

Uvod u primjenu mikrokontrolera

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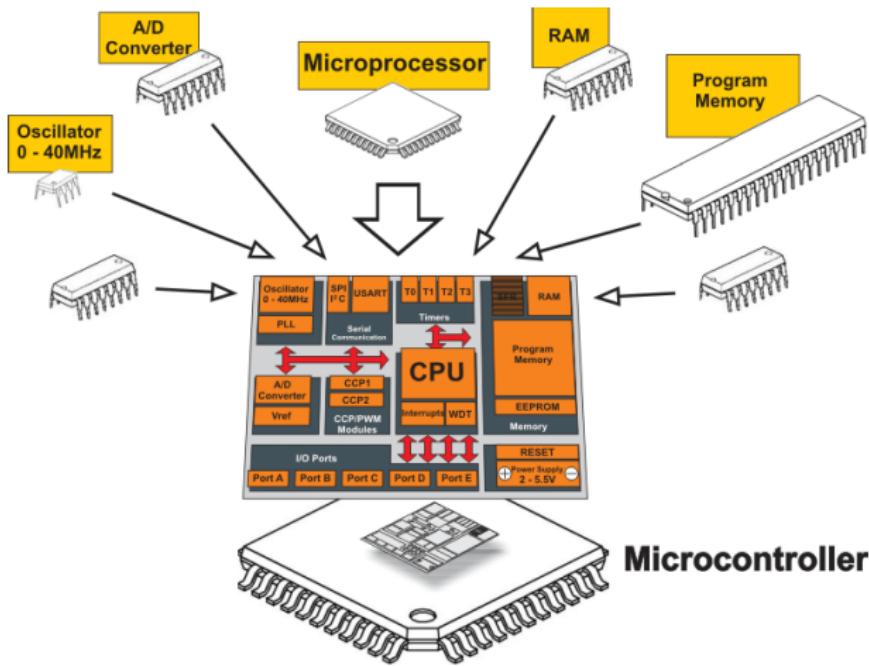
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- 1 Uvodno o mikrokontrolerima
- 2 Proizvođači mikrokontrolera
- 3 Razvojna okruženja s mikrokontrolerima za Rapid Prototyping
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Mikrokontrolери

- Mikrokontrolери (MCU) - samostalni integrirani krugovi koji se programiraju za specifične zadatke.

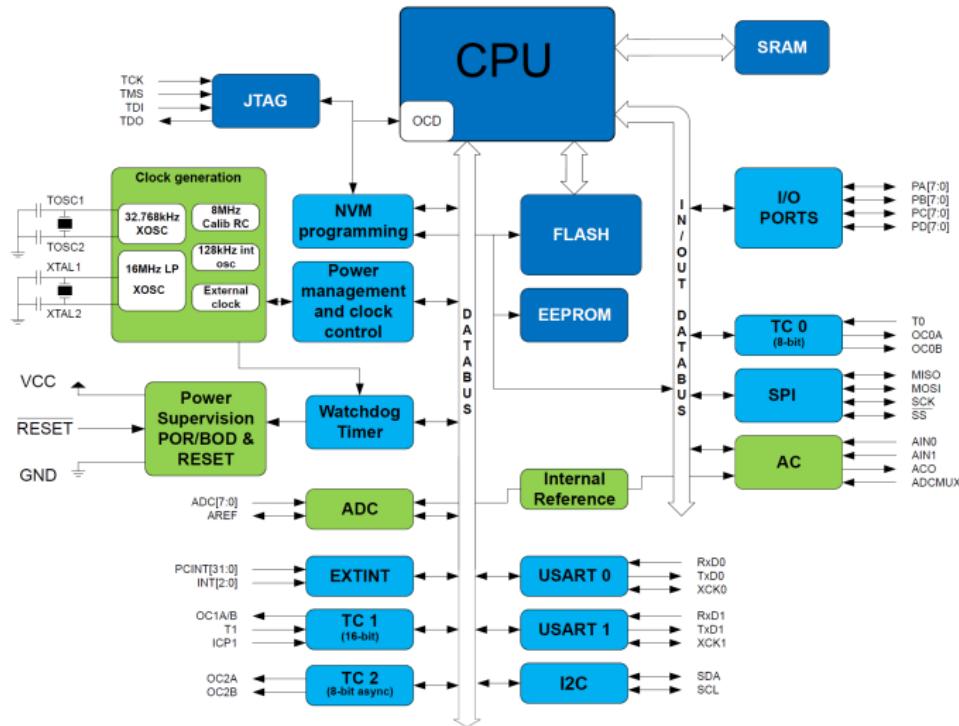


Primjena mikrokontrolera

- Automobilska industrija
- Potrošačka elektronika
- Zdravstvo
- Industrijska elektronika
- *Internet of Things*



