Modern Applied Science
www.ccsenet.org/journal.html
Vol. 3, No. 12
December 2009

The Development and Operation of Thermostatic Oscillator with Network Monitoring

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Abstract

This paper introduces a method of thermostatic oscillator data transmission system which is based on embedded TCP/IP technology, while most thermostatic oscillator products don't have such a system of network data communication. The TCP/IP technology is used to achieve remote monitoring. It also uses the algorithm of PID and PWM for temperature and speed control, involving hardware and software design.

Keywords: The embedded system, Oscillator, TCP/IP, PWM, PID

1. Introduction

A thermostatic oscillator (also called a shaker) is a thermostatic biochemical instrument whose temperature and speed can be controlled. It is an indispensable precision training preparation laboratory equipment for plant, animal, microbial, genetic, environmental protection, medical viruses, scientific research, education system, and production department. TCP/IP which becomes a fact of popular network communication protocols for the international industrial standards, use a hierarchical structure to provide user with a rich application service. Meanwhile, the embedded system's internet network research capacity and application of the embedded technology are hot research topic.

This paper sets out to explain how the embedded system works, it is based on a core of ARM7 and communicates with the TCP/IP network, carrying out real-time monitoring of temperature and speed for the thermostatic oscillator.

2. The overall design and system structure

This system uses the MCU of LPC2368, which is the kernel of ARM7. The main frequency can reach 72M/Hz. Whether for high-speed, real-time processing or large capacity data transmission, it can all meet all the requirements. The main chip controls temperature and the speed module, etc. It has a built-in Ethernet module: this module contains a 10Mbps or 100Mbps Ethernet MAC (media access controller). The system also uses the National Semiconductor company DP83848 single road 10/100Mb/s Ethernet transceiver and Ethernet interface RJ45 which support 10MBit and 100MBit adaptive network speed to connect to the communication module. The whole design system is robust. The system frame is shown in figure1.

3. Network communication module design

a) Ethernet hardware implementation

The CPU of the system uses LPC2368 by Philips. The main frequency can reach 72M/Hz with an internal Ethernet integration module which supports 10M or 100Mbps PHY devices.

This system's Network Interface Card(NIC) is a 10 Mb/s or 100Mb/s single physical transceiver, which contains an Ethernet intelligent power and has low power usage. It works in a 50MHz crystal frequency and has the characteristics of energy testing mode. It has an intelligent, energy-saving mode.

Finally, connecting the NIC to the Ethernet interface RJ45, the interface supports 10MBit and 100MBit adaptive speed of network connection.

b) System communications protocol and communication process

i. Ethernet data frame transmission and reception

The data transmission in the Ethernet is MAC addressed rather than IP addressed. The IP address and the MAC address have a mapping relationship. An Ethernet packet includes: an introduction to the area, starting frame delimiter and an Ethernet frame. The Ethernet frame consists of a target address, the source address, an optional VLAN area, length/dry-farming, load and frame calibration sequence, as shown in figure 2. Each Ethernet frame is composed of one or more pieces, each corresponding to a descriptor. The DMA Ethernet module of Ethernet is able to manage an Ethernet frame multiple fragments scattered (for receiving) and concentrated (used to send).

ii. The TCP/IP protocol

The TCP/IP protocol is a connection-oriented, reliable end-to-end communication protocol. It is divided into four layers, namely: network interface layer, network layer, transport layer and network, as shown in figure 3.

iii. The system TCP/IP communication process

The data based on the TCP/IP protocol can be divided into three stages: connection, data transmission and disconnect. Its implementation process can be described by the state of the machine. There are two methods to establish a connection, namely the active open and passive open. The server, open passively, detects a connection request. The client, open actively, and transmits the connection request. There are also two ways to disconnect: one is active disconnection, the other is passive disconnection. To achieve active disconnection, a FIN packet is sent. On receiving confirmation of receipt FIN packets, a packet of reset is sent to achieve active disconnection.

This system's communication process is divided into 4 main steps:

The first part is a network which is composed of DP83848 chip and RJ45 hardware interface.

The second part is the TCP/IP protocol stack. Using this protocol stack to realize data communications, the network chip is solidified from the MAC layer and network layer to the transport layer protocol completely, thus there is no need to understand method or code.

