Analysis and Technology Realization of Power Grid Harmonic Detection System Based on ARM Embedded System

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Abstract. In our industrial production, ideally what we get from the grid should be a single power frequency. However, the actual situation is that with the generation, transformation, transmission, distribution and power consumption of the entire power system, as long as the current flows through the nonlinear load, harmonics are likely to be generated. So the detection of these harmonics and effective governance has become one of the requirements of China's power protection. Based on this situation, this paper discusses the analysis and technical implementation of ARM embedded harmonic detection system.

Keywords: Harmonic Detection Method, System, Analysis, Flushbonading

1. Introduction

The basic situation of our country requires that our country must establish a strong power network, but in the process of power operation, harmonics will inevitably produce and cause damage to the power grid. It should be known that, for the power system, sensitive devices such as relays will misoperate when disturbed by high-order harmonics, and high-order harmonics will also cause voltage and current waveform distortion of the power grid. Meanwhile, harmonic current and harmonic voltage will also affect the active/reactive power of the power grid, resulting in increased circuit loss. For transformers, harmonics increase copper loss and iron loss, as well as lead to an increase in transformer noise. If this goes on for a long time, the life of transformer is shortened obviously. Harmonics can also have a negative impact on instruments, it will affect the accuracy of the electricity meter, resulting in inaccurate measurement. The last harmonics can also interfere with communication signals and reduce the quality.
of communication. All these show that the harmonic control must not be slack at all times, to control the first to detect the existence of harmonics, then based on ARM embedded harmonic detection system of power grid is very necessary.

2. Development of harmonic measurement technology

The measurement technology of power harmonics has a long history. The initial harmonic measurement is based on the recorded data of harmonic waveform and manual calculation, which is not only low in precision, but also time-consuming. With the complexity of power system and the increasing requirement of power quality, the research on harmonic problem will be deepened, and finding more effective and feasible harmonic detection method and its realization technology will become the key of harmonic treatment.

The research of harmonic problems in power system involves a wide range, such as harmonic source analysis, harmonic detection, distortion waveform analysis, harmonic suppression and so on. One of the most important aspects is harmonic detection, which is the basis for solving other harmonic problems. However, because the harmonics of power system are influenced by many factors, such as randomness, non-stationarity and distribution, it is not easy to detect the harmonics in real time and accurately. With the development of AC power system, many harmonic detection methods have been gradually formed, such as analog filtering, frequency domain analysis based on Fourier transform, detection method based on instantaneous reactive power theory, wavelet transform, neural network and so on.

According to the different signal processing methods, there are two basic methods to realize harmonic detection: frequency domain measurement method and time domain measurement method. The principle of the frequency domain measurement method is shown in figure 1:

![Diagram of frequency domain measurement](image)

**Figure 1.** Schematic diagram of frequency domain measurement

The principle of the time domain measurement method is shown in figure 2:
3. Harmonic detection method

3.1. Analog filtering

The analog filter method belongs to the early harmonic detection method. There are two kinds of analog filter methods, one is to filter the fundamental current component by the filter to obtain the harmonic current component, the other is to use the band-pass filter to obtain the fundamental component, and then subtract from the detected current to obtain the harmonic current component. This method is simple in principle and circuit structure, can filter out some harmonics of natural frequency, is easy to control, but has large error, poor real-time performance, is greatly affected by the external environment, and the detection effect is obviously worse when the parameters change. Now it is basically not used.

3.2. Detection method based on instantaneous reactive power theory

The instantaneous reactive power theory (p-q theory) is a theory based on the instantaneous active power p and instantaneous reactive power q in time domain. The basic principle is to convert the three-phase instantaneous voltage and current into two-phase coordinates by rotating and orthogonal coordinate transformation. According to the two-phase instantaneous voltage and current combined into rotating voltage vector and current vector and projected to obtain the instantaneous active current and instantaneous reactive current of the three-phase circuit, the instantaneous active current and instantaneous reactive current of the three-phase circuit are obtained.

