CSSE2010

# CSSE2010/CSSE7201
# Lecture 19

## More I/O

School of Information Technology and Electrical Engineering
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# Today

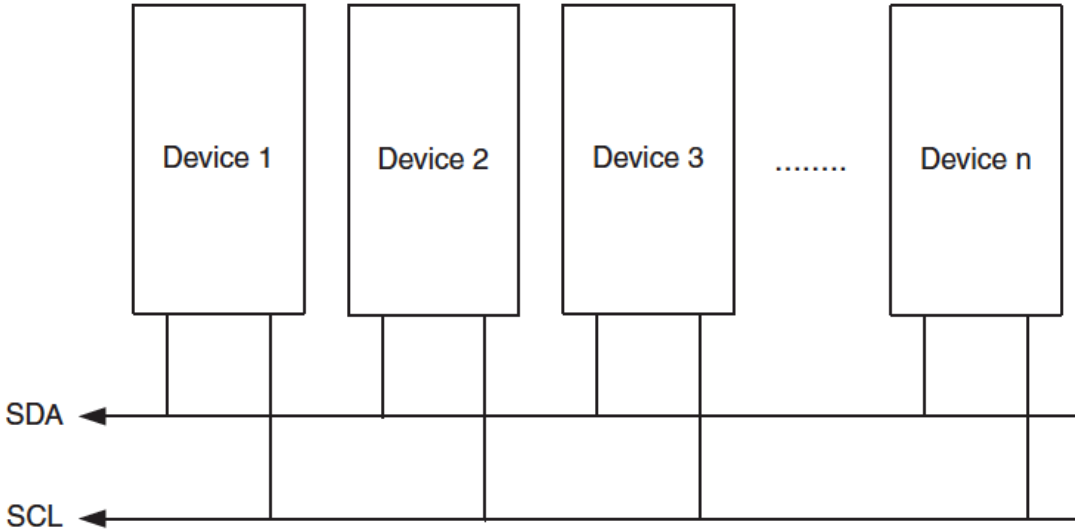
- More I/O
  - $I^2C$, TWI, SPI
    - Synchronous Serial
- AVR I/O coding
  - Volatile variables
  - Setting/clearing bits in I/O registers

# Bus Masters and Slaves

- Master
  - Device which initiates (and controls) the transfer of data
- Slave
  - Waits for requests
  - Responds to master
- Some devices can be both masters and slaves (at different times)
  - Memory can never be a bus master

# I²C, TWI

- I²C = Inter-Integrated Circuit
  - created by Philips Semiconductor (now NXP)
- TWI = Two-wire Interface
  - Name used by Atmel

