Distributed Embedded Systems Lab

Daniel Stojcsics, PhD
stojcsics.daniel@nik.uni-obuda.hu
mobil.nik.uni-obuda.hu/en/des/

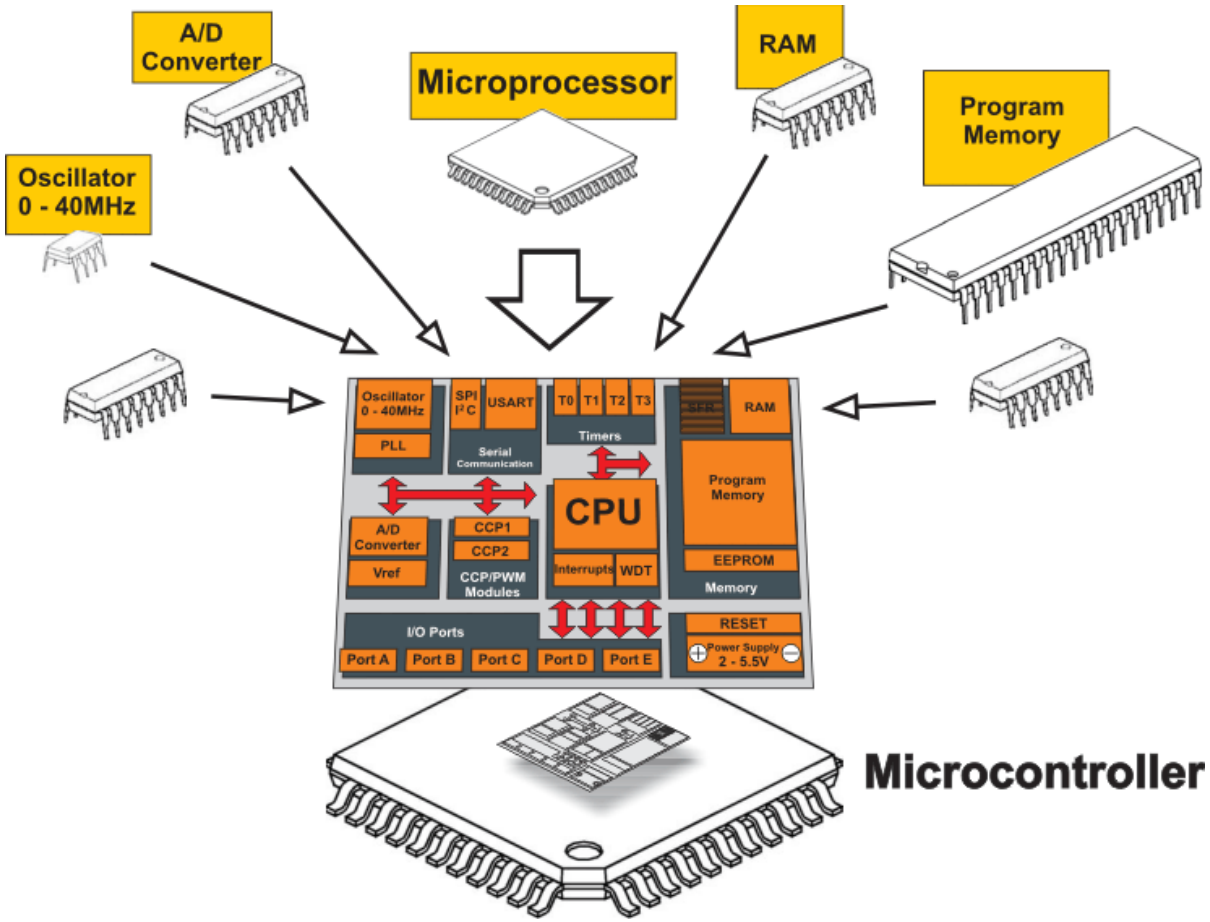
Distributed Embedded Systems

- Lectures:
- October 12: Laboratory (Lecturer: Dr. Dániel Stojcsics - Practice, homework, scheduling)
- October 19: Theory (Lecturer: György Eigner)
- October 26: Theory (Lecturer: György Eigner)
- November 2: Theory (Lecturer: György Eigner)
- November 9: Theory (Lecturer: György Eigner)
- November 23: Test
- November 30: Replacement of test; deadline for pratical homework

Embedded devices

- Low computition power
- Low memory
- Low power mode
- Small size
- Low level peripherials
  - I/O: GPIO (digital)
  - Converters: ADC, DAC
  - Communication interfaces: U(S)ART, I2C, SPI, CAN …
  - Timers: Capture/Comprare, RTC, PWM …
  - Debug: JTAG, ISP, ICSP …
  - Usuall off-board addon: Ethernet, WiFi, Bluetooth, SD card, Serial Camera …

Microcontroller



Embedded software architectures

- Simple control loop
- Interrupt-controlled loop
- Cooperative/Preemptive multitasking
- Microkernels (RTOS)

Arduino basics

Arduino

- Open source project
  - Both HW and SW
- Based on Atmel 8-, 16- or 32-bit AVR MCUs
- Arduino IDE
  - Processing language
  - Arduino bootloader -> easy program & debug via serial connection (USB). No programmer device needed!
- 3rd party IDEs
  - MS VS based Visual Micro
  - Autodesk Circuits.io Simulator

ATMEL

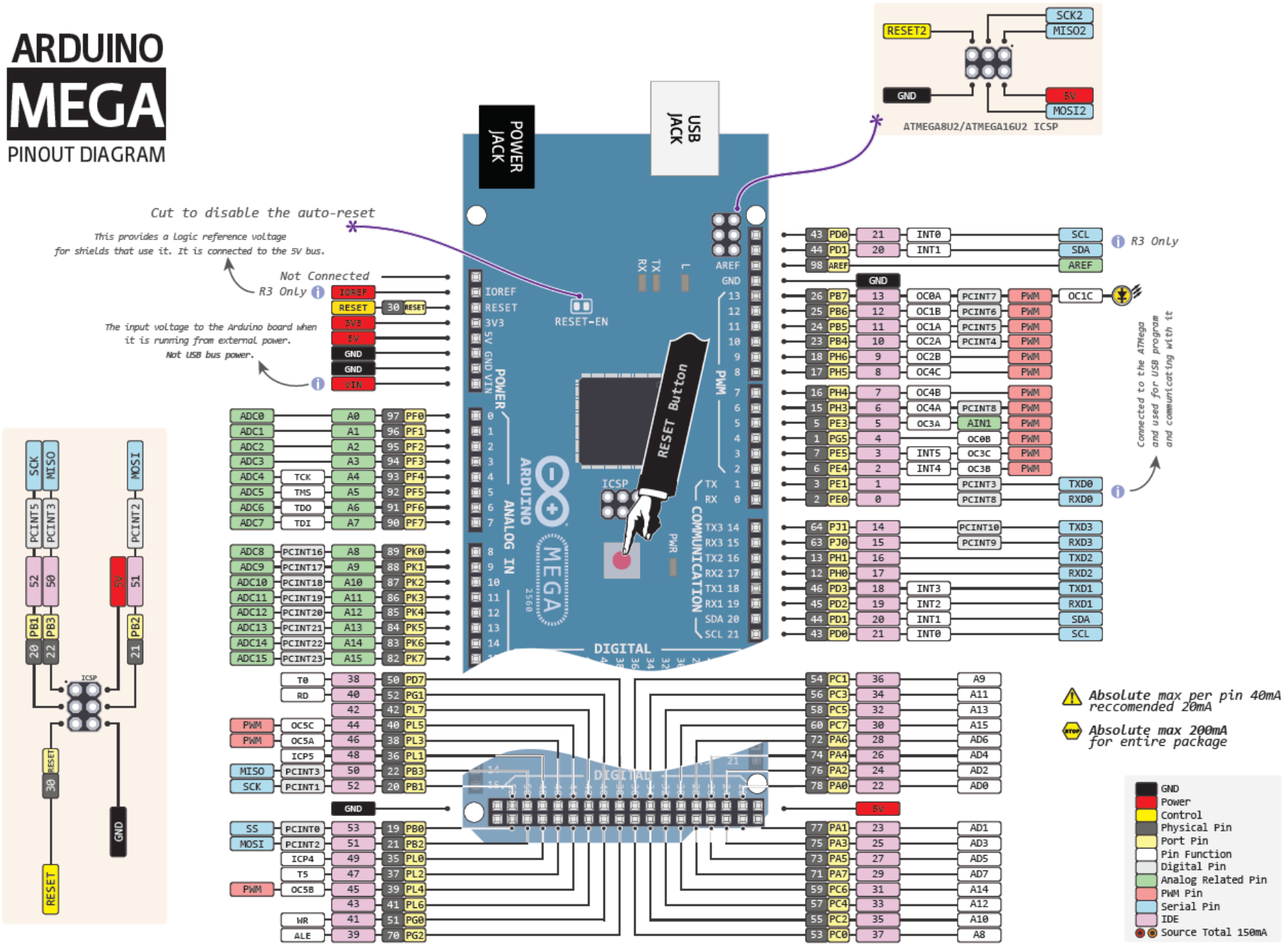
- ATMEGA (ATmega2560) – 8bit
  - Pl. Ardunio Mega

ATMEL

- ATMEGA (ATmega2560)

