ORIGINALARTICLE

Network Key Equipment Design Adapted to Underground Pipe Rack and Urban Energy Metering

Haodong Zhang[1], Zhiqiang He[2], Xiaohong Rao[3]

Chongqing ChuanYi Automation Co., Ltd. Chong Qing , 401121 ,China

ABSTRACT Traditional energy automatic metering management scheme has solved the two level problem of monitoring and application, but there is shortcoming at the transport level. Along with the advancement of industrialization and informationization, a variety of sensing devices, interconnection and unified transport demand is becoming more and more urgent. Based on FPGA platform and multichannel parallel MBUS communication mode, fusion NB - IoT technology, this paper puts forward a suitable for underground pipe rack and the network of urban energy metering design method of key equipment, it is a good way to adapt to a variety of field and meet the requirements of multiple class sensor interconnectivity unified transmission, has the very good application value.

KEYWORDS

Parallel communication

FPGA

MBUS

Underground pipe gallery

Energy metering

Gateway

NB - IoT

INTRODUCTION

Along with the social progress and the urban development level enhances unceasingly, the process of industrialization and informatization integration gradually speeding up, the past man type of energy management mode is to intelligent automation management mode transformation. Whether to build industrial energy use, suitable for family or monitoring and analysis of comprehensive automation management system, and the construction of intelligent controls the integration of the urban underground pipe rack, is to promote the development of city green, building a conservation-minded society. To realize the energy efficiency of the whole society control network system, to ensure the security of city, improve the urban construction, beautify the city landscape, promote the development of the city intensive efficiency and transformation, realize the beautiful China is of great significance.

At present, most of the energy management by monitoring, transmission, using three levels of management model, to some extent, solve the low efficiency of manual monitoring management in the past. Diversified sensing monitoring equipment development, solve the underground pipe gallery object temperature, humidity and other environmental monitoring problem, has realized the coverage of domestic and industrial use of water, electricity, gas, heating and other digital measurement of energy;

The technology development and related research for many years, while applied in monitoring and two levels have made some achievements, but at the transport level related scheme is not enough mature and universal. Such as household energy measurement of a variety of sensing equipment adopted different ways of communication interface and communication, more than the traditional research USES the following ways:

1.1.RS485 serial bus 485 , is used more widely. Although the device to connect, but not to power a device. Need an additional cable, high cost, engineering economy;

1.2.Electric power carrier wave communication, the realization of the electric power meter reading, but can not be applied to other types of energy metering, susceptible to interference, communication reliability is bad;

1.3.GPRS (General Packet Radio Service, General Packet Radio Service), a kind of wireless communication technology based on the public, but the technology of deep cover ability is insufficient, can not apply for a underground pipe rack etc environment, communication power consumption is high, easy to use battery life.

1.4.Support MBUS (meter bus, instrument bus) devices with embedded processor, it adopts serial data processing method, multiple channels through the consumption of all equipment with a long cycle communication, meets the requirement of data real-time change monitoring. Traversing the data acquisition is completed, all equipment status has changed, lost the data accuracy and validity.

doi: 10.18686/esta.v3i1.5

Technology above ways although widely exist in all kinds of engineering, but caused a lot of problems: send enough to communication equipment, electric power, water supply companies, gas companies, such as different owner has a independent way of monitoring. Do not have a unified monitoring, data does not cause the repeated investment and the waste of resources, also bring inconvenience to the user. In the construction of urban underground pipe, independent of each other, there is also a network information block each other. Many device isolation, data island limit the data value.

In today's industrial era, the rise of data only big unification, the aggregation can dig more business value. Connectivity between devices, data flow, each other between different elements between aggregation is a key to maximize the value of each other. In this paper, based on principles of universal gm, economic and easy to use, with FPGA (Field - Programmable Gate Array, Field Programmable Gate Array) as the foundation of hardware platform, the integration of MBUS communication technology used widely in Europe and the rise of a new generation of Internet communication technology NB - IoT (narrowband cellular Internet of things), and explore the design of a fusion ideas of industrial automation communication network of key equipment (gateway to illustrate the generation), it can be widely adapted to the underground pipe rack and urban energy management applications.

1. Method

At present, widely used in household energy metering management mode of the automatic monitoring using remote meter reading device for the equipment for remote copy data read, has eliminated the traditional manual meter reading. Due to different data types, of the various energy equipment for different energy is different also, remote meter reading device is a device for remote meter reading can only be one type of equipment for copy to read. But in household or industrial applications equipment is diversified, so traditional practices more USES the many kinds of remote meter reading device to copy to read a variety of types of devices. Multiple copy meter reading device for a variety of devices to read time or method is different, lead to can't unity gain more data such equipment, low working efficiency of meter reading system. In addition, the adopted technology of the traditional way is congenitally deficient, RS485 communication can't give equipment power supply, load points is limited; Power carrier based on power line communication are susceptible to interference, reliability, and low rate of problem difficult to solve.

In the construction of urban underground pipe is in its infancy, so the lack of unified standards to guide. A variety of sensing monitoring set does not have unified the means of transport, with optical fiber or 2 g / 3 g / 4 g, RS485 communication mode to mix. In view of the large integrated management system of urban underground pipe, not unified access to diverse equipment monitoring, greatly reduce the efficiency of urban energy system global regulation.

In addition, whether indoor or pipe rack deployment equipment, involves to the power supply problem. Most of the use of wireless network sensor devices, using solar energy storage battery or more. Battery power is limited, however, for a long time continuous data monitoring will shorten power supply sustainable cycle; So the traditional way of application is not a universal.

