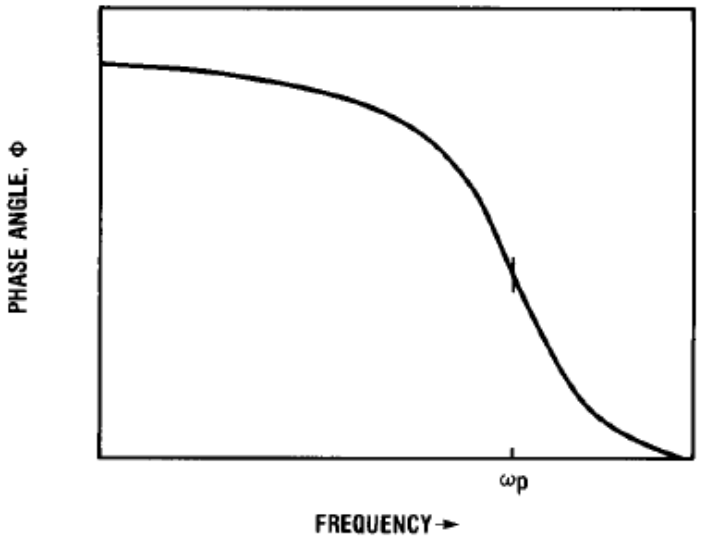
- http://www2.egr.uh.edu/~glover/applets/Sampling/Sampling.html

- Additional resource:

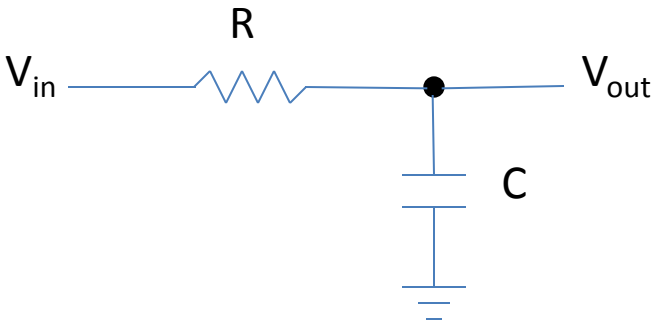
  National Semiconductor,
  "An Introduction to the Sampling Theorem,"
  http://www.national.com/an/AN/AN-236.pdf

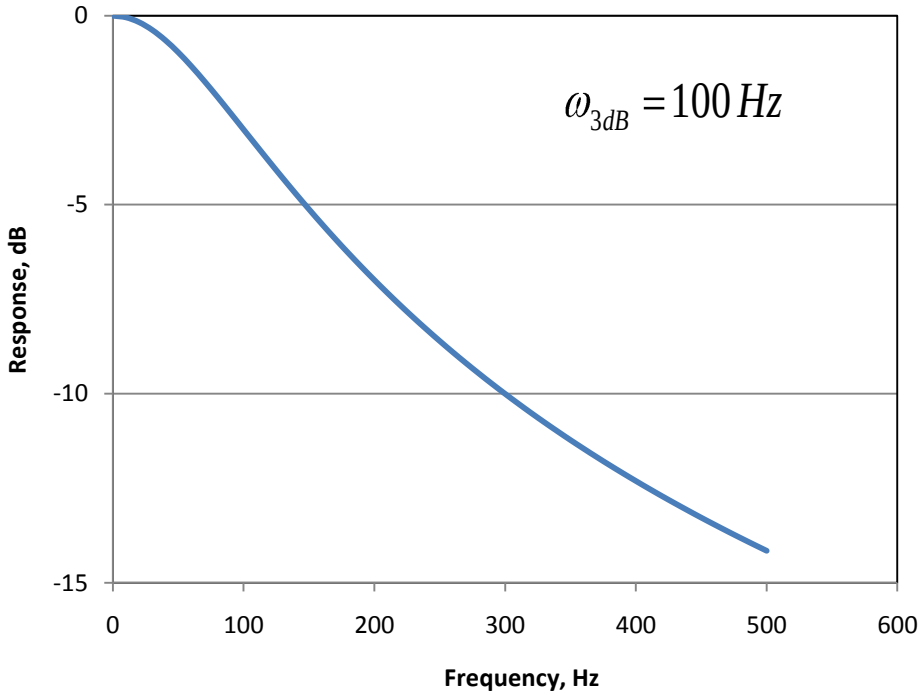
Need to Band Limit Signals before Sampling





