

Noise Cancellation System Based On IIR Low Pass Digital Filter Design by Using LabVIEW

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Abstract:

Aiming at importance of virtual instruments in the field of Digital Signal Processing, a digital IIR Filter system is developed using National Instruments (NI) data LabVIEW software package. All the types of IIR filters like Butterworth filters, Chebyshev filters, inverse Chebyshev filters, and Elliptic filters are designed to generate their magnitude response and filter coefficients. The LabVIEW software is used to develop virtual instrument (VI) that includes a front panel and a functional diagram. The VI reads the desired parameters of the filters entered by the user on the front panel and determines its magnitude response and filter coefficients.

Keywords:

Digital IIR Filter, LabVIEW, Virtual Instruments, Low Pass Filter, Digital Signal Processing

1. Introduction

The importance of digital filters is well established. Digital filters, and more generally digital signal processing algorithms, are classified as discrete-time systems. They are commonly implemented on a general purpose computer or on a dedicated digital signal processing (DSP) chip. Due to their well-known advantages, digital filters are often replacing classical analogue filters. In this application note, we introduce a new digital filter design and analysis tool implemented in LabVIEW with which developers can graphically design classical IIR and FIR filters, interactively review filter responses, and save filter coefficients. In addition, real-world filter testing can be performed within the digital filter design application using a plug-in data acquisition board [1,2,3,4].

IIR digital filters are recursive systems that involve fewer design parameters, less memory requirements, and lower computational complexity than finite impulse response (FIR) digital filters. These are primary advantages of implementing IIR

digital filters. If there is no requirement for a linear-phase characteristic within the passband of a digital filter, the aforementioned advantages make IIR filters more attractive to a system designer. This type of recursive system belongs to an important class of linear time-invariant discrete-time systems characterized by the general linear constant-coefficient difference equation as follows:

$$y(n) = - \sum_{k=1}^N a_k y(n-k) + \sum_{k=1}^M b_k y(n-k)$$

Transforming this difference equation into the z-domain by means of the z-transform, such a class of linear time-invariant discrete-time systems is also characterized by the transfer function as follows:

$$H(z) = \frac{\sum_{k=0}^M b_k z^{-k}}{1 + \sum_{k=0}^N a_k z^{-k}}$$

Digital filters are used in a wide variety of signal processing applications, such as spectrum analysis, digital image processing, and pattern recognition. Digital filters eliminate a number of problems associated with their classical analog counterparts and thus are preferably used in place of analog filters. Digital filters belong to the class of discrete-time LTI (linear time invariant) systems, which are characterized by the properties of causality, recursibility, and stability. They can be characterized in the time domain by their unit-impulse response and in the transform domain by their transfer function. Obviously, the unit-impulse response sequence of a causal LTI system could be of either finite or infinite duration and this property determines their classification into either finite impulse response (FIR) or infinite impulse response (IIR) system. To illustrate this, we consider the most general case of a discrete-time LTI system with the input sequence denoted by $x(kT)$ and the resulting output sequence $y(kT)$. As it can be seen from (1), if for at least one $v, a_v \neq 0$, the corresponding system is recursive; its impulse response is of infinite duration (IIR system). If $a_v = 0$, the corresponding system is nonrecursive (FIR system); its impulse response is of finite duration and the transfer function $H(z)$ is a polynomial in z^{-1} . Commonly, b_μ is called the μ^{th} forward filter coefficient and a_ν the ν^{th} feedback or reverse filter coefficient [5,6,7].

2. Procedure for Digital Filter Design

The design of digital filters involves the following basic steps:

- Determine the desired response. The desired response is normally specified in the frequency domain in terms of the desired magnitude response and/or the desired phase response.
- Select a class of filters (for example, linear-phase FIR filters or IIR filters) to approximate the desired response.
- Select the best member in the filter class.
- Implement the best filter using a general purpose computer, a DSP, or a custom hardware chip.
- Analyze the filter performance to determine whether the filter satisfies all the given criteria.

