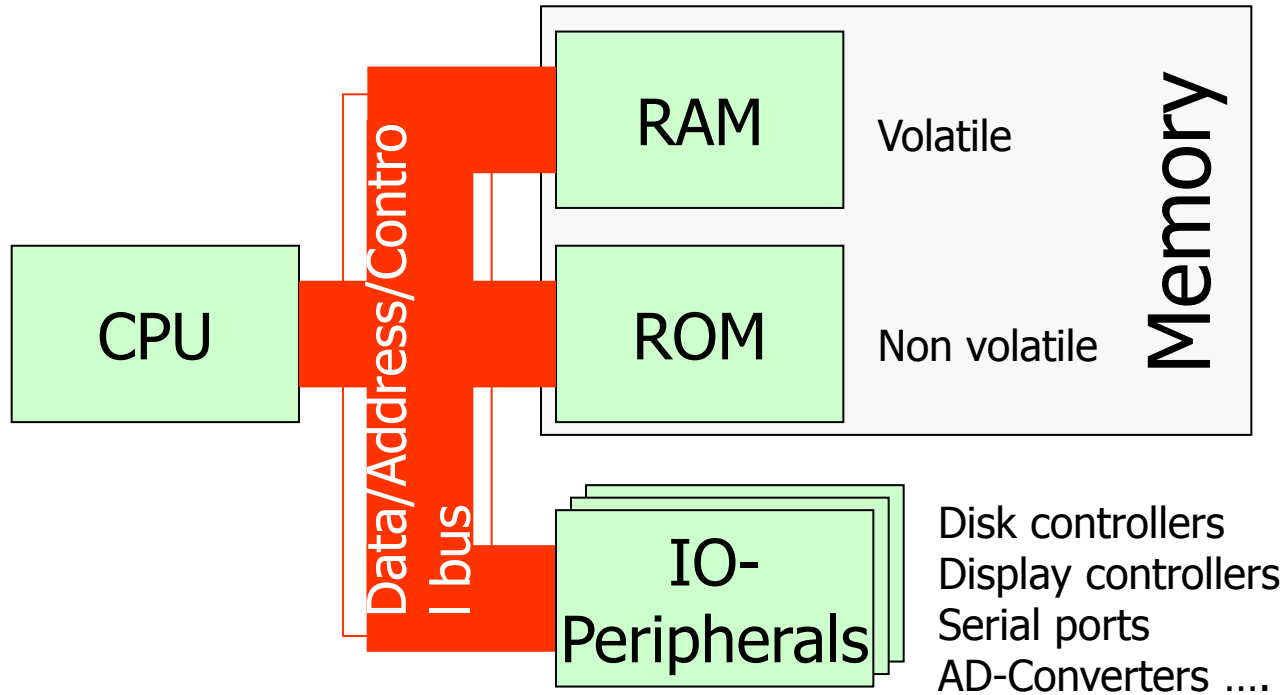# Lesson

Introduction
to
Micro Controllers

Main topics

- A overview over processors in general (6800)

- A look at an AVR processor

The basic parts of the computer

CPU

Data/Address/Control bus

Memory

RAM — Volatile

ROM — Non volatile

IO-Peripherals

Disk controllers
Display controllers
Serial ports
AD-Converters ….

Microcontrollers

- Complete computers with build in memory, IO-peripherals , serial channels, analogue IO etc.

- Microcontrollers for prototypes
  - With external EPROM
  - With build in EPROM
  - With build in PROM

- Microcontrollers for production
 - Manufactured with pre-programmed ROM

Busses

- Address bus
  - Point out memory or IO-location to manipulate with
  - Can be multiplexed
  - 4-many bits
- Data bus
  - Contains data (nipple, byte, word ..) to store or retrieve from memory or IO
- Control bus
  - R/W, interrupt, chip select, reset ...

CPU Registers

- Program counter
  - Keeps track of instructions
- Accumulators
  - All calculations is performed in the accumulators
- General registers
  - Used to load and store data
  - Indexing addresses
- Status/condition registers
  - Zero, carry, over flow, interrupt etc.

