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# Resarch and design for Low-power Wireless Meter Reading System

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## Abstract:

Traditional manual meter reading method consumes time and manpower, and the precision and timeless is not reliable which makes relevant marketing and business management software can't get detailed enough and exact raw data. Therefore, we present a remote wireless meter reading system(MRS) based on ZigBee and GPRS technology. The design reduces the system cost and power consumption and improves the system's flexibility and practicality.

**Keywords:** Low power**,** Wireless meter reading, ZigBee

## 1 Introduction

Over the past decade, from manual meter, 485 meter, power line carrier meter reading development to wireless meter reading, the residents of low pressure meter reading system has made tremendous progress, but with the development and progress of the national economy and science and technology, manual meter reading and 485 meter Since labor costs, and error-prone wiring and other issues has been basically eliminated. The current widespread use of power line carrier meter reading due to the impact of fluctuations in the power grid and grid load, the meter reading is not stable enough; some can't even work properly[1][2].

Wireless technologies have been rapidly developed during recent years. Starting from military and industrial controls, it is now being widely applied in environmental monitoring and agriculture. Its advantages include the liability, simplicity, and low cost in both installation and maintenance. In the current study, we present a remote wireless meter reading system based on ZigBee and GPRS technology. ZigBee technology is especially suitable for those fields of wireless meter reading, industrial automation for its low power consumption, long-distance, low cost and excellent networking capability.

## 2 ZigBee Technology

ZigBee is an intelligent digital protocol, operating at three frequencies, with the commonest one being at 2.4GHz.Wi-Fi, Bluetooth and ZigBee work at similar RF frequencies, and their applications sometimes overlap . In the current study, we chose the following five main factors of ARMS networks to compare: cost, data rate, number of nodes, current consumption and battery life[3][4][5].

(1) Data rate: ZigBee is 250 kbps, while Wi-Fi and Bluetooth are 54 Mbps and 1~2 Mbps, respectively. Despite the lowest data rate, ZigBee is sufficient for AMRS. Generally, data traffic in a ARMS is low—usually small messages. And also, low data rate helps to prolong the battery life.

(2) Number of nodes. The capacity of network is determined by the number of nodes, and ZigBee has up to 254 nodes, the largest among the three. It meets the application demand of more and more sensors and actuators in MRS.

(3) Current consumption: ZigBee has the lowest current consumption, 30mA, while Wi-Fi, 350mA, and Bluetooth, 65~170 mA. It also greatly helps to prolong the battery life.

(4) Battery life: ZigBee chip has the longest battery life, a few months or even years.

As a whole, ZigBee technology offers long battery life, small size, high reliability, automatic or semi-automatic installation, and, particularly, a low system cost. Therefore, it is a better choice for ARMS than other wireless protocols.

## 3 Our Wireless solution for MRS

### 3.1 Overview of the solution

The constitution of MRS is shown in Fig.1. This system adopts the gateway of embedded processor STM32F407 with 32 positions of the Cortex-M4 framework. Meters are controlled through the expanded control module MSP430 and the receiving-dispatching data module CC2530 of the gateway. The gateway also communicates with all child nodes of the network via its wireless module. As shown in Fig.1, the meter is connected to ZigBee reduced-function device(RFD) module through the RS485 interface to communicate with each other in the wireless automatic meter reading system, the meter's data is transformed to the ZigBee communication protocol package by ZIGBEE RFD module and sent to the neighbor (full-function device)FFD module, then the FFD Module choose a best communication path according to the table-driven routing algorithm, and the package is spreat to the zigbee gateway with the help of the other FFD module through the way of multi-class jump along the path. After the gateway node receives the package successfully, it sends back an acknowledgement to the RFD module which sends the data first along the primary path to realize the hand-shaking communication, otherwise the RFD module will continue to send the data, until it receives the acknowledgement. Meanwhile, it transmits the package to the central manage computer which concentrate those data through the GPRS network. So realized the whole process of the wireless automatic meter reading[6][7][8].

