UART Programming with Atmega128

In this tutorial we are going to learn how to communicate with PC using UART protocol. Atmega128 has two USART, USART0 and USART1. For more information about basics of UART refer AVR tutorial. We will discuss in this tutorial about USART0 thoroughly.

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UART Module

Atmega128 has two UART are named USART0 and USART1. Each UART has Receiver and Transmitter pins which are name as RXD0 and TXD0 for USART0 and similarly RXD1 and TXD1 for USART1. Atmega128 has multiplexed pins so we configure these if we want to use UART's. Below table shows the multiplexed pins related to UART.

Port Pin	Pin no.	Port Function	Port Function
PE0	2	PDI	RXD0
PE1	3	PDO	TXD0
PD2	27	INT2	RXD1
PD3	28	INT3	TXD1

UART Register

The below table shown registers are associated with Atmega128 UART.

Register	Description
UDR	USART Data Register
UCSR0A	USART0 Control and Status Register A
UCSR0B	USART0 Control and Status Register B
UCSR0C	USART0 Control and Status Register C
UBRR0L	USART0 Baud Rate Register L
UBRR0H	USART0 Baud Rate Register H

UART Register Configuration

We will see now how to configure the UART registers.

UCSR0A							
D7	D6	D5	D4	D3	D2	D1	D0
RXC0	TXC0	UDRE0	FE0	DOR0	UPE0	U2X0	MPCM0

This bit is used to show the status of the received buffer.
Bit 7 - RXC0 : USART Receive complete
1 : Unread data in the Receiver buffer
0 : Receive buffer is empty.

This bit us used to show the status of the transmitted buffer.
Bit 6 - TXC0 : USART transmit complete
1 : No data present in the buffer register to transmit
0 : Transmit complete interrupt is executed.

This bit indicates whether Transmit data buffer ready to receive new data.
Bit 5 - UDRE0 : USART Data Register empty
1 : Transmitter buffer is empty
0 : Transmitter is ready.

This bit us used to show the Frame error.
Bit 4 - FE0 : Frame error
1 : Next character in the receiver buffer had error
0 : Writing to UCSR0A.

This bit us used to show the Receiver data over run occure.
Bit 3 - DOR0 : Data over run
1 : Receiver buffer is full (Receiver data over run occure)
0 : Writing to UCSR0A.

This bit us used to show the parity error.
Bit 2 - UPE0 : Parity Error
1 : Next character in the receiver buffer had a parity error
0 : Writing to UCSR0A.

This bit has effect for the Asynchronous operation. For Synchronous operation write this bit to 0.
Bit 1 - U2X0: Double the USART transmission speed
1 :Reduces the divisor of the baud rate divider from 16 to 8 effectively doubling the transfer rate of Asynchronous communication
0 : Synchronous operation.

This bit enables the multiprocessor communication.
Bit 0 - MPCM0: Multiprocessor communication mode
1 :All the incoming frames received by the USART Receiver that do not contain address information will be ignored.
0 : Writing to UCSR0A.

UCSR0B

D7	D6	D5	D4	D3	D2	D1	D0
RXCIE0	TXCIE0	UDREIE0	RXEN0	TXEN0	UCSZ20	RXB80	TXB80

This bit is used to show the status of the received interrupt.
Bit 7 - RXCIE0: RX Complete Interrupt Enable
1 : A USART0 Receive Complete interrupt will be generated
0 : no interrupt.

This bit us used to show the status of the transmitted interrupt .
Bit 6 - TXC0 : USART transmit complete
1 : A USART0 Transmit Complete interrupt will be generated
0 : no interrupt.

Bit 5 - UDRIE0: USART Data Register Empty Interrupt Enable
1 : enables interrupt on the UDRE0 flag
0 : no interrupt.

Bit 4 - RXEN0: Receiver Enable
1 : The Receiver will override normal port operation for the RxDn pin
0 : Receiver will flush the receive buffer invalidating the FEn, DORn and UPEn flags.

