



**ASN Filter Designer Professional/Lite
Getting Started Guide**

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1. Introduction

Thank you for your interest in the ASN Filter Designer. This product is available in two flavours, as summarised below:

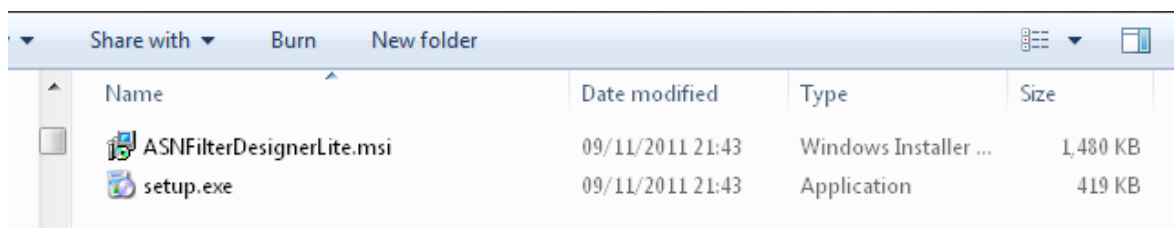
	Professional	Lite
Maximum IIR filter order:	4	4
Maximum FIR filter order:	248	64
Maximum Frequency:	1 GHz	10KHz
Maximum zoom depth:	15	5
Licence:	Commercial use	Evaluation/non-commercial use
Price:	€125 + VAT	Free

Please contact us at support@advsolned.com if you would like to buy a licence for the professional edition. We also offer academic and group licensing discounts, so please ask!

1.1. Getting started

The ASN filter designer has been designed around Microsoft's .NET technology, and as such requires .NET framework 4 to be installed before installation of the ASN Filter designer can continue. Where, the currently supported operating systems are: Windows 7, Windows 7 Service Pack 1, Windows Server 2003 Service Pack 2, Windows Server 2008, Windows Server 2008 R2, Windows Server 2008 R2 SP1, Windows Vista Service Pack 1, Windows XP Service Pack 3.

After downloading the '.zip' archive from ASN's website, please double click on 'setup.exe' in order begin the installation procedure.



Setup.exe will automatically check to see if .NET framework 4 needs to be downloaded, and will then continue with the installation. It is important that the latest updates to the .NET framework 4 are installed, so please run Windows update after the install wizard has completed.

1.2. Types of Filters

The ASN Filter designer implements both IIR (infinite impulse response) and FIR (finite impulse response) type filters. Unlike other filter design packages, the ASN Filter Designer aims to simplify the task of digital filter design by limiting the number of options to the bare essential.

A common problem experienced by many engineers is, "what parameters do I need to enter ?"

Although the cut-off frequency, sampling frequency and the type of filter may be clear, extra details, such as passband ripple, stopband attenuation, filter order require much more understanding. We hope that the ASN Filter Designer's simplified GUI addresses these issues, by providing users with a simple and intuitive design tool.

1.2.1. IIR Filters

All IIR filters are implemented as biquad filters (i.e. two poles and two zeros), where you may choose either a 2nd or 4th order implementation. The biquad implementation is particularly useful for fixed point implementations, as the effects of quantization and numerical stability are of no great concern. However, the overall success of any biquad implementation is dependent upon the available number precision, which must be sufficient enough in order to ensure that the quantized poles are always inside the unit circle.

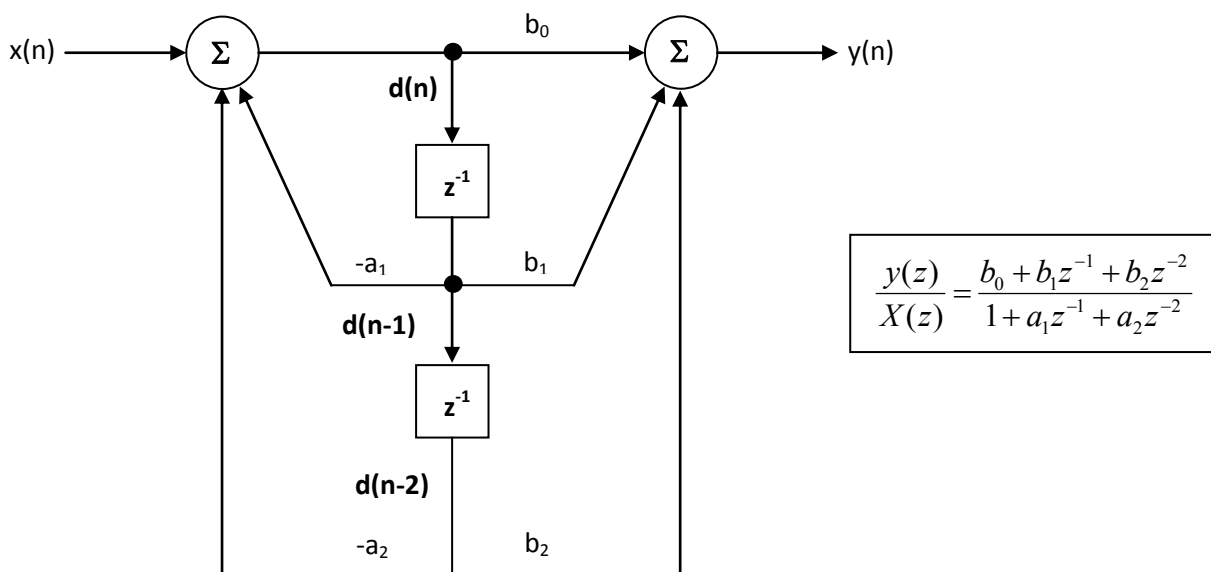


Figure 1 – Direct form II (biquad) IIR filter realization.

