RESEARCH ON THE RELIABILITY OF WSN COMMUNICATION SYSTEMS FOR ACTIVE DISTRIBUTION SYSTEMS

Youwei Huang
Shenzhen power supply planning design insititute
Shenzhen -China
853078452@qq.com

Liang Li, Chongjie Zou
Shenzhen university
Shenzhen -China
liliang060312@126.com
chongjiezou@163.com

Jinyong Lei
China southern power grid
Guangzhou-China
leijinyong@163.com

Yi Qin, Lei Zhang
Microgrid EMS LAB
Shenzhen –China
Jason.qin@microgridlab.cn
zhangl@microgridlab.cn

ABSTRACT

The active power distribution system is a power distribution system which has flexible structure and can realize active control and active management, and one of its key technology is to establish a real-time and effective communication system[11]. Since WSN is flexible, easy to expand, and don't need wiring, has been widely used. This paper describes the design of using TI's a system on a chip --CC2530 of Zigbee sensor network as a communication carrier communication system for WSN, describes the key technology which is the time division multiplexing technology has been achieved on the platform of CC2530 of ZigBee system-on-chip .The proposed solution can establish real-time communication between communication terminal, communication sub-station, and the main communication station three real-time connection, and based on the real-time monitoring and prediction of energy management system, and It has been practical application in the laboratory ,which is independently developed by our laboratory, Its reliability has been verified.

Key words: active power distribution system, WSN communication system, reliability

INTRODUCTION

In the process of the development of smart grid, power shift from passive to active. Active power distribution system is more advantageous to the participation of distributed generation, more conducive to the improvement of power quality, more conducive to the efficient use of energy. To make the distributed energy off-grid successful operation, at the same time, improve the utilization of distributed energy, alleviate the distributed energy impact to power grid, a new kind of grid structure and technology - micro power grid was put forward. Micro power grid is a concentration of power and electricity as one of the miniature with the grid, is an effective way to implement active power distribution system. As the state, enterprises of renewable energy power generation growing importance, unified management of distributed energy and important load demand also increasingly clear and compelling. The growing demand make the demand of micro power grid project also to increase rapidly. And how to build a real-time, effective and efficient micro grid communication system became the key problem of the research of micro power grid.

From the corner of the active power distribution system in this paper, the concept of micro power grid and its application, according to the requirement of micro grid communication system construction is put forward based on Zigbee wireless communication solutions. And built based on a laboratory environment, effective WSN (Wireless Sensor Network) communication system, independent research and development of energy management system of power distribution in the laboratory, the reader to a novel active power distribution system of WSN communication system solutions.

Later, we studied the reliability of WSN communication, wireless channel signal gain and optimization planning solutions. The scheme to improve the reliability of communication.

ESTABLISHMENT OF THE WSN COMMUNICATION SYSTEM

The establishment of the WSN communication system described in this paper is based on micro network laboratory (nanshan district, shenzhen, China). The WSN communication system uses the TI's CC2530 of ZigBee SoC sensor networks as a communication carrier to design a real-time time-division multiplexed sensor network, it is characterized by small-scale, multi-node, real-time requirements[7]. Grid structure of lab shown in Figure 1 (The red line in the figure represents the communication system structure of the network laboratory):

Based on Zigbee wireless communication technology we construct the conmmunication system, and WSN technology's application in the micro network is: through the photovoltaic inverter, power distribution cabinets, PCS, BMS deployed on some of the sensor nodes, gathering all kinds of power and non-electricity information, such as voltage, current, power, power generation, switching state, environmental temperature, etc., and transmitted by wireless sensor network (WSN) to the energy management system, the real-time display, at the same time for all kinds of equipment running

status, power quality, such as real-time monitoring, data can be the limit, the circuit breaker tripped, switch displacement, equipment failure, communication failure alarm, etc. It can also be carried out on the circuit breaker, disconnecting switch, etc points switch remote control operation, the safe and stable operation of power grid plays an important role.

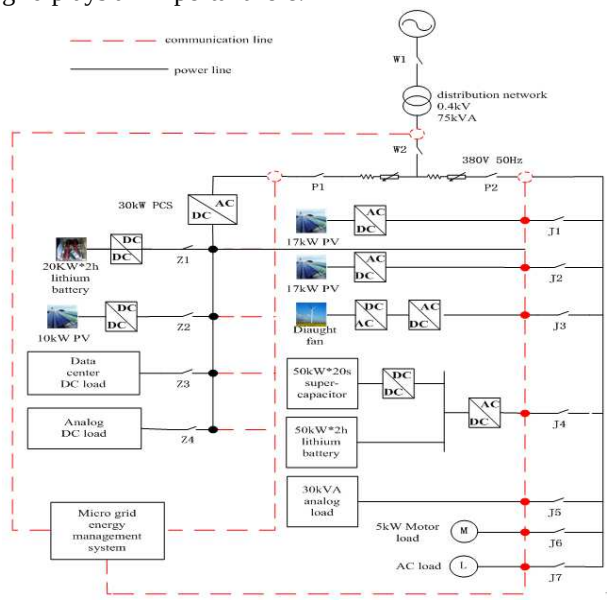

Figure 1 grid structure of micro network lab

The construction of the whole WSN communication system based on Zigbee wireless sensor network, the network topology diagram shown in figure 2 as follows.

