



Research Article

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Design of wireless sensor network node based on CyFi technology and ARM7 system

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ABSTRACT

This paper presents design of wireless sensor network node based on CyFi and ARM7 system. The system is based on ARM7 system with high performance and low power LPC2214 as hardware platform, and the system is designed based on the principle of modular. This paper designs the nodes in wireless sensor network and gets the infrared sensor circuit, RF communication circuit, and peripheral interface circuit design and data transmission process together. In this paper, using the CyFi wireless sensor network, and through the implementation of binding and data nodes collection of USB interface in the PC machine. The experimental results show that the mobile node is suitable for dynamic information in wireless sensor networks, complex tasks. The sensor node has the characteristics of simple configuration, easy expansion, and high reliability.

Keywords: Wireless sensor network, ARM7, Sensor nodes, CyFi.

INTRODUCTION

Wireless sensor network nodes are tiny, very limited resources is the basic function unit without sensor network, responsible for information collection, data processing, information transmission. With the development of MEMS technology, microelectronics technology, network technology and computer technology, the wireless sensor network has become a reality. Researchers use the embedded technology to develop a small board of wireless sensor network node, which in 30 years ago is still only an idea; single chip wireless sensor network node is already published, but from the utility still have quite a way to go. In order to networking technology and energy management technology research of wireless sensor network, we developed a sensor network node based on ARM7 LPC2214.

Sensor network node design is based on ARM microcontroller. Presents the principle diagram of hardware design based on ARM7 series LPC2214 chip as the core, elaborated the infrared sensor circuit, RF communication circuit, peripheral interface circuit design and data transmission process. The sensor node has the characteristics of simple configuration, easy expansion, and high reliability. Sensor network can realize the data collection, processing and transmission applications, it is a hotspot in the field of information.

Through the use of direct sequence spread spectrum (DSSS) modulation technology, CyFi is able to transmit data back from the possible errors, thus providing excellent connection reliability [1]. For the interference from the same work in a very crowded 2.4 GHz band Wi Fi, Bluetooth, ZigBee and other wireless technology, the frequency hopping technology CyFi can channel to preset frequency interval automatically search for clean communication, as shown in figure 1. At the same time, CyFi link management function according to network environment will transmit power; the transmission rate is automatically adjusted to ensure reliable links on optimal allocation. DSSS modulation, frequency hopping technology and mature link management algorithm makes CyFi become the high reliability of the wireless solution 2.4 GHz band.

The development of the research hotspot in wireless sensor networks mainly focuses on the network technology and the protocol should be used. The key technology of the network itself mainly in three aspects: network communication protocol, network management technology, network support technology. In network communication protocol research is focused on the study of the data link layer of MAC protocol and network layer routing protocol; in the network management technology layer, the major implementation issues of data collection management, energy saving solution and network communication security; in the network supporting technology level, realize the main point to solve the problem of node localization, time synchronization technology the realization and user application interface.

Sensor networks operating principle is: mobile node based on wireless sensor network is composed of a number of sensor nodes by the composition, with a base station of the sensing area (computer) management of the whole network, input data storage of each sensor node, the node data transmission to the base station via a conserved routing, this paper presents design of wireless sensor network node based on CyFi and ARM7 system.

2. Using ARM7 and LPC2214 to Design Nodes of Wireless Sensor Network

The sensor nodes detect data through XMesh wireless multi-hop ad network transmission group to the base station, or through relay Mote is transmitted to a base station. Mote is the basic of the wireless sensor network node, composed of processor and RF chip, small volume of it, so called "Mote". The base station is the gateway equipment used for communication in wireless sensor network and the existing IP network. The base station sends the data transmission to the central server through Xserver middleware, after analysis, the user can be monitored by the IT application software system.

