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EGCO334: Microprocessor and Interfacing

AVR C Programming

Outline

- AVR C Programming
- AVR GCC Inline Assembly

AVR C Programming

High Level Languages

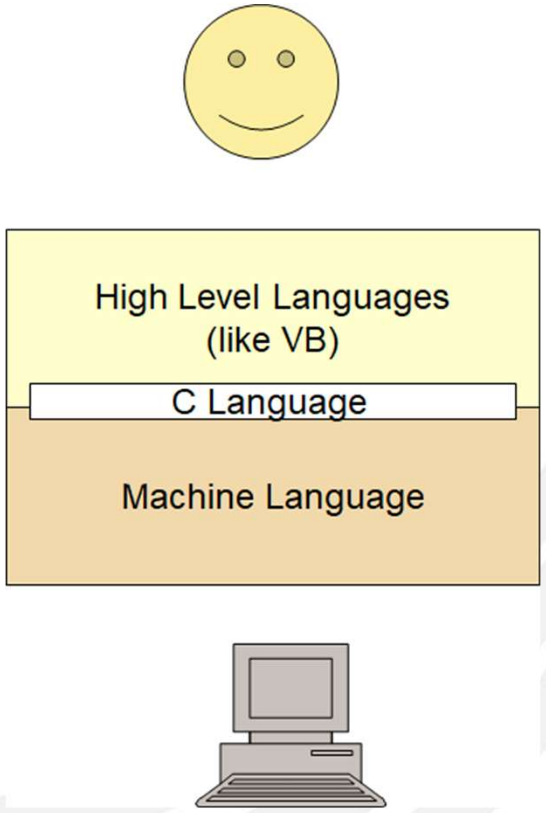
- Easy to develop and update

C Language

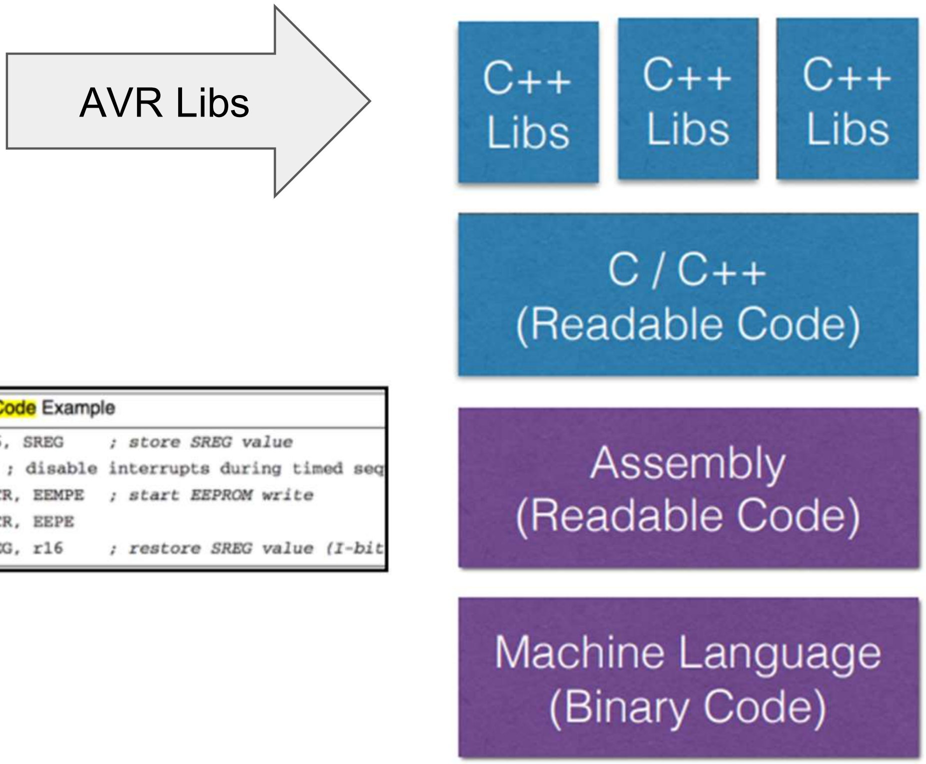
- Acceptable performance
- Easy to develop and update
- Portable

