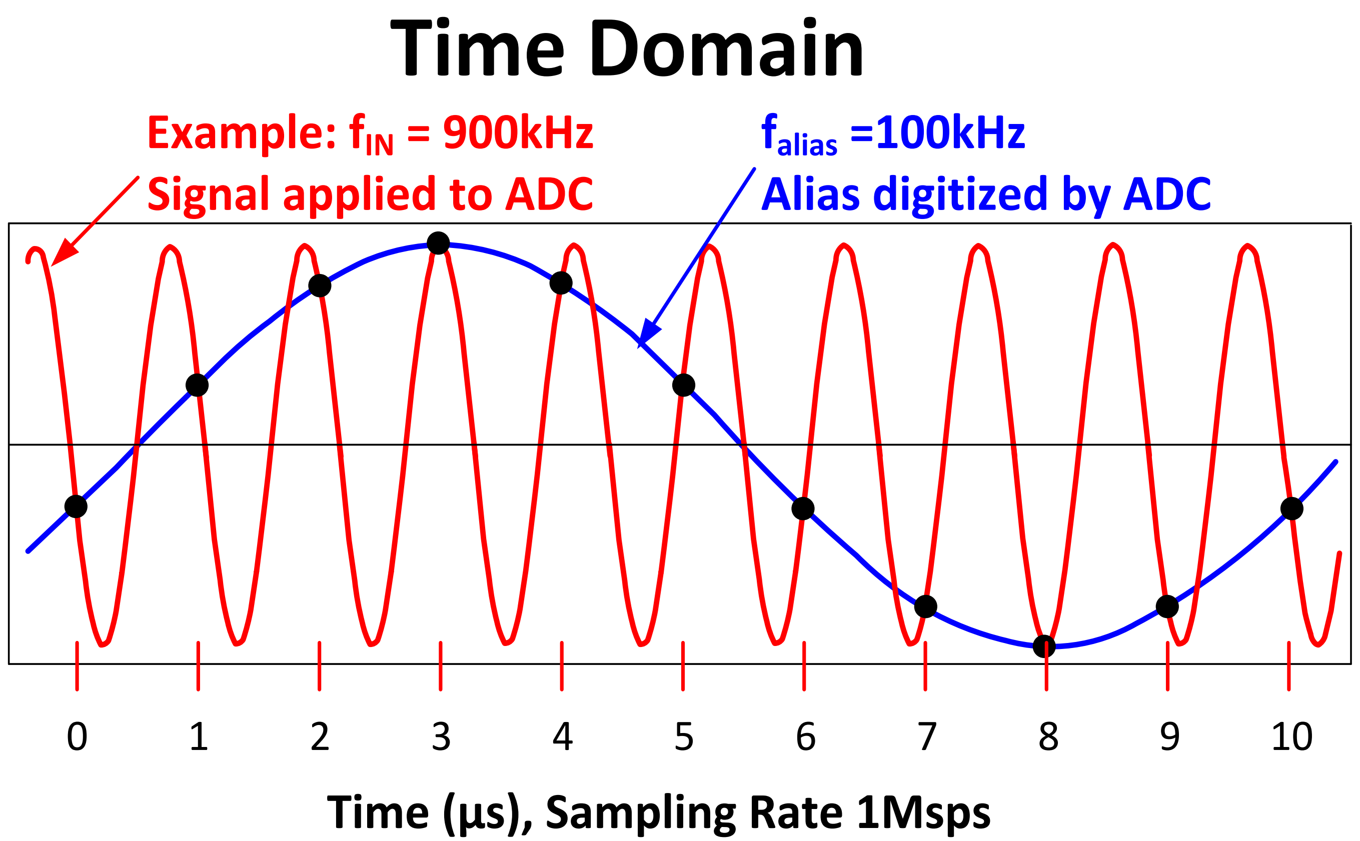
Aliasing and Anti-aliasing Filters

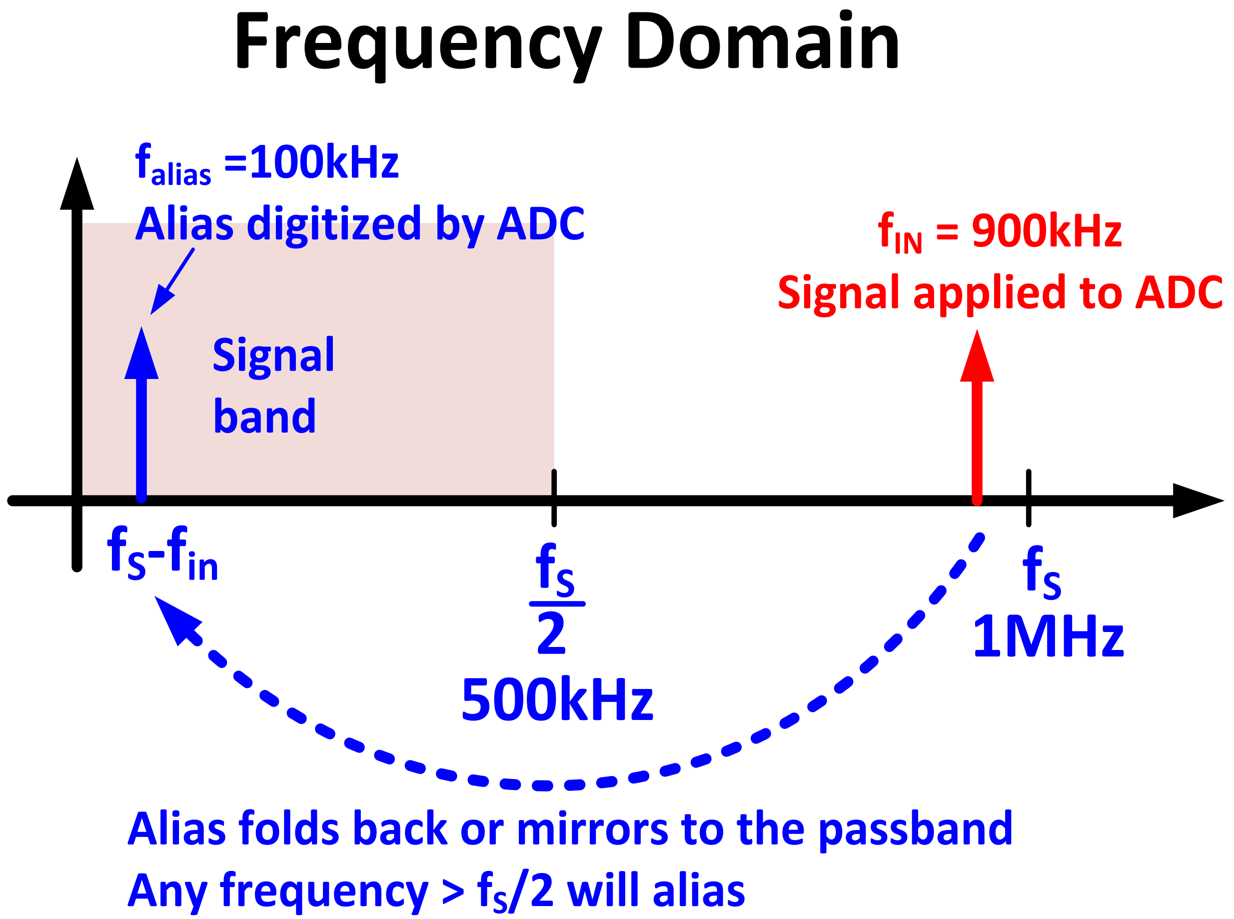
TIPL 4304
TI Precision Labs – ADCs

Created by Art Kay

Presented by Peggy Liska