Analysing Figure 1, it can be seen that the biquad structure is comprised of two feedback paths (scaled by a_1 and a_2) and two feed forward paths (scaled by b_1 and b_2). The filtering operation of Figure 1 can be summarized by the following set of recursive equations:

$$d(n) = x(n) - a_1d(n-1) - a_2d(n-2) \quad (1)$$

$$y(n) = b_0d(n) + b_1d(n-1) + b_2d(n-2) \quad (2)$$

Analyzing Eqns. (1) and (2) notice that the biquad implementation only requires four additions and five multiplications, which can be easily accommodated on any modern micro-controller/DSP. Also, implementing the direct form realization into two steps, i.e., Eqns. (1) and (2) significantly reduces the filter's sensitivity to quantization error. Please visit our website for more details about fixed point filter implementation.

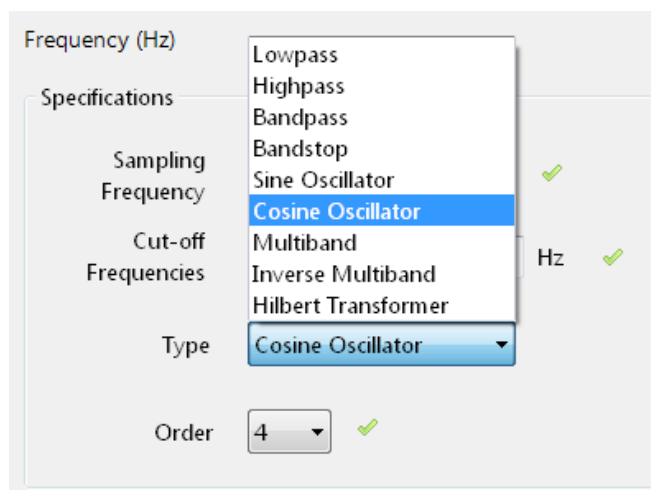
The following analogue prototypes (transformed using the Bilinear transform) are available:

- Butterworth
- Chebyshev Type I (passband ripple 0.1dB)
- Chebyshev Type II
- Elliptic (passband ripple 0.1dB)

You may choose a stopband attenuation of either 20 or 40dB.

1.2.1.1. Sine/Cosine Oscillators

The GUI facilitates the design and analysis of simple sine and cosine oscillators by virtue of placing a conjugate pole pair directly onto the unit circle. You may choose either a Sine or Cosine waveform from the `Type` menu, as shown below:



The GUI will automatically set the filter order to 2.

Care should be exercised when performing analysis on the phase delay and group delay plots when using `double precision`, as the extra detail may (in some case) result in misleading results. We therefore advocate using `single precision` for floating point analysis.

1.2.2. FIR Filters

FIR (finite impulse response) filters are useful for a variety of signal processing applications, including audio signal processing and noise cancellation. Although several practical implementations for FIRs exist, the direct form I structure is perhaps the most commonly used, and as such all designed filter coefficients are intended for implementation in a Direct form I structure.

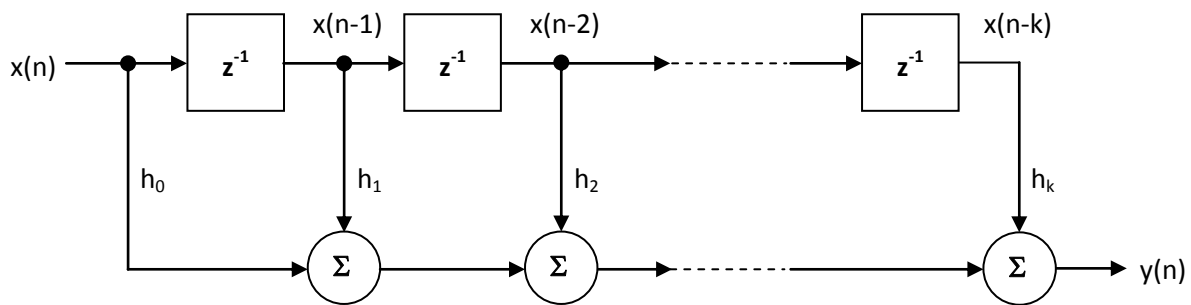


Figure 2 – Direct form I FIR filter realization.

$$y(n) = \sum_{m=0}^k h_m x(n-m) \quad \text{for } n = 0, 1, 2, 3, \dots, N-1 \quad (3)$$

All standard FIR filters (lowpass, highpass, bandpass and bandstop) are designed based on the Window method. However, the Multiband filters are based on the frequency sampling method. The following window functions are available:

- Blackman
- Blackman Harris
- Hamming
- Hanning
- Chebyshev
- FlatTop
- Gaussian ($\alpha = 2.5$)
- Lanczos

A filter order of up to 248 may be implemented in the professional edition, whereas this is limited to 64 in the Lite edition.