MC6800 register set
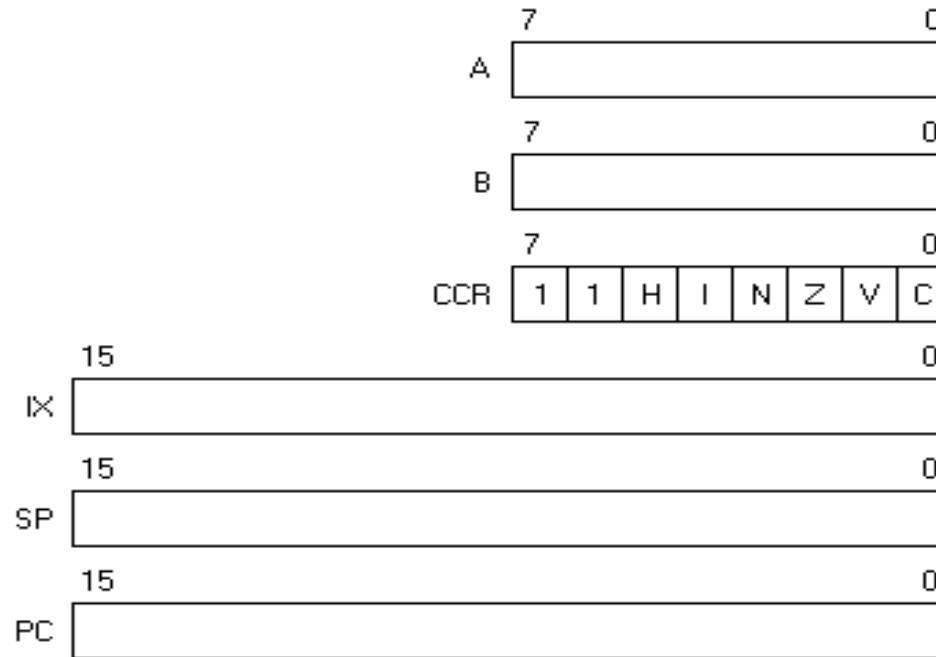
MC6800 Condition Code Register

The Condition Code Register

The CCR register holds all the system flags. Most flags reflect the status of the machine after mathematical instructions.

The CCR contains 6 system flags:

H Half Carry flag

I Interrupt mask flag

N Negative sign flag

Z Zero flag

V Overflow flag

C Carry Flag

```
   MC6800 Instruction set
Operation                |Mnem.|Immed.|Direct|Index |Extend|Inher.|Operation  |CC Reg|
                         |     |OP·~·#|OP·~·#|OP·~·#|OP·~·#|OP·~·#|           |HINZVC|


-------------------------------------------------------------------------------


   Add                   |ADDA |8B·2·2|9B·3·2|AB·5·2|BB·4·3|  ··  |A=A+M      |T•TTTT|
                         |ADDB |CB·2·2|DB·3·2|EB·5·2|FB·4·3|  ··  |B=B+M      |T•TTTT|
   Add Accumulators      |ABA  |  ··  |  ··  |  ··  |  ··  |1B·2·1|A=A+B      |T•TTTT|
   Add with Carry        |ADCA |89·2·2|99·3·2|A9·5·2|B9·4·3|  ··  |A=A+M+C    |T•TTTT|
                         |ADCB |C9·2·2|D9·3·2|E9·5·2|F9·4·3|  ··  |B=B+M+C    |T•TTTT|
   And                   |ANDA |84·2·2|94·3·2|A4·5·2|B4·4·3|  ··  |A=A+M      |••TTR•|
                         |ANDB |C4·2·2|D4·3·2|E4·5·2|F4·4·3|  ··  |B=B+M      |••TTR•|
   Bit Test              |BITA |85·2·2|95·3·2|A5·5·2|B5·4·3|  ··  |A+M        |••TTR•|
                         |BITB |C5·2·2|D5·3·2|E5·5·2|F5·4·3|  ··  |B+M        |••TTR•|
   Clear                 |CLR  |  ··  |  ··  |6F·7·2|7F·6·3|  ··  |M=00       |••RSRR|
                         |CLRA |  ··  |  ··  |  ··  |  ··  |4F·2·1|A=00       |••RSRR|
                         |CLRB |  ··  |  ··  |  ··  |  ··  |5F·2·1|B=00       |••RSRR|
   Compare               |CMPA |81·2·2|91·3·2|A1·5·2|B1·4·3|  ··  |A-M        |••TTTT|
                         |CMPB |C1·2·2|D1·3·2|E1·5·2|F1·4·3|  ··  |B-M        |••TTTT|
   Compare Accumulators  |CBA  |  ··  |  ··  |  ··  |  ··  |11·2·1|A-B        |••TTTT|
   Complement 1's        |COM  |  ··  |  ··  |63·7·2|73·6·3|  ··  |M=-M       |••TTRS|
                         |COMA |  ··  |  ··  |  ··  |  ··  |43·2·1|A=-A       |••TTRS|
                         |COMB |  ··  |  ··  |  ··  |  ··  |53·2·1|B=-B       |••TTRS|
   Complement 2's        |NEG  |  ··  |  ··  |60·7·2|70·6·3|  ··  |M=00-M     |••TT12|
                         |NEGA |  ··  |  ··  |  ··  |  ··  |40·2·1|A=00-A     |••TT12|
                         |NEGB |  ··  |  ··  |  ··  |  ··  |50·2·1|B=00-B     |••TT12|
   Decimal Adjust        |DAA  |  ··  |  ··  |  ··  |  ··  |19·2·1|*          |••TTT3|
   Decrement             |DEC  |  ··  |  ··  |6A·7·2|7A·6·3|  ··  |M=M-1      |••TT4•|
                         |DECA |  ··  |  ··  |  ··  |  ··  |4A·2·1|A=A-1      |••TT4•|
                         |DECB |  ··  |  ··  |  ··  |  ··  |5A·2·1|B=B-1      |••TT4•|
   Exclusive OR          |EORA |88·2·2|98·3·2|A8·5·2|B8·4·3|  ··  |A=A(+)M    |••TTR•|
                         |EORB |C8·2·2|D8·3·2|E8·5·2|F8·4·3|  ··  |B=B(+)M    |••TTR•|
   Increment             |INC  |  ··  |  ··  |6C·7·2|7C·6·3|  ··  |M=M+1      |••TT5•|
                         |INCA |  ··  |  ··  |  ··  |  ··  |4C·2·1|A=A+1      |••TT5•|
                         |INCB |  ··  |  ··  |  ··  |  ··  |5C·2·1|B=B+1      |••TT5•|
   Load Accumulator      |LDAA |86·2·2|96·3·2|A6·5·2|B6·4·3|  ··  |A=M        |••TTR•|
                         |LDAB |C6·2·2|D6·3·2|E6·5·2|F6·4·3|  ··  |B=M        |••TTR•|
```

Addressing modes

- Inherent (Register manipulation)

- Immediate/literal (literal number as operant)

- Direct (memory access by short address)

- Extended (memory access by full address)

- Indexed (Register points to memory)

