Automobile electronic leakage signal detection system based on wavelet transform

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Abstract

Automobile electronic leakage signal has the character of weakness and instantaneity. Current leakage signal detection methods can't avoid this kind of weakness and instantaneity, which results in the low accuracy in leakage signal detection. A new kind of automobile electronic leakage signal detection system is designed. The system consists of hardware and software. Hardware design mainly introduces the leakage signal collecting module and a filter circuit based on PCI1712 data acquisition card; Software is completed by LADVIEM and MATLAB simulation software programming. The paper mainly expounds the design method of wavelet transform filter, and gives some leakage signal acquisition programs. The experimental results show that the system can effectively improve the accuracy of the automobile electronic leakage signal detection and detection efficiency.

Key words: WAVELET TRANSFORM, AUTOMOBILE ELECTRONICS, LEAKAGE SIGNAL, SIGNAL DETECTION

1. Introduction

With the rapid development of China's automobile industry, more and more Chinese families own their automobiles [1-5]. The automobile has been becoming the indispensable part of people's life [6]. The existing automobile electronic leakage can bring potential trouble to the driving safety. Sometimes it even can cause traffic accident [7]. In the last decade, a new mathematical microscope has allowed scientists and engineers to view the details of time varying and transient phenomena, in a manner hitherto not possible through conventionaltools. This invention, which goes by the name of wavelet transform, has created revolutionary changes in the areas of signal processing, image compression, not to speak about the basic sciences.

The effect of traditional detection methods in detecting the electronic leakage signal is not ideal [8-10]. Because the leakage signal has the character of weakness and instantaneity, in the detecting process, a lot of electromagnetic interference signal may easily interfere the process, which may result in the low detecting accuracy. Wavelet theory is often seen as an alternative to time-frequency analysis. Like time-frequency analysis, wavelet theory has many roots and has become an interdisciplinary field combining harmonic analysis, applied mathematics, and signal and data processing. Wavelet transform divides a given data into different frequency components at different scales. In biometrics, operating in wavelet domain provides additional edge and frequency information useful for fusion and recognition.

In order to avoid the above traditional detecting deficiency, this paper puts forward a kind of automobile electronic leakage signal detection

system based on wavelet transform. And the effectiveness of this system is verified through experiments in this paper.

2. The overall design of the automobile electronic leakage signal detection system

The automobile electronic leakage signal detection system based on wavelet transform algorithm mainly consists of electrical system, filter system, signal acquisition system, diagnostic system and human-computer interface. The design framework of the system can be described by Figure 1:

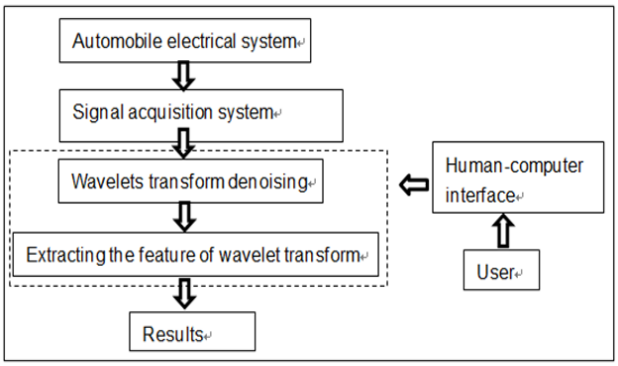

Figure 1. The framework of the automobile electronic leakage detection system

The picture 1 shows that the electrical signal in the electrical system of the automobile which is used as the diagnostic signal is put into the detection system. First, signal measurer is used to collect the electrical signal of the automobile electrical system. There are mainly wavelet transform denoising processing module and wavelet property processing module in wavelet transform processing unit. The major function of the wavelet transform denoising processing module is to get rid of the interference signal in the process of electrical signal detection and lay the accurate data foundation for extracting the electrical signal feature. The major function of the wavelet property processing module is to accurately extract the property of electrical leakage signal and fulfill the detection of the automobile electrical leakage signal. Then the diagnostic results will be displayed on the human-machine interface to offer the accurate information for testers.