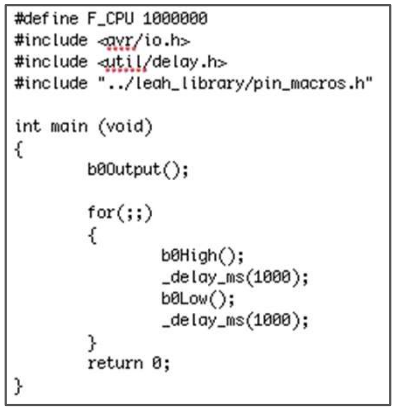
Low Level Languages

- High performance
- Not portable

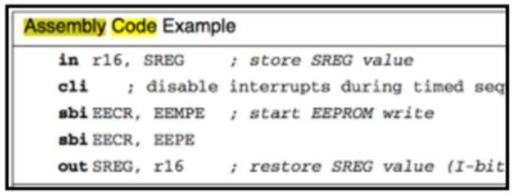


AVR C Programming



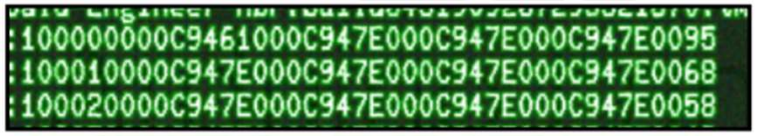


```
#define F_CPU 1000000
#include <avr/io.h>
#include <util/delay.h>
#include "../leah_library/pin_macros.h"

int main (void)
{
        b0Output();

        for(;;)
        {
                b0High();
                _delay_ms(1000);
                b0Low();
                _delay_ms(1000);
        }
        return 0;
}
```



Assembly Code Example

```
in r16, SREG     ; store SREG value
cli     ; disable interrupts during timed seq
sbi EECR, EEMPE  ; start EEPROM write
sbi EECR, EEPE
out SREG, r16    ; restore SREG value (I-bit
```



```
:100000000C9461000C947E000C947E000C947E0095
:100010000C947E000C947E000C947E000C947E0068
:100020000C947E000C947E000C947E000C947E0058
```

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AVR C Programming

Regular C programming

Write a program that calculate the sum of {1,3,…,13,15}

```
int main ()
{
    unsigned int sum;

    for (int i = 1; i <= 15; i+=2)
        sum += i;

    while (1);
    return 0;
}
```

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AVR C Programming

AVR C program to send value 0xAA to PORTD

```
#include <avr/io.h>

int main ()
{
   DDRD = 0xFF;
   PORTD = 0xAA;

   while (1);
   return 0;
}
```

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AVR C Programming

Data Types

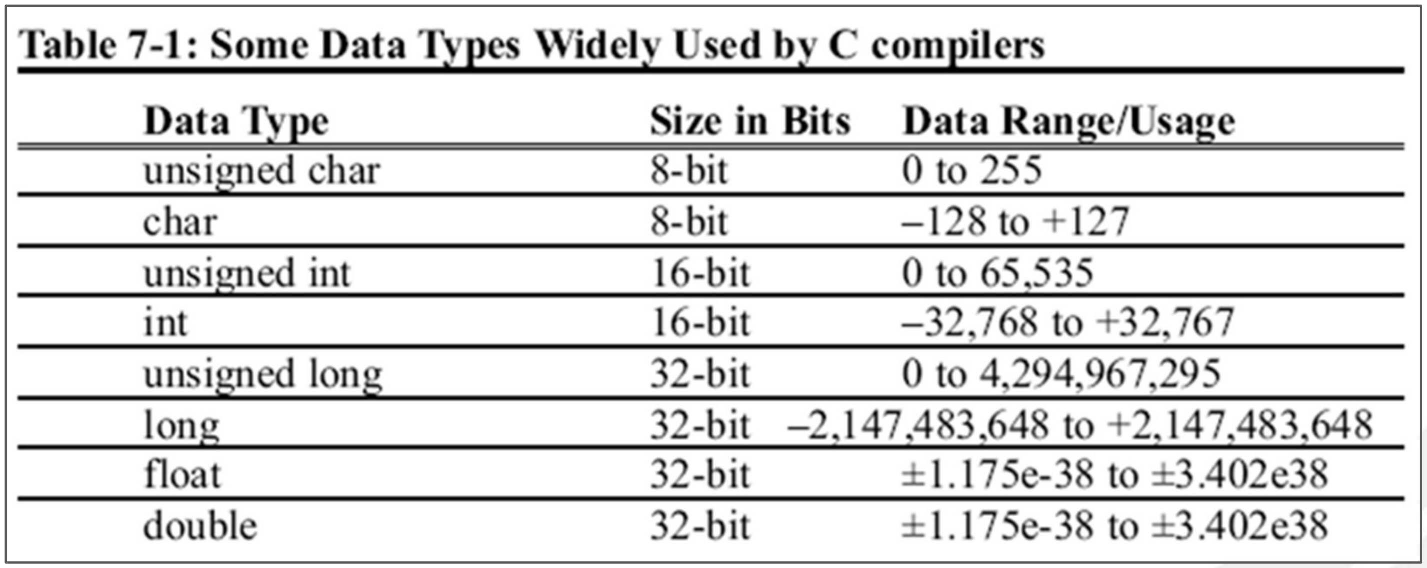
Table 7-1: Some Data Types Widely Used by C compilers