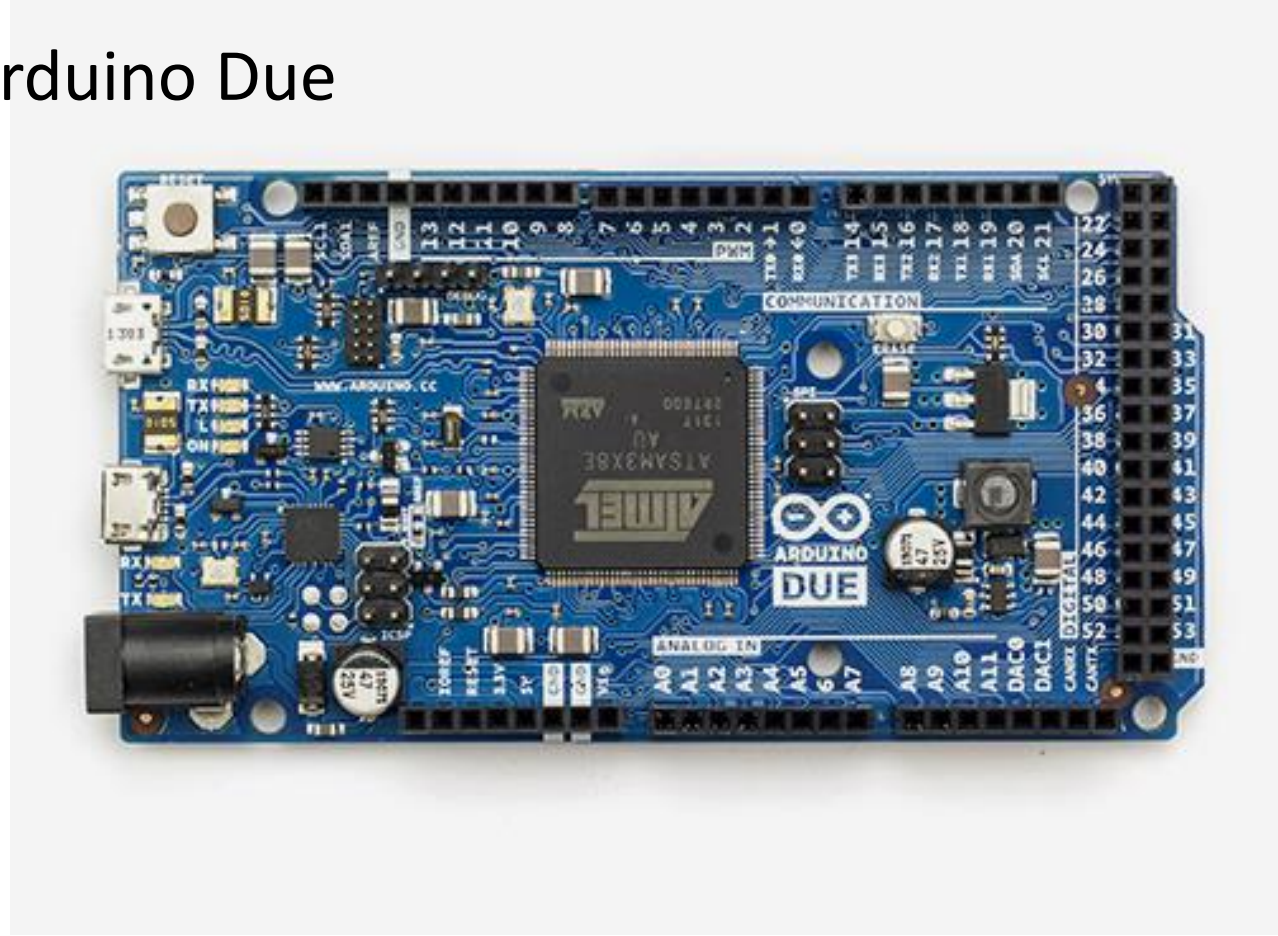
Digital I/O Pins	54 (of which 15 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz

ARDUINO MEGA PINOUT DIAGRAM



ATMEL

- Atmel SAM3X8E ARM Cortex-M3 CPU – 32bit
  – Arduino Due

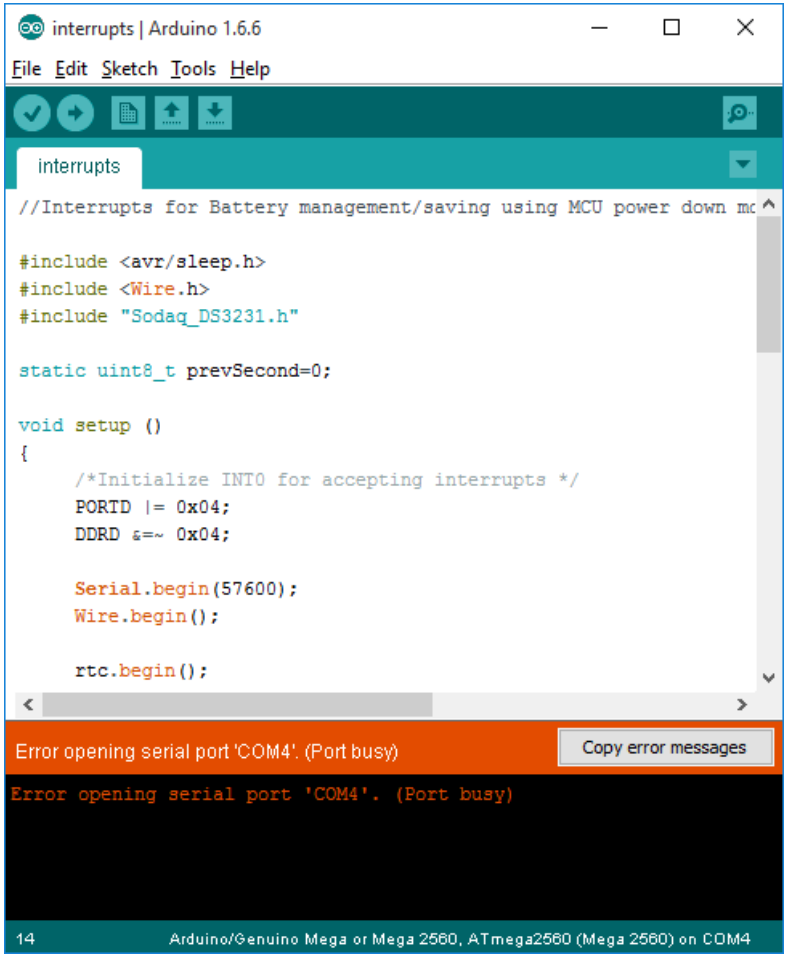


ATMEL

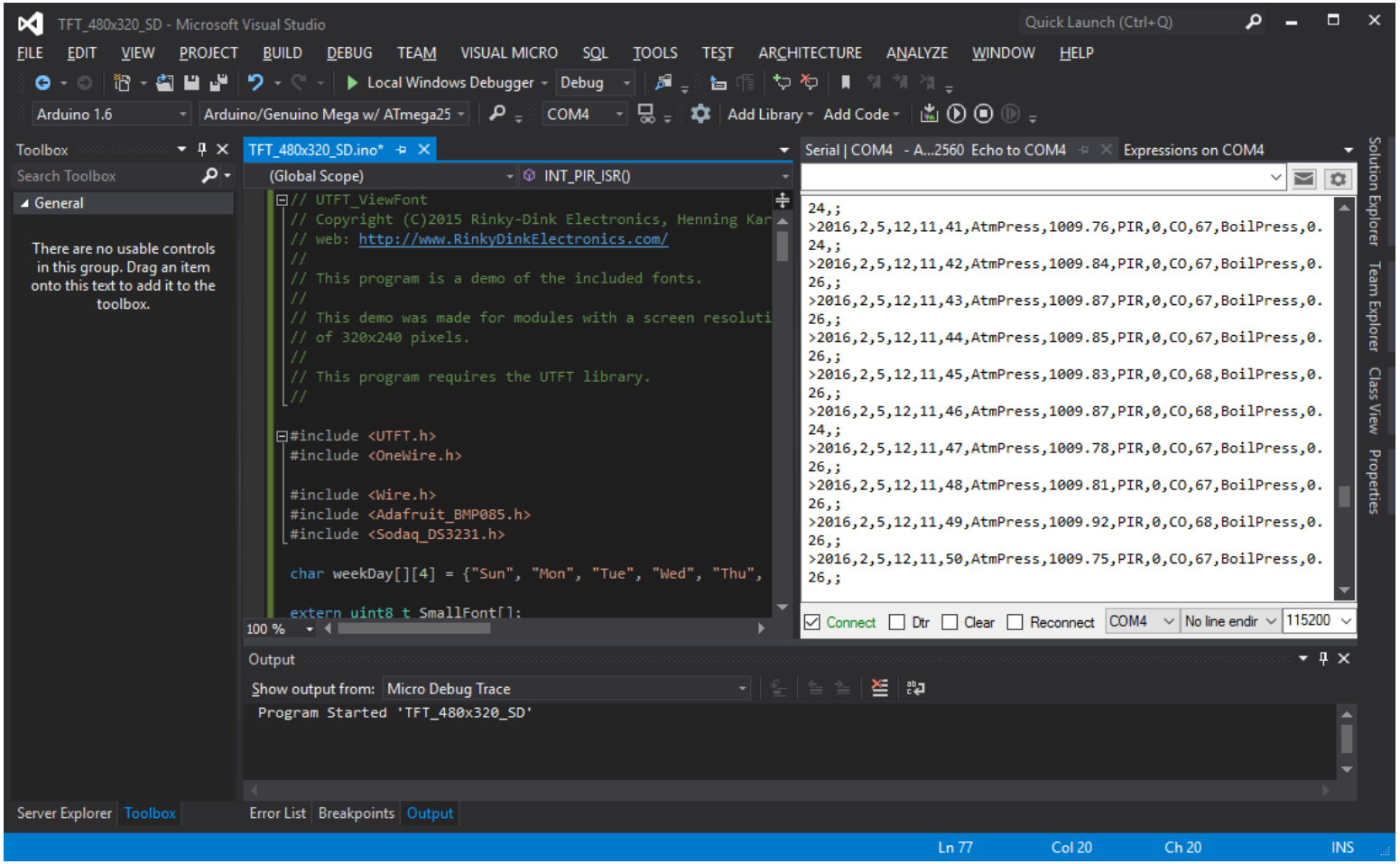
Microcontroller	AT91SAM3X8E
Operating Voltage	3.3V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-16V
Digital I/O Pins	54 (of which 12 provide PWM output)
Analog Input Pins	12
Analog Output Pins	2 (DAC)
Total DC Output Current on all I/O lines	130 mA
Flash Memory	512 KB all available for the user applications
SRAM	96 KB (two banks: 64KB and 32KB)
Clock Speed	84 MHz

