Micro Controllers Summary
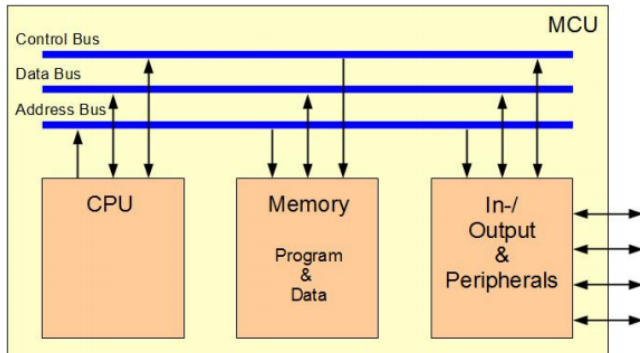
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Contents

1 System Components

1.1 Von Neumann Architecture

Components:

- **CPU**, Central Processing Unit

- **Memory**, Program and Data

- **In-/Output**-Unit, Peripherals

- **Bus**-System: Communication

*One **shared bus and memory** for program and data.*

1.2 Harvard-Architecture

*basically same as Von Neumann, with the difference, that there are **two separate bus systems** for program and data*

1.3 Numerical Systems

Numerical value Z_B of a n-digit, integer number with base B ($B \geq 2$):

$$Z_B = \sum_{i=0}^{n-1} x_i \cdot B^i$$

Decimal	Dual / Binary	Hexadecimal
197	0b1100'0101	0xC5
$B = 10$	$B = 2$	$B = 16$
$= 1 \cdot 10^2 +$	$= 1 \cdot 2^7 + 1 \cdot 2^6 +$	$= C \cdot 16^1 + 5 \cdot 16^0$
$9 \cdot 10^1 +$	$0 \cdot 2^5 + 0 \cdot 2^4 +$	$= 12 \cdot 16^1 + 5 \cdot 16^0$
$7 \cdot 10^0$	$0 \cdot 2^3 + 1 \cdot 2^2 +$	
	$0 \cdot 2^1 + 1 \cdot 2^0$	

The amount of presentable numbers is B^n. The highest presentable number is $B^n - 1$. Calculated from $x_i = B - 1$ for $n - 1 \geq i \geq 0$

1.4 hex / binary

H	D	B	Dec	Bin	
0	0	0000	16	2^5	(max 31)
1	1	0001	32	2^6	(max 63)
2	2	0010	64	2^7	(max 127)
3	3	0100	128	2^8	(max 255)
4	4	0101	256	2^9	(max 511)
5	5	0110	512	2^{10}	(max 1'023)
6	6	0111	1'024	2^{11}	(max 2'047)
7	7	1000	2'048	2^{12}	(max 4'095)
9	9	1001	4'096	2^{13}	(max 8'191)
A	10	1010	8'192	2^{14}	(max 16'383)
B	11	1011	16'384	2^{15}	(max 31'767)
C	12	1110	32'768	2^{16}	(max 65'535)
D	13	1011			
E	14	1011			
F	15	1011			

1.5 Signed numbers

two's compliment is beeing used

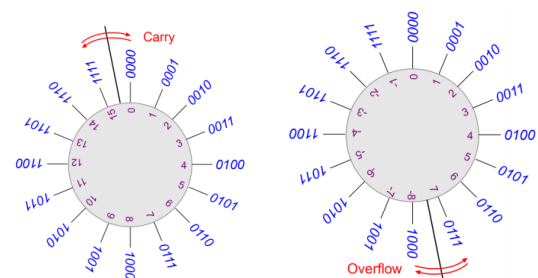$$Z_{signed} = -x_{n-1} \cdot 2^{n-1} + \sum_{i=0}^{n-2} x_i \cdot 2^i$$

most significant bit is negative
Example: -1 as 16-bit Hex $= 0xFFFF$
Conversion:

1. *Invert binary : $-6 \to 0110 \to 1001$*

2. *increment by 1 : $1001 + 0001 \to 1010$*

1.6 carry / overflow

Carry *is set on crossover between lowest and highest number*

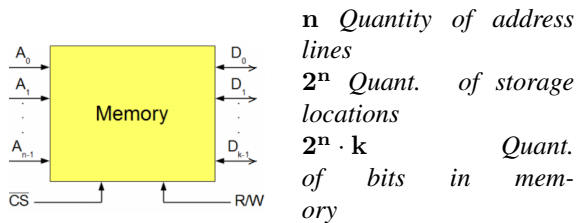**Overflow** *happens on crossover between highest absolut values*

