AVR301: C Code for Interfacing AVR® to AT17CXXX FPGA Configuration Memories.

8-bit RISC Micrcontroller

Application Note

Features

- **C Routines for Software I^{2}C Interface**
- **Example Circuit for AVR Programming FPGA Configuration Memories**
- **User Programmable Speed**
- **Supports AT17Cxxx and AT24Cxxx Families of EEPROM**

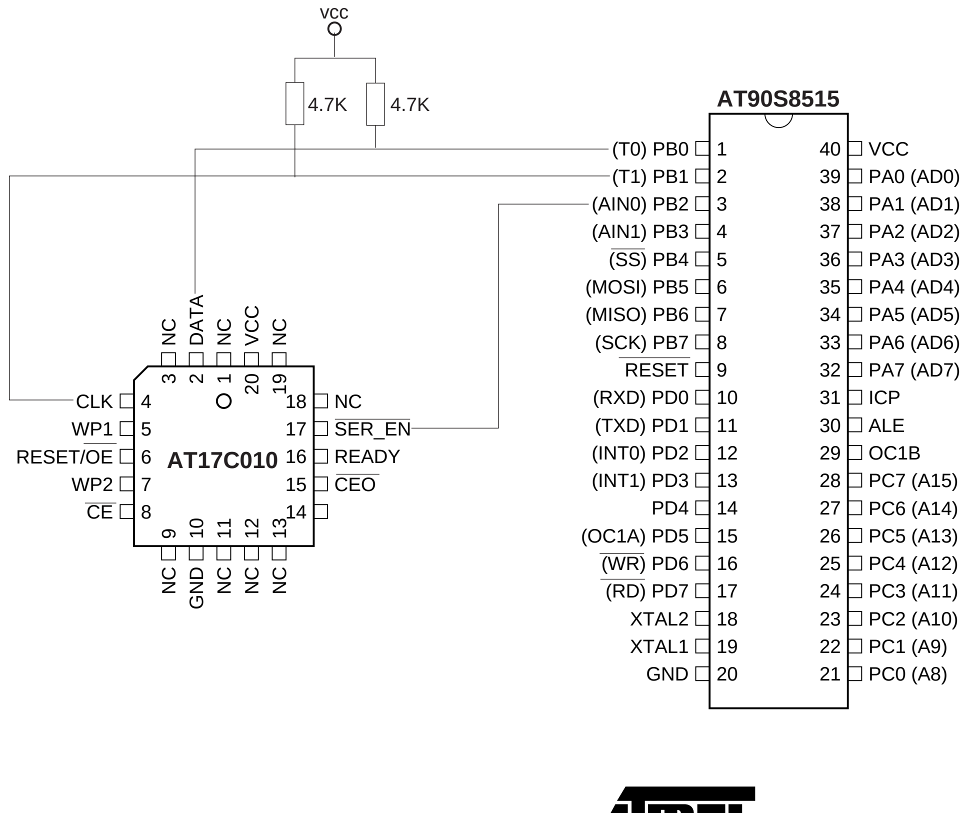
Introduction

This application note describes how to In-System-Program (ISP) an Atmel FPGA Configuration memory using an Atmel AVR Microcontroller and how to bit bang I²C using port pins on an AT90S8515 AVR Microcontroller. The AT17CXXX family of FPGA configuration memories, ranging from 64k bits to 1M bits, uses the I²C protocol for In-System Programming.

This application note assumes that the user is familiar with the AT90S8515 and AT17C010 datasheets and the application note titled "Programming Specification for Atmel's Configuration Memory E²PROMS AT17C65/128/256/512/010".

This application note is written specifically for the 1 Mbit device. C routines to read and write data are included. The code can easily be recompiled for all AVR controllers with 256 bytes SRAM or more.

Figure 1. Circuit Diagram



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Theory of Operation

The I²C bus is a two-wire synchronous serial interface consisting of one data (SDA) and one clock (SCL) line. By using open drain/collector outputs, the I²C bus supports any fabrication process (CMOS, bipolar and more). The I²C bus is a multi-master bus where one or more devices, capable of taking control of the bus, can be connected. When there is only one master connected to the bus, the resulting code is much simpler because handling of bus contentions and inter master access (a master accessing another master) is not necessary. Only master devices can drive both the SCL and SDA lines while a slave device is only allowed to issue data on the SDA line. This application note implements a single master I^{2}C-interface.