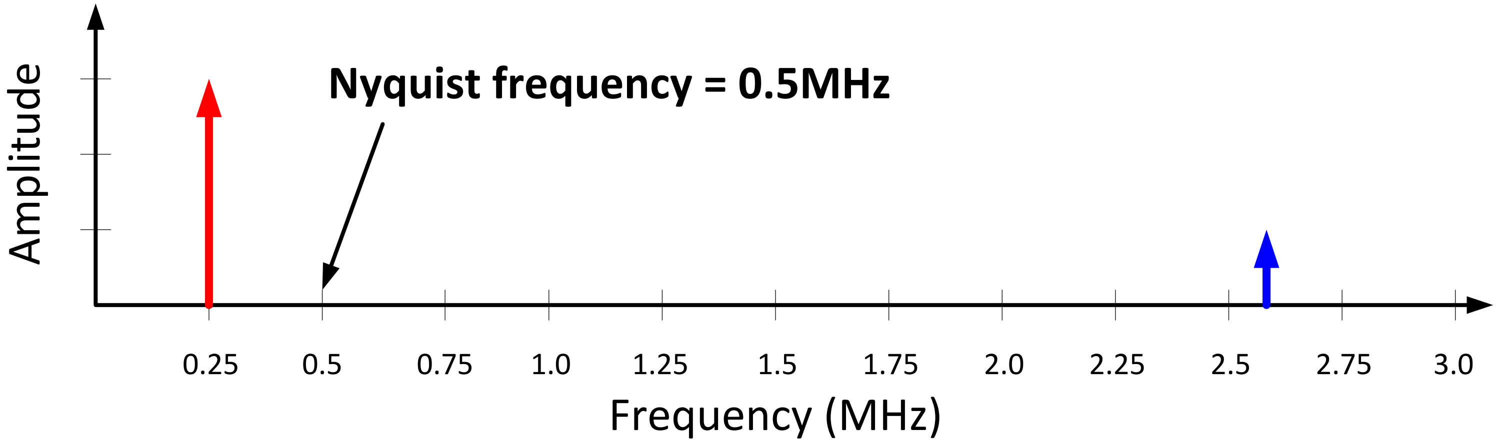
Aliasing: Time Domain vs. Frequency Domain

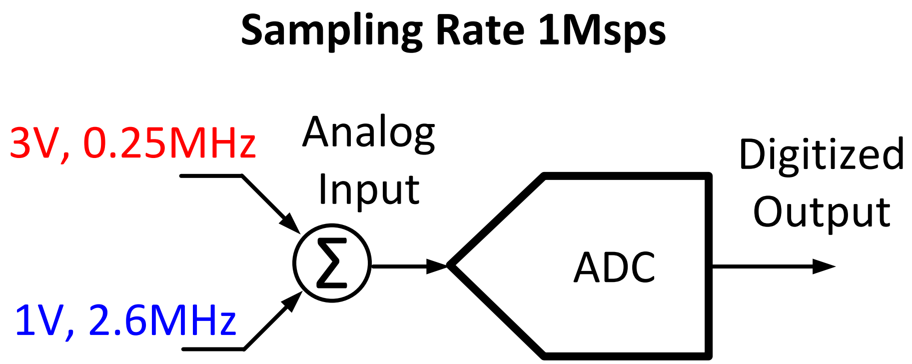


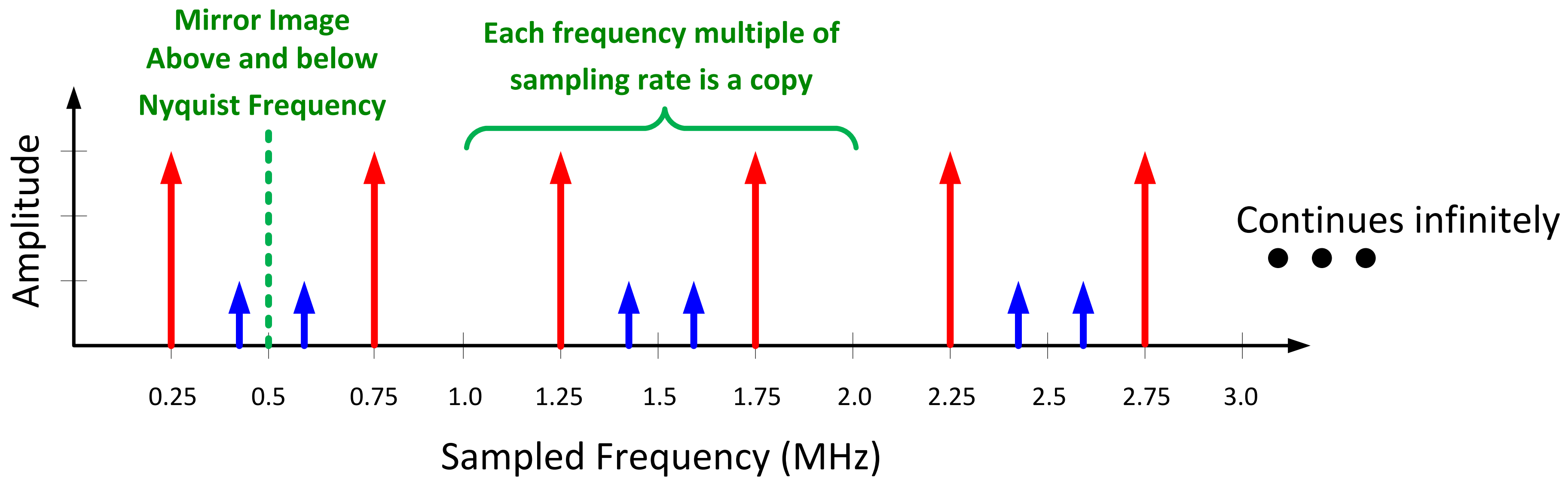


Nyquist frequency = fs/2, the maximum input signal without aliasing.

