The Design of Forest Fire Monitoring System Based on Wireless Sensor Network

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Abstract: Forest fires burn the infrastructure, and may result in high human death toll near urban areas. As we all know, the forest is considered as one of the most important and indispensable resources, the prevention and detection of the forest fire, have been researched hotly in worldwide forest fire prevention departments. Based on the deficiencies of conventional forest fire detection on real time and monitoring accuracy, the wireless sensor network technique for forest fire detection was introduced. The project is to develop an embedded system design a wireless Forest Fire monitoring system which enables to monitor the weather parameter in any Forest by using Zigbee technology and display the parameter on the PC’s screen. The system contains two parts. One is transmitter node and another one is receiver part. The transmitter part consists of weather sensors, microcontroller and Zigbee and the receiver part consists of a PC interfaced with Zigbee through PC serial port.

Keywords: Forest Fire, Wireless Sensor Network, Zigbee.

I. INTRODUCTION

Forests are part of the important and indispensable resources for human survival and social development that protect the balance of the earth ecology. However, because of some uncontrolled anthropogenic activities and abnormal natural conditions, forest fires occur frequently. These fires are among the most serious disasters to forest resources and the human environment. In recent years, the frequency of forest fires has increased considerably due to climate change, human activities and other factors. The prevention and monitoring of forest fires has become a global concern in forest fire prevention organizations. Currently, forest fire prevention methods largely consist of patrols, observation from watch towers and lately satellite monitoring. Although observation from watch towers is easy and feasible, it has several defects. In the first place, this method requires many financial and material resources and a trained labor force. Second, many problems with fire protection personnel abound, such as carelessness, absence from the post, inability for real-time monitoring and the limited area coverage. The scope of application of satellite detection systems is also restricted by a number of factors, which reduces its effectiveness in forest fire detection. For example, a satellite monitoring system has a long scanning cycle and the resolution of its saturated pixel dots of images is low. Another problem is cloud layers may mask images during the scanning period and the real-time mathematical quantification of fire parameters is very difficult to achieve. Given these shortcomings of traditional monitoring, we suggest the Zigbee wireless sensor network technology and explain its application as a monitoring system. This system can monitor real-time related parameters, e.g., temperature, relative humidity, and send the data immediately to the computer of the monitoring center. The collected data will be analyzed and managed by the computer. Compared with the normal meteorological information and basic forest resource data, the system can make a quick assessment of a potential fire danger. The analytical results will then be sent to the relevant department as the policy-making basis by which the department will make the decision of fire fighting or fire prevention.

II. BLOCK DIAGRAM AND MODULES DESCRIPTION

A. LPC2148 Microcontroller

LPC2148 microcontroller board based on a 16-bit/32-bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combine microcontrollers with embedded high-speed flash memory ranging from 32 KB to 512 KB. A 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution at the maximum clock rate. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30% with minimal performance penalty. The meaning of LPC is Low Power Low Cost microcontroller. This 32-bit microcontroller manufactured by Philips semiconductors (NXP). Due to their tiny size and low power consumption, LPC2148 is ideal for applications where miniaturization is a key requirement, such as access control and point-of-sale.

1. Features of Lpc2148 Microcontroller
   - 16-bit/32-bit ARM7TDMI microcontroller in a tiny LQFP64 package.
- 8 KB to 40 KB of on-chip static RAM and 32 KB to 512 KB of on-chip flash memory; 128-bit wide interface/accelerator enables high-speed 60 MHz operation.
- USB 2.0 Full-speed compliant device controller with 2 KB of endpoint RAM. In addition, the LPC2148 provides 8 KB of on-chip RAM accessible to USB by DMA.
- One or two (LPC2141/42 Vs, LPC2144/46/48) 10-bit ADCs provide a total of 6/14 analog inputs, with conversion times as low as 2.44 ms per channel.
- Single 10-bit DAC provides variable analog output (LPC2148 only)
- Two 32-bit timers/external event counters (with four capture and four compare channels each), PWM unit (six outputs) and watchdog.
- Low power Real-Time Clock (RTC) with independent power and 32 kHz clock input.

