



# AVR42783: Using USART to Wake Up ATmega328PB from Sleep Mode

#### **APPLICATION NOTE**

## Introduction

This application note describes how to wake up ATmega328PB (on the ATmega328PB Xplained Mini kit) from sleep mode by using USART of the Atmel® AVR® ATmega328PB device. The source code is available for download from Atmel START. An ATmega328PB Xplained Mini kit is used to demonstrate the application.

#### **Features**

- Sleep modes
- USART start frame detection
- · Wake up from sleep mode by using USART

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# 1. Prerequisties

The solution discussed in this document requires:

- Atmel Studio 7.0 or later
- ATmega328PB Xplained Mini kit
- Example Source Code available in Atmel START



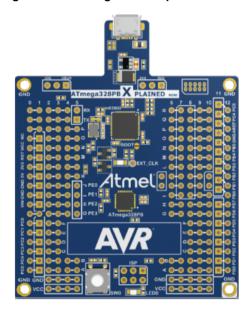
## 2. ATmega328PB Xplained Mini

#### 2.1. Board Overview

The ATmega328PB Xplained Mini evaluation kit is a hardware platform to evaluate the Atmel ATmega328PB microcontroller. The evaluation kit comes with a fully integrated debugger that provides seamless integration with Atmel Studio 7.0 (and later). The kit provides access to the features of the ATmega328PB enabling easy integration of the device in a custom design.

For more details about this kit, refer to the Atmel ATmega328PB Xplained Mini user guide available at <a href="http://www.atmel.com/Images/Atmel-42469-ATmega328PB-Xplained-Mini">http://www.atmel.com/Images/Atmel-42469-ATmega328PB-Xplained-Mini</a> User-Guide.pdf.

Figure 2-1. ATmega328PB Xplained Mini Kit



#### 2.2. Enumeration and Detection

When the ATmega328PB Xplained Mini kit is connected to the PC, Windows<sup>®</sup> will enumerate the device and install the appropriate driver. If the driver installed successfully, mEDBG will be listed in the Device Manager as mEDBG Virtual COM port under Ports as shown in the two figures below.

Figure 2-2. Tool Enumeration

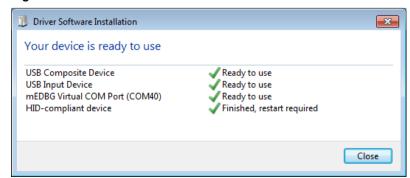
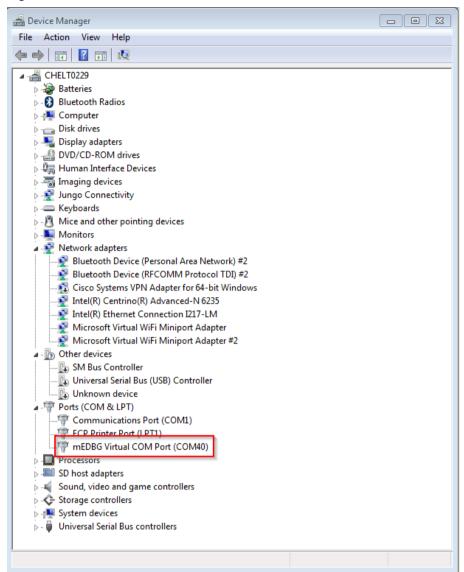




Figure 2-3. Successful mEDBG Driver Installation





## 3. Sleep Modes

#### 3.1. Overview

Sleep modes enable the application to shut down unused modules in the MCU, thereby saving power. The device provides various sleep modes allowing the user to tailor the power consumption to the application requirements.

## 3.2. Six Sleep Modes

The following table shows the different sleep modes, BOD disable ability, and their wake-up sources.

Table 3-1. Active Clock Domains and Wake-up Sources in the Different Sleep Modes.

Active clock domains					Oscillators		Wake-up sources						Software BOD				
Sleep Mode	clkCPU	cikflash	clkIO	clkADC	cikasy	clkpTC	Main clock sSource enabled	Timer oscillator enabled	INT and PCINT	TWI address mMatch	Timer2	SPM/ EEPROM ready	ADC	WDT	USART <sup>(4)</sup>	Other I/O	disable
Idle			Yes	Yes	Yes	Yes	Yes	Yes <sup>(2)</sup>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
ADC Noise Reduction				Yes	Yes	Yes	Yes	Yes <sup>(2)</sup>	Yes <sup>(3)</sup>	Yes	Yes <sup>(2)</sup>	Yes	Yes	Yes	Yes		
Power-down									Yes <sup>(3)</sup>	Yes				Yes	Yes		Yes
Power-save					Yes	Yes	Yes	Yes <sup>(2)</sup>	Yes <sup>(3)</sup>	Yes	Yes			Yes	Yes		Yes
Standby <sup>(1)</sup>							Yes		Yes <sup>(3)</sup>	Yes				Yes	Yes		Yes
Extended Standby					Yes <sup>(2)</sup>	Yes	Yes	Yes <sup>(2)</sup>	Yes <sup>(3)</sup>	Yes	Yes			Yes	Yes		Yes

#### Note:

- 1. Only recommended with external crystal or resonator selected as clock source.
- 2. If Timer/Counter2 is running in asynchronous mode.
- 3. For INT1 and INT0, only level interrupt.
- 4. Start frame detection, only.