Nyquist Theorem, Sampling Frequency = 1Msps



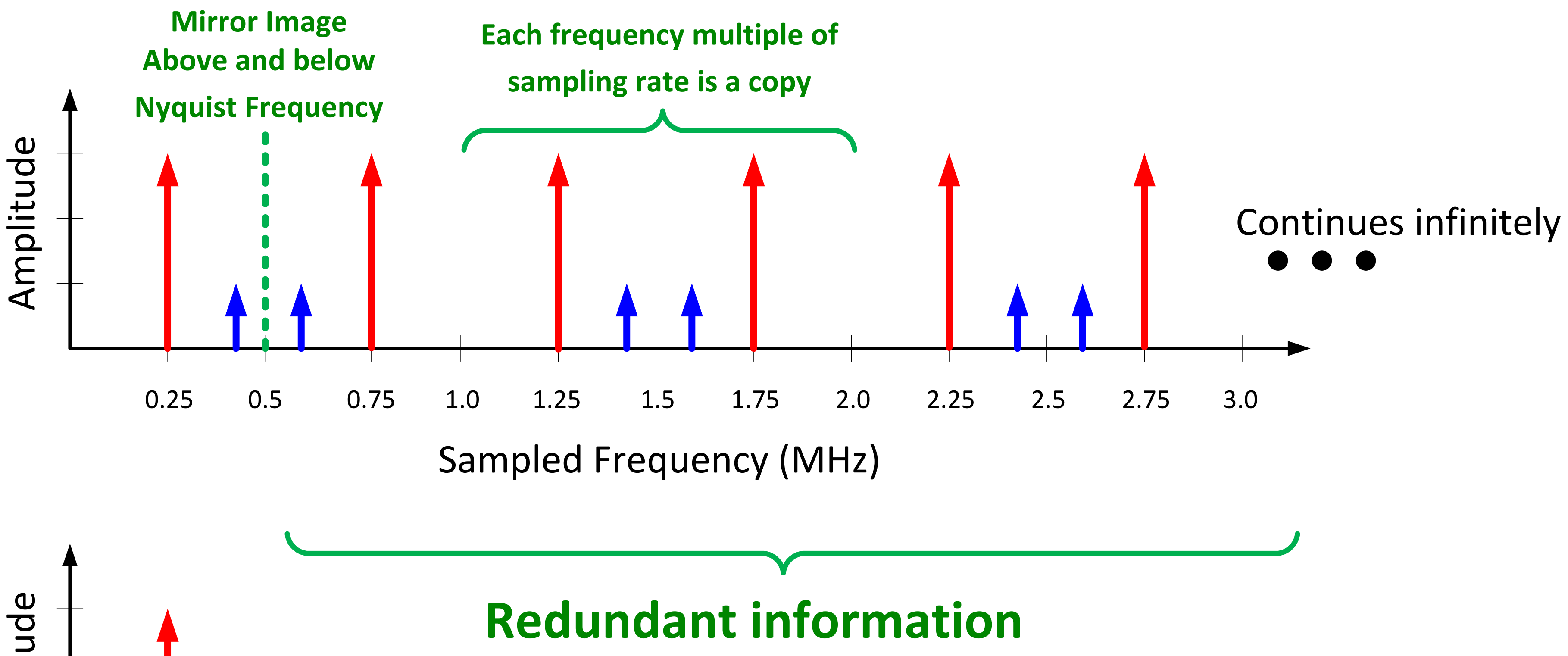




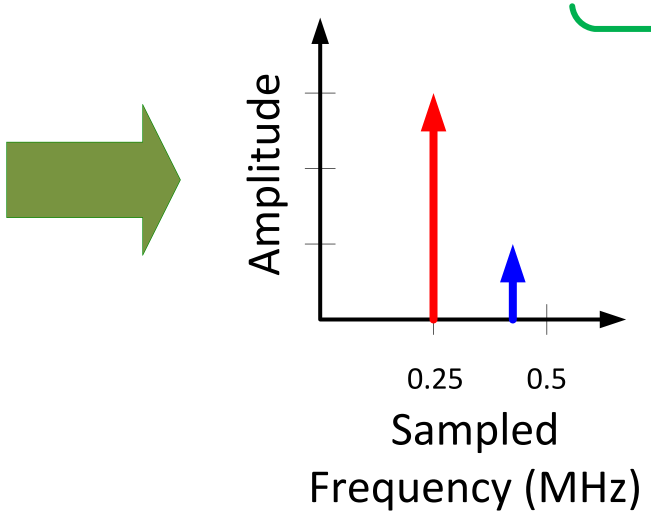
Nyquist Theorem:

The maximum frequency that can be applied to a sampled system without aliasing is half the sampling frequency. This maximum frequency is called the Nyquist frequency.