Blok diagram mikrokontrolera - 1. dio¹

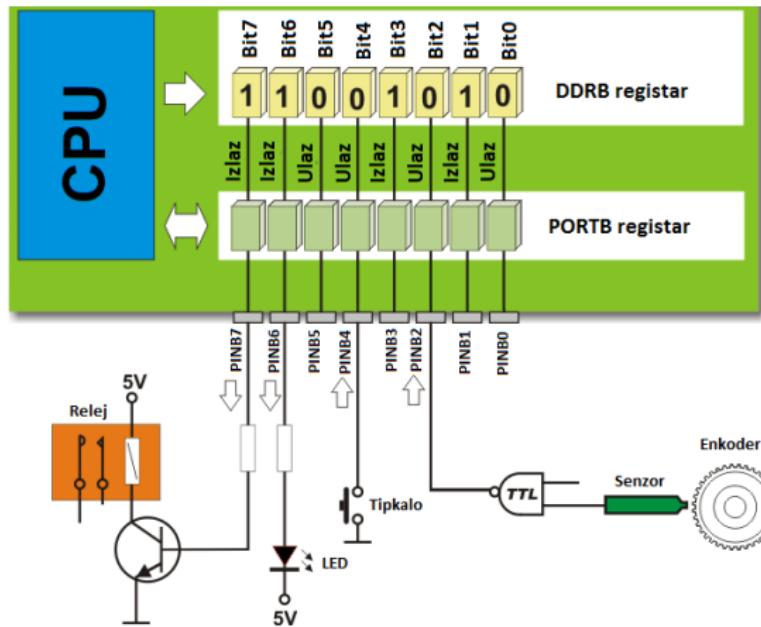


¹CPU, memorija, radni takt, programiranje, nadzor napajanja, WDT, GPIO.



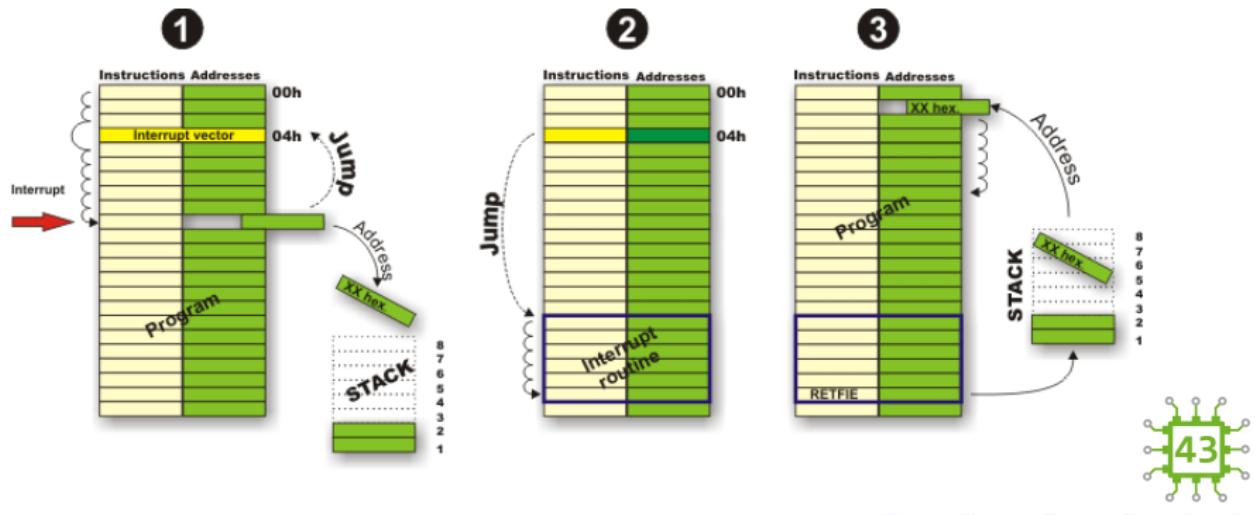
General-purpose input/output (GPIO)

- Pinovi se mogu konfigurirati kao:
 - digitalni ulazi (mogućnost uključenja *pull-up* otpornika)
 - digitalni izlazi (max. struja pina je 20 mA)

