

Design of handheld meter reading terminal based on UHF RFID

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Abstract: In order to solve the common problem of electric energy meter industry, which is a slow speed of manual meter reading and inventory, this project designs the handheld meter reading terminal based on UHF RFID. It has many characteristics such as once reading multiple tags, long distance identification, high transmission rate and high reliability. The handheld meter reading terminal has combined Android OS with UHF RFID, WIFI and 4G, and is applied to the intelligent meter reading system and meter warehouse management system. It effectively improves the reliability of the meter reading data and the convenience of maintenance management, minimizes the workload of staff. This paper elaborates the overall scheme design of the system, and introduces the important components of software and hardware. This RFID handheld terminal has already been applied in the project, and the system worked well, stably and efficiently.

1. Introduction

With growth in the living standard in China, demands for goods increase step by step and technologies applicable to identifying types of goods and information are upgraded. Bar code technique developed at an early phase has been rather mature and rather cheap. However, Internet of Things that takes form highlights its defects, such as rigorous identification conditions and single identification. Clearly, it no longer satisfies people's need to check items quickly. RFID featured with remote fast batch identification has been also formed with the progress in the Internet of Things. In addition to tens of thousands of rewriting supported, RFID also have the capacity to store larger and richer information content. Without doubt, the application of RFID is a guarantee for intelligence, efficiency and convenience of corporate production management and logistics management in future.

In links of power generation and consumption, people has always been concerned about the fact whether data reading of an electric energy meter is rapid and accurate. Under the circumstance of reading meter technology updating, popularity of RFID just conforms to such a demand. Dependent on RFID, the system acquires functions of remote reading and batch processing to instantly and automatically read information of tags in quantity, substantially reduce the time consumed by backtrack search and improve accuracy of query and checking. Android operating system, ultra high frequency RFID technology, WIFI/3G/4G and cloud platform technology are combined together to develop handheld RFID equipment for the purpose of solving common problems currently existing in



electric energy meter industry, effectively improving quality and reliability of data and the convenience of management, operation and maintenance of such meters, and lowering relevant workload to the greatest extent.

2. Product Design Requirements

According to the practical production application demands, such an RFID handheld reading meter terminal should be equipped with the following major functions.

- (1) An electric power data read-write function to read the data (e.g., electric quantity and power, etc.) displayed by RFID in a meter and read the data of multiple meters once.
- (2) A meter information inventory read-write function to rapidly read serial numbers of meters in a warehouse, which makes it convenient for statistical warehouse management of meters.
- (3) A radio communication function to upload data acquired to a cloud platform via wireless network or 4G network, which is beneficial for data storage, data transfer and data analysis.
- (4) A display function with a human-computer interaction interface; Android system with which people are familiar in daily life is adopted to conduct interface development, which is to the benefit of operators.

As for a meter reading system of RFID handheld terminal, its schematic diagram has been presented in Fig. 1.

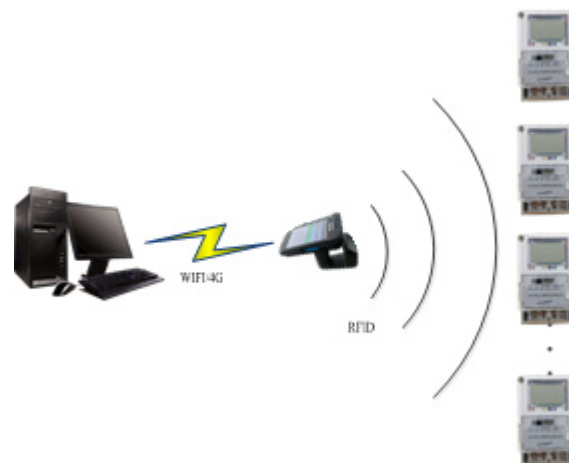


Fig.1 Diagram of the meter reading system

3. Hardware Circuit Design of the System

Such an RFID handheld meter reading terminal mainly consists of the following functional modules, an RFID module, a display module, a power module, a WIFI module and a 4G communication module. Each module has its own roles to play. To achieve the overall function, circuits of different modules were designed one by one.