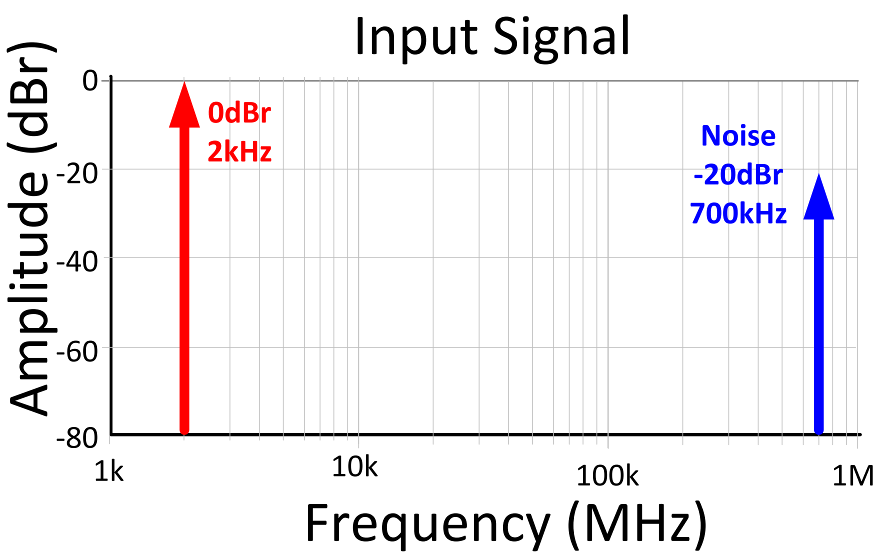
Eliminate redundant information

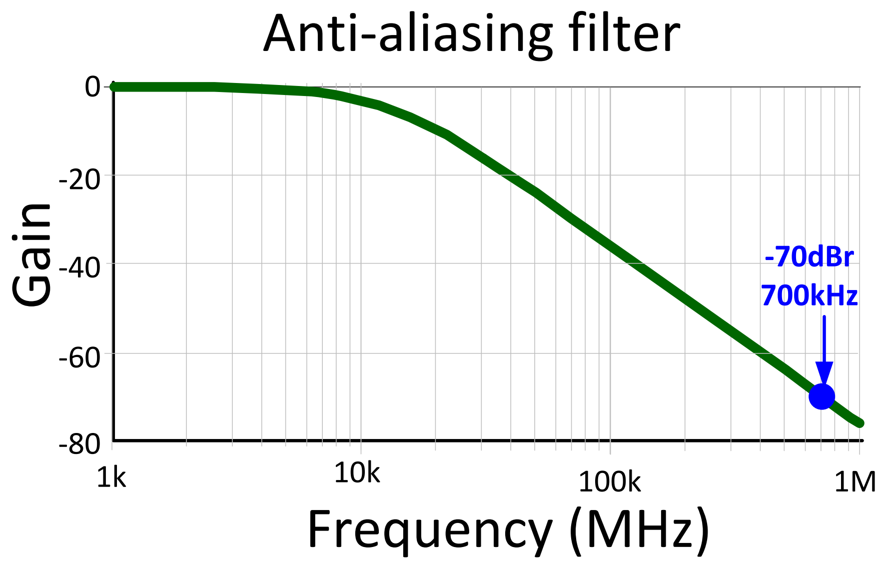


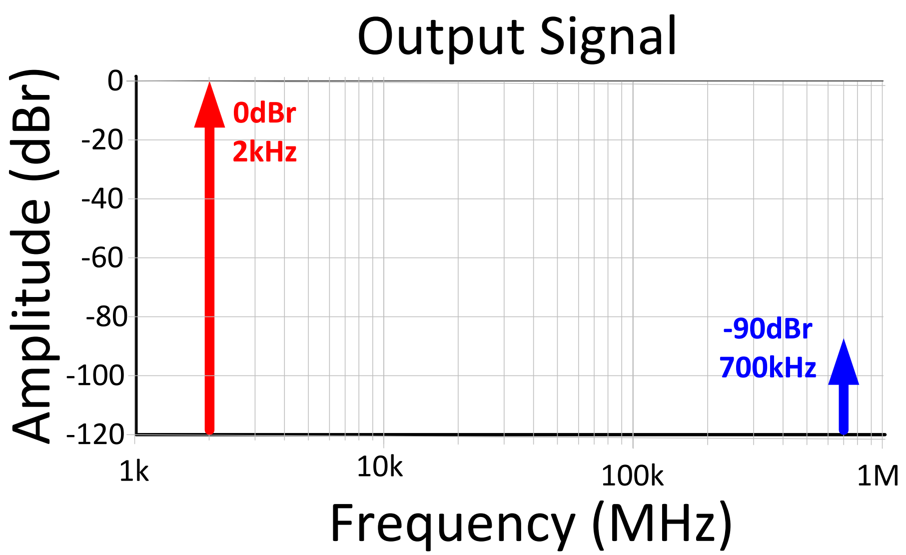
What we normally display



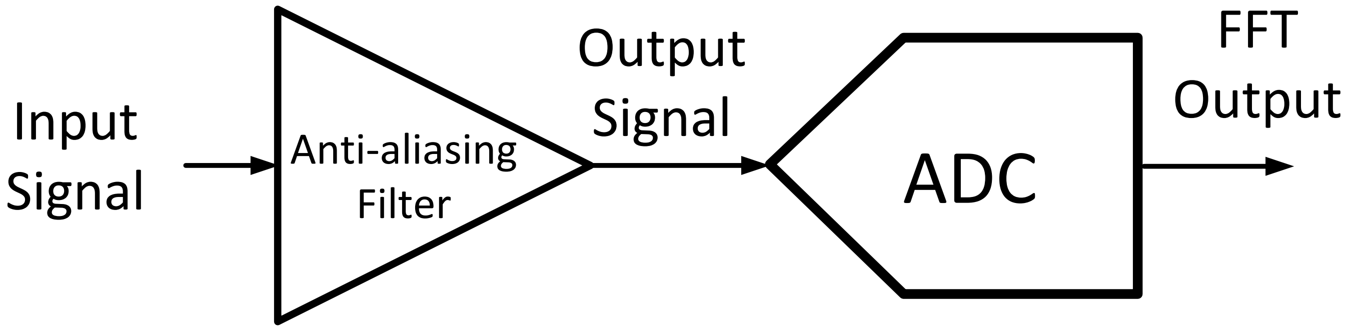
Anti-aliasing filter (f_s = 1Msps)