This paper puts forward a general suitable for underground pipe rack and family gateway design method of energy metering. Figure 1 depicts the gateway information data of external connection diagram. Gateway to a variety of sensing equipment by MBUS communication convergence, unified into a standard Ethernet and narrow-band wireless communication network to the upper transmission. All kinds of sensing device by MBUS channels connected to the gateway, the gateway based on two cables by MBUS interface implementation for equipment of power supply and the communication between the interaction;When the equipment is in the running state, transfer their key features of the data to the gateway, the gateway based on the data key feature to automatically create device address, type, status and information table;Upper management system based on Ethernet is applied to implement the data communication and parameters of gateway address table configuration, equipment management, etc.;Configured, gateway according to internal parameters to achieve target addressing and channel selection, after several MBUS channel down to send data, with multiple MBUS parallel communication interface connected device;Each channel to return to the data stored in the internal buffer, for internal core processing, processed based on Ethernet or NB - IoT transmitted to upper application management system.

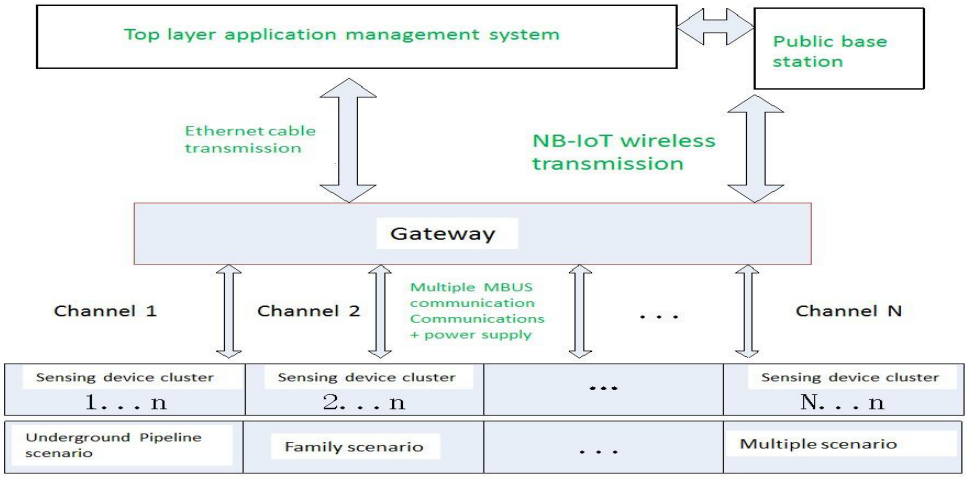

Figure 1 Connection diagram

The above description has the following features:

1.1.Using multi-channel MBUS transmitting real-time data of each equipment

MBUS bus compared with the traditional 485 bus and power carrier, has some advantages: MBUS bus for two wire, each channel can take up to 200 devices, multiple channel design can be covered for more quantity of equipment acquisition at the same time; Rate is high, it can be finished in a short time rapid data aggregation function;At the same time solve the equipment of power supply and communication, not solely to increase power supply for power supply equipment, saving the cost of the power supply equipment and cables.For nonpolar connection between multiple devices and gateway, convenient for construction workers, especially in complex environment, such as underground pipe gallery.

1.2.Adopt parallel multichannel communication, shorten the communication cycle, and improve the communication efficiency

Concurrent logical processing advantages, based on the FPGA design for multiple independent of each other in the gateway MBUS channel, realize the multiplex MBUS communication concurrent access to multiple devices, several times higher than that of traditional MCU processing efficiency of communication.

1.3. Using the wired and wireless NB - IoT communication mode, improve the ability of universal to the environment

Underground pipe gallery environment and community building for sensing, especially not suitable for the deployment cable Ethernet environment, the NB - IoT communication gateway access application management system, play a narrow-band honeycomb IoT depth of coverage, long distance advantage, reduce the cost of cable Ethernet cable wiring. Narrowband cellular Internet of things based on the public base station communication operators, than traditional 2 g, 3 g, 4 g network, lower power consumption, lower cost, can meet a long, wide coverage, underground deep coverage requirements.

In the area of suitable for wiring and cabling, cable Ethernet communication mode is adopted, the gateway access application management system.

1.4. in the internal building device type and device information mapping describe transformation mechanism, implement different kinds of communication equipment

Analytical description file provided by the equipment manufacturer information, analytical data description import information through the application management system, automatic configuration gateway internal data management model, through the network in the gateway of the internal construction of equipment information data types, structure, key feature extraction and information extraction table transformation way, realize the information mapping described analytical dictionary, different equipment information into a uniform format, realize the level in the gateway of such equipment, the unified information transmitted to the application management system, realize the whole network connectivity to multiple devices under the framework of information.

2. Implementation

In view of above method described in this section, in this paper, the specific technical implementation. Gateway based on FPGA platform, involves two aspects of hardware and software.

2.1. Hardware platform

Hardware selection Xilinx XZC7010 as the main chip of the company. Hardware block diagram is shown in figure 2, the interior are embedded ARM processor, convenient for data processing, embedded control software design. External has rich resources of programmable logic, suitable for extending different communication interface and implementation in parallel processing logic of communication.

