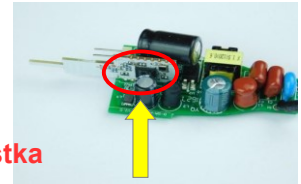
Embedded Computing / vnorené systémy

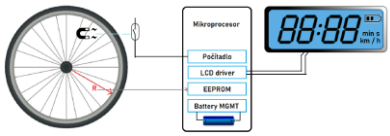


počítač = súčiastka

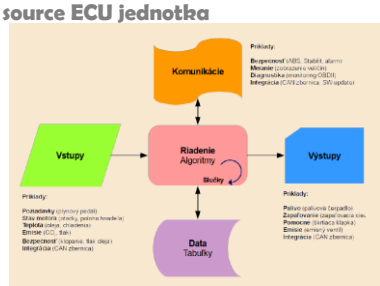
Vnorené systémy
Embedded systems

embedded system
systém *spracovania informácií*, ktorý je navrhnutý na špecifický účel v rámci väčšieho systému, často s požiadavkou na prácu v *reálnom čase*.

IEC 60 050



Vnorené systémy
microRusEfi = open source ECU jednotka



Internet vecí
Internet of Things

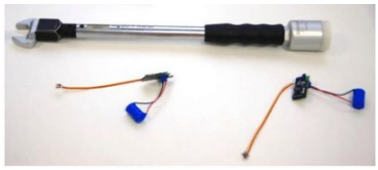
The first generation (1982)

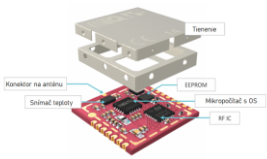
Mike Kazar (Server Software)
David Nichols (Documentation and User Software)
John Zsarnay (Hardware)
Ivor Durham (Finger interface)

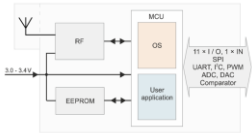
MTBC = 12 min
(Mean Time Between Cola)

http://www.cs.cmu.edu/~coke/

Internet vecí
Internet of Things







Strojový kód vs. jazyk symbolických adries

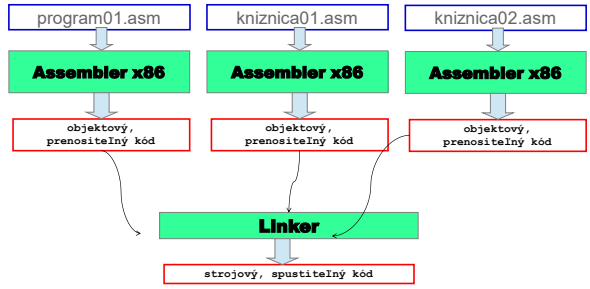
```
        ; sucet dvoch cisel A a B
START:  MVI A, 01h      ;vloz 01 do A
        MVI B, 02h      ;vloz 02 do B
        ADD B                   ;A = A + B
```

Assembler

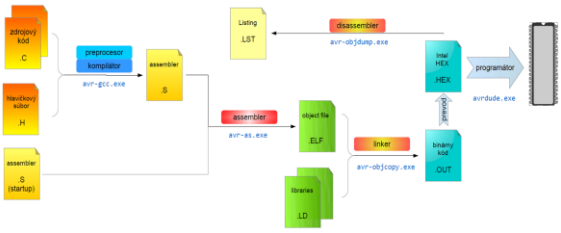
```
0000 3A 0D 00 47 3A 0E 00 80 0008
32 0F 00 76
```

Mikroprocesor rozumie len strojovému kódu!

