Research on Dynamic Monitoring Method of Electromagnetic Interference Spectrum Based on Fuzzy Theory

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Abstract: In order to better detect and investigate electromagnetic interference, a dynamic monitoring method of electromagnetic interference spectrum based on fuzzy theory is proposed. By combining the fuzzy theory with the electromagnetic interference spectrum fault tolerance algorithm at night, the electromagnetic interference spectrum influence degree value is calculated, and the debugging steps of the electromagnetic interference characteristic value are optimized according to the interference influence value, so that the effective monitoring of the electromagnetic interference spectrum dynamics is finally realized. Finally, the experiment proves that the electromagnetic interference spectrum dynamic monitoring method based on fuzzy theory has higher accuracy and effectiveness than the traditional method, and fully meets the research requirements.

1. Introduction

The poor detection effect of electromagnetic interference frequency is the main problem affecting the application effect of current electrical products[1]. The investigation shows that there are many methods to detect the electronic interference spectrum of electronic equipment at present. However, due to the impact of the explosion of electronic business volume, the electromagnetic interference and radiation problems are becoming more and more serious[2]. In order to better promote the development of modern electronic information technology and ensure the safe and stable operation of equipment, a dynamic monitoring method of electromagnetic interference spectrum based on fuzzy theory is proposed. In order to further optimize the effectiveness of electromagnetic interference spectrum dynamic monitoring method based on fuzzy theory[3]. As the overall environment for monitoring the electromagnetic interference spectrum is relatively complex, and the monitoring results are changeable due to the influence of external factors, the best friend, dynamics and reliability of the detection content are optimized in combination with fuzzy theory, the conventional numerical value and spectrum characteristics of electromagnetic operation, real-time monitoring of spectrum analog signals, statistics of mosaic time domain, investigation of signal interference and other issues. So as to realize the target of dynamic quasi-monitoring of electromagnetic interference spectrum.

2. Electromagnetic Interference Spectrum Dynamic Monitoring

2.1. Spectrum Fault Tolerance Algorithm for Electromagnetic Interference Based on Fuzzy Theory

Electronic equipment is prone to fault tolerance after being subjected to electromagnetic interference, which reduces the safety and stability of equipment operation, and mistakenly detects electromagnetic interference spectrum[4]. In order to ensure the detection effect, firstly, the spectrum characteristics of electromagnetic interference are collected and analyzed, and fault-tolerant detection processing is carried out according to the collected results. In the process of collecting electromagnetic interference spectrum data characteristics, firstly, the equipment

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operation and related data need to be tracked and detected by sensor devices, and electromagnetic fault tolerance value, electromagnetic interference value and standard spectrum are divided into specifications according to the detected data information[5]. The operation rules of the three kinds of information are collected and standardized, and the electromagnetic spectrum information is output according to the standard results. In order to ensure the rationality of the collected data, the monitoring parameters of magnetic interference spectrum signals are standardized, as shown in the following table:

Table 1 Monitoring Parameters of Electromagnetic Interference Spectrum Signals

Name	Indicators	Standard numerical range
size	10mm×5mm×5mm	1.05
Input voltage	20V	100V-120V
Output voltage	15V	100V-120V
Working current	10mA	1500A-2000A
measuring range	30Hz~80Hz	30Hz~80Hz
Working temperature	-50~50℃	-50~50℃
Operating humidity	20~60%	20~60%
Operating humidity	100kbps	80-120kbps
transmission rate	100kbps	80-120kbps
Sensitivity	-100dBm	-100--80dBm
Anti - interference	CSMA/CA	CSMA/CA

Digital processing is carried out based on the information in the above table, and intermediate frequency signals generated in the electromagnetic interference process are collected, and digital frequency conversion and thinning processing are realized according to the collected results[6]. The electromagnetic spectrum is flexibly configured by the upper software of the electronic equipment so as to effectively collect spectrum interference signals, as shown in the following figure:

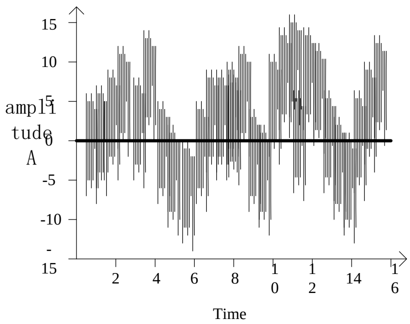


Fig. 1 electromagnetic interference signal

According to the above analysis, it is not difficult to find that although the electromagnetic interference spectrum is relatively complex, there is still a certain regularity in the whole, so compensation is carried out based on its overall regularity, so as to extract the interference value from the overall spectrum signal and realize fault-tolerant compensation processing on the collected characteristic value[7]. Assuming that the collected overall electromagnetic spectrum signal is s(n), where the interference signal is s1(n), the degree of electromagnetic spectrum interference is judged. The specific judgment criteria are as follows:

$$\begin{cases} S_1(n) \in S(n) \\ S_1(n) \in (ta_1, ta_2) \geq k \end{cases} \quad (1)$$

