1

Richard Balogh
Štefan Chamraz

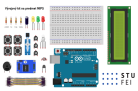
STU FEI

2

Cvičenia

Google Classroom

senzor



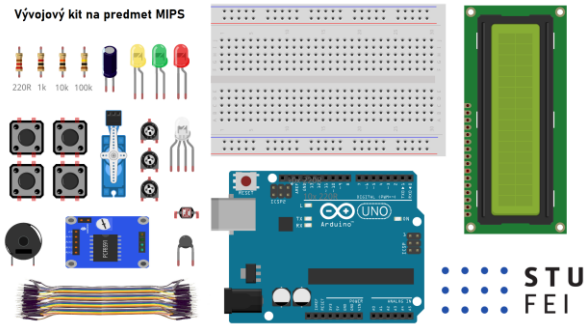
Podmienky absolvovania predmetu (40% z každej časti):

Cvičenia: 40 b. za úlohy z cvičení (2021: 43b.)
20 b. záverečný projekt + 10 b. prezentácia

Skúška: 100 - X bodov (2021: 37b)

3

Vývojový kit na predmet MIPS



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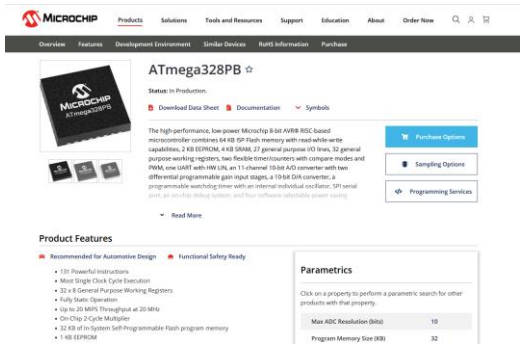
4

profesia

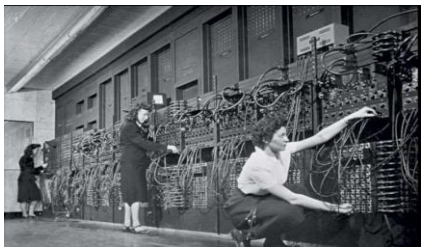
embedded c alebo arduino?

5



6

Physical / Virtual Computing



Jean Jennings, Marlyn Wescoff a Ruth Lichterman programujú počítač ENIAC na Pennsylvánskej univerzite v USA, 1946.

7

Physical / Virtual Computing

8

Vývoj HW

4+1
1 MB pamäte
550 W
29 kg
1,2 MIPS

6000 x
100 x
150 x
8000 x

4+4
6 GB RAM + 64 GB sd
5 W
191 g
10 000 MIPS

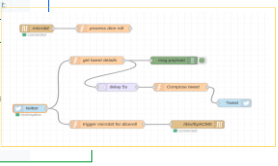
9

Vývoj SW

```
        .ORG    0030h
        DB      03h,01h,02h,03h
        .ORG    0000

        LDA     0030H
        MOV     C,A ; Initialize C-counter
        SUB     A ; sum = 0
        LXI     H,0031H ; Initialize pointe
BACK:   ADD     M ; SUM = SUM + data
        INX     H ; increment pointer
        DCR     C ; Decrement counter
        JNZ     BACK ; if counter 0 repeat
        STA     040H ; Store sum
```

```
for (;;)
{
 c = (char)rand();
 printf("%d,%d\r",(int)(100*(sin(x)+1)),c);
 if (c>245)
  printf("Alarm! Temperature HIGH!!!\r");
 if (c<5)
  printf("Alarm! Temperature LOW!!!\r");
 _delay_ms(300);
 x=x+0.1;
 }
 return 0;
} /* End Of Main */
```

```
from microbit import *

display.show(Image.YES)

while True:
    if button_a.is_pressed() and button_b.is_presse
        display.show(Image.HEART)
        sleep(500)
    elif button_a.is_pressed():
        display.show(Image.HAPPY)
    elif button_b.is_pressed():
        display.show(Image.SAD)
```



Vývoj programovacích jazykov: Asembler, jazyk C, Python a Node-Red

10

Miniaturizácia

11

Miniaturizácia

12

Moorov zákon

Ak by sa rovnako rozvíjal automobilový priemysel:

300 000 km/h **850 000 km / liter** **0,04 $ / ks**

13

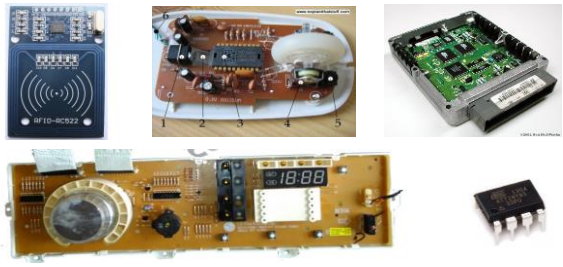
Embedded Computing / vnorené systémy

počítač = súčiastka

14

Embedded computer

Embedded computer



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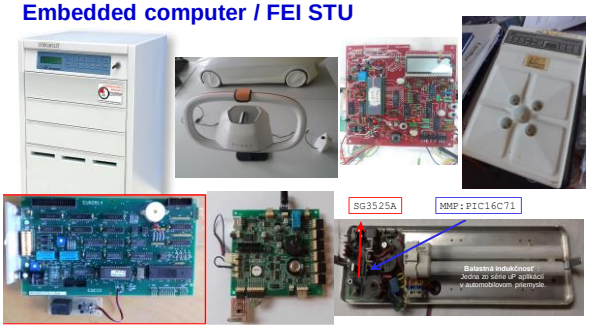
Embedded computer / FEI STU



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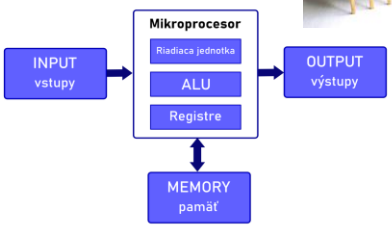
Mikroprocesor



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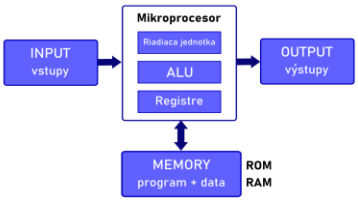
Architektúra Von Neumann (*Princetonská*)



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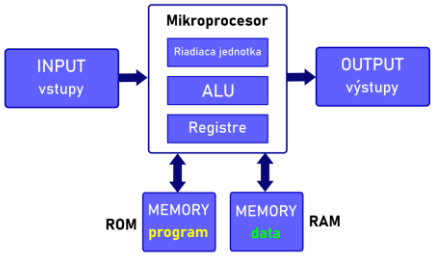
Harvardská architektúra (Aiken)



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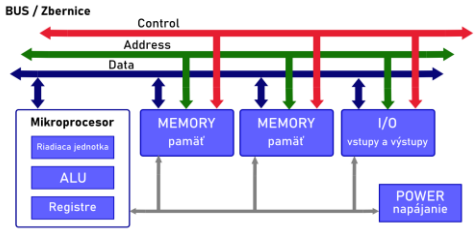
Štruktúra počítača



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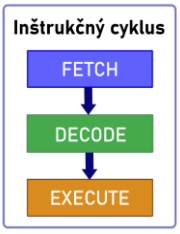
Opakovanie: Inštrukčný cyklus

- Výber inštrukcie z pamäte
- Dekódovanie inštrukcie
- Výber operandov
- Vykonanie požadovanej operácie
- Zápis výsledkov do pamäte



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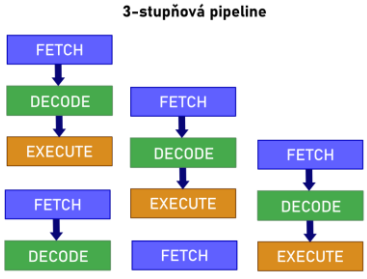
Paralelizmus: pipeline



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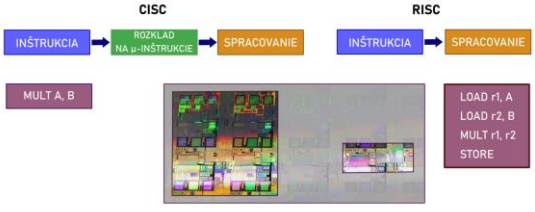

CISC: *málo* (4-100)

execution time = počet inštrukcií x CPI x frekvencia

RISC: *veľa* 1

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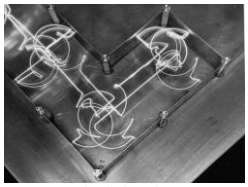
Historické okienko

1952

24

C. Shannon - Theseus:
Maze-Solving Mouse (1952)



Source: http://cyberneticzoo.com

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1974

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From CPU to software, the 8080 Microcomputer is here.

