Design and Implementation of Power Protection Based on Single-chip Microcomputer
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Abstract. The protection of instantaneous loss of storage data is an important function of industrial or civil equipment. The data of MCU is in RAM memory, therefore data in RAM is unreserveable after losing power. After the power drop, the data in MCU is saved to the EEPROM memory in time. This method is a good solution to the data of MCU after power loss. The principles and methods and procedures are given in this paper.

Introduction of System
Loss of storage data is an important function of industrial or civilian equipment, for example, the production line of automatic production counting, switch life detection instrument and so on. These are all records of temporary data, some of which can't even appear to be missed, and are not allowed to lose all data due to sudden power outages. The data of microcomputer is present in RAM (random memory). The data in RAM is not retained after losing power, so how to make the data not lost after losing power? This requires an EEPROM or FLASHROM memory. In the microcomputer system, it is generally used to extend the memory, microcomputer and memory interface through I²C or SPI to communicate data. In the field of measurement and control, the data in the internal and external RAM of the microcomputer is often required, and the data in RAM can be kept when the power is lost.

Instruction of Chip Pin
The serial EEPROM of AT24C series has the function of I²C bus interface. The power supply voltage is 2.5 ~ 2.6V and the current is about 3mA. It has many models, large capacity and I/O port is not used for microcomputer. Chip extended convenience and can be read and written easily. According to different models, the storage capacity is shown in table 1.

<table>
<thead>
<tr>
<th>model</th>
<th>Capacity/B</th>
<th>Number of bytes in a load (page write)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT24C01</td>
<td>128×8</td>
<td>4</td>
</tr>
<tr>
<td>AT24C02</td>
<td>256×8</td>
<td>8</td>
</tr>
<tr>
<td>AT24C04</td>
<td>512×8</td>
<td>16</td>
</tr>
<tr>
<td>AT24C08</td>
<td>1024×8</td>
<td>16</td>
</tr>
<tr>
<td>AT24C16</td>
<td>2048×8</td>
<td>16</td>
</tr>
</tbody>
</table>

The AT24CXX series has many kinds of encapsulation, with the example of 8-pin, the chip pin drawing is shown in figure 1.

Figure 1. AT24CXX series pin drawing.

Table 1. AT24C serial EEPROM parameters.
The pin function is as follows:
SDA: serial data input/output terminal, serial two-way data input/output line
SCL: serial clock terminal, which is used to synchronize input and output data.
WP: write protection, this pin is used for hardware data protection.
A0~A2: chip selection or page selection address input.
VCC: power supply
VSS: grounding

**24C16 Read and Write Operation**

**Read Operation.** The reading operation is divided into three types: (1) Read the data of the current address storage unit; (2) Read the data of the specified address storage unit; (3) Read the data of the continuous address storage unit.

**Read the data of the current address storage unit.** The internal data store address counter of E²PROM records the operation address, which is the address of the last cell to be accessed in the last read or write operation. If the chip constantly, the address has been effective in the operation, when the MCU read data, back to the response signal and E²PROM chips was introduced, the current address points to storage unit is a serial data output.

**Read the data of the specified address storage unit.** MCU signal began to read data, and then send the read/write control word, the MCU send address to read data in E²PROM chips was introduced, if E²PROM chips was introduced to track the response signal, and record the current address of the storage unit. The MCU sends the start signal, sends the chip address and the read-write control signal, and then outputs the data sequentially if the E²PROM sends the reply signal. After reading the data, the microcomputer sends back the non-reply signal and a stop signal. In the controller program, the random byte program in 24C16 is put into an R24C16 subroutine, and the R24C16 subroutine is called whenever the data of 24C16 is read in the 89C52 MCU.

```assembly
; subroutine of random bytes read 24C16
R24C16:   NOP
RSTART:   CLR ESCL
           NOP
           NOP
           SETB ESDA
           NOP
           SETB ESCL  ; Open the START
           NOP
           CLR ESDA
           NOP
           CLR ESCL

; Write 8 control words 1#
           MOV A, #10100010B ;DEVICE ADDRESS
           MOV R7, #08H
        READ1:   RLC A
           MOV ESDA, C        ; A7
           NOP
           SETB ESCL
           NOP
           CLR ESCL
           NOP
           DJNZ R7, READ1
           SETB ESCL          ;ACK FROM 24C16
           NOP
           MOV C, ESDA
           CLR ESCL
```
NOP
; Write 8-bit addresses
MOV R7, #08H  ; ADDRESS
MOV A, RDATAADR
READ2:
RLC A
MOV ESDA, C
NOP
SETB ESCL
NOP
CLR ESDA
NOP
DJNZ R7, READ2
SETB ESCL  ; ACK FROM 24C16
NOP
MOV C, ESDA
CLR ESDA
NOP
CLR ESCL
NOP
SETB ESDA
NOP
SETB ESCL  ; ANOTHER START
NOP
CLR ESDA
NOP
CLR ESCL
; Write control word 2#
MOV A, #10100011B  ; DEVICE ADDRESS2
MOV R7, #08H
READ3:
RLC A
MOV ESDA, C  ; A7
NOP
SETB ESCL
NOP
CLR ESCL
NOP
DJNZ R7, READ3
SETB ESCL  ; ACK FROM 24C16
NOP
MOV C, ESDA
CLR ESDA
NOP
; Read 8-bit data
MOV R7, #08H  ; RDATA
MOV A, #03h
READ4:
MOVC, ESDA
NOP
SETB ESCL
NOP
CLR ESCL
NOP
RLC A
DJNZ R7, READ4
MOV RDATA, A
LJMP R24END