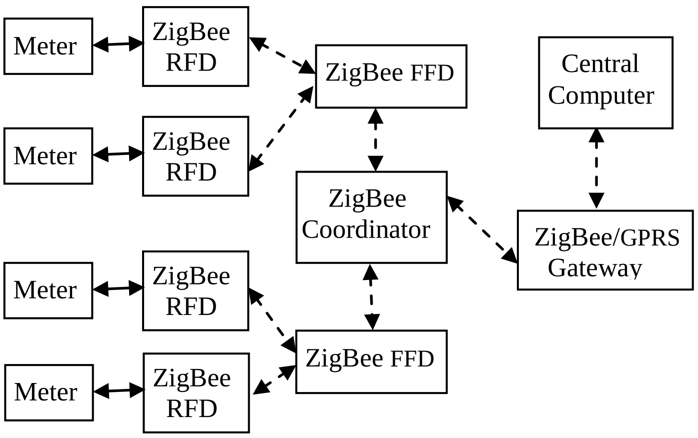


**Fig.1 Overview of the proposed solution for MRS**

### 3.2 System hardware design

The network node hardware design which includes the design of sensor node and gateway node is the basic work to construct the wireless sensor network.

### *3.2.1 Sensor node hardware design*

The constitution of sensor node hardware is shown in Fig.2.The sensor node in the system has adopted MSP430 as its microprocessor . MSP430 has rich memory resource. With 5MHz working frequency, the energy waste of MSP430 is about 1.5mw and this minor-controller has several power saving modes available to choose. Apart from rich memory resource and several power saving modes, MSP430 has several AD interfaces and I/O data lines which make it easy to use software to program. These interfaces can also be used as the interface for connecting sensor.

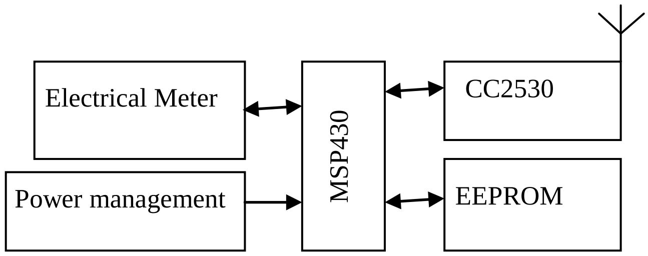


**Fig.2 hardware structure of sensor node**

The function of the corresponding module of the node of sensors is CC2530 module produced by TI Company. The CC2530 is a true system-on-chip(SoC) solution for IEEE 802.15.4,Zigbee and RF4CE applications. It enables robust network nodes to be built with very low total bill-of-material costs. The CC2530 combines the excellent performance of a leading RF transceiver with an industry-standard enhanced 8051 MCU, in-system programmable flash memory,8-KB RAM, and many other powerful features. The CC2530 comes in four different flash versions:CC2530F32/64/128, with 32/64/128/KB of flash memory, respectively. The CC2530 has various operating modes, making it highly suited for systems where ultra low power consumption is required. Short transition times between operating modes further ensure low energy consumption. Combined with the industry-leading and golden-unit-status ZigBee protocol stack(Z-Stack™)from Texas Instruments, the CC2530F256 provides a robust and complete ZigBee solution.