- Relative (Adds or subtracts a value to Program Counter) typical branches

Stacks
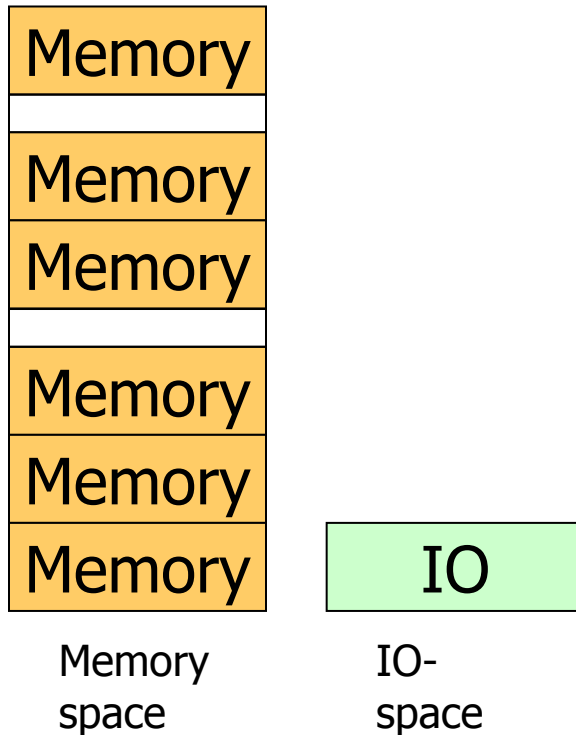
- User stacks

- Processor stacks
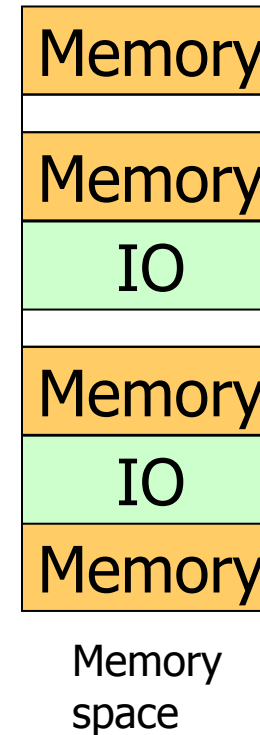
Memory

Linear or mapped address room

- Linear:
  - The processor can directly address all memory
  - Means many address pins on the processor
- Mapped:
  - The memory is divided into blocks
  - The processor selects which blocks should be available
  - When a block is selected it works like linear memory
  - Allows real big amount of memory

IO and Memory

Port mapped IO

Memory
Memory
Memory
Memory
Memory
Memory

IO

Memory
space

IO-
space

Memory mapped IO

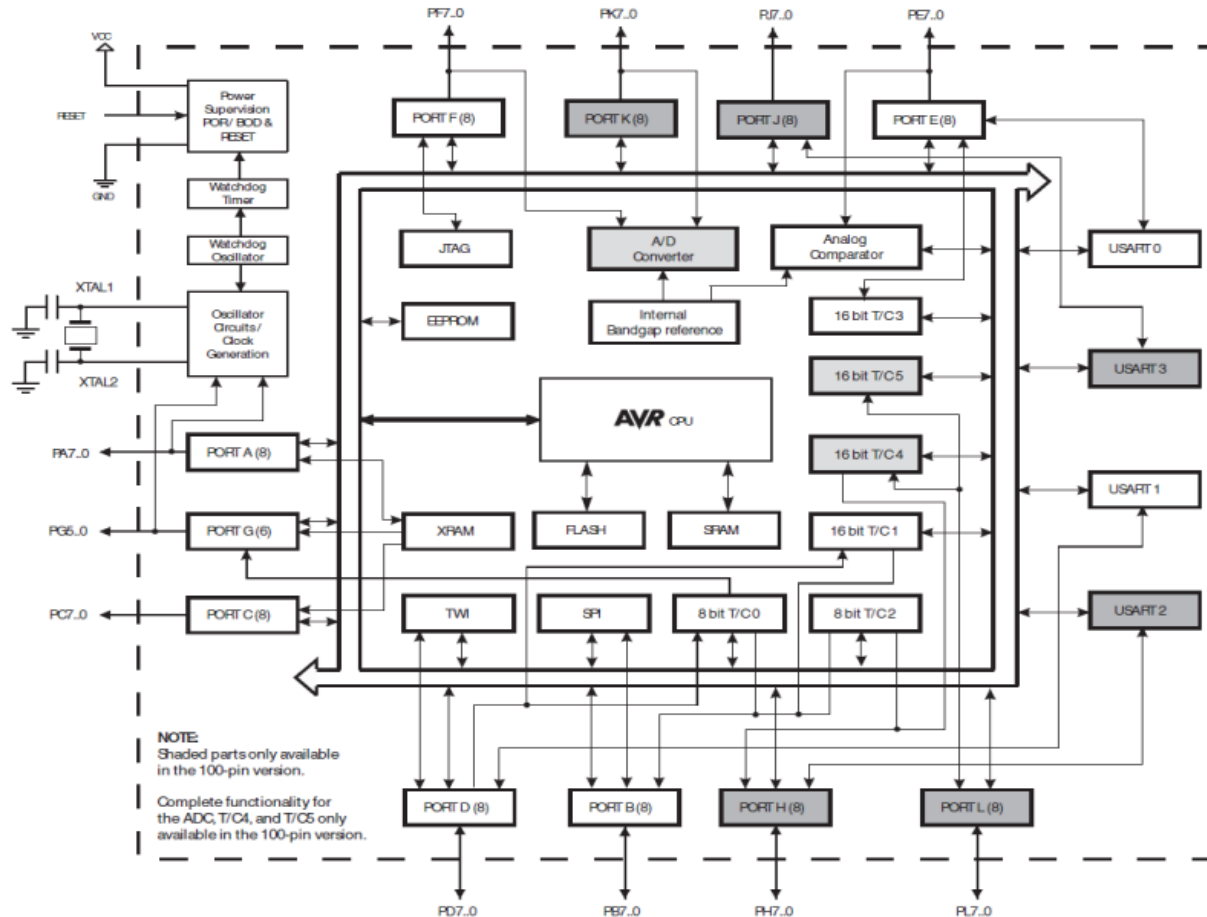| Memory |
|--------|
| Memory |
| IO |
| Memory |
| IO |
| Memory |