Software Description

The generic I²C routines listed below were compiled with size optimization using IAR's C Compiler Version 1.40. These routines implement a single master I²C implementation. The AT90S8515 used to perform the master function is driven by an external 7.3728 MHz crystal. The routine BitDelay is executed in 15 clock cycles or a 2.03 µs period and provides the quarter period bit timing necessary to meet the 3.3V timing specifications found in the above mentioned application note.

This code uses PORTB of the AT90S8515. On power-up, PORTB is initialized to all inputs with the internal pull-ups turned off, the external pull-ups pull the SDA and SCL lines high and the PORTB output latch bits SCL and SDA are initialized to zero. Routines WriteSDA and WriteSCL toggle their respective data direction bit depending on the value of parameter "state". When state is a '1' the port pin is configured as input (external pull-ups pull high). When state is a '0' the port pin is configured as an output and the latch drives the pin low. Table 1 lists the generic I²C routines and the amount of code space used by each routine. WriteSDA and WriteSCL are very simple routines that could be incorporated into their respective calling routines to further reduce the code size.

Table 1 lists the number of clock cycles used while implementing the function. Compiler options were set to generate minimum code.

Table 1. Size and Execution Time for I^{2}C Routines

Routine	Clocks	Bytes
SendStartBit	138	22
SendByte	1050-1054	74
SendStopBit	110	16
BitDelay	15	10
SetSCLHigh	33	38
WriteSCL	12-13	12
WriteSDA	12-13	12
GetByte	1089-1090	66

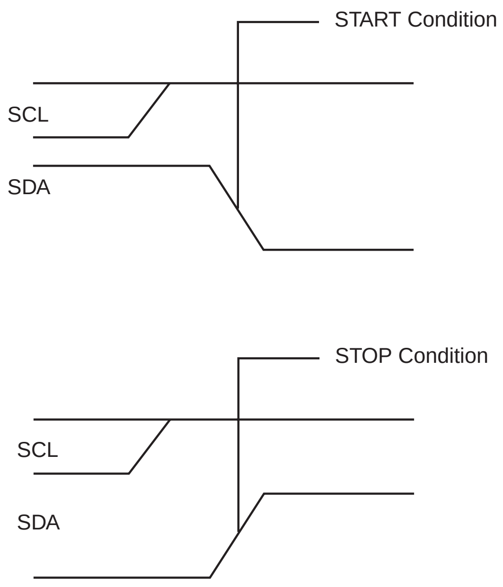
General calling sequence for the I²C routines

Write:
```
SendStartBit();          /*start* /
SendByte(byte,msbfirst); /*send address MSB first*/
SendByte(byte,lsbfirst); /*send data byte to that*/
                         /*address LSB first*/
SendStop():              /*stop*/
```

Read:
```
SendStartBit();          /*start*/
SendByte(byte,msbfirst); /*send address MSB first*/
byte = GetByte(lastbyte);/*read byte from that*/
                         /*address last byte = 1
                         /*for the last byte*/
                         /*in a serial stream*/
SendStop();              /*stop*/
```

The routines SendStartBit, SendByte, and GetByte all leave the SCL signal low on exit, allowing the next routine to write data to SDA (I²C allows changes on SDA only when SCL is low; otherwise the I²C device will interpret a start or stop condition). SendByte returns a flag indicating a successful write to the I²C slave, 0x01 signals that the slave did not acknowledge the transfer and that something is wrong on the I²C bus or with the slave. WritePage and ProgramResetPolarity use this flag for data polling. Figure 1 shows I²C start and stop bit conditions.