Kompilátor – prekladač + linker

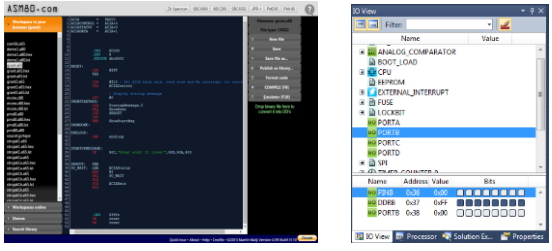


Vývojové prostriedky pre vnorené systémy

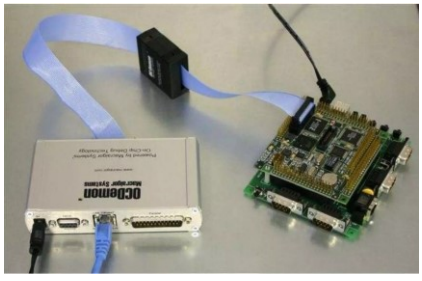


Vývojové prostriedky pre vnorené systémy

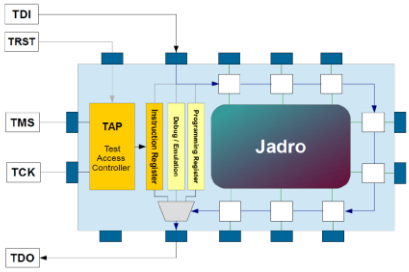
Simulátor procesora



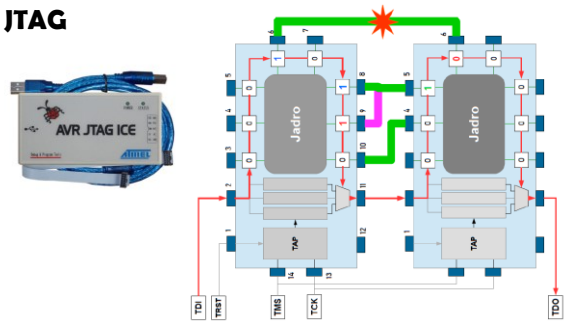
Emulátor procesora



Rozhranie JTAG

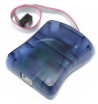


JTAG



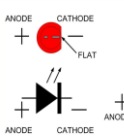
Prenesenie programu do pamäti AVR

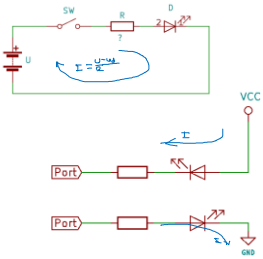
- paralelný programátor
- programovanie cez SPI rozhranie (MISO/MOSI)
- programovanie cez JTAG alebo debugWire
- programovanie bootloaderom

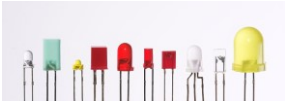



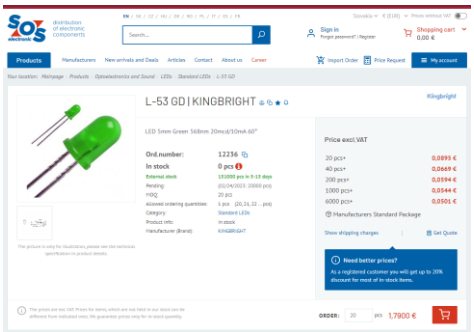

Jednobitový výstup - LED

Light Emitting Diode

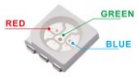






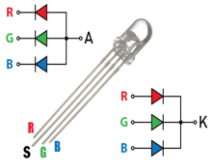


Jednobitový výstup



5050 RGB Chip

3 chips in 1 LED



Elektrické parametre

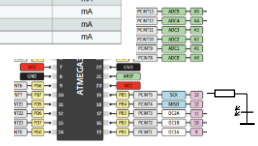
(naučme sa čítať datasheety)

28.1 Absolute Maximum Ratings

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Parameters	Min.	Typ.	Max.	Unit
Operating temperature	–55		+125	°C
Storage temperature	–65		+150	°C
Voltage on any pin except RESET with respect to ground	–0.5		V_{CC} + 0.5	V
Voltage on RESET with respect to ground	–0.5		+13.0	V
Maximum operating voltage		6.0		V
DC current per I/O pin		40.0		mA
DC current V_{CC} and GND pins		200.0		mA
Injection current at V_{CC} = 0V		±5.0[1]		mA
Injection current at V_{CC} = 5V		±1.0		mA

Note: 1. Maximum current per port = ±30mA



Elektrické parametre 2

28.2 DC Characteristics (Continued)

T_A = –40°C to +125°C, V_{CC} = 2.7V to 5.5V (unless otherwise noted)

Parameter	Condition	Symbol	Min.	Typ.	Max.	Unit
Input low voltage, RESET pin	V_{CC} = 2.7V to 5.5V	V_{IL2}	–0.5		$0.1V_{CC}$[1]	V
Input high voltage, RESET pin	V_{CC} = 2.7V to 5.5V	V_{IH2}	$0.9V_{CC}$[2]		V_{CC} + 0.5	V
Output low voltage[3]	I_{OL} = 20mA, V_{CC} = 5V I_{OL} = 5mA, V_{CC} = 3V	V_{OL}			0.8 0.5	V
Output high voltage[4]	I_{OH} = –20mA, V_{CC} = 5V, I_{OH} = –10mA, V_{CC} = 3V	V_{OH}	4.2 2.3			V
Input leakage Current I/O pin	V_{CC} = 5.5V, pin low (absolute value)	I_{IL}			1	µA
Input leakage Current I/O pin	V_{CC} = 5.5V, pin high (absolute value)	I_{IH}			1	µA
Reset pull-up resistor		R_{RST}	30		60	kΩ
I/O pin pull-up resistor		R_{PU}	20		50	kΩ
Analog comparator Input offset voltage	0.4V < V_{in} < V_{cc} – 0.5 (absolute value)	V_{ACIO}		10	40	mV
Analog comparator Input leakage current	V_{CC} = 5V V_{in} = V_{CC}/2	I_{ACLK}	–50		+50	nA