In the above algorithm, a1 and a2 are the positive and negative highest peaks respectively representing electromagnetic spectrum signals; T is a time gradient indicating detection; K is the highest threshold for frequency interference[8]. Based on the above algorithm, the highest fault tolerance value of the electromagnetic spectrum interference signal is identified and compensated, compensation parameters are calculated, and further information calculation is carried into the fuzzy set, so as to obtain the real signal of the electromagnetic interference spectrum. Based on formula (1), the characteristics of electromagnetic spectrum interference signals are extracted. Due to the complexity and diversity of interference influencing factors, unified quantitative detection of signals cannot be carried out during the acquisition process[9]. Therefore, the electromagnetic spectrum interference signals need to be preprocessed by combining fuzzy algorithm and Fourier transform principle. The specific algorithm is as follows:

$$F(x) = S_1(n) / Df^{kr\phi(a_1-a_2)} \quad (2)$$

In the above formula, d represents the transverse spectrum value of the electromagnetic disturbance brand signal, f represents the longitudinal spectrum value of the electromagnetic disturbance brand signal, $\phi(a_1 - a_2)$ represents the value of spatial radiation generated during electromagnetic interference spectrum detection[10]. R is the necessary transmission parameter of electromagnetic interference spectrum generated during equipment operation. If it represents the acquisition frequency of electromagnetic interference spectrum, V represents the time delay parameter in the monitoring process. The first derivative Rn(v) in the electromagnetic disturbance spectrum detection process is calculated, and the following results are obtained:

$$R_{\mathrm{n}}(v) = \int_{-\infty}^{+\infty} r(m) S_n(m,v)\, dx \quad (3)$$

Based on the above algorithm, the effective description of the interference signal transformation can be carried out in the instantaneous range in an effective time, thus judging the time domain and frequency domain spatial interference values of the interference signal according to the characteristic acquisition result, and realizing accurate acquisition of the interference spectrum.

2.2. Electromagnetic Interference Characteristic Numerical Debugging Steps

Based on the further optimization of electromagnetic interference spectrum information acquisition results, combined with fuzzy theory, the electromagnetic interference numerical debugging algorithm is improved. Combining the constraint principle and fuzzy clustering algorithm, the electromagnetic spectrum with different frequencies generated in the monitoring process is mixed, the interference spectrum is centrally clustered, and the characteristic transformation parameters sn(m,v) of the interference signal in the monitoring process are calculated according to the clustering result, so that:

$$S_{\mathrm{n}}(m,v) = 2p\pi \begin{cases} D_{\mathrm{n}} \exp\left(\pi\left(m^2 \cos d + v^2 \cos \mathrm{d} - 2vm \cos \mathrm{d}\right)\right) \mathrm{d} \neq p\pi \\ \lambda(m-v)\mathrm{d} = 2p\pi\mathrm{d} = 2p\pi \\ \lambda(m+v)\mathrm{d} = 2p\pi\mathrm{d} = 2p\pi \pm \pi \end{cases} \quad (4)$$

In the above algorithm, d is the farthest influence distance of interference signal; P is the spectrum conversion parameter; λ represents the radius of the transformation of the spectrum range. In order to ensure the effective operation of relevant equipment, Fourier transform is further carried out on the acquired interference spectrum signals, and the interference spectrum characteristic algorithm can be obtained as follows:

$$R_n(\mathrm{m},v) = \int_{-\infty}^{+\infty} r(v) h(m-v) S_n(m,v)\, dv \quad (5)$$

In the above formula, H is the variation difference coefficient of the interference spectrum. If the total data amount of the spectrum is I and the nonlinear wave frequency is J, the characteristics of the disturbance signal are identified. The identification algorithm is as follows:

$$\mathrm{h} = R_n(\mathrm{m},v) * \sum_{j=1}^{d} \sum_{i=1}^{m} \sum_{k=1}^{t} a_{ij}^{n} \left(1 - b_{jk}\right)^2 \quad (6)$$

In the above algorithm, if the electromagnetic spectrum information disturbance signal generated under the influence of external factors is in a minimized state, it is optimized by combining the fuzzy theory, and the spectrum weight and fuzzy index in different stages and different environments are calculated to obtain the electromagnetic interference characteristic numerical debugging value. The principle is as follows:

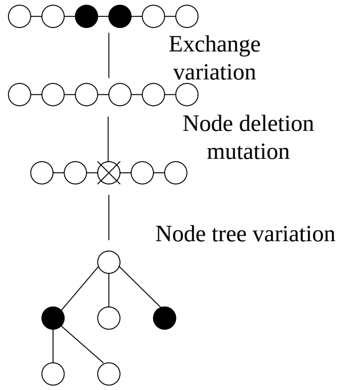


Fig. 2 Principle of Numerical Debugging of Electromagnetic Interference Characteristics

Based on the above principles, the numerical debugging steps of electromagnetic interference characteristics are optimized, specifically:

(1) electromagnetic interference signal acquisition: by analyzing and acquiring electromagnetic wave frequency signals, signal characteristic values are obtained, and interference extreme values and allowable interference value ranges are standardized

(2) interference spectrum clustering processing: performing iterative processing based on the collected signals, the calculated interference extremum and the tolerable interference value, and establishing an initial matrix through clustering processing;

(3) interference spectrum value: after completing the iteration number and clustering processing of the data, the fault tolerance in the electromagnetic spectrum monitoring process is standardized;

(4) fuzzy processing is carried out on the acquired interference frequency spectrum, and interference errors are compensated.

Based on the above steps, the collection and analysis of the dynamic characteristics of the pure interference spectrum combined with the constrained fuzzy clustering algorithm can be effectively realized, the disturbance signals can be effectively identified, and the effectiveness and accuracy of the dynamic monitoring of the electromagnetic interference spectrum can be better guaranteed.

2.3. Realization of Dynamic Monitoring of Electromagnetic Interference Spectrum

Based on the collected electromagnetic interference spectrum characteristic information, the dynamic real-time monitoring of the ignition interference spectrum is realized. In the monitoring process, it is necessary to observe the frequency oscillation ring and frequency changes in different periods of time, and collect and fuzzy cluster the relevant information such as tunable interference signals, fixed frequency signals, initial and termination frequencies, frequency intervals and the like in the spectrum of the Pu 'an section, so as to obtain weak spectrum signals capable of generating interference to electromagnetism in the region range, thereby judging the electromagnetic interference process and interference degree. In the process of detecting the dynamic interference spectrum, it is necessary to screen other interference factors by combining the spectrum segmentation cancellation algorithm and the confidence level cooperative detection algorithm, so as to ensure the effectiveness and accuracy of the monitoring result. In order to better improve the correctness probability of electromagnetic interference spectrum monitoring, and mostly to effectively suppress and check the interference value, the concept of confidence is introduced in the monitoring process. The method comprises the following steps of: setting an initial confidence level on a detection value, and automatically changing the confidence level according to spectrum changes.

(1) Specification for electromagnetic interference frequency monitoring range. The local oscillation monitoring range is 4450-8960 MHz. The monitoring range of the second local oscillator is 3.0-3.4 GHz; The monitoring range of independent vibration is 700-1000 MHz;

(2) Specification of scanning frequency for dynamic monitoring of electromagnetic interference spectrum. The minimum resolution is 12Hz and the monitoring accuracy is ≤0.154

(3) Reference value specification for frequency monitoring.

(4) RF tuning resolution specification. ＜＜0.6Hz

(5) monitoring noise interference extreme value: 100dBc/Hz

After the above fuzzy clustering constraint processing is completed, the dynamic characteristic detection process of electromagnetic interference spectrum is optimized. In order to carry out dynamic monitoring, a processing module for collecting and locating interference spectrum is designed according to the data analysis of the aforementioned weak signals so as to observe the fluctuation of interference spectrum signals. And record into a table, as follows:

Table 2 Electromagnetic Interference Spectrum Fluctuation Characteristics

Parameter	Spectrum fluctuation	Interference characteristics	Monitoring time	Electromagnetic interference maintenance
S0002	1010	branch out	6:00	No location
S0600	4201	It is allowed to control the frequency converter.	9:00	location 1
S0601	1124	Start sampling	11:00	location 2
S0602	9132	Manual sampling	12:00	location 3
S0603	1046	Acceleration control	13:00	location 4
S0604	1323	Deceleration control	15:00	location 2/4
S1000	4152	Allow the inverter to be controlled	18:00	location 1/3/5
S1110	1054	Time acceleration	21:00	location 2/4
S2000	1036	Time deceleration	24:00	location 1/3/5

Based on the information in the above table, further analysis should be carried out. In the detection process, a complete electromagnetic interference spectrum dynamic signal should be obtained by combining traditional single frequency, digital, discrete, frequency band scanning and other detection methods. The specific flow is shown in the following figure:

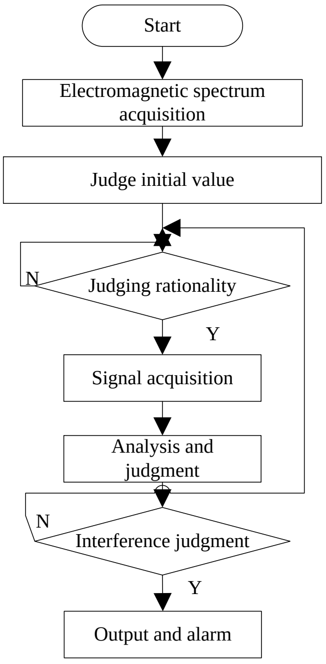


Fig. 3 electromagnetic interference spectrum dynamic characteristic detection flow

Based on the above steps, the output spectrum change values detected in different time periods are collected and stored, and the interference spectrum values in different time periods are fused and spliced to obtain relatively complete interference detection data. According to the obtained data, the electromagnetic interference testing steps are optimized, the influence degree of the interference spectrum is analyzed and compatible processed, and further interference sources are searched in the electromagnetic field, interference capability signals are checked or converted through different ways, and the coupling value is within the electromagnetic field range, so as to ensure that the electromagnetic interference spectrum can be accurately monitored and analyzed in a complex environment, and the following figure can be obtained.

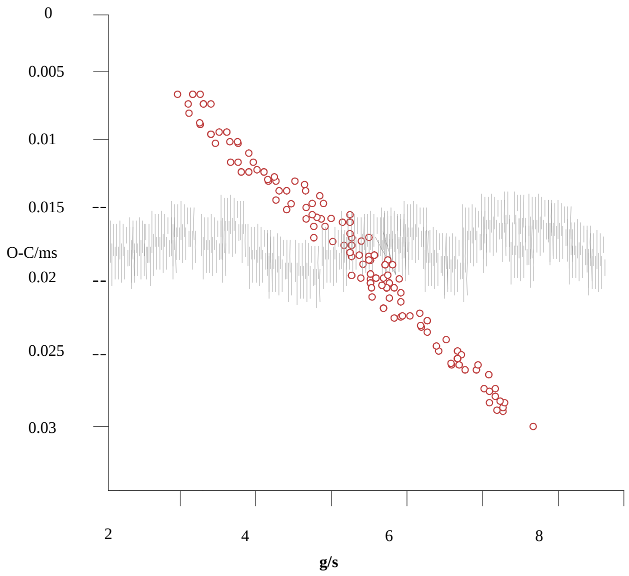


Fig. 4 electromagnetic field interference spectrum coupling principle

Based on the above method, real-time tracking and detection of the dynamic characteristics of electromagnetic interference spectrum can effectively realize accurate judgment and positioning processing of interference values, ensure the stable operation of related equipment to the maximum extent, and avoid potential safety problems that are easy to occur in the operation process.

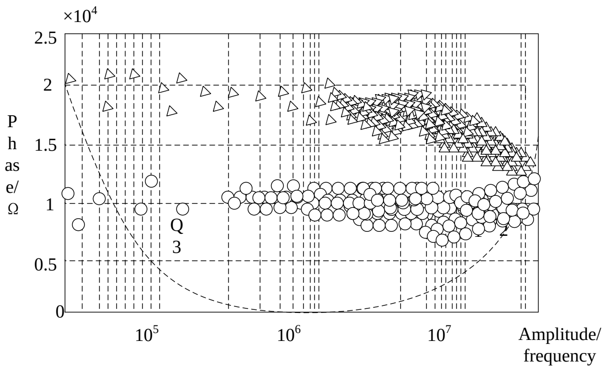
3. Analysis of experimental results

In order to verify the effectiveness of the electromagnetic interference spectrum dynamic monitoring method based on fuzzy theory, comparative testing experiments were carried out. In order to ensure that the test results are authentic, the experimental parameters and environment are standardized. Specific experimental parameters are shown in the following table:

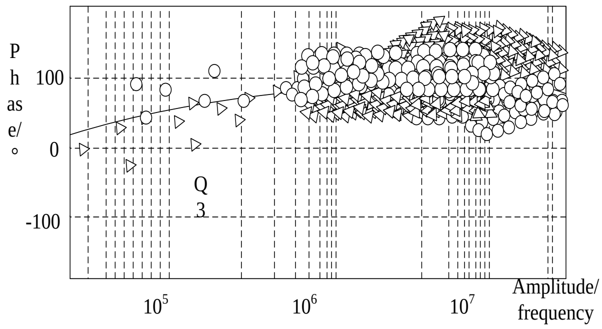
Table 3 Experimental Parameter Table

Projects	Parameter
Parameter	Windows NT
Interface connection mode	CAN bus serial
System operating power	1200W
System operating voltage	500V
System operating current	1500A