Figure 2. I²C Start and Stop Bits



The AT17C010 device is programmed/verified on a 128-byte page boundary. During normal FPGA configuration operations the read of the device starts at address 0 and continues until the FPGA has completed its configuration. The routines WritePage and ReadPage write and read 128 byte pages from the configuration memory and use the generic I²C routines to perform this function. WritePage and ReadPage are both called with the page address to write/read to, and a pointer to a 128-byte page buffer. At the end of a page write the data polling method is used to determine the end of the internal page programming cycle. ProgramResetPolarity and VerifyResetPolarity write and read data from memory locations 0x20000 - 0x20003 in effect setting and verifying the reset/oe polarity.

Table 2. Code Size and Execution Time for Page Read/Write

Routines	Cycles	Bytes
WritePage	287872	146
ReadPage	145901	126
ProgramResetPolarity	156104	106
VerifyResetPolarity	157269	98

PORTB on the AT90S8515 is used to communicate with the FPGA Configuration Memory. Bit assignments are as follows:

```
/*PB0 = SDA*/
/*PB1 = SCL*/
/*PB2 = SER_EN - used to put AT17C010 in I2C mode*/
/*PB3 = CS*/
/*PB4 = RESET/OE*/
```

The routine Init.c initializes the AT90S8515 peripherals. Routines Timer0.c and Timer1.c are general-purpose time out routines. Main is used to call WritePage, ReadPage, ProgramResetPolarity, and VerifyResetPolarity and serves to illustrate proper calling conventions for those routines.

Modifications and optimizations

Impact on Changing Crystal Frequency

If the user decides to change oscillator frequencies then the following routines would have to be modified:

BitDelay

ProgramResetPolarity

SetSCLHigh

WritePage

BitDelay uses NOP's to effect a quarter bus period delay. Add or remove NOP's to increase or decrease the delay. In the routines ProgramResetPolarity and WritePage timer 1 is used to generate a time-out after 20 milliseconds, the programming operation should have completed by then. Timer 0 is used in SetSCLHigh to generate a time out after 35 microseconds. If the SCL line is not high by then, then something is wrong on the bus.

References

The I²C Bus and How to use it, April 1995 Update- Philips Semiconductors

Programming Specification for Atmel's Configuration Memory E²PROMS - Atmel Corporation

AT17C512/LV512/010/LV010 FPGA Configuration Memory Data Sheet - Atmel Corporation

AT90S8515 Data Sheet - Atmel Corporation

Main.c

```
/* main
use the STK200 starter kit and external prototype board to program
an Atmel AT17C010 device. LEDs on PORTC are used as visual status indicators
4.7k ohm pull-up resistors are used on SDA and SCL */

#include "i2c.h"

volatile unsigned char t0_timed_out;
volatile unsigned char t1_timed_out;
tiny unsigned char wrbuf[128];
unsigned char rdbuf[128];

extern void WritePage(unsigned int address, unsigned char *bufptr);
extern void ReadPage(unsigned int address, unsigned char *bufptr);
void ProgramResetPolarity(unsigned char state);
unsigned char VerifyResetPolarity(void);
extern void Init(void);

void C_task main(void)
{
    unsigned int address = 0;
    unsigned char i;

    Init();

    _SEI(); /* enable interrupts */

    /* init test buffer */
    for (i = 0; i < 128; i++)
        wrbuf[i] = i;

    while (1)
    {
        PORTC = 0x00; /* LEDs off */

        for (address = 0; address < MAX_PAGES; address++)
        {
            WritePage(address,&wrbuf[0]);
            PORTC = address; /* LEDs on */
            ReadPage(address,&rdbuf[0]);

            /* verify programmed page */
            for (i = 0; i < 128; i++)
            {
                if (wrbuf[i] != rdbuf[i])
                {
                    PORTC = 0xff; /* LEDs on */
                }
            }
```

```
                ProgramResetPolarity(0);
                if (VerifyResetPolarity())
               {
                        PORTC = 0xaa;
                }

                ProgramResetPolarity(0xff);
                if (!VerifyResetPolarity())
               {
                        PORTC = 0x55;
                }

                /* clear verify buf */
                for (i = 0; i < 128; i++)
                    rdbuf[i] = 0;
            }
        } /* while (1) */
    } /* main */
```