2. The GUI

The ASN Filter designer can design both [IIR](#) and [FIR](#) filters, and as seen below has very simple to use user interface. At start-up, a default 4th order IIR Butterworth filter is designed and its frequency response plotted.

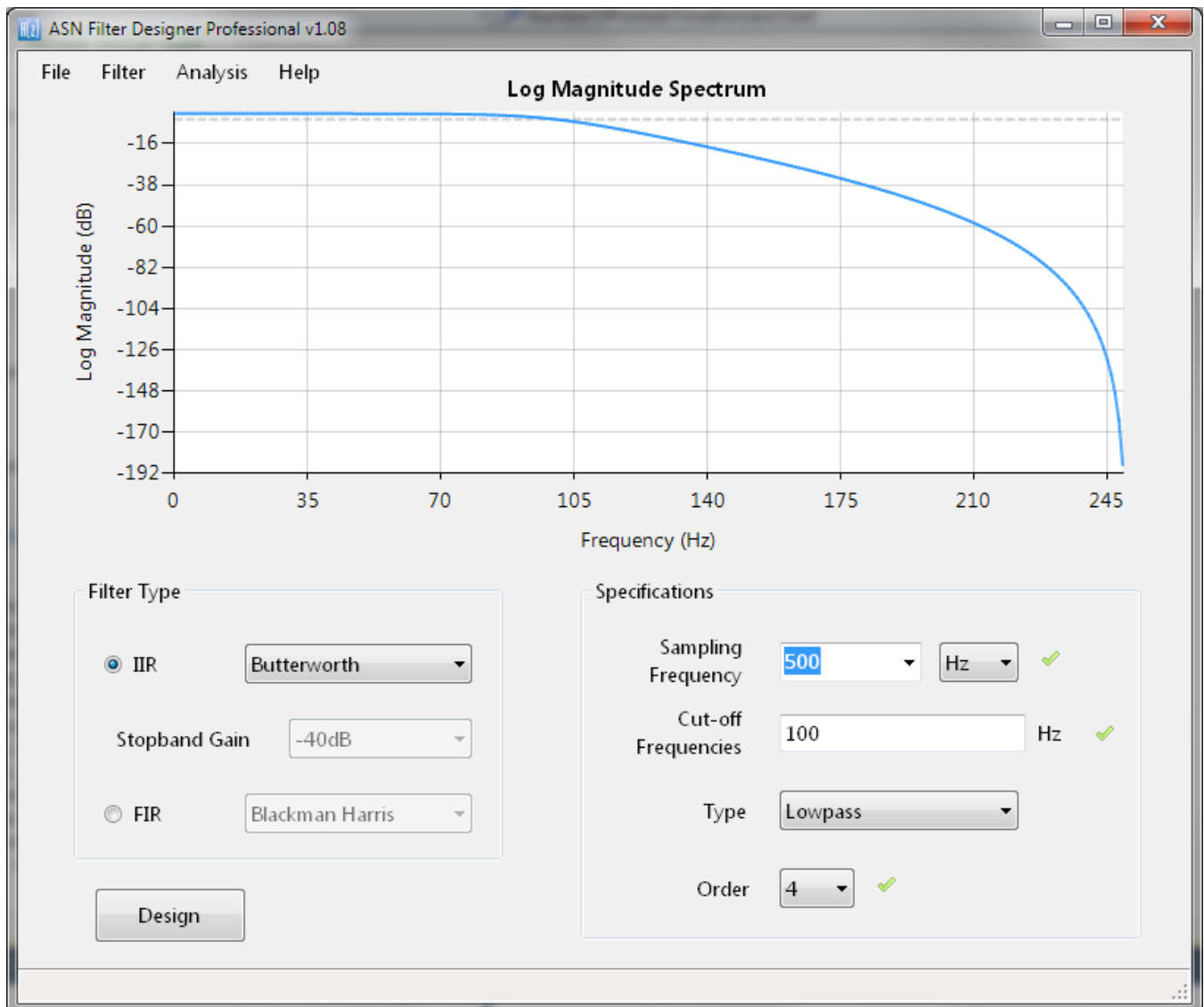


Figure 3 - The default GUI.

The GUI automatically checks for invalid entries as the user types, and as such a green check mark ✓ is shown for a valid entry or alternatively red cross ✗ is shown for any invalid entries. Pressing on the `Design` button will design the filter for the entered specifications.

