

A Rapid Detection System based on LabVIEW and Microcomputer

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Abstract

Excessive inhalation of formaldehyde is harmful to health. A quickly digital detection model of the content of formaldehyde in the air is designed in this paper. It can change nanoamps current into proper Voltage for TLC1543 through MAX407 and OP37. And a hardware circuit is designed for adaption and acquisition of the data. The method of this system is sending the signal to the host computer through a serial port and then showing the content of formaldehyde on the PC. Such digital detection of formaldehyde can be used to judge whether the content of formaldehyde is over the sustaining level of human body in a intuitive and quickly way.

Keywords: micro current collection, transducer, LabVIEW, formaldehyde, digital detection

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1. Introduction

Formaldehyde is a colorless, with a strong irritating smell gas in room temperature. Formaldehyde is found in most chemical product [1], and which can result in poison incident. Poisoning symptoms varies from low concentration of having peculiar smell and discomfort to higher concentration of nausea and vomiting, asthma or even immediate death [2]. In the detection of toxic substance, electrochemical transducer has a sharply higher efficiency than other chemical methods.

2. Hardware Design

This paper introduces a design of the formaldehyde gas collection instrument. The acquired signal is processed by the formaldehyde transducer and sent to the MCU for dealing, then input to the host PC through serial port and for data processing and being showed through LabView [3].

2.1. Ensemble Part

Formaldehyde transducer is applied in this method and the acquisition of signal is realized through the diffusion theory. TLC1543 is used as A/D chip with the receiving range "0~5V". Once formaldehyde existed, an direct current would be generated. And then we should change the weak DC into receiving voltage signal of TLC1543, and finally send this signal to the host PC through a serial port of the MCU after processed by it [4].

2.2. Transducer and Adjuction

Formaldehyde transducer generate a current signal of "250~300nA/ppm".

The detection range is "0~50ppm", so the transducer would output a signal ranging from 0 to 15 μ A. Due to A/D can just receive Voltage signal, so we use MAX4072 to switch current signal into voltage one. The chip internal op-amp A1 and Q1, Q2 constitute a differential input. This can enhance the anti-interference ability of the transducer. Rsense is an sampling resistance. It determines the voltage to current conversion ratio.

To weak current, a large R_{sense} should be adapted for preventing the accuracy of the detection from the influence generated by a small switching output voltage. So in this case, a resistance of $4.7k\Omega$ is chosen for acquiring signals with the formaldehyde sensor.

The output signal of current-voltage conversion cannot match the requirement of the accuracy of the A/D conversion chip. Considering this, we elect amplification gain of 50 by choosing OP37A chip. Which is a high-performance operational amplifier very suitable for using as an instrument of the amplifier linear optimization. The amplified signal ranges from 0 to 3V. This can meet the sampling requirement of TLC1543 and control the output voltage ranging from 0 to 5V. Because the host PC uses battery supporting, it's not necessary to use a filter circuit to process the signal. This can avoid some interference. Current - voltage conversion and amplification hardware design is shown as Figure 1.

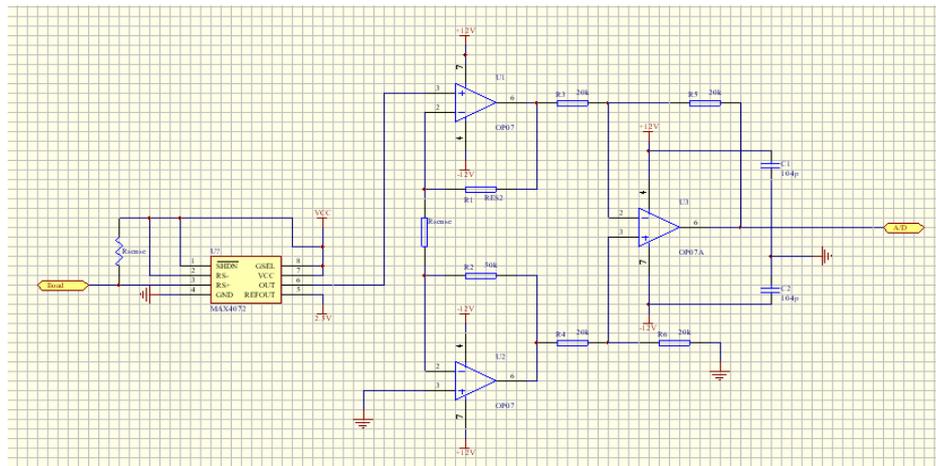


Figure 1. Current-voltage Conversion and Amplification Hardware Design

2.3. AD Serial Port

SPI port is used in data transfer between TLC1543 chip and microprocessor. The connection of hardware is shown as Figure 2.