The Digital Filter Design (DFD) tools in the Signal Processing Toolset are complete filter design and analysis software that you can use to design digital filters to meet required filter specifications. The underlying filter design software is implemented in LabVIEW, a complete graphical software development system. With the toolset, users can graphically design IIR and FIR filters, interactively review filter responses, save filter design work, and load design work from previous sessions [8,9,10,11,12]. In addition, the DFD software includes a digital filter DLL that can be accessed from other Windows applications such as Visual Basic or Microsoft C. Plus, the DFD software includes functions so that other applications such as LabVIEW and LabWindows/CVI can load the filter coefficient and execute the filter design within the environment. Lastly, interactive real-world filter testing can be performed within the DFD application using a standard National Instruments data acquisition device. You can view the time waveforms or the spectra of both the input signal and the filtered output signal to show how the present filter performs on real-world signals. This feature delivers the ability to test the filter design before it is implemented in a custom application in LabVIEW, LabWindows, Visual Basic, or Microsoft C. Noise Cancellation System for Android Mobile Phones is emphasizes in this research.

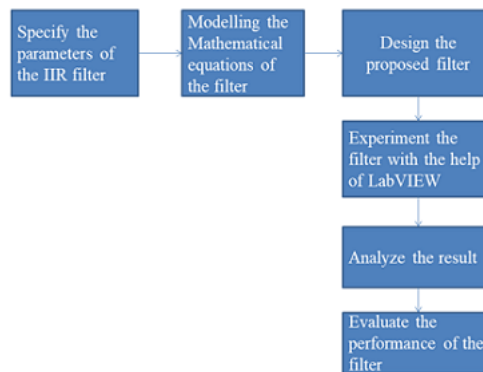


Figure 1. System Block Diagram.

2.1. Classical IIR Filter Design

The Classical IIR Filter Design panel is used to design classical IIR digital filters. These filters include the classic types such as Low Pass, highpass, bandpass, and the classic designs such as Butterworth, Chebyshev, Inverse Chebyshev, and Elliptic. The IIR Design panel consists of a graphical interface with the Magnitude vs. Frequency cursors and plot on the left side and a text-based interface with digital controls on the right side. The classical IIR filters are designed by adjusting the filter specifications on the panel. The passband and stopband requirements either are designed by using the text entry or the cursors in the Magnitude vs. Frequency graph. As the cursors are moved, the text entries are updated accordingly.

Digital filter design and implementation consist of several interacting steps and call for efficient design and simulation tools. To facilitate this, National Instruments has developed graphical digital filter design and analysis software for LabVIEW in the Signal Processing Toolset. The graphical user interface greatly eases the burden associated with the specification-design-test cycle at the heart of digital filter design. The result of repeated interactive graphical design sessions is that the designer can acquire a feel for how design parameters affect filter performance.

2.2. Implementation

The Low Pass IIR digital filters were designed with the help of LabVIEW environments. Figure 2 shows the Low Pass Butterworth IIR Filter Design with 1kHz sampling frequency. Figure 3 illustrates the Low Pass Chebyshev IIR Filter Design with the same sampling frequency. Figure 4 describes the Low Pass Inverse Chebyshev IIR Filter Design with 1kHz sampling frequency. Figure 5 mentions the Low Pass Elliptic IIR Filter Design with the same sampling frequency. There are 132 filter orders for performance analysis.

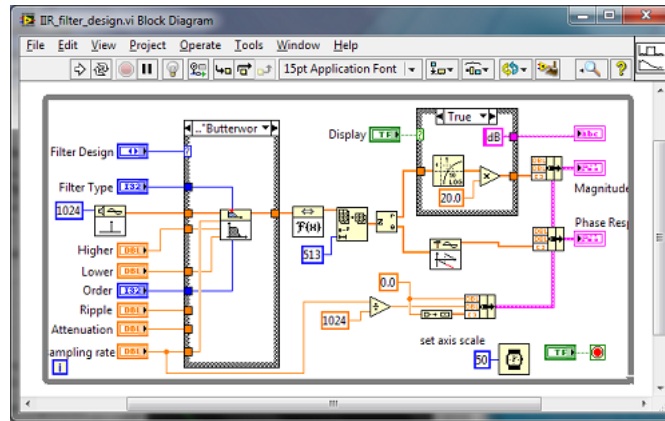


Figure 2. Low Pass Butterworth IIR Filter Design.

