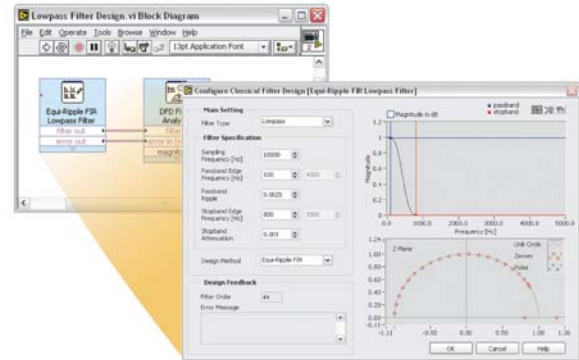


LabVIEW Tools for Digital Filter Design and Implementation

NI Digital Filter Design Toolkit

- Interactive and programmatic design, analysis, and implementation of FIR/IIR digital filters within LabVIEW
 - More than 30 filter types backed by more than 25 classical and modern design algorithms and 23 filter topologies
 - Single-stage and multistage FIR filters for interpolation, decimation, and resampling
 - Fixed-point filter design, analysis, and simulation, including single-rate filters and multirate filters
 - LabVIEW FPGA and ANSI C code generation for fixed-point filter implementation on an FPGA or DSP
- System Requirements**
- Windows Vista/XP/2000
 - LabVIEW 8.6 or later (Full or Pro)



Overview

The NI Digital Filter Design Toolkit extends NI LabVIEW with comprehensive tools for the design, analysis, and implementation of both single-rate digital filters and multirate digital filters. Novices can interactively explore common designs, while experienced users can select from a comprehensive set of filter types backed by a breadth of design algorithms, filter topologies, and analysis tools for design, modeling, and implementation.

An extensive set of more than 75 examples can serve as a starting point for your floating- or fixed-point designs. For fixed-point filters, you can model quantization effects and automatically generate ANSI C and LabVIEW FPGA code for digital signal processing (DSP) or field-programmable gate array (FPGA) deployment.

The Digital Filter Design Toolkit also offers sets of LabVIEW MathScript filter design functions for users who are accustomed to text-based filter design.

Digital Filter Selection

The first stage of digital filter design involves selecting an appropriate filter type for your application. The Digital Filter Design Toolkit offers more than 30 types of filters that are useful in a variety of applications such as those presented in Table 1.

Filter Type	Example Application
FIR bandpass	Extract a radio station from a broadband radio signal
Comb	Separate luminance and chrominance components from a composite TV signal
N-stage multirate	Resample a signal to increase or decrease the sampling rate of a signal by a factor that is a rational fraction
Group delay compensator (allpass)	Reduce phase distortion that occurs after applying a filter with a nonconstant group delay
Raised cosine	For a digitally modulated signal, limit the occupied bandwidth and reduce intersymbol interference

Table 1. Common Applications of the Digital Filter Design Toolkit

To specify and design a filter, the toolkit includes Express VI-based interactive tools for classical filter designs and design through placement of poles and zeros. As you modify parameters, the interface immediately shows the magnitude response and pole-zero locations on the Z-plane based on your selections. Using the pole-zero design tools, you can click and drag poles and zeros for placement on the Z-plane. You can also programmatically design these and other filter types with included LabVIEW programs (VIs) that are easily wired into LabVIEW diagrams. The toolkit includes a comprehensive variety of more than 25 design algorithms ranging from classical (Butterworth, Chebyshev, window, and so on) to modern optimizing options including Remez exchange (for arbitrary magnitude FIR filters and multirate filters) and least Pth norm (for arbitrary magnitude and phase FIR/IIR).

LabVIEW Tools for Digital Filter Design and Implementation

Analyze Your Design

To analyze your design, the Digital Filter Design Toolkit provides VIs to quickly plot frequency response, pole-zero locations, group delay, phase delay, impulse response, and step response. It also installs a set of process signal VIs with which you can further evaluate or deploy your filter immediately by applying it to a signal. Because you are working within the LabVIEW development environment, you have easy access to live, simulated, and previously acquired signals. To implement your filter, simply wire your design and signal into an appropriate process signal VI from the toolkit.

Deployment Options

While you might deploy your filter immediately on a PC, you are free to export the result of your design as a set of coefficients. The Digital Filter Design Toolkit also handles embedded DSP or FPGA targets with fixed-point tools that include filter structure conversion, modeling of quantization effects, and automatic code generation. The toolkit includes 23 filter structures, ranging from the direct form and cascaded form to lattice AR (autoregressive), lattice MA (moving average), and lattice ARMA (autoregressive-moving average). Automatic code generation capability includes integer LabVIEW, single-cycle timed loop LabVIEW FPGA, and ANSI C. For multirate filters, you can also generate the single-cycle timed loop LabVIEW FPGA codes for deployment.