Bit 3 - TXEN0: Transmitter Enable
1 : The Transmitter will override normal port operation for the TxDn pin
0 : the Transmitter will not become effective until ongoing and pending transmissions are completed

Bit 2 - UCSZ02: Character Size
1 : number of data bits (character size) in a frame the Receiver and Transmitter use
0 :nil

Bit 1 - RXB8n: Receive Data Bit 8
RXB8n is the ninth data bit of the received character when operating with serial frames with 9-data bits. Must be read before reading the low bits from UDR0.

Bit 0 - TXB8n: Transmit Data Bit 8
TXB8n is the 9th data bit in the character to be transmitted when operating with serial frames with 9 data bits. Must be written before writing the low bits to UDR0.

UCSR0C D7 D6 D5 D4 D3 D2 D1 D0
URSEL0 UMSEL0 UPM10 UPM00 USBS0 UCSZ10 UCSZ00 UCPOL0
This bit is used to show the status of the received interrupt.
Bit 7 - Reserved Bit

This bit selects between Asynchronous and Synchronous mode of operation.
Bit 6 - UMSEL0: USART Mode Select
1 : Synchronous Operation
0 : Asynchronous Operation.

These bits enable and set type of parity generation and check
Bit 5:4 ? UPM01:0: Parity Mode

UPM01	**UPM00**	**Parity Mode**
0	0	Disabled
0	1	(Reserved)
1	0	Enabled,Even parity
1	1	Enabled,odd parity

This bit selects the number of stop bits to be inserted by the Transmitter. The Receiver ignores this setting. **Bit 3 - USBS0: Stop Bit Select**
1 : 2-bits
0 : 1-bit

The UCSZ01:0 bits combined with the UCSZ02 bit in UCSR0B sets the number of data bits (character size) in a frame the Receiver and Transmitter use. **Bit 2:1 - UCSZ01:0: Character Size**

UCSZ02	**UCSZ01**	**UCSZ00**	**Character Size**
0	0	0	5-bit
0	0	1	6-bit
0	1	0	7-bit
0	1	1	8-bit
1	0	0	Reserved
1	0	1	Reserved
1	1	0	Reserved
1	1	1	9-bit

This bit is used for synchronous mode only. **Bit 0 - UCPOL0: Clock Polarity**
1 : Synchronous
0 :Asynchronous

USART Baud Rate Register

	UBRRH				**UBRRL**
D15	D14	D13	D12	D11:D8	D7:D0
URSEL	-	-	-	**UBRR[11:8]**	**UBRR[7:0]**

? **Bit 11:0 - UBRR11:0: USART Baud Rate Register**

This is a 12 bit register which contains the USART baud rate. The UBRRH contains the four most significant bits, and UBRRL contains the 8 least significant bits of the USART baud rate.

Baud Rate Calculation

Baud rates for asynchronous operation can be generated by using the UBRR settings. Oscillator frequency(fosc) and baud rate needs to put in below formula for UBRR value generation.

$$UBRR = fosc - (Baudrate * 8)/Baudrate * 16 $$

Let us calculate UBRR value,
Given oscillator frequency is 16MHz and required baud rate is 9600.
$$UBRR = 16M - (9600 * 8)/9600 * 16 $$ $$UBRR = 103$$

Steps for Configuring UART0

Below are the steps for configuring the UART0.

1. Step1: The USART has to be initialized before any communication can take place. Enable Receiver and Transmitter by configuring UCSR0B register.
2. Step2: Select the Asynchronous mode by configuring UCSR0C register.
3. Step3: Clear the USART status register by configuring UCSR0A register.
4. Step4: Set the baud rate by configuring UBRR register.

After this the UART will be ready to Transmit/Receive Data at the specified baudrate.