+ DMA, DAC, 32bit

Arduino IDE


interrupts | Arduino 1.6.6
File Edit Sketch Tools Help
interrupts
//Interrupts for Battery management/saving using MCU power down mc
#include <avr/sleep.h>
#include <Wire.h>
#include "Sodaq_DS3231.h"
static uint8_t prevSecond=0;
void setup ()
{
/*Initialize INT0 for accepting interrupts */
PORTD |= 0x04;
DDRD &=~ 0x04;
Serial.begin(57600);
Wire.begin();
rtc.begin();
Error opening serial port 'COM4'. (Port busy)
Copy error messages
Error opening serial port 'COM4'. (Port busy)
14
Arduino/Genuino Mega or Mega 2560, ATmega2560 (Mega 2560) on COM4

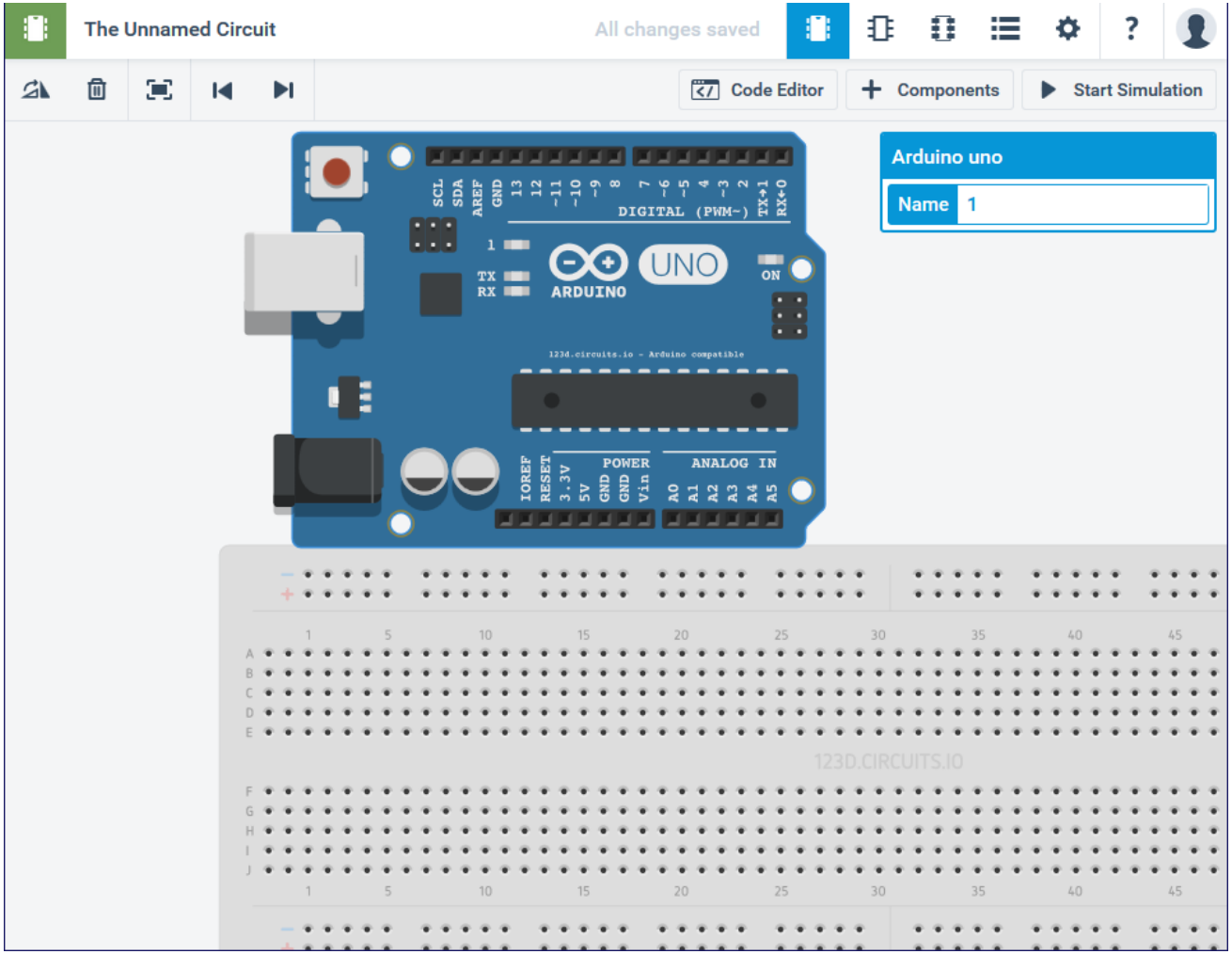
VisualMicro (VS)



- Sketch
  - Source: .ino (before v1.0: .pde)
  - .C, .CPP, .H
  - Libraries (legacy / 3rd party)
  - Examples
- *setup()*: a function that runs once at the start of a program and that can initialize settings.
- *loop()*: a function called repeatedly until the board powers off.
- Reference:
  - https://www.arduino.cc/en/Reference/HomePage