Intel's new 8080 n-channel microcomputer is here—incredibly easy to interface, simple to program and with up to 10 times the performance of p-channel MOS microprocessors.

Best of all, the 8080 is real—in production at Intel and available in volume quantities, today. It's also available through distributors along with a growing line of peripheral circuits and a new version of the Intellec®, a program and hardware development system for the 8080, all supported with software packages, design documentation and manuals, and backed by an entire line of MOS memory and peripheral support.

The 8080 is the inevitable successor to complex custom MOS and many large discrete logic subsystems. It is the industry's first general purpose n-channel microcomputer and the first high performance single-chip CPU, with extremely simple interface requirements and straightforward programming. It uses a full instruction cycle of 2.0 microseconds, and yet it retains the low power economic benefits of Intel's p-channel microcomputers to a new universe of systems that need fast, multi-port controllers and processors. These systems include intelligent terminals, point of sale systems, process and numeric controllers, advanced calculators, word processors, self-calibrating instruments, data loggers, communications controllers, and many more.

The 8080 has 16 bit address, 8 bit data, 256 output channels, handle almost unlimited interrupt levels, directly access 64 kilobytes of memory, and put many satellite 8080 processors around a single memory.

Interfacing is minimal and design is easy with the 8080 because all controls are fully decoded on the CPU chip itself and inputs and outputs are TTL compatible. There are separate data, address and control buses.

The 8080 instruction set/architecture has 78 basic instructions, including the 8008 set plus new ones that make possible such features as vectored multi-level interrupt, unlimited subroutine nesting and very fast decimal and binary arithmetic.

Program development for the 8080 can be done either on a large computer using the Intel software cross products (PL/M systems language, complex macro-assembler and simulator), or on an Intellec 8 development system with a resident monitor, text editor and macro-assembler.

The new 8080 product family includes performance matched peripheral and memory circuits configured to minimize design effort and maximize system performance. Large, low cost RAMs, PROMs, PROMs and I/O devices are available now and we will soon announce other 8080 LSI support circuits.

Intel's 8080 is the most powerful, most versatile, most easy to use high performance microcomputer in sight. It's here now in volume, from the inventors of the microcomputer and the people who lead the industry in production and design support.

Intel Corporation, 3065 Bowers Avenue, Santa Clara, California 95051 (408) 246-7501

intel Microcomputers. First from the beginning.

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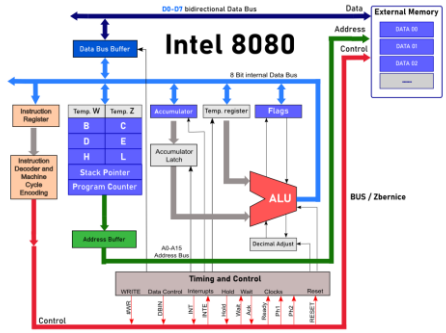

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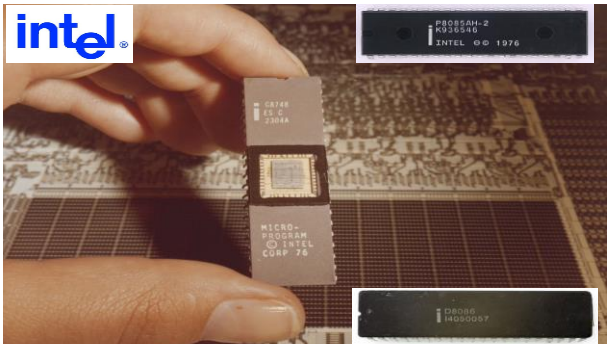
1976