The third part is the sending and receiving buffer. The main chip LPC2368 communicates with other hosts on the net via the buffer.

The fourth part is the Ethernet physical interface. DP83848 achieves 10 / 100 M data transmission rate.

In the master machine talks to slave machine whose control chip is a LPC2368. The host shows the temperature and the speed of real-time data under the control of LPC2368.

Specific processes are initialized in the first layer which includes physical equipment and register. Then regular program continues to process the network, TCP/IP stack and users. After that, the listening socket is set to decide the frame processing. Finally, is the dynamic HTTP server. Here the HTML code is stored in a custom array: the array includes the real-time data of temperature and speed. If an application-layer processes calls, the array can visit the real-time data and the real-time data can be displayed to web pages.

Network communication processes as shown in figure 4:

4. Speed and temperature control

4.1 Temperature module

4.1.1 Hardware component

This system produces and controls PWM with the different duty factor in main chip LPC2368 and it adopts full-bridge drive IGBT inverter. When the control requires, the inverter commences work. Inverter's IGBT module is composed of a FSBS10CH60.

4.1.2 PWM control technology

In accordance to certain rules, the main chip LPC2368 controls the inverter switch components, conduction and shutoff. The inverter produces a group of rectangular pulses with the same amplitude but different width, approximately equivalent voltage wave in sine. The pulse width corresponds proportionally to the pulse of area under the sine wave, as shown in figure 5.

4.1.3 PWM control method

PWM control methods have many rules. The sampling method is one of these methods is used widely in engineering. It uses a triangle wave as carrier generally. The principle is to get ladder wave by the sampling sine wave with the triangular wave. The control switch device operates at the intersection of the ladder and triangular wave. And then bring into play the speed control function. The method is used to determine the switch time, as shown in figure 6, a1, a2,... a18;, b1, b2,... b18;, c1, c2,... c18 at the intersection of A, B and C phase sine and the triangular signals, respectively.

The phase output voltage is high when the value of sine is higher than the triangle wave at the same moment; but if lower, the phase output voltage is 0. Through the determination of value, each switch point can be obtained by A, B and C phase modulation of output voltage waveform. Then the switch pattern with different time can be coded by three binary putting all this data into a table. In this way PWM modulation and speed control are maintained..

4.2 Temperature module

This module achieves the temperature control. First the temperature parameter is set in the running state. Then the oscillator cabinet environmental temperature is collected by the A/D conversion. According to the deviation between cabinet and setting temperature, the PID algorithm is used to do the area control. This oscillator divides into three interval situations. And automatically adjust for temperature fluctuation.

4.2.1 Software workflow

The temperature control module mainly executes the process flowcharts, as shown in figure 7: (1)initialize (2) input the preset temperature by keyboard (3) collect and calculate the temperature in the box (4) call integral PID subroutines, heating power or compressor power to adjust the temperature (5) display the Settings of the temperature inside the cabinet.

4.2.2 Control method

This system uses PID control method for temperature control. The existing like product is under constant temperature control and the needs compressor to be at the full power operation which is because the compressor is not allowed to start frequently. Frequent stopping and starting can cause many problems. Such things as energy, noise and life span of the system. This system fully utilizes the advantages of the embedded ARM function, using the capacity of PD frequency adjustment to realize the compressor control of temperature. This overcomes the deficiencies found in the similar product, improves product quality. And importantly conserves energy while protecting the environment.

This system uses integral-separation PID method can eliminate the big overshoots what is produced by the integral effect and keep shaking by instrument in the start-stop or sharp drops.

The control algorithm process which as shown in figure 8.

The temperature module has high precision and effective control methods. These are the main indexes: Temperature range: - 30--+ 80℃; Temperature measurement precision≤±0.1℃; The precision of temperature control≤ ±0.4℃; and more than 20 percent energy-saving which compare with similar products.

5. Conclusion

This paper had introduced the design principle of the thermostatic oscillator, based on TCP/IP, which used embedded ARM LPC2368 as the main control chip. It controlled the realization of the function of all modules. This paper provided the details of the system's remote monitoring function. While most of the current market similar products do not have such a function. The paper also outlined the working and operating principle for speed and temperature modules. The combination of hardware and software ensures steady working state and constant temperature and speed. The design features of the thermostatic oscillator ensure it is both practical and stable. It is able to meet user's demands very well which have been proved already.