Bitdelay.c

```
    /* BitDelay.c
    for a 3.3v device min clock pulse width low and high is 4 us
    generate 2us delay for bit timing using NOP's
    7.3728MHz crystal */

    #include "i2c.h"

    void BitDelay(void)
    {
        char delay;

        delay = 0x03;
        do
        {
         while(--delay)
        ;
        _NOP();
        return;
    }
```

Getbyte.c

```
    /* GetByte.c
    reads a byte from the I2C slave, lastbyte is used to tell slave that the read is over */

    #include "i2c.h"

    extern void WriteSCL(unsigned char state);
    extern void WriteSDA(unsigned char state);
    extern void BitDelay(void);
    extern unsigned char SetSCLHigh(void);
```

```
unsigned char GetByte(unsigned char lastbyte)
{

/* lastbyte == 1 for last byte */

    unsigned char i, bit;
    unsigned char result = 0;

    DDRB &= 0xfe; /* SDA to input */

    for (i = 0;i < 8;i++)
    {
    /* each bit at a time, LSB first */
        SetSCLHigh();
        BitDelay();
        bit = (PINB & 0x01);
        result = (bit << (i)) | result;
        WriteSCL(0);
        BitDelay();
    }

    /* send ACK */
    WriteSDA(lastbyte); /* no ack on last byte ... lastbyte = 1 for the last byte */
    BitDelay();
    SetSCLHigh();
    BitDelay();
    WriteSCL(0);
    BitDelay();
    WriteSDA(1);
    BitDelay();

    return(result);
}
```

Init.C

```
/* init.c */

#include "i2c.h"

void Init(void)
{
/* P0 = SDA - bidirectional */
    /* P1 = SCL - output */
    /* P2 = SER_EN - output */
    /* P3 = CS - output */
    /* P4 = RESET/OE - output */

    /* P7, P6, P5, P4, P3, P2, P1, P0 */
    /* O   O   O   O   O   O   O   O */
```

```
        /* 1   1   1   1   1   1   1   1 */
        DDRB = 0xfc;
        PORTB = 0xfc;

        /* Port c used to light leds on prototype board */
        DDRC = 0xff;
        PORTD |= 0xff;
        PORTC = 0x00; /* 0 turns leds off ... really should be the other way around */

        /* use pushbutton switches on atstk200 kit to start events */
        DDRD = 0x00;



        TCCR1A = 0x00; /* timer/counter 1 PWM disable */
        TCCR1B = 0x00; /* timer/counter 1 clock disable */
        TCNT1H = 0x00;
        TCNT1L = 0x00; /* clear counter */
        TCNT0 = 0x00;
        TCCR0 = 0x00;  /* stop the clock */
        TIMSK |= 0x82; /* enable timer counter 0 & 1 interrupt on overflow */
    }
```

ProgramResetPoliarity.c

```
    /* ProgramResetPolarity.c
    Locations 0x20000 through 0x20003 are used to store the reset/ouput enable polarity.
    0xff = active high reset and active low output enable.
    0x00 = active low reset and active high output enable.
    So the memory location values determine the reset polarity.
    After programming the data polling method is used to determine the end of
    the internal programming cycle.
    Timer/Counter1 is used to ensure the polling code exits its while loop. */

    #include "i2c.h"

    extern volatile unsigned char t1_timed_out;

    extern unsigned char SendByte(unsigned char byte, unsigned char order);
    extern void SendStartBit(void);
    extern void SendStopBit(void);

    void ProgramResetPolarity(unsigned char state)
    {
        unsigned char i;
        unsigned char test_ack = 0xff;

        PORTB &= 0xf7; /* bring CS low */
        PORTB &= 0xef; /* bring RESET/OE low */
        PORTB &= 0xfb; /* bring SER_EN low */

        SendStartBit();
        SendByte(AT17C010 + WRITE,MSB_FIRST);    /* send device address byte */
        SendByte(0x00,MSB_FIRST);                 /* 1st address byte */
        SendByte(0x00,MSB_FIRST);                 /* 2nd address byte */
        SendByte(0x02,MSB_FIRST);                 /* 3rd address byte ... most significant byte */

        for (i = 0; i < 4; i++)
            SendByte(state,LSB_FIRST);

        SendStopBit();

        t1_timed_out = FALSE; /* set in timer counter 0 overflow interrupt routine */

        /* 20 milli-second timeout */
        /* 7.3728MHz / 1024 = 7200 Hz */
        /* 7200 Hz = 138.8 us */
        /* 20 ms / 138.8 us = 144.09 */
        /* 65536 - 144 = 65392 = ff70 */
        /* interrupt on ffff to 0000 transition */
        TCNT1H = 0xff;
        TCNT1L = 0x70; /* load counter */
        TCCR1B = 0x05; /* timer/counter 1 clock / 1024 */

        /* continue sending start bit and device address until we get an ack back */
        /* data poll to program complete ... time out for error */
        while (test_ack && !t1_timed_out)
        {
            SendStartBit();
            test_ack = SendByte(AT17C010 + WRITE,MSB_FIRST); /* send device address byte */
        }
        SendStopBit();

        PORTB |= 0x04; /* bring SER_EN high */
        PORTB |= 0x10; /* bring RESET/OE high */
        PORTB |= 0x08; /* bring CS high */
    }
```

