Design and Realization of Power Quality Monitoring Scheme for Measuring Ship

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Abstract. A kind of network distributed power quality monitoring system is studied for the power quality monitoring of the measuring ship. The system uses DSP and ARM as the controller for the terminal monitoring module, connected via the LAN. The experimental results show that compared with the traditional onshore instruments, the system has a wealth of measurement capability and high measurement accuracy.

1. Introduction

With the increasing size of the ship's distribution system, the rectification type, the impact and the non-linear load in the power distribution system are increasing constantly. The existence of these nonlinear loads often causes serious pollution to the ship's power quality, so that the quality of the ship's power grid to reduce, there may be deteriorating the operation of the power grid.

Ship power distribution system is an important part of the ship system, we can see that the ship power quality problem is very serious, can properly handle the power quality problems directly affect the system operating efficiency and security. In this way, how to improve the power quality of the ship's power grid to ensure the safe operation of the ship's equipment system has become the focus of the shipbuilding industry. Power quality monitoring helps identify power quality problems, minimizes equipment losses, and improves equipment efficiency.

Currently on the market with more power quality monitoring equipment is mainly used for land-based power grid, such as the United States Fluke introduced Fluke1760, Fluke1750 power quality analyzer, the German company launched the UMG508, 505 and other analyzers, Baoding Long Letter of the LCT-FB601-type analyzer, Israel Elspec company and Beijing Ruitaike products. However, these instruments are not oriented to the ship's environment, but it is of great significance for the study of the power quality inspection system of the ship's electric power system, which is related to the measurement equipment of ship power system parameters and the evaluation of power quality.

The traditional power quality monitor design on the ship mostly uses the industrial computer plus the data acquisition card to realize the data acquisition and analysis of the power quality. The main reason for this kind of equipment is that the computer adopts the computer as the field analysis tool the cost is high; the flexibility of the equipment configuration, versatility is relatively poor, the application of small; real-time analysis of poor ability, a large number of data must be transmitted to a specific analysis software for processing, resulting in relatively large storage capacity of the device, increase the cost [1-4].

With the development of technology, there has been a lot of monitoring equipment at home and abroad. In general, there are still some shortcomings, mainly in: the data accuracy is not enough, due to the backward data processing algorithm, the lack of effective data based on the judge, it is difficult
to use in-depth analysis of the impact of power quality; Monitoring cycle is long, monitoring points scattered and other issues, can not keep abreast of the level of power quality. Therefore, the need to design and develop embedded power quality monitoring equipment, and it must have a high real-time.

2. Program design

2.1. Overall design

Power quality problems can be divided into two kinds of steady-state problems and transient problems. Steady-state problems are mainly characterized by waveform distortion, including three-phase imbalance, harmonics and interference. Transient problems are mainly characterized by short duration and randomness. All monitoring data need to be processed in a timely manner and passed to the control center to help the staff quickly understand the overall power quality of the ship.

For the power quality monitoring needs, as shown in Figure 1, the system design using LAN to connect all monitoring terminals. In the terminal more, the important position of the cabin layout control center, centralized monitoring of the power quality of some cabin to achieve the purpose of redundant backup and disaster recovery, while the ship power plant layout of the ship control center. The total control center automatically stores data for a long time, automatically analyze a period of time the ship power quality problems.

2.2. Monitor terminal module design

In order to achieve efficient monitoring, the system needs comprehensive advanced monitoring technology to Fourier transform, wavelet transform and instantaneous reactive power theory, based on the integration of artificial neural network technology to improve the speed of computing, to improve the data required for processing space and processing accuracy.