https://circuits.io/lab

- Free

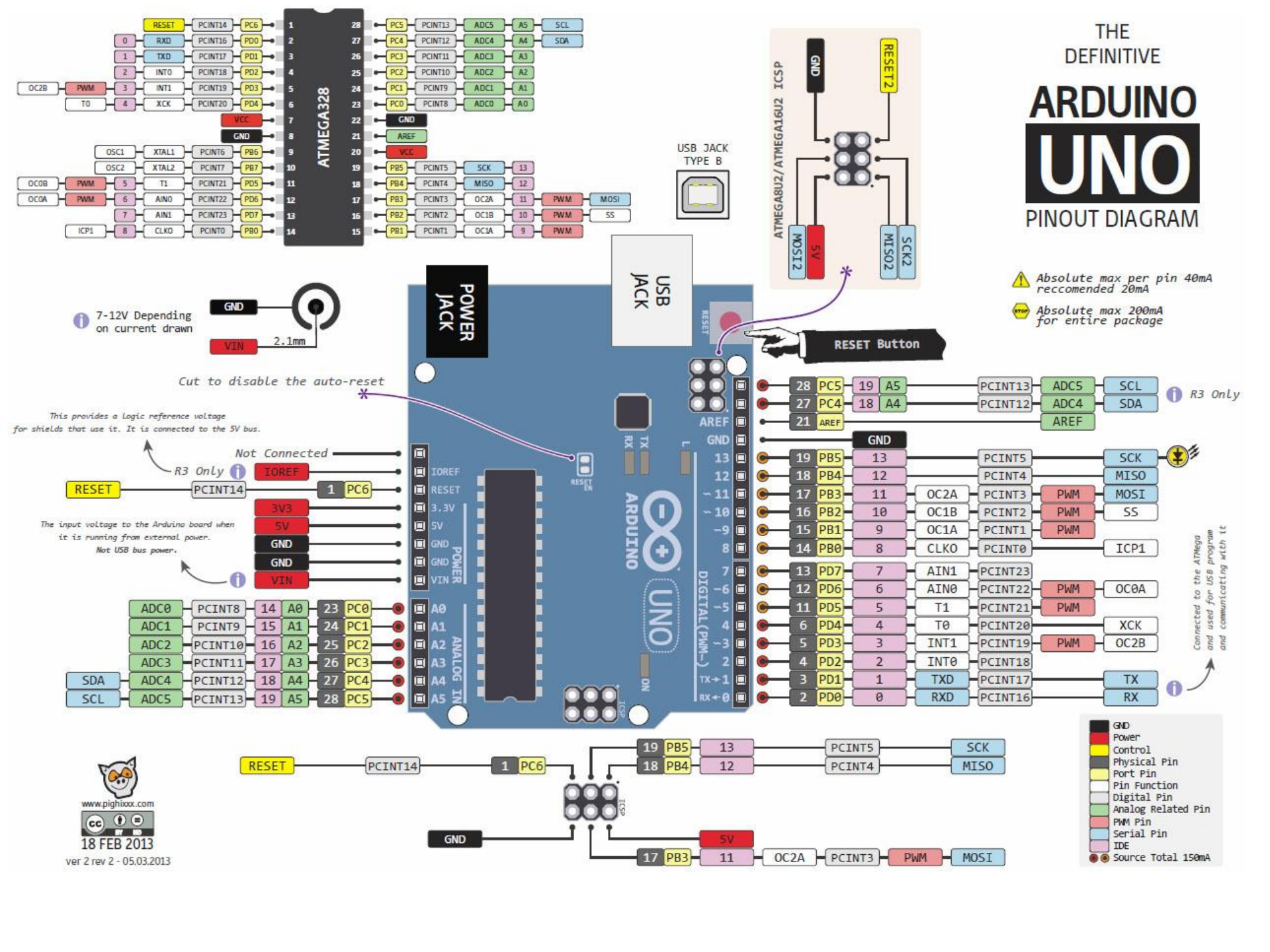


First project

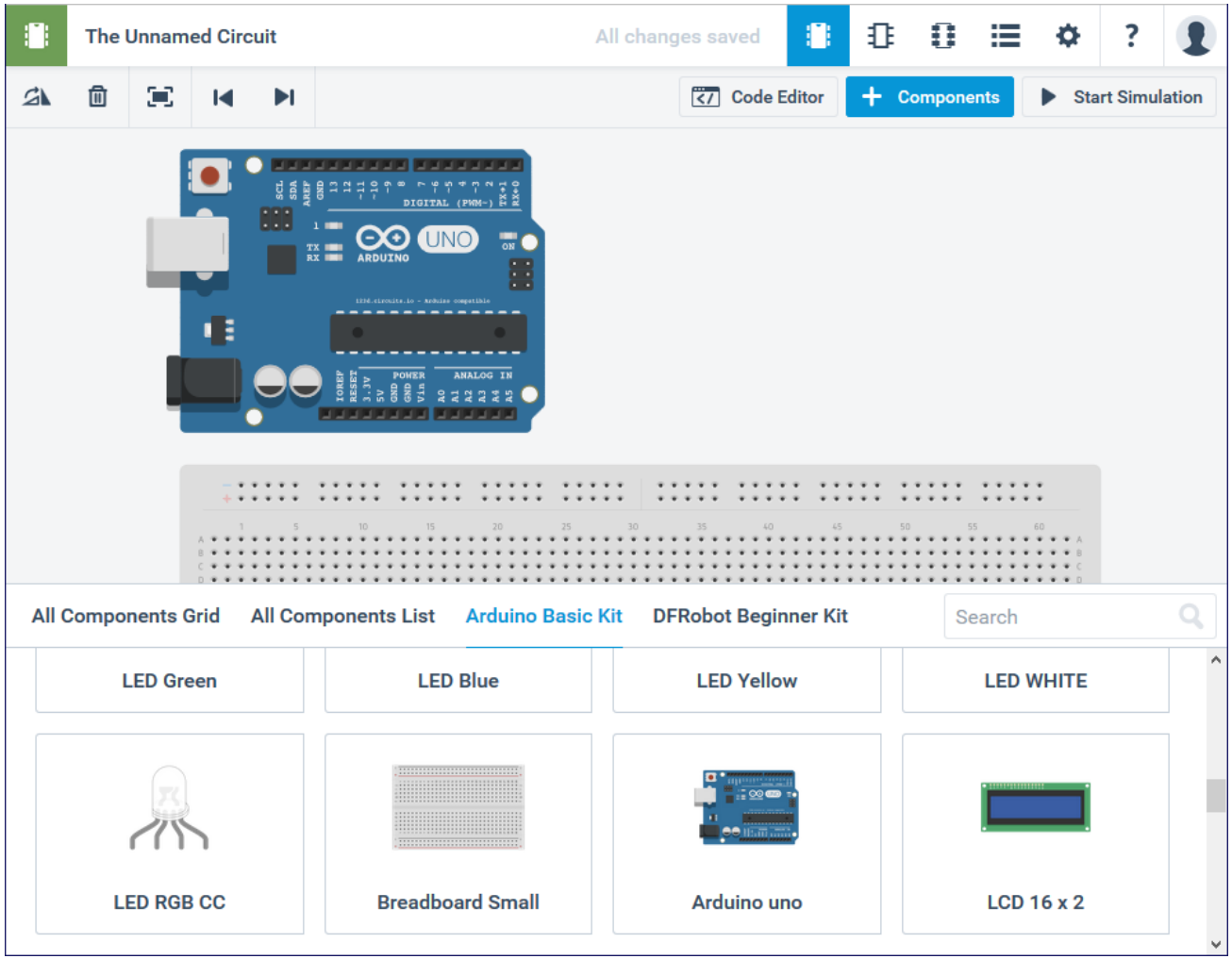
- Register to circuits.io and login
- Electronics Lab / New Electronics Lab

Hello world!

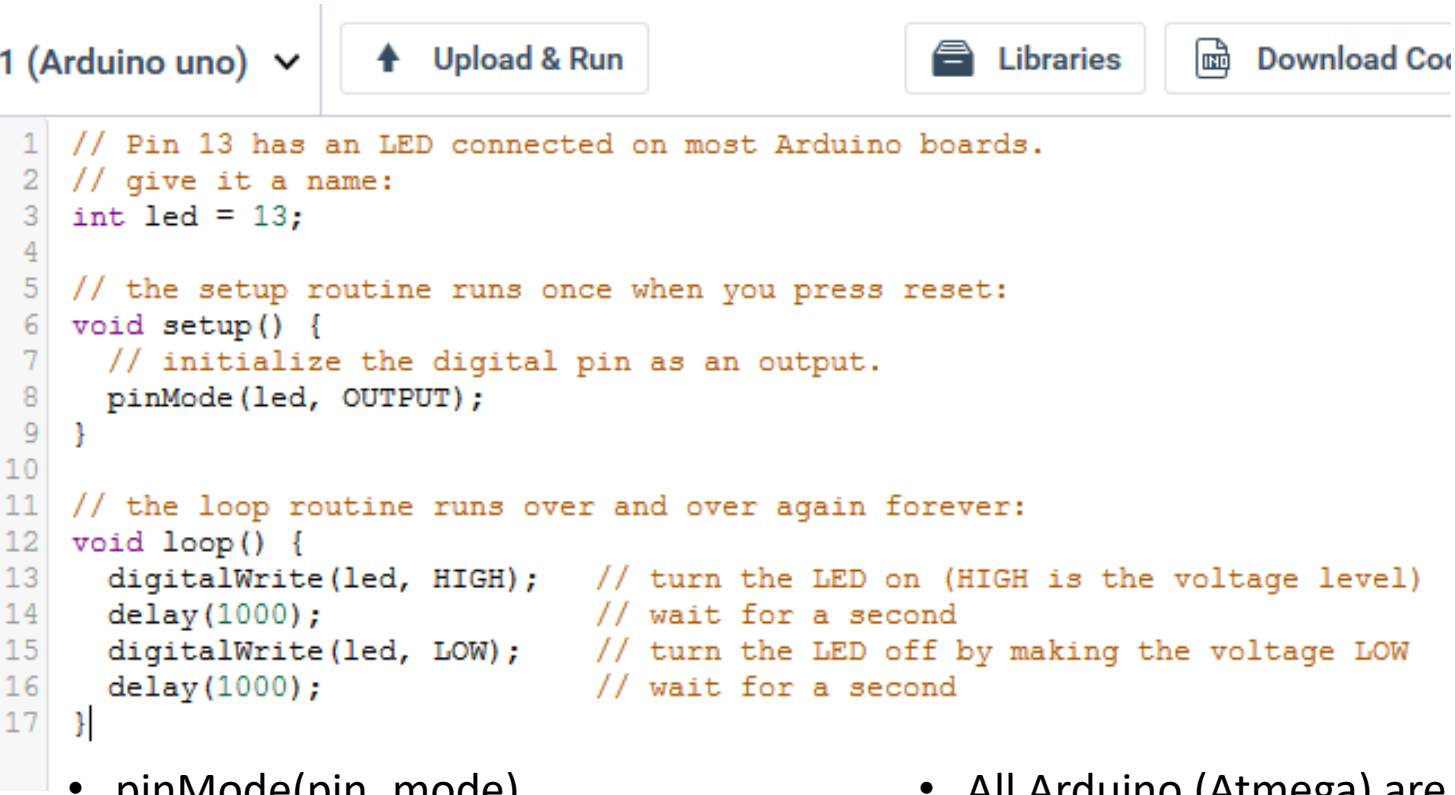
- Led blink


THE DEFINITIVE
ARDUINO UNO
PINOUT DIAGRAM
ATMEGA328
ATMEGA8U2/ATMEGA16U2 ICSP
USB JACK TYPE B
POWER JACK
USB JACK
RESET Button
Cut to disable the auto-reset
7-12V Depending on current drawn
2.1mm
Absolute max per pin 40mA
reccomended 20mA
Absolute max 200mA
for entire package
R3 Only
Not Connected
This provides a Logic reference voltage for shields that use it. It is connected to the 5V bus.
The input voltage to the Arduino board when it is running from external power. Not USB bus power.
Connected to the ATMega and used for USB program and communicating with it
www.pighixxx.com
18 FEB 2013
ver 2 rev 2 - 05.03.2013
GND
Power
Control
Physical Pin
Port Pin
Pin Function
Digital Pin
Analog Related Pin
PWM Pin
Serial Pin
IDE
Source Total 150mA