RERR:
SETB ERRFLAG

R24END:
SETB ESDA ; NO ACK
NOP
SETB ESCL
NOP
CLR ESCL
NOP
CLR ESDA ; STOP
NOP
SETB ESCL
NOP
SETB ESDA
NOP
CLR ESCL
NOP
RET

**Read the data of the continuous address storage unit.** Read continuous data can start from the current address or from a specified cell address. MCU reads one byte data, if sending a response signal to E²PROM chips was introduced, receiving response signal E²PROM chips was introduced, the address of a storage location will add 1, continue to order the output data to the MCU, until received single chip MCU of response signal, and then received a stop bit . MCU stop reading data storage unit.

The process is: start→write control word→answer→address→reply→read data (N data)→end.

subroutine of read page 24 c16
; inputting 24C16 starting address RDATAADR
; RAM starting address RAM_ADR
; Read the number RDATA_NO
; Write control word 1#
; Write the address
; Write control word 2#
; Read 8-bit data
; After the answer, read the next byte of data

**The Write Operation.** Write operations are written in bytes and pages.

**Byte writing.** Byte writing is a MCU sending 1B data to EEPROM. MCU sends the start signal, and then sends the chips addressing control byte to SDA bus. When the EEPROM chip sends back a response signal, After MCU receiving the response signal, 1 byte of storage cell address code will be written to the EEPROM chip address pointer. When MCU receives a response from an E²PROM, a single byte of data is sent to the EEPROM, and the data is temporarily stored in the data buffer. Once again, the E²PROM sends a reply signal, and MCU produces a stop signal P to end the operation. The byte write program in the controller is put into the W24C16 subroutine, which calls the W24C16 program whenever the MCU writes a byte of data to 24C16.

**Page writing.** The MCU sends the first address of E²PROM unit and N byte data to E²PROM, then sends the start signal and then controls the byte. In the 9th clock cycle, E²PROM sends back a reply bit. The MCU sends out the first address of the E²PROM unit and puts it into an E²PROM address pointer. E²PROM chips was introduced to receive 8 bits of data, each will produce a response, and the received data sequence in the slice data buffer, until the MCU signal to stop, this will be continuous order to deposit the received data to the on chip , this is called page writing. The controller calls the PW24C16 subroutine when the continuous data is written to 24C16.
The process is: start→write control word→answer→write address→reply→write data (N data)→end.

Fault Tolerance and Data Security Measures

The time of reading and writing 24C16 is about 600us, accounting for about 3% of the total program running time. The assumption is that the security of the data will not be guaranteed if the system is dropped when it happens to be reading and writing 24C16. To improve the design of the circuit, it is feasible to add the circuit protection circuit, but the system cost has been added, and the careful study of the function of 24C16 finally found a feasible solution. The controller and 24C16 hardware connection diagram are shown in figure 2.

When initializing, the same data is stored in the same address in the 3-page storage area of 24C16. The same data will be written to these three pages each time. When reading the operation, 3 pages of data separately will be read to RAM area in order to compare. Only one page of data can be affected when the system is dropped. Compare the three data, if the three data are the same, the data is safe. Otherwise, start the calibration procedure to copy two identical data to the different page. This self-healing function is very effective.

References