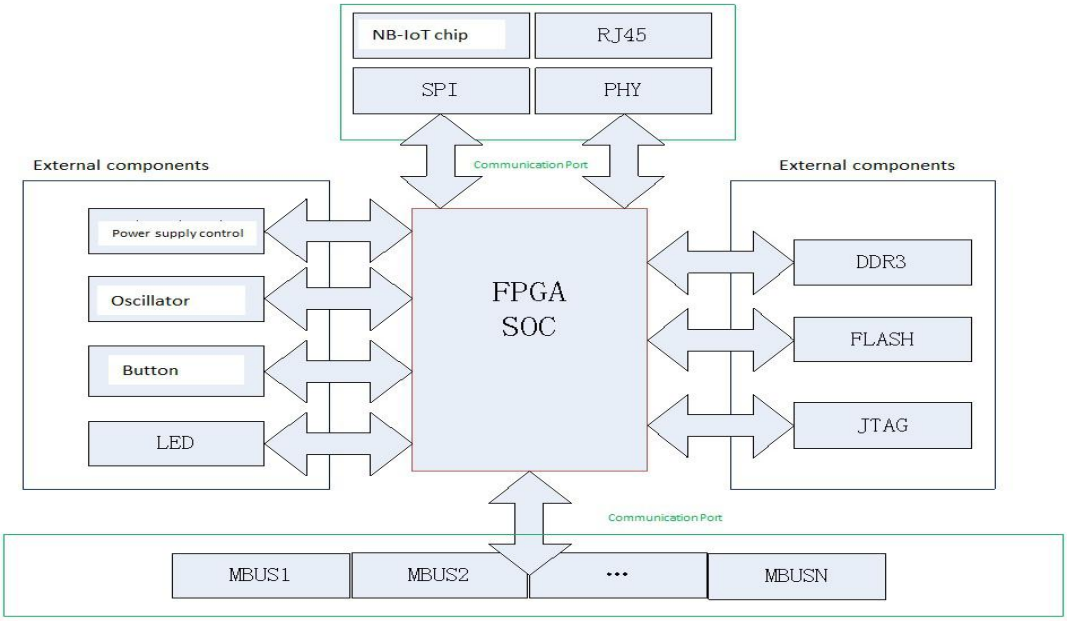

Figure 2 Overall block diagram

2.2. Software platform

ARM processor chip internal integration and external support programmable logic. Based on design tools to build a platform of embedded "hard", its external connected by means of logical bus communication interface with internal processor, realizes the logical processing and processor data processing of the two process.

Using local partition, and the overall scheduling of design thought. To complete the various tasks of subdivision to each function module, the module itself is a separate process. In each module design is completed, will be integrated within the framework of various modules in the main, the implementation of various modules of intensive processing and task scheduling. From part to whole, from whole to part of the mind is good for the building of the whole system, easy to implement the various functions of screening and debugging, also can be a very good deal with each functional task switching between, to ensure that the system is accurate, safe and reliable operation. Module partition as shown in figure 3.

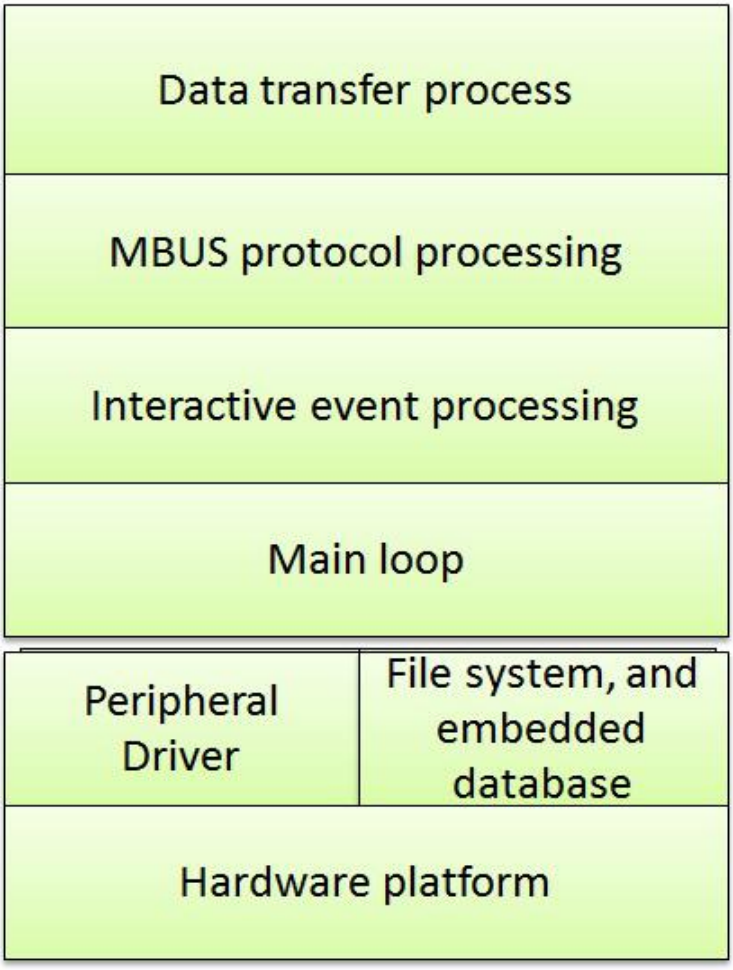

Figure 3 module partition

Different modules related to different tasks, in view of the space, this article only choose some key tasks in this paper.

2.2.1. the main process implementation

After power on the system, the implementation of equipment configuration and initialization process module driver, and initializes the SD (Secure Digital Memory Card) Card, file system and embedded database, after loading the LCD menu, enter the main loop. In the main loop, to determine whether the configuration profile information changes. There is any change to the configuration file information refresh to the equipment list. If refresh fails, the system will turn to the configuration configuration mode, repeated cyclic waits to receive configuration configuration information, until the configuration is complete, exit configuration configuration mode. If refresh is successful, will determine whether there is a user interaction tasks. If you have, the judge is the command switch configuration or menu, the former will return to the configuration mode, keep loop configuration; If not, is directly implemented MBUS communications task, there are data reception for protocol processing, the start of the NB - no data receiving IOT communication tasks. If NB - IOT communications task start, no any network data, retreat to the task, otherwise into NB - IOT agreement process. Each loop tail to guard dog dog operation, to determine whether a watchdog reset, if reset to reload the program running, no reset, continued to run in the main loop.