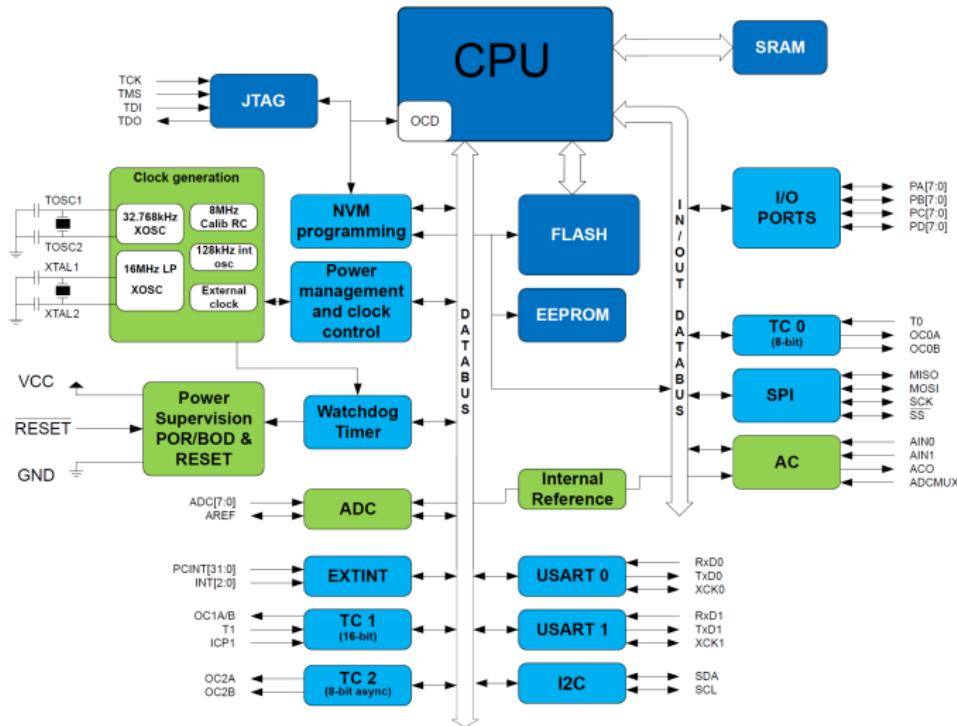


Interrupts

- Prekid (eng. *Interrupt*) je mehanizam mikrokontrolera koji omogućava da se na neke događaje odgovori u trenutku kada se oni dogode bez obzira na izvršavanje glavnog programa.
 - *Interrupt Service Routine* - rutine koje se izvršavaju na pojavu prekida.



Blok diagram mikrokontrolera - 2. dio²



²Vanjski prekid, ADC, AC, TC, USART, I2C, SPI, ...



Raspodjela pinova

DIP

(PCINT8/XCK0/T0) PB0	1	PA0 (ADC0/PCINT0)
(PCINT9/CLK0/T1) PB1	2	PA1 (ADC1/PCINT1)
(PCINT10/INT2/AIN0) PB2	3	PA2 (ADC2/PCINT2)
(PCINT11/OC0/AIN1) PB3	4	PA3 (ADC3/PCINT3)
(PCINT12/OC0B/ SS) PB4	5	PA4 (ADC4/PCINT4)
(PCINT13/MOSI) PB5	6	PA5 (ADC5/PCINT5)
(PCINT14/MISO) PB6	7	PA6 (ADC6/PCINT6)
(PCINT15/SCK) PB7	8	PA7 (ADC7/PCINT7)
RESET	9	AREF
VCC	10	GND
GND	11	AVCC
XTAL2	12	PC7 (TOSC2/PCINT23)
XTAL1	13	PC6 (TOSC1/PCINT22)
(PCINT24/RXD0) PD0	14	PC5 (TDI/PCINT21)
(PCINT25/TXD0) PD1	15	PC4 (TDO/PCINT20)
(PCINT26/RXD1/INT0) PD2	16	PC3 (TMS/PCINT19)
(PCINT27/TXD1/INT1) PD3	17	PC2 (TCK/PCINT18)
(PCINT28/XCK1/OC1B) PD4	18	PC1 (SDA/PCINT17)
(PCINT29/OC1A) PD5	19	PC0 (SCL/PCINT16)
(PCINT30/OC2B/ICP1) PD6	20	PC7 (TOSC2/PCINT23)
	21	PC6 (TOSC1/PCINT22)
	22	PC5 (TDI/PCINT21)
	23	PC4 (TDO/PCINT20)