Notes: 1. "Max" means the highest value where the pin is guaranteed to be read as low
2. "Min" means the lowest value where the pin is guaranteed to be read as high
3. Although each I/O port can sink more than the test conditions (20mA at V_{CC} = 5V, 10mA at V_{CC} = 3V) under steady state conditions (non-transient), the following must be observed:
ATmega328P:
1] The sum of all I_{OL}, for ports C0 - C5, should not exceed 100mA.
2] The sum of all I_{OL}, for ports B0 - B5, D5 - D7, XTAL1, XTAL2 should not exceed 100mA.
3] The sum of all I_{OL}, for ports D0 - D4, should not exceed 100mA.

Elektrické parametre 3

28.2 DC Characteristics

T_A = –40°C to +125°C, V_{CC} = 2.7V to 5.5V (unless otherwise noted)

Parameter	Condition	Symbol	Min.	Typ.	Max.	Unit
Input low voltage, except XTAL1 and RESET pin	V_{CC} = 2.7V to 5.5V	V_{IL}	–0.5		$0.3V_{CC}$[1]	V
Input high voltage, except XTAL1 and RESET pins	V_{CC} = 2.7V to 5.5V	V_{IH}	$0.6V_{CC}$[2]		V_{CC} + 0.5	V
Input low voltage, XTAL1 pin	V_{CC} = 2.7V to 5.5V	V_{IL1}	–0.5		$0.1V_{CC}$[1]	V
Input high voltage, XTAL1 pin	V_{CC} = 2.7V to 5.5V	V_{IH1}	$0.7V_{CC}$[2]		V_{CC} + 0.5	V

Notes: 1. "Max" means the highest value where the pin is guaranteed to be read as low
2. "Min" means the lowest value where the pin is guaranteed to be read as high
3. Although each I/O port can sink more than the test conditions (20mA at V_{CC} = 5V, 10mA at V_{CC} = 3V) under steady state conditions (non-transient), the following must be observed:
ATmega328P:
1] The sum of all I_{OL}, for ports C0 - C5, should not exceed 100mA.
2] The sum of all I_{OL}, for ports B0 - B5, D5 - D7, XTAL1, XTAL2 should not exceed 100mA.
3] The sum of all I_{OL}, for ports D0 - D4, should not exceed 100mA.
If I_{OL} exceeds the test condition, V_{OL} may exceed the related specification. Pins are not guaranteed to sink current greater than the listed test condition.
4. Although each I/O port can source more than the test conditions (20mA at V_{CC} = 5V, 10mA at V_{CC} = 3V) under steady state conditions (non-transient), the following must be observed:
ATmega328P:
1] The sum of all I_{OH}, for ports C0 - C5, D0- D4, should not exceed 150mA.
2] The sum of all I_{OH}, for ports B0 - B5, D5 - D7, XTAL1, XTAL2 should not exceed 150mA.
If I_{OH} exceeds the test condition, V_{OH} may exceed the related specification. Pins are not guaranteed to source current greater than the listed test condition.

Inžiniering...

Výpočet

Úlohou je navrhnúť rezistor R, tak, aby LED diódou tiekol dostatočný, ale nie zbytočne príliš veľký prúd.

Zvolíme I_F = 5 mA.
Z grafu (datasheet) odčítame hodnotu U_F = 2,0 [V].

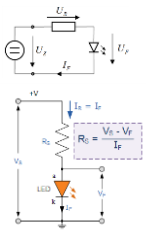
Teraz vieme vypočítať hodnotu R:

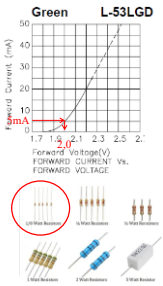
$U_R = U_Z - U_F = 3{,}0 - 2{,}0 = 1{,}0$ [V]

$R = U_R / I_F = 3{,}0\ V / 5\ mA = 600$ [Ω]

Príkon rezistora je $P = U_R I_F = 1{,}0V \cdot 5mA = 5$ [mW]

Takáto hodnota odporu sa nevyrába. Ako postupovať?





