Micro Controllers Summary

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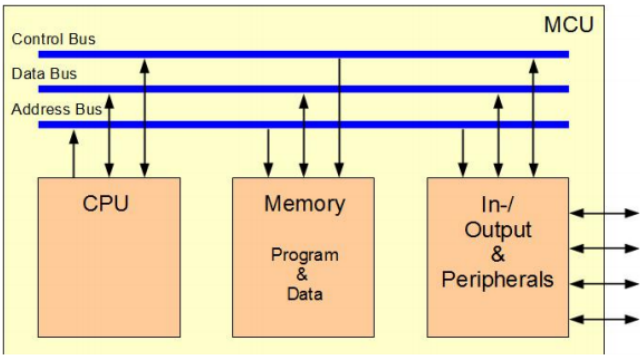
June 13, 2019

Contents

1 Basic MC

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 Hexadecimal

$0-9$	A	B	C	D	E	F
$0-9$	10	11	12	13	14	15
$xxxx$	1010	1011	1100	1101	1111	

1.5 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			

1.6 Signed numbers

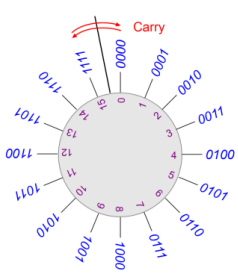
two's compliment is beeing used

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

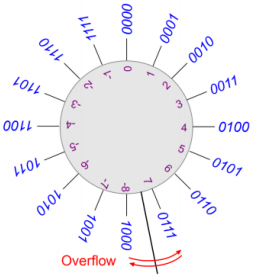
most significant bit is negative
Example: -1 as 16-bit Hex = $0xFFFF$
Conversion:

1. *Invert binary :* $-6 \rightarrow 0110 \rightarrow 1001$
2. *increment by 1 :* $1001 + 0001 \rightarrow 1010$

1.7 carry / overflow



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

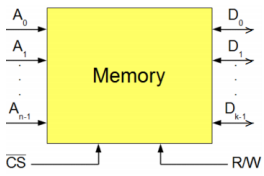


***Overflow** happens on crossover between highest absolut values*

1.8 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*

1.9 Quantity of address lines



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

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

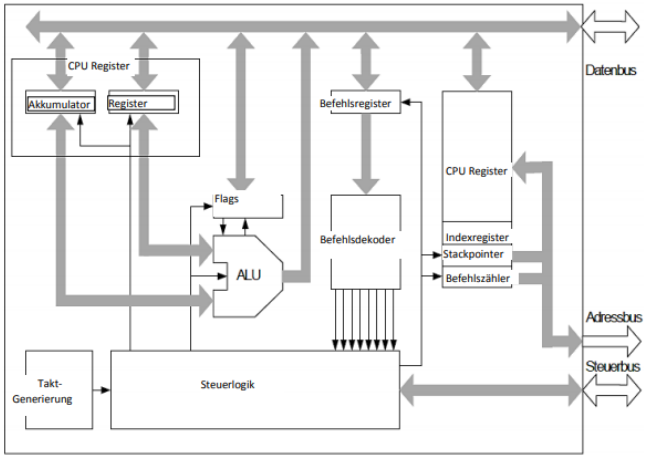
example, $32K \times 8$ *memory storage space:*

bits storage: $32 \cdot 2^10 \cdot 8 = 2^5 \cdot 2^10 \cdot 2^3 = 2^18 \rightarrow 18$ *Bits*
number address lines: $32 \cdot 2^10 = 2^15 = 32\,768$
highest address: $2^{18} - 1 = 0x7FFF = 262'143$

1.10 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.*

1.11 CPU components



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

1.12 Instruction Cycle Steps

1. instruction fetch
2. instruction decode
3. (operand fetch)
4. instruction execute
5. next address and inc PC

1.13 Types of MCU Registers

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

```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;
}
```