29



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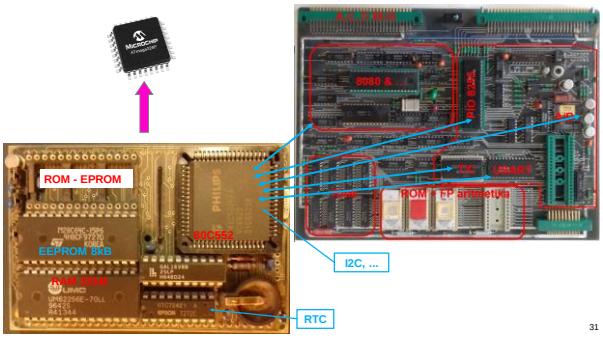

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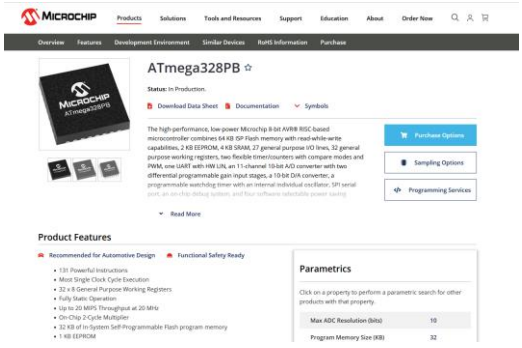

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AVR

1995 AVR architektúra: ***Alf-Egil Bogen a Vegard Wollan***, študenti na *Norwegian Institute of Technology v Trondheime*

Alf and **V**egard's **R**ISC processor
Advanced **V**irtual **R**ISC processor

original AVR MCU -- local ASIC house in Trondheim, Norway (now *Nordic Semiconductor*)

1996 technology was sold to Atmel from Nordic VLSI further developed by Bogen and Wollan at ***Atmel Norway***

jeden z prvých bol AT90S8515, 40-pin DIP pinout as an 8051 (polarity of the RESET line was opposite).

1997 začala výroba

len do r. 2003, Atmel had shipped *500 million* AVR

2019 Atmel -> ***Microchip Technology***

Procesor optimalizovaný pre jazyk C
+ RISC: väčšina inštrukcií trvá **1SC**
+ FLASH: rapídne zrýchlenie a zlacnenie vývoja

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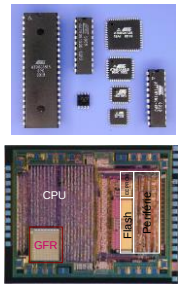
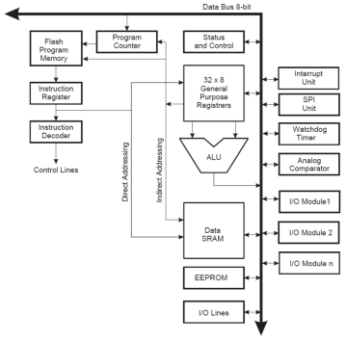
AVR - Architektúra





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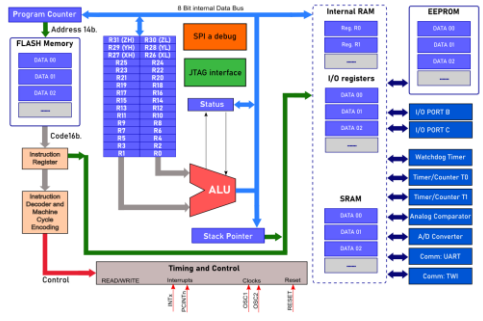
AVR -



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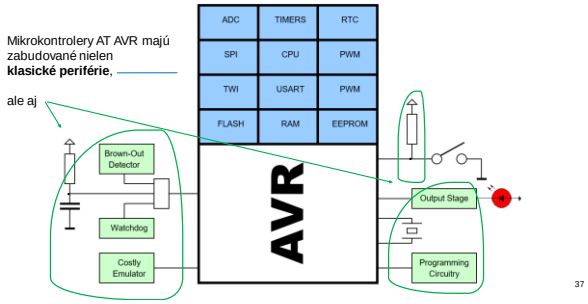
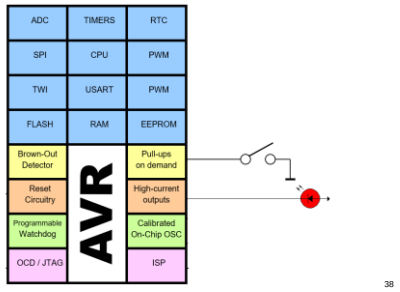
Pomocou AT AVR mikroprocesorov možno realizovať jednočipové riešenie