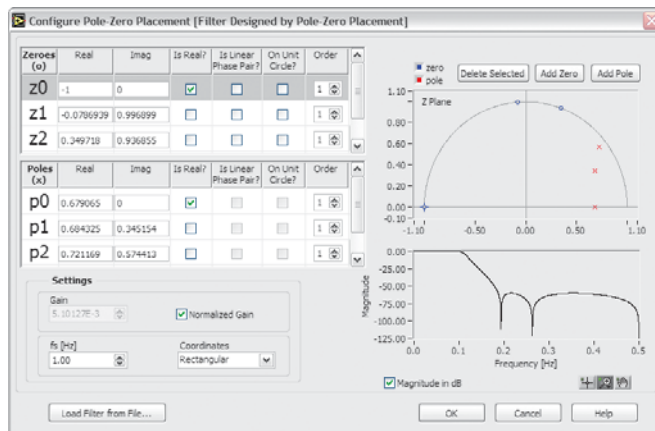


Figure 1. You can drag and drop poles and zeros to design a filter with the Configure Pole-Zero Placement Express VI.

Function List Highlights

Filter Design Functions and VIs

- Classical Design Express VI
- Pole-Zero Placement Express VI
- Filter order estimation VIs
 - Dolph-Chebyshev order estimation
 - Kaiser order estimation
 - Remez order estimation
 - Butterworth order estimation
 - Chebyshev order estimation
 - Inverse Chebyshev order estimation
 - Elliptic order estimation
- FIR/IIR filter design VIs
 - Dolph-Chebyshev design
 - Kaiser design
 - Windowed FIR design
 - Butterworth design
 - Chebyshev design
 - Inverse Chebyshev design
 - Elliptic design
 - Bessel design
 - Least Pth norm design
 - Arbitrary group delay design
 - Group delay compensator
 - IIR comb design
 - IIR notch peak design
 - Maxflat design
 - Narrowband filter design

Program Examples

- Design a Filter Step by Step.vi
- Advanced Remez Design with Exact Gain Control.vi
- Advanced Remez FIR Filter Design.vi
- Arbitrary Group Delay Filter Design.vi
- Arbitrary Shape Lowpass Filter Design.vi
- Bessel IIR Filter Design.vi
- Elliptic IIR Filter Design.vi

LabVIEW Tools for Digital Filter Design and Implementation

- Group Delay Compensation.vi
- IIR Comb Filter Design.vi
- IIR Notch Peak Filter Design.vi
- Lpth Norm Complex Approximation-Compensate Channel Distortion.vi
- LPth Norm IIR Filter Design.vi
- LPth Norm Weighting Filter Design.vi
- Noise Cancellation for ECG Signal by Comb Filter.vi
- Noise Cancellation for ECG Signal by Notch Filter.vi

Filter Analysis

Functions and VIs

- Filter Analysis Express VI
- Plot frequency response
- Plot phase delay
- Plot group delay
- Plot pole-zero
- Plot impulse response
- Plot step response
- Plot narrowband frequency response
- Get frequency response

Program Examples

- Analyze Frequency Response of Filter with Log Spaced Freq Bins.vi
- Analyze Frequency Response of Filter.vi
- Analyze Impulse and Step Response of Filter.vi
- Analyze Coefficients-Quantized Filter.vi
- Analyze Quantized Filter with Different Structure.vi

Filter Conversion

Functions and VIs

- Cascade filters
- Convert structure
- Get filter structure
- Scale filter

Program Examples

- Change Structure of Filter.vi
- Cascade Lowpass and Highpass to Bandpass Filter.vi
- Scale Filter before Targeting to FXP.vi
- Structure Selection and Quantization.vi

Filter Processing

Functions and VIs

- Filtering
- Integer delay
- Narrowband filtering

Program Examples

- Delay Signal.vi
- Filtering.vi
- Narrowband Filtering - DFD.vi
- Online Filtering - DFD.vi
- Extract the Sine Wave - DFD.vi
- Train Wheel PtByPt - DFD.vi

Fixed-Point Filter Tools Functions and VIs

- Quantize filter coefficients
- Fixed-point filter coefficients report
- Fixed-point filter modeling
- Fixed-point filter simulation
- Fixed-point filter simulation report
- Fixed-point filter code generation
- Fixed-point filter postprocessing
- Get fixed-point filter quantizer
- Set fixed-point filter quantizer
- Convert fixed-point to integer
- Convert integer to fixed-point

Program Examples

- Analyze Coefficients-Quantized Filter.vi
- Analyze Quantized Filter with Different Structure.vi
- Easy Fixed-Point Filter Modeling and Simulation.vi
- Customized Fixed-Point Filter Modeling and Simulation.vi
- Continuous Overflow Statistics.vi
- Conversion between FXP and Integer.vi
- Export FIR Coef to Xilinx COE File.vi
- Generate LabVIEW FPGA Code for Exponentially Weighted Moving Average Filter.vi
- Get Integer Coef of Fixed-Point FIR Filter.vi
- LabVIEW C Code Generation.vi
- Simulation with Integer Inputs.vi