Under the above experimental parameters, the experimental environment is standardized. During the experiment, an electromagnetic equipment switch with a frequency of 50.0kHz is adopted, in which the normal voltage during the operation of the equipment is 100V-120V, and the rated complex current is 1500A-2000A. The A/D sampling principle is adopted to regulate the initial data of the equipment, the monitoring and control parameters of CAN are regulated, and the TUC382 chip is used as the main control chip. The experimental platform is unified as a Windows NT code A-6.2 detection platform. The processor is an Intel Core i5 processor with 126G memory and 2.6GHz Intel Iris graphics card. The signal-to-noise ratio generated during the experiment is set to -25db, -20db,-15db, -10db. Under the above experimental environment and experimental parameters, the interference spectrum dynamic monitoring effects of the traditional method and the method in this paper are compared. In the experimental process, the normal degree of spectrum threshold generated in the detection process has a positive correlation with the dynamic range of interference spectrum. Therefore, in the detection process, analyzing the normal degree of HP4395A spectrum threshold can effectively reduce the dynamic range of interference spectrum. Set the experimental spectrum threshold to the values of Q10, Q15 and Q20 to obtain the detection curve of interference spectrum, as shown in the following figure.



(a)traditional method



(b)This method

Fig. 5 spectrum fluctuation threshold standard effect comparison detection

As can be seen from fig. 5, compared with the traditional method, the electromagnetic interference spectrum east tower detection method based on fuzzy theory proposed in this paper is relatively more effective in standardizing the spectrum fluctuation threshold, and the overall coupling effect on the spectrum fluctuation information is also far due to the traditional method. The phase value is obviously higher than that of the traditional method. The accuracy of dynamic monitoring of electromagnetic interference spectrum is further compared and detected, and the detection results are recorded, as shown in the following figure:

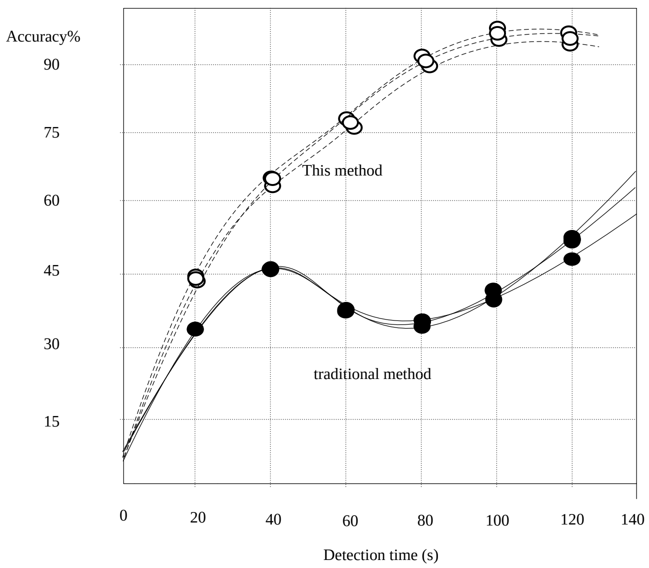


Fig. 6 comparison test results

It is not difficult to observe the above detection results. Compared with the traditional spectrum monitoring method, the electromagnetic interference spectrum dynamic monitoring method based on fuzzy theory proposed in this paper has higher accuracy. Therefore, the above two groups of experiments can fully confirm that the electromagnetic interference spectrum dynamic monitoring method based on fuzzy theory can realize the dynamic monitoring of electromagnetic interference spectrum more quickly and accurately, and fully meet the research requirements.

4. Conclusion

In order to better ensure the stability of electronic equipment in the county, you first put forward a dynamic monitoring method of electromagnetic interference spectrum based on fuzzy theory. Through investigating the research status at home and abroad for optimization, this paper analyzes the key influencing factors in the electromagnetic spectrum monitoring process, and introduces in detail the collection and optimization process of electromagnetic spectrum interference information, so as to finally realize the quasi-monitoring of the real-time dynamic changes of electromagnetic spectrum. Experiments show that the dynamic monitoring method of electromagnetic interference spectrum based on fuzzy theory has higher practical value. However, due to the limitation of current scientific and technological development, the dynamic monitoring method of electromagnetic interference spectrum based on fuzzy theory still needs to be improved.

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