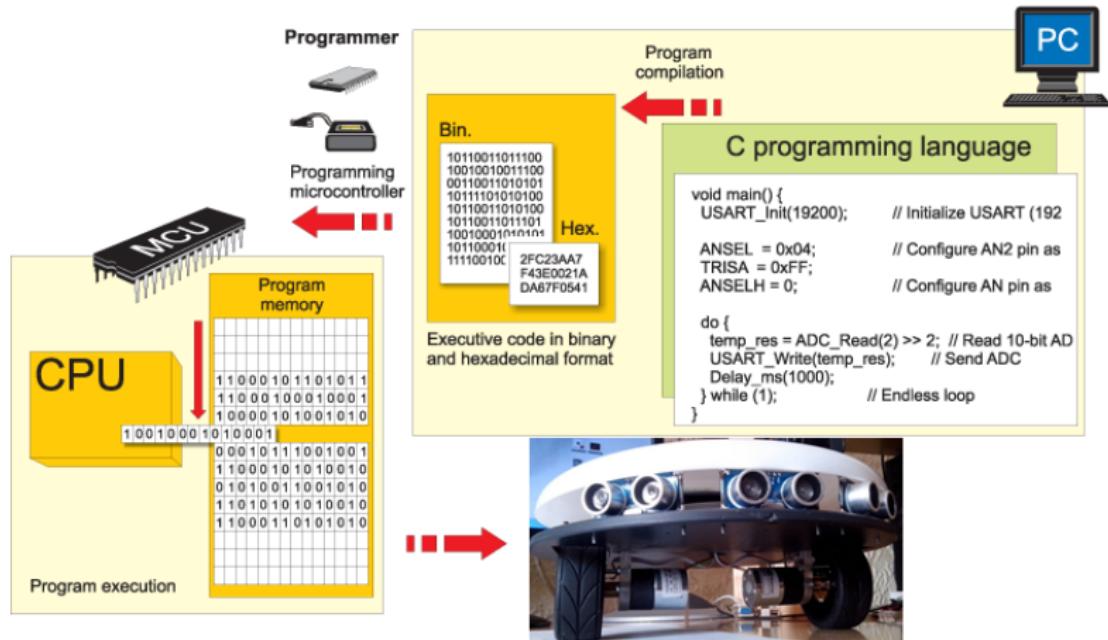
QFP

(PCINT13/MOSI) PB5	1	PA4 (ADC4/PCINT4)
(PCINT14/MISO) PB6	2	PA5 (ADC5/PCINT5)
(PCINT15/SCK) PB7	3	PA6 (ADC6/PCINT6)
RESET	4	AREF
VCC	5	GND
GND	6	AVCC
XTAL2	7	PC7 (TOSC2/PCINT23)
XTAL1	8	PC6 (TOSC1/PCINT22)
(PCINT24/RXD0) PD0	9	PC5 (TDI/PCINT21)
(PCINT25/TXD0) PD1	10	PC4 (TDO/PCINT20)
(PCINT26/RXD1/INT0) PD2	11	PC3 (TMS/PCINT19)
(PCINT27/TXD1/INT1) PD3	12	PC2 (TCK/PCINT18)
(PCINT28/XCK1/OC1B) PD4	13	PC1 (SDA/PCINT17)
(PCINT29/OC1A) PD5	14	PC0 (SCL/PCINT16)
(PCINT30/OC2B/ICP1) PD6	15	PC7 (TOSC2/PCINT23)
	16	PC6 (TOSC1/PCINT22)
	17	PC5 (TDI/PCINT21)
	18	PC4 (TDO/PCINT20)
	19	PC3 (TMS/PCINT19)
	20	PC2 (TCK/PCINT18)
	21	PC1 (SDA/PCINT17)
	22	PC0 (SCL/PCINT16)
	23	PC7 (TOSC2/PCINT23)
	24	PC6 (TOSC1/PCINT22)
	25	PC5 (TDI/PCINT21)
	26	PC4 (TDO/PCINT20)
	27	PC3 (TMS/PCINT19)
	28	PC2 (TCK/PCINT18)
	29	PC1 (SDA/PCINT17)
	30	PC0 (SCL/PCINT16)
	31	PA6 (ADC6/PCINT6)
	32	PA5 (ADC5/PCINT5)
	33	PA4 (ADC4/PCINT4)
	34	PA3 (ADC3/PCINT3)
	35	PA2 (ADC2/PCINT2)
	36	PA1 (ADC1/PCINT1)
	37	PA0 (ADC0/PCINT0)
	38	VCC
	39	GND
	40	PCINT10/INT2/AIN0
	41	PCINT11/OC0/AIN1
	42	PCINT12/OC0B/SS
	43	PCINT13/XCK0/T0
	44	PCINT14/XCK0/T1

- Orange: Power
- Black: Ground
- Blue: Programming/Debug
- Cyan: Digital
- Green: Analog
- Grey: Crystal/Dac



Programiranje mikrokontrolera i izvođenje programa



Proizvođači mikrokontrolera



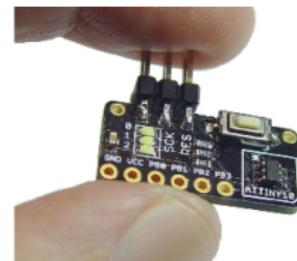
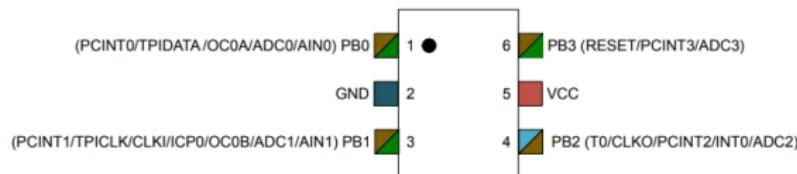
↑
2016.