Rezistory sa vyrábajú v radoch E6 E12 E24 E48 E96 E192
zodp. presnosť ±20 % ±10 % ±5 % ±2.5 % ±1 % ±0.5 %

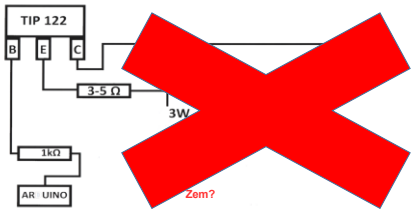
Rady do technickej praxe zaviedol francúzsky technik *Charles Renard*.

E12: 100, 120, 150, 180, 220, 270, 330, 390, 470, 560, 680, 820

Schéma zapojenia?

NIE

Schéma zapojenia?



NIE

Schéma zapojenia

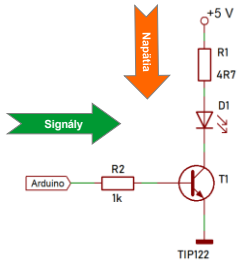
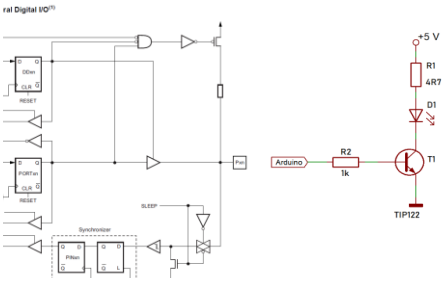
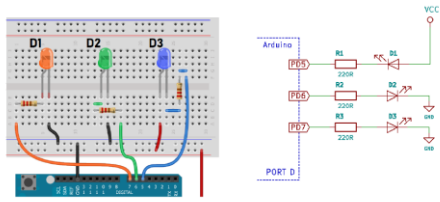


Schéma zapojenia

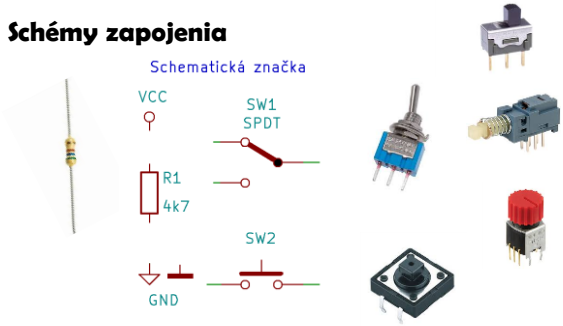


Schémy zapojenia

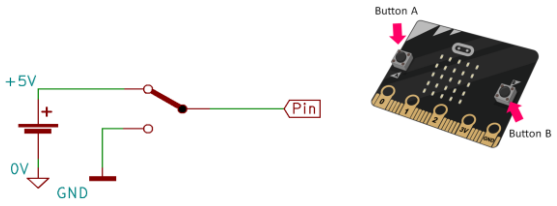


Obr. 1.36: Vľavo zapojovací diagram, vpravo štandartná schéma zapojenia.

