Design of Software and Hardware of Analog Display Board Based on RS485 Communication

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Abstract. As an important human-machine interaction component in the ship damage control system, the analog display board has a large number of indicator lights arranged on the board. But meanwhile, the indicator lights are in different working states and need to be controlled by multiple driving circuit boards. Thus, the application of RS485 bus communication can effectively solve the problem of communication between the controller side and multiple driving circuit boards. And the multiplexing of output ports on each driving circuit board will be regarded as a pragmatic approach to solve the numerous indicator lights that are in different working states on the board.

1. Overview

In the ship damage control system, the analog display board is an important human-machine interaction component of the monitoring station and the display console. It serves an intuitive and clear announcer for equipment’s status, fault alarms and various damage alarms in the damage control system, and it displays all kinds of alarm signals in the form of indicators on the analog display board. Since there are often dozens of equipment and cabins in each damage control area and the monitor and display consoles are concentrated in several damage control areas, the number of indicators on the analog display board reaches a dozen or even more than a hundred. There are four statuses of the indicators: lit, extinguished, quick flash, and slow flash based on the conditions of the device, fault alarms, and damage alarms.

The indicator drive circuit of the analog display board receives the information sent by the control end and controls the status of the indicator light. The drive circuit is very close to the control end (generally within 1 m). The number of indicators of the drive circuit is often large. RS485 bus using master-slave communication has a strong anti-jamming ability, making it suitable for the communication between the control end and drive circuit.

The control end transmits the condition of the analog display board in time and accurately through RS485 communication, and the single chip microcomputer of the drive circuit displays the status of many indicators on the analog display board by controlling the 3-8 decoder and latch and multiplexing output pin.
2. Composition and working principle of analog display board
The analog display board has a large number of indicators, the indicator light needs to be controlled by several drive circuit boards, and the drive circuit controls the status of the indicator light board by receiving information from the control end, as shown in Figure 1.

![Figure 1. Analog Display Board composition](image)

The drive control circuit board uses 8 latches and one 3-8 decoder to realize the multiplexing of the single-chip pin. The 8 output pins of the single-chip computer are connected to the input of the latch, while one latch can control 8 indicators. Therefore, one drive circuit board containing 8 latches can control 64 indicators. The 3 pins of the single-chip computer control the 3-8 decoder, which are used to select 8 latches. The 8 output pins of the single-chip computer will be connected to different latches to reuse of the output pins, as shown in Figure 2. SN74HC273 and 54HC138 are chosen respectively as the latch and the 3-8 decoder.

![Figure 2. Working principle of the analog display board](image)

Because of the large number of indicators on the analog display board, a unified time base is necessary in order to avoid messy display. The unified time base ensures synchronization between
quick flashes and slow flashes and links quick flashes and slow flashes respectively to different drive circuit boards.

The latch and 3-8 decoder are used together. The selected pin of single-chip computer controls 3-8 decoder so as to select any latch; at this time, output the corresponding selected pin of single-chip computer to control the status of analog display board lamp. The connection of 3-8 decoder circuit is shown in Figure 3 [2].

![Figure 3. Connection diagram of 3-8 decoder circuit](image)

Single-chip microcomputer has no built-in RS485 communication function and it achieves RS485 communication through SN75LBC18 differential signal transceiver. The sending and receiving pins of the UART0 of the single-chip computer are connected to the R and D ends of the SN75LBC18 differential signal transceiver, and the two differential signals of the RS485 bus are connected to the A and B ends of the SN75LBC18 differential signal transceiver. The functions of sending, receiving, and switching of the SN75LBC18 differential signal transceiver are realized using the single chip microcomputer at the RE and DE end, as shown in Figure 4.

The output end of the latch is connected to the ULN2803 Darlington Tube drive to drive loads such as indicators, as shown in Figure 5.

![Figure 4. Connection diagram of RS485 Communication Circuit](image)

![Figure 5. Connection diagram of latch and Darlington Tube Drive circuit](image)

3. Software requirements analysis and communication protocol development

Analog display board of individual single-chip computer receives and decodes the information of the status of different lights from control end in real time, and then output the status by controlling the corresponding I/O port of the single-chip computer.

Since each drive circuit board connects different indicators, they receive different data when they communicate with the control end. Because of the large amount of information and the need to save response time, each drive circuit board only accept information they need. The control end in the
frame head distinguishes the information, and the number of bytes in the communication protocol is based on the actual amount of transmission. The last 4 bits of a byte are used as flags of the frame header and tail, the last 4 bits of each byte in the data segment are 0, and the first 4 bits of the bytes are for filling data, as shown in Table 1. The drive circuit board receives the information sent by the control end in the UART interrupt [1].

| Flag Bit of Frame head | 0 | 0 | 0 | 0 |
|------------------------|---|---|---|---|
| 0                      | 0 | 0 | 0 | 0 |
| 0                      | 0 | 0 | 0 | 0 |
| 0                      | 0 | 0 | 0 | 0 |
| 0                      | 0 | 0 | 0 | 0 |

Table 1. Frame header, frame tail, and data format

3.1. The demand of RS485 serial communication
1) Receive data from the control end in real-time;
2) Single-chip computer judges the data frame head and decides whether to receive data or not;
3) Calculate the checksum and compare it with the checksum contained in the sent data frame; feedback the information to the control side.