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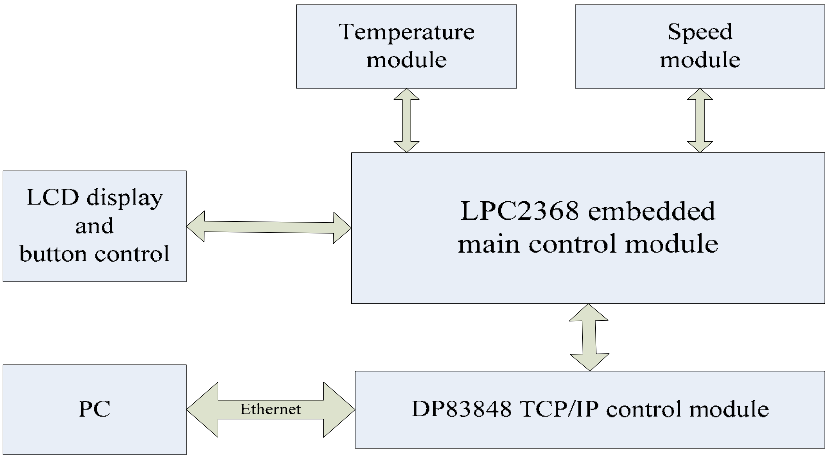