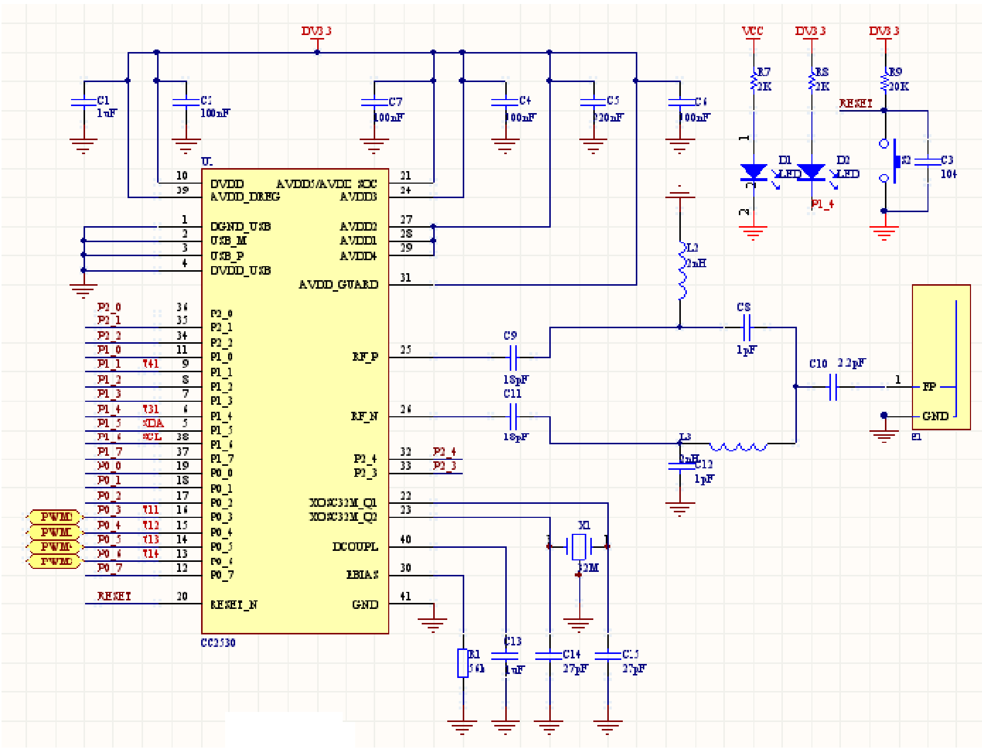


**Fig.3 CC2530 circuit**

## *3.2.2 Gateway hardware design*

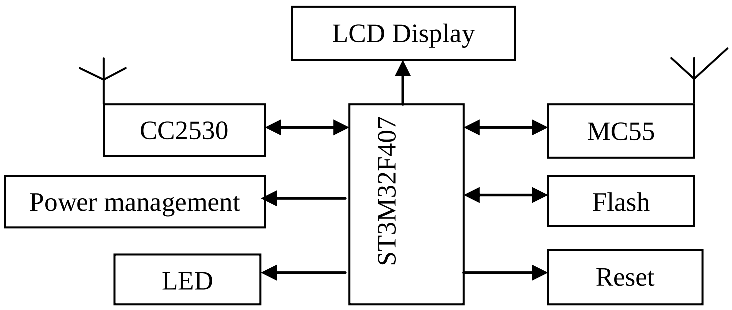


**Fig.4 hardware structure of Gateway**

ZigBee wireless network system conducts design and installation with a building as the unit. Each unit establishes a gateway. The gateway mainly realizes the work of interconnection between the ZigBee network and Internet network, on the one hand it transmits the data to remote central computer through the GPRS network, and on the other hand it sends the command which comes from the central computer to the sensor nodes of the Zigbee network. Fig4. shows the hardware structure of the GPRS/ZigBee gateway, and the gateway adopts the embedded processor STM32F407with 32 bit of the Cortec-M4 framework, MC55 produced by Siemens Company as the GPRS module. MC55 is a tri-band GSM/GPRS engine that works on the three frequencies GSM 900 MHz, GSM 1800 MHz, and GSM 1900 MHz,  has an embedded TCP/IP stack that is driven by AT commands and enables our sytem easily access the Internet.

### 3.3 Network establishment

IEEE 802.15.4 defines three types of logical devices, a personal area network (PAN) coordinator, a coordinator, and a device. ZigBee denotes them as ZigBee coordinator, ZigBee router, and ZigBee end-device, respectively. For clearness, we utilize the naming of IEEE 802.15.4 from now on. PAN coordinator is the primary controller of PAN, which initiates the network and operates often as a gateway to other networks. Each PAN must have exactly one PAN coordinator. Coordinators collaborate with each other for executing data routing and network self-organization operations. Devices do not have data routing capability and can communicate only with coordinators. Due to the low-performance requirements of devices, they may be implemented with very simple and low-cost hardware. The standard designates these low-complexity nodes as reduced function devices (RFD). Nodes with the complete set of MAC services are called as full function devices (FFDs).

The standard supports two network topologies, star, and peer-to-peer. In the star topology, all data exchanges are controlled by a PAN coordinator that operates as a network master, while devices operate as slaves and communicate only with the PAN coordinator. This single hop network is most suitable for delay critical applications, where large network coverage is not required. A peer-to-peer topology allows “mesh” type of networks, where any coordinator may communicate with any other coordinator within its range, and have messages multi-hop routed to coordinators outside its range. This enables the formation of complex self-organizing network topologies. The network may contain also RFDs as devices. Mesh topologies are suitable for industrial and commercial applications, where efficient self-configurability and large coverage are important[9][10][11].

In our project, we established the network according to the mesh topology. As shown in Fig.5, once the FFD is activated for the first time, it establishes its own network and becomes the PAN coordinator. Then it initializes the hardware, stack and application variables, choosing an unused PAN identifier of zero, and broadcasting beacon frames to sensor nodes(RFD).