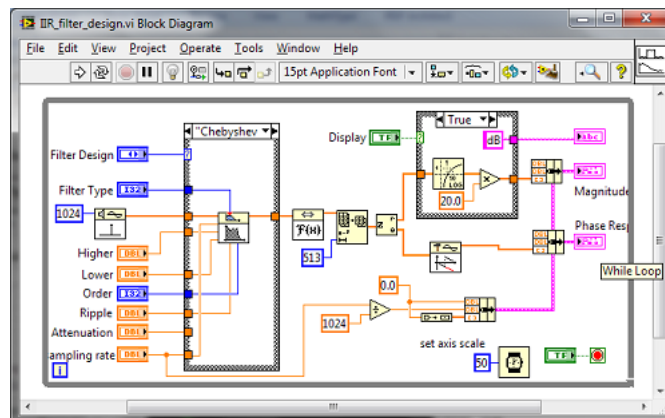


Figure 3. Low Pass Chebyshev IIR Filter Design.

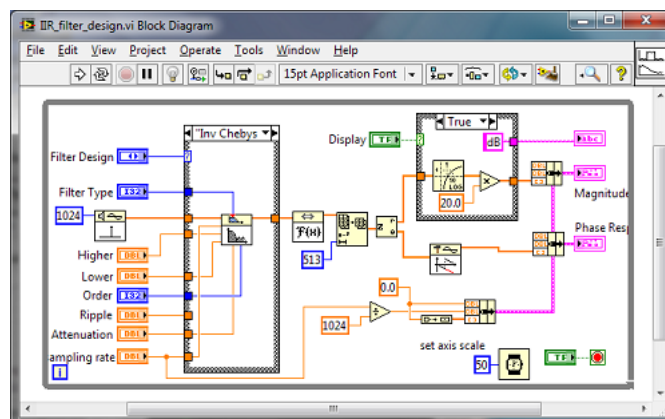


Figure 4. Low Pass Inverse Chebyshev IIR Filter Design.

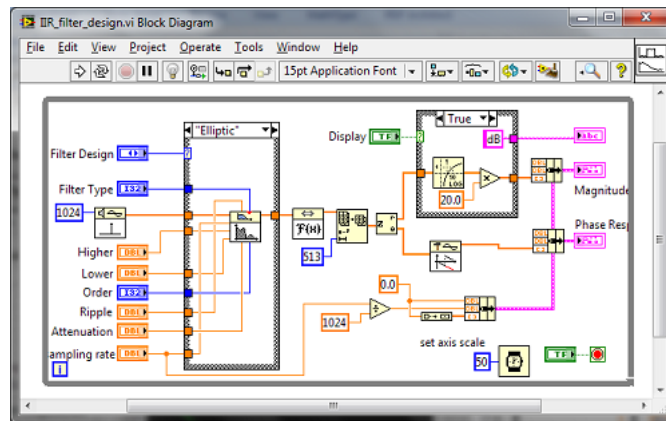


Figure 5. Low Pass Elliptic IIR Filter Design.

2.3. System Flowchart

The system flowchart for proposed filter design analysis is illustrated in Figure 6. We have to specify the pass band and stop band for proposed filter design. The filter types have to be selected for the specified purposes. The LabVIEW based proposed filter design will be analysed.

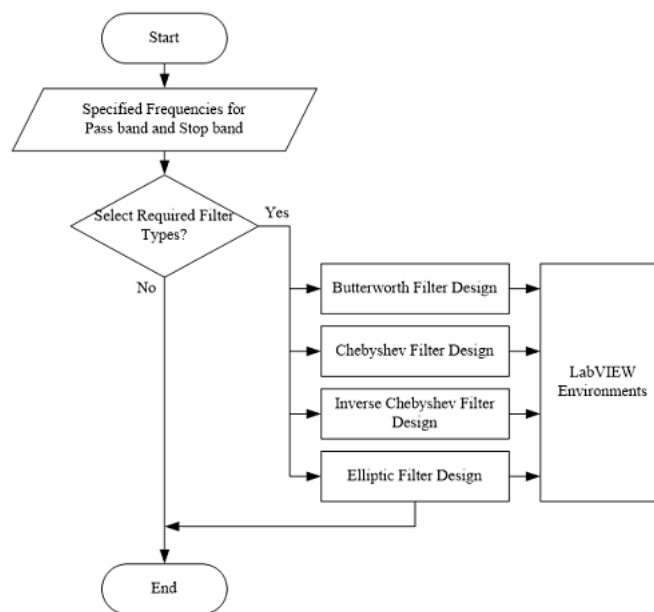


Figure 6. System Flowchart.

