

Introduction to Microcontroller Systems



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Introduction to Microcontroller Systems

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Embedded system

- Real time
- Size
- Price
- Power consumption
- User interface
- Limited memory
- Hardware/software



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Assembler or C?

- Performance (assembler)
- Development (C)



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Datatypes 1

- Floating point/fix point
- Integer/fractional numbers



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Datatypes 2

- Bit
- Byte (8 bits)
- Word (16 bits)
- Double word (32 bits)



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Datatypes 3

- Bit
 - High or low, one or zero
- Byte (8 bits)
 - $0 - (2^8-1) = 0 - 255$



Datatypes 4

- Signed/unsigned
 - $0 - 255$ unsigned
 - $-128 - + 127$ signed
 - 2-complement

$$64_{16} = 01100100_2 = 100_{10} \text{ signed}$$

$$64_{16} = 01100100_2 = 100_{10} \text{ unsigned}$$

$$83_{16} = 1000011_2 = -125_{10} \text{ signed}$$

$$80_{16} = 1000011_2 = 131_{10} \text{ unsigned}$$



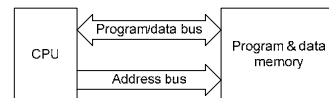
Datatypes 5

- Word (16 bits)
 - $0 - (2^{16}-1) = 0 - 65535$ unsigned
 - $-32768 - +32767$ signed
- Double word (32 bits)
 - $0 - (2^{32}-1) = 0 - 4294967295$ unsigned
 - $-2147483648 - +2147483647$ signed



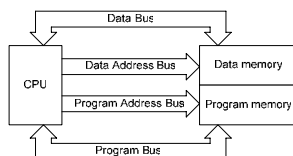
Computer Architecture

von Neuman Architecture

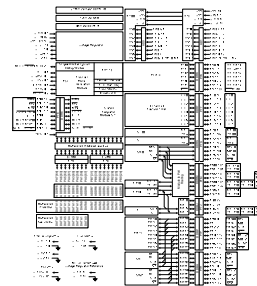


Computer Architecture

Harward Architecture



Motorola MC9S12DG256B

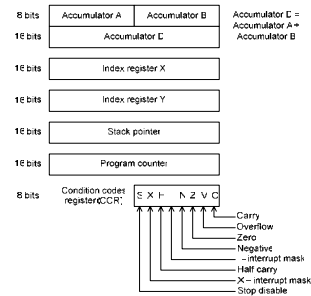


Processor units

- Central processing unit (CPU)
- Registers
- Memory
- I/O



Registers

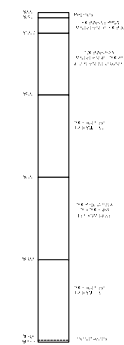


Memory types

- Read only memory (ROM)
 - Electrically erazable programmable read only memory, EEPROM
 - Flash memory
- Read/write memory
- Random access memory (RAM)
 - Static
 - Dynamic



Memory



Peripheral units

- Timer/counter
- Serial communication interface (SCI)
- Serial peripheral interface (SPI)
- Analog-to-digital converter (A/D)
- Pulse width modulation (PWM)
- Controller area network (CAN)



Timer/counter

- Free running counter
- Input capture
- Output compare
- Time measurements
- Pulse accumulator



Serial communication interface (SCI)

- Asynchronous
- Baudrate (bits/sec)
- Synchronisation
- Startbit(s)
- Stopbit(s)
- Parity bit



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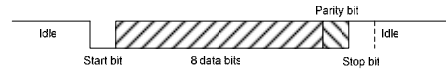
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SCI pattern



- Odd/even parity



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Serial peripheral interface (SPI)

- Synchronous
- Master/slave
- Baudrate (bits/sec)
- Synchronisation

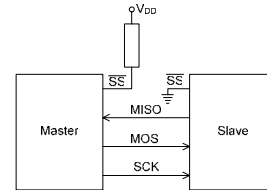


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Serial peripheral interface (SPI) Configuration