Memory
space

AVR
8-bit Microcontrollers (ATMega1280)

AVR
8-bit Microcontrollers (ATMega1280)

- **High Performance, Low Power Atmel® AVR® 8-Bit Microcontroller**
- **Advanced RISC Architecture**
  - **135 Powerful Instructions – Most Single Clock Cycle Execution**
  - **32 × 8 General Purpose Working Registers**
  - **Fully Static Operation**
  - **Up to 16 MIPS Throughput at 16MHz**
- **High Endurance Non-volatile Memory Segments**
  - **64K/128K/256KBytes of In-System Self-Programmable Flash**
  - **4Kbytes EEPROM–8Kbytes Internal SRAM**
  - **Write/Erase Cycles:10,000 Flash/100,000 EEPROM**
  - **Data retention: 20 years at 85°C/ 100 years at 25°C**
  - **Optional Boot Code Section with Independent Lock Bits**
    - **In-System Programming by On-chip Boot Program**
    - **True Read-While-Write Operation**
  - **Programming Lock for Software Security**
    - **Endurance: Up to 64Kbytes Optional External Memory Space**

AVR
8-bit Microcontrollers (ATMega1280)

- **JTAG (IEEE std. 1149.1 compliant) Interface**
    - **Extensive On-chip Debug Support**
    - **Programming of Flash, EEPROM, Fuses, and Lock Bits through the JTAG Interface**
- **Peripheral Features**
    - **Two 8-bit Timer/Counters with Separate Prescaler and Compare Mode**
    - **Four 16-bit Timer/Counter with Separate Prescaler, Compare- and Capture Mode**
    - **Real Time Counter with Separate Oscillator**
    - **Four 8-bit PWM Channels**
    - **Twelve PWM Channels with Programmable Resolution from 2 to 16 Bits**
    - **Output Compare Modulator**
    - **16-channel, 10-bit ADC**
    - **Four Programmable Serial USART**
    - **Master/Slave SPI Serial Interface**
    - **Byte Oriented 2-wire Serial Interface**
    - **Programmable Watchdog Timer with Separate On-chip Oscillator**
    - **On-chip Analog Comparator**
   - **Interrupt and Wake-up on Pin Change**

AVR
8-bit Microcontrollers (ATMega1280)

