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An Improved Digital Filtering Method Based on First Order Inertia Link

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Abstract. Digitalization of low-pass filter produced from first-order inertia link is carried out firstly in this paper. Then an improved algorithm is proposed to achieve better low-pass characteristics by smoothing the first n-part data and using the smoothed data instead of n-1 based on the first step. At last, through the detailed numerical simulation analysis, the correctness and validity of the proposed improved filter design method are verified.

Introduction

Filter is an electronic devices that passes useful frequency signal and inhibits the unwanted frequency signal, which is often used for signal processing, data transmission and interference suppression [1-3]. In the filter design, we need to first change the technical requirements of filter to that of the corresponding low-pass filter, and then design a low-pass filter to get the transfer function, and finally obtain the transfer function of the desired filter from that of the low-pass filter through the frequency transform [2-4]. This paper focuses on the low-pass filter with first-order model, the simulation of the traditional low-pass filter is carried out firstly, and weighted smoothing is used to improve the low-pass performance.

Model Description of Traditional Low-pass Filter

The traditional low-pass filter is generally designed as the following first-order system, which can be described by differential equation 1as follows [5-6].

$$\dot{y} = -\frac{1}{T}y + \frac{1}{T}u \tag{1}$$

The transfer function can also be described as following formula 2 [7].

$$\frac{y}{u} = \frac{1}{Ts+1} \tag{2}$$

The following numerical equation 3 is discretized using computer programming.

$$[y(n) - y(n-1)]/\Delta T = [-y(n-1) + u(n-1)]/T \tag{3}$$

Where ΔT is the sampling interval. The formula 3 can be organized as formula 4.

$$y(n) = y(n-1) - \frac{\Delta T}{T}y(n-1) + \frac{\Delta T}{T}u(n-1) \tag{4}$$

Simulation Analysis of Traditional Low-pass Filter

Set $T = 0.1s$, assuming that the input signal is $u = u_a + u_b, u_a = \sin(5t), u_b = 2\sin(10^5 t)$, and $0.2\sin(10^5 t)$ is the noise signal. The performance of the designed filter is verified by comparing the signal before the filter with that after the filter [8]. The simulation results are shown from figure1 to figure 3.

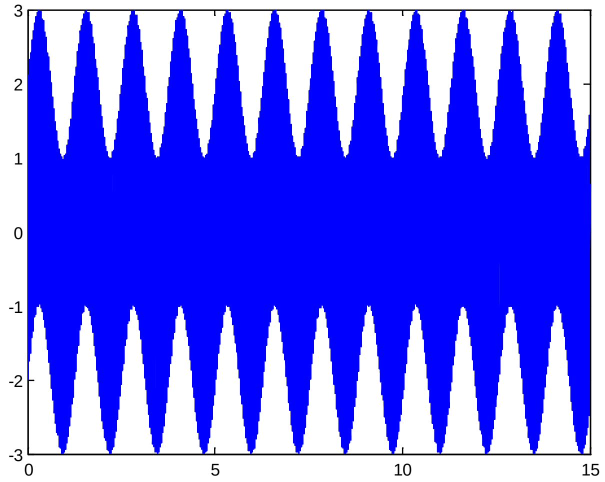

Figure 1 Source signal mixed with noise signal

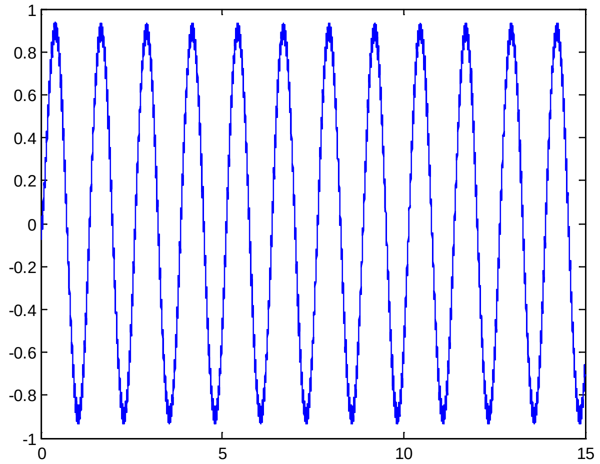

Figure 2 Filtered signal

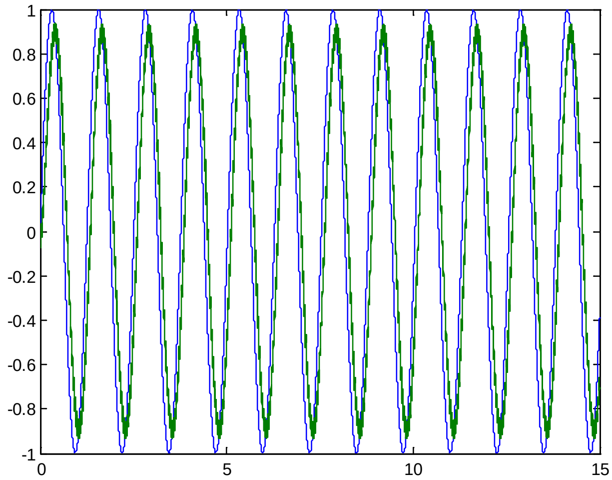

Figure 3 Comparison of filtered signal with useful signal

Improvement Design by Weighted Smoothing

The following improvement design is proposed as formula 5.

$$y(n)=\sum_{i=0}^{j}a_i y(n-1-i)+\frac{\Delta T}{T}y(n-1)-\frac{\Delta T}{T}u(n-1) \quad (5)$$

And it satisfies the formula 6.

$$\sum_{i=0}^{j}a_i=1 \quad (6)$$

Simulation results are shown from figure 4 to figure 6.