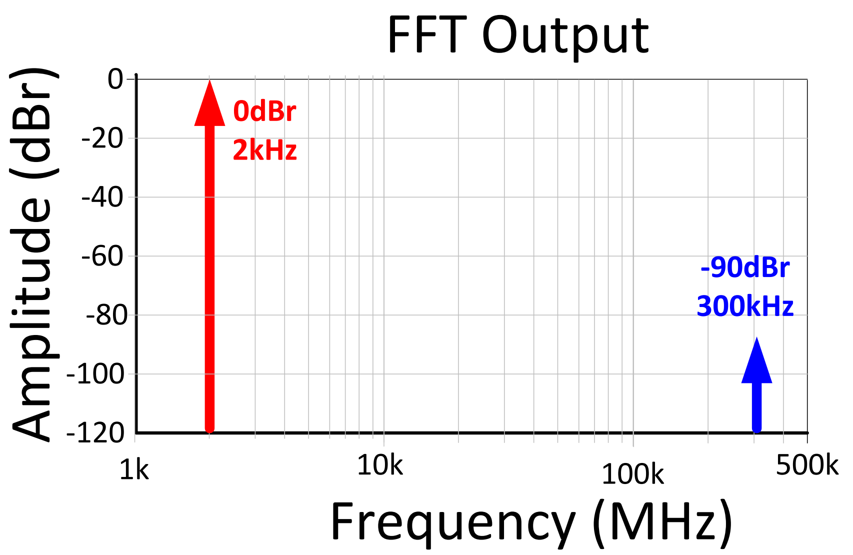




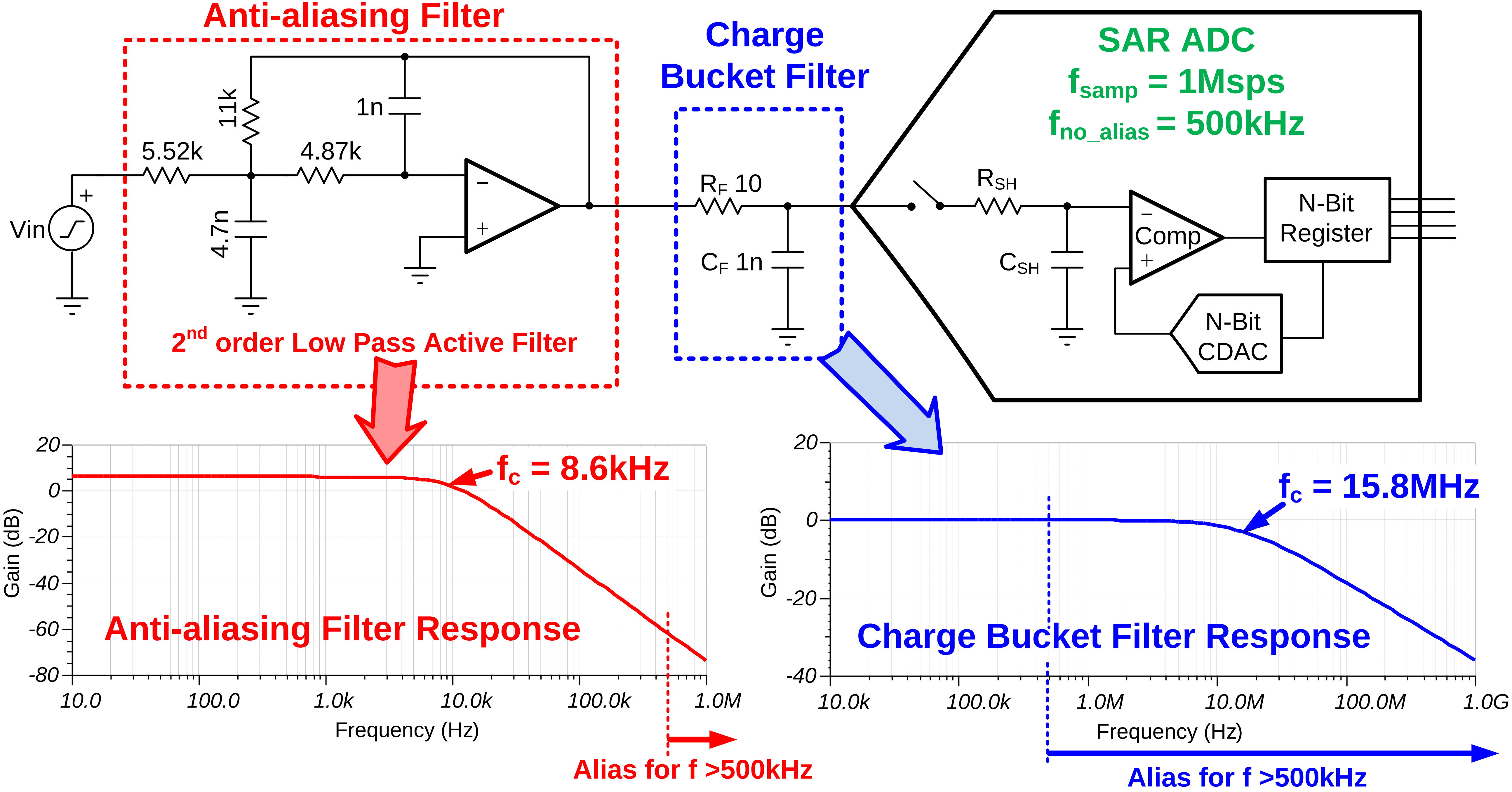


Sampling frequency = fs = 1Msps



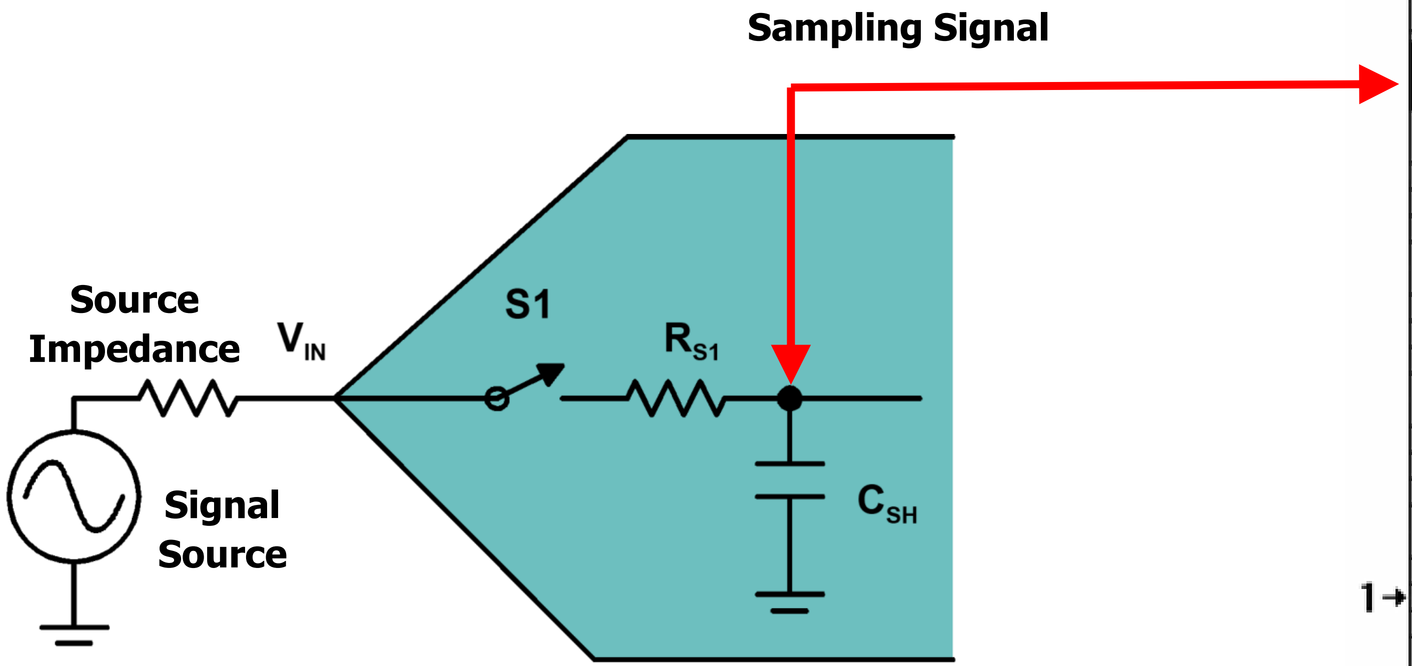


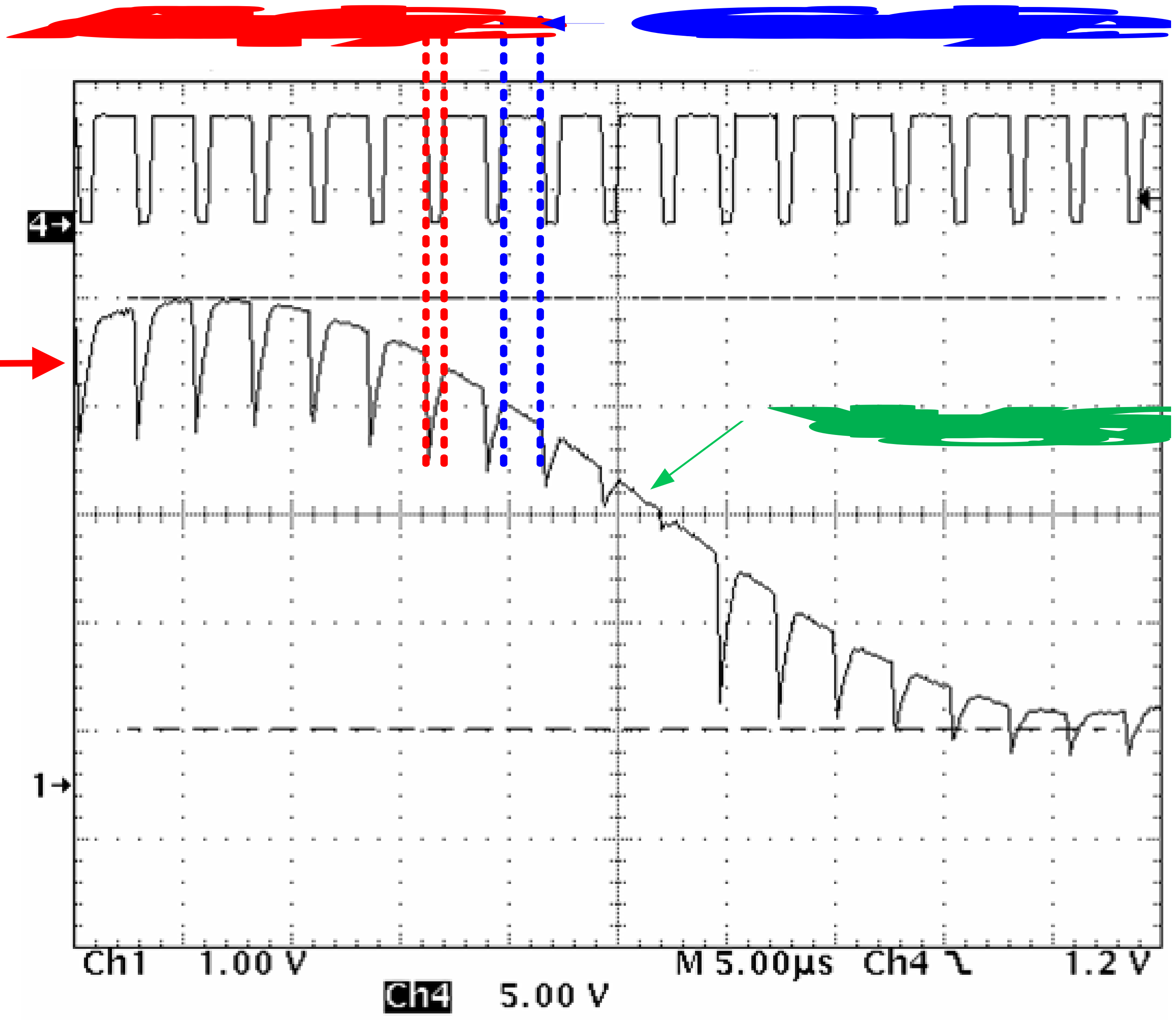
SAR Anti-aliasing Filter Design



What's the "Charge Bucket" for?