From <Components> select <Arduino UNO>

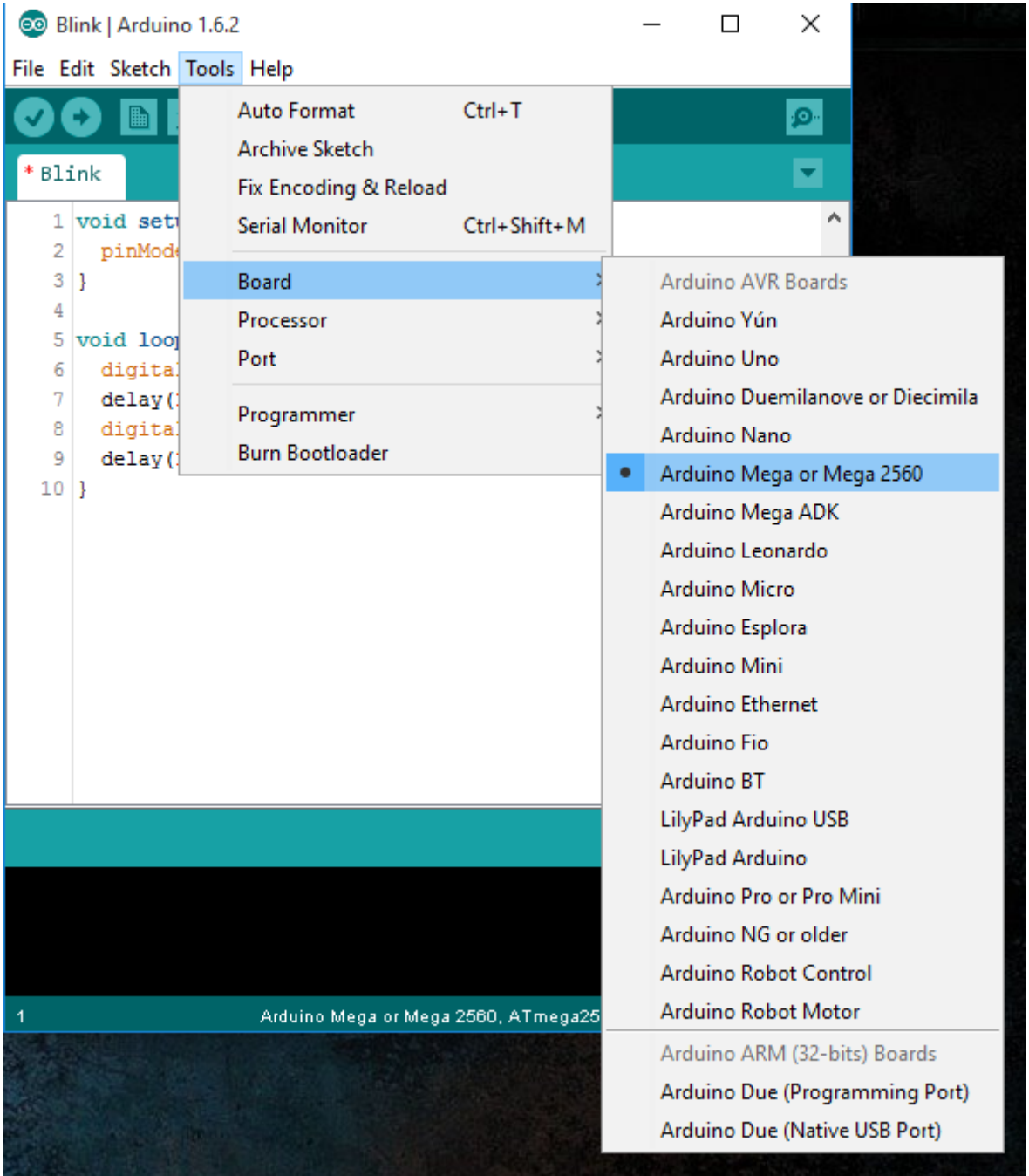


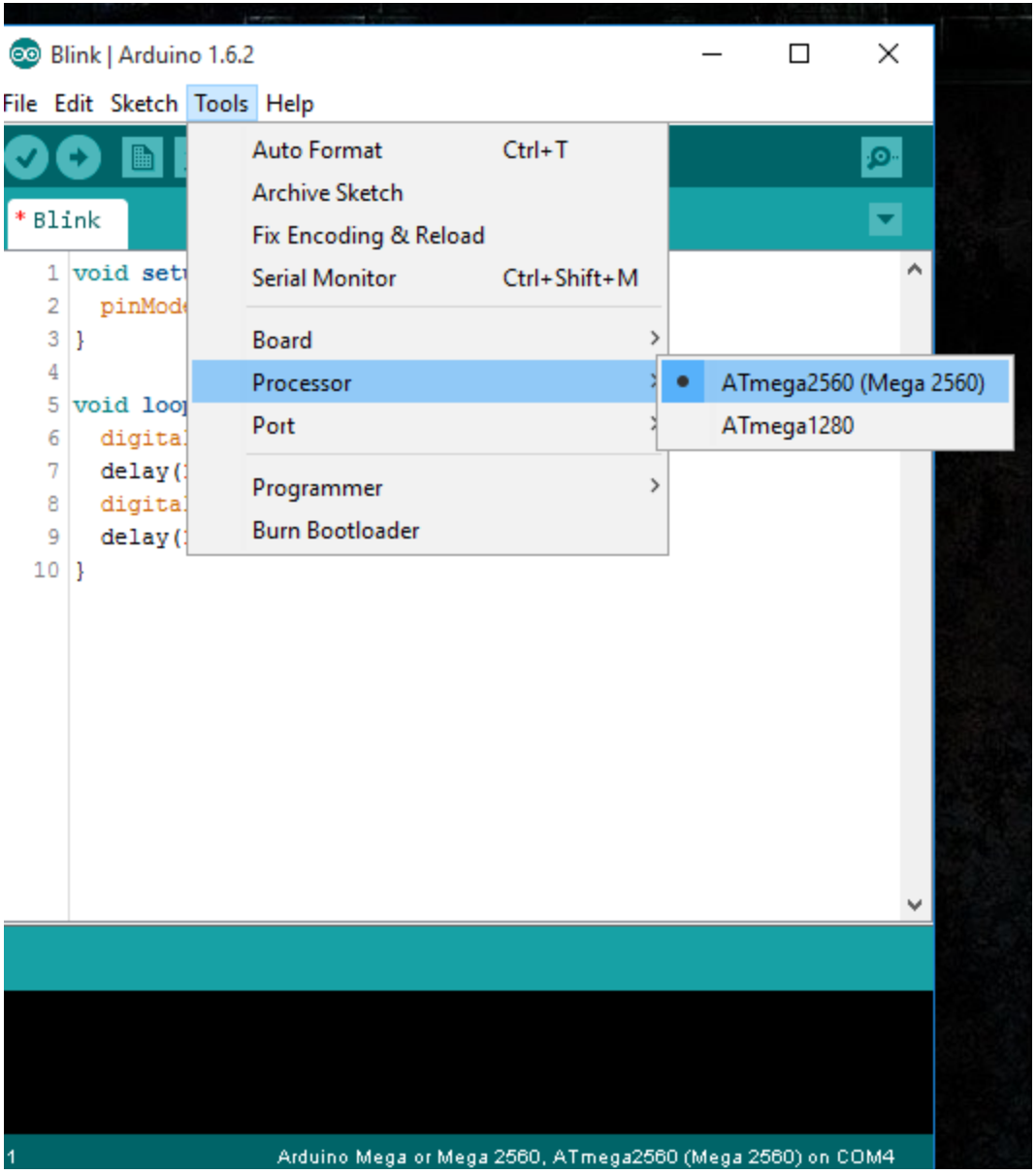
Select <Code Editor>

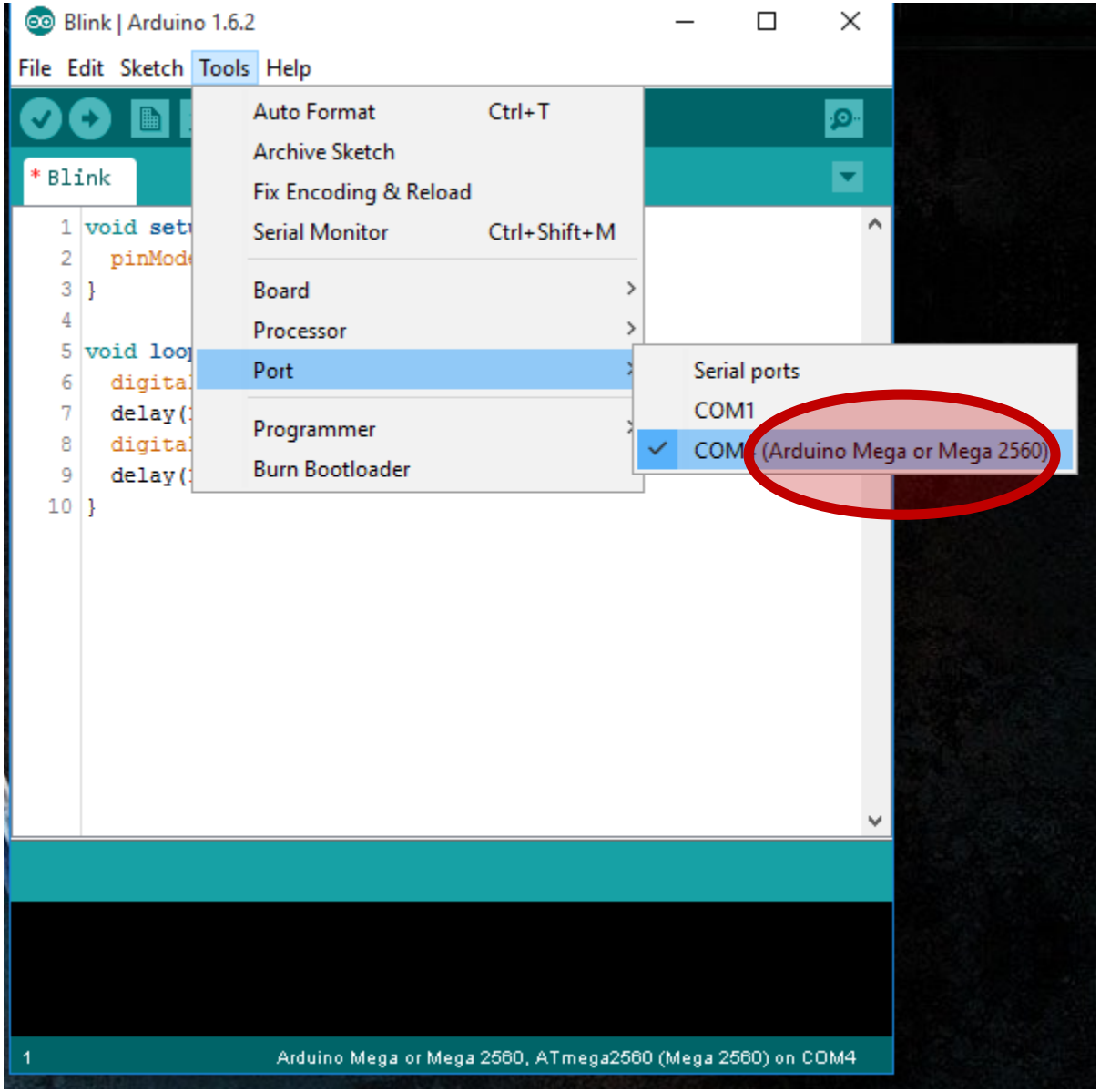


- pinMode(pin, mode)
- Mode:
  - INPUT
  - OUTPUT
  - INPUT_PULLUP

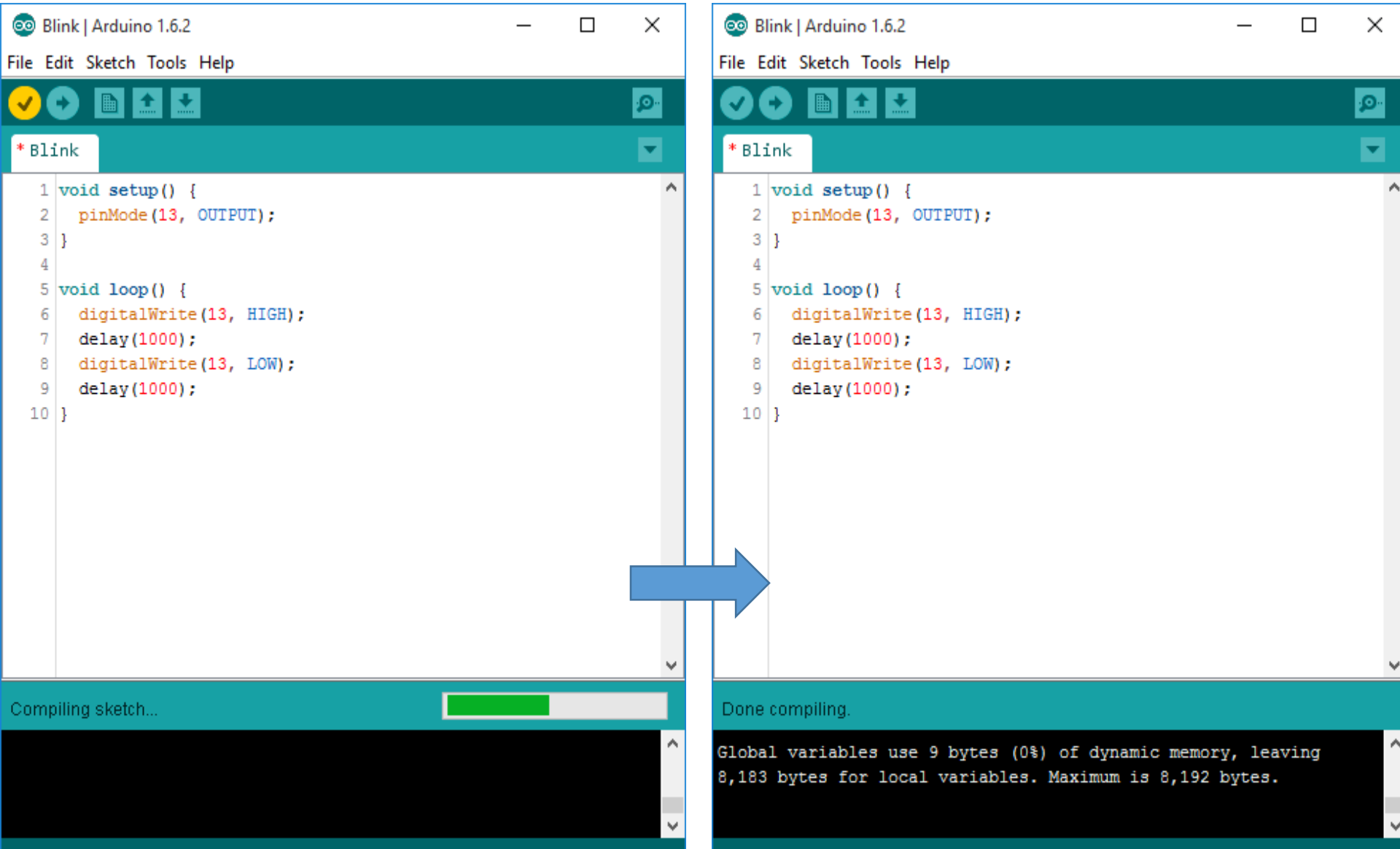
- All Arduino (Atmega) are inputs by default
- Output max power: 40mA (20mA advised!)


Blink | Arduino 1.6.2
File Edit Sketch Tools Help
Blink
Auto Format Ctrl+T
Archive Sketch
Fix Encoding & Reload
Serial Monitor Ctrl+Shift+M
Board
Processor
Port
Programmer
Burn Bootloader
Arduino AVR Boards
Arduino Yún
Arduino Uno
Arduino Duemilanove or Diecimila
Arduino Nano
Arduino Mega or Mega 2560
Arduino Mega ADK
Arduino Leonardo
Arduino Micro
Arduino Esplora
Arduino Mini
Arduino Ethernet
Arduino Fio
Arduino BT
LilyPad Arduino USB
LilyPad Arduino
Arduino Pro or Pro Mini
Arduino NG or older
Arduino Robot Control
Arduino Robot Motor
Arduino ARM (32-bits) Boards
Arduino Due (Programming Port)
Arduino Due (Native USB Port)
Arduino Mega or Mega 2560, ATmega25


Blink | Arduino 1.6.2
File Edit Sketch Tools Help
Auto Format Ctrl+T
Archive Sketch
Fix Encoding & Reload
Serial Monitor Ctrl+Shift+M
Board
Processor
Port
Programmer
Burn Bootloader
ATmega2560 (Mega 2560)
ATmega1280
* Blink
Arduino Mega or Mega 2560, ATmega2560 (Mega 2560) on COM4


Blink | Arduino 1.6.2
File Edit Sketch Tools Help
Auto Format Ctrl+T
Archive Sketch
Fix Encoding & Reload
Serial Monitor Ctrl+Shift+M
Board
Processor
Port
Programmer
Burn Bootloader
Serial ports
COM1
(Arduino Mega or Mega 2560)
* Blink
1 void set
2 pinMod
3 }
4
5 void loo
6 digita
7 delay(
8 digita
9 delay(
10 }
1
Arduino Mega or Mega 2560, ATmega2560 (Mega 2560) on COM4

