DESIGN AND IMPLEMENTATION OF WIRELESS HOME LAMP CONTROL SYSTEM BASED ON ZIGBEE

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ABSTRACT
Now every family has many different lamps, correspondingly they have their own switches and wire layouts, too. This brings our life to much trouble, and many resources are wasted. So in this paper, a new Home-Lamp System (HLS) controlled by wireless network is proposed. This system is not only clever and expedient, but also can reduce many wire layouts to spare resources. The proposed HLS is based on IEEE802.15.4, especially ZigBee protocol. The proposed scheme consists of two main parts. The one part is the hardware design; the other is the software design. The hardware design is based on CC2430 as the controller core. The hardware part hat one network coordinator, some router nodes and some terminal control nodes. The coordinator is responsible for building and managing network. The router is working for the relay controller. The terminal control nodes can get some information for its controllable devices from WPAN (wireless personal area network). The software part uses IAR Embedded Workbench. Based on Zstack-1.4.2-1.1.0 protocol provided by TI, man can program the control codes of the system. The proposed scheme can also provide the well-defined interface and the necessary basis for preparing the smart home system.

KEY WORDS
ZigBee, IEEE802.15.4, CC2430, WPAN, Smart home

1 INTRODUCTION

The present Home-Lamp control System adopts mostly the wire layout. It is complex to operate, less flexibility, and hat high cost. Additionally, it causes the resource to waste. Recently with the development and the wide application of ZigBee wireless technology, ZigBee technology is used in the Home-Lamp System. The method is not only clever and expedient, but also hat easy installation and convenient maintenance. In addition, by the combination with the different new sensors and the power controller, it can implement the remote control in the home environments. The work adopts ZigBee technology to design a new Home-Lamp wireless control System.

ZigBee is a specification for a suite of high level communication protocols based on an IEEE 802.15.4 standard for personal area networks.[1] ZigBee hat the following features: low-cost, low-power, large network capacity, high security and long transmission distance, etc. The low-cost allows the technology to be widely used in wireless control. Low power usage allows longer life with smaller batteries. Short-distance allows building WPAN (wireless personal area network). However, ZigBee is not a completely new technology and protocol. Its physical layer, MAC (medium access control) layer and data-linker layer are

defined in IEEE802.15.4-2003. ZigBee Alliance defines network layer and application layer. IEEE802.15.4-2003 specifies 3 radio bands; 868 MHz in Europe, 915 MHz in the USA and Australia, and 2.4 GHz in most jurisdictions worldwide. Data transmission rates vary from 20 to 900 kilobits/second. [2]

ZigBee network of this work consists of Coordinator, Router nodes, End Device nodes. ZigBee Coordinator and Router are Full Function Device (FFD), while End Device is Reduced Function Device (RFD). FFD has complete protocol function, for example FFD can build and manage a network, can communicate with another FFD or RFD. RFD has the simplest function, for example, RFD can not directly communicate with another RFD, only receiving the signals from WPAN (wireless personal area network).

2. HARDWARE DESIGN OF THE SYSTEM

Based on ZigBee technology, the Home-Lamp wireless control System consists of microcontroller (RFD) installed in lamp circuit, controlling and monitoring center (FFD) and wireless network system (Router). The microcontroller (RFD) contains an optical sensor, dimming controller of home lamp, communication controller system and DC power, etc. By the automatical routing function of Routers, the system can build the communication between Routers and RFD nodes to implement the wireless automatic control of Home-Lamp System.

This network has a coordinator what controls the monitor system. The coordinator manages the network, displays the net-working information and the working state of Home-Lamp System and controls the switching state of the whole network . And the system has also some Routers, that work as the relay controller of wireless nodes for the remote control. Meanwhile, the Routers are used as RFD nodes to control the switchs of home lamps, too. Additionally, the system has many End Devices, that receive only the wireless signals from WPAN to control the working state of a home lamp.

ZigBee supports three network tepology structures: star and tree typical networks, and generic mesh networks. Because the system is used in home environment, it adopts star-network structure.

The system adopts the wireless transceiver-CC2430. It is developed by Chipcon company in Norway. It is a true System-on-Chip (SoC) solution for 2.4GHz IEEE802.15.4. It has the following characteristics: low power, high receivering sensitivity, strong anti-interference, etc. It integrates ZigBee Radio-Frequency (RF) front-end, memory and microcontroller. It uses a 8-bit Microcontrolunit (MCU)-8051, and has 128Kb programmable Flash and 8Kb RAM. Additionally, it has also 14 bit Analog-to-Digital Converter (ADC), 4 Timers, Watch-Dog timer, and 21 programmable I/O pins.

CC2430 needs only few peripheral components to build a hardware circuit. Its peripheral components include the two parts, one is crystal clock circuit, the other is RF Input/Output matching circuit. The intrinsinc signal of the chip is provided by external active-power crystal, or internal circuit. The RF Input/Output matching circuit has a main purpose to match the Input/Output resistance of the chip. Meanwhile, it can provide the DC bias for internal PA and LNA of the chip.

