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Wireless Sensor Network in the Photovoltaic Power Generation Monitoring System

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Abstract

The sensor layer in the monitoring and control system of Solar PV Power Generation collects PV array state information. The amount of solar PV array is so large and the distribution of solar PV array is so wide that cable connection isn't suitable. The wireless communication technology ZigBee is a data communication network protocol based on the underlying short-range data 802.15.4, which can conveniently collect surrounding environment information and status data of photovoltaic power.

***Keywords**: photovoltaic power generation, ZigBee, RFD, FFD*

1. Introduction

The monitoring and control system of Solar PV Power Generation consists of three layers: the sensor layer, the PLC field monitoring and control layer and the remote network monitoring and control layer. The sensor layer is the lowest layer which is in charge of collecting state information; the PLC field monitoring and control layer is middle layer which is in charge of spot communication、test and control, collecting and processing information; the remote network monitoring and control layer is in charge of realizing the optimized control, failure diagnosis. The solar photovoltaic (PV) power generation utilizes solar PV array to achieve photoelectric conversion. The amount of solar PV array is so large and the distribution of solar PV array is so wide that in the sensor layer, it is difficult and expensive to transmit signals with cable connection. On the other hand, the signals are all weak, the cable connection will consume the power of signals and decrease the anti-jamming ability. ZigBee wireless sensor network can not only save the cost but also realize signal's lossless and reliable transmission.

The wireless communication technology ZigBee is a data communication network protocol based on the underlying short-range data 802.15.4, which is a two-way wireless communication technology of short range, low complexity, low power consumption, low rate and low-cost [1-3]. It is mainly applied to the electronic equipments of short range, low power consumption and low transmission speed to transmit data as well as the transmission of periodic, intermittent and low reaction time data.

The topological structure of the wireless sensor network of ZigBee, photovoltaic power system, is adopted. The device type of the network panel point includes FFD and RFD. FFD acts as the network coordinator to establish, initialize, and configure network. As the terminal panel point, RFD connects various kinds of sensors and deliver information to FFD (RFD can only contact FFD and RFD cannot contact among themselves). The Network will choose an FFD as the main FFD panel point from which data will be transferred to network.

2. Hardware Design of ZigBee wireless

2.1. RFD Design

RFD is primarily in charge of collection, preprocessing and wireless transmission of the relevant inverter parameters and working environmental parameters in the synchronized

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photovoltaic power system, and information such as the working temperature current voltage open-circuit voltage and short-circuit current of the photovoltaic module. CC2530 and the corresponding sensor module is the core device to realize RFD in the design process. From the perspective of function, RFD can be divided into power module, data-collecting module and micro control function module. The corresponding relations of each modules and hardware structures are illustrated in Figure 1.

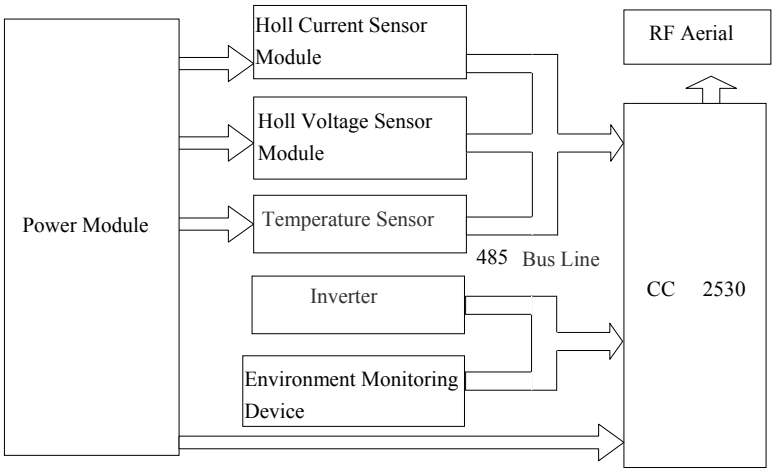

Figure 1. The Program Flow Chart of the Sensor Panel Point

2.1.1. Power Module

In design, the dry battery supply and solar power supply are combined. When solar cells work normally, solar power supply electricity to RFD; when the solar cells can't supply enough power, the backup dry battery will feed CC2530 in order to ensure the continuity of monitoring system.