For more details about all six sleep modes, refer to the Atmel ATmega328PB datasheet available at http://www.atmel.com/devices/ATMEGA328PB.aspx.

#### 3.3. Enter Sleep Mode

To enter any of the six sleep modes, the Sleep Enable bit in the Sleep Mode Control Register (SMCR.SE) must be written to '1' and a SLEEP instruction must be executed. The table below (SMCR.SM[2:0]) select which sleep mode (Idle, ADC Noise Reduction, Power-down, Power-save, Standby, or Extended Standby) will be activated by the SLEEP instruction.

Table 3-2. Sleep Mode Select

SM2,SM1,SM0	Sleep Mode
000	Idle
001	ADC Noise Reduction
010	Power-down
011	Power-save



SM2,SM1,SM0	Sleep Mode
100	Reserved
101	Reserved
110	Standby
111	Extended Standby

## 3.4. Wake Up from Sleep Mode

If an enabled interrupt occurs while the MCU is in a sleep mode, the MCU wakes up. The MCU is then halted for four cycles in addition to the start-up time, executes the interrupt routine, and resumes execution from the instruction following SLEEP. The contents of the Register File and SRAM are unaltered when the device wakes up from sleep. If a reset occurs during sleep mode, the MCU wakes up and executes from the Reset Vector.



## 4. Using USART to Wake Up ATmega328PB from Sleep Mode

The USART start frame detector can wake up the MCU from all six sleep modes when it detects a start bit.

When a high-to-low transition is detected on RxDn, the internal 8MHz oscillator is powered up and the USART clock is enabled. After start-up the rest of the data frame can be received, provided that the baud rate is slow enough in relation to the internal 8MHz oscillator start-up time. Start-up time of the internal 8MHz oscillator varies with supply voltage and temperature.

The USART start frame detection works both in asynchronous and synchronous modes. It is enabled by writing the Start Frame Detection Enable bit (SFDE). If the USART Start Interrupt Enable (RXSIE) bit is set, the USART Receive Start Interrupt is generated immediately when start is detected.

When using the feature without start interrupt, the start detection logic activates the internal 8MHz oscillator and the USART clock while the frame is being received, only. Other clocks remain stopped until the Receive Complete Interrupt wakes up the MCU.

The table below describes how to use USART to wake up ATmega328PB from sleep mode.

SFDE	RXSIE	RXCIE	Description
0	Х	Х	Start frame detector disabled
1	0	0	Reserved
1	0	1	Start frame detector enabled. RXC flag wakes up the MCU from all sleep modes.
1	1	0	Start frame detector enabled. RXS flag wakes up the MCU from all sleep modes.
1	1	1	Start frame detector enabled. Both RXC and RXS wake up the MCU from all sleep modes.

## 4.1. Example

The application note provides a code example about how to wake up ATmega328PB from the Power-down mode (which has the least consumption of all the sleep modes) by using USART. For other sleep modes, just change the argument in the set\_sleep\_mode() function. The source code is available for download from Atmel START. Here below is the main() function:

```
int main(void)
{
    power_reduction();
    uart_init();
    sei();
    while(1)
    {
        if(!ring_buffer_is_empty(&ring_buffer_in)) {
            usart_transmit( ring_buffer_get(&ring_buffer_in));
        } else {
            set_sleep_mode(SLEEP_MODE_PWR_DOWN);
            sleep_mode();
        }
    }
}
```



### 4.1.1. USART Configuration

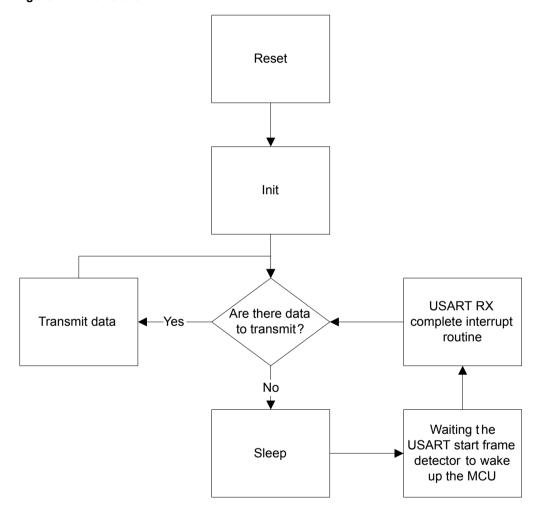
This example uses USART0 module. PD0 is used to receive data, and PD1 is used to transmit data. In this example the USART will be configured with the following settings:

- Asynchronous mode
- 38400 Baudrate
- 8-bits, No Parity and one Stop Bit

#### 4.1.2. Firmware Flowchart

The figure below shows the firmware flowchart of the example code.

Figure 4-1. Flowchart





## 5. References

- ATmega328PB datasheet (http://www.atmel.com/devices/ATMEGA328PB.aspx)
- ATmega328PB Xplained Mini kit (http://www.atmel.com/tools/MEGA328PB-XMINI.aspx)
- Atmel Studio (http://www.atmel.com/tools/atmelstudio.aspx?tab=overview)
- Atmel START (http://start.atmel.com)



# 6. Revision History

Doc Rev.	Date	Comments
42783A	09/2016	Initial document release















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