Active power and reactive power are separated and transformed by high order harmonics to obtain harmonic current component. p-q theory breaks through the mean meaning of traditional power theory and is suitable not only for sine wave but also for non-sinusoidal wave. The detection method based on instantaneous reactive power theory is simple in principle, fast in dynamic response, small in delay, and has good real-time performance, which can detect harmonics and compensate reactive power. However, this method has a large error in analyzing the distorted three-phase voltage, and can not accurately detect the harmonics.

To address the shortcomings of the p-q algorithm, an improved d-q method based on synchronous rotational coordinate transformation has emerged, which can accurately detect harmonic current in the case of asymmetric voltage and waveform distortion in the power network.
3.3. Detection method based on wavelet transform

As the work crystallization of harmonic analysis, wavelet analysis is becoming a hot field in recent years. It is widely used in signal processing, speech recognition and synthesis, machine vision, mechanical fault diagnosis and monitoring and other scientific and technological fields. It can be used to replace the traditional Fourier analysis. Because wavelet analysis can calculate the frequency distribution of a certain time and decompose the spectrum signals composed of different frequencies into signal blocks of different frequencies, the fundamental current can be calculated accurately by wavelet transform. Finally, the harmonic component is obtained. The research time of wavelet transform theory and application is not long, there are still many imperfections in harmonic measurement, and the application in practice needs further study.

3.4. Detection method based on neural network

Recent years, the research literature on the application of neural networks to power system harmonic analysis has increased rapidly at home and abroad, and summarized in two main aspects: on the one hand, a power system harmonic analysis method based on multi-layer feedforward neural network is proposed. This method uses the function approximation ability of multi-layer feedforward network to carry out harmonic analysis by constructing special multi-layer feedforward neural network; on the other hand, the Adaline neural network and adaptive noise elimination technology are combined to carry out harmonic analysis.

The detection method based on neural network mainly involves the construction of model, the determination of sample and the selection of algorithm. The detection of harmonic and reactive current by neural network has good fast tracking ability for both periodic and aperiodic current, and also has good recognition ability for high frequency random interference. At present, the neural network method and wavelet transform method are in the research stage, but still have a great application prospect.

3.5. Frequency domain analysis based on fourier transform.

The frequency domain analysis method based on Fourier transform is calculated according to the current value (or voltage value) of a period collected, and the harmonic number and the amplitude and phase coefficient of each harmonic are obtained. The required error signal is obtained by Fourier transform and the compensation signal is obtained by Fourier transform.

At present, the harmonic analysis of power system is mostly realized by this method. The discrete Fourier transform needs to deal with the digital signal obtained by sampling and A/D conversion. When using Fourier transform to analyze the signal, there will be spectrum leakage, and the effect of spectrum leakage can be reduced by windowing function, which can improve the accuracy of calculation. By using the digital phase-locked synchronous sampling method, the signal frequency and sampling frequency can be synchronized. The phase and frequency of the sampling signal are compared with the synchronous feedback signal output by the phase comparator. The frequency of VCO is controlled after filtering until the input frequency and feedback frequency are synchronized.

With the improvement of harmonic detection requirements in power systems and the maturity of various new harmonic detection methods, the frequency domain analysis method using Fourier
transform in steady-state harmonic detection also adopts fast Fourier transform and its improved algorithm.

4. Integral design of embedded harmonic detection system

4.1. Harmonic detection system based on industrial control computer

Most industrial control computers are similar in volume and composition to PC computers, but they have strict requirements in body design and chip selection, so they can work in a relatively bad environment. IPC has great advantages in hardware resources, and can run general operating system and rich application software. And the industrial control computer has good expansibility, which is convenient for the replacement and upgrade of each hardware module, such as hard disk, memory, etc. However, although the IPC has a relatively perfect function, there are still many shortcomings: using IPC as a field detection and analysis tool leads to high equipment cost; field equipment often does not have real-time analysis ability. A large amount of data must be transmitted to special analysis tools for processing, resulting in large storage and poor real-time, large volume, poor portability, high power consumption, intelligent, network level, so it does not meet the current harmonic detection requirements of real-time measurement.

