AVR306: Using the AVR® UART in C

Features

- **Setup and Use of the AVR UART**
- **Code Examples for Polled and Interrupt Controlled UART**
- **Compact Code**
- **C Code Included for AT90S8515**

Description

This application note describes how to set up and use the UART present in most AVR devices. C code examples are included for polled and interrupt controlled UART applications.

Polled UART

The application is continously checking the UDRE bit in the UART Status Register to control when the UART has finished sending a byte. When receiving data, the application is continously checking the RXC bit in the UART Status Register to control when the UART has completed receiving a byte.

Interrupt Controlled UART

The UART generates an interrupt when the UART has finished transmitting or receiving a byte. The interrupt handling routines uses modulo 2n addressing of circular buffers for buffering incoming and outgoing data. The buffer sizes must be defined before using the routines. Set the UART_RX_BUFFER_SIZE and UART_TX_BUFFER_SIZE variables to the buffer size in bytes. Note that these variables must be a power of 2. If not, a compiler error message will be flagged.

An extra function is added to the UART2 example code. The DataInReceiveBuffer returns zero if the receive buffer does not contain any data. This function does, in contrast to the ReceiveByte function, not wait for incoming data, but returns immediately the status of the buffer. Note: this routine does not return the number of bytes in the buffer.

Table 1.

Polled UART	Interrupt controlled UART
Compact code	Reasonable code size
Application busy while communicating	Application free while communicating

8-bit AVR® Microcontroller

Application Note

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Usage

Both examples use the same set of routines. If other devices than AT90S8515 is used, the include file in the code must be changed accordingly.

void InitUART(unsigned char baudrate);

Enables the UART and sets the baud rate. Using baud rates that differs more than ±0.5% is not recommended. Please refer to the UART section in the data sheet for selecting the baud rate. The value passed to this function will be written to the UART Baud Rate Register.

unsigned char ReceiveByte(void);

Waits for one byte to be received and returns it's value.

void TransmitByte(unsigned char data);

Waits for transmission to be allowed, sends byte given as parameter to the UART transmitter and returns.

unsigned char DataInReceiveBuffer(void);

Returns zero (0) if the receive buffer is empty.

UART1.c - Polled

```
/* includes */
#include <io8515.h>

/* UART Control Register Bit Definitions */
#define    RXCIE        7
#define    TXCIE        6
#define    UDRIE        5
#define    RXEN         4
#define    TXEN         3
#define    CHR9         2
#define    RXB8         1
#define    TXB8         0

/* UART Status Register Bit Definitions */
#define    RXC          7
#define    TXC          6
#define    UDRE         5
#define    FE           4
#define    OVR          3


/* Prototypes */
void InitUART( unsigned char baudrate );
unsigned char ReceiveByte( void );
void TransmitByte( unsigned char data );


/* main - a simple test program*/
void main( void )
{
  InitUART( 11 );                          /* set the baudrate to 19,200 bps using a
                                               3.6864MHz crystal */
  while ( 1 )                              /* forever */
  {
    TransmitByte( ReceiveByte() );         /* echo the received character */
  }
}
```

```
/* initialize UART */
void InitUART( unsigned char baudrate )
{
  UBRR = baudrate;                                  /* set the baud rate */
  UCR  = ( (1<<RXEN) | (1<<TXEN) );                 /* enable UART receiver and transmitter */

}


/* Read and write functions */
unsigned char ReceiveByte( void )
{
  while ( !(USR & (1<<RXC)) )                       /* wait for incomming data */
  ;                                                 /* return the data */
  return UDR;
}

void TransmitByte( unsigned char data )
{
  while ( !(USR & (1<<UDRE)) )
    ;                                              /* wait for empty transmit buffer */
  UDR = data;                                      /* start transmittion */
}
```