The CC2430 hardware circuit is shown in the figure 1. The circuit adopts a nonequilibrium antenna, what connects a nonequilibrium transformer to improve

the performance of the antenna. The nonequilibrium transformer consists of capacitor C341, inductor L341, L321, L331 and a microwave transmission line.

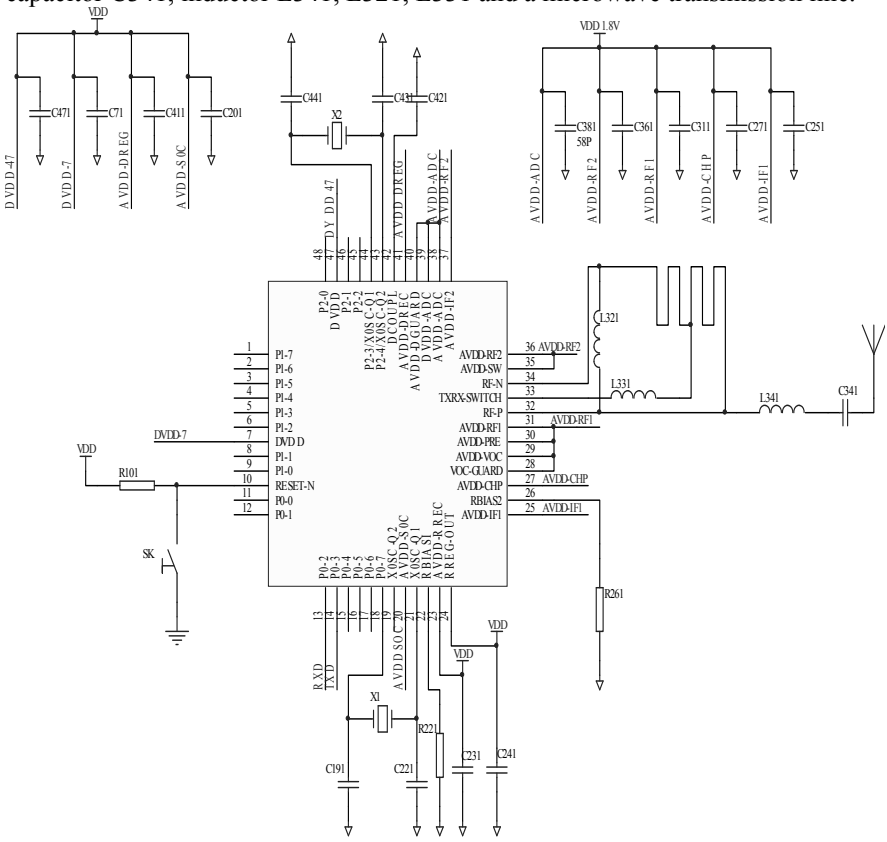

Fig.1 Diagram of CC2430 hardware application circuit

The whole circuit can meet the requirement, that the RF Input/Output matching resistance is 50Ω . R221 and R261 are the diverging resistance. R221 works for providing a suitable current for 32MHz-crystal oscillating circuit. This oscillating circuit consists of a 32MHz-quartz crystal (X1) and two capacitors (C191 and C211). A 32.768KHz quartz crystal (X2) and two capacitors (C441 and C431) compose a 32.768KHz crystal oscillating circuit. The voltage regulator supplies power for all demanding 1.8V pins and internal circuit. C241 and C421 are decoupling capacitor, that realize supply power filter to improve the stability of the chip. In order to reduce the external interference and improve the performance of RF, the anti-interference measures must be implemented for the design of analog part. For example, magnetic bead or inductor are added for the analog power; the analog grounds and the digital grounds are separately; the filter capacitors are as much as possible close to the chip; etc.

The coordinator of Home-Lamp wireless control System needs display the present network state. So the coordinator consists of CC2430, serialport part, keys and LCD. Its diagram is shown in figure2.

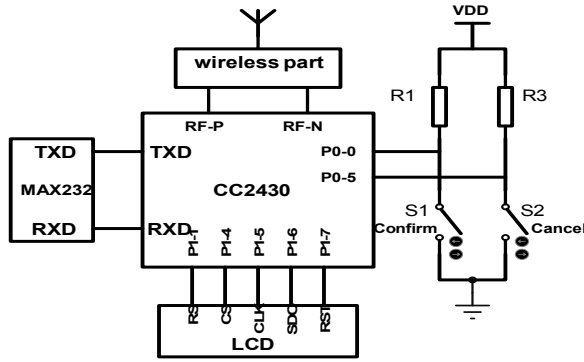

Fig. 2 Diagram of Coordinator circuit

RFD nodes and Router nodes consist of CC2430, photoresistance, serial extended interface, light-adjusting control circuit, shown in the figure 3.

3 SOFTWARE PROGRAM DESIGN

In this paper, we adopt "IAP Embeded Workbench" development environment. And based on ZStack-1.4.2-1.1.0 provided by TI, the applicationprogram of the system is writed. ZStack provides also some application interfaces, for example *aplFormNetwork()*, *aplJoinNetwork()* and *aplSendMSG()* functions, etc. User can write their development and application program by calling these functions.