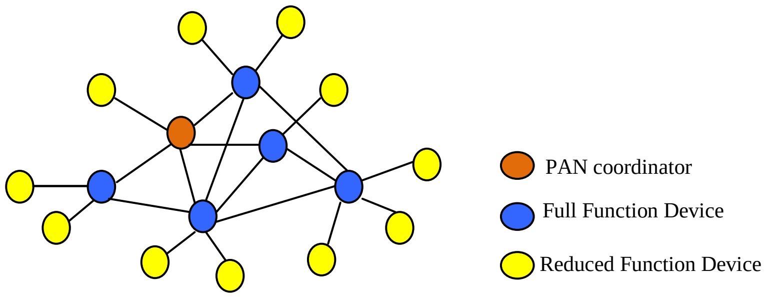


**Fig. 5 Mesh Topology**

Sensor nodes receiving a beacon frame may request to join the network. The coordinator will add them as a child device in its neighbor list and return a response. The sensor nodes will add the coordinator as its parent in their neighbor list and return an acknowledgement. The coordinator monitors all network nodes in real-time, maintaining the network information database PIB (PAN Information Base).

### 3.4 Nodes software system

The main task of the software system is the communication among the wireless nodes. It is divided into two parts, the initialization process and the information processing process. We designed the software system according to the Reference Manual:JN5121-EK000 Demonstration Application. In each node's code, interrupts are used extensively to synchronize operation, which allows the device to put the CPU to sleep for long periods whilst nothing is happening[12][13].

Fig.6 shows the initialization of the communication. Once the coordinator creates PAN, it sends out regular beacons. After the sensor/actuator nodes successfully receive and verify the data frame and MAC command frame, they send back an acknowledgement to the coordinator. Sensor nodes then go to the sleep mode. The coordinator converts its host-slave role with the sensor nodes. The coordinator then works under the slave mode, waiting for responding to a request for connection. At this time the sensor nodes work under the host mode, waiting for being demandawaken and initiating a connection request. After the initialization, the sensor nodes work under the sleep mode, refusing any connection request. This design greatly reduces the power consumption of the sensor nodes. Furthermore, because the sensor/actuator nodes are demand-activated, it effectively prevents the illegal connection request of other sensors, thus provides a safety and reliability for the communications between the coordinator and sensor nodes.