Capacitor Charging Kickback





Texas Instruments

Thanks for your time! Please try the quiz.

Quiz: Aliasing and Anti-aliasing Filters

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Quiz: Aliasing and Anti-aliasing Filters

1. How do you determine Nyquist frequency?
   a) It is equal to the sampling rate of the data converter.
   b) It is equal to twice the sampling rate of the converter.
   c) It is equal to half the sampling rate of the converter.
   d) It depends on the anti-aliasing filter.

2. Applying an input signal that exceeds the Nyquist frequency will ________.
   a) Cause an erroneous "alias" signal to be measured by the ADC.
   b) Cause damage to the ADC.
   c) Introduce significant distortion in the signal.
   d) Cause a dramatic reduction in SNR.

Quiz: Aliasing and Anti-aliasing Filters

3. A data converter has a sampling rate of 1MHz. The input amplifier has a second order low pass filter with a cutoff frequency of 1MHz. What is a potential issue?
   a) No problem, this configuration will work well for antialiasing.
   b) Any input form 500kHz to 1MHz will not be attenuated at all and will produce aliases.
   c) A second order filter will not work for antialiasing.
   d) A band pass filter is required for antialiasing.

4. A data converter has a sampling rate of 1MHz. A 900kHz input signal is applied. What frequency will show up in the FFT?
   a) 100kHz.
   b) 400kHz.
   c) 500kHz
   d) No result will be displayed as this exceeds the Nyquist frequency.

Quiz: Aliasing and Anti-aliasing Filters

4. Design an anti aliasing filter for a data converter with a 1Msps sampling rate. The desired input signal range is 0 to 100kHz. The filter must attenuate all alias input signals by at least 40dB. Use FilterPro or Filter Designer to design the circuit.

Below is a link to FilterPro. This is a downloadable active filter design tool that helps design op amp active filters.

https://e2e.ti.com/support/amplifiers/precision_amplifiers/w/design_notes/3076.filterpro-v3-1

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http://www.ti.com/design-tools/signal-chain-design/webench-filters.html?keyMatch=filter%2520designer&tisearch=Search-EN-Everything

Solutions

Quiz: Aliasing and Anti-aliasing Filters

1. How do you determine Nyquist frequency?
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   c) **It is equal to half the sampling rate of the converter.**
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2. Applying an input signal that exceeds the Nyquist frequency will ________.
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Quiz: Aliasing and Anti-aliasing Filters

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Quiz: Aliasing and Anti-aliasing Filters

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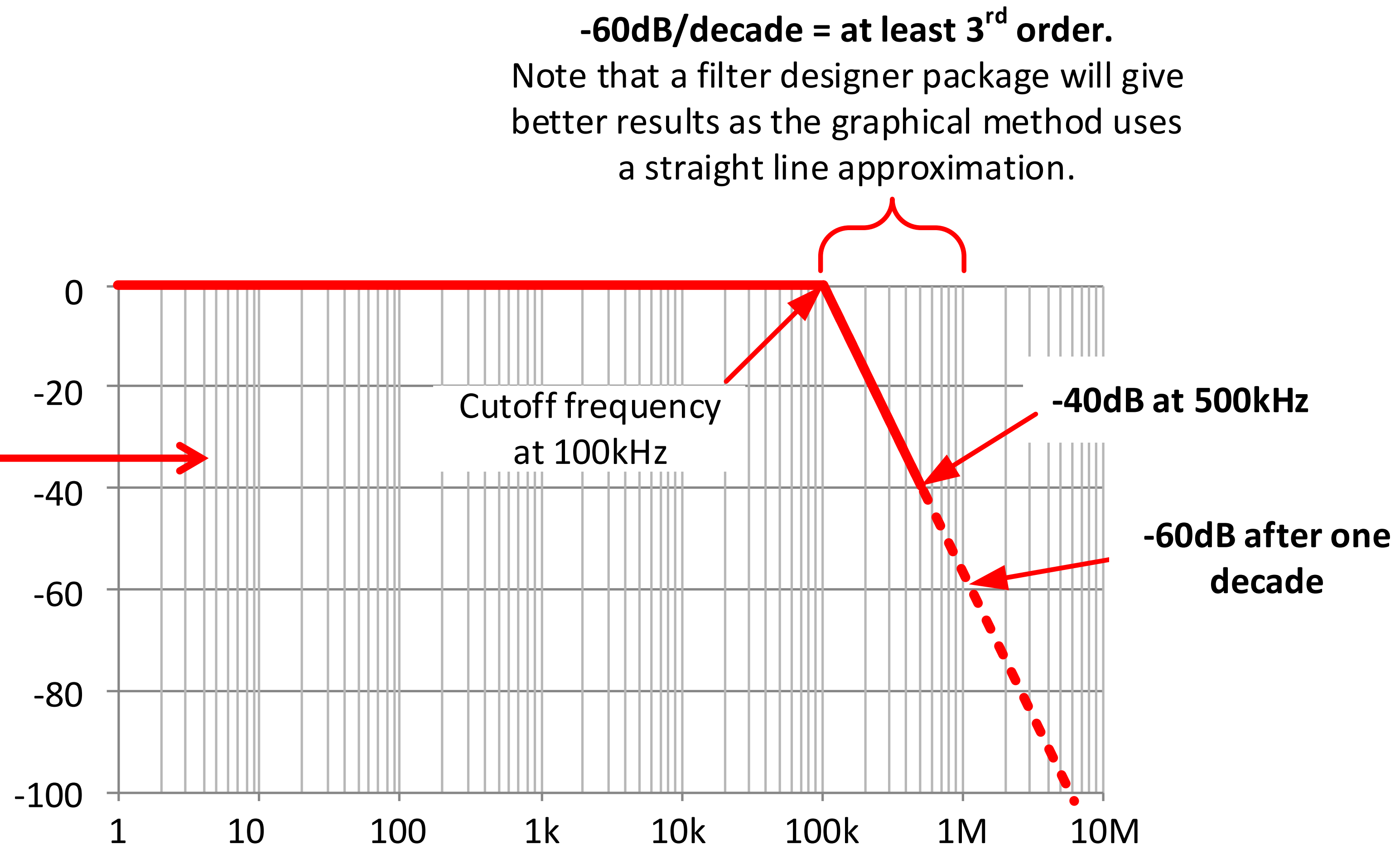
A simple graphical method can be used to estimate the filter order if you don't use a filter design package. You will see in the next few slides that FilterPro will give more accurate and detailed results.