In order to achieve the above objectives, based on the current monitoring technology and instrument research status and the relevant national power quality standards require a deeper understanding on the basis of DSP and ARM power quality monitoring equipment used to achieve the power of the ship to promote the quality of power monitoring and analysis [5]. As shown in Figure 2, according to the functional division can be divided into the following modules: system power module, signal acquisition and conditioning module, AD sampling module, DSP processing module, ARM engineering module. The system power supply module is responsible for meeting the power demand of the system. The signal acquisition and conditioning module realizes the conversion and filtering of the high voltage and high current signals to be measured so that the measured signal satisfies the AD sampling amplitude. The AD sampling module is responsible for completing the test signal processing module; signal processing module is responsible for the conversion of the digital signal after the data processing and analysis. ARM engineering module is mainly used to complete the construction of human-computer interaction interface and with the outside world for data communication and transmission.
Figure 1. Schematic diagram of intelligent monitoring system for ship power quality.

Figure 2. Block diagram of the intelligent monitoring of ship power quality.

3. Verification and analysis of test results
In order to detect the measurement accuracy of the system, the test results of the system and the traditional instrument are compared. On the basis of obtaining the measurement accuracy, a long time power quality monitoring is carried out for a measuring ship.

3.1. Comparative Analysis of measurement accuracy
As shown in Table 1, to measure a ship A phase 1~30 times harmonic, for example, the United States Fluke introduced Fluke1750 power quality analyzer measurement data for the actual value as a reference, the figure can be seen from the power quality intelligent Monitoring data and Fluke1750
power quality analyzer data accuracy error within $9.25 \times 10^{-4}$, to meet the needs of measurement.

**Table 1.** Comparison of intelligent monitoring data for a ship's power quality.

| Number of harmonics | Amplitude /V | Phase /π | Relative error | Number of harmonics | Amplitude /V | Phase /π | Relative error |
|---------------------|--------------|----------|----------------|---------------------|--------------|----------|----------------|
| Actual value        | Test value   | Actual value | Test value       |                     | Actual value | Test value       |                     |
| 1                   | 311          | 311.0001 | 3.21×10^{-7}    | 1                   | 0.0000       | 0.0000       | 0.00            |
| 3                   | 285          | 285.0001 | 3.51×10^{-7}    | 3                   | 0.1667       | 0.1666       | 0.06            |
| 5                   | 255          | 255.0000 | 0               | 5                   | 0.3333       | 0.3333       | 0.00            |
| 7                   | 225          | 224.9998 | 8.99×10^{-7}    | 7                   | 0.5833       | 0.5833       | 0.00            |
| 9                   | 210          | 209.9999 | 4.76×10^{-7}    | 9                   | 0.7500       | 0.7499       | 0.01            |
| 11                  | 180          | 180.0002 | 1.11×10^{-6}    | 11                  | 0.9167       | 0.9166       | 0.01            |
| 13                  | 150          | 149.9999 | 6.66×10^{-7}    | 13                  | -0.9167      | -0.9166      | 0.01            |
| 15                  | 120          | 120.0001 | 8.33×10^{-7}    | 15                  | -0.7500      | -0.7500      | 0.00            |
| 17                  | 90           | 90.0009  | 1.00×10^{-5}    | 17                  | -0.5833      | -0.5833      | 0.00            |
| 19                  | 60           | 60.0001  | 1.83×10^{-6}    | 19                  | -0.4167      | -0.4167      | 0.00            |
| 21                  | 35           | 34.9968  | 9.11×10^{-5}    | 21                  | -0.2500      | -0.2500      | 0.00            |
| 23                  | 30           | 30.0000  | 1.00×10^{-6}    | 23                  | 0.0000       | 0.0001       | 0.00            |
| 25                  | 10           | 9.9999   | 1.60×10^{-5}    | 25                  | 0.1667       | 0.1667       | 0.00            |
| 27                  | 7            | 6.9999   | 1.14×10^{-5}    | 27                  | 0.3333       | 0.3333       | 0.00            |
| 29                  | 4            | 3.9999   | 9.25×10^{-6}    | 29                  | 0.5833       | 0.5833       | 0.00            |

3.2. Measurement results

As shown in Table 2 and Table 3, the system designed in this paper has done a long time to monitor and analyze the power quality of a measuring ship. During the test, the measurement of 380V power supply bus harmonic current, harmonic voltage, frequency deviation, and three-phase voltage unbalance and voltage deviation power quality indicators can meet the national standard, inter-harmonic, long-term voltage flicker power quality indicators not meet the national standard requirements.