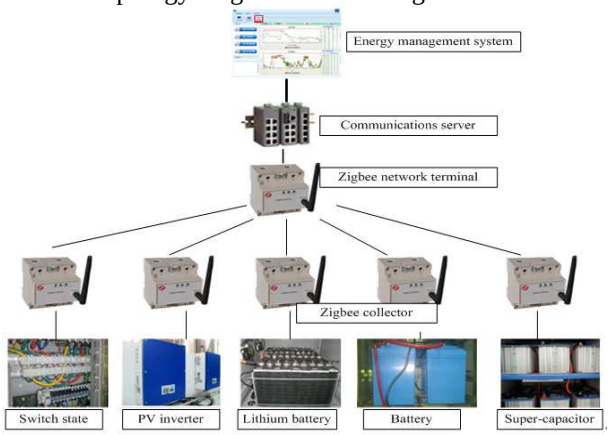

Figure 2 Network topology diagram

From figure 2, the Zigbee collector directly with distribution cabinets, photovoltaic inverter, battery, super capacitor equipment connected to each device have their separate addresses, so as not to conflict. Zigbee collector will be collected data such as current, voltage, power, temperature, switch state and output forwarded to Zigbee network terminal, Zigbee network terminal to collect data is passed to the communication server protocol conversion and eventually passed to the energy management system.

CC2530 be designed by time-division multiplexing

In order to ensure WSN communication system can run reliably and quickly ,using the features of CC2530 that can be applicabled to time-critical time-division multiplexing wireless communication, the reliability of the communication system proposed solution to ensure the reliability of the whole micro-grid communications laboratory .

Because ZigBee random access MAC layer, and does not support time division multiplexed channel access method, it is not well supported some real business. [4]The high performance CC2530 RF transceiver physical layer ZigBee / IEEE 802.15.4 protocol implementation, send and receive status consistent jumps, jump from any one state to the next state can be calculated from the time of its chip data for time-critical time-division multiplexing wireless communications.

CC2530 RF Radio Frame Format							
Frame Head		Data In FIFO					
Preamble squence	SFD	Frame Length	Frame Control Field (FCF)	Data Sequence Number	Address Information	Frame Payload	Frame Check Sequence (FCS)

Figure 3 frame format of CC2530

CC2530 includes a separate RX FIFO and TX FIFO, the maximum length allowed valid data is 127byte[5], the frame format shown in Figure 3, the first four bytes of data sent the guide head (Preamble squence) and a byte delimiter when sending (SFD), and then read the data in the TX FIFO, FIFO indicates the first byte of the last two bytes in the FIFO data packet length, the packet is automatically generated RF module checksum, the other mode configuration users can choose to use the data, such as frame filter, the source address matching, automatic retransmission, automatic reply. Said transmission and reception functions of the system design to meet the time-division multiplexing the data protocol off the RF module, the master node and the data transmission from the node of the process shown in Figure 4 and Figure 5.

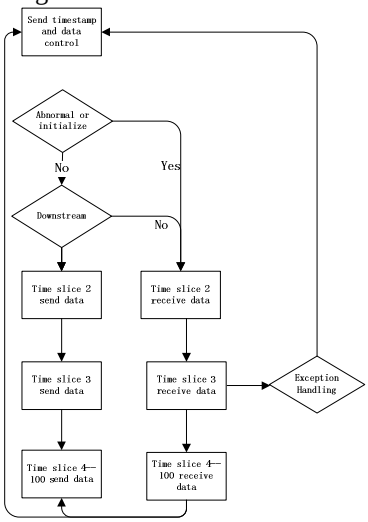

Figure 4 The master node flowchart

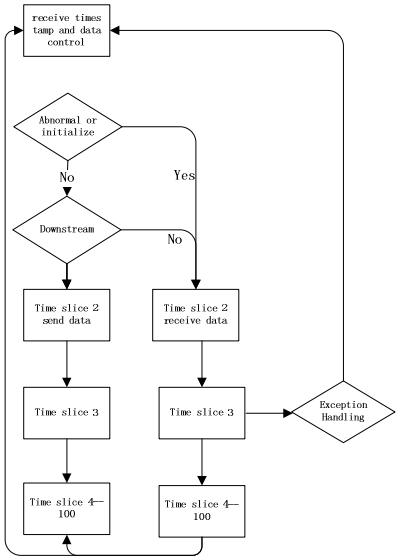

Figure 5 The slave node flowchart

After booting into the system initialization state, the master node sends the time stamp to synchronize the slave nodes, and receive feedback from the node at the time of registration from the network nodes. After initialization, the master node sends a timestamp with a data control commands to control the following data transmission period (1s) within receipt of this information, the synchronization time, receive control commands, and enters the data transfer status from the node. After each master node downstream data for a time period to send the next period of time to receive confirmation from the node, if an exception occurs, the system re-enter the initialization state, restore the data path.

Experimental results are shown in Figure 5 and Figure 6.