Sensor nodes are divided into static and mobile nodes, static nodes of sensor node in the network configuration, can not change the location, sensing range fixed, because the energy consumption of nodes from the network is easy to change the original network structure, pay New Year's call, resulting in information not according to the original path transmission, mobile sensor nodes with mobility, storage a large quantity of advantage, can be dynamically constructed network, so as to safeguard network communication function, mobile nodes to the sensor, sending RF signal, establish link to activate the static nodes, each node in its own node address code in turn transmits the data to a mobile sensor node, the final transmission to the base station. Thus, without the application of mobile sensor nodes in a sensor network can line, enhance the performance of the network, communication ability.

Relative to the processor speed and power consumption increase, the improvement of battery performance is slow; the energy management has become one of the biggest challenges in wireless sensor networks. In order to save the requirement of wireless sensor networks nodes with dynamic power management (DPM) function, should enter a low power mode to save energy in the node is idle. Takes microcontroller support function of the realization of DPM, because ARM technology with there is nothing comparable to this advantage in the field of wireless communication, wireless communication equipment has more than 85% using ARM technology. We chose ARM with high performance, low power Philip company production of the micro controller LPC2138 to construct processing unit, as is shown by equation1 [2].

$$f : R^3 \longrightarrow R^2$$

$$(X, Y, Z)^T \longrightarrow (x, y)^T \quad (1)$$

LPC2212/LPC2214 is a 16/32 based on ARM7TDMI-S, and to support real-time simulation and tracking of CPU, and with 128/256 K bytes (k) high-speed embedded Flash memory. Accelerating structure 128 bit wide memory interface and a unique 32 bit code can operate at a maximum clock rate. Application of strict control can use 16 Thumb modes to reduce code scope for more than 30% of the code size, and the performance loss is very small. LPC2212/LPC2214 uses 144 pin package, power consumption is very low, a plurality of 32 timer, 8 10 ADC, output and external up to 9 interrupt.

The design goal of traditional MAC protocol is to maximize throughput, minimize the delay and fairness. About MAC layer protocol for WSNs design is to minimize the energy consumption, which determines that it should be appropriate to reduce the throughput and delay. Because the WSNs node always cooperates to complete an application task, so the usual fairness is not the main problem. In addition, some typical WSNs application also proposed is different from traditional wireless network design requirements for the MAC layer protocol.

In order to make the node can be used two AA batteries, construction of power supply unit using boost DC-DC MAX756. In addition to boost MAX756 also has a power supply monitoring function, when the V_{in} (via R1 and R3) was lower than 1.25 V, the LBO pin output low level, sink (Figure 1). It cannot accurately give the battery state

of charge (SOC) of how many, can let the sensor nodes know the battery state of charge decreased to some degree, the node is no longer suitable for heavy work. Change the node working state, reduced energy consumption, prolong the using time of the node.

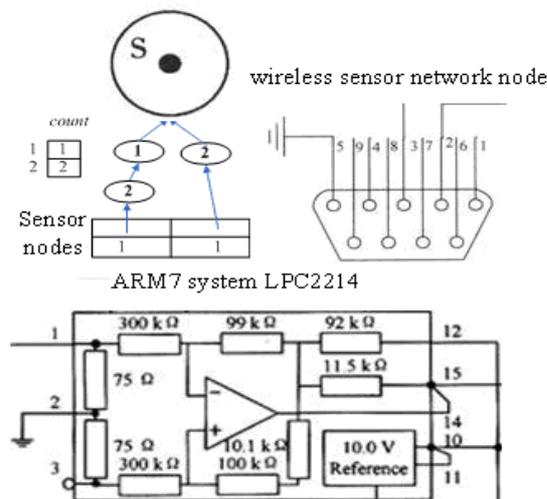


Fig. 1. ARM7 and LPC2214 to design nodes of wireless sensor network

Byte 512 lines of programming for 1ms. Single sector or full chip erase time is 400ms; Embedded ICE-RT can realize the breakpoint and watch point. When using the internal Real Monitor software debugging on the front desk task, interrupt service program can continue running; 120 bit A/D converter, conversion time as low as 2.44 μ s; 2 32 timer (with 4 capture and 4 road channel), PWM (6 unit of output), real-time the clock and watch dog; vector interrupt controller. Configurable priority and vector address; external memory can be set (addressing the maximum range of 16MB, support 8/16/32 data width).