Quiz: Aliasing and Anti-aliasing Filters

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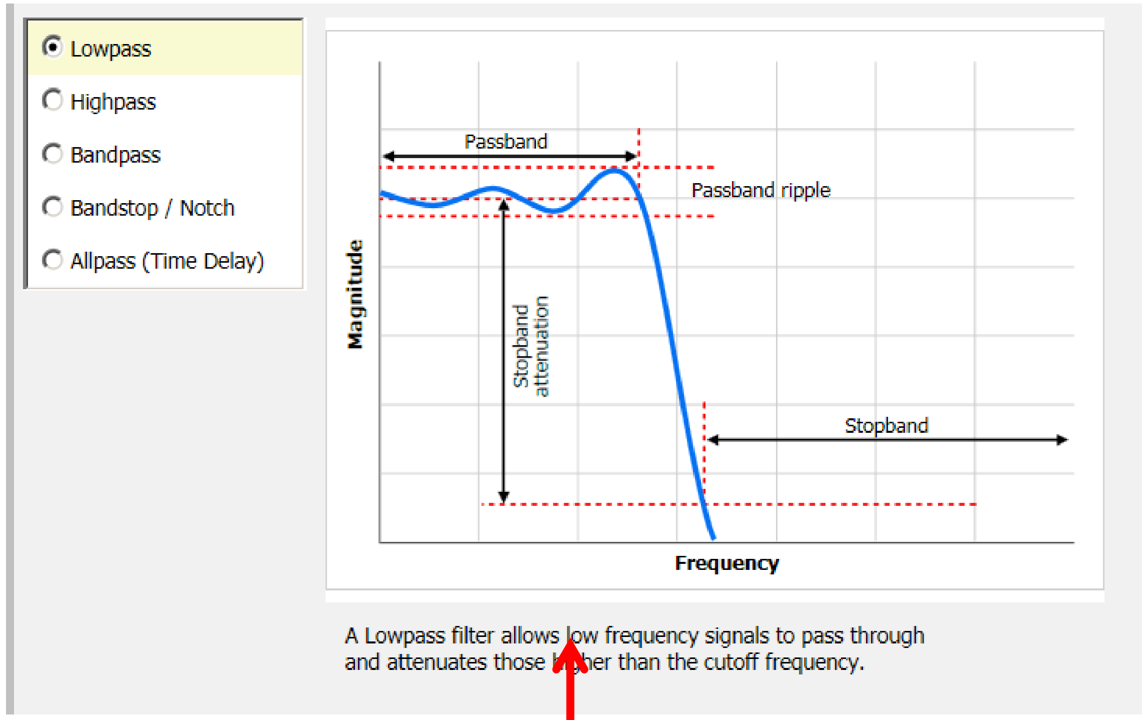
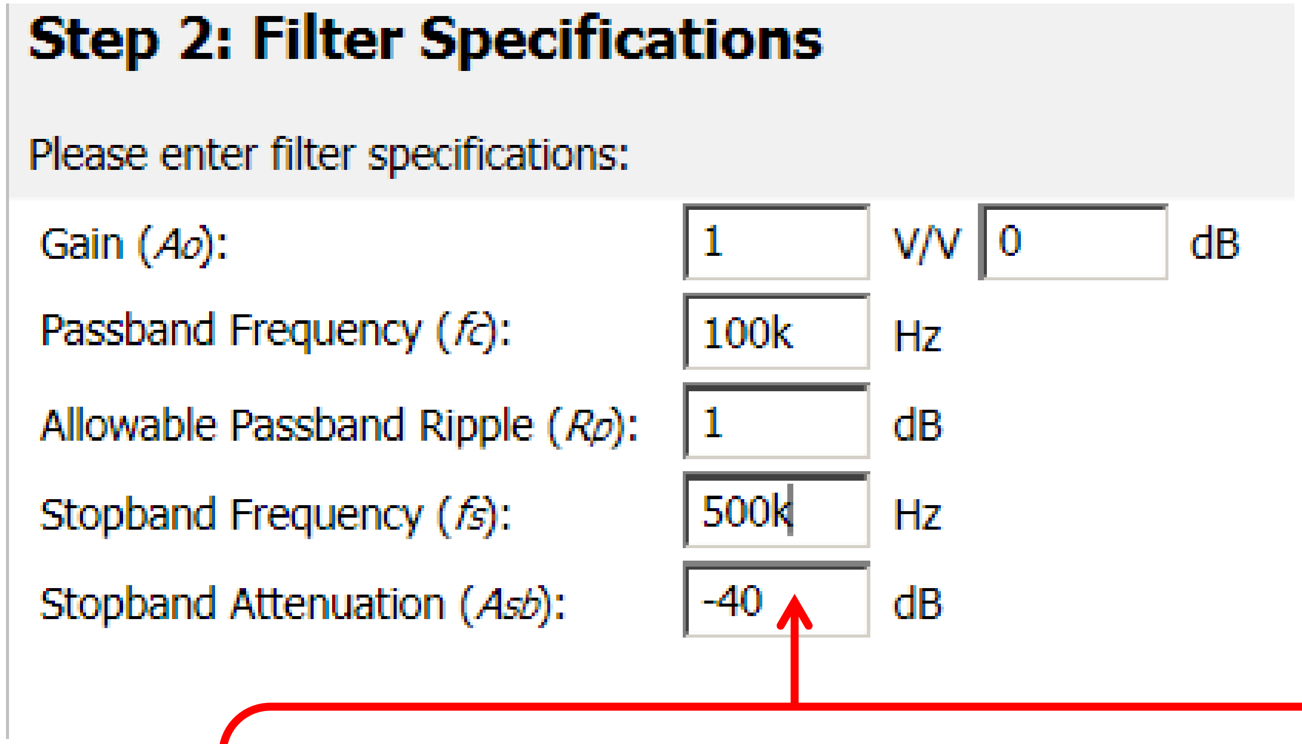




