

# Digital Filtering Technology in Industrial Measuring and Control System

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**ABSTRACT** This article aims at the technical problems in modernized industrial measuring and control system such as interruption signal, noise signal and other useless signal. First introduces the features and importance of digital filtering technology and then elaborates on the realization methods of digital filtering and frequently used digital filtering calculation methods in the industrial measuring system. The research reveals that integrated usage of numerous methods or even complex digital filtering technology is adopted to calculate and treat such digital signals like random interruption, heat noise, system noise, measuring error and zero-point offset and thus meet the system requirements. The digital filtering technology is widely applied in the processing of HD signal, such as digital audio, radar, image processing, data transmission and biological and medical fields and pledges to provide strong assurance for the real-time, stable and reliable properties of modernized industrial measuring and control system.

## KEYWORDS

Measuring system  
Digital filtering  
Signal processing

## 1. Introduction

With the complexity of modernized industrial measuring and control system, any electronic system has its own frequency band width (limitation of maximum signal frequency); the frequency features reflect the basic features of electronic system. The filter refers to a project application circuit designed according to the circuit parameter impact on frequency band width. The modernized electronic circuits have even greater interruption to each other; as for the collection of system data, especially processing of weak signals of measuring and control instrument, the analog filtering circuit can no longer meet the requirements of measuring and control system; however, digital filtering technology makes use of complex processing process to block the noise, remove interruption and upgrade the measuring precision and reliability of measuring and control instrument. It does not need hardware cost or suffer from impedance matching problem and enjoys a high degree of

reliability; it is mainly realized by software calculation method; multi-input channels can share one filtering procedure to reduce the system expenditure; the calculation methods or parameters of digital filtering procedure are changed to change the filtering features. The digital filtering technology is featured as high degree of reliability, high precision, remote control and change of features, strong real-time property, convenient integration and stable operation.

## 2. Digital filter and realization methods of digital filtering

The digital filtering adopts the digital equipment; it makes use of certain calculation methods and filters the signals and obtains new signals. In essence, the digital filtering is a calculation method which is easily realized in the digital equipment.

The digital filter refers to a discrete time system which filters digital signals and obtains the expected response features. The digital filter operates in the digital signal domain; the processing object is digital digit signal converted from analog signal by the sampling components. In the digital circuit, the digital filter makes use of the register, delayer, adder and multiplying unit and calculates and treats input digital signals and thus realizes the features required by the design. It can be changeable or unchangeable, causal or non-causal, linear or non-linear. The most frequently applied is linear and unchangeable digital filter.

The microcontroller is easy to realize the human-ma-

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doi: 10.18686/esta.v2i1.8

Received: October 7, 2015; Accepted: October 26, 2015; Published online: December 3

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chine interface with limited speed and resources; it is not good at realizing calculation methods or making complex calculation. It is capable for realizing digital filtering of some simple calculation methods.

The general programmable DSP chip is in the improved Harvard general line structure; it is collocated with hardware accumulator and multiplying unit; besides, the common digital system is collocated to adapt to the digital signal processing and realize digital filtering. It is also feasible to adopt programmable gate array components to develop the digital filter [1].

### 3. Frequently used digital filtering calculation methods in the industrial measuring and control system

In the industrial measuring and controlling system, overcoming outbreak interruption caused by occasional factors of external instrument environment or sharp pulse interruption caused by error code in the unstable operation of instrument is the first processing step of instrument data; generally, simple non-linear filtering methods are adopted such as limited amplitude filtering method (also called procedure judgment filtering method) and median filtering method.

#### 3.1. Limited amplitude filtering method

The limited amplitude filtering aims to take advantage of the procedure and judge the change amplitude of measured signal and thus remove the sharp pulse interruption of slow-changing signal. It is able to effectively overcome pulse interruption caused by occasional factors; but it cannot block the periodic interruption and suffers from a poor smoothness.

#### 3.2. Median filtering method

The median filtering is a typical non-linear filtering featuring simple calculation; it can not only filtrate pulse noise, but also protect detailed signal information. It is able to effectively overcome fluctuation interruption caused by occasional factors and plays a favorable filtering effect to the measuring instrument with slow-changing fluid level; on the contrary, it is not suitable to the swift-changing parameters such as flow and speed.

Generally, the linear filter with low-pass property is collocated to block small amplitude high frequency electronic noise, electronic component's heat noise and A/D quantitative noise, such as arithmetic mean filtering method, recursion average filtering method, weighted recursion average filtering method and first-order lag digital filtering method [2].

#### 3.3. Arithmetic mean filtering method

The arithmetic mean filtering method aims to add "N" continuous sampling values and adopt the arithmetic mean value as the measured filtering value. If N is rather large, the signal smoothness is rather high but flexibility is rather low; if N is rather small, signal smoothness is rather low

but flexibility is rather high. N is selected as follows: flow, N = 12; pressure, N = 4. It is not applicable to the real-time control with slow measuring speed or swift data calculation; besides, it wastes RAM.

#### 3.4. Recursion average filtering method

Various average filtering calculation methods have one point in common: Several samples are taken to obtain an effective sampling value; if the sampling is slow, the real-time property of system cannot be assured. The recursion average filtering method (also called sliding average filtering method) only takes sample for one time, integrates the sampling value and previous sampling values to calculate the average mean value and obtains the effective sampling value for normal operation.