Code for Transmitting Char

Code for Receiving Char

Code

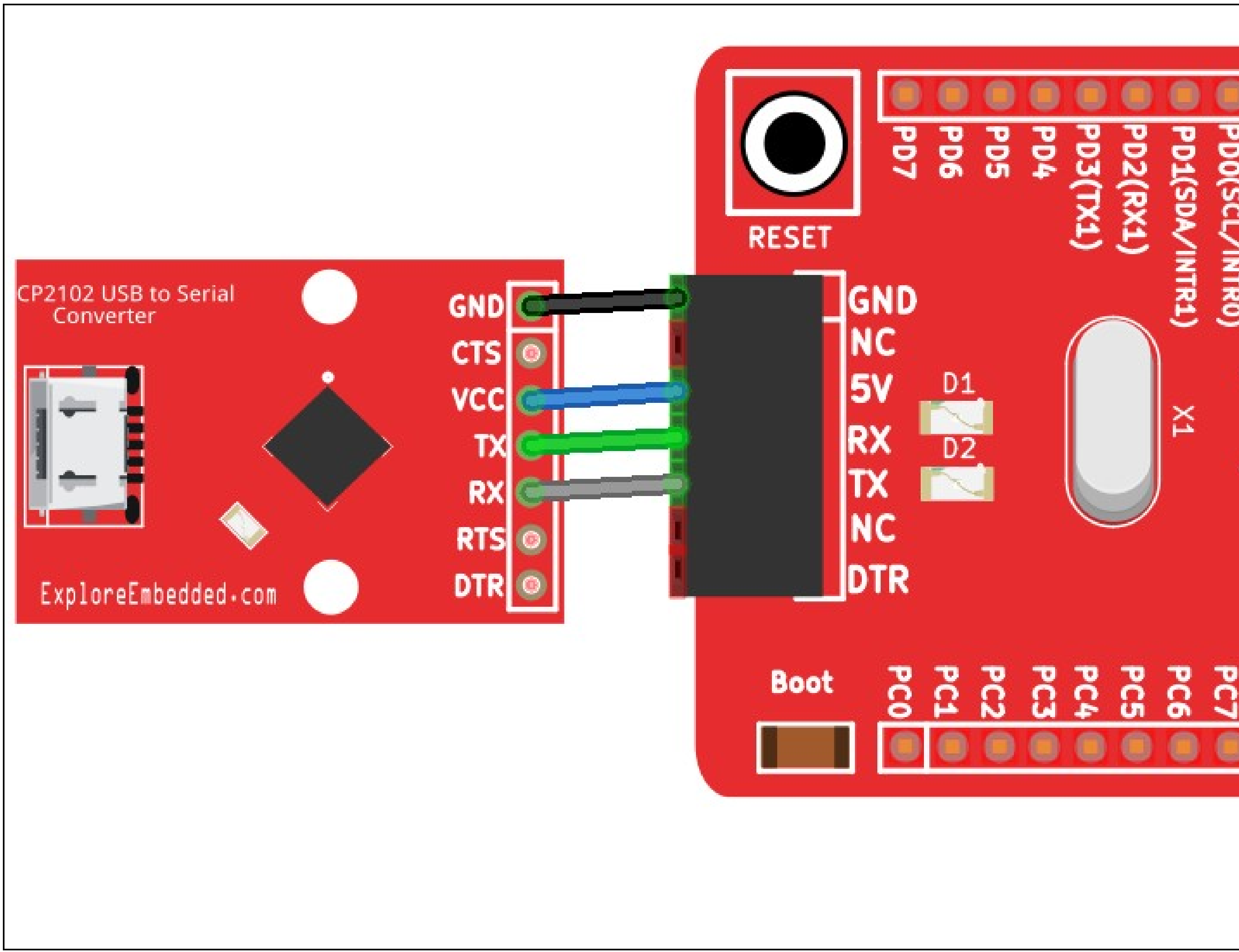
Below is the code for transmitting and receiving chars at 9600 baud