**NODE 1:**

![Block Diagram](image1)

**Fig 1. Block Diagram.**

**B. Power Supply**

All electronic circuits works only in low DC voltage, so we need a power supply unit to provide the appropriate voltage supply for their proper functioning. This unit consists of transformer, rectifier, filter & regulator. AC voltage of typically 230volts rms is connected to a transformer voltage down to the level to the desired ac voltage. A diode rectifier that provides the full wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation. A regulator circuit can use this dc input to provide dc voltage that not only has much less ripple voltage but also remains the same dc value even the dc voltage varies somewhat, or the load connected to the output dc voltages changes.

**Fig 2. LPC2148 Microcontroller Architecture.**

**Fig 3. General Block of Power Supply Unit.**

1. **Transformer:** A transformer is a static piece of which electric power in one circuit is transformed into electric power of same frequency in another circuit. It can raise or lower the voltage in the circuit, but with a corresponding decrease or increase in current. It works with the principle of mutual induction. In our project we are using a step down transformer providing a necessary supply for the electronic circuits. Here we step down a 230volts ac into 12volts ac.

2. **Rectifier:** A dc level obtained from a sinusoidal input can be improved 100% using a process called full wave rectification. Here in our project for full wave rectification we use bridge rectifier. From the basic bridge configuration we see that two diodes(say D2 & D3) are conducting while the other two diodes (D1 & D4) are in off state during the period t = 0 to T/2. Accordingly for the negative cycle of the input the conducting diodes are D1 & D4. Thus the polarity across the load is the same. In the bridge rectifier the diodes may be of variable types like 1N4001, 1N4003, 1N4004, 1N4005, 1N4007 etc... can be used. But here we use 1N4007, because it can withstand up to 1000v.

3. **Filters:** In order to obtain a dc voltage of 0 Hz, we have to use a low pass filter. So that a capacitive filter circuit is used where a capacitor is connected at the rectifier output & a dc is obtained across it. The filtered waveform is essentially a dc voltage with negligible ripples & it is ultimately fed to the load.
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4. Regulators: The output voltage from the capacitor is more filtered & finally regulated. The voltage regulator is a device, which maintains the output voltage constant irrespective of the change in supply variations, load variations & temperature changes. Here we use fixed voltage regulator namely LM7805. The IC LM7805 is a +5v regulator which is used for microcontroller.

C. Liquid Cristal Display

LCD is a type of display used in digital watches and many portable computers. LCD displays utilize to sheets of polarizing material with a liquid crystal solution between them. An electric current passed through the liquid causes the crystals to align so that light cannot pass through them.

E. MAX-232

RS232 is not compatible with today’s Microprocessor and Microcontroller, we need a line drive (voltage converter) to convert the RS232 signal to TTL voltage levels that will be acceptable to the 8051’s TxD and Rxd pins. The information from microcontroller is sent to system through serial communication by using MAX-232 IC in between micro controller and RS232 (DB9 connector). This MAX-232 acts as voltage level translator i.e., the TTL logic voltage level is to be transformed to RS232 DB9 connector voltage level of the system. In short a MAX –232 is nothing but a clamper circuit, the voltage level translation is done through clamping circuit here diodes are inbuilt, whereas the capacitors are to be connected externally. In order to connect micro controller to a modem or a pc to modem a serial port is used. Serial is a very common protocol for device communication that is standard on almost every PC.

D. LM35 Temperature Sensor

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1/4°C at room temperature and ±3/4°C over a full −55 to +150°C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35’s low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 μA from its supply, it has very low self-heating, less than 0.1°C in still air. The LM35 is rated to operate over a −55° to +150°C temperature range.

Features
- Calibrated directly in ° Celsius (Centigrade)
- Linear + 1.0.0 mV/°C scale factor
- 0.5°C accuracy guarantee able (at +25°C)
- Rated for full −55° to +150°C range
- Suitable for remote applications
- Low cost due to wafer-level trimming
- Operates from 4 to 30 volts
- Less than 60 μA current drain
- Low self-heating, 0.08°C in still air
- Nonlinearity only ±1/4°C typical
- Low impedance output, 0.1 W for 1 mA load