ReadPage.c

```
/* ReadPage.c
Read 128 bytes at address into bufptr
Starts reading at address 0 within the page
Please refer to the application note titled:
"Programming Specification for Atmel's Configuration Memory E²PROMS AT17C65/128/256/512/010"
found at www.atmel.com for detailed device address decoding and page address formatting */

#include "i2c.h"

extern void BitDelay(void);
extern unsigned char SendByte(unsigned char byte, unsigned char order);
extern unsigned char GetByte(unsigned char lastbyte);
extern void SendStartBit(void);
extern void SendStopBit(void);

void ReadPage(unsigned int address, unsigned char *bufptr)
{
    unsigned char i;
    unsigned char addr1;
    unsigned char addr2;
    unsigned char addr3;

    PORTB &= 0xf7; /* bring CS low */
    PORTB &= 0xef; /* bring RESET/OE low */
    PORTB &= 0xfb; /* bring SER_EN low */

    BitDelay();

    addr1 = (unsigned char)(address >> 9);
    addr2 = (unsigned char)(address >> 1);
    addr3 = (unsigned char)(address << 7);

    SendStartBit();
    SendByte(AT17C010 + WRITE,MSB_FIRST);      /* send device address byte */
    SendByte(addr1,MSB_FIRST);                 /* 1st address byte */
    SendByte(addr2,MSB_FIRST);                 /* 2nd address byte */
    SendByte(addr3,MSB_FIRST);                 /* 3rd address byte */

    SendStartBit();
    SendByte(AT17C010 + READ,MSB_FIRST);  /* send device address byte with read bit */

    for (i = 0; i < 127; i++)
        bufptr[i] = GetByte(0);

    bufptr[127] = GetByte(1); /* 1 signals last byte of read sequence */

    SendStopBit();

    PORTB |= 0x04; /* bring SER_EN high */
    PORTB |= 0x10; /* bring RESET/OE high */
    PORTB |= 0x08; /* bring CS high */
}
```

SendByte.c

```
/* SendByte.c
send a byte of address or data to the I2C slave
parameter order used to select between sending LSB or MSB first
returns a 1 if the slave didn't ack and a 0 if the slave did */

#include "i2c.h"

extern void WriteSCL(unsigned char state);
extern void WriteSDA(unsigned char state);
extern void BitDelay(void);
extern unsigned char SetSCLHigh(void);

unsigned char SendByte(unsigned char byte, unsigned char order)
{
    unsigned char i;
    unsigned char error;

    for (i = 0; i < 8; i++)
    {
        if (order)
        {
            WriteSDA(byte & 0x80); /* if > 0 SDA will be a 1 */
            byte = byte << 1; /* send each bit, MSB first for address */
        }
        else
        {
            WriteSDA(byte & 0x01); /* if > 0 SDA will be a 1 */
            byte = byte >> 1; /* send each bit, LSB first for data */
        }

        BitDelay();
        SetSCLHigh();
        BitDelay();
        WriteSCL(0);
        BitDelay();
    }

    /* now for an ack */

    /* master generates clock pulse for ACK */
    WriteSDA(1); /* release SDA ... listen for ACK */
    BitDelay();
    SetSCLHigh(); /* ACK should be stable ... data not allowed to change when SCL is high */

    /* SDA at 0 ?*/
    error = (PINB & 0x01); /* ack didn't happen if bit 0 = 1 */

    WriteSCL(0);
    BitDelay();

    return(error);
}
```