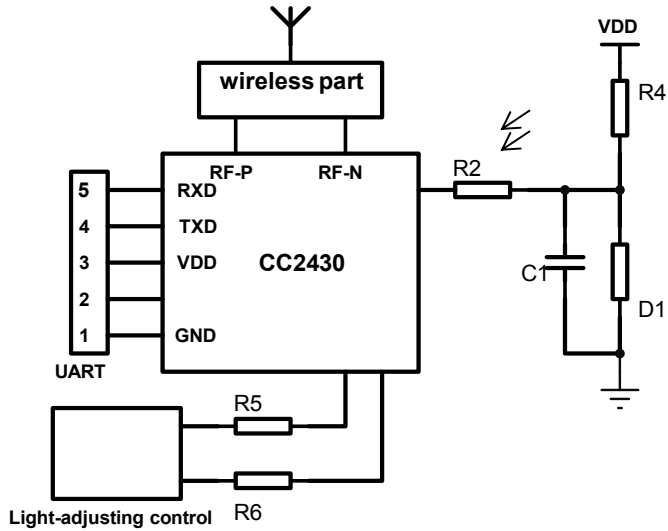

Fig. 3 Diagram of RFD and Router circuit

During working of the system, the coordinator of the wireless network will periodically detect whether keys are pressed to implement the relevant power ON/OFF commands. When the coordinator is idle, it is able to monitor wireless

signals in the air. Then it judges whether new nodes want to join in the network, and if yes, allocates new IP addresses for the new nodes.

Router is usually in the monitoring state. If it receives the power-ON command, it executes the command, and decides to retransmit or not. Meanwhile, accoding to the present light intensity, it decides turn on or not home lamps. RFD nodes are easy. They receive only the commands from WPAN, and implement them.

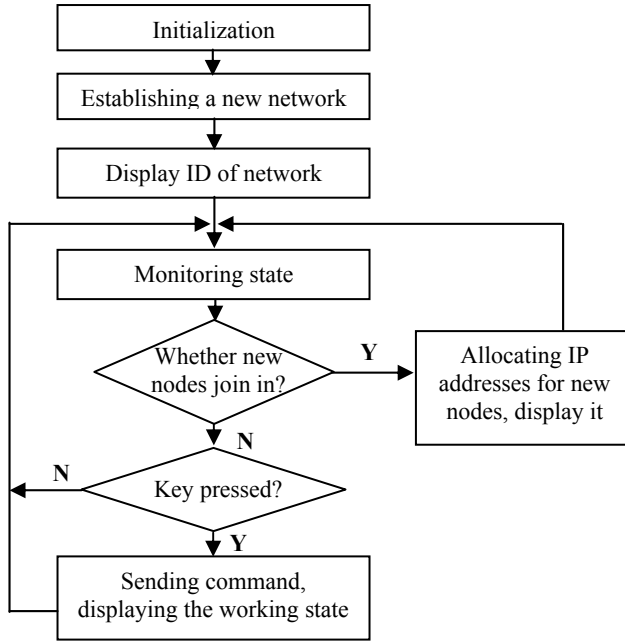

Fig. 4 Flow chat of Coordinator

In ZigBee network, the coordinator has the following functions: establishing a new network, allocating IP address, allowing the connect between MAC Layer and Application Layer, etc. After the initialization of the coordinator, it will call *aplFormNetwork()* to establish a network. The coordinator builds a network through scanning a empty channel. Then it chooses a random PANID to monitor the channel. The flow chat of coordinator is shown in figure 4.

After building a network, it is considered, how Router nodes and RFD nodes can join in the network. They can do it through calling *aplJoinNetwork()* function. They scan channels to find the coordinator. Then they obtain the IP address of the coordinator, and send their IP addresses to it. After joining in the network, the network nodes are in dormant state, until commands or data need be sent.

4. RESULT

We test the network building delay of the system, data transmission rate, and the influence of communication distance to data transmission, etc.

For single coordinator and single node, the using time of building network is 20s. For scanning 16 channels, the average using time is 150s. The using time

in first time is longer, mainly because of waiting for beacon frames, determining the channel of the coordinator. Under the condition: ca. 10m indoor distance and no partition board, data transmission rate is 250kbps. In vacancy outdoor environment and distance between 35m and 70m, the rate is 40kbps. When the distance is 300m, the rate is 20kbps.Additionally, the working current of the system is 25.7mA (sending), and 29.3mA (receiving). When it is idle, the current is only 2.5 μ A.

5. CONCLUSION

The paper adopts new ZigBee technology in Home-Lamp System. The method decrease the wire layout and cost of the system. The developed system has the following advantages: low power, low cost, easy installation, maintenance convenience, etc. So the scheme of Home-Lamp System will be widely used, and provides the well-defined interface and the necessary basis for preparing the smart home system.

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