Data Type	Size in Bits	Data Range/Usage
unsigned char	8-bit	0 to 255
char	8-bit	–128 to +127
unsigned int	16-bit	0 to 65,535
int	16-bit	–32,768 to +32,767
unsigned long	32-bit	0 to 4,294,967,295
long	32-bit	–2,147,483,648 to +2,147,483,648
float	32-bit	±1.175e-38 to ±3.402e38
double	32-bit	±1.175e-38 to ±3.402e38

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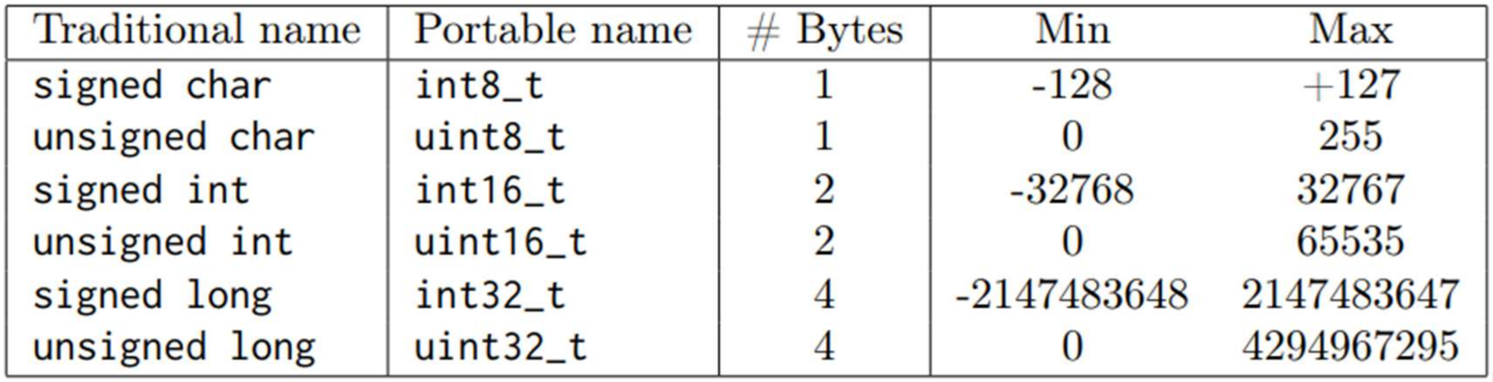
AVR C Programming

Data Types



Traditional name	Portable name	# Bytes	Min	Max
`signed char`	`int8_t`	1	-128	+127
`unsigned char`	`uint8_t`	1	0	255
`signed int`	`int16_t`	2	-32768	32767
`unsigned int`	`uint16_t`	2	0	65535
`signed long`	`int32_t`	4	-2147483648	2147483647
`unsigned long`	`uint32_t`	4	0	4294967295

AVR C Programming

AVR C Programming

Everything is same as regular C programming style.