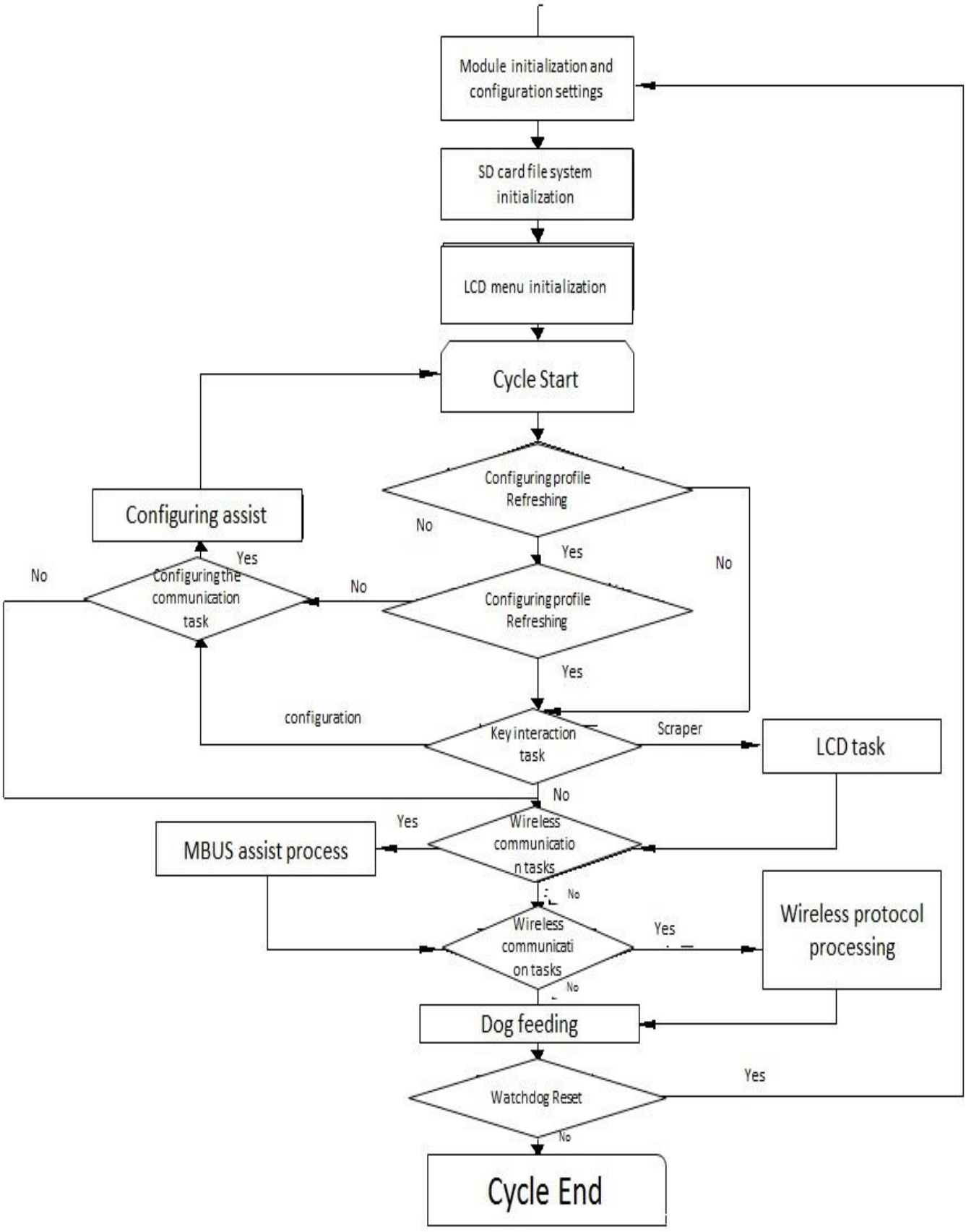

Figure 3 main process

2.2.2.Key processing task process

Key task processing by scanning state, using delay to shake algorithm to judge which key is pressed, and connecting with the menu classification layered tag judge the current LCD screen should be displayed which the content of the interface. System design of the four buttons, respectively corresponding to the up (increase), down (reduce), confirm and return operation. Each key under different levels of menus, will produce different interaction effects. Key processing tasks and LCD menu display task to cooperate with each other mutual support user interaction function.