Minimum system under different operation modes of actual current value determination is to download the C program in the system, respectively measuring system under different current in the pattern of consumption [3]. Testing environment for the laboratory, temperature 20°C; Use a millimeter and a 100 resistors, ICCAVR development environment, STK500 downloader to download. Resistance power interface in the portable controller is connected in series with a 100 Omega, the system model under different voltage resistance values were measured, and then calculate the current value, as is shown by equation2.

$$X_{i+1,V}(m) = \bar{H}_i^* X_{i,V}(m) + \sum_{r=1}^{q-1} \bar{G}_{r,i}^* X_{i,r,D}(m) \quad (2)$$

The core idea of MCL algorithm is a probability distribution of possible locations after said by a series of weighted sampling value, objective is to determine the probability distribution of the possible locations of the nodes after. Algorithm of every step including location prediction and location update two stages. Position prediction stage is to describe the process of posterior probability distribution by using M weighted sampling value; location update stage is through the importance sampling operation timely update of the weight value, sampling values from O and L.

The L298N chip can drive the two phase motor, can also drive a four phase motor, the output voltage of the Gao Keda 50V, can be directly through the power to regulate the output voltage; can directly use the SCM IO port to provide signal; and the circuit is simple, the use is convenient. L298N can accept standard TTL logic level signal VSS, VSS can be connected up to 4.5 ~ 7 V voltage. 4 pin VS is connected to a power supply voltage, VS voltage range of VIH to 2.5 ~ 46 V. Output current up to 2.5 A, and it can drive the inductive load.

Topological structure of wireless sensor network node caused imbalance between energy use, so the wireless sensor network, each node needs to know the use of electricity, battery state of charge and the switching node role, dynamically changing network topology to offset the imbalance. So for the wireless sensor network, regardless of the state of the battery simply through the DPM technology node into a low-power state can't make use of the network to achieve the optimal range of energy, prolong the network lifetime.

$$\delta I_i = \begin{cases} I(P) - I(P_i), & i = 0, 1, 2, 3 \\ I(P_i) - I(P), & i = 4, 5, 6, 7 \end{cases} \quad (3)$$

In the initial stage of node algorithm without any a priori knowledge is the location of WSN. Thus the initial position is estimated by centroid algorithm. The core thought of cancroids algorithm is: ordinary nodes in geometric cancroids all beacon nodes in the communication range of the estimated position themselves as it [4]. The process is very simple: beacon node to the neighbor node broadcasting a beacon signal, the signal contains a beacon node ID and position information. When the common node location unknown receives a beacon signal from the number of beacon nodes exceeds a preset threshold value, the node that node and the beacon communication, and its position is determined as the centroid consisting of all beacon nodes communicated with the polygon.

In recent years, many new routing protocols have been proposed, such as to choose the route with the method of sampling data flow optimization, the protocol of MAC layer and routing layer binding design, using cross-layer optimization techniques to further save power consumption etc.. Although some progress has been made, there are still many unsolved key problems, such as balance, and energy saving communication quality of service routing protocol, application oriented security routing protocols, energy saving since nodes in a sensor network distribution, large coverage, many complex work environment, by replacing the battery to prolong the network lifetime it is not realistic.

Provided the perfect DPM support LPC2138: with the dormancy and power down two low power state, through the external interrupt wakes it up; support 1 ~ 30 MHz external crystal oscillation mode, CPU can be obtained by phase-locked loop frequency up to 60 MHz, in order to save energy by 8 MHz crystal chip peripherals in addition; can control register through peripheral power opening and closing, outside, its working frequency can be adjusted by frequency divider for the processor clock frequency of 1 / 2 or 1 / 4 [5]. In addition, storage acceleration can greatly quicken the speed of the program, improve the energy efficiency. This makes the LPC2138 suitable for application to considerable processing capacity and low power consumption system.