Except the coding structure

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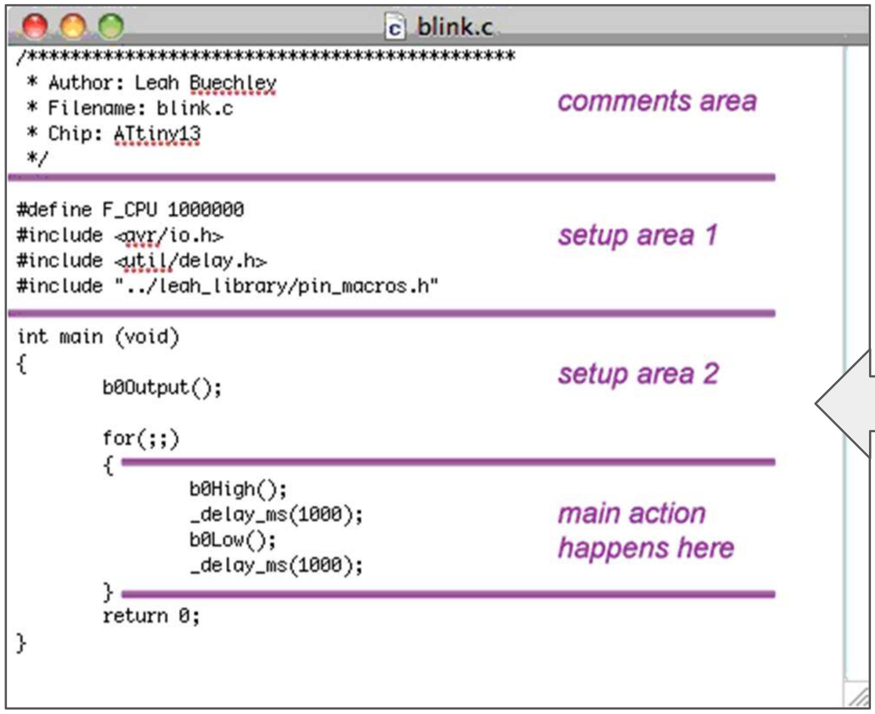
AVR C Programming

Coding Structure

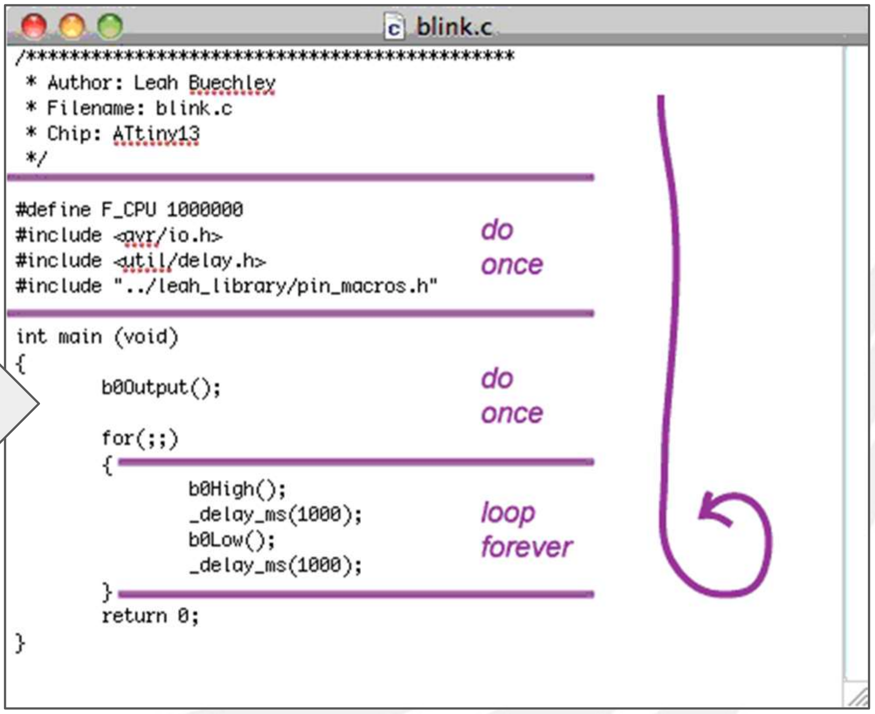


```
/*******************************************
 * Author: Leah Buechley
 * Filename: blink.c
 * Chip: ATtiny13
 */

#define F_CPU 1000000
#include <avr/io.h>
#include <util/delay.h>
#include "../leah_library/pin_macros.h"

int main (void)
{
        b0Output();

        for(;;)
        {
                b0High();
                _delay_ms(1000);
                b0Low();
                _delay_ms(1000);
        }
        return 0;
}
```