If "N" sampling values are obtained to calculate the average mean, "N" data buffer areas must be enabled in the storage area. The newly collected data is stored into the buffer area and the oldest data is removed; "N" data are maintained the latest. This is the "first inlet, first outlet" principle. "N" data in the line are calculated to obtain the arithmetic mean value and thus new filtering result. Value N is selected as follows: flow: N = 12; pressure: N = 4; fluid level: N = 4~12; temperature: N = 1~4. The digital filtering method plays a favorable block role to the periodic interruption and enjoys a better smoothness; it is suitable to the high frequency oscillation system with low flexibility; it has a poor block role to the occasional pulse interruption. It is not suitable to the conditions with serious pulse interruption; it wastes RAM [3].

#### 3.5. Weighted recursion average filtering method

The weighted recursion average filtering method makes an improvement in the recursion average filtering method. The working theory of it is as follows: multiply continuous "N" sampling values by different weighted factor and accumulate. Generally, the weighted factor is small at first and large later to extrude the subsequent sampling effect; the system consciousness of parameter change trend is enhanced. Various weighted factors are less than 1 and meet the termination condition of sum total = 1. Therefore, the accumulative sum upon weighted calculation is an effective sampling value. The arithmetic model of weighted recursion average filtering method is as follows:

$$\bar{X}_n = \frac{1}{n} \sum_{i=0}^{n-1} C_i X_{n-i}, C_0 + C_1 + \dots + C_{n-1} = 1,$$

$$C_0 < C_1 < \dots < C_{n-1} = 0 \quad (1)$$

Where,  $\bar{X}_n$  = Weighted average mean of "n" sampling values;  $X_{n-i}$  = Sampling value of "n - I" time; n = Sampling frequency;  $C_i$  = Weighted factor. The weighted factor  $C_i$  demonstrates the ratio of various sampling values in the average mean. The weighted recursion average filtering method is able to extrude a part of signals and block the other part of signals in order to upgrade the change

flexibility of sampling value. Larger weighted factor of new sampling value leads to higher flexibility and lower signal smoothness. It is suitable to the object with rather large pure lag time constant and system with rather short sampling cycle. The slow-changing signal cannot swiftly respond to the system interruption severity and suffers from poor filtering effect [5].

### 3.6. First-order lag digital filtering method

The filtering result is  $(1-a) * \text{sampling value} + a * \text{previous filtering result}$ ;  $a = 0 \sim 1$ ;  $a = \text{filtering factor}$ ; generally,  $a$  is much smaller than 1. The first-order lag digital filtering method very well blocks the periodic interruption and is suitable to areas with rather high fluctuation frequency; however, it suffers from lagged phase position and low flexibility; the lag degree depends on value “ $a$ ”; it cannot remove the interruption signal whose filtering frequency is higher than the sampling frequency by 1/2. This filtering method is able to overcome the defect of traditional analog volume filter in reduced RC network precision; it is even suitable to the areas with rather large filtering constant requirements.

### 3.7. Median average filtering method

The median average filtering method (also called anti-pulse interruption average filtering method) is equivalent to the “median filtering method” + “arithmetic average filtering method”; it belongs to a composite filtering method. “ $N$ ” continuous samples are taken and the maximum value and minimum value are removed; then arithmetic average mean of “ $N-2$ ” data is calculated. Value  $N$  is selected as follows: 3–14. This filtering method can not only block random interruption, but also filtrate obvious pulse interruption; however, it suffers from slow measuring speed and wastes RAM.

### 3.8. Amplitude average filtering method

The amplitude average filtering method is equivalent to “amplitude filtering method” + “recursion average filtering method”; it belongs to a composite filtering method. In the area with serious pulse interruption, it can not only block occasional pulse interruption, but also remove sampling value deviation caused by pulse interruption. However, it wastes RAM; it is suitable to the filtering of slow-changing signal [4,6].

### 3.9. Wobble elimination filtering method and amplitude wobble elimination filtering method

As for the slow-changing measured parameters, the “wob-

ble elimination filtering method” is able to avoid repeated switch-on/off in the controller near critical value or tilting of value in the display. The “amplitude wobble elimination filtering method” inherits the strengths of “amplitude” and “wobble elimination” and prevents interruption value from leading into the system.

Upon confirmation of signal band width, it is designed into the digital filter with numerous and complex calculation methods such as high pass, low pass, band pass and band resistance. The typical digital filters include IIR filtering, FIR filtering, Kalman filtering, Wenner filtering, self-adaptive filtering and wavelet transform etc.

## 4. Conclusion

The software calculation methods realized the digital filtering technology which constitutes an important part of the industrial measuring and control system. In the application of industrial measuring and control system, more than one filtering methods may be adopted. The said methods or even complex digital filtering method is adopted to calculate and treat digital signals like random interruption, heat noise, system noise, measuring error and zero-point offset and thus meet the system requirements. The digital filtering technology is widely applied in the processing of HD signal, such as digital audio, radar, image processing, data transmission and biological and medical fields.

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