Primjeri AVR mikrokontrolera (Microchip)

- ATtiny10

- 1024 B programske memorije, radni takt do 12 MHz, 54 instrukcije, 32 B podatkovne memorije, ...
- Cijena na bazi 5K komada: \$0,24

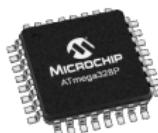


Primjeri AVR mikrokontrolera (Microchip)

- ATmega328P

- 32 kB programske memorije, radni takt do 20 MHz, 131 instrukcija, 2KB podatkovne memorije, ...
- Cijena na bazi 5K komada: \$1.46

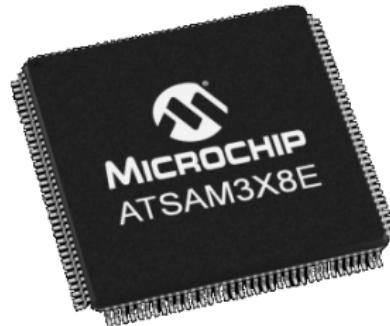
(PCINT14/RESET) PC6	1	28	PC5 (ADC5/SCL/PCINT13)
(PCINT16/RXD) PD0	2	27	PC4 (ADC4/SDA/PCINT12)
(PCINT17/TXD) PD1	3	26	PC3 (ADC3/PCINT11)
(PCINT18/INT0) PD2	4	25	PC2 (ADC2/PCINT10)
(PCINT19/OC2B/INT1) PD3	5	24	PC1 (ADC1/PCINT9)
(PCINT20/XCK/T0) PD4	6	23	PC0 (ADC0/PCINT8)
VCC	7	22	GND
GND	8	21	AREF
(PCINT6/XTAL1/TOSC1) PB6	9	20	AVCC
(PCINT7/XTAL2/TOSC2) PB7	10	19	PB5 (SCK/PCINT5)
(PCINT21/OC0B/T1) PD5	11	18	PB4 (MISO/PCINT4)
(PCINT22/OC0A/AIN0) PD6	12	17	PB3 (MOSI/OC2A/PCINT3)
(PCINT23/AIN1) PD7	13	16	PB2 (SS/OC1B/PCINT2)
(PCINT0/CLKO/ICP1) PB0	14	15	PB1 (OC1A/PCINT1)



Primjeri SAM mikrokontrolera (Microchip)

- **SAM3X8E**

- ARM Cortex-M3 core, radni takt do 84 MHz, 512KB programske memorije, 100KB podatkovne memorije, USB, Ethernet, 4 x USART, 2 x I2C, 6 x SPI, 16 x ADC, 2 X DAC, 9 x Timer, 8 x PWM, ...
- Cijena na bazi 5K komada: \$6.99



Programiranje mikrokontrolera AVR i SAM



A screenshot of the Atmel START tool interface. The title 'Atmel | START' is at the top. Below it, a text block says: 'This tool will help you select and configure software components and tailor your embedded application in a usable and optimized manner.' At the bottom are two green buttons: 'CREATE NEW PROJECT' and 'BROWSE EXAMPLES'. To the right, there's a stylized image of a hand interacting with a glowing digital interface on a circuit board. A small green icon of a microcontroller with the number '43' is in the bottom right corner.

Razvojna okruženja s mikrokontrolerima za Rapid Prototyping

- Arduino
- mbed
- micro:bit



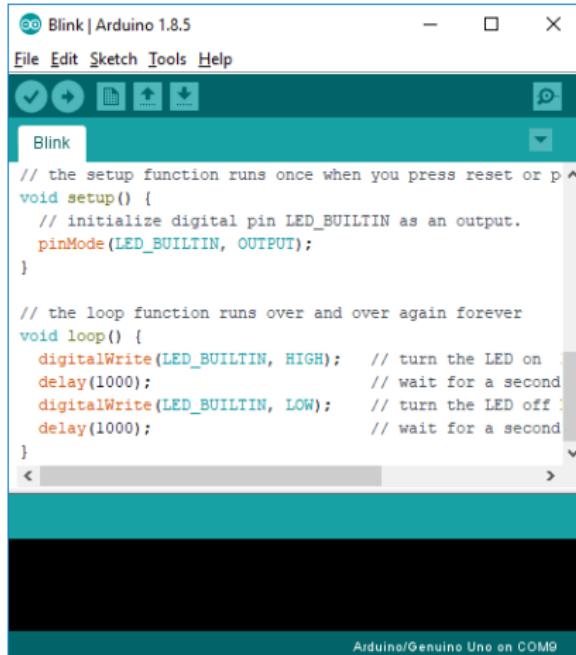
Arduino

- Web: <http://arduino.cc>
- Arduino okruženja:
 - Arduino UNO (baziran na ATmega328P)
 - Arduino Leonardo (baziran na ATmega32u4)
 - Arduino Mega 2560 (baziran na ATmega2560)
 - Arduino Due (baziran na Atmel SAM3X8E ARM Cortex-M3 procesoru)