Prediction of phase in the MCL algorithm, the node from the previous stage to calculate the set of possible locations Lt-1, for each sampling value mobile model application node to obtain a new set of sampled values Lt. The moving speed and direction of nodes is assumed unknown, and only know the speed value is less than Vmax then, if lit-1 is a possible location of the node, then the node where the current position is located may with lit-1 as the center, radius of circular Vmax region. If D (L1, L2) represents the Euclidean distance is between two points L1 and L2. And the moving speed of nodes in the interval [0, Vmax] follows a uniform distribution, then the node probability estimation of the current position of the previous position distribution can be uniformly distributed to form based on it, as is shown by equation4.

$$w = \begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix} * \frac{1}{16} \quad (4)$$

The large-scale application of wireless sensor network is not mature; there is still large development space. I believe that in the near future, along with the corresponding key technology, wireless sensor network will penetrate into every corner of society, obtained the full application. In general, the main future sensor network research has the following directions: nodes miniaturization: make use of the current MEMS, micro wireless communication technology, sensor design of micro volume, long life of the retransmission node is one of the most important research. Bokede University developed dust sensor node, the sensor size is reduced to a cubic millimeter, make these sensor particles suspended in the air.

Usually, in wireless sensor networks, a large number of sensor nodes are densely distributed in an area, the message may be required after a certain number of nodes to reach the destination, but also due to the dynamic nature of the sensor network, so there is no fixed infrastructure, so each node needs to have routing function [6]. Since each node is a potential routing node, and therefore more vulnerable to attack. The main attack types of wireless sensor network.

$$z(m, \delta) = \Psi_w(m, s) \chi(m) + \bar{v}(m, s), s=1, 2, \dots, M \quad (5)$$

In actual deployment, Crossbow uses hierarchical network architecture [7]. Each of the current wireless sensor nodes in the monitoring area consists of a subnet, subnet nodes rely on Xmesh wireless multi-hop self-organizing protocol, the data is transmitted to the base station by multi-hop manner. The base station after data preprocessing, data will be sent back to the central server through IP network distance. Each sensor node contains the breeze vibration detection sensor, wireless sensor network node, data acquisition board and the battery module supply. The shock vibration information detection sensor real-time access to high voltage cable, wireless sensor networks have the breeze oscillation digital information after data acquisition board, and after the pretreatment in wireless multi-hop routing transmit the data back to the base station.

NRF905 is composed of frequency synthesizer, demodulator, a power amplifier, a crystal oscillator and a modulator, without external sound filter, Shock Burst TM mode, automatic processing of prefix and CRC (cyclic redundancy check), use the SPI interface with a microcontroller communication, configuration is very convenient. In addition, the power consumption is very low, with only 11mA current output power - the launch of 10dBm, current work on the receiving mode is 12.5mA, built in idle mode and Guan Jimo, easy to realize energy saving.

Battery state of charge is usually expressed as the currently available capacity and rated capacity ratio, linear function and it is not the discharge time and discharge current of the battery, affected by the inherent property of "rated capacity effect" and "recovery effect", as the battery design, system evaluation, optimized battery usage strategy, researchers from different aspects put forward a variety of battery model. The study of cell model based on Markov process in, by introducing the minimum available unit of charge the battery state of charge is expressed as a discrete transient stochastic process [8]. The circle of $N, N-1, \dots, 1, 0$, said a moment battery nominal capacity; Q_i probability that consumption of i charge unit in a period of time. If you start the battery when the N unit of charge, in a certain period of time the consumption of 3 unit of charge, so the probability of the event denoted as Q_3 , residual charge unit cell $N-3$.

This section describes in detail the hardware design, including sensor module, infrared transmission close to L298N as the core of the drive module, receiving module basic and peripheral circuit module based on NRF905. And are drawn each big module and LPC2214 interface, thus completing the hardware design platform, provide the physical basic for software design.