F. ZIGBEE (IEEE 802.15.4)

Zigbee is the set of specs built around the IEEE 802.15.4 wireless protocol. The IEEE is the Institute of Electrical and Electronics Engineers. They are a non-profit organization dedicated to furthering technology involving electronics and electronic devices. The 802 group is the section of the IEEE involved in Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks including mid-sized networks. Group 15.4 deals specifically with wireless networking (Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (WPANs)) technologies. Zigbee devices are actively limited to a through-rate of 250Kbps, operating on the 2.4 GHz ISM (The Industrial, Scientific and Medical)
band, which is available throughout most of the world. An LR-WPAN (Low Data Rate-Wireless Personal Area Network) is a simple, low-cost communication network that allows wireless connectivity in applications with limited power and relaxed throughput requirements. The main objectives of an LR-WPAN are ease of installation, reliable data transfer, short-range operation, extremely low cost, and a reasonable battery life, while maintaining a simple and flexible protocol.

G. LDR (Light Dependent Resistor)

A photo resistor or light dependent resistor (LDR) is a resistor whose resistance decreases with increasing incident light intensity; in other words, it exhibits photoconductivity. A photo resistor is made of a high resistance semiconductor. If light falling on the device is of high enough frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electron (and its whole partner) conducts electricity, thereby lowering resistance. A photoelectric device can be either intrinsic or extrinsic. An intrinsic semiconductor has its own charge carriers and is not an efficient semiconductor, for example, silicon. In intrinsic devices the only available electrons are in the valence band, and hence the photon must have enough energy to excite the electron across the entire band gap. Extrinsic devices have impurities, also called dopants, and added whose ground state energy is closer to the conduction band; since the electrons do not have as far to jump, lower energy photons (that is, longer wavelengths and lower frequencies) are sufficient to trigger the device. If a sample of silicon has some of its atoms replaced by phosphorus atoms (impurities), there will be extra electrons available for conduction. This is an example of an extrinsic semiconductor. Photo resistors are basically photocells.

III. SIMULATION

In order to verify the communication effect more intuitively, this paper uses LabVIEW as host computer monitoring interface. Lab VIEW is a kind of graphical programming language that uses icon instead of text to create application. Traditional textual programming language based on sequence of statement and command to determine the execution order of program, but LabVIEW uses data flow to program. Data flow among nodes in the block diagram determines the execution order of program [11]. This paper assumes that the position of the nodes have been known, and takes temperature as the collection parameter. Forest monitoring area is divided into several small areas, and each small node in the monitoring area is divided into two parts: one is in the working mode; the other is in the sleeping mode like the one shown in Fig.8.

Fig.7. LDR and its parts.

Fig 8. Forest monitoring areas.

When the nodes that are in working mode work, the nodes that are in sleeping mode sleep, when the sleeping nodes wake up to work, the working nodes go into sleeping. This circulatory work mode can greatly reduce the energy consumption in small monitoring areas, so that the energy consumption of the whole monitoring network is reduced. Host computer monitoring interface is shown in Fig.9. Temperature data is family passed to the PC through serial port, the serial communication can be realized by host computer by using the VISA library in Lab VIE W. VISA library includes VISA configuration serial port, VISA write in, VISA read out, VISA close, VISA serial port bytes number and other functions, where the VISA configuration serial port function mainly configure baud rate, data bits, parity check, stop bits, etc, VISA write in and read out functions are responsible to write in data in buffer area and read out data from it, VISA close function is used to close the serial port, and VISA serial port bytes number function is to specify the number of bytes of input buffer in bytes. By calling these functions data that transmitted from lower grade computer can be obtained in serial ports, Fig.10 is a brief configuration flow chart of serial communication.

Fig.9. Host computer monitoring interface.

Fig.10. A brief configuration flow chart of serial communication.
IV. HARDWARE RESULT

This paper has described the design and implementation of a wireless sensor network for forest fire detecting system. Forest fires have multidimensional negative effects in social, economic and ecological matters. It is difficult to say that fire fighting can be successful without enough data about fire such as spread direction and speed etc. The more data about forest fire means the more effective fire management. Economically, fire fighting is well known to be a costly task. It is wise to invest in early warning systems which are definitely much less costly on the whole. WSNs are thus the right choice and the least costly of all surveillance and early detection systems. The ongoing research in wireless sensor networks is promising that cost effective systems shall immerge for forest fire sensing and detection applications. Finally, we conclude that wireless sensor network is a very powerful and suitable tool to be applied in this application.

V. REFERENCE


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