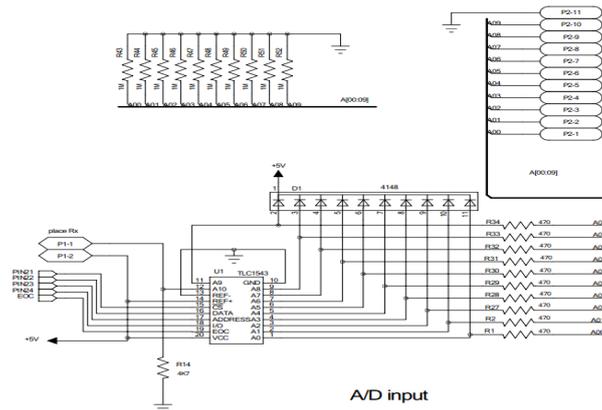


Figure 2. Hardware Connection

RS232 chip has been used for hardware design of serial port. 232-RXD and 232-TXD are connected separately with RXD and TXD in MCU. The specific hardware connection is shown as Figure 3.

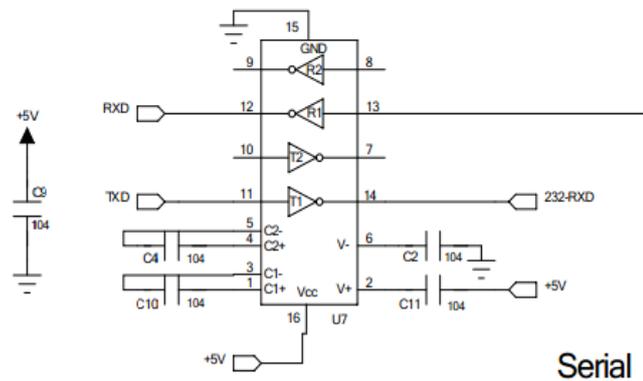


Figure 3. Specific Hardware Connection

3. Software Design of MCU

3.1. Ensemble Part

Software design of MCU can be divided into two parts: receiving data and transmit data. The part of receiving data starts from the serial port interrupt, the host PC sends an interrupt request and the MCU split the data which read from the A/D chip into four bytes. To facilitate the sending, a single-chip serial port interrupt is used in the software processing of data transmission. The general hardware connection is shown as Figure 4.

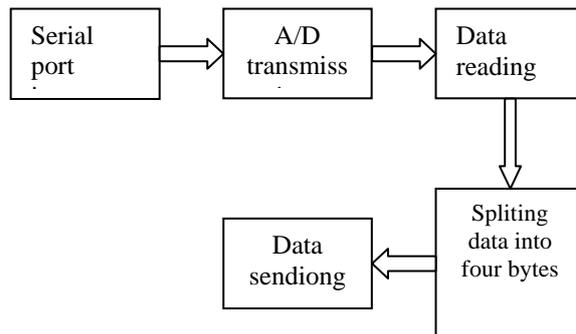


Figure 4. General Hardware Connection

3.2. A/D Program of Serial Interrupt

Serial port interrupt will start MCU to send instructions when the PC send code 0x11. The software of interrupt is shown as Figure 5.

```
void s_int(void) interrupt 4
{
    RI=0;
    ES=0;
    pc_command=SBUF;
    ES=1;
}
```

Figure 5. Software of Interrupt

TLC1543 enabled or prohibited by CS, the chip starts when CS=1. Taking the results of A/D conversion requires two times (Getting D9&D8 the first time and then D7-D0) because that the A/D chip is ten bits. There is no automatic sample-hold circuit in chip. At the end of the conversion, output EOC goes high to indicate the conversion is completed. Finally, the converted value will be saved in the function ad_result (). The software of receiving data is shown as Figure 6.

```

uint read1543(uchar port)
{
    uint ad;uint data i;
    uchar data ah=0,al=0;
    CLOCK=0;
    CS=0;
    port<<=4;
    for (i=0;i<4;i++)
    {
        D_IN=(bit)(port&0x80);CLOCK=1;CLOCK=0;
        port<<=1;
    }
    for (i=0;i<6;i++)
    {
        CLOCK=1;CLOCK=0;
    }
    CS=1; nop_0; nop_0; nop_0; nop_0; nop_0;
    nop_0; nop_0; nop_0; nop_0; nop_0; nop_0;
    nop_0; nop_0; nop_0; nop_0; nop_0; nop_0;
    nop_0; nop_0; nop_0; nop_0; nop_0;
}

CS=0;
nop_0; nop_0; nop_0;
for (i=0;i<2;i++)
{
    D_OUT=1;
    CLOCK=1;
    ah<<=1;
    if (D_OUT) ah|=0x01;
    CLOCK=0;
}
for (i=0;i<8;i++)
{
    D_OUT=1;
    CLOCK=1;
    al<<=1;
    if (D_OUT) al|=0x01;
    CLOCK=0;
}
CS=1;
ad=(uint)ah;ad<<=8;ad|=(uint)al;
return (ad);
}