3. Design of Wireless Sensor Network Node based on CyFi

Realization of wireless sensor networks emerge in an endless stream, such as infrared, Bluetooth, ZigBee, Wi-Fi etc.. But there are problems of these protocols, such as infrared technology meets the obstacle is failure, Bluetooth is power, ZigBee protocol is more complicated. Aiming at these problems, the company introduced the Cypress low-power wireless solution CyFi, at the same time also introduced for the novice PSoC FirstTouch Starter Kit CY3271 and other extension kit. In this paper, using this kit set up CyFi wireless sensor network, and through the implementation of binding and data nodes collection of USB interface in the PC machine.

This paper analyzed the hardware and software design method of low power consumption, in different tasks under different operating mode is of great significance to reduce power consumption. In the use of the software and hardware measures properly, the design of the portable controller module battery service life reached about half a year, to meet the needs of the application of wireless sensor networks system. Low power design methods and ideas in this paper have some reference value for the development of practical products.

Filtering conditions expressed all beacon nodes grouping nodes can listen to N . T said the neighbor node N and node can listen to N itself cannot listen to all beacon nodes. Therefore, filtering the Condition node location of L by type (2) said. If the filter condition is false, then the probability distribution of P nodes ($l_t|O_t$) value is zero, or $P(LT|O_t)$ with uniform distribution, so. You can from all possible to remove those inconsistent with observed values of the location in the collection node [9]. After filtering, may position node remaining may be less than N . The prediction process and the filtering process are repeated, and combined with the node has been found possible positions, at least N possible positions until the node.

In order to achieve low power consumption, CyFi try to work in sleep mode. This means that in the interference under the condition of weak, CyFi will be as quickly as possible (1 Mbps) transmission, to shorten the transmission time; and in the case of strong interference, will enable the DSSS modulation technology and improve the RF transmission power to transmission rate of 250 Kbps, thereby reducing the retransmission may. When a node and Hub distance is close, the node can also reduce the transmission power to reduce power consumption. Power management mechanism that effectively makes the typical sensor applications using CyFi on 2 AA batteries can use 4 years.

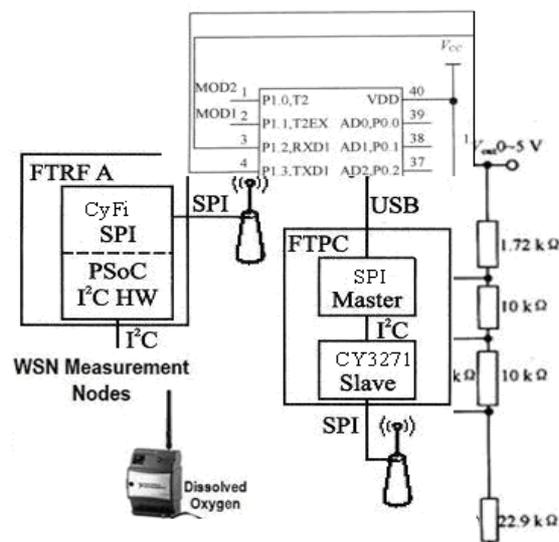


Fig. 2. Design of Wireless Sensor Network Node based on CyFi figure

Because the CyFi is using the star broadcasting network protocol, all messages need to go through the center of Hub, the realization process of node A to node B data communication are as follows: the node A through I2C protocol collection multi-functional panel A CapSense touch the position of the slide, 3 LED light as well as the data, and ID and the target node B through RF to send out; the Hub detects messages in the network, and then forwards the message out according to ID target node in the message, and save data to the cache for PC machine to read; node B receives the message according to the message data, the same control 3 LED lights multi-function panel on the B through the I2C protocol to eliminate the bright. The Hub device FTFC has 2 PSoC cores: the main kernel implementation of USB - I2C conversion and each card (including kernel) programming function; from the kernel to realize Hub function, at the same time by connecting I2C to the main kernel.

Mobile sensor node is composed of a plurality of mobile nodes and static nodes based on it, each node must have a unique address code and the specific format of data transmission in the network. The mobile node address code by the host address coding and NRF905F address code consists of two parts, a host node number specific code.