Core of the RFID handheld meter reading terminal is microprocessor. All modules should be under precise and effective control so that their functions can interact with each other to achieve objectives of data reading, uploading and storage. Among them, the RFID module is responsible for collecting power data and meter information, that are further sent back to the microprocessor where such information acquired is displayed on the display module. Meanwhile, the information gathered can be also delivered to a cloud platform system by virtue of the 4G communication or the WIFI module.

3.1 Model Choice for Microprocessor

Qualcomm MSM8916 is a quad-core microprocessor. Its master frequency ranges from 1.2GHz to 1.4GHz at the maximum. In addition, the internal storage supports single channel 64-bit LPDDR2/3 and video coding supports H.265. Integrated with MSM9x25 base band, WiFi 802.11ac and Bluetooth 4.1 are supported. The memory interface is standard eMMC 4.5. Thanks to a high integration level,

power supply capacity of the battery is effectively improved, which means the reduction of power consumption. In terms of practical application and commissioning, price, energy conservation performance and low power dissipation characteristics of the microprocessor are all important reasons why it is selected. Qualcomm MSM8916 microprocessor has a large market share so that it is rather cheap. Considering that multiple multi-media functions have been integrated into the baseband chip, the number of peripheral components considerably lowers with the improvement of chip integration, the decrease in power consumed by handheld equipment and the drop of the area occupied by mainboard of the handheld equipment. These are all critical indexes to select the Qualcomm MSM8916 microprocessor.

3.2 Model Choice for RFID Chip

In this system, performance of radio frequency (RF) chip is an important factor to judge the entire system. Through overall consideration PR9000, AS3992 and R200 common in the market and comparison among them in Tab. 1, it has been observed that they all support ISO18000-6C protocol and Indy R2000 has an obvious advantage in terms of receiving sensitivity and power regulating range. Additionally, R2000 is the only reader chip with carrier suppression capability, which can be utilized to optimize performance of the development platform.

Tab.1 Comparison table of radio frequency chip

Name of Chip	Sensitivity	Operating Frequency	Power Regulating Range	Protocol Supported
PR9000	-86dBm	840~960 MHz	20dB	ISO18000-6C
AS3992	-86dBm	840~960 MHz	20dB	ISO18000-6A/B/C
IndyR2000	-95dBm	840~960 MHz	30dB	ISO18000-6C

RF front-end chip of IndyR2000 ultra high frequency RFID reader was selected for the design and it takes the responsibility of sending, receiving, demodulation and baseband signal processing. The diagram of Indy R2000 development platform has been presented in Fig. 2.

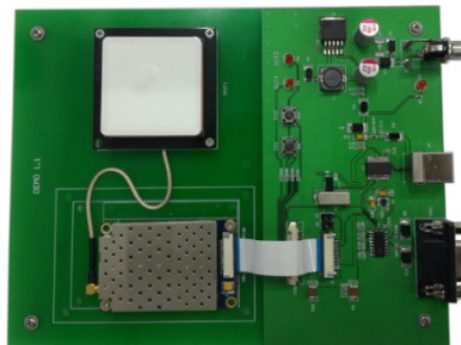


Fig.2 The development platform of Indy R2000 reader

3.3 WIFI Module

Low-cost and low-power dissipation WIFI module with serial to Ethernet manufactured by Hi-Link in Shenzhen was adopted. Its model number was HLK-RM10. Such a module is equipped with abundant peripheral communication interfaces. In a handheld meter reading terminal designed in this paper, main control chip MSM8916 was connected to HLK-RM10 through a serial interface without changing any configuration to transfer information via WIFI.

HLK-RM10 module supports three working modes of STA, AP and STA+AP; and, each mode

covers three subpatterns, namely, a TCP server, a TCP client and UDP. In STA mode, the WIFI module connects to the Internet by virtue of a router; AP mode is a default mode serving as a hotspot to realize communication between the module and other wireless devices so as to further form a wireless local area network (WLAN); and, the STA+AP mode is a coexistence state of two modes described above. In this paper, AP mode of the WIFI module was selected according to functional demands of RFID handheld meter reading terminal.

There was a built-in AT instruction set in the WIFI module. In AT mode, main control module plays a role in conducting functional configuration for parameters of the WIFI module based on AT instructions of the serial port. In this design, WIFI module of the RFID handheld terminal was set as a client mode and host system as a server mode. Considering that the module has embedded TCP/IP, the RFID handheld meter reading terminal has the ability to directly upload data acquired to the host computer via the WIFI module without relevant software programming for protocol conversion.