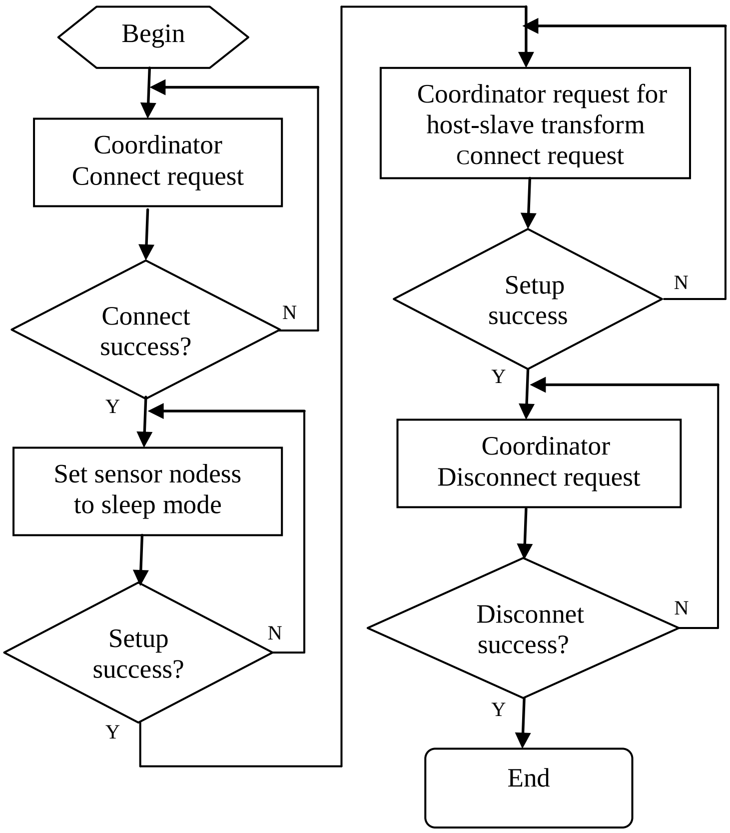


**Fig.6 Initialization of the communication**

The information processing is further divided into two sub-processes. Fig.7 shows the information processing between the coordinator and the sensor nodes. When the sensor nodes detect changes of the monitoring parameters, they primarily deal with the information, initiate the connection request and transmit the dealt information to the coordinator. It shows the information processing between the coordinator and the sensor nodes. Fig.8 shows the information processing When the sensor nodes receive an interrupt request from the coordinator, they are activated and begin to receive a command from the coordinator. After a transmission and a reception are completed, the sensor nodes return to their sleep modes. It has been proved in engineering testing that the wireless sensor nodes are under a sleep mode for 99% of the whole time, and the mathematical expectation of the power consumption may be as low as 30 μA.

# 4 Conclusion

In this study, we discussed the wireless solution of MRS based on ZigBee technology, and designed the wireless nodes, network establishment and software system. With the capabilities of self-organizing, self-configuring, self-diagnosing and self-healing, the ZigBee based AMRS provides nearly unlimited

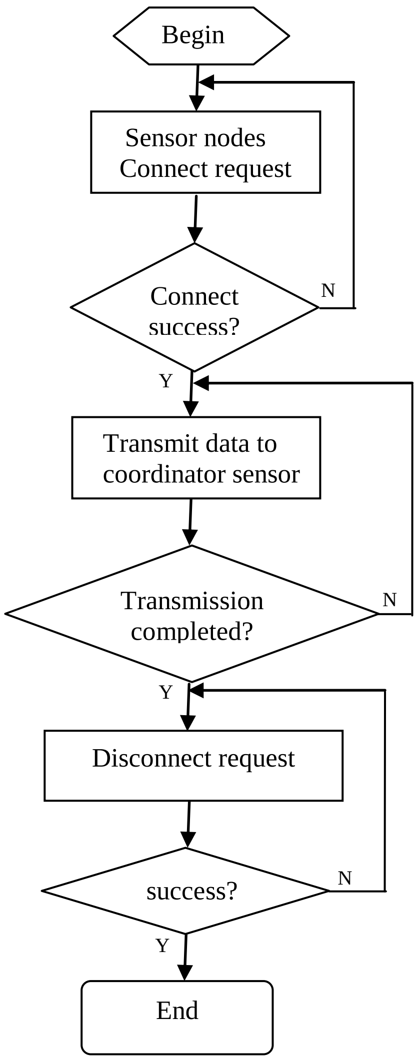


**Fig.7 Information processing**

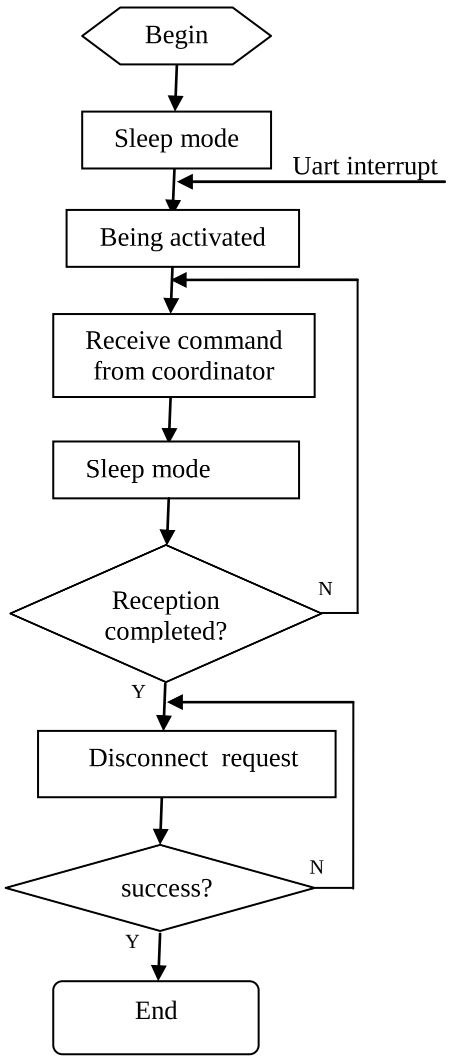


**Fig.8 Interrupt procedure**

installation flexibility for transducers, increases network robustness, and considerably reduces costs. We, therefore, conclude that the ZigBee-based monitoring and control system can be a good solution for AMRS.

## ACKNOWLEDGMENT

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