2.1.2. Data Collection Module

CC2530 has eight configurable 12-bit ADC input. Integrated temperature sensor in CC2530 can collect temperature signal. The collection of open circuit voltage、short circuit current、work voltage and work current is done by Holl sensor. Figure 2 shows the way of holl sensor connection [4].

(a) Current measuring circuit (b) Voltage measuring circuit

Figure 2. Holl Sensor Wiring Diagram

Environmental signal can be achieved by solar radiation monitoring system which can monitor all solar radiation、scattered radiation、direct radiation、reflected radiation、net radiation and duration of sunshine and can store date automatically in long time. Besides, air velocity transducer can used to monitor wind direction and velocity.

Figure 3. Solar Radiation Monitoring System

2.1.3. Micro Control Module

The core device of micro control module is CC2530 which has 2.4GHZ RF transceiver. The wireless module design can be accomplished by add-in inductance and capacitance on the pin RF_N and RF_P2. Figure 4 is CC2530 applied circuit principle drawing.

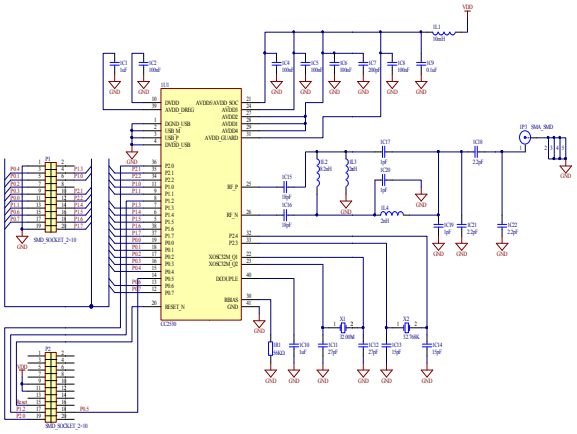

Figure 4. CC2530 Applied Circuit Principle Drawing

2.2. FFD Design

FFD is responsible for the establishment of the wireless sensor network and receiving, checkout and transmission of information. The core device of FFD is also CC2530. In terms of hardware design, RFD has data-collecting module while FFD does not. The former has serial interface communication module while the latter does not.

3. Software Design of ZigBee wireless

The IAR embedded operation platform is adopted. The software is based on the ZigBee protocol introduced by TI Corporation. The version used is IAR Embedded Workbench 7.51A. The ZigBee protocol version is Z-Stack-CC2530-2.3.0.

3.1. RFD Software Design

RFD program flow chart is shown as Figure 5. The system start-up and system initialization primarily aim at the transfer and application of the Z-Stack protocol. The other part

of the program flow chart is the software development in the application layer [5-7].

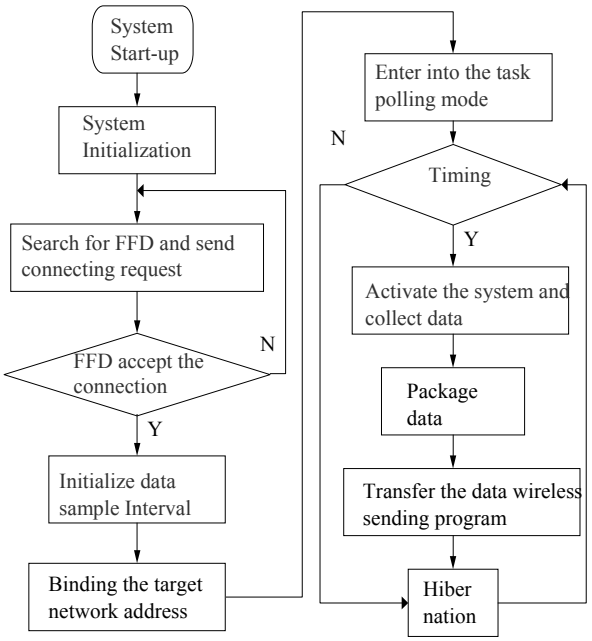

Figure 5. The Program Flow Chart of the Sensor Panel Point

3.2. FFD Software Design

The main task of FFD is to build the wireless sensor network, to respond to the access request of RFD and to transfer the collected data to the mainframe. The program flow chart of coordinator panel is illustrated as Figure 6.