CY3271 kit CD-ROM provides design examples of each PSoC, part PSoC the design revisions based on these examples is the. In order to realize the function, you need to add the destination node in the node A sends B message ID information, so that Hub will receive the message and then forwarded out. Each CyFi transceiver 2 ID; a 6 byte Radio ID, the ID transceiver factory burned into, cannot be changed and the only global; another is 1 bytes of Node ID, the ID identified in node bindings, can be specified in advance can be dynamically allocated by Hub. Because Radio ID is complex, developers can ignore the RadioID in the development process, and focus only on Node ID.

Wireless communication circuit using NRF905 as the control chip to send and receive data. The NRF905 is a monolithic RF transceiver chip produced by Nordic company, working on the 433/868/915MHz3 ISM channel, low power consumption. The built-in integrated data protocol and CRC tree error detection can automatically complete word processing [11]. Automatic completion of Manchester is coding / decoding. Simply complete the wireless transmission of all through the SPI can be very convenient for model configuration for the four industries: power off and SPI programming mode, standby and SPI programming mode, transmission mode, the receiving mode. NRF905 is a data packet transmission rate up to 32Mb/s, additional antenna communication distance is more than 120m, can meet a variety of wireless sensor network data transmission requirements.

$$\begin{cases} \Psi^1(x, y) = \varphi(x)\psi(y) \\ \Psi^2(x, y) = \psi(x)\varphi(y) \\ \Psi^3(x, y) = \psi(x)\psi(y) \end{cases} \quad (6)$$

CY3271 is Cypress for low cost USB interface kit novice launched a with CyFi, including the PSoC integrated development environment PSoCDesigner, used for data collection induction control software SCD, RF function with PC bridge FTFC, multi-functional panel FTMF, support for long distance wireless application and band power amplifier RF expansion board FTRF, and 2 panels. Among them, the PC bridge FTFC as CyFi devices using the

Hub; RF expansion board FTRF for use as a CyFi node equipment, at the same time with a temperature sensor with ultra-low power consumption; and multi-functional panel FTMF with CapSense touch sensor, proximity sensor, temperature sensor, a light sensor and a red, yellow, blue 3 LED lamps.

4. Design of Wireless Sensor Network Node based on CyFi and ARM7 System

The hardware platform with ARM7 LPC2214 microprocessor as the core, the hardware structure as shown below: the system uses ARM7 LPC2214 processor as the control core, the key technologies of wireless sensor, communication technology, designed the whole of wireless sensor network nodes [12]. The system can be divided into the clock circuit, reset circuit, power supply circuit, motor drive circuit, wireless communication circuit, display circuit, near infrared sensor circuit, control circuit and alarm circuit.

This model relative to the cell model to describe the partial differential equation, the amount of calculation is reduced greatly and the result is accurate, can quickly assess the impact of design of embedded system structure on the battery status. But its use for real-time evaluation of wireless sensor network node state of charge overhead is too large, it is necessary to further explore the battery modeling problems, node working current node power application is the external assessment battery state of charge. Because of no sensor node is composed of a number of discrete devices, so its power can be obtained from the combination of these discrete devices effective power state.

Although the CY3271 supporting the CD has been included for data acquisition and control software of SCD, but in order to clear the FTTPC equipment USB interface to read and write process, as well as the future Hub will be ported to other platforms, and the PC software functions can be customized. This software is written in VisualC++2005, at the same time, the use of the TeeChart control chart showing. The CY3271 FTTPC device by using USB interface and PC connection, and the USB device has been modeled as a standard HID device, the communication device with the FTTPC PC software only need to control and read using a standard HID device write function.

$$SSD = \sum_{X \in \Omega} [I_k(W(X, P) - I_{k-1}(X))]^2 \quad (7)$$

Method of wireless sensor network nodes is developed here, ARM7 system LPC2214 as the core, through the modular design, simple and efficient management process. Drawing the design principle diagram and it is the design of hardware and software diagram. And it introduces the design of wireless sensor network and the chip and the hardware device to use. Including LPC2214, L298N, nRF904, SP708S, LED, and respectively introduces their characteristics, working principle, using method and choose their advantage.

