Smart Home System Based on Zigbee Wireless Sensor Network

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Abstract: As billions of sensors and smart meters connect to the Internet of Things (IoT), current wireless technologies are taking decisive steps to ensure their sustainable operation. Parameters like temperature, humidity and working condition information of electric appliances are acquired through various types of sensors. Construction of wireless home network is done through wireless transmission chip CC2530. Monitoring on family inner or electric appliances is finished through PC client. Actual measurement results show that this system keeps convenient networking and stable operation, which meets general requirements of Internet of Things smart home system.

Key words: Smart home, ZigBee, CC2530

1. INTRODUCTION

Smart home is the utilization and realization of informatization and networking in home environment. Proposition of it leads home environment not to be simple physical habitat or living environment any more. It provides intelligent information for people to acquire healthy, safe, environmental, convenient and comfortable life(Chen Yan-Ming, Diao Bo-Yu, Zhao QingJie, Xu Yong-Jun, 2016). In the 1990s, networked smart home systems in real sense appeared such as Family Manager of IBM, smart home of Microsoft Corporation, etc. In the year of 2003, Digital Home Organization Alliance was constructed by giant corporations like Microsoft and Sony which produce equipment. This aims at development of Internet of Things(Pang Yajing, Jia Sujuan, 2016). In 2014, relevant research on smart home entered blowout stage with rapid development of intelligent device and virtual device technologies. More and more Internet enterprises and traditional electric appliance manufacture companies gradually entered in which available and practical products constantly increased, such as smart home Control System of Hisense Group, Household Ecological Chain of Millet Technology and Intelligent Network Home System developed by Kelon Group. Smart home devices gradually enter families of ordinary people. Relevant industries also present geometric growth trend(Rashid M.A., Han Xiao, 2016).

ZigBee Protocol is communication protocol under IEEE802.15 protocol family, which is suitable for constructing small-size home local area network and keeps features of low power consumption and fast networking speed (Han D., Jae-Hyun L., 2010). Compared with other wireless protocols like wifi and bluetooth, it is more simple with lower cost and power consumption. From top to bottom, this protocol is mainly divided into five layers including application layer, network layer, transmission layer, media access control layer and physical layer(Byun J., Boungju J., Junyoung N., Youngil K., Sehyun P., 2012). Its networking mode is ad hoc network in which devices carrying this module would search for those which also carry ZigBee module within certain distance and connect with them. Therefore its network speed is fast(Xiaoling Mo, 2014). This paper designs a sort of smart home control system based on ZigBee wireless communication technology, which could collect parameters of temperature, humidity and working condition of household appliance thus realizing intelligent control on them. This system utilizes two CC2530 wireless single-chip microcomputer modules to compose upper and lower computers. Lower computer connects with various kinds of sensors, taking in charge of collecting parameters of temperature, humidity and working condition of electric appliance and sending them to upper computer. As the control center of system, upper computer connects to relay control module which is responsible for receiving and processing data from the lower computer. Meanwhile it assigns control signal to relay control module in order to control switch-on and switch-off of electric appliance. Upper computer also transmits the received data to PC through serial port for display and storage.

2. SYSTEM DESIGN AND WORKING PRINCIPLE

This system utilizes zigBee wireless transmission technology whose system design block diagram is shown in Figure 1. It is divided into sensor signal emitting end namely lower computer and signal processing end meaning upper computer. Lower computer is composed of sensor and one ZigBee wireless single-chip microcomputer module, which reads data of sensor and sends it to upper computer through wireless transmission. Upper computer is composed of ZigBee wireless single-chip microcomputer module and relay control module, which does processing and analysis on data from lower computer thus determining to open or close the controlled operating circuit. It also communicates with PC through serial port.
3. HARDWARE DESIGN

3.1. **ZigBee wireless single-chip microcomputer module**

CC2530 internally integrates RF transceiver meeting standard of 2.4G IEEE802.15.4. After ZigBee protocol stack is added on software, ZigBee would realize networking. This chip has built-in 32M crystal oscillator and RC oscillators of 16M and 32.768K. Under different application requirements, corresponding oscillators would be chosen to reduce energy consumption. 32.768K RC oscillator would be utilized under sleep mode. CC2530 also has built-in abundant communication interfaces, for example A/D analog-to-digital conversion interface, SPI interface and UART universal asynchronous transceiver which cater for application requirements of most sensor interfaces. Therefore the application of this chip helps acquisition of system to keep good expansible (Jian Yu, Wangang Wang, 2015).