2.4. Simulation Results

The simulation results of Magnitude and Phase Response for Low Pass Butterworth IIR Filter Design is shown in Figure 7.

The screenshot results of Magnitude and Phase Response for Low Pass Chebyshev IIR Filter Design is shown in Figure 8. The replication results of Magnitude and Phase Response for Low Pass Inverse Chebyshev IIR Filter Design is shown in Figure 9. The reproduction results of Magnitude and Phase Response for Low Pass Elliptic IIR Filter Design is shown in Figure 10. The magnitude and phase responses show the useful frequency range of the noise cancellation for specific purposes. The better results are based on the application for technical point of view on the analysis.

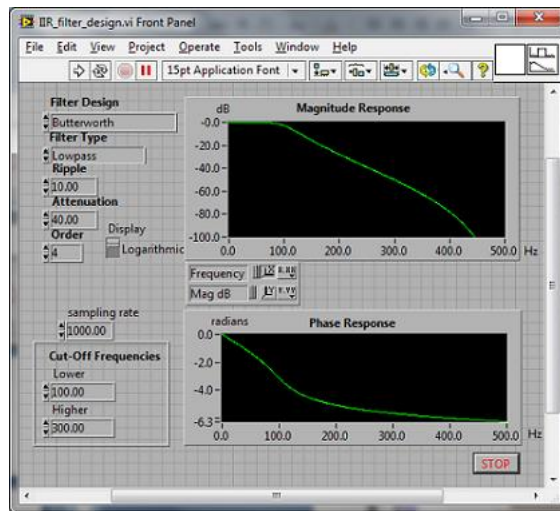


Figure 7. Magnitude and Phase Response for Low Pass Butterworth IIR Filter Design.

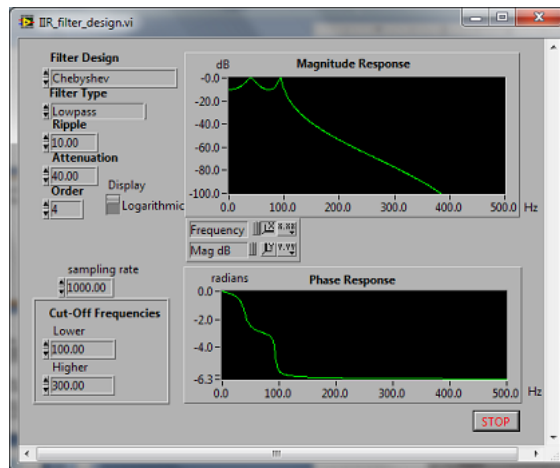


Figure 8. Magnitude and Phase Response for Low Pass Chebyshev IIR Filter Design.

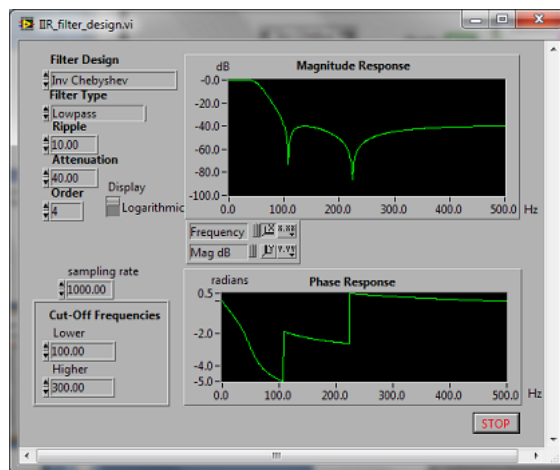


Figure 9. Magnitude and Phase Response for Low Pass Inverse Chebyshev IIR Filter Design.