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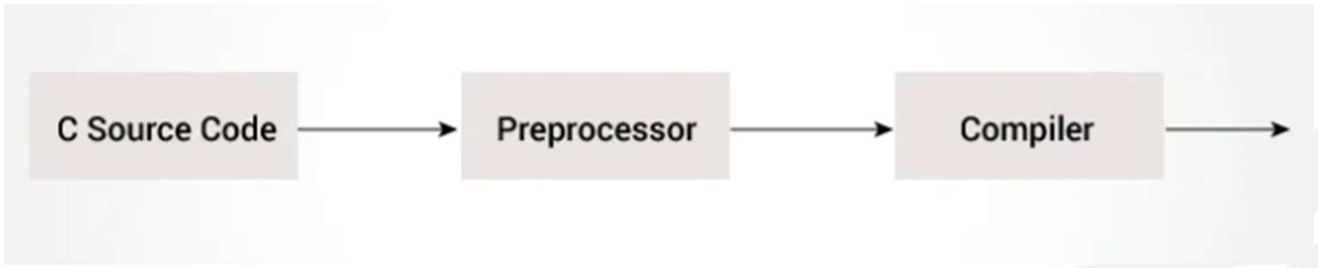
                b0High();
                _delay_ms(1000);
                b0Low();
                _delay_ms(1000);
        }
        return 0;
}
```

AVR C Programming

Preprocessor

The C **preprocessor** is a macro processor that is used automatically by the C compiler to transform your program before actual compilation.

It is called a macro processor because it allows you to define macros, which are brief abbreviations for longer constructs.



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AVR C Programming

AVR Preprocessor

#assert	Assertions
#cpu	Assertions
#define	**Macros with Arguments**
#elif	**The `#elif' Directive**
#else	**The `#else' Directive**
#error	The `#error' and `#warning' Directives
#ident	Miscellaneous Preprocessing Directives

***Assertions** are a more systematic alternative to macros in writing conditionals to test what sort of computer or system the compiled program will run on

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AVR C Programming

AVR Preprocessor

#if	**Syntax of Conditionals**
#ifdef	**Conditionals and Macros**
#ifndef	**Conditionals and Macros**
#import	Once-Only Include Files
#include	**The `#include' Directive**
#include_next	Inheritance and Header Files
#line	Combining Source Files

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AVR C Programming

AVR Preprocessor

#machine	Assertions
#pragma	Miscellaneous Preprocessing Directives
#pragma once	Once-Only Include Files
#system	Assertions
#unassert	Assertions
#warning	The `#error' and `#warning' Directives

AVR C Programming

AVR Preprocessor

#define: is a macro that requires arguments, you write a `#define' directive with a list of argument names in parentheses after the name of the macro.

Example

- #define PI 3.14
- #define circleArea(r) (3.1415*(r)*(r))
- #define min(X, Y) ((X) < (Y) ? (X) : (Y))

AVR C Programming

AVR Preprocessor

#if, #else, #elif : expresses the condition for preprocessing (logically similar as using in C programming).

Kindly note, **#endif** is not required to be used for ending **#if** condition

Syntax

```
#if expression
        Text if true
#elif expression
        Text if true
#else
        Text if true
#endif
```

AVR C Programming

AVR Preprocessor

#if, #else, #elif

Example