1. Using FilterPro we can select low pass filter.

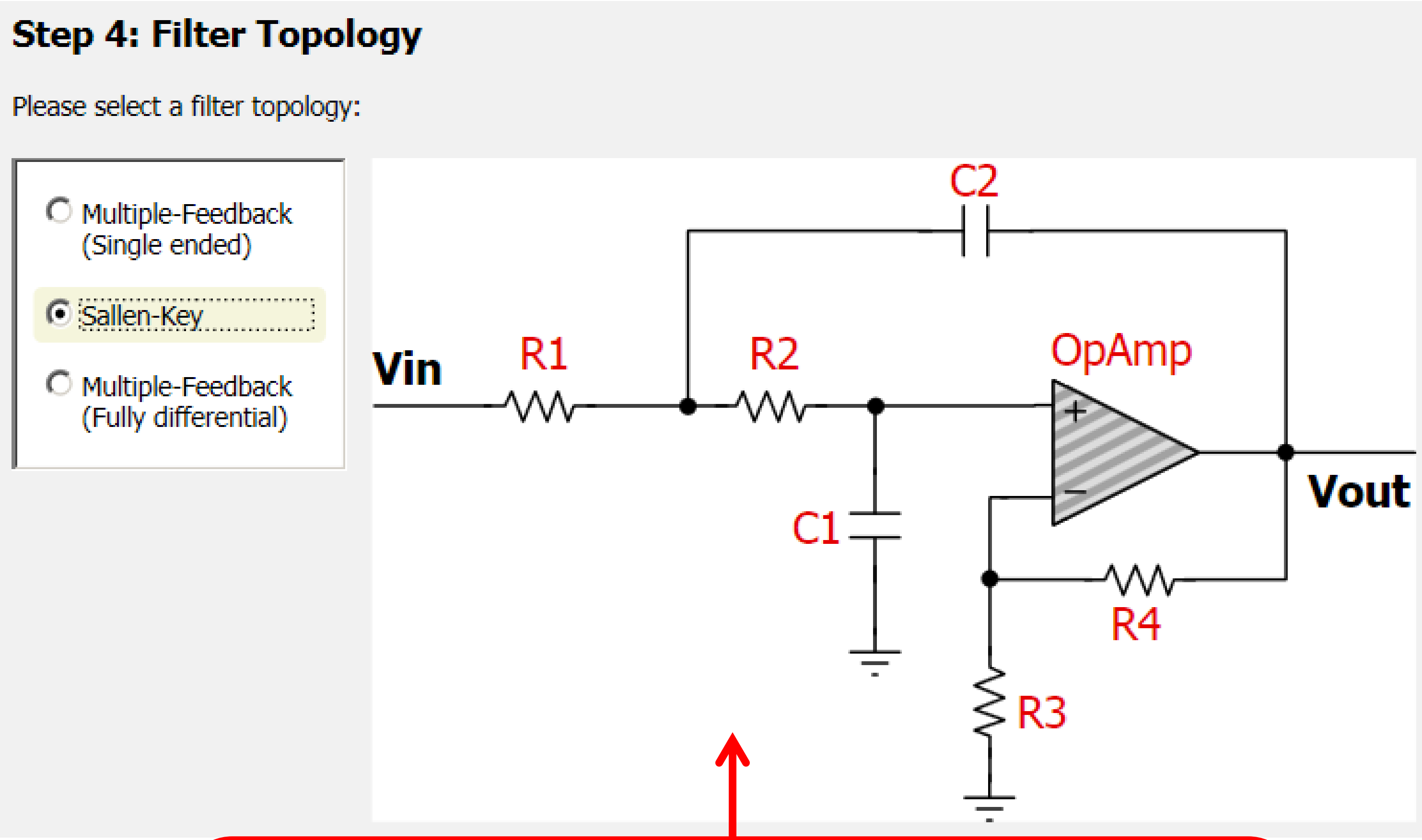
2. Using FilterPro we can enter the passband frequency, stopband frequency and stopband attenuation.

Quiz: Aliasing and Anti-aliasing Filters

4 (continued) Using filter Pro.

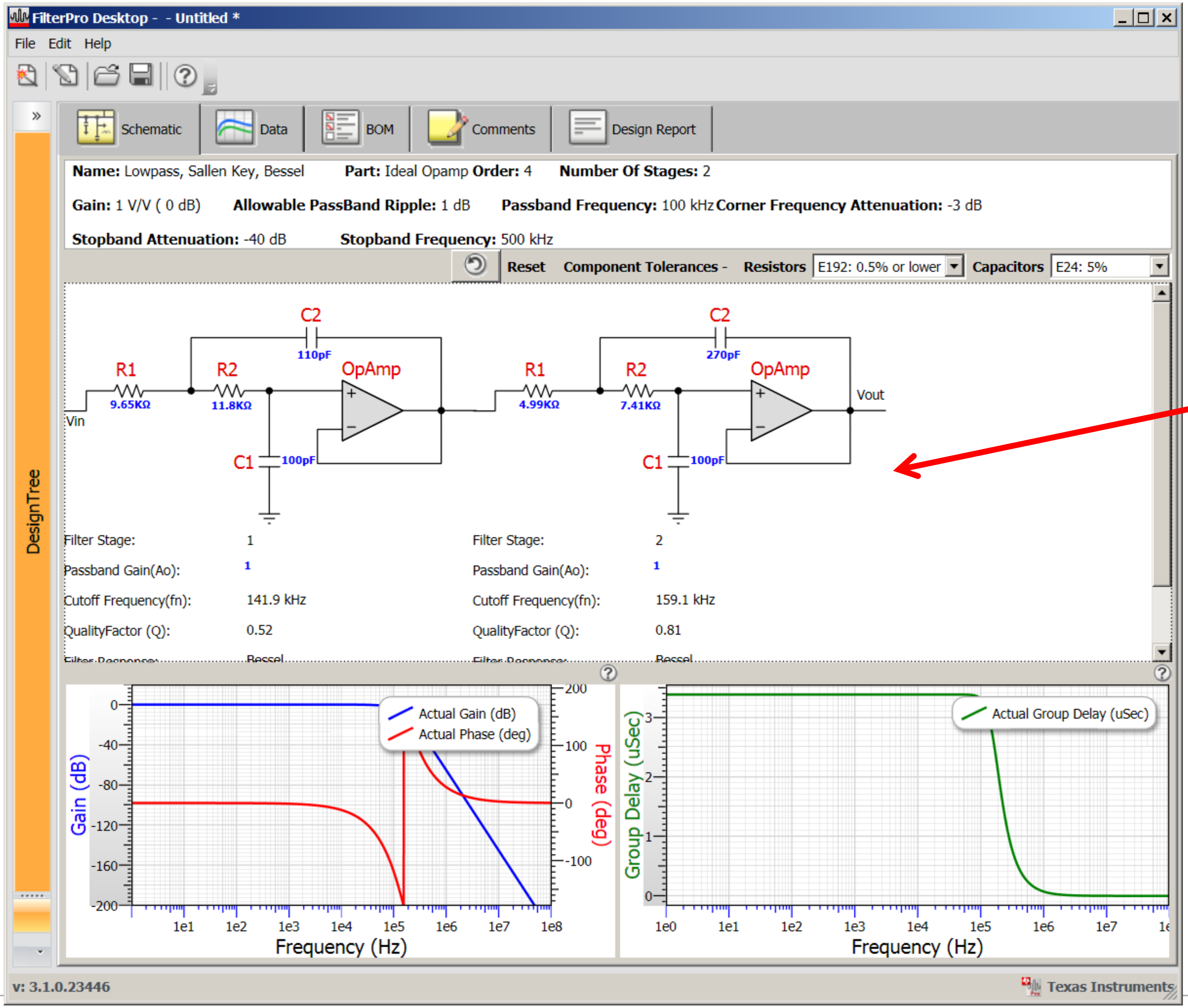
	Response Type	Order	No. of Stages	Max. Q
○	Gaussian to 12 dB	4	2	0.58
◉	**Bessel**	**4**	**2**	**0.81**
○	Butterworth	3	2	1
○	Linear Phase 0.05°	4	2	1.07

3. Next, using FilterPro we can select the filter type. Bessel is a very common filter type used for antialiasing



4. Next, using FilterPro we can select the topology. Sallen-Key works for non-inverting topology.

Quiz: Aliasing and Anti-aliasing Filters



4. Finally, FilterPro provides the active filter component selection that will meet your requirements.

Quiz: Aliasing and Anti-aliasing Filters

The final filter can be verified using simulation in TINA.