2.1. The design method of the leakage signal acquisition hardware

The major parts of the automobile electrical leakage signal acquisition consist of leakage signal acquisition card, PCI1712 data acquisition card, filter circuit and IPC, which is illustrated in Figure 2:

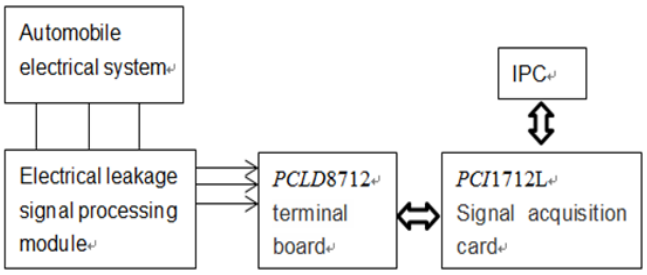

Figure 2. The framework of the hardware of leakage monitoring system

The function of the terminal block of the signal acquisition card is to connect the automobile electrical system with the signal acquisition card. This paper uses PCLD-8712 terminal block. This kind of acquisition card has 16-single-block input and 8 differential analog input.

The main function of the automobile electrical leakage signal processing module is to magnify the electrical signal, eliminate interference and transform A/. In automobile electrical system, the leakage signal usually is weak. Then a preamplifier which makes use of the impedance transformation to output comparatively strong signal electricity is necessary to be put into the detecting circuit. The leakage signal processing module is illustrated in Figure 3:

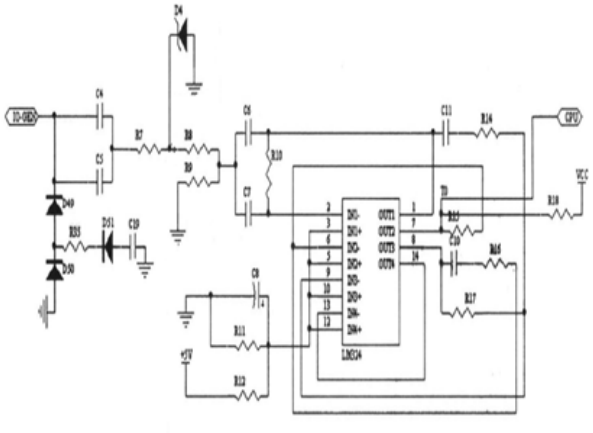

Figure 3. Electrical leakage signal processing module

The interference signal would also be magnified while the leakage signal is magnified, which would influence the noise-signal ratio of the leakage signal. Therefore, a filter circuit is required to enhance the noise-signal ratio. The filter circuit is illustrated in Figure 4:

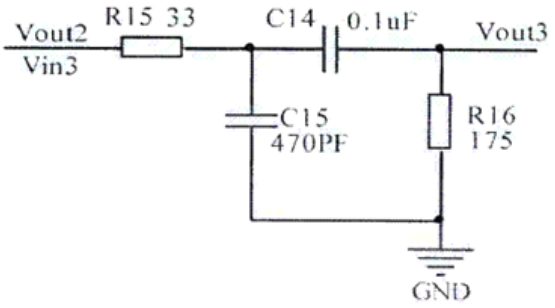

Figure 4. The filter circuit of the leakage signal monitoring system

2.2. The design method of wavelet transform filter

The wavelet transform filter can extract the key points of the leakage signal feature, which is unnecessary to restore the full waveform of the leakage signal. The design procedure of the wavelet transform filter is illustrated as follows:

First, the known waveform's current signal is set. Suppose $\overline{S_0} = [S_0(0), S_1(1), S_0(M-1)^T]$ is M dimensional current signal vector whose amplitude value is 1, then the following function can be obtained:

$$Max\left[s_0(0), s_0(1), ..., s_0(M-1)^T \right] = 1 \quad (1)$$

Signal vector whose amplitude value is a with the same current waveform can be calculated by the following function:

$$\overline{S_0} = a\left[s_0(0), s_0(1), ..., s_0(M-1) \right]^T \quad (2)$$

Suppose $\overline{S_0} = \overline{S_1}$ is the current signal template quantitive value, then the coefficient vector of the wavelet transform filter can be calculated by the following function:

$$\overline{b}_{opl} = k\overline{S}_c = k \times \left[s_0(M-1), s_0(M-2), ..., s_0(2) \right]^T \quad (3)$$