For the reason of changeable application environment of RFID handheld meter reading terminal, an alternative plan was made in the event of WIFI being non-existent, that is applied design of 4G communication module. The reason why such a design scheme is selected 4G LTE module is that wireless technology it carries provides high spectral efficiency, high data rate and low delay.

4. Android Software Programming

The handheld meter reading terminal was based on an Android system providing a free open-source SDK and using JAVA to develop user-friendly meter reading machine with a simple Android based interface and being easy to operate. Not only is it convenient for a meter reader to upload data (meter reading data uploaded by WIFI/4G), but the meter reader can conveniently inquire information about the electric energy meter (QR code identification and RFID identification). The machine featured with convenient and flexible carrying and accurate information passing and receiving is applicable to electric energy meter warehouse management and electric energy data reading and acquisition.

Android system concerned with the design was divided into 6 major functional modules for the convenience of user operation. As regards such modules, registration and login functions are inevitable. Moreover, the client application must be equipped with functions of meter reading and warehouse management. In the end, there are also some miscellaneous functions conducive to reading meter, which are also innovative functions of the client software, such as RFID power and RFID center frequency query, etc.

Dependency of functional modules and primary execution sequences of the system are as follows.

(1) After system start-up, the first thing you see is a login interface. For users who use this system for the first time, he/she needs to register an account by entering the account number and password and confirming the password manually. Since then, the user can select to remember the account and its password before login. In this way, there is no need for the user to enter them again when the procedure is activated next time.

(2) After login check, the user enters a RFID connection interface. Please select Bluetooth to scan RFID and connect a RFID device as required.

(3) On a meter reading interface, there are two meter reading patterns for choice, namely, single reading and group reading. As for the former, meter number should be manually entered to obtain the corresponding meter information; however, meter numbers and corresponding data of multiple electric energy meters can be acquired by virtue of the latter. In the end, all data are uploaded to a cloud platform. Additionally, there also exists a meter maintenance function.

(4) On a warehouse management interface, ex-warehouse and in-warehouse conditions of electric energy meters in the warehouse can be queried.

(5) On an equipment interface, both RFID power and RFID center frequency can be queried.

(6) On a settings interface, RFID parameters and system functions can be established.

4.1 Android-based RFID Power Operation Interface

RFID handheld meter reading terminal plays a role in setting up RFID center power and RFID

operating frequency. To be specific, the center operating frequency should be established according to different frequency bands in different countries and the relevant settings interface has been given in Fig. 3(a). Setting o operating frequency depends on the distance between a handheld terminal to an electric meter. In the case that the terminal has been activated, it automatically acquires a frequency or manually adjusts the frequency by judgment. For meter data acquired from a long distance, the corresponding operating frequency should be regulated to a higher value to a moderate degree; otherwise, the operating frequency should be lowered to achieve the goal of power saving. The setting interface has been given in Fig. 3(b).



(a) Center Frequency Setting Interface



(b) Operating Frequency Setting Interface

Fig.3 RFID power operation interface

4.2 Android-based Meter Reading Interfaces

Such an interface incorporates three functions of single reading, group reading and meter maintenance. The meter reading interface has been presented in Fig. 4(a).



(a) Meter Reading Interface



(b) Single Meter Reading Interface



(c) Group Meter Reading Interface

Fig.4 Meter reading interface

(1) Single reading refers to scan the tag with RFID after clicking the link. Firstly, electric energy meter number is input in the column of “Meter Address” to acquire the required data by clicking “Electric Quantity”, “Voltage”, “Current” and “Power” buttons respectively. A hidden menu on the top right corner of this interface can be utilized to store data collected and then upload them to a cloud platform. The interface of single reading has been presented in Fig. 4(b).

(2) Group reading means that RFID is used to scan multiple surrounding electric energy meters and display major data about these meters. In other words, click the button “Start” after successful connection to obtain the corresponding meter information, including meter number, the current time revealed on the meter, the current total power of the meter, the current sharp electric quantity of the meter, the current peak electric quantity of the meter, the current off-peak electric quantity of the meter, the current valley electric quantity of the meter, the freezing time of the meter, the frozen total power of the meter, the frozen sharp electric quantity of the meter, the frozen peak electric quantity of the

meter, the frozen off-peak electric quantity of the meter, the frozen valley electric quantity of the meter, running status word 1, running status word 3 and running status word 4. Likewise, a hidden menu on the top right corner of this interface can be utilized to store data collected and then upload them to a cloud platform. The interface of group reading has been presented in Fig. 4(c).