Verify

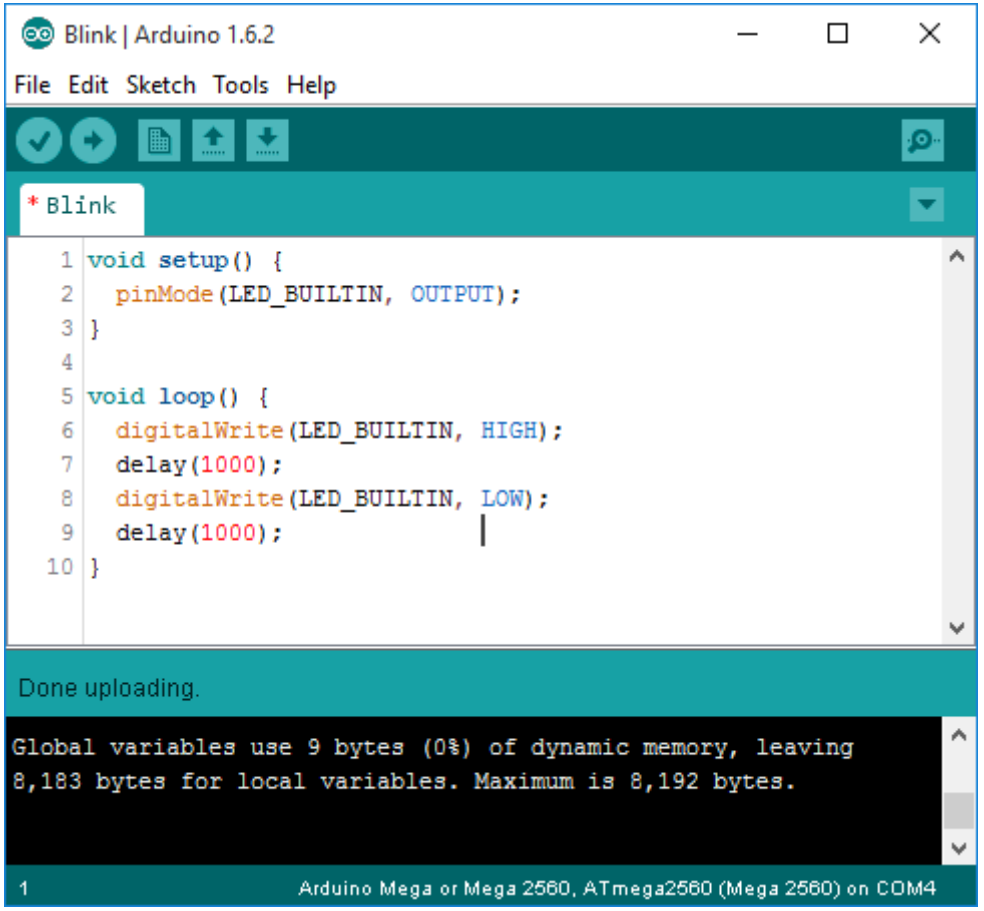

Blink | Arduino 1.6.2
File Edit Sketch Tools Help
* Blink
1 void setup() {
2 pinMode(13, OUTPUT);
3 }
4
5 void loop() {
6 digitalWrite(13, HIGH);
7 delay(1000);
8 digitalWrite(13, LOW);
9 delay(1000);
10 }
Compiling sketch...
Blink | Arduino 1.6.2
File Edit Sketch Tools Help
* Blink
1 void setup() {
2 pinMode(13, OUTPUT);
3 }
4
5 void loop() {
6 digitalWrite(13, HIGH);
7 delay(1000);
8 digitalWrite(13, LOW);
9 delay(1000);
10 }
Done compiling.
Global variables use 9 bytes (0%) of dynamic memory, leaving
8,183 bytes for local variables. Maximum is 8,192 bytes.

Upload


Blink | Arduino 1.6.2
File Edit Sketch Tools Help
* Blink
1 void setup() {
2 pinMode(13, OUTPUT);
3 }
4
5 void loop() {
6 digitalWrite(13, HIGH);
7 delay(1000);
8 digitalWrite(13, LOW);
9 delay(1000);
10 }
Done uploading.
Global variables use 9 bytes (0%) of dynamic memory, leaving
8,183 bytes for local variables. Maximum is 8,192 bytes.
1
Arduino Mega or Mega 2560, ATmega2560 (Mega 2560) on COM4

Konstansok

- LED_BUILTIN



U(S)ART

- Atmega: 4 uart
- Serial (0)
  - 0 (RX)
  - 1 (TX)
- Wired to Virtual Com Port (VCP) (FTDI or CN340, etc)
- Arduino IDE serial monitor
- Serial.begin(baud)
  - 8n1 (8 data bit, no parity bit, 1 stop bit)
- Serial.begin(baud,config)
  - Config: pl. SERIAL_8N1 (the default)

1 (Arduino uno) | Upload & Run | Libraries | Download Code | Debugger | Serial Monitor

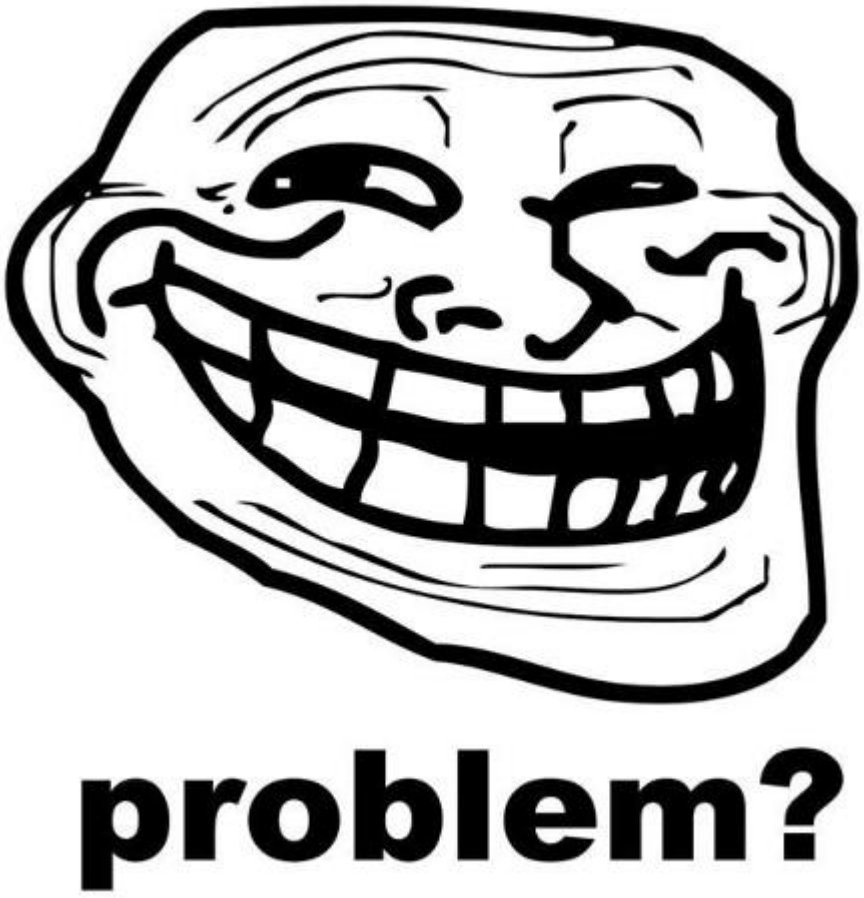
```
// Pin 13 has an LED connected on most Arduino boards.
// give it a name:
int led = 13;

// the setup routine runs once when you press reset:
void setup() {
  // initialize the digital pin as an output.
  pinMode(led, OUTPUT);
  Serial.begin(9600);
  Serial.println("System ready");
}

// the loop routine runs over and over again forever:
void loop() {
  digitalWrite(led, HIGH);   // turn the LED on (HIGH is the voltage level)
  Serial.print("Hello ");
  delay(1000);               // wait for a second
  digitalWrite(led, LOW);    // turn the LED off by making the voltage LOW
  Serial.println("World!");
  delay(1000);               // wait for a second
}
```

```
``System ready
HelloWorld!
HelloWorld!
HelloWorld!
HelloWorld!
HelloWorld!
HelloWorld!
System ready
Hello World!
Hello World!
Hello World!
Hello World!
Hello World!
Hello World!
Hello World!
Hello World!
Hello World!
```

Send

Debug

Debug?



1 (Arduino uno) | Upload & Run | Libraries | Download Code | Debugger | Serial Monitor

```
// Pin 13 has an LED connected on most Arduino boards.
// give it a name:
int led = 13;
unsigned long time;

// the setup routine runs once when you press reset:
void setup() {
  // initialize the digital pin as an output.
  pinMode(led, OUTPUT);
  Serial.begin(9600);
  Serial.println("System ready");
}

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void loop() {
  digitalWrite(led, HIGH);   // turn the LED on (HIGH is the voltage level)
  Serial.print("Hello ");
  delay(1000);               // wait for a second
  digitalWrite(led, LOW);    // turn the LED off by making the voltage LOW
  Serial.println("World!");
  time=millis();
  Serial.println(time);
  delay(1000);               // wait for a second
}
```