```
#if X == 1
      ...
#elif X == 2
      ...
#else /* X != 2 and X != 1*/
      ...
#endif /* X != 2 and X != 1*/
```

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AVR C Programming

AVR Preprocessor

#ifdef, #ifndef:

- #ifdef name → is equivalent to `#if defined (name)'.

- #ifndef name → is equivalent to `#if ! defined (name)'.

AVR C Programming

AVR Preprocessor

#include

- #include <file>: searches for a file named file in a list of directories specified by you, then in a standard list of system directories

- #include “file” : searches for a file named file first in the current directory

AVR C Programming

AVR Preprocessor

#include

- #include <file>: searches for a file named file in a list of directories specified by you, then in a standard list of system directories

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AVR C Programming

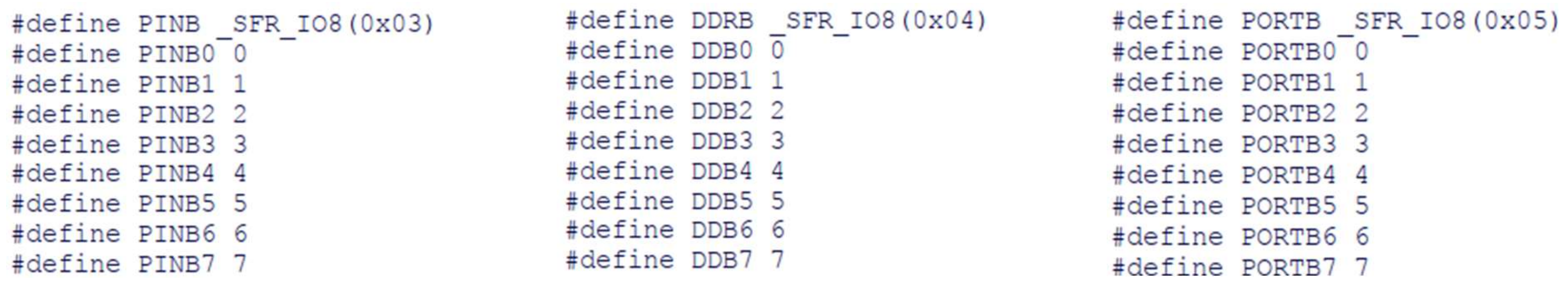
Libraries

- avr/ioXXXX.h
  This header file includes the appropriate IO definitions for the device
- util/delay.h
  The convenience (busy wait) functions where actual time values can be specified rather than a number of cycles to wait for
- avr/interrupt.h
  Interrupt handling functions
- regular C library
  - string.h
  - string.h
  - math.h
  - stlib.h

AVR C Programming

Libraries

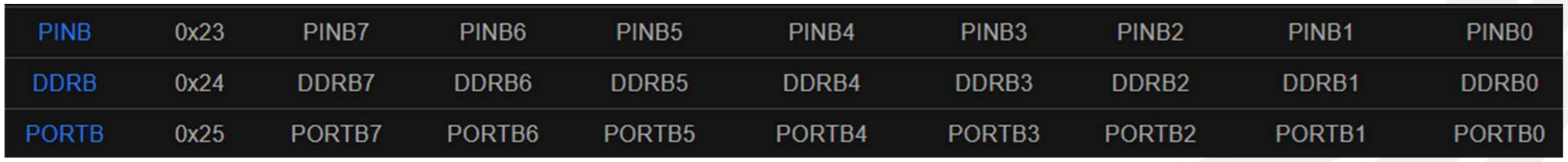
avr/ioXXXX.h



```
#define PINB _SFR_IO8(0x03)
#define PINB0 0
#define PINB1 1
#define PINB2 2
#define PINB3 3
#define PINB4 4
#define PINB5 5
#define PINB6 6
#define PINB7 7
```

```
#define DDRB _SFR_IO8(0x04)
#define DDB0 0
#define DDB1 1
#define DDB2 2
#define DDB3 3
#define DDB4 4
#define DDB5 5
#define DDB6 6
#define DDB7 7
```