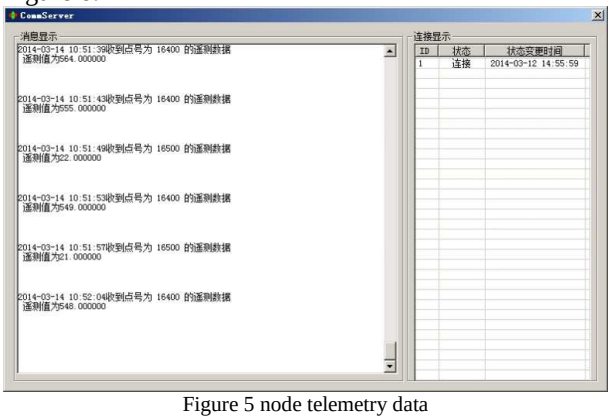

Figure 5 node telemetry data

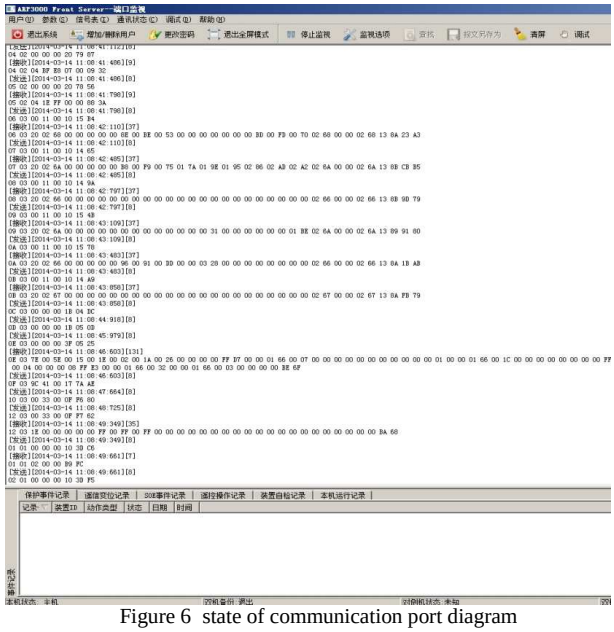

Figure 6 state of communication port diagram

Analysis: This method is for the communication network load is low is very effective. Through testing, the system was indeed an effective organization, this mechanism ensures reliability under low load conditions communications.

Conclusion

With the development of wireless networks, the integration of sensor technology, information processing technology and network communication technology, wireless sensor networks are more and more popular in the eyes, it was named one of the three high-tech industry in the future. ZigBee technology appears to fill the low-cost, low-power and low-rate wireless communications market gaps and become the best choice to play the current task of organizing wireless sensor networks.

This paper describes a comprehensive Shenzhen Micro Grid Energy Management Laboratory WSN communication system, the communication system based on IEEE 802.15.4/ZigBee protocol using CC2530 apply to time-critical time-division multiplexing wireless communication characteristics of wireless sensor network data acquisition system designed for precise, its reliability, high speed through experimental verification, better able to meet the needs of active distribution systems, providing more data to support the power system operators and planners to better adapt to actual project needs.

REFERENCES

[1] F. Goodman et al., 2009 ,“Update to Strategic Plan for ADA/Smarter Distribution Systems”, EPRI Technical Report 1016031.

[2] Texas Instrument. 2009,”Z-Stack Monitor and Test API Datasheet. “

[3] The ZigBee Allianee, 2002," ZigBee Overview".
[4] Jon Adams California. ,2004,"Designing with 802.15.4 and ZigBee". Industrial Wireless APPlications Summit.
[5] Jian-Ming Liao ; Xue-Qin He ; Guo-Ming Lu ; Si-Yu Zhan ,2013,"The research and design of Zigbee wireless networking based on CC2530", Wavelet Active Media Technology and Information Processing (ICCWAMTIP), 2013 10th International Computer Conference , Digital Object Identifier, Page(s): 263 - 266 .
[6] Gang Lu, Bhaskar Krishnamaehari, Raghavendra Cauligi S. Performance Evaluation of the IEEE 802.15.4 MAC for Low-Rate Low-Power Wireless Networks DePartment of Electrical Engineering, Universityof Southern California Los Angeles.
[7] Parker Andrew D ,2004,"A Guide For the Clueless: IEEE 802.15.4 Standard for Low-Rate Wireless Personal Area Networks(LR-WPAN)".
[8] An Update on Wireless Standards Activity,High Frequeney Electronics,2004.
[9] Texas Instrument. 2009.12," ZigBee Sensor Monitor Datasheet."
[10] Doo Seop Yun,Sung Ho Cho. 2008,"A data transmission method in ZigBee networks using power efficient device". Advanced Technologies for Communications..pp.162-165.
[11] G. Celli, E. Ghiani, S. Mocci, F. Pilo, G. Pisano and G.G. Soma,Aug. 2010 ,"Reliability Assessment of Active Distribution Network", in Proc. Of CIGRE Session 43, paper C4-303
[12] NIST, , 2010, "Office of the National Coordinator for Smart Grid Interoperability," NIST Framework and Roadmap for Smart Grid Interoperability Standards.