Arduino

- Programiranje u programskom jeziku *Processing* (C/C++ kompatibilno)
 - Arduino IDE <http://arduino.cc/en/Main/Software>



```
// the setup function runs once when you press reset or power
void setup() {
  // initialize digital pin LED_BUILTIN as an output.
  pinMode(LED_BUILTIN, OUTPUT);
}

// the loop function runs over and over again forever
void loop() {
  digitalWrite(LED_BUILTIN, HIGH);    // turn the LED on
  delay(1000);                      // wait for a second
  digitalWrite(LED_BUILTIN, LOW);     // turn the LED off
  delay(1000);                      // wait for a second
}
```

Arduino/Genuino Uno on COM9

- **main()** funkcija koja poziva funkcije **setup()** i **loop()**

```
int main(void)
{
  init();
  initVariant();
  setup();

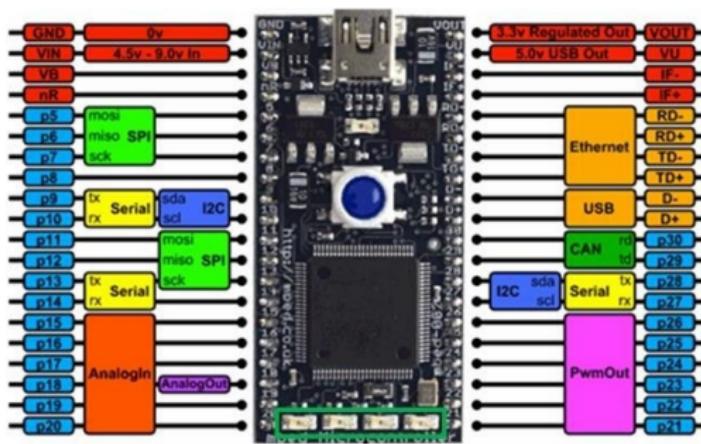
  for (;;) {
    loop();
    if (serialEventRun)
      serialEventRun();
  }

  return 0;
}
```



mbed

- Razvojno okruženje zasnovano na 32-bitnim ARM Cortex-M mikrokontrolerima
- Web: <https://www.mbed.com/en/>
- mbed mikrokontroler NXP LPC1768 (32-bit ARM Cortex-M3 core)



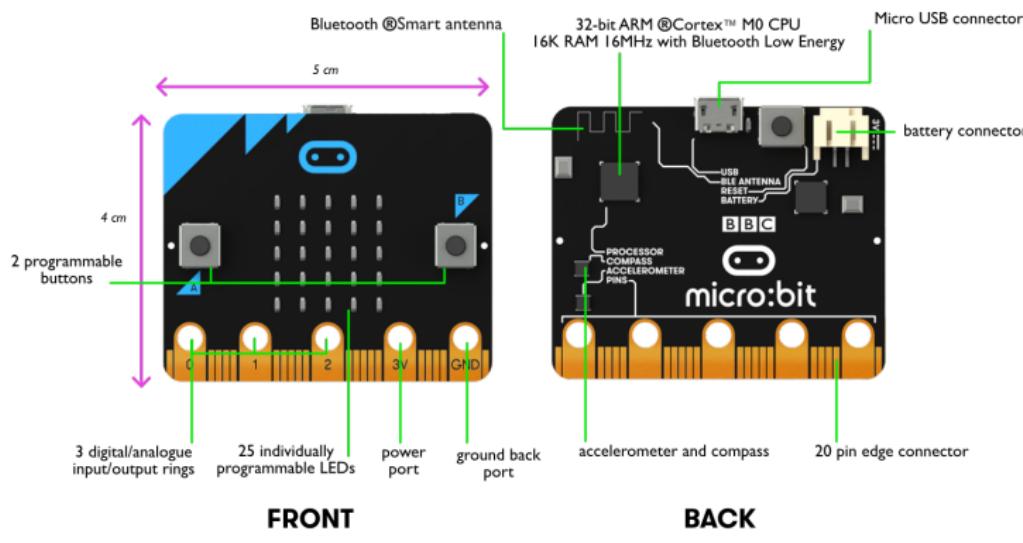
mbed

- Cloud mbed IDE: <https://os.mbed.com/compiler/>
 - Programiranje u programskom jeziku C++