3.2. Processing and executing commands
1) After receiving the data, begin to analyze the status of each light from the data frame;
2) Output the status of the indicator light according to the status of each lamp, the configuration of the latch, and multiplexing single-chip pin of 3-8 decoder.

4. Analog display board software design

4.1. Program Flowchart
The analog display board works in a passive state, meaning it output the status of the light by analyzing the data sent by the control end. Therefore, data reception is random and intermittent. Taking into account the data volume and the characteristics of real-time display, the baud rate is set to 38400 while taking serial interrupt receiving method. Different drive boards receive the corresponding data without confusion. After the data reception is completed, the status of the corresponding indicators can be resolved. Output all corresponding pins of the single-chip computer by controlling the 3-8 decoder and latch, as shown in Figure 3. Selected pin of single-chip computer output controls 3-8 decoder. According to the corresponding relationship shown in Table 2, 8 latches are selected in turn, and in the meantime, the state of the lamp of corresponding latch is written into the selected pin of single-chip computer.

| Input | Output |
|-------|--------|
| S1    | D1     |
| S2    | D2     |
| S3    | D3     |
|       | D4     |
|       | D5     |
|       | D6     |
|       | D7     |
|       | D8     |

Table 2. 3-8 decoder input-output relationship
4.2. Programming
According to the communication demand of RS485, the corresponding UART library function is called to transmit the data. Some of the code is as follows:

1) Initializing

```c
void InitUart0(UINT32 BPS)
{
    PCONP |= (0x01 << 3); //enable Uart0
    PINSEL0 &= ~(UINT32)0x0F;
    PINSEL0 |= ((UINT32)0x05);
    //Set baud rate
    U0LCR =0x80;
    U0DLL=Fpclk/(16*BPS)&0x000000ff; //Take the lower 8 bits
    U0DLM=(Fpclk/(16*BPS)) >>8; // Take the higher 8 bits
    uU0LCR.Bits.DLAB_BIT =0x00; //Unable divisor latch
    U0LCR =0x03;
    U0FCR =0x01; //Single character trigger,
}
```

2) Receiving

```c
void Uart0Rcv(UINT32 Len,UINT8 *Buf)
{
    UINT32 i,j;
    if(Len >16)
    {
        i=16;
    }
    else
    {
        i=Len;
    }
    for(j=0;j<i;j++)
    {
        *(Buf+j)=(UINT8)(uU0RBR.Bits.BR_BIT);
    }
```

When data is received and stored in the array r x[][], the main program needs to immediately analyze the state of the lamp because of its large amount of data, so that the new data will not overwrite the old. The state of the lamp is saved in the array L Status[]. The analyzing and output process is shown as follows [3,4]:

```c
for (i=0;i<8;i++)
{
    for (j=0;j<8;j++)
    {
        if (Rx[i][j]==0x00)
        {
            LStatus[i]&=(~(1<<j));
        }
        if (Rx[i][j]==0x01)
        {
            if(sign1==0)
            LStatus[i]=((1<<j));
            if(sign1==1)
            LStatus[i]&=(~(1<<j));
        }
    }
```

```c
}
```
if (Rx [i][j]==0x02)
{
    if(sign2==0)
        LStatus [i]|=((1<<j));
    if(sign2==1)
        LStatus [i]&=(-(1<<j));
}
if (Rx [i][j]==0x03)
{
    LStatus [i]=((1<<j));
}
for(n=1; n<9;n++)
{
    LPC_GPIO2->FIOPIN=LStatus [n];
    LPC_GPIO0->FIOSET=0X00008000;        LPC_GPIO0->FIOCLR=0X00330000;
    //enable end of the decoder and set it as the decoder input 001
    LPC_GPIO0->FIOSET=0X00300000;//unable decoder
}

5. Conclusion
This paper focuses on the software and hardware design of analog display board based on the specific needs of the analog display board, taking advantage of the characteristics of RS485 communication, which is each analog display board is configured with multiple drive circuit boards while different drive circuit boards receive data correspondingly, and the control 3-8 decoder and latch is controlled according to the state of the indicator light to write the value of the output pin of the single-chip computer. The results show that the program runs stably and reliably.

References
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