4.2. Harmonic detection system based on single chip microcomputer

Because of its high reliability, low cost, small volume and low power consumption, single chip microcomputer has been widely used in many fields, such as industrial control, data acquisition, intelligent instrument, office automation and so on. The word length of single chip microcomputer is usually 8 bits and 16 bits, among which 8 bits single chip microcomputer is the most widely used. many mcu also integrate a variety of functions on the chip, such as analog/digital converter, USB interface and so on, which makes the system integration of such mcu higher and smaller. At present, most domestic power harmonic detection systems use single chip microcomputer as the control core.

The detection system with single chip microcomputer as the control core has some advantages in volume and cost, but because of the low processing ability of single chip microcomputer, it is difficult to meet the requirements of multi-channel data processing, which makes this kind of system very limited in function. It can only realize basic display and alarm functions.

4.3. DSP based hardware platform

DSP has strong ability in digital processing. Can adapt to various digital signal processing algorithms, especially suitable for FFT, digital filtering and other algorithms. And its cost-performance ratio is very high, the technology is also quite mature, can satisfy the various applications of different occasions. A platform with DSP as the core can process high-speed data to meet the requirements of high real-time system. but its control ability is limited, there is no rich external interface, such as LCD, keyboard, touch screen, USB and so on. And DSP can only support a very small number of operating systems, can not achieve a variety of rich software functions, such as databases, networks and so on. Therefore, the hardware platform based on DSP is generally suitable for monitoring devices with large amount of data processing, high real-time requirements and relatively low control ability and powerful software functions.
Due to the limitation of hardware and software technology, traditional harmonic measurement devices often have some shortcomings, such as low function integration, low measurement accuracy, no friendly graphical interface, poor function expansibility and poor software and hardware configuration. Therefore, this paper proposes that the high performance embedded processor ARM as the hardware platform, using its good control ability and rich peripheral interface, can realize friendly man-machine interface, the most important thing is to run the embedded operating system on the ARM core. Greatly improve the ability of hardware platform, but also bring a lot of convenience to system development.

The measuring device with ARM9 as the core improves the performance of the harmonic measuring device as a whole and meets the needs of the development of the measuring device to miniaturization, intelligence, multifunction, hardware and software, network. Therefore, this paper uses embedded system technology to construct the hardware platform of power harmonic detection system based on ARM S3C2410.

4.4. Software platform programme

According to the ARM hardware platform scheme adopted by this device, the software platform is closely connected with the selection of hardware platform. Considering the functional requirements of the system and the selected software platform scheme, the system adopts embedded operating system, which can speed up the development progress and reduce the difficulty of development.

ARM support a variety of embedded real-time operating systems, such as Windows CE, Linux, VxWorks, can achieve multi-task scheduling, synchronization, communication and other functions, including rich software functions, such as database, network, GUI interface display, etc. The biggest advantage of operating system is to isolate hardware and software completely and simplify the difficulty of application development.

µC/OS-II operating system is used in the system, which is characterized by: small kernel, open source code, detailed annotations, its kernel belongs to stripped real-time kernel, strong portability. Because of µC/OS-II ingenious conception, simple and able structure, strong readability and all the functions of real-time operating system, it is very suitable for development and application.

µC/OS-II is powerful, supports 56 user tasks, supports semaphore, message mailbox, message queue and other commonly used inter-process communication mechanisms, can deprive the real-time kernel to make the task-level system response time optimal, and the response time is known, which is very suitable for the system with high real-time requirements. It provides a mechanism for organizing each functional module of the application. It enables each functional module to reuse the CPU resources according to the high and low priority timesharing under the arrangement of the system scheduler through configurable kernel services. Each task thread coordinates through synchronization, communication, data exchange, etc.

5. Conclusion

Harmonic detection is not a simple problem, at the same time it is an important, extremely need to be solved, with practical significance of a problem. In this paper, the author discusses the analysis and technical implementation of the harmonic detection system based on ARM embedded system, but it is
not specific, just hope to provide some thoughts for the official launch of the system, for China's power grid industry to put forward a possibility, and then make some contributions.

Acknowledgments

2020 project of university talents support program (GXYQ2020081) - Research on power network analysis and harmonic problems under embedded technology.

2020 the natural science research project of Anhui Universities (KJ2020A0799) - Research on reactive power and harmonic problems of AC / DC side of PWM rectifier

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