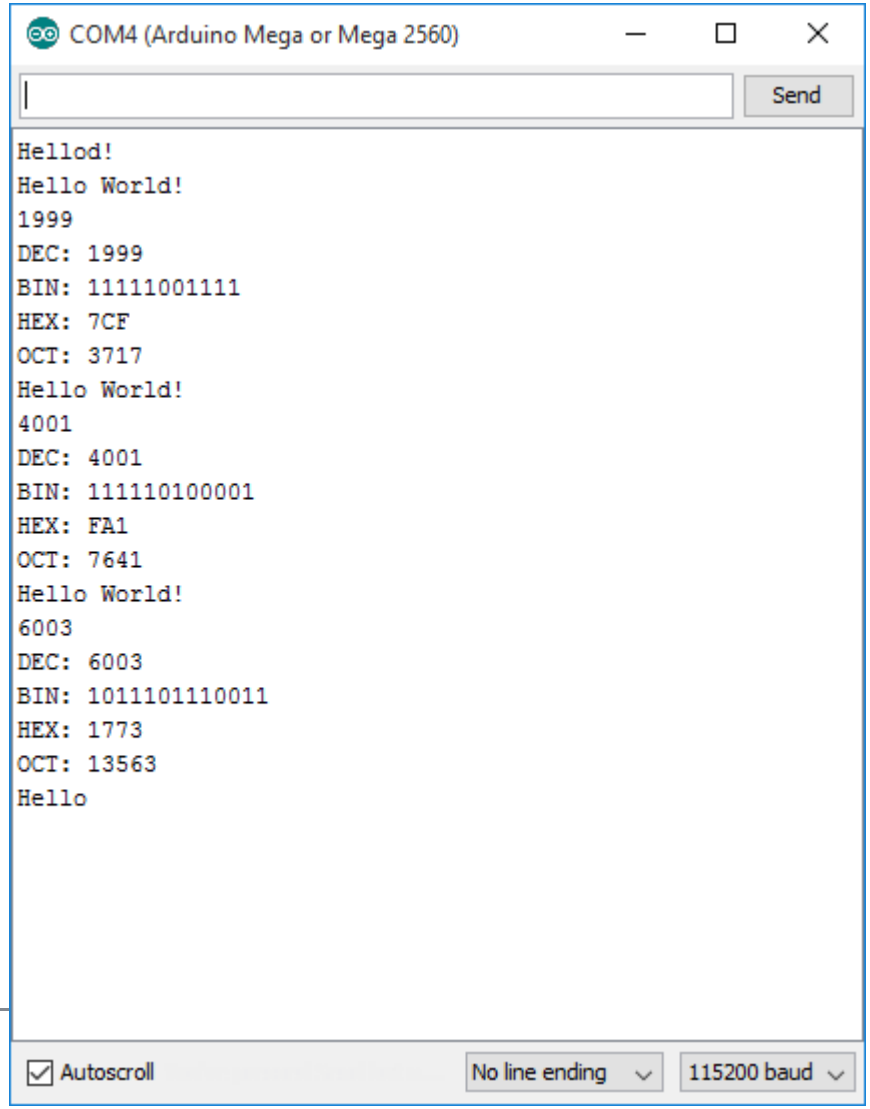
```
y
Hello World!
1000
Hello World!
3001
Hello World!
5003
Hello World!
7004
Hello World!
9006
Hello World!
11006
Hello World!
13008
Hello World!
15010
Hello World!
17011
Hello World!
19013
Hello World!
21015
Hello World!
23016
```

millis()

- Returns with the runtime (ms – unsigned long)
- After nearly 50 days will run into overflow

println()

```
15    time = millis();
16    Serial.println(time);
17    Serial.print("DEC: ");
18    Serial.println(time, DEC);
19    Serial.print("BIN: ");
20    Serial.println(time, BIN);
21    Serial.print("HEX: ");
22    Serial.println(time, HEX);
23    Serial.print("OCT: ");
24    Serial.println(time, OCT);
25  }
```



```
// Pin 13 has an LED connected on most Arduino boards.
// give it a name:
int led = 13;
unsigned long time;

// the setup routine runs once when you press reset:
void setup() {
  // initialize the digital pin as an output.
  pinMode(led, OUTPUT);
  Serial.begin(9600);
  Serial.println("System ready");
}

// the loop routine runs over and over again forever:
void loop() {
  time=1000;
  while (Serial.available()>0){
   time=Serial.parseInt();
   Serial.println("New delay time: "+String(time));

      digitalWrite(led, 1-digitalRead(led));
      Serial.println("Led blink");
  }
  delay(time);                // wait
  digitalWrite(led, 1-digitalRead(led));
  Serial.println("Led blink");
}
```

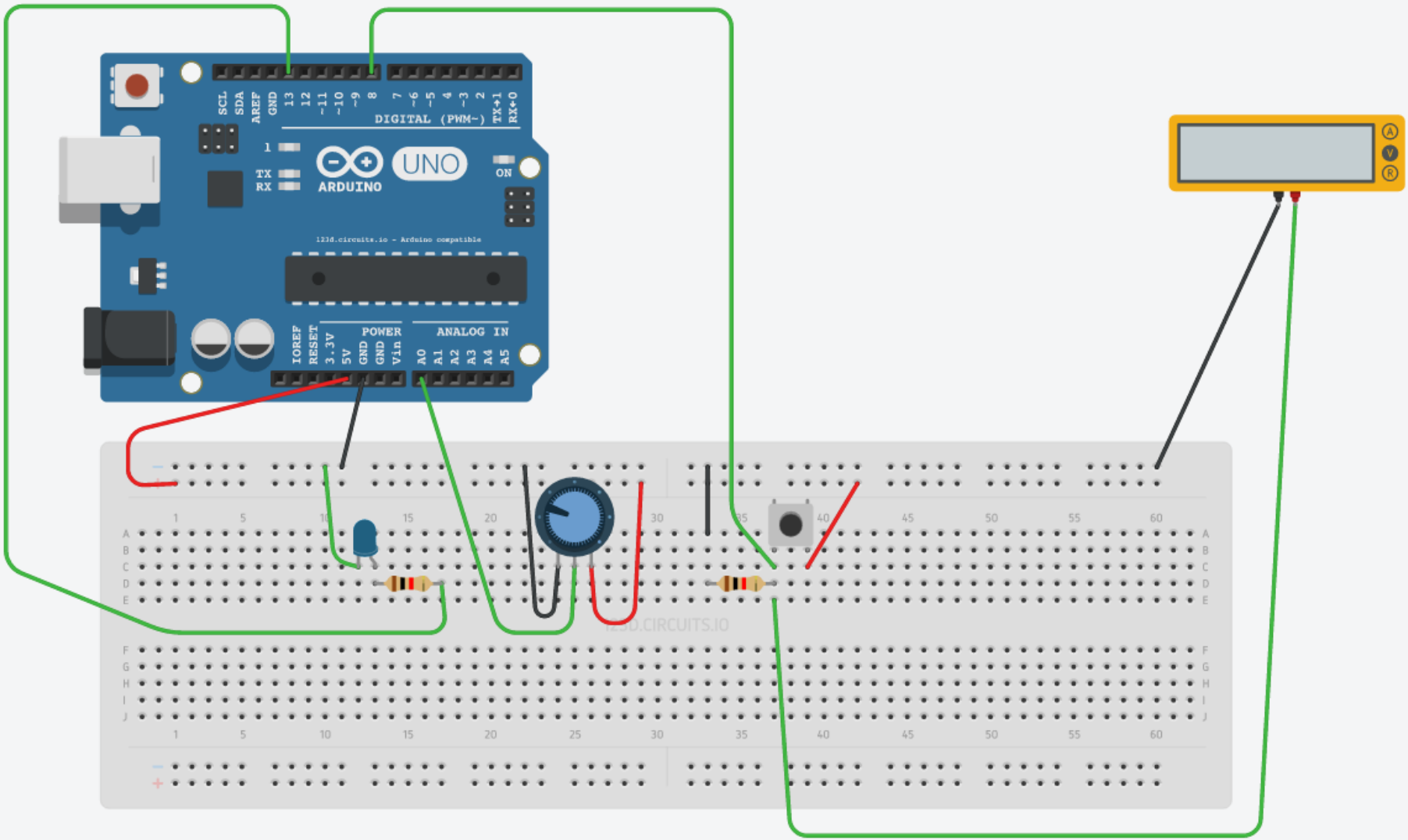
```
0
System ready
New delay time: 200
Led blink
System ready
Led blink
Led blink
Led blink
Led blink
Led blink
Led blink
New delay time: 2000
Led blink
Led blink
Led blink
Led blink
Led blink
Led blink
Led blink
Led blink
Led blink
```

int Serial.available()

- Returns the byte count in RX buffer
  - serial RX puffer
  - Max. 64 byte

long Serial.parseInt()

- Acceptable:
  0…9, ’-’
- Returns 0 if other


SCL
SDA
AREF
GND
13
12
~11
~10
~9
8
7
~6
~5
4
~3
2
TX→1
RX←0
DIGITAL (PWM~)
L
TX
RX
ARDUINO
UNO
ON
123d.circuits.io - Arduino compatible
IOREF
RESET
3.3V
5V
GND
GND
Vin
POWER
A0
A1
A2
A3
A4
A5
ANALOG IN
A
V
R

```
// Pin 13 has an LED connected on most Arduino boards.
// give it a name:
int led = 13;
int adc_input = A0;
int value;
int pushbutton=8;

// the setup routine runs once when you press reset:
void setup() {
  // initialize the digital pin as an output.
  pinMode(led, OUTPUT);
  Serial.begin(9600);
  Serial.println("System ready");
}

// the loop routine runs over and over again forever:
void loop() {
 analogRead(adc_input);

  delay(10);                    // wait
  value=analogRead(adc_input); //return: 0-1023
  Serial.println(value);
  analogWrite(led, value/4); //input: 0-255
  if(digitalRead(pushbutton)==HIGH){
    Serial.println("Button");
    delay(500);
  }
}
```

Homework

- 30. November: deadline for pratical homework
- Homework must contain at least 5 differemnt sensors / components (e.g. keypad, servo, light sensor, gas sensor, pir, etc…) from circuits.io
- Look for similar projects at e.g. instructables, Arduino forums, etc…
- Be creative! ☺
- Homework is at least 10 pages of documentation with source code and circuit
- Send it via email to: stojcsics.daniel@nik.uni-obuda.hu