1.7 Bit groups

Nibble/Tetrade *has the size of 4 bits*
Byte *has the size of 8 bits*
Word *is MC9S08JM60 specific, it has 16 bits*

1.8 Quantity of address lines

n *Quantity of address lines*
2^n *Quant. of storage locations*
$2^n \cdot k$ *Quant. of bits in memory*

1 K	=	2^{10}	=	1024 Bit	≙	10 Adresslines
64 K	=	2^{16}	=	65536 Bit	≙	16 Adresslines

example, $32K \times 8$ *memory storage space:*

bits storage: $32 \cdot 2^10 \cdot 8 = 2^5 \cdot 2^{10} \cdot 2^3 = 2^18 \to 18$ *Bits*
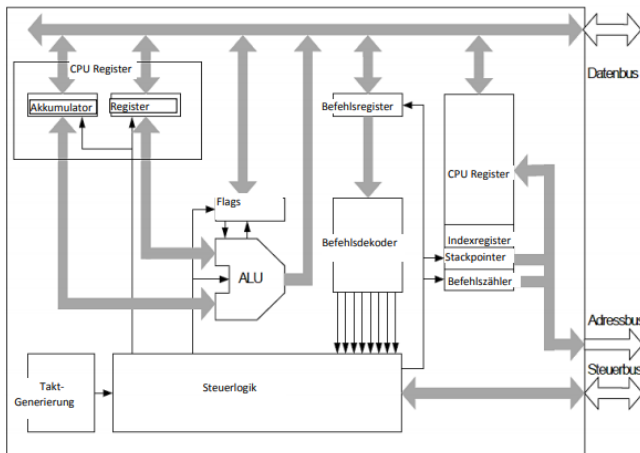**number address lines**: $32 \cdot 2^10 = 2^15 = 32\,768$
highest address: $2^{18} - 1 = 0x7FFFF = 262'143$

1.9 Microprocessor vs Mircocontroller

Mircocontroller *contains CPU (Processor), Peripherals (I/O) and Memory (RAM / ROM). Basically a small computer.*
Mircoprocessor *has only CPU and som integrated Circuits.*

1.10 CPU components

ALU (Aritmetic Unit), AKKU (Accumulator), PC (Programming Counter), Busses, Instruction-Register, Address-Register, Operand-Register, Control Unit, ..

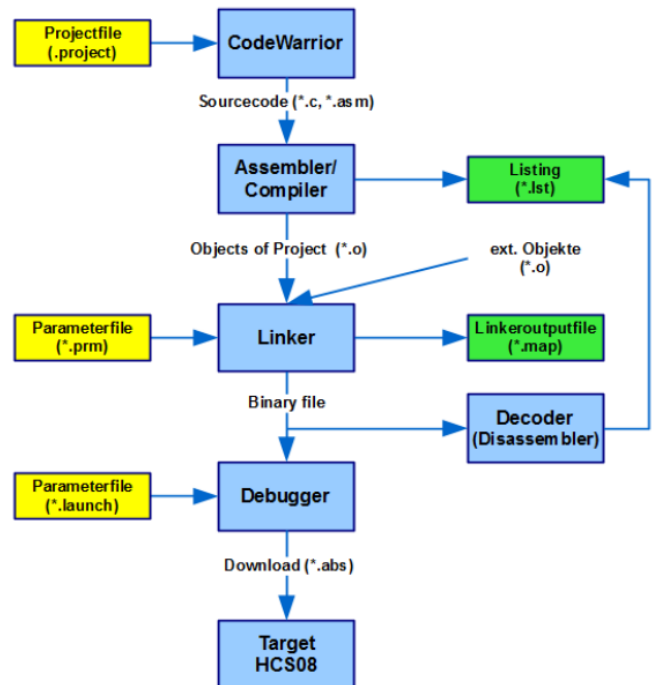## 1.11 Instruction Cycle Steps

1. instruction fetch

2. instruction decode

3. (operand fetch)

4. instruction execute

5. next address and inc PC

1.12 Types of MCU Registers

AKKU, PC, Instruction-Register (decoder), Operand-Register

2 Compiling

2.1 Codewarrior Designflow

2.2 Assembler Code-Format

Label   Instruction   Operands   comment

```c
#include <stdio.h>
#define N 10
/* Block
 * comment */

int main()
{
    int i;

    // Line comment.
    puts("Hello world!");

    for (i = 0; i < N; i++)
    {
        puts("LaTeX is also great for
            programmers!");
    }

    return 0;
}
```