- **Special Microcontroller Features**
  - **Power-on Reset and Programmable Brown-out Detection**
  - **External and Internal Interrupt Sources**
  - **Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby and Extended Standby**
- **I/O and Packages**
  - **86 Programmable I/O**
  - **100-lead TQFP, 100-ball CBGA**
- **Ultra-Low Power Consumption**
  - **Active Mode: 1MHz, 1.8V: 500µA**
  - **Power-down Mode: 0.1µA at 1.8V**
- **Speed Grade:**
  - **0 - 4MHz @ 1.8V - 5.5V, 0 - 8MHz @ 2.7V - 5.5V**
  - **0 - 8MHz @ 2.7V - 5.5V, 0 - 16MHz @ 4.5V - 5.5V**

8-bit Microcontrollers (ATMega1280)

AVR Info

- http://atmel.com/products/AVR/
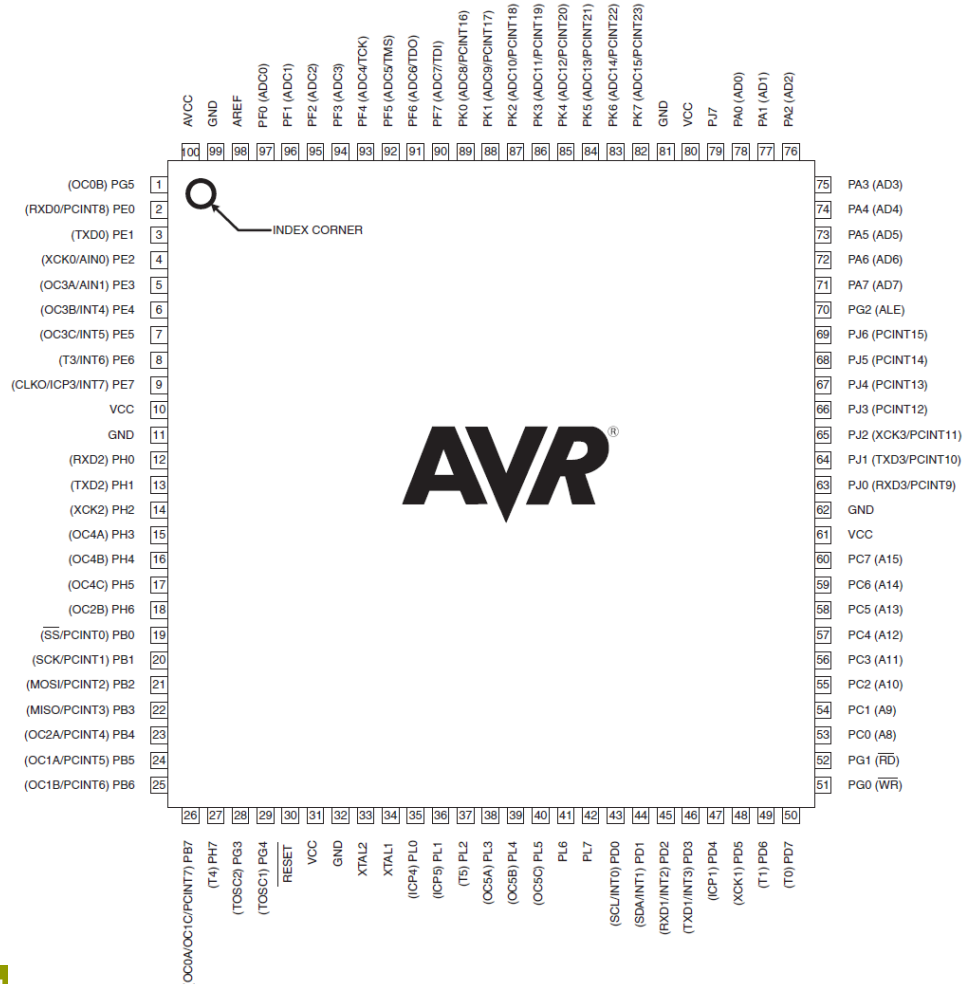
- Download the full datasheet for ATMega1280:
  http://www.atmel.com/devices/atmega1280.aspx?tab=documents

Test AVR tool-chain

- With AVR-Studio 5