2.1. Valid Frequencies

The professional edition of the product allows you to enter sampling frequencies from 1Hz to up to 1GHz - whereas, the Lite version is limited to a maximum frequency of 10KHz. As seen above, three frequency ranges are available: Hz, KHz and MHz. You may enter a sampling frequency in the range 1-1000, including fractional sampling frequencies up to 3 decimal places. As an example, a sampling frequency of 1248Hz, should be entered as:



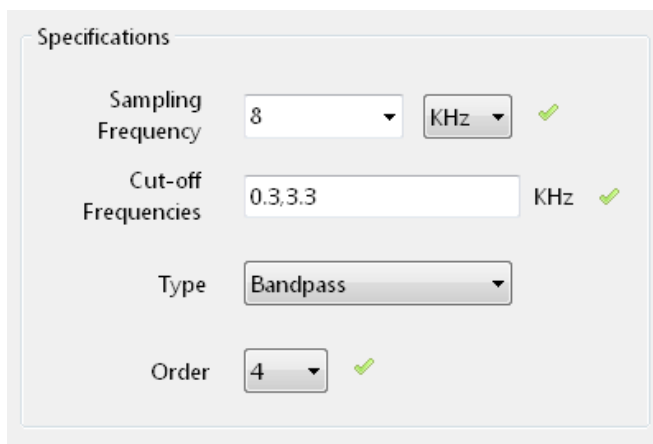
Specifications

Sampling Frequency: 1.248 KHz ✓

In all cases, the program will validate the user input and in the event of an invalid entry, a pop up text box will provide hints and tips.

2.1.1. Cut-off Frequencies/Stop band frequencies

All cut-off frequencies as standard should be entered in ascending frequency pairs, i.e. start frequency and stop frequency. Where, the two frequencies must be delimited (separated) by a ',' or ';'. For example: 100,250 and/or 100;250 are valid entries, whereas: 100 250 or 250,100 are not.