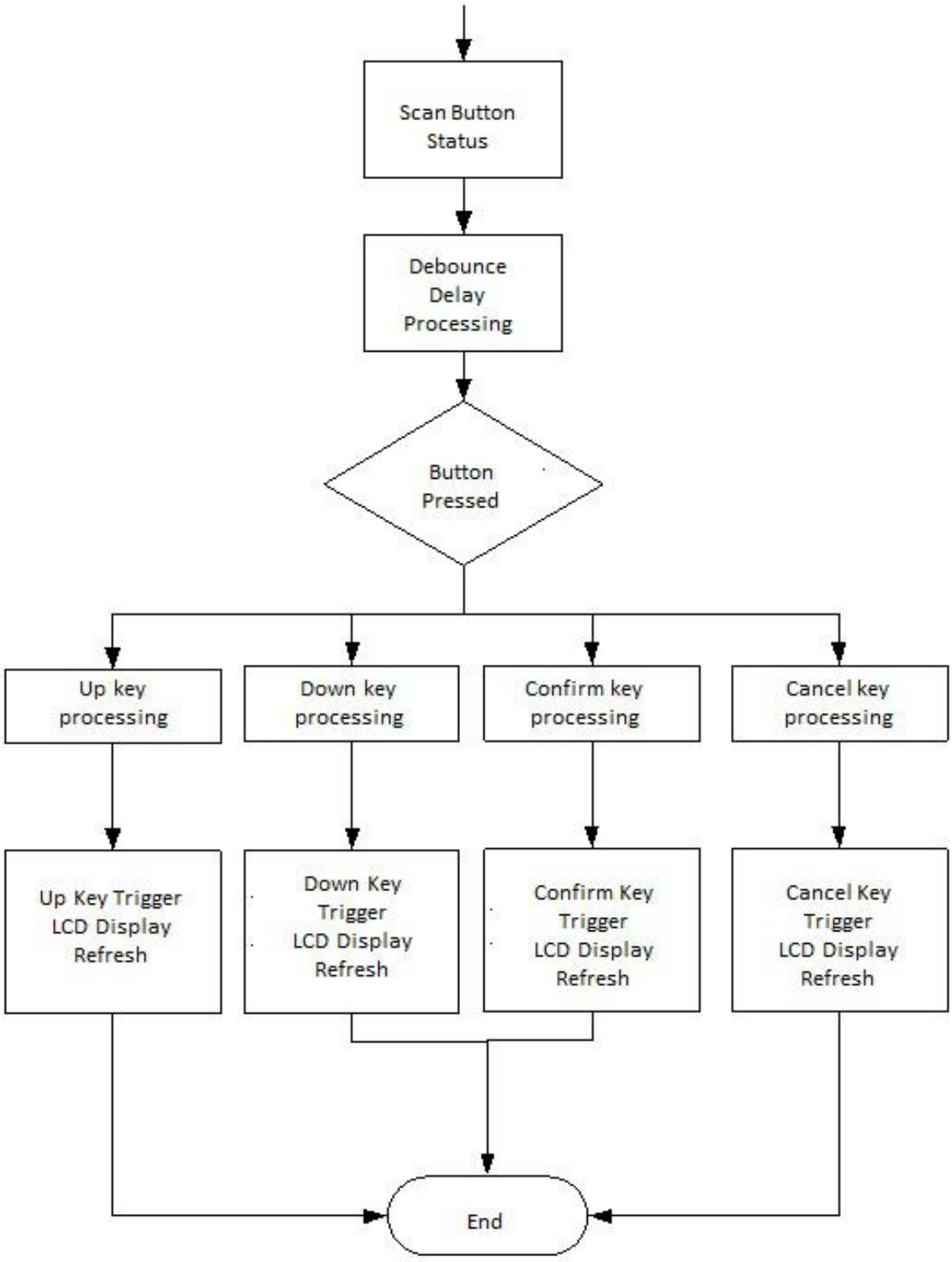

Figure 4 Key interaction process

2.2.3 LCD menu processing task flow

LCD menu processing tasks by getting the menu hierarchy number marking switch interface. First gets the current display menu series, then gets the current cursor position and the cursor mode (view or modify mode). If there are buttons, refresh operation will produce. , if the up key action will determine the cursor up or modify values increase, if the cursor operation, the judgment is the cursor up or flip the page; if the down key action is to determine the cursor down or modify the value decreased, if the cursor operation, is to determine the cursor down or page after page;If the confirmation key action, will enter judgment is the next level menu or save the current value;If the return key action, the direct return to the higher level menu refresh.