Simple Low Pass Filter





$$\frac{V_{out}}{V_{in}} = \frac{1}{1+\omega^2 R^2 C^2 \ ^{1}\!/_{2}}$$

$$\omega_{3dB} = \frac{1}{RC}$$

Classical Analog Filter Types

Name	Transition	Passband Ripple	Time Delay
Butterworth	Okay	Best	Poor
Chebyshev	Steepest	Selectable	Poor
Bessel	Poor	Poor	Best

Filter Amplitude Responses

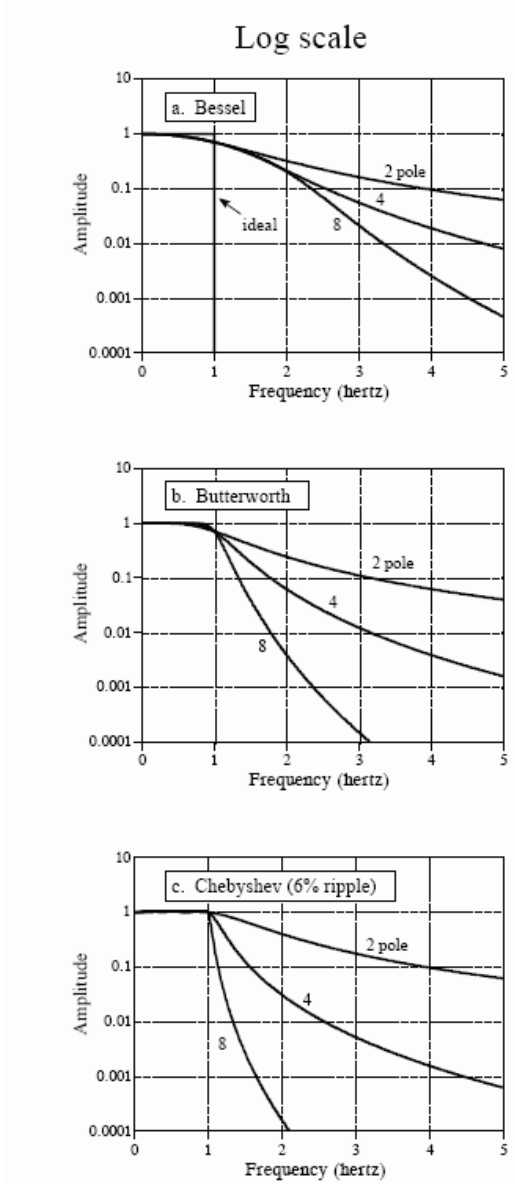


FIGURE 3-11
Frequency response of the three filters on a *logarithmic* scale. The Chebyshev filter has the sharpest roll-off.