```
#define PORTB _SFR_IO8(0x05)
#define PORTB0 0
#define PORTB1 1
#define PORTB2 2
#define PORTB3 3
#define PORTB4 4
#define PORTB5 5
#define PORTB6 6
#define PORTB7 7
```



PINB	0x23	PINB7	PINB6	PINB5	PINB4	PINB3	PINB2	PINB1	PINB0
DDRB	0x24	DDRB7	DDRB6	DDRB5	DDRB4	DDRB3	DDRB2	DDRB1	DDRB0
PORTB	0x25	PORTB7	PORTB6	PORTB5	PORTB4	PORTB3	PORTB2	PORTB1	PORTB0

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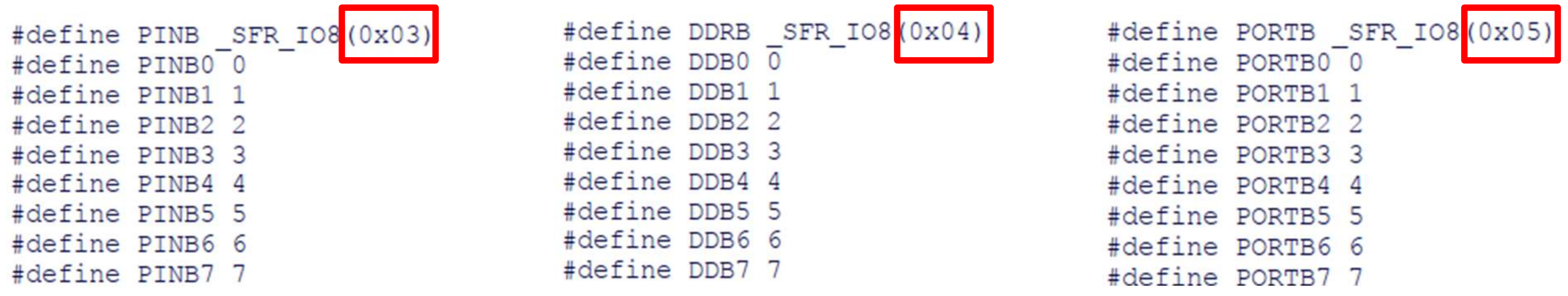
AVR C Programming

Libraries

avr/ioXXXX.h



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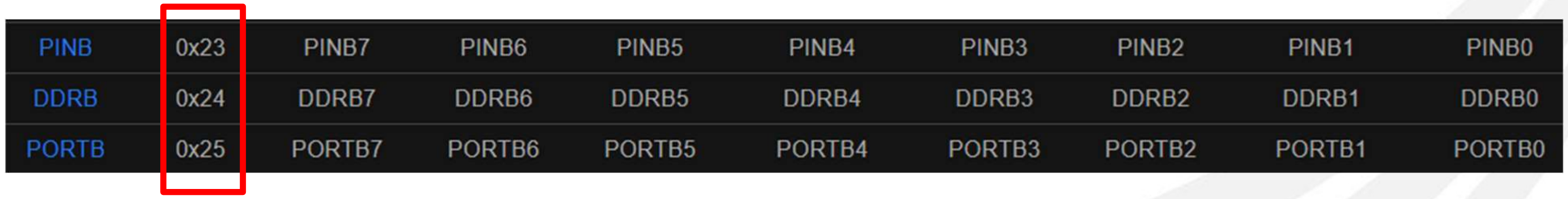

PINB	0x23	PINB7	PINB6	PINB5	PINB4	PINB3	PINB2	PINB1	PINB0
DDRB	0x24	DDRB7	DDRB6	DDRB5	DDRB4	DDRB3	DDRB2	DDRB1	DDRB0
PORTB	0x25	PORTB7	PORTB6	PORTB5	PORTB4	PORTB3	PORTB2	PORTB1	PORTB0

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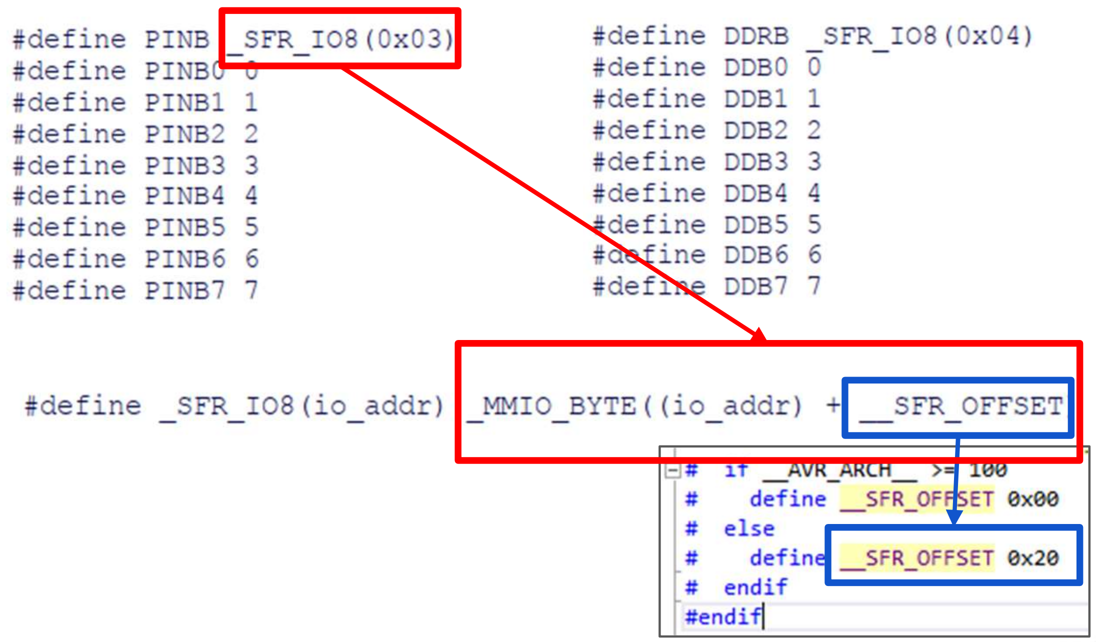
AVR C Programming

Libraries

avr/ioXXXX.h