CyFi appear to be smoothly done or easily solved various problems in wireless sensor networks, and the user module of PSoC greatly facilitates the developers, the developers only need to drag and drop and add a simple code, can easily complete the design and development of wireless sensor network applications of complex [13]. At the same time, simulate the starter kit Hub equipment into the standard HID equipment, but also enable the development of applications on the PC machine to be an easy job to become.

Operating system is the kernel of ARM7, the chip LPC2214 is designed based on ARM processor, three characteristics: strong function, less power consumption is 16 /32 instruction set and the multitudinous partner. Small size, low power consumption, low cost, high performance; support for Thumb (16) /ARM (32) instruction set, can be compatible with 8 bit /16 a good devices; extensive use of registers, instruction execution speed; most data operations are completed in the register; addressing mode is simple, execution high efficiency; fixed length instruction.

The system uses magicarm270 development platform of experiment teaching simulation system debugging. MagicARM270 experimental box was developed by Guangzhou Zhiyuan Electronics Co., Ltd. is a use Linux 2.6.18 and WinCE 5 operating system, support QT, MiniGUI graphics system, set a number of functions in the experimental development of advanced ARM teaching platform. Characteristics: MiniARM270 core board, a standard configuration for Intel's XScale processor PXA270, 64M bytes of NOR FLASH, 128M SDRAM, 256M NAND FLASH byte byte and 1G bytes of E2PROM; 8 inch 640X480 color TFT LCD screen can be rotated, and equipped with LCD screen shell mold complete given support; 4 wire resistive touch screen, and equipped with touch pen; adaptive 10/100M Ethernet interface, and have the only legal MAC address.

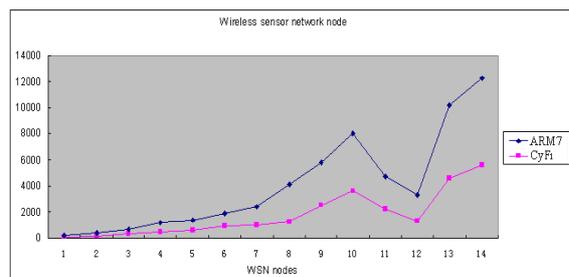


Fig. 3. Comparison design of wireless sensor network node based on CyFi and with ARM7 system

Wireless sensor network has a very broad application prospects, is a revolutionary information acquisition technology. The wireless sensor network has many technical problems are not solved, especially in energy management, large-scale networking issues outstanding. The importance of energy in wireless sensor networks require researchers to find cost less to accurately predict battery state of charge to balance the network node lifetime, optimize the network energy consumption.

Wireless sensor network node based on ARM, the hardware system with high performance and low power LPC2214 microcontroller as the core, simplifies the design of peripheral interface circuit, and improves the performance and data processing ability of the system. The experimental results show, the mobile node is suitable for dynamic information in wireless sensor network, complete the complex task. Related to the operating system, applications and it is wireless communication protocol knowledge. This task is difficult to connect each module, connecting each interface is appropriate, let their collaborative work together.

CONCLUSION

The ARM7 LPC2214 processor as the control core and it is the key technologies of wireless sensor, communication technology, the overall design of the wireless sensor network node. The clock circuit, reset circuit, power supply circuit, motor drive circuit, wireless communication circuit, display circuit, near infrared sensor circuit, control circuit and alarm circuit series, the completion of the system tasks. Generally speaking, this paper takes the red signal as the research object, so the distance is limited. This paper presents design of wireless sensor network node based on CyFi and ARM7 system. In accordance with the above method, and it is combined with the definition and the command Hub PSoC programs: Bus Hound capture the results obtained, it can perform the appropriate operation on FTPC equipment in the Hub, such as access to the bound state, reads the bind results, read the received message. After the success of node bindings, you can view real-time data acquisition, including data acquisition time and the slider position value.

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