Suppose the amplitude value of the leakage current signal is a, then the output value which matches the wavelet filter is:

$$y_s(m) = ak \sum_{i=0}^{M-1} s_c(i) s_0(m-i) \quad (4)$$

Then after the wave filtering, that is $m = M-1$, the output of the wavelet transform filter reaches its maximum signal-noise ratio:

$$y_s(M-1) = ak \sum_{i=0}^{M-1} s_0^2(i) \quad (5)$$

Make $k = 1 / \sum_{i=0}^{M-1} S_0^2$, then substitute it to formula (5), formula (6) is obtained:

$$y(M-1) = a \quad (6)$$

The formula (6) shows that when the output current signal's signal-noise ratio reaches the maximum, the vector coefficient selected from the wavelet transform filter can make the waveform's amplitude value of the output leakage signal still have the same value of the original signal after the original current signal is filtered through the wavelet transform filter.

3. The software design of the automobile electrical leakage signal detection system

The software of the automobile electrical leakage signal detection system based on wavelet transform is programmed by LADVIEM and MATLAB simulation software. The software can acquire the leakage signal and store, analyze and display it. The core of it is the electrical leakage signal detection based on wavelet transform.

In the node program of the software system, the function wavedec can fulfill the multi-scale wavelet decomposition of the wavelet transform. The grammar [C, L]=wavedec(x,6,db20) can describe the wavelet transform and decompose the leakage signal into 6 layers. The function wrcodF can reconstruct one of the wavelet coefficients from the wavelet transform. The grammar X=wrecodf(type,c,l,db20,N) can describe the signal reconstruction of the different frequency signal waveform in layer N's one dimensional entropy processed by "db20" wavelet transform.

LABVIEW can make the hardware of the leakage signal acquisition and computer constitute a complete leakage signal acquisition and display system. The leakage signal detection platform can store the acquired leakage signal into the data base and then read the data from the data base to do the wavelet transform processing. The design process of the software system is illustrated in picture 5.

The output of the current signal acquisition process is taken as an example. The prototype program is: □15DO_WritePort(U16 CardNumber,U15 Port,U15 Vaiue). In order to make the programming concise, the function void CRealCompDlg::_DO(int PortlNo, BOOL on2off) is introduced to make it more concise. In this way, the acquired the results can be displayed in the display interface. The following program is part of the processing program of the automobile leakage current signal:

```
UINT ProcessThread(LPVOID PParam)
{
BOOLEAN HalfReady,fstop;
BOOLEAN bFlag=FALSE;
U32 COUNT;
cRealCompApp
pRca=(CRealCompApp)AfxGetApp();
do{
do{
AL_AsyncDblBufferHalfReady(pRca_card.&Half
Ready.&fstop);
}while(!HalfReady);
AL_AsyncDblBufferTransfer(pRca_card,pRca_p
_ai_bul2);
if(bFlag)
{
//current signal，  output control}
Else pRca_p_ai_buf2+=256;
bFlag=!bFlag;
}while(!pRca_clear_op);
AL_AsyncClear(pRca_card,&count);
return 0;       //stop thread
}
```