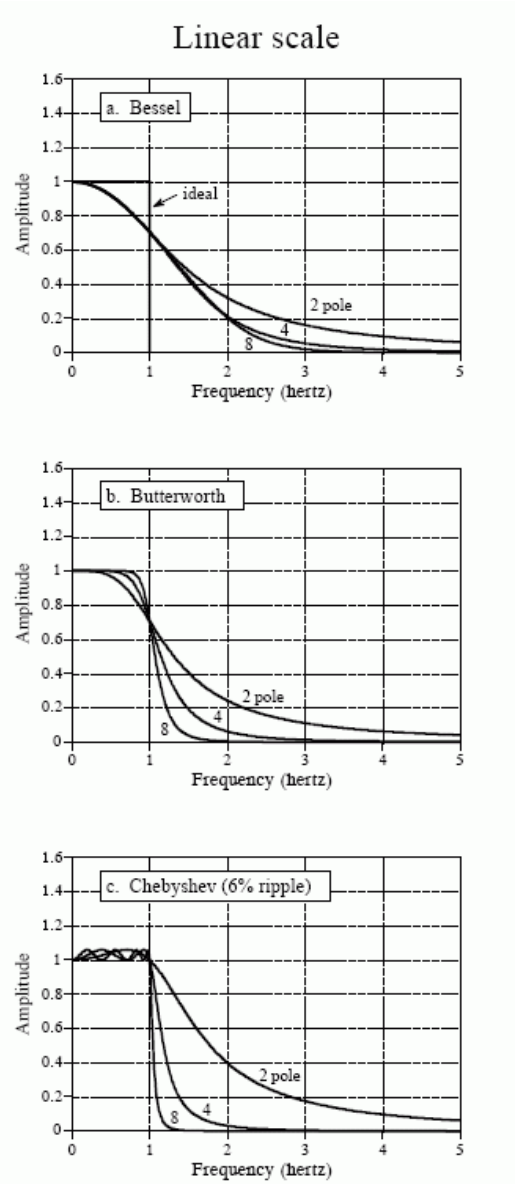
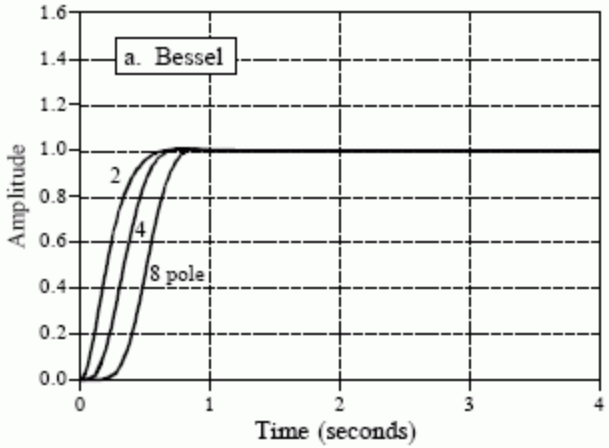
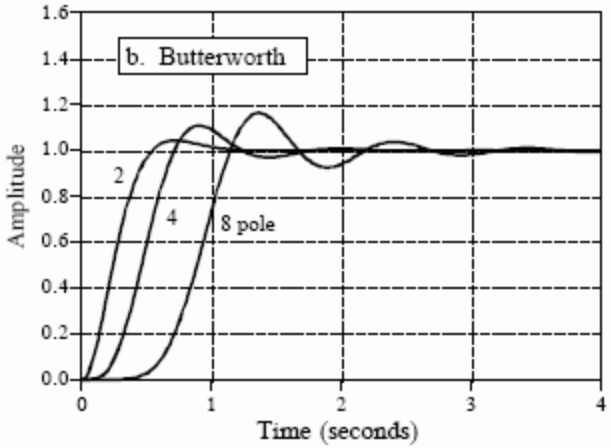


FIGURE 3-12
Frequency response of the three filters on a *linear* scale. The Butterworth filter provides the flattest passband.