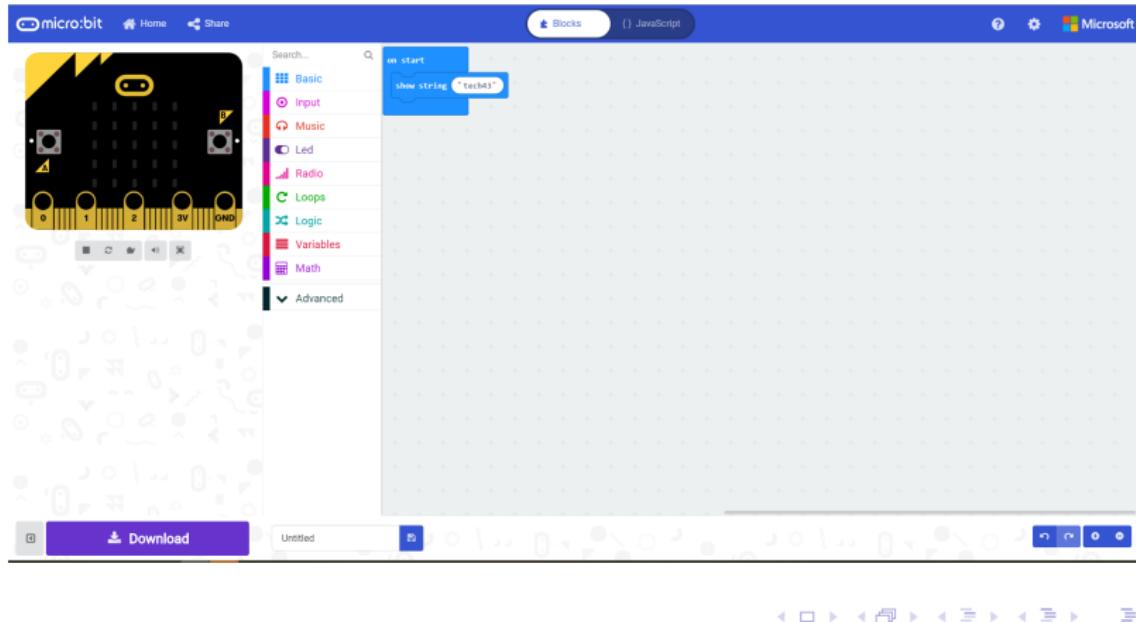
micro:bit

- Web: <https://microbit.org/hr/>
- Nordic Semiconductor nRF51822 (32-bit ARM Cortex-M0 core)



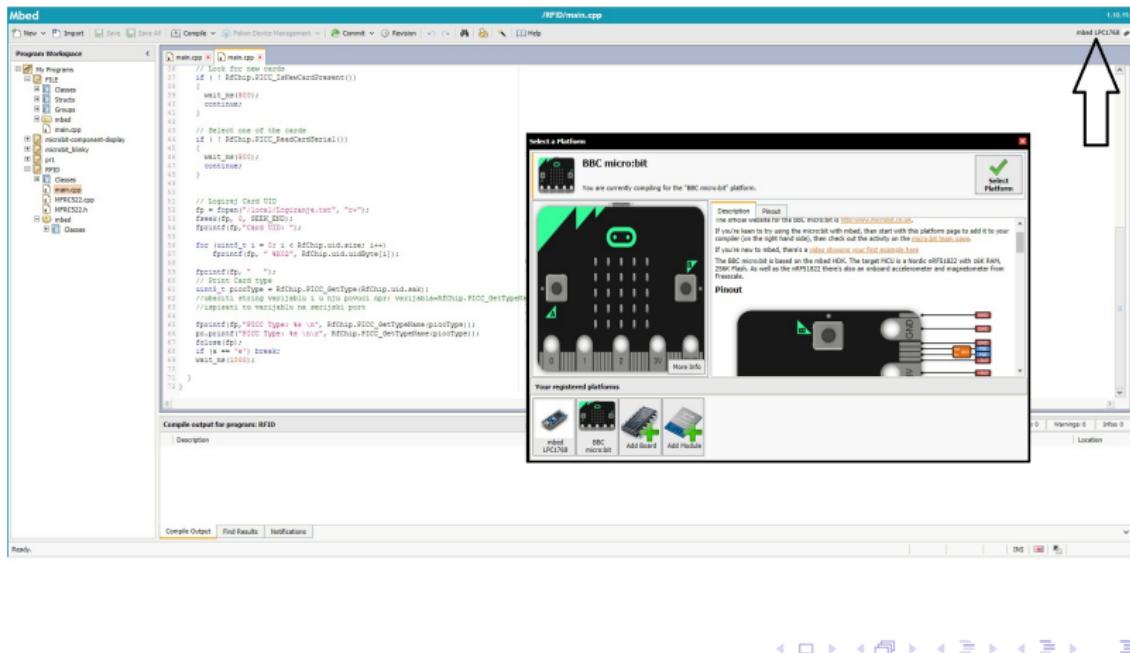
micro:bit

- Cloud micro:bit IDE: <https://makecode.microbit.org/>
- Programiranje u programskom jeziku Blocks ili JavaScript



micro:bit

- Cloud mbed IDE: <https://os.mbed.com/compiler/>
- Programiranje u programskom jeziku C++