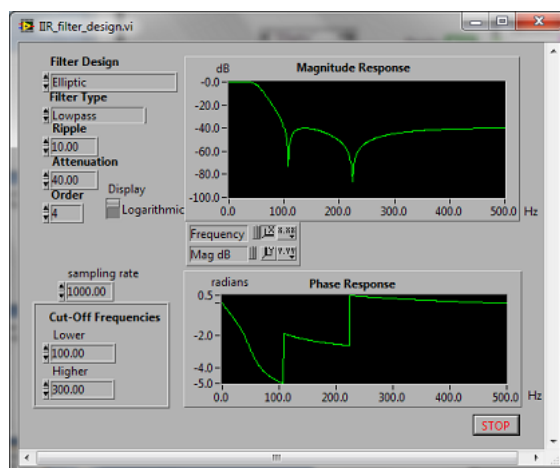


Figure 10. Magnitude and Phase Response for Low Pass Elliptic IIR Filter Design.

3. Conclusion

In this work, the design of IIR filters was considered with the help of LabVIEW. Several results of magnitude and phase responses were verified in the design. The characteristics of a number of important approximations Butterworth, Chebyshev, and Elliptic were affirmed from the results obtained. Experimental results are very enthusiastic. In LabVIEW the parameters can be changed at the time of execution of the program but in case of MATLAB it is not possible. LabVIEW Design is based on G-Programming so that the analysis of the performance can be done very easily.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

Author Contributions

This study is mainly focused on the noise cancellation system based on IIR low pass digital filter design by Using LabVIEW. There have been several literature background ideas for implementing the mathematical modeling of the filtering techniques in LabVIEW environments for experimental studies. This work emphasizes on the numerical analysis to develop the applied filtering techniques for noise cancellation system for various applications such as communication design or biomedical applications. This work could be provided the fundamental concepts with the help of numerical analysis especially computer supported applied design for implementation of mathematical expressions for undergraduate students.

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References

- [1] Mitra, S.K.; Kaiser, J. Handbook for Digital Signal Processing, 1993 John Wiley and Sons, Inc.
- [2] Kodosky, J.; McCrisken, J.; Rymar, G. Visual Programming Using Structured Dataflow, Proceedings of 1991 IEEE Workshop on Visual Languages, October 8-11, 1991/Kobe, Japan.
- [3] Jamal, R.; Wenzel, L. The Applicability of the Visual Programming Language LabVIEW to Large Real-World Applications, Proceedings of 1995 IEEE Symposium on Visual Languages, September 4-8, 1995/Darmstadt, Germany.
- [4] Kodosky, J.; Perez, E. Linear Systems in LabVIEW, National Instruments Application Note 08, January 1991.
- [5] Licata, W.H.; Principal, S.; Engineer, S. Automatic Target Recognition (ATR). Beyond the Year 2000, 2001.
- [6] Bhanu, B.; Lin, Y. Genetic algorithm based feature selection for target detection in SAR images. *Image and Vision Computing*, 2003, 21, 591-608.
- [7] Li, B.; Chellappa, R.; Zheng, Q. Experimental Evaluation of FLIR ATR Approaches—A Comparative Study. *Computer Vision and Image Understanding*, 2001, 24, 5-24.
- [8] Pasquariello, G.; Satalino, G.; Spilotros, F. Automatic target recognition for naval traffic control using neural networks. *Image and Vision Computing*, 1998, 16(2), 67-73.
- [9] Choras, R.S. Image Feature Extraction Techniques and Their Applications for CBIR and Biometrics Systems. *International Journal of Biology and Biomedical Engineering*, 2007, 1, 6-16.
- [10] Howe, N.R.; Science, C. Silhouette Lookup for Automatic Pose Tracking. *Pattern Recognition*, 2004.
- [11] Mangasarian, O.L. A Feature Selection Newton Method for Support Vector Machine Classification. *Sciences-New York*, 2004, pp. 185-202.
- [12] Mundy J.L.; Zisserman, A. Geometric Invariance in Computer Vision, The MIT press, Cambridge, Massachusetts, 1992.



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