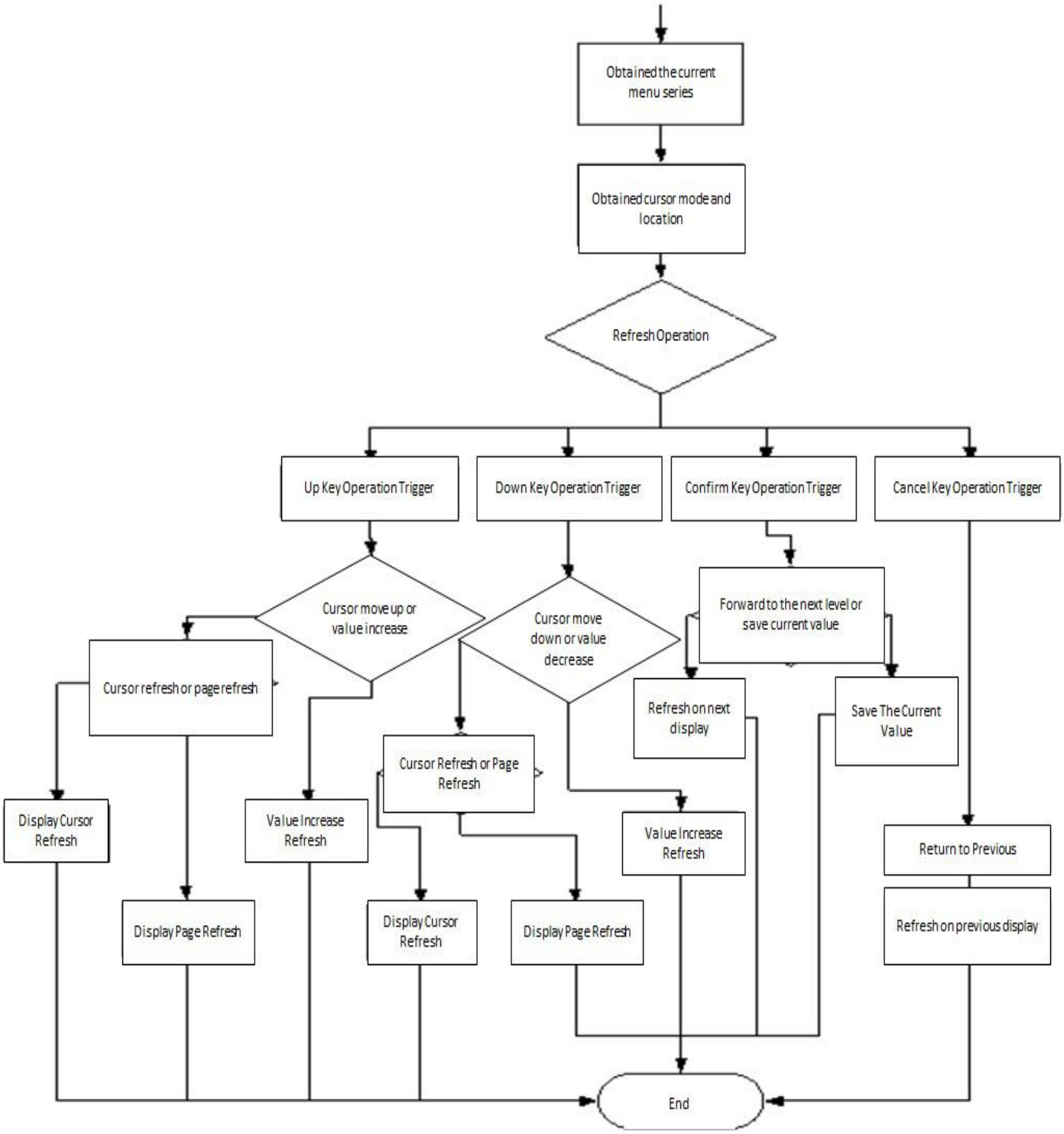

Figure 5 LCD menu handling process

2.2.4. MBUS communication processing task process

MBUS processing mainly according to MBUS protocol, design MBUS communication standard data structure and data operation command frame, the design is based on control code, address, and type of command generating function equipment. Based on the received data from the device frame according to protocol parsing process, complete the equipment management and operation of reading, MBUS data link and data communication between the master-slave MBUS station. MBUS operation process is decomposed into several subtasks:

On the gateway, MBUS processing module according to address increasing order parallel device node for each channel, determine the node equipment of online, construct the basic online node list, in order to complete online condition monitoring for the node equipment;

A time period set by the user, regularly read gateway mounted under each device node data and status information, online time (or day) the hour will read data into the database to save, so that users to backup and query data;

Based on the time period, a time period set by the user, the timing (every 3 months or 6 months) to clear of the historical data of the stored in the database, release of storage space, optimize database storage;

According to the online device list, polling data read equipment, will read the data package, latest by wireless module to the application management software (partitioned piecewise upload or merged into big packet overall upload).

According to the management system of wireless module receives the transmission of data command, targeted to specific locations and types of equipment to implement real-time readings and read state, complete the data operations on a particular device;

According to generate the list of equipment configuration, read the fixed format configuration information, refresh the polling list, complete the configuration data processing operation of all equipments in the list;

According to every time with the equipment state of data communication, determine equipment state of offline and online, real-time refresh list online.