The screenshot shows the mbed Cloud IDE interface. On the left, the 'Programs Workspace' pane displays a project structure with files like main.cpp, RFID/main.cpp, and various configuration and build files. The main workspace shows the source code for main.cpp:

```

main.cpp
1 // Look for new card
2 if (1 == Rd5chip.RD5C_InitialCardPresent())
3 {
4     while(1)
5     {
6         Rd5chip.RD5C_SelectCard();
7         Rd5chip.RD5C_ReadCardSerial();
8         Rd5chip.RD5C_WaitMs(1000);
9         Rd5chip.RD5C_DeSelectCard();
10    }
11 }
12 // Select one of the cards
13 if (1 == Rd5chip.RD5C_SelectCardSerial(0))
14 {
15     Rd5chip.RD5C_WaitMs(1000);
16     Rd5chip.RD5C_DeSelectCard();
17 }
18
19 // Logistic Card UID
20 fp = fopen("local/Logistic@e.txt", "w");
21 fprintf(fp, "Card ID: %s", Rd5chip.RD5C_UidString());
22 fclose(fp);
23
24 fcc = (uint8_t) g = 0x1 < Rd5chip.UidString[4];
25 fp=fopen(fp, "a");
26 fpwrite(fp, "%02X", Rd5chip.Uid.UidByte[4]);
27 fpclose(fp);
28
29 // Print Card type
30 uid_type_e puidtype = Rd5chip.RD5C_GetType(Rd5chip.Uid.uid);
31 //Rd5chip.RD5C_SetVariable(g, 0x00); //Set Variable
32 //Rd5chip.RD5C_SetVariable(g, 0x01); //Set Variable
33 //Rd5chip.RD5C_SetVariable(g, 0x02); //Set Variable
34
35 fp=fopen(fp, "R00C Type: %c", Rd5chip.RD5C_GetTypeValue(puidType));
36 fpwrite(fp, "%c", Rd5chip.RD5C_GetTypeValue(puidType));
37 fpclose(fp);
38
39 if (g == 'a') break;
40 wait_ms(1000);
41
42 }
43
44 }

```

The bottom pane shows the 'Compile output for program: RFID'. The right side of the interface features a 'Select a Platform' dialog box for the BBC microbit, which is currently selected. This dialog includes a preview of the micro:bit board and its pinout, along with a 'Platform' section containing a diagram of the board with pins labeled.

Izbor mikrokontrolera

- Potrebni resursi mikrokontrolera u sustavu
- Cijena i dostupnost mikrokontrolera za zadane količine
- Programska razvojna okruženja i podrška
- Potrošnja energije
- Prethodna iskustva

Product	Family	Program Memory Size (KB)	SRAM (Bytes)	ADC Input	Max ADC Resolution (Bits)	DAC Outputs	UART	SPI	I2C
[Reset] AT91RM9200 AT91SAM9200 AT91SAM9201 AT91SAM9202 AT91SAM9203 AT91SAM9CN11 AT91SAM9CN12 AT91SAM9G10 AT91SAM9G10 AT91SAM9G10h	[Reset] 16-bit DSC 16-bit MCU 32-bit MCU 8-bit PIC Enhanced Mid-Range 8-bit PIC High Performance ATmegaAVR ATSAM ATSAM-E ATSAM-I	7 9 12 14 16 18 28 32 48 56	8 16 2 3 4 128 256 512 768 1174	0 2 3 4 5 6 7 8 0	0 8 10 12 13 14 16 0 0	0 1 2 3 4 5 6 7 0	0 1 2 3 4 5 6 7 0	1 1 2 3 4 5 6 7 1	0 1 2 3 4 5 6 7 0
ATmega324PA	ATmegaAVR	32	2048	8	10	0	2	3	1
ATmega328PB	ATmegaAVR	32	2048	8	10	0	2	2	2



Literatura i korisni linkovi

- Mikroelektronika: <https://www.mikroe.com/ebooks/pic-microcontrollers-programming-in-assembly/introduction>
- Microchip selektor mikrokontrolera: <https://www.microchip.com/selection-tools>
- MicroSolutions Digital Magazine:
<https://www.microchip.com/about-us/microsolutions-eneWSletter>
- Atmel Start, <http://start.atmel.com/>
- Cloud MPLAB IDE: <https://mplabxpress.microchip.com/mplabcloud/ide>
- Arduino Web Editor, <https://create-dev.arduino.cc/editor>
- Cloud mbed IDE: <https://os.mbed.com/compiler/>
- Cloud micro:bit IDE, <https://makecode.microbit.org/>
- Vrhovski, Zoran; Miletic, Marko: Mikroračunala - Programiranje mikrokontrolera porodice Atmel u programskom okruženju Atmel Studio 6, Visoka tehnička škola u Bjelovaru, Bjelovar, 2014.



Demonstracija rada mikrokontrolera i pitanja