After analysis, the following problems:

1) In the case of two or three generators running in parallel, the interphase voltage content and the long-term voltage flicker index do not meet the national standard requirements, mainly due to the large power load start;

2) The bow thruster from the start to the normal operation of the process 2 times, 4 times and other even harmonic increase is more obvious, an increase of 100%;

3) The number of times, 5 times, 7 times and the total harmonic content of the marine chillers were increased by 40%.

**Table 2.** Power quality data for two generators running side by side.

| parameter                  | Maximum | Average | Minimum | 95% value | GB value | conclusion |
|----------------------------|---------|---------|---------|-----------|----------|------------|
| Frequency (Hz)             | 50.06   | 49.92   | 49.81   | 50.01     | ±0.2     | PASS       |
| Three-phase voltage unbalance (%) | 0.18    | 0.12    | 0.09    | 7.31      | 2.00     | PASS       |
| Long Flicker               | A 3.67  | 3.67    | 3.67    | 3.67      | 1.00     | FAIL       |
|                            | B 3.50  | 3.50    | 3.50    | 3.50      | 1.00     | FAIL       |
|                            | C 3.59  | 3.59    | 3.59    | 3.59      | 1.00     | FAIL       |
Table 3. Three generators parallel operation of the inter-harmonic voltage.

| Number of Interharmonic | GB value | A phase | Average | conclusion | B phase | Average | conclusion | C phase | Average | conclusion |
|-------------------------|---------|---------|---------|------------|---------|---------|------------|---------|---------|------------|
| 0.5                     | 0.2     | 0.234   | FAIL    | 0.255      | FAIL    | 0.29    | FAIL       |
| 1.5                     | 0.2     | 0.254   | FAIL    | 0.241      | FAIL    | 0.26    | FAIL       |
| 2.5                     | 0.5     | 0.075   | PASS    | 0.066      | PASS    | 0.249   | PASS       |
| 3.5                     | 0.5     | 0.045   | PASS    | 0.037      | PASS    | 0.245   | PASS       |
| 4.5                     | 0.5     | 0.034   | PASS    | 0.029      | PASS    | 0.068   | PASS       |
| 5.5                     | 0.5     | 0.027   | PASS    | 0.022      | PASS    | 0.040   | PASS       |
| 6.5                     | 0.5     | 0.024   | PASS    | 0.020      | PASS    | 0.031   | PASS       |
| 7.5                     | 0.5     | 0.022   | PASS    | 0.019      | PASS    | 0.024   | PASS       |
| 8.5                     | 0.5     | 0.018   | PASS    | 0.015      | PASS    | 0.022   | PASS       |
| 9.5                     | 0.5     | 0.016   | PASS    | 0.013      | PASS    | 0.020   | PASS       |
| 10.5                    | 0.5     | 0.015   | PASS    | 0.013      | PASS    | 0.016   | PASS       |
| 11.5                    | 0.5     | 0.015   | PASS    | 0.012      | PASS    | 0.014   | PASS       |
| 12.5                    | 0.5     | 0.014   | PASS    | 0.012      | PASS    | 0.014   | PASS       |
| 13.5                    | 0.5     | 0.013   | PASS    | 0.011      | PASS    | 0.013   | PASS       |
| 14.5                    | 0.5     | 0.012   | PASS    | 0.009      | PASS    | 0.013   | PASS       |
| 15.5                    | 0.5     | 0.012   | PASS    | 0.009      | PASS    | 0.012   | PASS       |

4. Conclusion

With the further development of automation and control technology, intelligent monitoring based on ship power quality has become a reality. The intelligent monitoring of the ship's power quality can analyze the monitored data and provide the quantitative basis for the automatic adjustment of the power quality control equipment, and send the process and result to the monitoring center for reference by the staff, which is expected to realize the ship's electric energy quality control, and further improve the reliability and safety of the ship operation, enhance the overall performance of the ship.

Reference

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