37

Pomocou AT AVR mikroprocesorov možno realizovať jednočipové riešenie



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AVR families

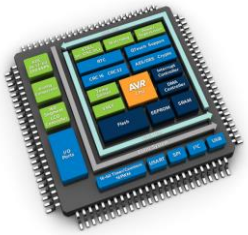
tinyAVR

megaAVR

XMEGA (real time, USB, comm)

AVR UC3 L3 (battery, low power)

avr32



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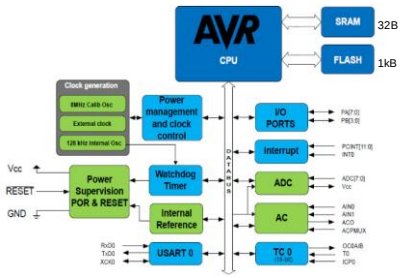
ATtiny



Microchip Technology ATtiny102/104 AVR 8-Bit Microcontrollers

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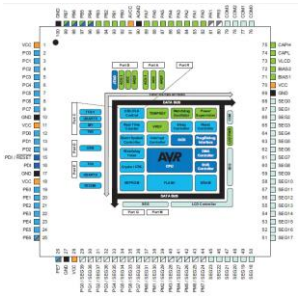
XMEGA

128 kB FLASH
8 kB boot
8 kB SRAM
2 kB EEPROM



Microchip Technology AVR® XMEGA® 8/16-bit Microcontroller 128B1

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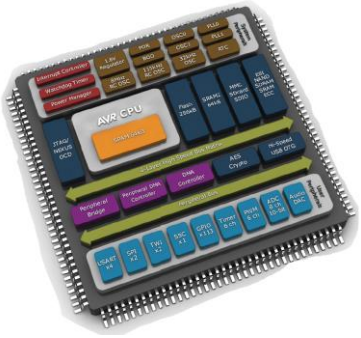
AVR32

256 kB FLASH
64 kB SRAM
SDcard



Microchip AVR® 32-bit AVR UC3

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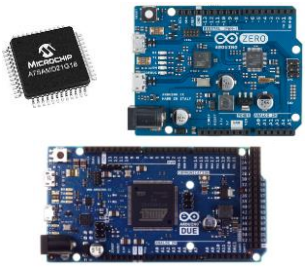
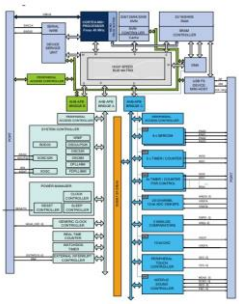
SAM -> nie je AVR!





Microchip Technology ATSAMD21

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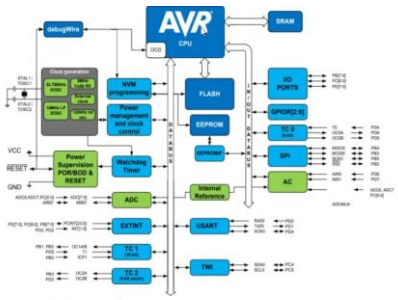
ATmega328



Microchip Technology ATmega328 AVR 8-Bit Microcontrollers

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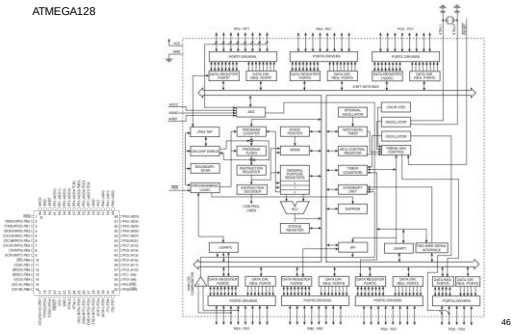
ATMEGA128



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Vstupy a výstupy

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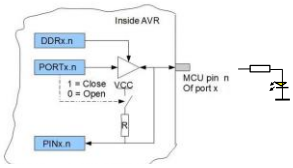
Vstupy a výstupy (I/O)

PORT A
PORT B
PORT C
PORT D
PORT E
PORT F

PORT B.0
PORT B.1
PORT B.2
PORT B.3
PORT B.4
PORT B.5
PORT B.6
PORT B.7



13.4.2 PORTB – The Port B Data Register

Bit	7	6	5	4	3	2	1	0	
0x05 (0x25)	PORTB7	PORTB6	PORTB5	PORTB4	PORTB3	PORTB2	PORTB1	PORTB0	PORTB
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