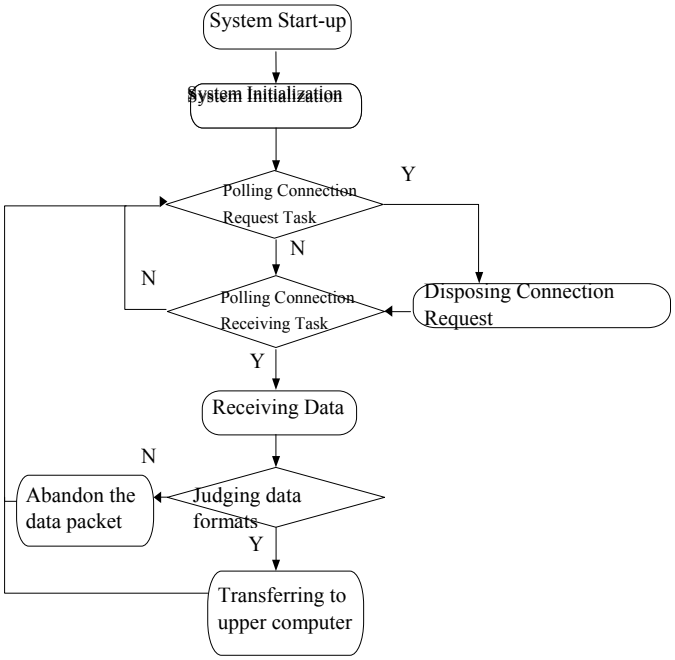

Figure 6. The Program Flow Chart of the Coordinator Panel Points

4. Experimental Analysis

Experimental panel consists of PV array、sensor、grid-connected inverter、solar radiation monitoring system、ZigBee network、WEB servicer、Internet and remote computer. In the remote monitoring design, B/S model is used as architecture; SQL Server 2005 is used as data base design platform; ASP.NET is used as server development technology; Internet is used as communication platform; IE browser is used as client.

In experiment, all data from the sensor and actuator layer can be received by remote computer. Figure 7 is client human machine interface. Figure 8 and figure 9 is data display chart which includes voltage、current、environmental data and so on.

Figure 7. Client Human Machine Interface

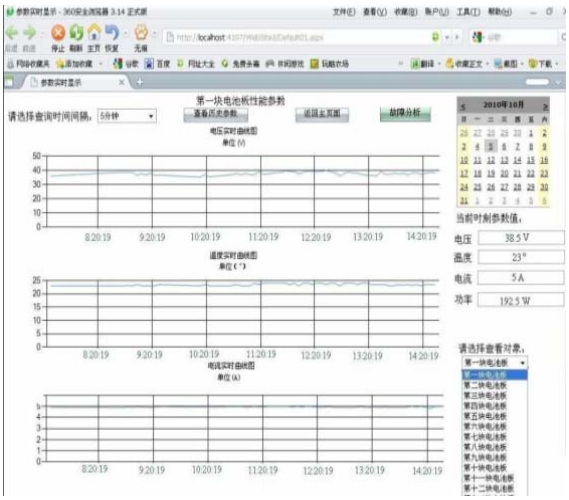

Figure 8. Data Display Chart

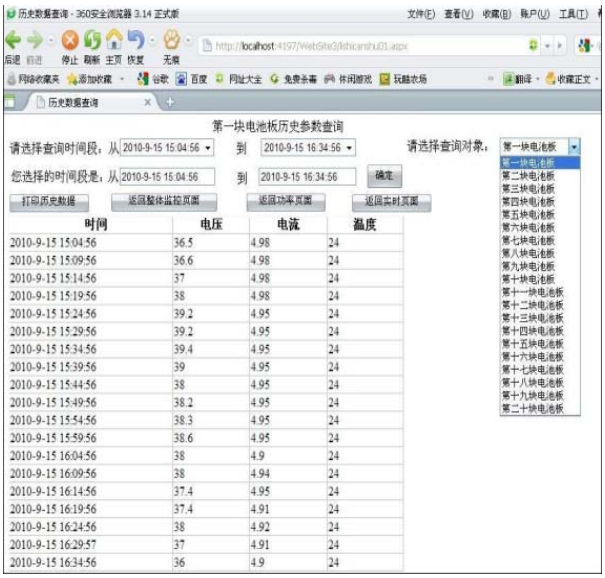

Figure 9. Data Display Chart

5. Conclusion

The ZigBee underlying data collection of photovoltaic power generation is characterized by wide coverage, strong self-adaptability and convenient and flexible layout. It can conveniently collect surrounding environment information and status data of photovoltaic power on unattended conditions.

Acknowledgements

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