Specifications

Sampling Frequency: 8 KHz ✓

Cut-off Frequencies: 0.3,3.3 KHz ✓

Type: Bandpass

Order: 4 ✓

Example: Speech filter

$F_s = 8\text{KHz}$

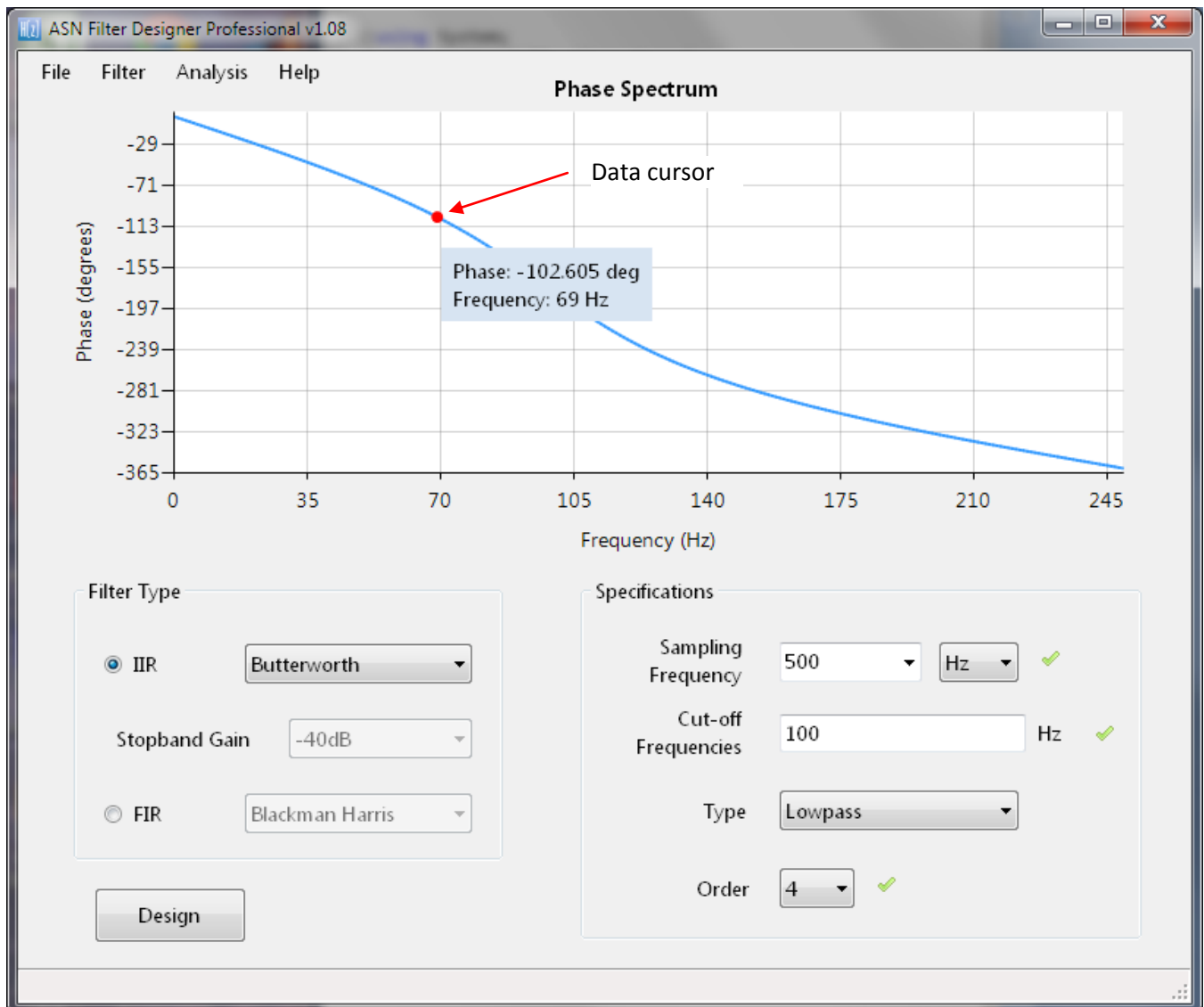
Lower frequency = 300Hz

Upper frequency = 3.3KHz

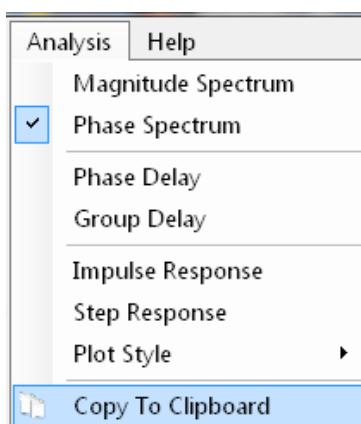
NB. [Multiple cut-off frequencies](#) used in [Multiband filters](#) require at least two pairs of cut-off frequencies. However, it is important to realize that lowpass and highpass filters only require one cut-off frequency, and as such are a special case of the standard rule.

2.2. Data analysis

Data analysis is performed with the mouse. Where, moving the mouse over the graph will automatically produce the data cursor and the data point's details, as seen below:



you may swap between the Magnitude spectrum, phase spectrum, Group delay, phase delay, Impulse response or step response via the **Analysis** menu.



The current plot may be copied to the clipboard by selecting the **Copy to Clipboard** option. The resulting image may then be pasted into a third party application.

2.3. Advanced frequency zoom

The GUI implements an advanced frequency zoom feature by virtue of a specialized implementation of the DFT (discrete Fourier transform). This allows for detailed frequency analysis with very little computational power, resulting a fast responsive GUI.

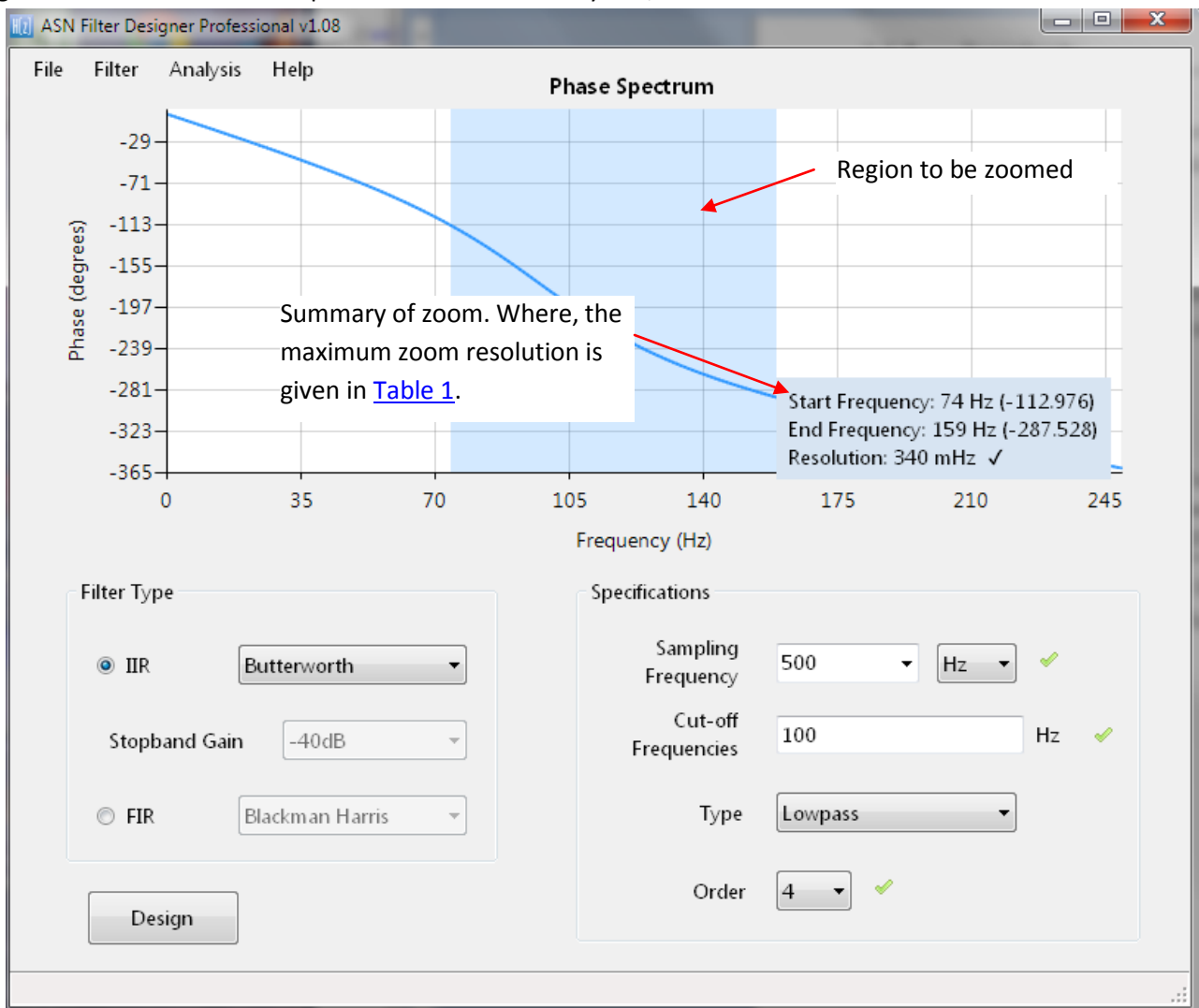
Frequency Range	Maximum Zoom Resolution
MHz	1KHz
KHz	1Hz
Hz	10mHz