Figure 1. Thermostatic oscillator based on TCP/IP

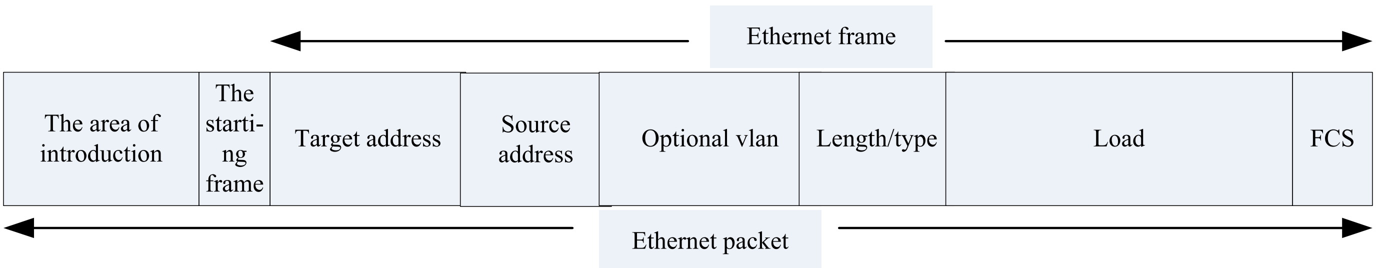

Figure 2. Ethernet packet structure and data frame structure

Application layer protocol
Transport layer
Network layer
Network interface layer

Figure 3. TCP/IP protocol model

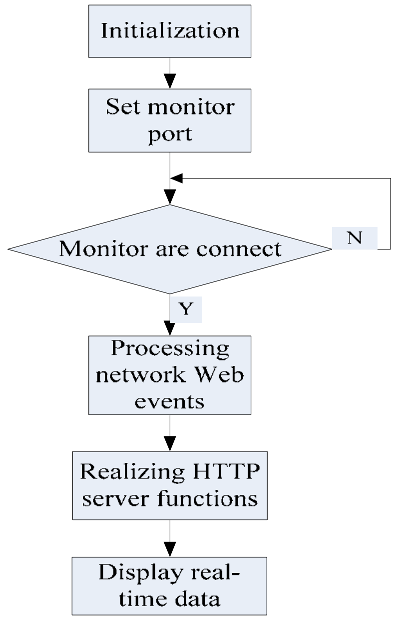

Figure 4. Network communication flowcharts

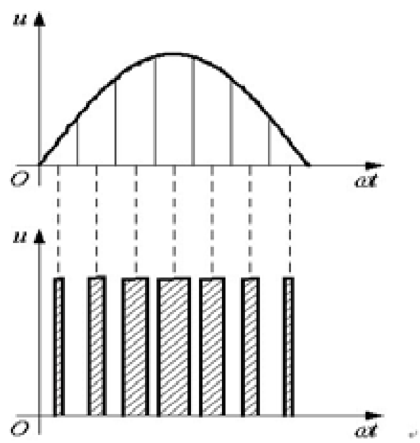

Figure 5. PWM pulse width modulation

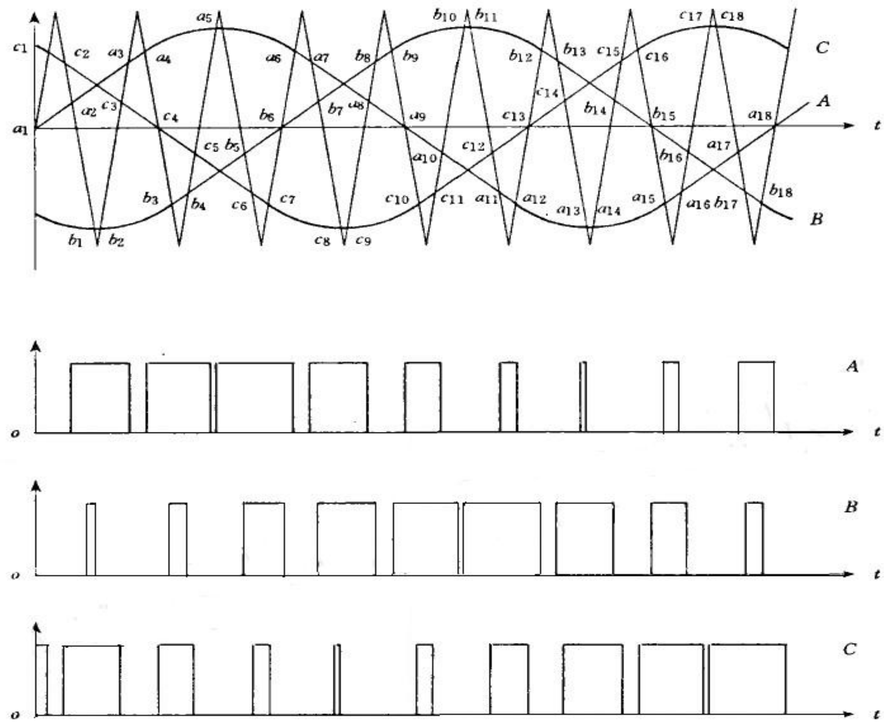

Figure 6. PWM modulation method in this system

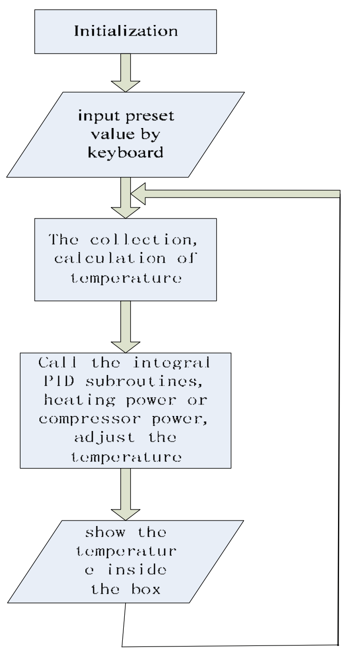

Figure 7. Temperature control chart

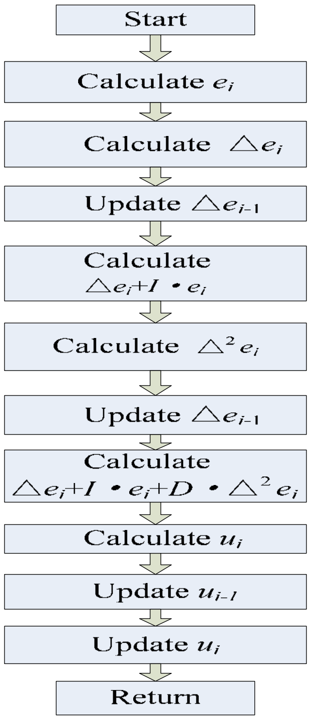

Figure 8. PID algorithm process

e_i is the deviation for the given and the actual value, u_i is the output value, I and D are the coefficients of integral and differential separately.