Filter Utilities

Functions and VIs

- Build filter from cascaded coefficient
- Build filter from lattice coefficient
- Build filter from transfer function
- Build filter from zero-pole-gain
- Get cascaded coefficient
- Get lattice coefficient
- Get order
- Get transfer function

LabVIEW Tools for Digital Filter Design and Implementation

- Get zero-pole-gain
- Filter file operations
 - Save to file
 - Save to text file
 - Load from file
 - Load from text file
- Rendering functions
 - Render difference equation
 - Render transfer function equation
 - Render zero-pole-gain equation

Program Examples

- Get Cascaded Coefficients of IIR Filter.vi
- Get Lattice Coefficients of Filter.vi
- Get Transfer Function of Filter.vi
- Get Zero-Pole-Gain of Filter.vi
- Build an Exponentially Weighted Moving Average Filter.vi
- Create Filter from Lattice Coefficients.vi
- Create Filter from Transfer Function.vi
- Create Filter from Zero-Pole-Gain.vi
- Create IIR Filter from Cascaded Coefficients.vi
- Filter Rendering.vi
- Save and Load Filter to and from Text File.vi
- Save and Load Filter.vi

Multirate Filter Design Functions and VIs

- Multirate Filter Design Express VI
- Multistage Multirate Filter Design Express VI
- Multirate CIC Design Express VI
- Halfband design
- Nyquist design
- Raised cosine design

Program Examples

- Design a Multirate Filter Step by Step.vi
- Single Stage Multirate Filter Design.vi
- Multistage Decimation Filter Design.vi
- Multistage Multirate Filter Design (with CIC).vi
- Multistage Multirate Filter Design.vi
- CIC Filter Design.vi
- Halfband Filter.vi
- Nyquist Filter.vi
- Raised Cosine Filter.vi

Multirate Filter Analysis Functions and VIs

- Plot multirate frequency response
- Plot multistage multirate frequency response

Program Examples

- Analyze Coefficients-Quantized Multirate Filter.vi
- Analyze Coefficients-Quantized Multistage Multirate Filter.vi

Multirate Filter Processing Functions and VIs

- Multirate filtering for single block
- Multirate filtering
- Multistage multirate filtering for single block
- Multistage multirate filtering

Program Examples

- Multirate Filtering.vi
- Decimation Filtering for Single Block.vi
- Interpolation Filtering for Single Block.vi
- Multistage Multirate Filter Continuous Processing.vi
- Single Stage Multirate Filter Continuous Processing.vi
- Zero Phase Multirate Filtering.vi

Fixed-Point Multirate Filter Tools Functions and VIs

- Multirate filter coefficients quantization
- Fixed-point multirate filter modeling
- Fixed-point multirate filter simulation
- Fixed-point multirate filter code generation
- Fixed-point multirate filter postprocessing
- Get multirate filter coefficient quantizer
- Get multirate filter output quantizer
- Multistage multirate filter coefficients quantization
- Fixed-point multistage multirate filter modeling
- Fixed-point multistage multirate filter simulation
- Fixed-point multistage multirate filter code generation
- Fixed-point multistage multirate filter postprocessing
- Moving average filter code generation

Program Examples

- Analyze Coefficients-Quantized Multirate Filter.vi
- Analyze Coefficients-Quantized Multistage Multirate Filter.vi
- Export Multirate FIR Coef to Xilinx COE File.vi
- Fixed-Point Multirate Filter Modeling and Simulation.vi

LabVIEW Tools for Digital Filter Design and Implementation

- Fixed-Point Multistage Multirate Filter Modeling and Simulation.vi
- Generate LabVIEW FPGA Code for Moving Average Filter.vi
- Generate LabVIEW FPGA Code for Multirate Filter.vi
- Generate LabVIEW FPGA Code for Multistage Multirate Filter.vi

Multirate Filter Utilities Functions and VIs

- Build CIC Filer
- Get multirate CIC parameters
- Build multirate filter
- Get multirate filter parameters
- Get multirate filter structure
- Multirate filter file operations
 - Save to file
 - Load from file
 - Save multirate filter to text file

Program Examples

- Create Multirate Filter.vi
- Get Parameters of Multirate Filter.vi
- Save Multirate Filter to Text File.vi

LabVIEW MathScript Filter Design Functions and VIs

- fircband
- firgr
- firlnorm
- firminphase
- iircomb
- iirgrpdelay
- iirlpnorm
- iirlpnormc
- iirnotch
- iirpeak
- firhalfband
- firnyquist

Program Examples

- Export SOS Coef to MathScript.vi
- Export SOS Zero-Pole-Gain to MathScript.vi

Ordering Information

NI LabVIEW Digital Filter Design Toolkit779023-03

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