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山地果园中低功耗无线滴灌控制装置设计与试验

Design and test of wireless drip irrigation control in orchard with low-power

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中文关键词: 单片机 无线传感器网络 控制系统 滴灌 低功耗 果园

英文关键词:microcontrollers wireless sensor networks control systems drip irrigation low power dissipation orchard

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中文摘要:

针对山地果园布线困难，而大面积滴灌需要分区控制并集中管理的需求，构建了低成本、低功耗、能满足定时分区灌溉与集中管理需求的小型无线滴灌控制装置。装置采用无线通信方式，硬件选用低功耗微控制器与双稳态电磁阀，系统软件采用基于CC1100无线唤醒机制的低功耗间同步通信算法，具有避免信道拥塞的特点。试验表明，输入电压9 V时，控制系统静态电流为400 mA、无线唤醒工作电流为19 mA、工作周期内平均电流为439 mA；1节鹏辉450 mAh的AA电池可供系统至少可工作38 d；果园内RSSI信号衰减测试表明通信距离超过60 m，最高平均丢包率为23%；有遮挡的环境中数据丢包率将大于无遮挡环境，但接收信号强度相差不大；在果园环境中尝试使用电力线载波适配器、大功率WiFi无线网桥、GPRS DTU 3种远距离通信模块建立总控制器与远程监控端的数据链路，链路试验表明，GPRS DTU与大功率WiFi网桥均能成功建立通信链路。相比之下，GPRS有强的适应性；采用无线控制系统，系统准时开启电磁阀，开启时间误差小于5 min，土壤含水率变化呈现快速上升后缓慢下降的变化，灌溉区域的土壤含水率保持13%以上，可应用于岭南绝大部分山地果园。解决了控制装置的布线工程困难，实现可远程传输滴灌信息和监测滴灌状态，并可进一步实现分区控制与轮灌控制。

英文摘要:

Abstract: In China, commercial electricity was not available in most mountain orchards. Therefore, low-power systems are required. On the other hand, strong demands for developing automatic irrigation systems also existed in those areas. It's also important to implement the central management strategy for those irrigation systems. Wireless networks could be helpful in transmitting soil moisture information and monitoring irrigation status. Taking advantage of wireless networks in the irrigation system for further implementation of a central control strategy is becoming a hot topic in irrigation engineering. This paper is aimed at providing a low-cost and low-power wireless irrigation solution for small-scale orchard growers to realize automatic time-control irrigation. The system was composed of several nodes, each node of hardware consisted of a MSP430F2132 micro controller, a short range RF transceiver (CC1100, Texas Instrument), an RS-232 interface for long distance communication module, an LCD (liquid crystal display, JLX12865-0086PC) module, a 9 V Battery module, a valve driving circuit and a soil moisture sensor (Decagon EC-5 or other) interface. Time synchronization communication protocol was designed for system nodes; therefore, the whole system could enter the sleep mode when there was no irrigation task. Furthermore, the WOR (wake on radio) feature of the RF module also helped to reduce power consumption of the nodes when the nodes were woken up for synchronization. The system power consumption test was performed under 9 V battery voltage; the quiescent current consumption is 400 μA. While the WOR current consumption was 19 mA, the current consumption of the system was 439 μA on average. Calculations also indicated that the charge of daily operating a pulse solenoid valve covers only a tiny portion in a whole node's daily charge. The battery discharge experiment in the conditioning of 100 mA const current revealed that the selected battery module could provide a charge of 400 mAh. In the test, output voltage dropped from 9 V to 5 V. According to the estimation, the system could run for at least 38 days without changing batteries. Communication tests in mountain orchards showed that the minimum packet loss rate when nodes were randomly distributed was 6.19%, the effective communication distance with 3 dBi antenna on each node reached 70m. The RSSI (received signal strength index) did not show a significant difference in the experimental orchard compared with open field RSSI experiment results, but the packet loss rate was much higher when in the deep orchard. The test of long distance communication module showed that the PLC (power line communication) Module (Zinwell PWQ-5101) had few chances to establish a successful data link while the GPRS and high power WiFi module held a stable data link between the remote monitoring terminal and the control system. The system was utilized for irrigation control, irrigation valves were turned on every day at 8:00 am, the collected soil moisture showed a rapid increase when valves were turned on and decreased slowly after irrigation valves were turned off, the time control error was less than 5 minutes and soil moisture rate was maintained above 13% during experiment periods. These tests proved that this system could be suitable for mountain orchards in southern China.

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