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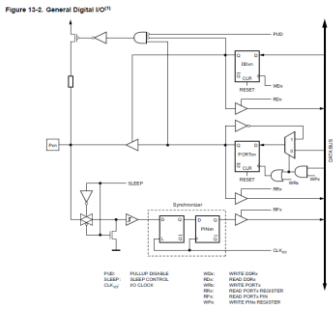

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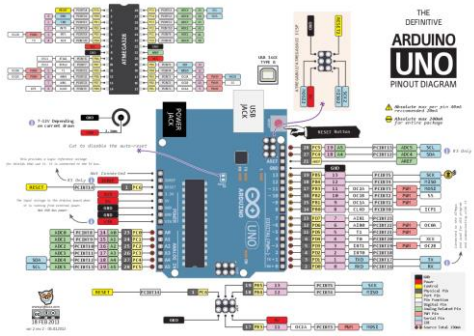

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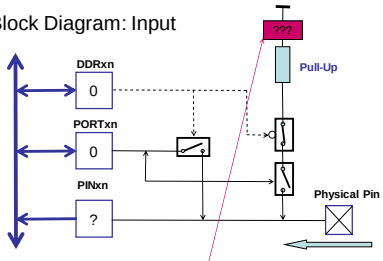
I/O Pin Block Diagram: Input



DDRxn	I/O	PORTxn	PUD (MCUCR)	Pull-up	Poznámka
0	In	0	X	No	Tri state (Hi-Z)

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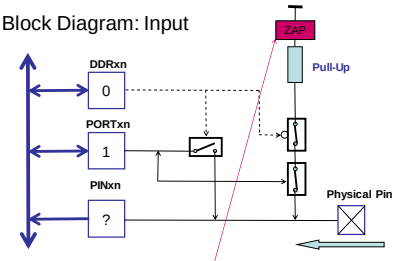
I/O Pin Block Diagram: Input



DDRxn	I/O	PORTxn	PUD (MCUCR)	Pull-up	Poznámka
0	In	1	0	Yes	Zdroj prudu (malého), ak „pulled down“

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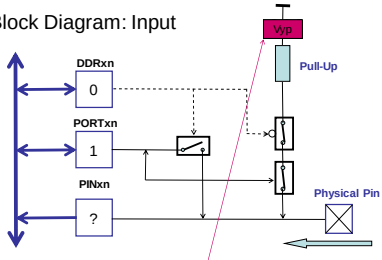
52

I/O Pin Block Diagram: Input



DDRxn	I/O	PORTxn	PUD (MCUCR)	Pull-up	Poznámka
0	In	1	1	No	Tri state (Hi-Z)

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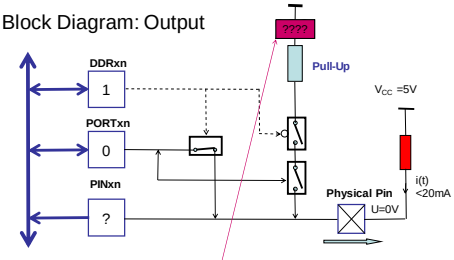
I/O Pin Block Diagram: Output



DDRxn	I/O	PORTxn	PUD (MCUCR)	Pull-up	Poznámka
1	Out	0	X	No	Out - L (Sink)

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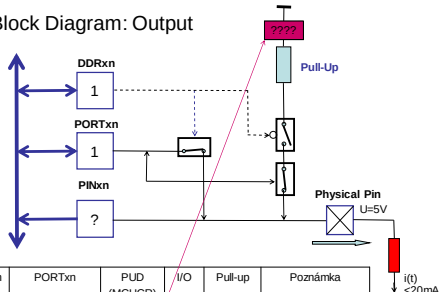
I/O Pin Block Diagram: Output



DDRxn	PORTxn	PUD (MCUCR)	I/O	Pull-up	Poznámka
1=Out	1=Pull-Up (off)	X	Out	No	Out - H (Source)