```
#define PINB _SFR_IO8(0x03)
#define PINB0 0
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#define DDRB _SFR_IO8(0x04)
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```

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#define PORTB _SFR_IO8(0x05)
#define PORTB0 0
#define PORTB1 1
#define PORTB2 2
#define PORTB3 3
#define PORTB4 4
#define PORTB5 5
#define PORTB6 6
#define PORTB7 7
```

```
#define _SFR_IO8(io_addr) _MMIO_BYTE((io_addr) + __SFR_OFFSET
```

```
#  if __AVR_ARCH__ >= 100
#    define __SFR_OFFSET 0x00
#  else
#    define __SFR_OFFSET 0x20
#  endif
#endif
```

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AVR C Programming

Libraries

avr/ioXXXX.h

```
#define PINB _SFR_IO8(0x03)
#define PINB0 0
#define PINB1 1
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#define PINB5 5
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#define DDB7 7
```

```
#define PORTB _SFR_IO8(0x05)
#define PORTB0 0
#define PORTB1 1
#define PORTB2 2
#define PORTB3 3
#define PORTB4 4
#define PORTB5 5
#define PORTB6 6
#define PORTB7 7
```

```
#define _SFR_IO8(io_addr) _MMIO_BYTE((io_addr) + __SFR_OFFSET)
```

```
#define _MMIO_BYTE(mem_addr) (*(volatile uint8_t *)(mem_addr))
```

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AVR C Programming

Libraries

avr/ioXXXX.h

Therefore, if we want to set bit 5 high, we can now just say

```
PORTB = PORTB | 0x20; // or more typically: PORTB |= 0x20;
```

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AVR C Programming

Libraries

util/delay.h

The functions available allow the specification of microsecond, and millisecond delays directly, using the application-supplied macro F_CPU as the CPU clock frequency (in Hertz).

#define F_CPU   1000000UL   *//The macro F_CPU specifies the CPU frequency to be considered by the delay macros*

void _delay_ms   (double __ms)   *//Perform a delay of milliseconds (The maximal possible delay is **262.14 ms / F_CPU** in MHz)*

void _delay_us   (double __us)   *//Perform a delay of microseconds (The maximal possible delay is **768 us / F_CPU** in MHz)*

AVR C Programming

Libraries

util/delay.h

Example

```
#define F_CPU 1000000UL
     _delay_ms(50);                     // 50ms delay
     PORTB &= ~(1 << PB0);              // LED off
          _delay_ms(50);                     // 50ms delay
          PORTB |=  (1 << PB0);              // LED on
```

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Exercise 8-1

Question 1

Write AVR C program read pins 1 and 0 of PORTB and send ASCII character to PORTD according to the following table

pin1	pin0	send
0	0	‘1’
0	1	‘2’
1	0	‘3’
1	1	‘4’

Exercise 8-1

Question 2

Write AVR C program that check the value of PORTB.7 every 100ms. If it is 1, make bit 4 of PORTB input, otherwise, change pin 4 of PORTB to output