Design and Implementation of Data Acquisition and Analysis System for Intelligent Meter in Smart Grid

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Abstract. Design a smart meter data acquisition and analysis system to collect and process electrical energy data, report remote data and collect electrical energy. The data collector of the smart meter supports multiple protocols and the collinear communication of the electric meters, and the collinear communication of the electric meters with different protocols, different models and different communication speeds is connected on the same communication line. The data is sent to the data collector through the RS-485 bus, and the data collector collects and processes the data and uploads it to the server through the WAN. The design of the smart meter data acquisition and analysis system effectively improves the scientific validity of electric energy billing.

Keywords: Smart meter, data collection and analysis, collector.

1. Introduction

The smart meter is an important part of the smart grid. As the node connecting the power company and the power user, it is no longer an electric energy meter in the traditional sense. With the precision and integration of electrical equipment, the requirements for the power quality of the power supply are getting higher and higher, and it is no longer simply limited to the scope of voltage stability. The smart meter is based on the electronic meter with communication, which can automatically upload the measurement data to the network. Therefore, compared with the current common meter and mechanical energy, the smart meter is functional, automated, and efficient. Both have great advantages. It is of great significance to analyze and monitor the power quality of the power grid in the process of power transmission and power measurement.

The characteristics of smart meters are low power consumption, high accuracy, strong overload capability, large power frequency range, and humanized functions. In addition, it has remote control and telemetry functions, that is, it can remotely obtain data and remotely cut off the power supply. The smart meter can upload complete electric energy data to the data network of the power company, and can do a large number of data calculations through software, and the benefits and expansion it brings will bring a great leap in the power grid. The application of network technology is used to check the electricity
consumption and account balance of one's own home through the Internet at any time through a computer or mobile phone, which facilitates the use of users.

Smart meters are generally divided into two categories in terms of structure, which can be divided into two categories: electromechanical and electronic. The electromechanical smart meter is the addition of electronic components to the original old mechanical watt-hour meter, the original mechanical meter is counted through the electronic counter component to realize the measurement, and then the data transmission is realized through the peripheral electronic circuit. Electronic smart meters all use electronic components. From sampling to data processing and transmission, they are all realized with electronic components. They have the characteristics of small size, high precision and low loss. Electronic meters are also currently used for electrical energy data collection. Its use on the power grid is of great significance.

2. Smart meter data collection and processing
Smart meters usually include smart remote meter systems, smart repeaters, smart converters, and smart system management software. The intelligent remote meter adds the function of pulse signal output on the basis of the original traditional meter. The pulse sent out can be carried to transmit the measured value, and then the pulse information of the intelligent remote meter is concentrated. The smart repeater mainly records the pulse signal, stores it in the memory of each repeater, and then transmits it to the management computer for query and processing. The smart converter mainly completes the communication with the repeater. The usual converter is to receive the electricity data of the collector in a regular loop, or to receive some data of a certain electric meter and a certain group of electric meters according to design principles. The basis of the intelligent system management software is communication, and its core is a database management software. The intelligent system records the user information of each user and records the real-time information of all meters, and stores this information in the database.

The front-end smart meter data processing part of the system collects the user's electric energy data, voltage and current, and sends these data to the data collector through the RS-485 bus. The data collector collects the data of all electric energy meters in a certain area. Process and make certain judgments on these data, and upload these data to the power company server through the WAN. The data transmission diagram of the smart meter system is shown in Figure 1.

![Data transmission diagram of smart meter system](image)

**Figure 1.** Schematic diagram of data transmission of smart meter system.

The front-end smart meter data processing part of the system consists of a keyboard control module for human-computer interaction, an MCU module for control and calculation, a meter chip module for
measurement, a display module and a front-end circuit conditioning module. The module is isolated from the mains by a current-type voltage transformer, and then the current is adjusted to a proper range by the current transformer, and then connected to a sampling resistor. The transformed signal is connected to the single-chip microcomputer, and the single-chip microcomputer completes the driving and calling of each module, and performs calculations. The voltage or current or power can be switched and displayed by pressing the function keys of the keyboard. The system can realize real-time recording of parameters such as current and voltage, as well as the calculation and measurement of power parameters such as electricity, power, and power factor. The schematic diagram of the information processing of the smart meter system is shown in Figure 2.