http://www.dspguide.com

Step Response





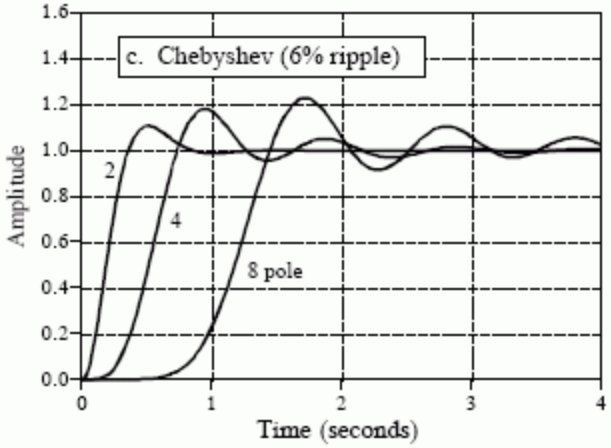
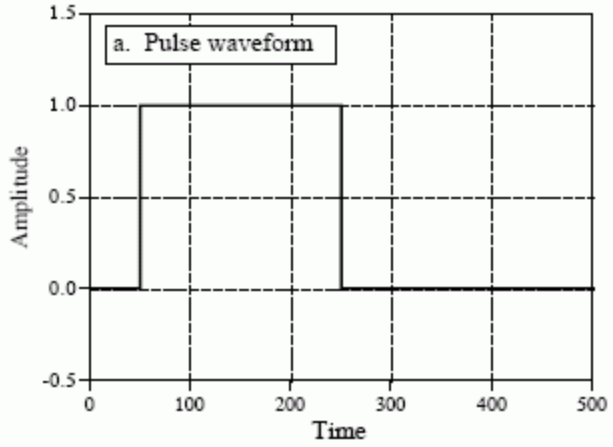


FIGURE 3-13
Step response of the three filters. The times shown on the horizontal axis correspond to a one hertz cutoff frequency. The Bessel is the optimum filter when overshoot and ringing must be minimized.

Pulse Response



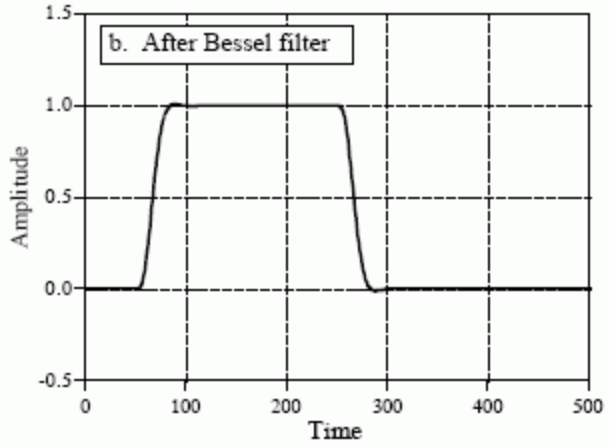
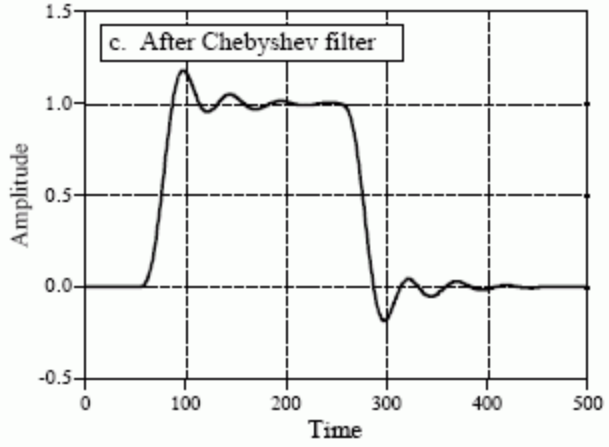


FIGURE 3-14
Pulse response of the Bessel and Chebyshev filters. A key property of the Bessel filter is that the rising and falling edges in the filter's output looking similar. In the jargon of the field, this is called *linear phase*. Figure (b) shows the result of passing the pulse waveform in (a) through a 4 pole Bessel filter. Both edges are smoothed in a similar manner. Figure (c) shows the result of passing (a) through a 4 pole Chebyshev filter. The left edge overshoots on the *top*, while the right edge overshoots on the *bottom*. Many applications cannot tolerate this distortion.



http://www.dspguide.com