4.3 Android-based Warehouse Management Interface

Warehouse management module of this client is aimed at making accurate records of intelligent ammeter ex-warehouse and in-warehouse conditions and querying relevant warehouse management data by entering the meter number when historical records are required. Warehouse management interface has been shown in Fig. 5.



Fig.5 Storeroom management interface

5. Experimental Analysis

50 electric energy meters were placed in the laboratory to collect data. Handheld terminals were put in positions 1m, 2m, 3m, 3.25m, 3.5m and 4m away from the meter for testing. After experiment, three representative tests and the mean value of 50 tests were selected, as those given in Tab. 2. In the context of shelter free in 3m, their accuracy reached 99%. By contrast, it dropped if the distance went beyond 3m, which signified that the accuracy was unstable. For the consideration of economic efficiency and actual demands, only data collected in 3m away from the meter conform to project requirement.

Tab.2 Accuracy rate table of distance test

Identification Distance (m)	1	2	3	3.25	3.5	4
Type I Meter Test	50	50	50	48	45	20
Type II Meter Test	50	50	48	15	12	8
Type III Meter Test	50	50	50	23	30	5
Mean Value of 50 Tests	50	50	49.48	36.72	20.22	12.36

With regard to group reading experiment, the cloud platform has the capacity to rapidly receive and store data uploaded, as shown in Fig. 6.

	meterID	count	meterData_now	meterDate_now	sign	pointData_now	peakData_now	flatData_now	valleyData_now
☐	3101222233301406AFF02	12	0.0	17-12-2614:58:56	group	0.0	0.0	0.0	0.0
☐	3101222233301406AFF05	30	0.0	17-12-2615:01:33	group	0.0	0.0	0.0	0.0
☐	3101222233301406AFF01	17	0.0	17-12-2615:01:33	group	0.0	0.0	0.0	0.0
☐	3101222233301406AFF14	9	0.0	17-12-2615:01:33	group	0.0	0.0	0.0	0.0
☐	3101222233301406AFF06	6	0.0	17-12-2615:01:34	group	0.0	0.0	0.0	0.0
☐	35023382DD90140000003	5	0.0	17-12-2615:01:34	group	0.0	0.0	0.0	0.0
☐	35073382DD90140000007	8	0.55	17-12-2615:01:34	group	0.0	0.42	0.0	0.13
☐	35033382DD90140000046	34	0.0	17-12-2615:01:34	group	0.0	0.0	0.0	0.0
☐	35073382DD90140000020	29	0.55	17-12-2615:01:34	group	0.0	0.42	0.0	0.13
☐	35023382DD90140000000	25	0.0	17-12-2615:01:34	group	0.0	0.0	0.0	0.0
☐	35023382DD90140000009	13	0.0	17-12-2615:01:34	group	0.0	0.0	0.0	0.0
☐	35033382DD90140000032	13	0.0	17-12-2615:01:35	group	0.0	0.0	0.0	0.0
☐	35073382DD90140000024	10	0.55	17-12-2615:01:35	group	0.0	0.42	0.0	0.13
☐	2330001174500000771027	102	0.74	17-12-2615:01:35	group	0.0	0.18	0.54	0.01
☐	2330001174500000571021	110	0.74	17-12-2615:01:35	group	0.0	0.18	0.54	0.01
☐	23300011745000002171023	51	0.63	17-12-2615:01:42	group	0.0	0.07	0.54	0.01

Fig.6 Group meter reading data

6. Conclusion

Research on key technology of handheld meter reading terminal was carried out in this study based on ultra high RFID. In addition to an overall design scheme of this terminal, emphasis was also laid on analyzing main control chip model selection, RFID identification module and the communication module, etc.. Meanwhile, the Android based handheld meter reading terminal software was briefly introduced. Cost of the scheme that has been in good condition during its application in the project designed is well-controlled. Therefore, prospect of the scheme is promising. It can be put into production and conveniently applied in other fields.

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