Using Explore Embedded Libraries

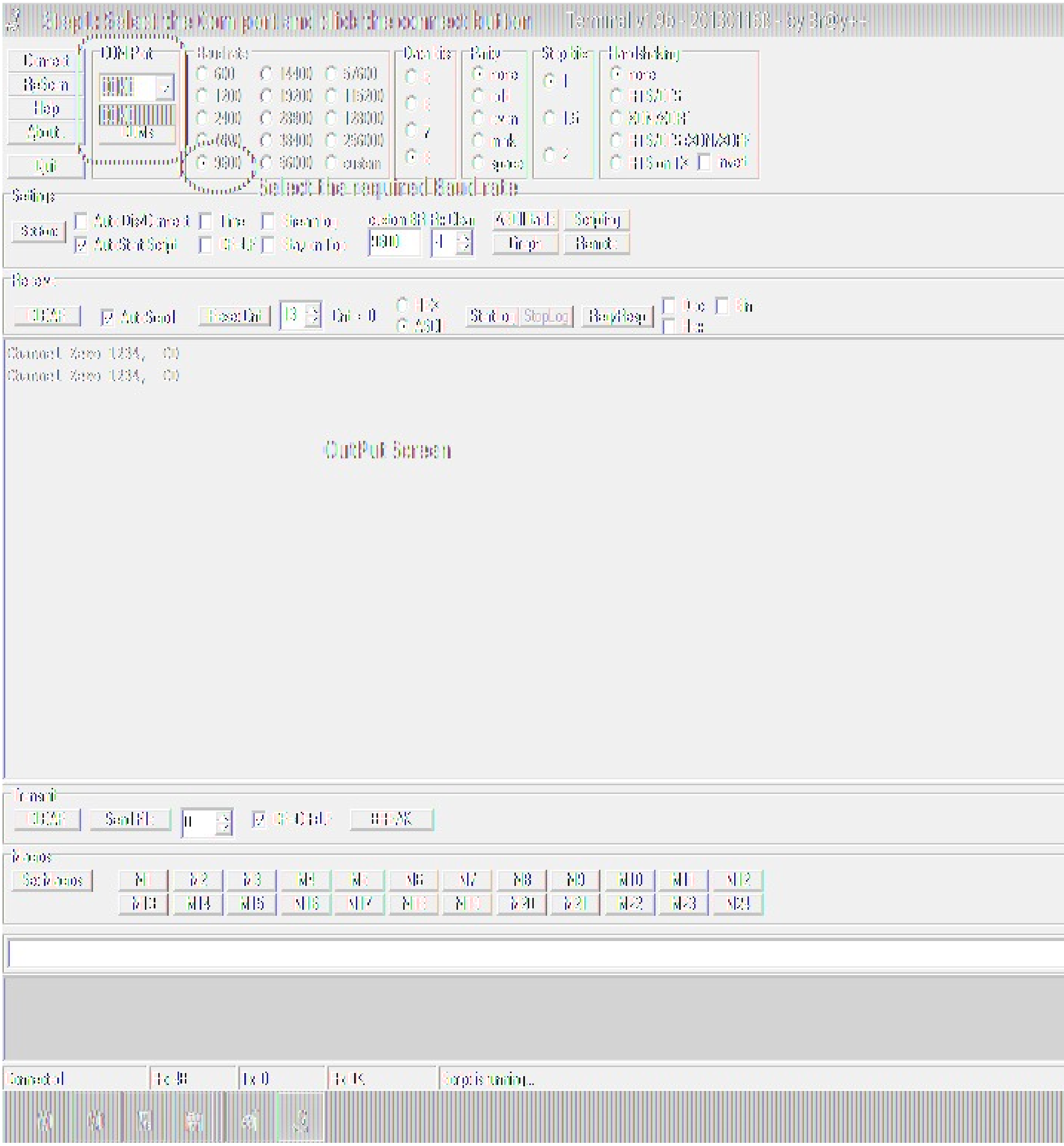
We have shown above how to configure the UART0 and written small code for transmitting string to pc. Now we will see how to print the string on hyper terminal using Explore Embedded libraries. Our below code covered both the channels (UART0 and UART1).

Testing

Make the connections as per below image. We have shown below only for UART0 connections. For UART1 you need to connect the PD2 (RXD1) to USB to Serial Converter TXD and PD3 (TXD1) to Serial Converter RXD.



Open the terminal software , select the COM port, set baud rate and hit the connect button.



Step 1: Select the Com port and click the connect button   Terminal v1.9b - 20130116B - by Br@y++

Select the required Baudrate

Baud rate: 9600 · Data bits: 8 · Parity: none · Stop bits: 1 · Handshaking: none

```
Channel Zero 1234,  C0
Channel Zero 1234,  C0
```

OutPut Screen

Connected | Rx 58 | Tx 0 | Rx 15 | Script is running...

Video Tutorial

For those of you, who would like to watch instead of read we have made a video with all the gyan.

Downloads

Download the complete project folder from the below link:
https://github.com/ExploreEmbedded/ATmega32_ExploreUltraAvrDevKit/archive/master.zip