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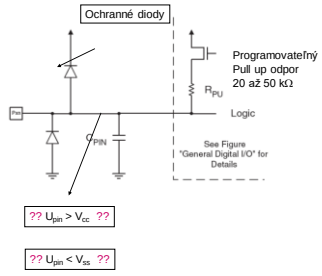
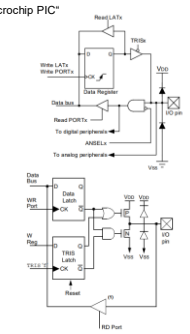
I/O Port – zapojenie vstupného pinu

„ATMEL AVR"



„Microchip PIC"



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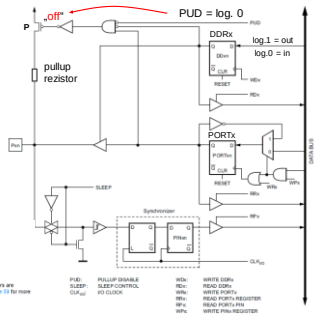
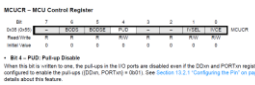
I/O Port – novšia architektúra portu:

DDRx RD/RW
PORTx RD/WR
PINx RD/(WR)
x = A,B,.. F





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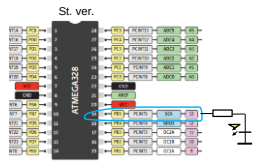
Programovanie I/O bitov v Arduino C

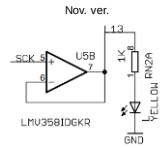
```
// initialize digital pin LED_BUILTIN as an output.
pinMode(LED_BUILTIN, OUTPUT);

// turn the LED on (HIGH is the voltage level)
digitalWrite(LED_BUILTIN, HIGH);

// turn the LED off by making the voltage LOW
digitalWrite(LED_BUILTIN, LOW);
```

LED_BUILTIN = 13

St. ver.



Nov. ver.



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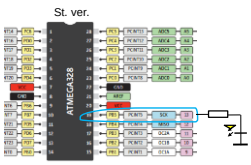
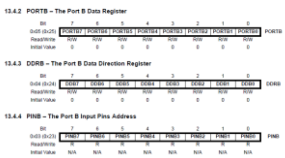
Programovanie I/O bitov v assembleri

```
START:      SBI 0x04,5      ; DDRB.5 = 1 (t.j. Output)
LOOP:       SBI 0x05,5      ; PORTB.5 = 1 (t.j. High, rozsvieť LED)
            CBI 0x05,5      ; PORTB.5 = 0 (t.j. Low, zhasni LED)
```

St. ver.





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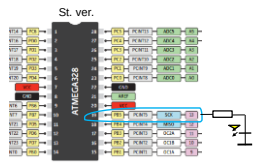
Programovanie I/O bitov v jazyku C

```
// initialize digital pin LED_BUILTIN as an output.
pinMode(LED_BUILTIN, OUTPUT);          DDRB |= (1 << DDRB5);

// turn the LED on (HIGH is the voltage level)
digitalWrite(LED_BUILTIN, HIGH);       PORTB |= (1 << PORTB5);

// turn the LED off by making the voltage LOW
digitalWrite(LED_BUILTIN, LOW);        PORTB &= ~(1 << PORTB5);
```

St. ver.



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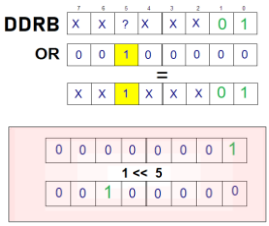
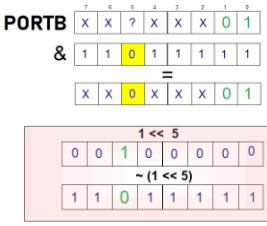
Programovanie I/O bitov v jazyku C

```
DDRB |= (1 << DDRB5);
DDRB  = DDRB | (1 << DDRB5);
```




```
PORTB &= ~(1 << PORTB5);
PORTB  = PORTB  &  ~(1 << PB5);
```



https://senzor.robotika.sk/sensorwiki/index.php/AVR_Bit_Magic

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Zhrnutie

- **Vnorené** (embedded, jednočipové) **mikropočítače**
- Základná **architektúra RISC procesorov rodiny AVR**
- **Univerzálne vstupy a výstupy**
  (štruktúra, ovládanie cez register)
- **Programovanie po bitoch** v assembleri a v jazyku C

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