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Analog-to-digital conversion (A/D)

- Uni/bipolar
- Resolution
- Conversion error
- Signal-to-quantization-noise-ratio (SQNR)
- Conversion time

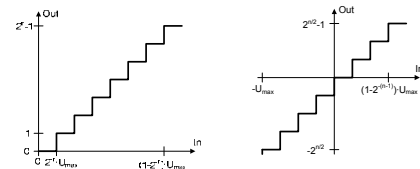


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Analog-to-digital conversion (A/D)



Unipolar

Bipolar



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Analog-to-digital conversion (A/D)

Resolution $\Delta = U_{\max}/2^n$

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Analog-to-digital conversion (A/D) Conversion error

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Analog-to-digital conversion (A/D) Signal to Quantisation Noise Error (SQNR)

$SQNR_{\text{unipolar}} \approx 6 \cdot (\text{number of bits} + 1)$
 $SQNR_{\text{bipolar}} \approx 6 \cdot \text{number of bits}$

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Analog-to-digital conversion (A/D) methods

- Integration
- Successive approximation
- Flash (direct)

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A/D-conversion Integrating converter

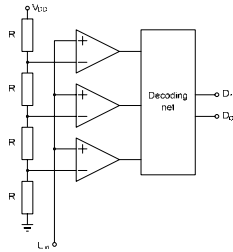
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A/D-conversion Successive approximation

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A/D-converter Flash converter



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Pulse width modulation (PWM)

- Frequency
- Duty cycle



- Driver circuits

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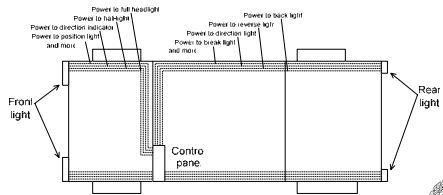
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Controller area network (CAN) 1

Car without CAN bus



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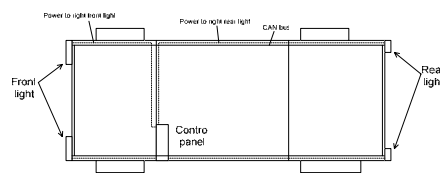
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Controller area network (CAN) 2

Car with CAN bus



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Controller area network (CAN) 3

- Communication bus
- Message based
- CSMA/CD
 - Carrier Sense Multiple Access with Collision Detect
- Arbitration

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Input/output (I/O)

- Digital inport
- Digital output
- Analog inport (A/D)
- Analog output (D/A)
- Serial ports (SCI, SPI)

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User interface

- Switch (button)
- DIP-switch
- LED
- Bargraph
- LCD
- Character/pixel



Assembler instruction groups 1

- Load and store
 - LDAA, STX
- Transfer and exchange
 - TAB, XGDX
- Move
 - MOVB, MOVW
- Add and subtract
 - ABA, ADDD



Assembler instruction groups 2

- (BCD-instructions)
- Decrement and increment
 - DECA, INC
- Compare and test
 - CBA, CMPB, TST
- Boolean logic
 - ANDA, ORAB



Assembler instruction groups 3

- Clear, complement and negate
 - CLRA, CLC, COMB, NEG
- Multiply and divide
 - MUL, EDIVS
- Bit test and bit manipulation
 - BITA, BSET
- Shift and rotate
 - ASRA, LSL



Assembler instruction groups 4

- Branch
 - BRA, BEQ, BGE, LBLO, DBEQ
- Jump and subroutine
 - BSR, JSR, RTS, JMP
- (Interrupt)
- Stack handling
 - PSHA, PULD
- Condition code
 - CLI, TPA



Addressing modes 1

- Inherent
- Immediate
- Direct/extended
- Relative
- Indexed
 - 5/9/16 bit offset
 - Pre/post inc/decrement



Addressing modes 2

- Indexed - indirect
 - 16 bit offset
 - D accumulator offset