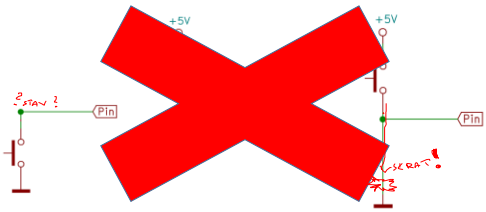
Schémy zapojenia



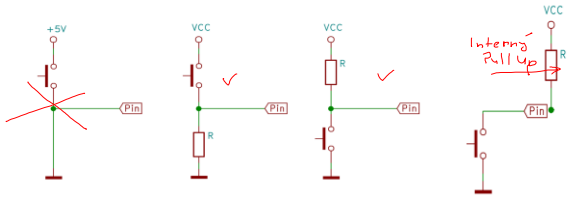
Jednobitový vstup - tlačítko



Jednobitový vstup - tlačítko

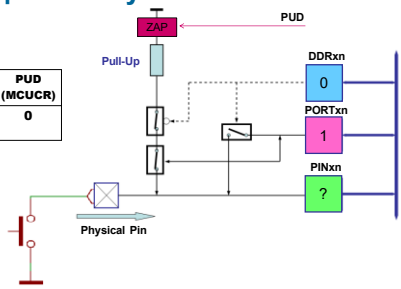


Jednobitový vstup - tlačítko

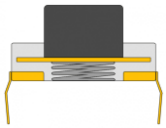


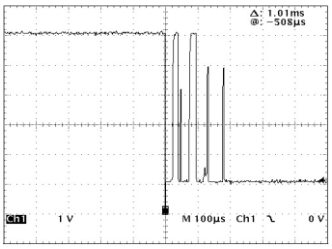
GPIO / Pull-up rezistory

DDRxn	I/O	PORTxn	PUD (MCUCR)
0	In	1	0

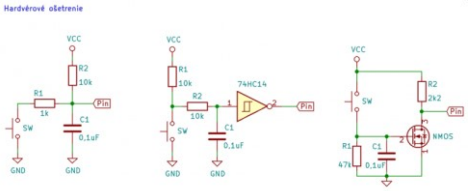


Ošetrenie zákmitov: debouncing

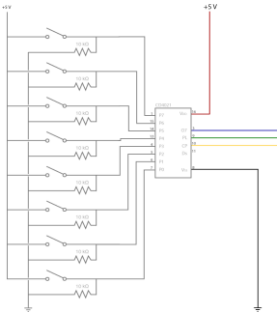




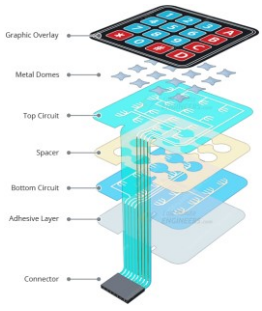
Ošetrenie zákmitov: debouncing



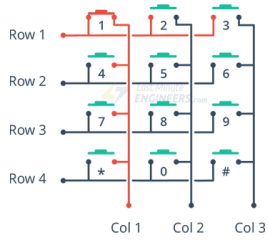
Vstup – klávesnica



Maticová klávesnica



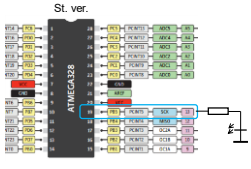
Maticová klávesnica

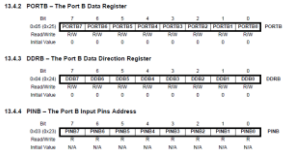


Programovanie I/O bitov v assembleri

OPAKOVANIE ✓

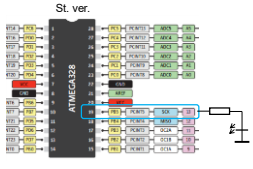
```
START:      SBI 0x04,5      ; DDRB.5 = 1 (t.j. Output)
LOOP:       SBI 0x05,5      ; PORTB.5 = 1 (t.j. High, rozsviet LED)
            CBI 0x05,5      ; PORTB.5 = 0 (t.j. Low, zhasni LED)
```





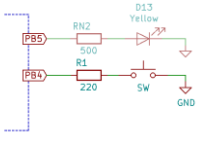
Programovanie I/O bitov v jazyku C

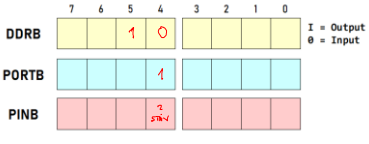
```
DDRB = DDRB | 0x20;     // PORTB.5 je vystup - tri rozlicne sposoby
DDRB = DDRB | (1<<5);
DDRB |= (1 << PB5);

PORTB |=  (1<<LED1);    // set PB5 na log. 1 , t.j. rozsviet LED

PORTB &= ~(1<<LED1);    // clear PB5 na log. 0, t.j. zhasni LED
```




```
DDRB = 0x23;

DDRB = 0b00100011;

DDRB = (1 << 5)|(1 << 1)|(1 << 0);

DDRB = (1 << PB5)|(1 << PB1)|(1 << PB0);
```

```
#define BUTTON PB4
#define LED PB5

 DDRB  = (1 << LED);
 DDRB |= (1<<LED);       // set LED pin as output

DDRB  &=~(1<<BUTTON);    // set BUTTON pin as input
PORTB |= (1<<BUTTON);    // set internal pull-up ON

PORTB |= (1<<LED);       // turn LED ON

 int x = PINB;                // read whole register
     x = PINB & 0b0001 0000 // read BUTTON
     x = PINB & (1<<BUTTON) // read and test with mask
```





Toggle bit

Toggle = *zmena: ak bol bit 1 tak nech je 0 a naopak.*

AVR implementuje funkciu toggle zápisom **1** do registra **PIN**

Napr.:
```
PINB = 0b00100000;
```
alebo
```
SBI PORTB,5
```

zmení stav B5 (ak je to výstup)

Datasheet:
"Writing a logic one to PINxn toggles the value of PORTxn, independent on the value of DDRxn.

microcontroler specific feature (ATmega 16,...328)