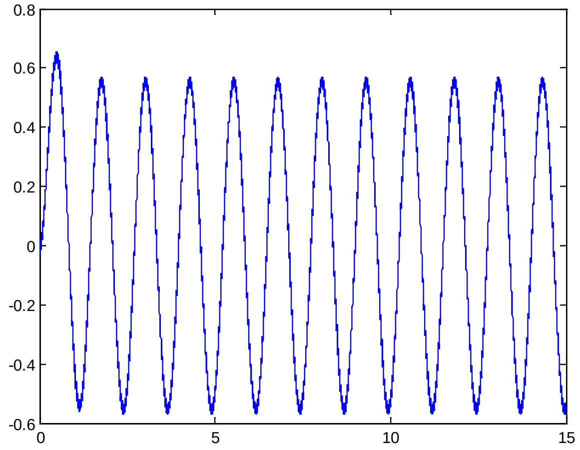

Figure 4 The signal of the improved digital filtering

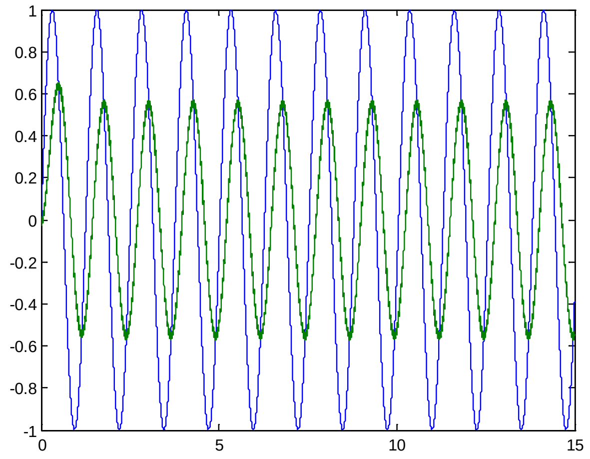

Figure 5 Comparison of the filter signal with the original signal

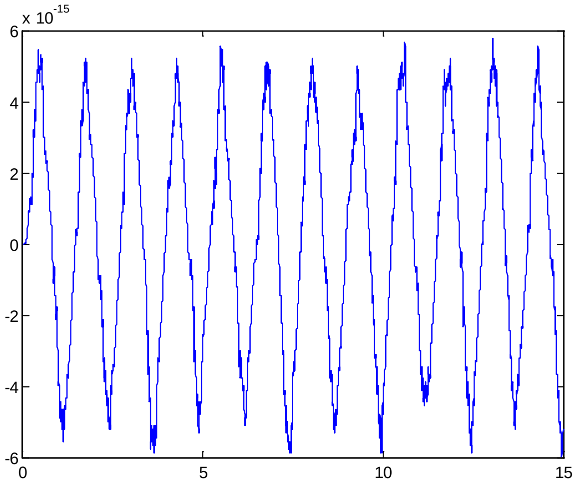

Figure 6 Error curves of two Methods

Figure 1 to Figure 3 shows the traditional filter effect and figure 4 to 6 shows the improved filter effect. It is obvious that figure 6 shows the difference of the two methods and the error is very small, so the method proposed in this paper can take place of the traditional method.

Conclusions

Traditional low-pass filter is designed based on first-order model in this paper. Then an improved algorithm is proposed by weighed smoothing. Simulation results show that the improve algorithm has better low-pass performance by smoothing the first n-part data and using the smoothed data instead of n-1.

Reference

[1] Wang Ling, Filter Research and Simulation [J], Industrial Control Computer, 2008 (7): 90-92(in Chinese).

[2] Xu Jingbo, Yuan Yibao, Liu Bo, Method of rational approximation for Gaussian low-pass filter in time domain measurement [J], Solid State Electronics Research and Development, 2011, 31 (6): 553-558(in Chinese).

[3] Zhao Yi, Digital filtering of the moving average and low-pass filter method [J]. Instrument Technology, 2001 (5): 40-40(in Chinese).

[4] Peng Yongsheng, Wang Taiyong, Low-pass filtering technology in measurement and control system [J], Precision Manufacturing and Automation, 2003 (S1): 108-110(in Chinese).

[5] Li Shengqing, Zhou Youqing, Zhu Yinghao, Harmonic current prediction method of integrated power filter based on weighted first-order local theory [J], Proceeding of the CSEE, 2004, 24 (6): 19-23(in Chinese).

[6] Lu Zhenxing, Gao Jing, Zhang Yifei, High frequency ground wave radar to eliminate the impact of first-order sea clutter on the target ranging method [J]. Telecommunications Technology, 2008, 48 (8): 43-46(in Chinese).

[7] Xia Kewen, Zhu Jun, Optimal Design of First Order Recursive Digital Filter [J]. Petroleum Equipment, 1995 (3): 164-166(in Chinese).

[8] Han Lichu et al. MATLAB Electronic Simulation and Application [M]. Beijing: National Defense Industry Press, 2003(in Chinese).