Table 1 - Maximum zoom resolutions.

The advanced zoom feature allows users to quickly and simply obtain detailed frequency response information even when the sampling frequency is several hundred MHz (professional edition only)!

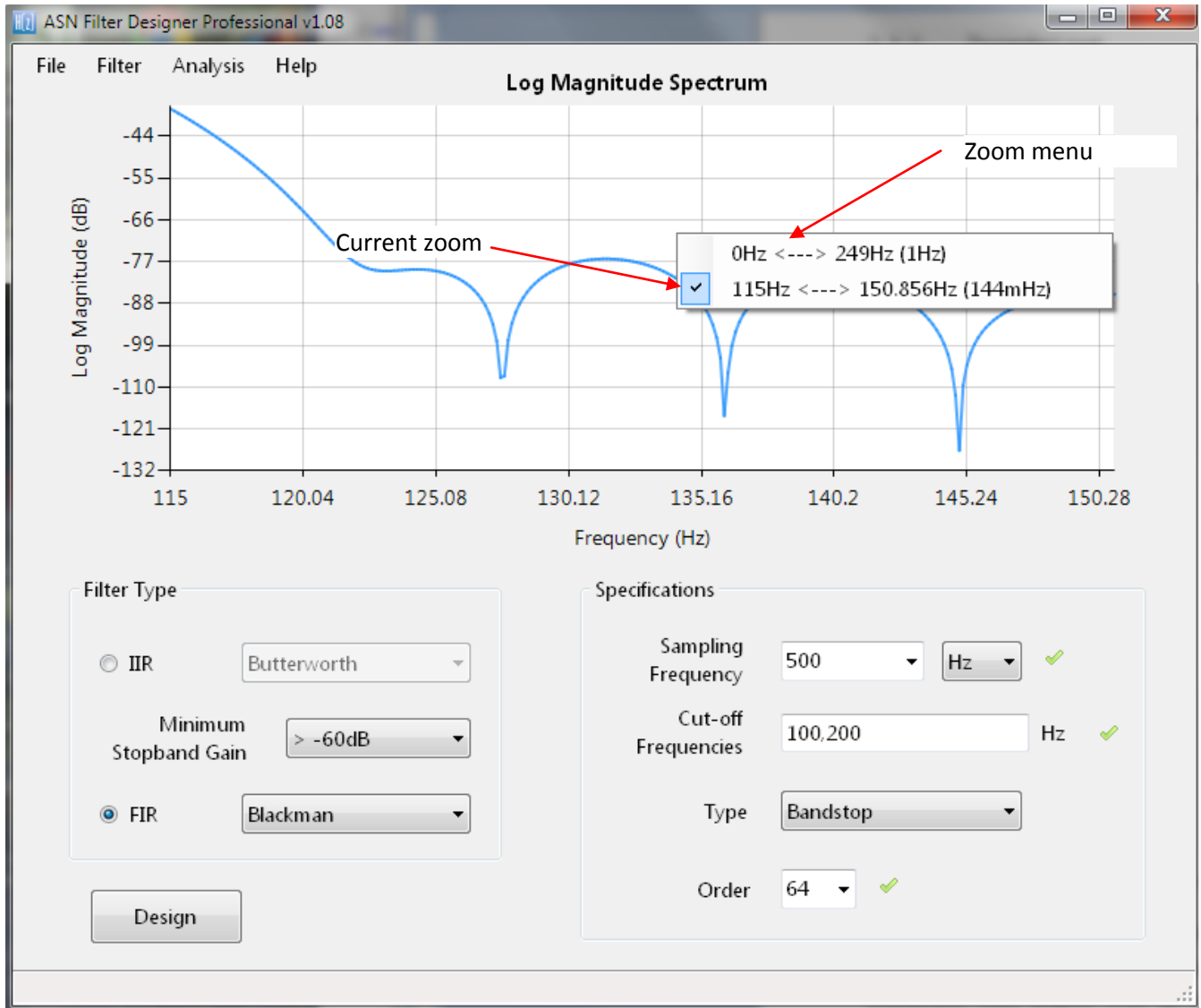
2.3.1. Zooming In

De-pressing the left mouse button on the plot and dragging the mouse either left or right will highlight the region to be zoomed and also produce a zoom summary box, as shown below:



2.3.2. Zooming out

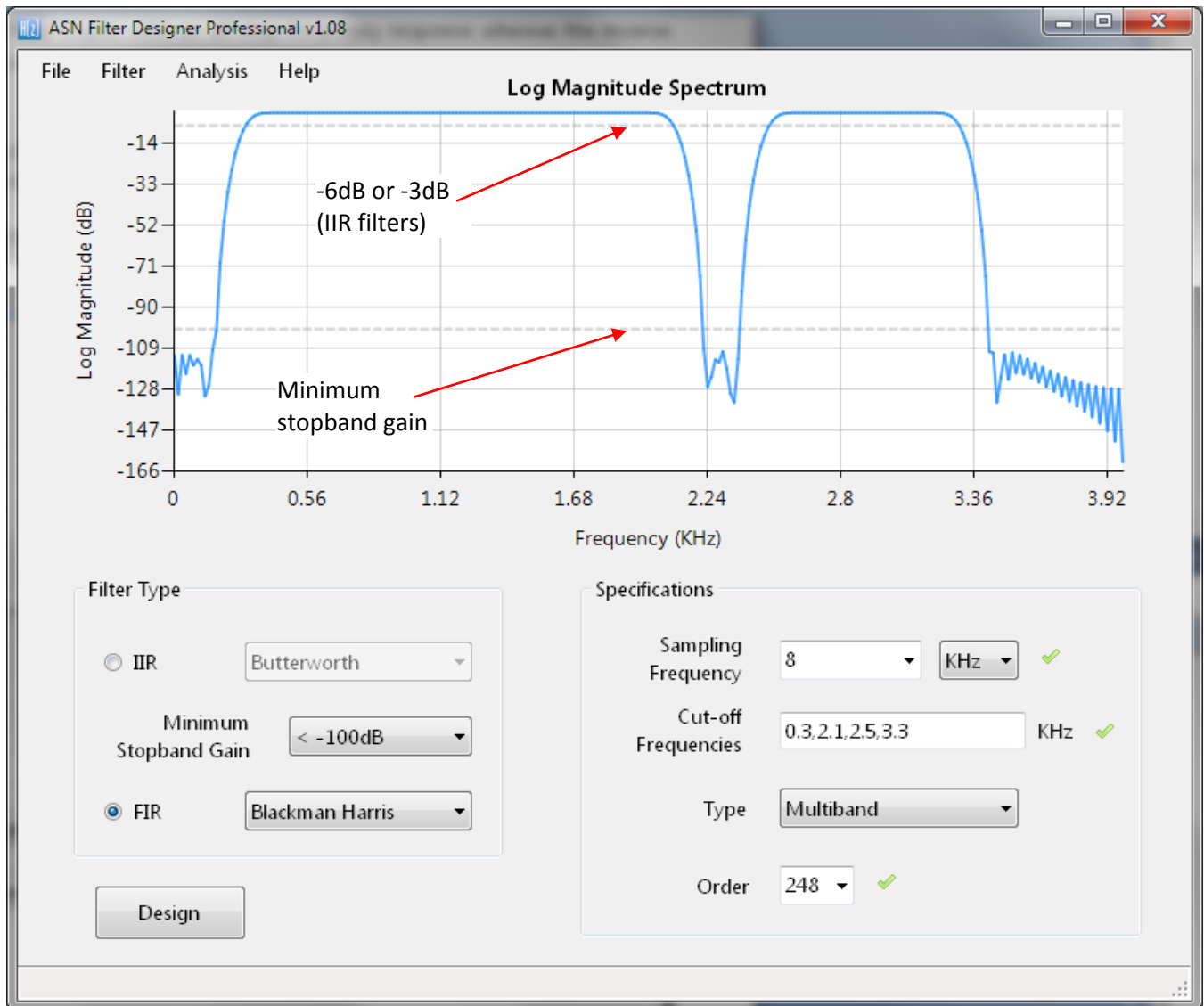
Right clicking on the plot will produce a `zoom` menu. A check mark identifies the current level of zoom and resolution. A maximum of fifteen levels of zoom can be accommodated for [professional edition](#), whereas only five levels can be accommodated for the [Lite edition](#).



2.4. Multiband Filters

In order to implement an arbitrary frequency response, you may use either the `Multiband` or `Inverse multiband` filter. The `Multiband` filter begins with an all stop frequency response whereas the `Inverse Multiband` filter begins with an all-pass frequency response. You may enter up to a maximum of five pairs of start and stop frequencies.

The example shown below demonstrates two pairs of start and stop frequencies with a `Blackman Harris` window for a 248th order FIR filter (double precision arithmetic).



2.5. The File Menu

All file related commands, such as export, printing, opening and saving the project are available via the `File` menu.

2.5.1. Exporting Data

You may export all plot data (at the current level of frequency domain zoom) to an ASCII text file via the `Export to File -> All plots` menu option. Please note, that all 250 points of time domain data are exported regardless of the time domain zoom.