SenStartBit.c

```
/* SendStartBit.c
generates an I2C start bit
start bit is a 1 to 0 transition on SDA while SCL is high
         ____________
        /
SCL ___/

    __________
              \
SDA            \_____

*/

#include "i2c.h"

extern void WriteSCL(unsigned char state);
extern void WriteSDA(unsigned char state);
extern void BitDelay(void);
extern unsigned char SetSCLHigh(void);

void SendStartBit(void)
{
    WriteSDA(1);
    BitDelay();
    SetSCLHigh();
    BitDelay();
    WriteSDA(0);
    BitDelay();
    WriteSCL(0);
    BitDelay();
}
```

SendStopBit.c

```
/* SendStopBit.c
generates an I2C stop bit
assumes SCL is low
stop bit is a 0 to 1 transition on SDA while SCL is high

         ____________
        /
SCL ___/

               ______
              /
SDA _________/

*/

#include "i2c.h"
```

```
extern void WriteSCL(unsigned char state);
extern void WriteSDA(unsigned char state);
extern void BitDelay(void);
extern unsigned char SetSCLHigh(void);

void SendStopBit(void)
{
    WriteSDA(0);
    BitDelay();
    SetSCLHigh();
    BitDelay();
    WriteSDA(1);
    BitDelay();
}
```

SetSCLHigh.c

```
/* SetSCLHigh.c
Det SCL high, and wait for it to go high.
Returns the value of t0_timed_out. If 0xff then we timed out before SCL went high and
should be used to indicate an error to the caller
Crystal frequency is 7.3728 MHz */

#include "i2c.h"

extern volatile unsigned char t0_timed_out;

extern void WriteSCL(unsigned char state);

unsigned char SetSCLHigh(void)
{
    WriteSCL(1); /* release SCL*/

    /* set up timer counter 0 for timeout */
    t0_timed_out = FALSE; /* will be set after approximately 34 us */
    TCNT0 = 0; /* clear counter */
    TCCR0 = 1; /* ck/1 ..  enable counting */

    /* wait till SCL goes to a 1 */
    while (!(PINB & 0x02) && !t0_timed_out)
    ;

    TCCR0 = 0; /* stop the counter clock */

    return(t0_timed_out);
}
```

Timer0.c

```
/* timer0 */

#include "i2c.h"

extern volatile unsigned char t0_timed_out;

interrupt [TIMER0_OVF0_vect] void TIMER0_OVF0_interrupt(void)
{
    t0_timed_out = TRUE;
}
```

Timer1.c

```
/* timer 1 timer */

#include "i2c.h"

extern volatile unsigned char t1_timed_out;

interrupt [TIMER1_OVF1_vect] void TIMER1_OVF1_interrupt(void)
{
    t1_timed_out = TRUE;
}
```