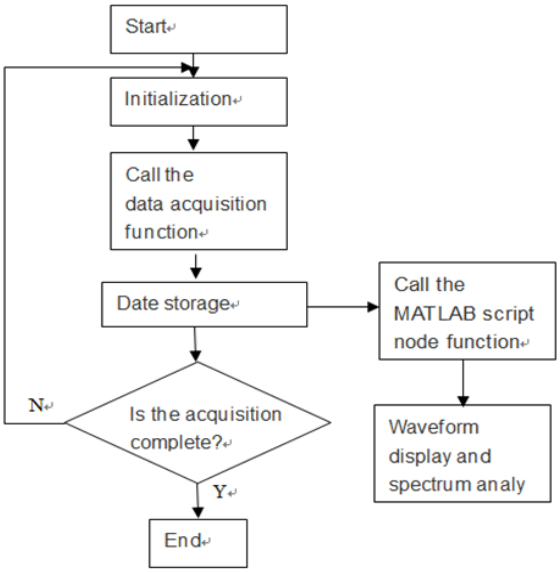

Figure 5. The design process of software system

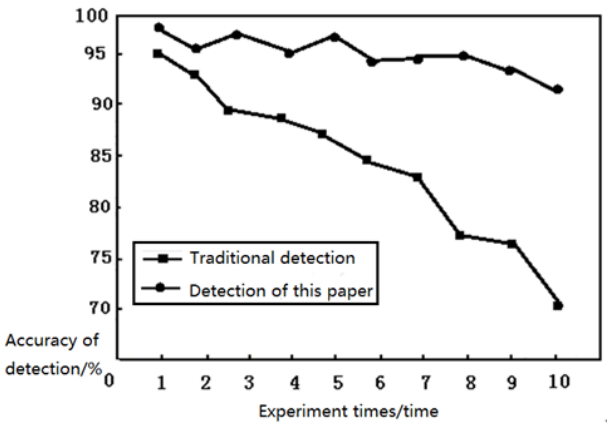

Figure 6. The contrast of accuracy rate of different systems

4. Results and analysis

In order to test and verify the effectiveness and superiority of the electrical leakage signal detection system based on wavelet transform put forward in this paper, simulation experiment is carried out by using simulation software Matlab 7.0 with computer basic requirement of Intel Pentium dual-core, 2.7 GHZ CPU, 2 gb memory. The traditional system and the system put forward by this paper are tested respectively.

In the experiment, the number of automobile leakage is set as 100. The results from different system accompanying the increasing interference signal can be described by Figure 6 and Figure 7.

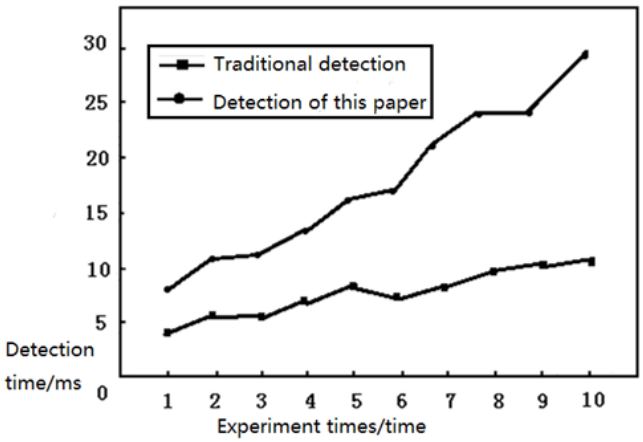

Figure 7. The contrast of time-consuming of different systems

The above figures show that with the increasing interference signal, the detection accuracy of traditional detection system decreases and time-consuming increases gradually, which are due to the neglect of the influence of the leakage signal's weakness and instantaneity. The system put forward in this paper can avoid the disadvantages of the traditional system and finally the results are obviously superior to the traditional detection system.

The data in the above experiments are analyzed and then the data in table 1 and table 2 are obtained:

Table 1. the accuracy rate of different system

NO.	the coefficient of the interference signal intensity	accuracy rate(%)	
		traditional system	system of this paper
1	0.02	95	99

2	0.11	93	96
3	0.23	89	97
4	0.35	88	96
5	0.44	87	97
6	0.57	85	95
7	0.62	84	95
8	0.76	78	95
9	0.84	77	94
10	0.93	70	93

Table 2. Time-consuming of different system

NO.	the coefficient of the interference signal intensity	time-consuming(ms)	
		traditional system	system of this paper
1	0.02	8	4
2	0.11	12	6
3	0.23	12	5
4	0.35	14	7
5	0.44	16	8
6	0.57	17	7
7	0.62	22	7
8	0.76	24	9
9	0.84	24	9
10	0.93	29	10

The above data show that the results from the experiment carried out under the system put forward by this paper is superior to the traditional system, which fully shows the advantages of this system.

5. Conclusion

The traditional automobile electrical leakage detection system cannot avoid the leakage signal's weakness and instantaneity, which results in the low accuracy rate of detection. Therefore, a kind of automobile electronic leakage signal detection system based on wavelet transform is designed. In hardware design, this paper mainly introduces leakage signal acquisition module based on PCI1712 data acquisition card and filter circuit. The software is programmed by LADVIEM and MATLAB simulation software. This part mainly illustrates the design method of the wavelet transform filter and offers some leakage signal acquisition programs. The experiments results show that the system of this paper can effectively increase the detection accuracy and efficiency.

Acknowledgements

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