UART2.c - Interrupt Driver

```
/* includes */

#include <io8515.h>
#include <ina90.h>

/* UART Control Register Bit Definitions */
#define    RXCIE        7
#define    TXCIE        6
#define    UDRIE        5
#define    RXEN         4
#define    TXEN         3
#define    CHR9         2
#define    RXB8         1
#define    TXB8         0

/* UART Status Register Bit Definitions */
#define    RXC          7
#define    TXC          6
#define    UDRE         5
#define    FE           4
```

```
#define    OVR          3

/* UART Buffer Defines */
#define UART_RX_BUFFER_SIZE  128      /* 1,2,4,8,16,32,64,128 or 256 bytes */
#define UART_RX_BUFFER_MASK ( UART_RX_BUFFER_SIZE - 1 )
#if ( UART_RX_BUFFER_SIZE & UART_RX_BUFFER_MASK )
#error RX buffer size is not a power of 2
#endif

/* Static Variables */
static unsigned char UART_RxBuf[UART_RX_BUFFER_SIZE];
static volatile unsigned char UART_RxHead;
static volatile unsigned char UART_RxTail;

static unsigned char UART_TxBuf[UART_TX_BUFFER_SIZE];
static volatile unsigned char UART_TxHead;
static volatile unsigned char UART_TxTail;

/* Prototypes */
void InitUART( unsigned char baudrate );
unsigned char ReceiveByte( void );
void TransmitByte( unsigned char data );


/* main - a simple test program*/
void main( void )
{
  InitUART( 11 );                                 /* set the baudrate to 19,200 bps using a
                                                     3.6864MHz crystal */
  _SEI();                                         /* enable interrupts => enable UART
                                                     interrupts */

  while ( 1 )                                     /* forever */
  {
    TransmitByte( ReceiveByte() );                /* echo the received character */
  }
}


/* initialize UART */
void InitUART( unsigned char baudrate )
{
  unsigned char x;

  UBRR = baudrate;                                /* set the baud rate */
                                                  /* enable UART receiver and transmitter, and
                                                     receive interrupt */
  UCR  = ( (1<<RXCIE) | (1<<RXEN) | (1<<TXEN) );

  x = 0;                                          /* flush receive buffer */
```

```
  UART_RxTail = x;
  UART_RxHead = x;
  UART_TxTail = x;
  UART_TxHead = x;
}


/* interrupt handlers */
interrupt [UART_RX_vect] void UART_RX_interrupt( void )
{
  unsigned char data;
  unsigned char tmphead;

  data = UDR;                                       /* read the received data */
                                                    /* calculate buffer index */
  tmphead = ( UART_RxHead + 1 ) & UART_RX_BUFFER_MASK;
  UART_RxHead = tmphead;                            /* store new index */

  if ( tmphead == UART_RxTail )
  {
    /* ERROR! Receive buffer overflow */
  }

  UART_RxBuf[tmphead] = data;                       /* store received data in buffer */
}

interrupt [UART_UDRE_vect] void UART_TX_interrupt( void )
{
  unsigned char tmptail;
                                                    /* check if all data is transmitted */
  if ( UART_TxHead != UART_TxTail )
  {
                                                    /* calculate buffer index */
    tmptail = ( UART_TxTail + 1 ) & UART_TX_BUFFER_MASK;
    UART_TxTail = tmptail;                          /* store new index */

    UDR = UART_TxBuf[tmptail];                      /* start transmition */
  }
  else
  {
    UCR &= ~(1<<UDRIE);                             /* disable UDRE interrupt */
  }
}


/* Read and write functions */
unsigned char ReceiveByte( void )
{
  unsigned char tmptail;
  while ( UART_RxHead == UART_RxTail )              /* wait for incomming data */
```

```
  ;
  tmptail = ( UART_RxTail + 1 ) & UART_RX_BUFFER_MASK;/* calculate buffer index */

  UART_RxTail = tmptail;                          /* store new index */

  return UART_RxBuf[tmptail];                     /* return data */
}

void TransmitByte( unsigned char data )
{
  unsigned char tmphead;
                                                  /* calculate buffer index */
  tmphead = ( UART_TxHead + 1 ) & UART_TX_BUFFER_MASK; /* wait for free space in buffer */
  while ( tmphead == UART_TxTail );

  UART_TxBuf[tmphead] = data;                     /* store data in buffer */
  UART_TxHead = tmphead;                          /* store new index */

  UCR |= (1<<UDRIE);                              /* enable UDRE interrupt */
}

unsigned char DataInReceiveBuffer( void )
{
  return ( UART_RxHead ! = UART_RxTail );         /* return 0 (FALSE) if the receive buffer is empty */
}
```

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) 1276-686-677
FAX (44) 1276-686-697

Asia
Atmel Asia, Ltd.
Room 1219
Chinachem Golden Plaza
77 Mody Road Tsimhatsui
East Kowloon
Hong Kong
TEL (852) 2721-9778
FAX (852) 2722-1369

Japan
Atmel Japan K.K.
9F, Tonetsu Shinkawa Bldg.
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) 4-4253-6000
FAX (33) 4-4253-6001

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

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