VerifyResetPolarity.c

```
/* VerifyResetPolarity.c
4 bytes are read from locations 0x20000 through 0x20003
The bytes are verified to be of all the same value. If they are then the value is returned.
return value = 0xff = active high reset and active low output enable.
return value = 0x00 = active low reset and active high output enable.
If they aren't then 0xaa is returned to signal an error condition. */

#include "i2c.h"

extern void BitDelay(void);
extern unsigned char SendByte(unsigned char byte, unsigned char order);
extern unsigned char GetByte(unsigned char lastbyte);
extern void SendStartBit(void);
extern void SendStopBit(void);

unsigned char VerifyResetPolarity(void)
{
    unsigned char loc_1;
    unsigned char loc_2;
    unsigned char loc_3;
    unsigned char loc_4;
    unsigned char value;

    PORTB &= 0xf7; /* bring CS low */
    PORTB &= 0xef; /* bring RESET/OE low */
    PORTB &= 0xfb; /* bring SER_EN low */
    BitDelay(); /* for good measure */

    SendStartBit();
    SendByte(AT17C010 + WRITE,MSB_FIRST);  /* send device address byte */
    SendByte(0x00,MSB_FIRST);              /* 1st address byte ... most significant byte first */
    SendByte(0x00,MSB_FIRST);              /* 2nd address byte ... most significant byte first */
    SendByte(0x02,MSB_FIRST);              /* 3rd address byte ... most significant byte first */

    SendStartBit();
    SendByte(AT17C010 + READ,MSB_FIRST);  /* send device address byte with read */

    loc_1 = GetByte(0);
    loc_2 = GetByte(0);
    loc_3 = GetByte(0);
    loc_4 = GetByte(1);
    SendStopBit();

    PORTB |= 0x04; /* bring SER_EN high */
    PORTB |= 0x10; /* bring RESET/OE high */
    PORTB |= 0x08; /* bring CS high */

    if ((loc_1 == loc_2) && (loc_2 == loc_3) && (loc_3 == loc_4))
        value = loc_1; /* valid reset/oe polarity */
    else
        value = 0xaa; /* error */

    return(value);
}
```

WritePage.c

```
/* WritePage.c
Writes 128 bytes at address from bufptr
Starts writing at address 0 within the page
Please refer to the application note titled:
"Programming Specification for Atmel's Configuration Memory E²PROMS AT17C65/128/256/512/010"
found at www.atmel.com for detailed device address decoding and page address formatting
After programming the data polling method is used to determine the end of
the internal programming cycle.
Timer/Counter1 is used to ensure the polling code exits its while loop. */

#include "i2c.h"

extern volatile unsigned char t1_timed_out;

extern unsigned char SendByte(unsigned char byte, unsigned char order);
extern void SendStartBit(void);
extern void SendStopBit(void);
extern void BitDelay(void);

void WritePage(unsigned int address, unsigned char *bufptr)
```

```
{
   unsigned char i;
   unsigned char addr1;
   unsigned char addr2;
   unsigned char addr3;
   unsigned char test_ack = 0xff;

    PORTB &= 0xf7; /* bring CS low */
    PORTB &= 0xef; /* bring RESET/OE low */
    PORTB &= 0xfb; /* bring SER_EN low */
    BitDelay();

    addr1 = (unsigned char)(address >> 9);
    addr2 = (unsigned char)(address >> 1);
    addr3 = (unsigned char)(address << 7);

    SendStartBit();
    SendByte(AT17C010 + WRITE,MSB_FIRST);      /* send device address byte with write bit */
    SendByte(addr1,MSB_FIRST);                 /* 1st address byte */
    SendByte(addr2,MSB_FIRST);                 /* 2nd address byte */
    SendByte(addr3,MSB_FIRST);                 /* 3rd address byte */

    for (i = 0; i < 128; i++)
        SendByte(bufptr[i],LSB_FIRST);

    SendStopBit();

    t1_timed_out = FALSE; /* set in timer counter 0 overflow interrupt routine */

    /* 20 milli-second timeout */
    /* 7.3728MHz / 1024 = 7200 Hz */
    /* 7200 Hz = 138.8 us */
    /* 20 ms / 138.8 us = 144.09 */
    /* 65536 - 144 = 65392 = ff70 */
    /* interrupt on ffff to 0000 transition */
    TCNT1H = 0xff;
    TCNT1L = 0x70; /* load counter */
    TCCR1B = 0x05; /* timer/counter 1 clock / 1024 */

    /* continue sending start bit and device address until we get an ack back */
    /* data poll to program complete ... time out for error */
    while (test_ack && !t1_timed_out)
    {
        SendStartBit();
        test_ack = SendByte(AT17C010 + WRITE,MSB_FIRST);  /* send device address byte */
    }
    TCCR1B = 0x00; /* disable timer/counter 1 clock */
    SendStopBit();

    PORTB |= 0x04; /* bring SER_EN high */
```

```
        PORTB |= 0x10; /* bring RESET/OE high */
        PORTB |= 0x08; /* bring CS high */
    }
```