```

Figure 6. Software of Receiving Data

3.3. Data Splitting and the Main Program

The main program of the software design process of signal acquisition is like this: Firstly, the PC sends instructions of transmitting data and the MCU starts to acquire signals, the result of acquisition is saved in the function ad_result. Next, to facilitate to transmit, the sensor transforms the analog signals collected to digital ones. To facilitate the next receive, the MCU will clear the first instruction. The data is converted into four bytes, however, MCU just can receive one byte every time that the transceivers process must cycle four times. When the transmission is complete, the PC sends completed flag. The software of converting is shown as Figure 7.

```

void data_convert(uint data_to_convert)
{
    data_conver[0]=0;
    data_conver[1]=(uchar)((data_to_convert&0x0300)>>8);
    data_conver[2]=(uchar)((data_to_convert&0x00f0)>>4);
    data_conver[3]=(uchar)(data_to_convert&0x000f);
}

while(1)
{
    ad_result=read1543(adconin);
    data_convert(ad_result);
    while(pc_command!=0x11);
    pc_command=0;
    for(i=0;i<4;i++)
    {
        SBUF=data_conver[i];
        while(TI==0);
        TI=0;
    }
}

```

Figure 7. Software of Converting

4. Software Design of Virtual Instrument

4.1. Graphical Display of LabVIEW

The main three types of information will be displayed in the front panel: the formaldehyde content of the chart, string and its length. The front panel and signal resolve are shown as Figure 8 and Figure 9.

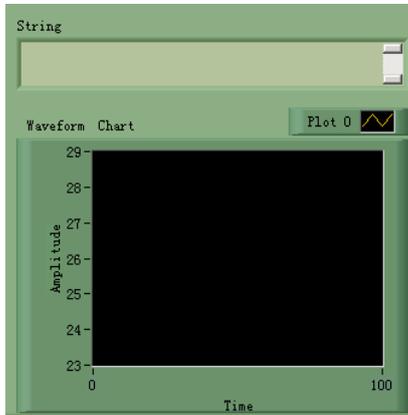


Figure 8. Front Panel

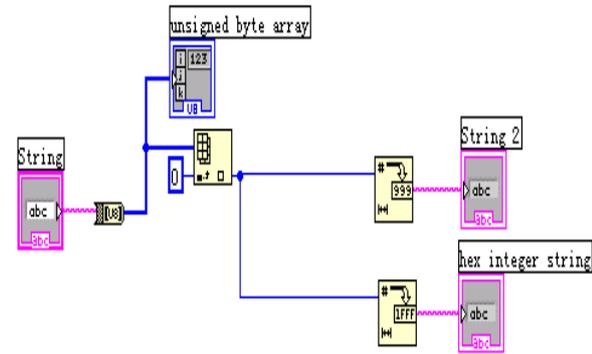


Figure 9. Signal Resolve

4.2 Receive and Display of serial port

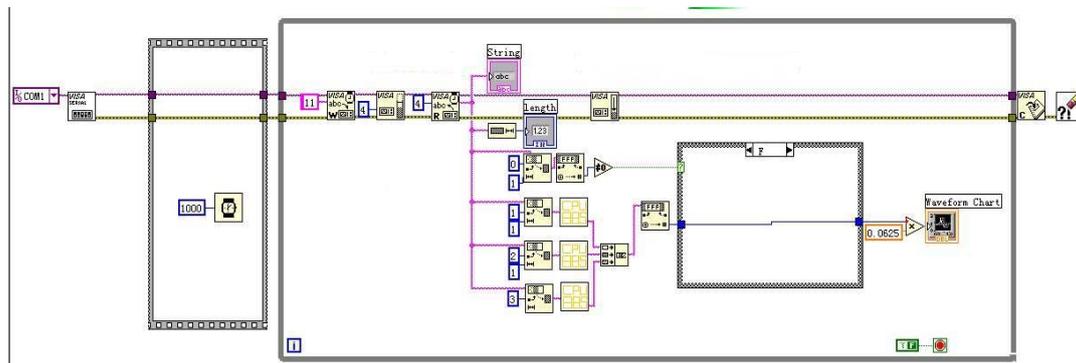


Figure 10. LabVIEW Program Design

Visa is a kind of high-level application programming interface which is used to communicate with a variety of instrument bus and it can be used to configure, program and debug the USB, GPIB, serial, XI, P XI and Ethernet systems. Visa not only control the set of functions, and also provides instrument control functions and resource management. The LabVIEW program design is shown as Figure 10.

Setting up receive buffer to change the random time-varying delay into fixed-time delay. We have processed the receiving data in three kind of methods, they are: showing the length of character string, displayed in the form of character sting, showed in the way of form. And in the last way, changing the receive ASCII into corresponding numeral.

5. Conclusion

In this paper, a formaldehyde detect platform is designed, the platform is composed by the host computer of virtual instrument and the lower machine of data acquisition and processing. The conversion and amplification of the signal is designed as hardware part, the

microprocessor transmits processed data to the host computer through the serial port, and the data will be displayed on the PC by the LabVIEW software. This method has some advantages of fast and clear, provides a new train of thought of formaldehyde detection.

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