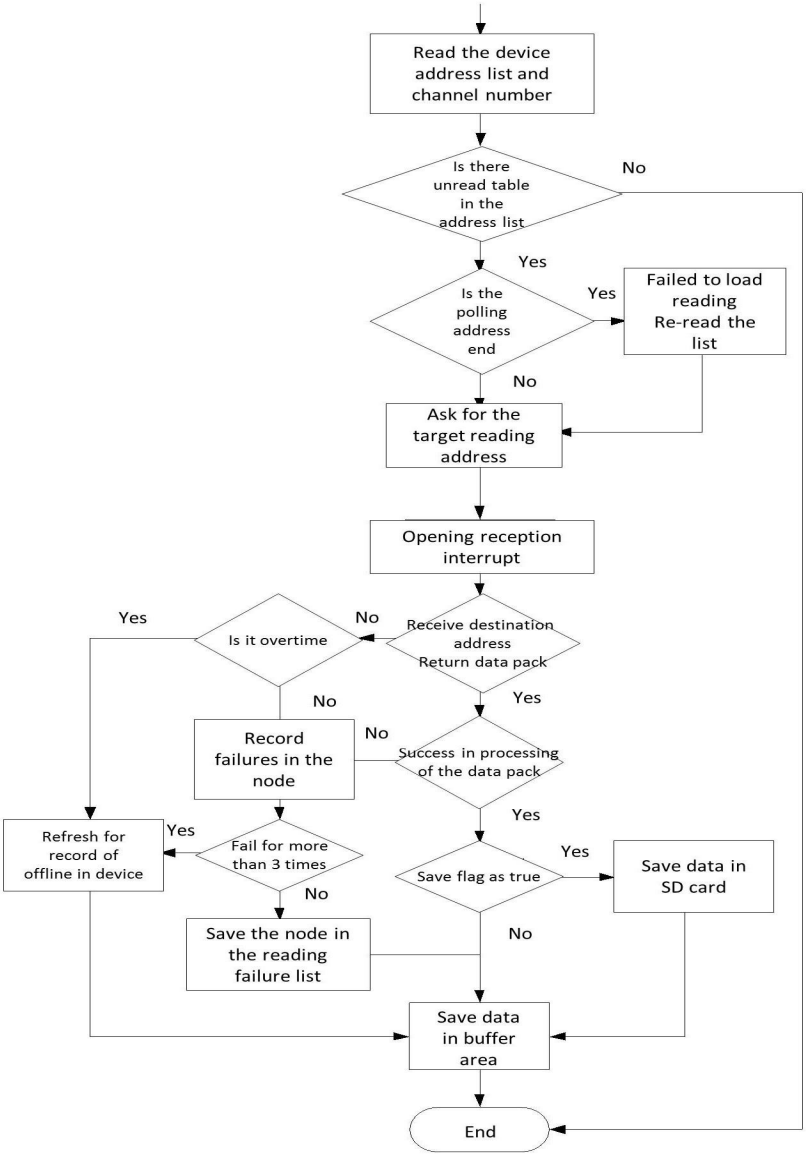

Figure 6 MBUS communication processing task process

In the MBUS communication task processing, protocol parsing module will received data frames to determine length, combined with the end tag to judgment of data integrity, and on the whole data frames for calibration. If a data frame was completely legal, implement data analysis for the frame;

2.2.5.Wireless processing module

Main complete wireless link initialization and wireless transmission data processing, wireless processing module is decomposed into several subtasks:

On the gateway, determine whether inserted into the mobile phone card; Initialized the wireless module, complete module power consumption control, network connection service configuration, data transfer mode configuration process; Access network signal status and link quality, complete the data transmission network.

To wirelessly transmit the data from receiving management system addendum command, parse command and extract the timestamp, device address, device type, such as keywords, to the historical data retrieval database, packaged retrieval results, through the wireless network to management system, in order to complete the history and orderly operation.

Through receiving wireless network management system under the command of real-time data, real-time command parsing and extracting address, type, such as keywords, the real-time data buffer for real-time data retrieval, the retrieval results packaging, through the wireless network to management system, in order to complete real-time data command operation.

Through wireless network management system downlink receiver configuration information, DNS configuration information and extract the configuration address, configuration types, such as keywords, refresh local configuration list, through the wireless network echo refreshes the complete message to management system, in order to complete the configuration information.

When the network is interrupted, real-time refresh network online, start the offline after reconnection mechanism, try three times. If three consecutive fails, turn to wait mode, wait for after the effective time (N), again for network reconnection.

When for wireless data transmission, periodically determine whether the network is normal, abnormal reconnection. Reconnection failure, temporary data transmission; To send data, such as network back to normal.

2.2.6. storage module

Main equipment data, equipment status information and configuration information. In order to guarantee the data retrieval of convenient, quick and retrieval based on time, and has designed two handling files and databases. File processing mainly in view of the save configuration configuration information, database processing is aimed at and time correlation data, real-time change of equipment.

A, local data backup file system based on SD card

FatFs (Generic FAT File System Module, general File allocation table File System Module) is a common type of FAT File System Module, mainly used in the embedded System. It is based on the C language to compile, completely out of the disk I/O layer. It is independent of the hardware system, can the very good application and compatible MCU, ARM MCU, etc. It has a FAT12 / FAT16, FAT32, support multiple volumes, two kinds of partition rules, rich configuration options (including: Support long file names, optional code page, the support multitasking and sector size, read-only property, minimize the API, the buffer allocation, etc.), etc. Can well ensure the stability and reliability of the data storage system.

System locally in the form of file storage, according to the key identification information, information content, information saved in the form of interval operator. When the configuration information is changed, refresh the local configuration file information in real time. When the system is power on, automatic loading local configuration system files.

To manage data and more convenient, such equipment to the uplink channel failure or data report failure problem of data error, designed the localization data backup strategy, choose file records stored data. In order to optimize the file to read and write, we design a data storage structure. According to the device type, respectively, to create different types of device type folder, avoid data record file data length before long, speaking, reading and writing;Under the different device types folder to create a channel number folder, to speed up a channel of retrieval, avoid looking for other channel equipment;Under the channel to create a folder node address, focus on a single node in the data file to a folder, convenient management;According to the real time on the way of naming data file name, speed up the time to retrieve;Within a single file is the reading time of the day as the key tag, the history data retrieval.

B Database real-time processing

Data request for daily real-time monitoring and periodic uncertainty, way of System gave up the regular file record real-time data, introduces a DBMS (Database Management System, Database Management System). In system design, using the embedded database as the data storage system. Database to facilitate system data insert, update, delete and user to associated retrieval operations such as multiple data records.

An embedded database Sqlite is this system adopts the database engine. The database is applied very extensive, has long been a variety of applications verified its outstanding performance. No matter fast, miniaturization and reliability, have very good application performance. Adobe PDF, Google's Android, Macfee antivirus software and the commonly used FireFox browser use Sqlite database engine as internal product database.

Database roles as shown in figure 7, assume MBUS module and storage module of data exchange.

In order to make good management from standing device address, and from the station, from the stand reading device information such as time, design the corresponding fields in the database to store the corresponding data.

Database two tables, it is proposed a data sheet for the equipment form (Figure 8), mainly complete equipment reading record store operation; Data table 2. Equipment log table (Figure 9), the main complete equipment status record store operation.