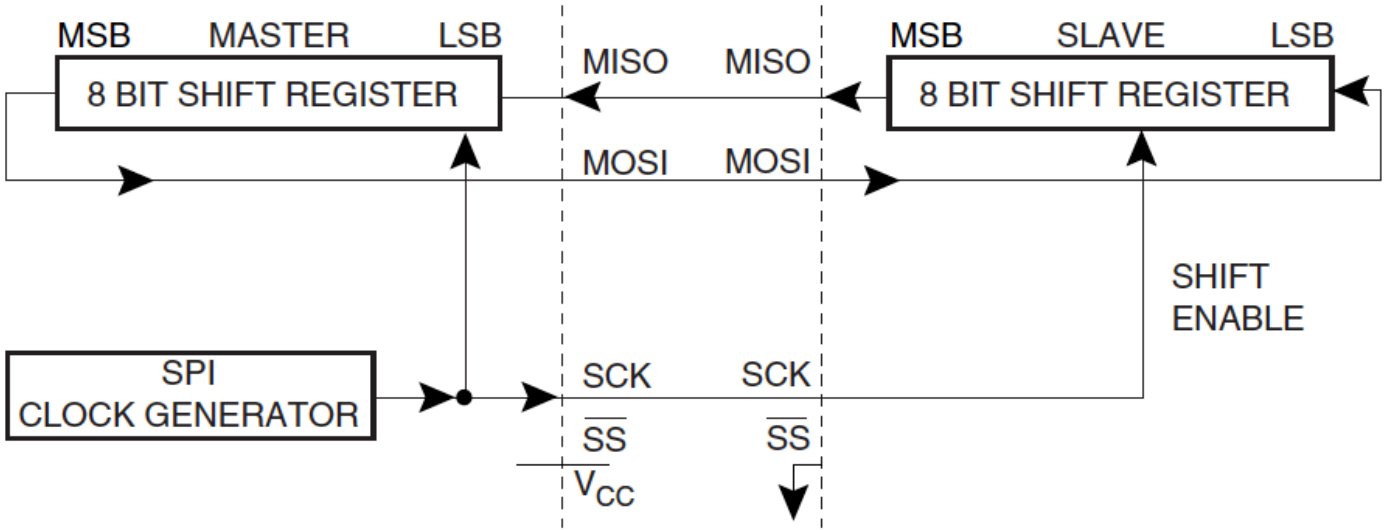


# TWI on AVR

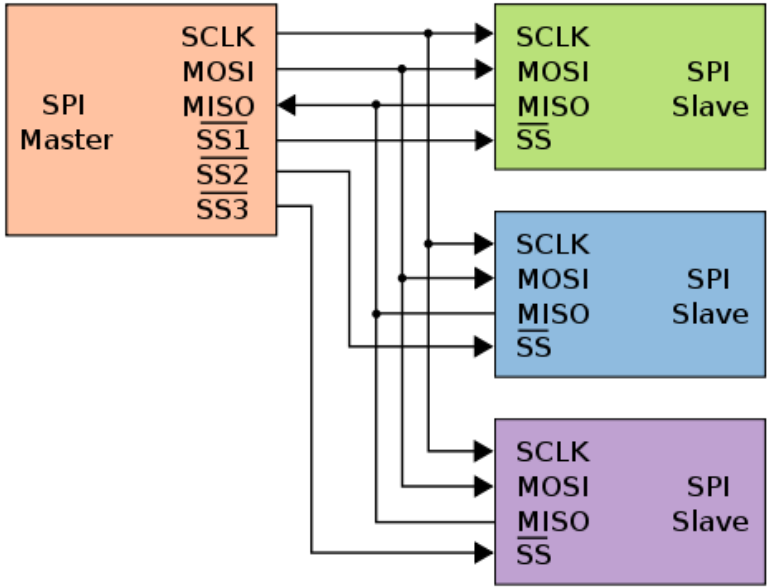
- ATmega324A has one TWI port
  - Alternate use for pins
    - C0 (SCL)
    - C1 (SDA)
- See datasheet pages 211 to 239 for details
  - Includes full description of TWI

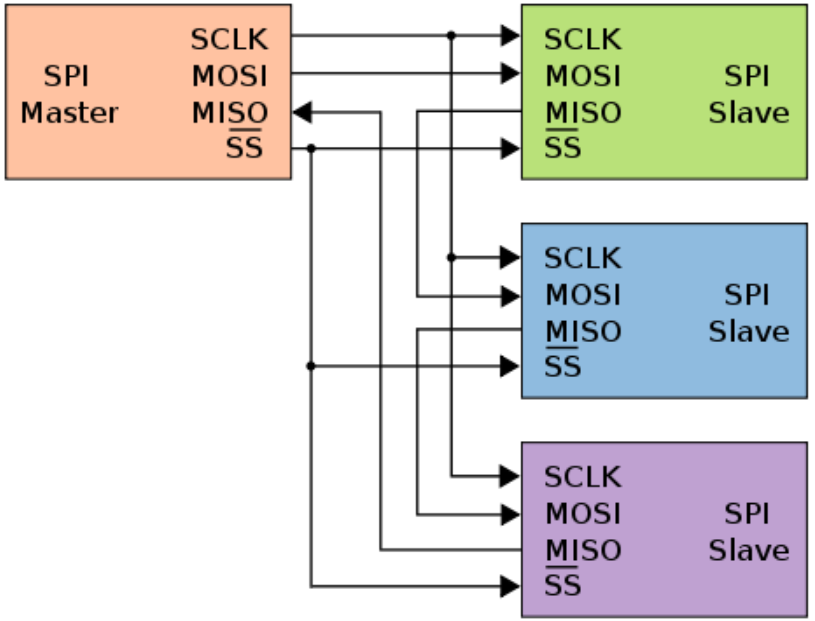
# SPI

- Serial Peripheral Interface



# SPI – Other configurations




Images by Colin M.L. Burnett

# SPI on the AVR

- ATmega324A has one SPI port
  - Shares pins with upper half of port B
  - Hardware takes care of generating signals
  - Can be master or slave
  - See datasheet pages 166 to 174
  - USARTs can also be used as SPI masters

# SPI on the AVR (cont.)

- For Master operation, can choose clock rate divider:
  - 2 (4MHz @ 8MHz clock)
  - 4 (2MHz)
  - 8 (1MHz)
  - 16 (500kHz)
  - 32 (250kHz)
  - 64 (125kHz)
  - 128 (62.5kHz)
- For slave operation, fastest clock is $f_{OSC}$ / 4  (2MHz in our case)

# Bit Bashing

- Sometimes microcontroller doesn't have support for a bus standard
  - Or enough interfaces of a particular standard
- Can simulate I/O standards using general purpose ports

# AVR I/O Coding
# Volatile variables

- Example: `volatile int running;`
- Tells compiler that variable can change outside of standard flow of control
  - e.g. in interrupt handler or a thread
- Prevents compiler applying optimisations
- Example:

```
running = 0;
while(!running) {
      ; /* Do nothing */
}
```

Without volatile, optimising compiler will change this to

```
while(1) {
      ;
}
```

# AVR I/O Coding
# Setting I/O register bits

- When setting/clearing specific bits in I/O registers, be explicit about the bits

Example (all have the same effect):

- Poor:
  - `TCCR1B = 10;`
- Better:
  - `TCCR1B = 0x0A;`
- Best:
  - `TCCR1B = (1<<WGM12)|(1<<CS11);`
- Makes code easier to understand

# Setting I/O register bits

- Where do names come from?
  - See datasheet (note errors – see IO register summary)
- e.g. for TCCR0B (page 112)

| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| 0x25 (0x45) | FOC0A | FOC0B | – | – | WGM02 | CS02 | CS01 | CS00 |
| Read/Write | W | W | R | R | R/W | R/W | R/W | R/W |
| Initial Value | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

- Bit names are defined as macros, e.g.

```
#define WGM02 3
```

- Can use same names in assembly language also, e.g.

```
ldi r16, (1<<WGM02)|(1<<CS01)
```

# Clearing/Toggling I/O register bits

- Same rules apply
- To clear a bit, e.g.

```
PINC &= ~(1<<5);
```

- To toggle a bit, e.g.

```
/* Enable Output Compare A Interrupt
** for timer 2 */
TIMSK2 ^= (1<<OCIE2A);
```