3.2. **Temperature sensor circuit**

This design selects DS18B20 to be temperature sensor which is a kind of single bus data temperature sensor with extensive measurement range and high precision. During communication only one communication line is needed instead of clock line which would communicate with any ordinary IO of CC2530. Its peripheral circuit configuration is very simple as shown in Figure 2 (Huang Bo, Peng Yong, 2016).

3.3. **Humidity measurement module**

Induction part of humidity measurement module is HS1101 humidity sensor which is a type of capacitor based on unique process. Humidity change results in changing of dielectric constant between two electrode plates thus leading to change of HS1101 capacitance value. Figure 3 shows the humidity measurement circuit (Huang Bo, Peng Yong, 2016). Frequency of multivibrator outputting signal which is composed of 555 timer changes with capacitance between 2nd port and ground. Put HS1101 between ground and 2nd port of 555 timer. This converts capacitance value into frequency value of outputting signal. Utilization of single-chip microcomputer could measure frequency of outputting signal of 555 multivibrator, according to which capacitance value and relative humidity value would be calculated.
3.4. Relay control module

Circuit design of relay control module is shown in Figure 4. As CC2530 outputs low current, which could not directly drive the electromagnetic relay. One triode accesses to the output end in which common-emitter amplifier circuit is utilized to amplify current and the amplified current is transmitted to electromagnetic relay. A simple working circuit is set at the back end of electromagnetic relay. When it operates, LED lights on.

3.5. Serial port communication circuit

Figure 5 shows circuit diagram of serial port communication module in which 11 pin and 12 pin of MAX232 chip are respectively connected with P0_3 port and P0_2 port of CC2530 chip. Besides being ordinary I/O ports, both them are UART0 serial port communication interface of CC2530. Communication with computer would be realized through setting UART0 associate register of CC2530.
4. SOFTWARE DESIGN

Software of this system includes upper computer software and lower computer software. Figure 6 is the flow diagram of lower computer master program. Compared with AT89S52 single-chip microcomputer, CC2530 has multiple crystal oscillators. During CPU initialization at the beginning, suitable oscillator would be selected after which radio frequency function is initialized. Besides system clock, CC2530 could set timer clock which is equal to or less than system clock. Its default state is equal to system clock. As humidity measurement needs precise timing to 1s, many times of system interruption are needed to finish this requirement. Reduction of timer clock would reduce the number of interruption times within 1s thus greatly improving timing precision.
Initialization of upper computer basically keeps the same with lower computer. The difference is that upper computer has one more serial port initialization. Upper computer program reads working conditions of electric appliances controlled by relay and does control on relay combining with the collected temperature and humidity data from lower computer. For example, air conditioner would be turned on if temperature was high. Humidifier would be turned on if humidity was low. After that, all data before control action and the acquired actions would be sent to PC and displayed through serial port transmission. More effective alarm would be done through PC if relevant software was written at PC terminal. Figure 7 shows the flow diagram of upper computer.
5. SYSTEM MEASUREMENT RESULTS

For the purpose of verifying accuracy of system, it does measurement on dropout rate and Receive Signal Strength Indicator namely RSSI. Data is transmitted to home gateway from computer client and then sent to terminal node through coordinator. After terminal node finishes data receiving, it sends data to computer client. The sent data are compared with the received data on PC in which measurement is done between different distances. The measurement results are shown in Table 1 and Table 2.

**Table 1. Measurement Results of System being at 85bit/s**

<table>
<thead>
<tr>
<th>Measurement distance/m</th>
<th>5</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dropout rate</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>RSSI</td>
<td>-31</td>
<td>-37</td>
<td>-48</td>
<td>-56</td>
<td>-57</td>
<td>-72</td>
</tr>
</tbody>
</table>

**Table 2. Measurement Results of System being at 140bit/s**

<table>
<thead>
<tr>
<th>Measurement distance/m</th>
<th>5</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dropout rate</td>
<td>0.10</td>
<td>0.09</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>RSSI</td>
<td>-61</td>
<td>-74</td>
<td>-80</td>
<td>-92</td>
<td>-79</td>
<td>-98</td>
</tr>
</tbody>
</table>

6. CONCLUSION
For the sake of realizing smart home management, this paper designs a system which would monitor parameters of family temperature, humidity and working conditions of household electric appliances. System measurement results show that this system keeps certain feasibility and stability, which could accurately and timely acquire parameters of temperature, humidity and working conditions of electric appliances. It realizes automation control on part of electric appliances thus reaching design objectives through processing these parameters. This paper basically finishes design requirements of smart home control system. Sensor measurement and control of other parameters are quite similar with temperature and humidity of this system. Just relevant sensors need attaching.

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