![Schematic diagram of information processing of smart meter system.](image)

After the current and voltage sampling signals are sent to the metering chip through sampling resistors, transformers, etc., the metering chip converts these signals into "analog-digital" through a high-precision ADC, and then compares and corrects them with the reference source. These complete digital signals are transmitted to the metering MCU via the high-speed communication interface through the isolation circuit. After the metering MCU obtains these data, the data required by the electric energy meter such as electric energy is obtained through calculation, which can effectively perform power quality analysis and improve the performance of the electric energy meter. Performance to meet market demand for electric energy meters.

3. Design and Realization of Data Acquisition of Smart Meter
The data collection device of the smart meter should support multiple protocols and collinear communication of the electric meters, and the collinear communication of the electric meters of different protocols, different models, and different communication speeds can be connected on the same communication line. Green free installation service software, friendly interface and powerful functions. Operations such as parameter setting, parameter modification, system upgrade, data export and fault diagnosis can be performed locally or remotely.
It supports the user's parameter pre-setting before installation of the project, debugging during on-site installation and real-time management of equipment. It supports remote upgrade and resumable transmission, which can avoid upgrade failure caused by bad channel. The upgrade process will not affect the communication and normal data collection of the collector. The online running collector supports individual upgrades of protocol program modules, and the online running collector supports parameter setting and debugging of newly added electric meters.

Connect the collector port to the pre-provided public telephone switching network signal line. Set the meter parameters on the service software, as shown in Figure 3 and Figure 4.

![Figure 3. Electric meter measuring point setting diagram.](image-url)
Figure 4. Electric meter basic parameter setting diagram. You can fill in the meter name, meter address, protocol name, communication parameters and other information in the basic setting dialog of the meter measurement point.

Figure 5. Parameter setting diagram of meter master station.
The master station parameters include information such as the master station name, collector address, collector password, communication protocol, and modem initialization string. The parameter setting of the main station of the electric meter is shown as in Fig. 5.

After the meter parameters and the master station parameters are set, you need to check each parameter in detail to ensure that it is correct. Select the electricity meter data collection cycle. The electricity meter data collection cycle can be set from 1 minute to 24 hours. Download the set parameters to the collector. After the parameters are downloaded, the collector will collect the meter data according to the set period, and actively dial the main station phone to upload the data.

The log function is a very important diagnostic method for debugging the collector. The log file contains communication messages, debugging information, error information, etc., which is an important method for debugging and solving problems.

4. Smart meter data collection and analysis
The actual measurement value of the smart meter when different current values are selected during the test is compared with the standard meter reading, and the measurement error rate of analysis of the voltage and current is shown in Figure 6 and Figure 7.

![Figure 6. Voltage measurement error rate graph.](image)

![Figure 7. Current measurement error rate graph.](image)

The error of the voltage measurement gradually decreases as the voltage increases. The current error is the largest at 4A. The main reasons for these errors are the composite error of the current transformer and the error caused by the voltage drop of the secondary conductor of the transformer. The existence of these errors has a certain impact on the measurement accuracy of the electric energy meter, especially in the electric energy after the watch runs uninterrupted for a long time, the accumulated error will gradually increase.

In order to solve this problem, current transformers and other electronic components with higher accuracy and better linearity should be selected. In addition, a complete error data table can be established, and the error can be compensated in real time through software compensation, so as to reduce the accumulated error and improve the measurement accuracy of the electric energy meter.

5. Conclusion
Analyze and study the design and implementation of data collection for smart meters, and use collectors to complete data collection. The collectors are a new generation of electric energy collection devices developed for the operation requirements of various scattered power grid industries in China, which can meet the requirements of various users to upload data to the master station. It is designed to connect to different protocol meters, to report remote data automatically and regularly, and to demand high power collection requirements. Fast and accurate detection of power parameters such as current, voltage, power, frequency and power factor in the power grid, and then take effective treatment to achieve stable
operation of the power grid. From the perspective of electric energy billing, it has also achieved accuracy and efficiency, which has improved the scientificity and rationality of electric energy billing.

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