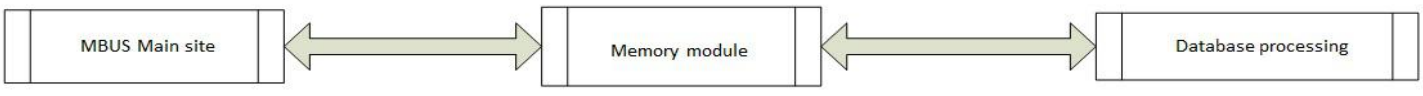

Figure 7 database module

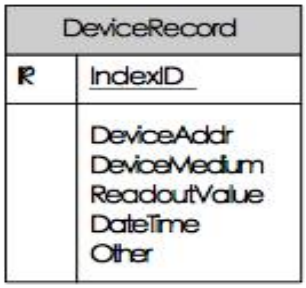

Figure 8 devices record

Equipment record table structure definition are shown in table 1, defines the primary key, field name, field type, field constraint conditions.

Table 1 Equipment record

Field 1 (primary key)	Field 2	Field 3	Field 4	Field 5	Field 6
IndexID (int)	DeviceAddr (int)	DeviceMedium (Varchar)	ReadValue (float)	DataTime (Datetime)	Other (Varchar)
Record the index Automatic counting	Device address no. 1-250	Device type Water, electricity, gas, temperature, humidity, etc	Reading the numerical	Reading time In (date) (month) (year)	Reserve

Field 1 is the primary key field for data record count, each a record, the automatic increase 1, and the data table can be got through the field at present how many data records;
Address field field 2, equipment, storage device address, range 1-250;
Field 3, equipment type fields, a storage device types, such as Water, Electric, Gas, etc.;
Field 4, reading numeric fields, a storage device reading values, floating point Numbers saved;
Field 5, reading time field, the storage device when reading time, specific to;
Field 6, other information fields, set aside for the time being.
Equipment record table structure definition are shown in table 2, defines the primary key, field name, field type, field constraint conditions.

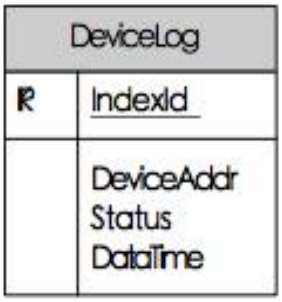

Figure 9 Equipment log tables

Table 2 Equipment log tables

Field 1 (primary key)	Field 2	Field 3	Field 4
IndexID (int)	DeviceAddr (int)	Status (Varchar)	DataTime (Datetime)
Record the index Automatic counting	Device address no. 1-250	Equipment state	Time In (date) (month) (year)

Field 1 is the primary key field for data record count, each a record, the automatic increase 1, and the data table can be got through the field at present how many data records;
Address field field 2, equipment, storage device address, range 1-250;
Field 3, equipment status field, storage devices, such as Active, Dead, Configured, etc;
Field 4, time, time, storage device status changes occur in the concrete to the points;
2.2.7. Configuration module
To construct a thread monitoring, monitoring based on Ethernet command and request from the application management software, complete the configuration of the gateway configuration.
2.2.8. Multithreaded processing mechanism
Gateway to handle multiple tasks, the traditional single process method is obviously insufficient, so the multithreading mechanism is introduced in the design. Because the data interaction between different modules, each thread Shared access to certain resources, will lead to a thread waiting for resources and the deadlock between the thread take up resources. , therefore, it is necessary to avoid deadlock, the main processing mechanism of planning, especially between each thread synchronization and mutex sequence.
Is proposed in the system time slice rotation thread scheduling, the thread scheduling method based on the operating system, the default Settings can be stable, safe and complete each thread between the rotation, so that they can very good to complete the processing of each function module.

3. Effect and prospect

Based on FPGA platform to MBUS and NB - IoT technology and industrial automation integration in the integration of gateway at the same time solve the problem of the scene of the equipment of power supply and communication, can be effectively applied to the underground pipe gallery and urban energy metering management. The user can through the custom application management system configuration and management gateway for different kinds of devices compatible ability and data communication based on variable time cycle. Maximum compatible with multiple devices and multiple occasions, has realized the energy measurement solutions in the optimization of the transport layer, and monitoring, application two aspects of the traditional solution to solve the problem of energy efficient management, to promoting the construction of resource-conserving society and beautiful China has a huge role.
In this paper, the design can be further in-depth study, such as for the fault tolerance of communication, can consider to research on link analysis and statistical correlation function, combined with the mathematical statistical methods and models, statistical data communication of the time, cycle and error, error analysis of the correlation factors, conclusion and will be transmitted to the upper system, in order to optimize scheduling, communication protocols and communication reliability of hoisting system of the whole; Can consider to adjust the function design of the different power requirements of power, using the method of line detection and mathematical analysis, to meet the needs of different current power adjustment model is established, in order to enhance the gateway

power of different types of equipment support ability, realize the monitoring of nets; Based on the FPGA parallel advantage, optimize the communication link, communication buffer, the data exchange between data processing engine, introducing the ping-pong buffer and improve the efficiency of read/write concurrent; Reference on TCP/IP data frame processing, optimized data communication transmission process, simplify the header, enable based on different quality of service level management, adjust data transmission priority, comprehensive promotion link communication efficiency.

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Author introduction

Haodong Zhang, male, master degree, information systems project management division, the solution architect; The research direction for embedded systems, industrial iot technology; Mainly engaged in industrial iot technology research design and the solution architecture.

Zhiqiang He, male, master, engineer; The research direction for application of Internet and wireless communications technology; Mainly from the things connected to the wireless communication technology research and hardware design.

XiaoGong Rao, female, master degree, engineers;The research direction for Internet communications technology; Mainly engaged in communications hardware design workThe research direction for Internet communications technology; Mainly engaged in communications hardware design work.