WriteSCL.c

```
    /* WriteSCL.c */

    #include "i2c.h"

    void WriteSCL(unsigned char state)
    {
        if (state)
            DDRB &= 0xfd; /* input ... pullup will pull high or slave will drive low */
        else
            DDRB |= 0x02; /* output ... port latch will drive low */
    }
```

WriteSDA.c

```
    /* WriteSDA.c */

    #include "i2c.h"

    void WriteSDA(unsigned char state)
    {
        if (state)
            DDRB &= 0xfe; /* input ... pullup will pull high or slave will drive low */
        else
            DDRB |= 0x01; /* output ... port latch will drive low */
    }
```

i2c.h

```
    /* i2c.h */

    #include "io8515.h"
    #include "ina90.h"
    #pragma language=extended

    #define MSB_FIRST           0xff
    #define LSB_FIRST           0x00
    #define READ                0x01
    #define WRITE               0x00
    #define AT17C010            0xa6
    #define TRUE                0xff
    #define FALSE               0x00
    #define MAX_PAGES           1024
    #define PAGE_SIZE           128
```

8515int.xlc

```
    -!    XLINK command file for AT90S8515. 512 bytes data address
              space and 8 Kbytes program address space. -!
        -!    Define CPU type (AVR) -!

    -ca90

        -! Define reset and interrupt vector segment, requires 28(dec) locations -!

    -Z(CODE)INTVEC=0-1B

        -! Define segments in flash memory -!

    -Z(CODE)RCODE,CDATA0,CDATA1,CCSTR,SWITCH,FLASH,CODE=1C-1FFF

        -! Define segments in RAM    -!
        -! The registers are in addresses 0-1F and memory mapped I/O in addresses 20-5F, built-in SRAM in
         addresses 60-25F. Data stack(CSTACK) size is 60 bytes(hex), return stack(RSTACK) size is 20 bytes(hex)-!

    -Z(DATA)IDATA0,UDATA0,RSTACK+20,IDATA1,UDATA1,ECSTR,CSTACK+60=60-25F

        -!  Select reduced "printf" support to reduce library size.
            See the configuration section of the IAR C-compiler Users Guide concerning use of printf/sprintf. -!

    -e_small_write=_formatted_write
    -e_small_write_P=_formatted_write_P

        -!  Disable floating-point support in "scanf" to reduce library size.
        See the configuration section of the IAR C-compiler Users Guide concerning use of scanf/sscanf -!

    -e_medium_read=_formatted_read
    -e_medium_read_P=_formatted_read_P

        -! Suppress one warning which is not relevant for this processor -!

    -w29

        -! Load the 'C' library -!

    cl1s
```

Atmel Headquarters

Corporate Headquarters
2325 Orchard Parkway
San Jose, CA 95131
TEL (408) 441-0311
FAX (408) 487-2600

Europe
Atmel U.K., Ltd.
Coliseum Business Centre
Riverside Way
Camberley, Surrey GU15 3YL
England
TEL (44) 1276-686677
FAX (44) 1276-686697

Asia
Atmel Asia, Ltd.
Room 1219
Chinachem Golden Plaza
77 Mody Road
Tsimshatsui East
Kowloon, Hong Kong
TEL (852) 27219778
FAX (852) 27221369

Japan
Atmel Japan K.K.
Tonetsu Shinkawa Bldg., 9F
1-24-8 Shinkawa
Chuo-ku, Tokyo 104-0033
Japan
TEL (81) 3-3523-3551
FAX (81) 3-3523-7581

Atmel Operations

Atmel Colorado Springs
1150 E. Cheyenne Mtn. Blvd.
Colorado Springs, CO 80906
TEL (719) 576-3300
FAX (719) 540-1759

Atmel Rousset
Zone Industrielle
13106 Rousset Cedex, France
TEL (33) 4 42 53 60 00
FAX (33) 4 42 53 60 01

Fax-on-Demand
North America:
1-(800) 292-8635
International:
1-(408) 441-0732

e-mail
literature@atmel.com

Web Site
http://www.atmel.com

BBS
1-(408) 436-4309