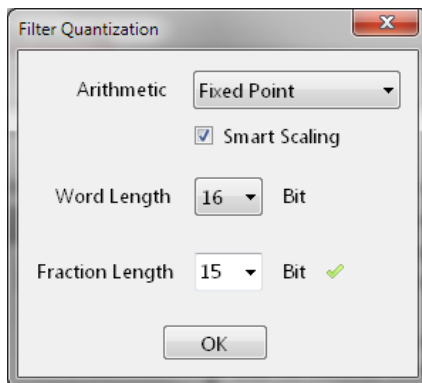
You may also export the filter summary and coefficients to a ASCII text file or a SensorPro¹ filter configuration file via the `Filter Coefficients` sub menu option.

2.6. The Filter Menu

All filter related operations, such as Arithmetic/quantization used in the computation may be accessed via the `Filter` menu.

2.6.1. Filter Arithmetic

The ASN filter designer allows you to quickly and easily analyse the effects of quantization on the designed filter via the `Arithmetic` menu option.



By default, 'Double precision' arithmetic is used for the calculation of all filter coefficients and their subsequent impulse and step responses. However, you may perform fixed point analysis by selecting `Fixed Point` from the `Arithmetic` menu (see left) and choosing the required `Word Length` and `Fraction length` that you require. All plots will display the results based on the quantization/Arithmetic settings.

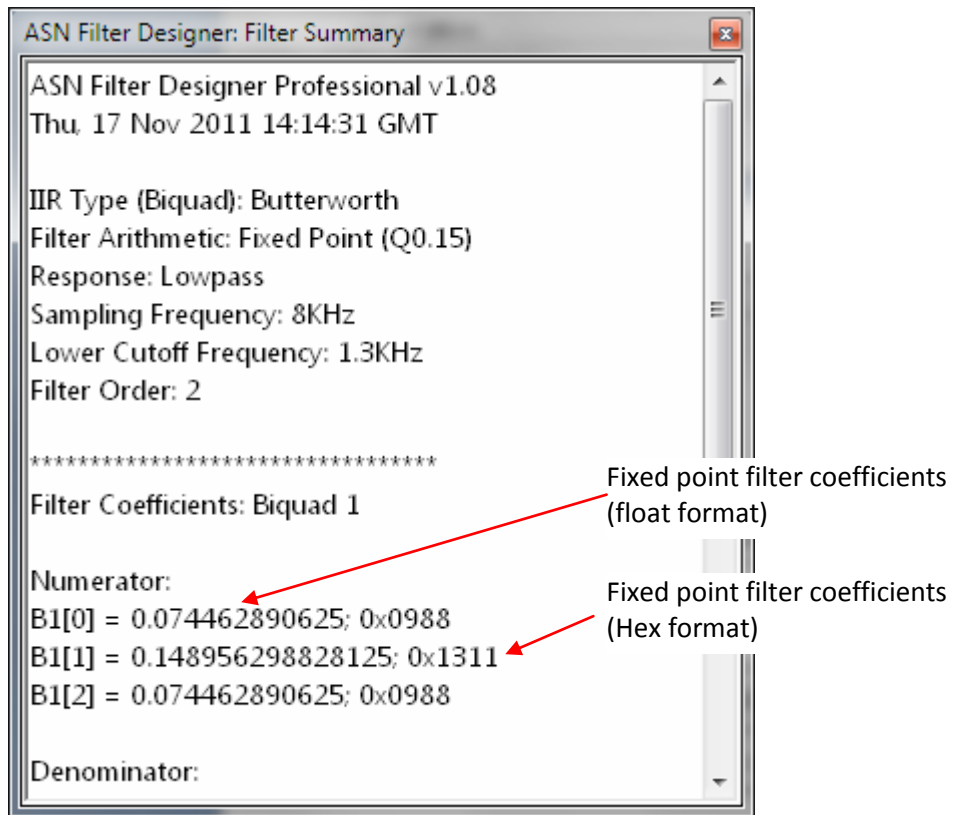
The `Smart Scaling` option is designed for IIR design in order to ensure that no internal overflow occurs in the designed Biquads and that all filter coefficients can be correctly represented. This is especially useful for cases when there is no integer component, e.g. Q15 (16 bit word length and a fraction length of 15 bits). You may enable or disable `Smart Scaling` via the check box (see left) if you wish to assess the performance of your filter without any scaling.

2.6.2. View current filter summary and filter coefficients

A summary of the designed filter is always available via the `View Current Summary` menu option. This function is handy in situations where the GUI parameters have been altered after designing a filter, and the user has forgotten what settings were used for the designed filter.

¹ SensorPro is Advanced Solutions Nederland's advanced real-time data acquisition and analysis module. Please contact us for more information.

The filter summary also displays results of the [quantization](#) procedure. If Fixed Point arithmetic is selected the resulting filter summary will display both the quantized filtered coefficients in float and Hex format, as shown below. The Hex format coefficients may be directly implemented in any DSP/micro-controller.



Document Revision Status

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1	Document released.	17/11/2011
2	Document updated for oscillators	12/12/2011