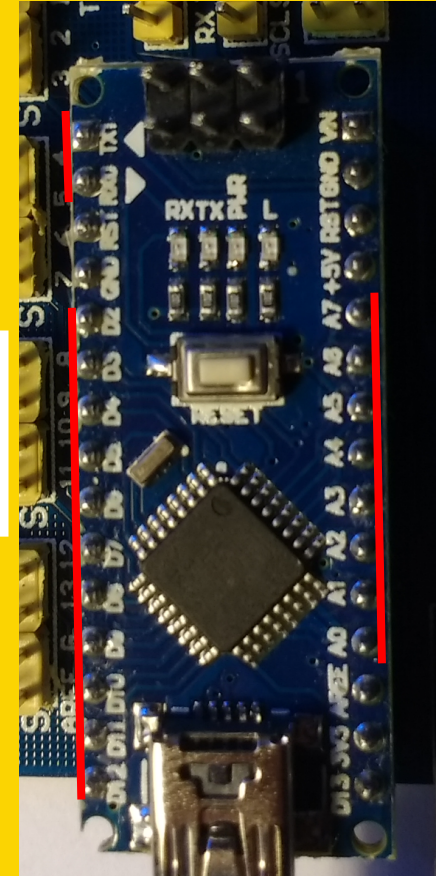
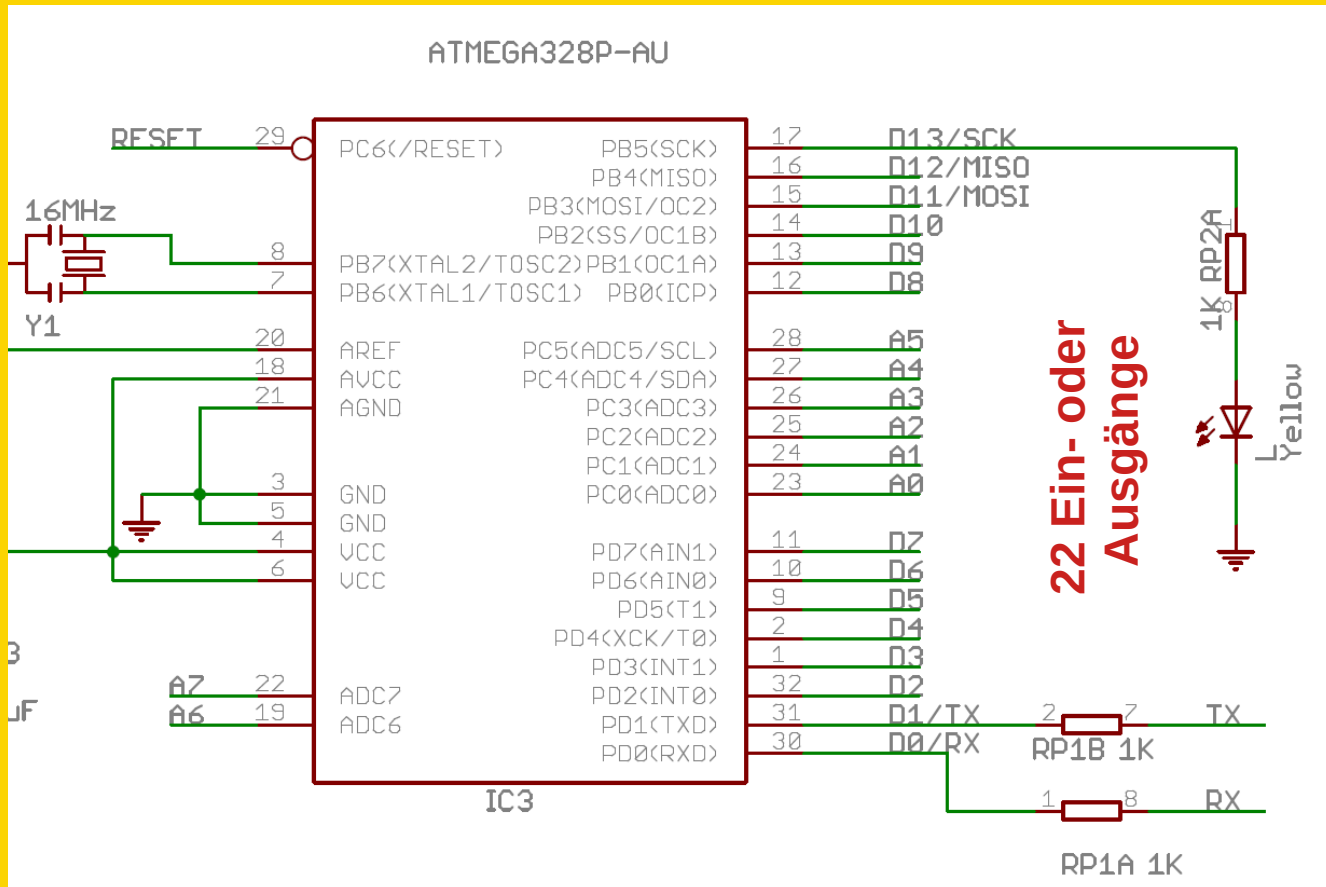


Montage und Programmierung  
eines Roboters für  
den Hessen SolarCup  
Disziplin: SolaRobot  
Teil 2.0: Hello World

Von Charlotte und Andreas

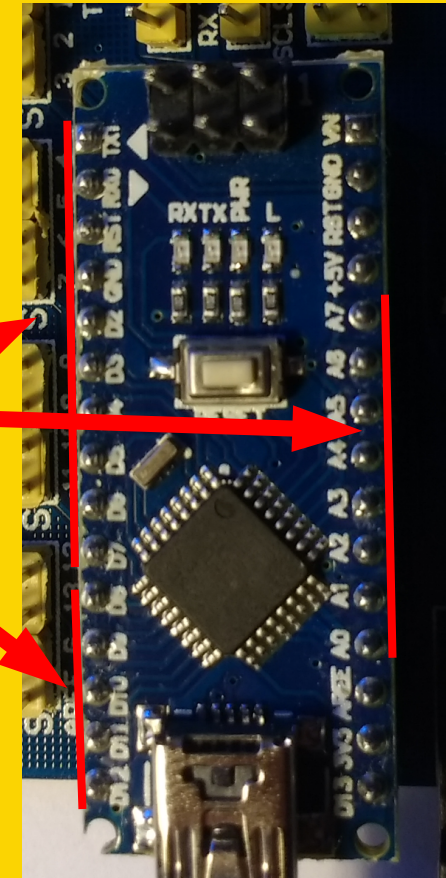
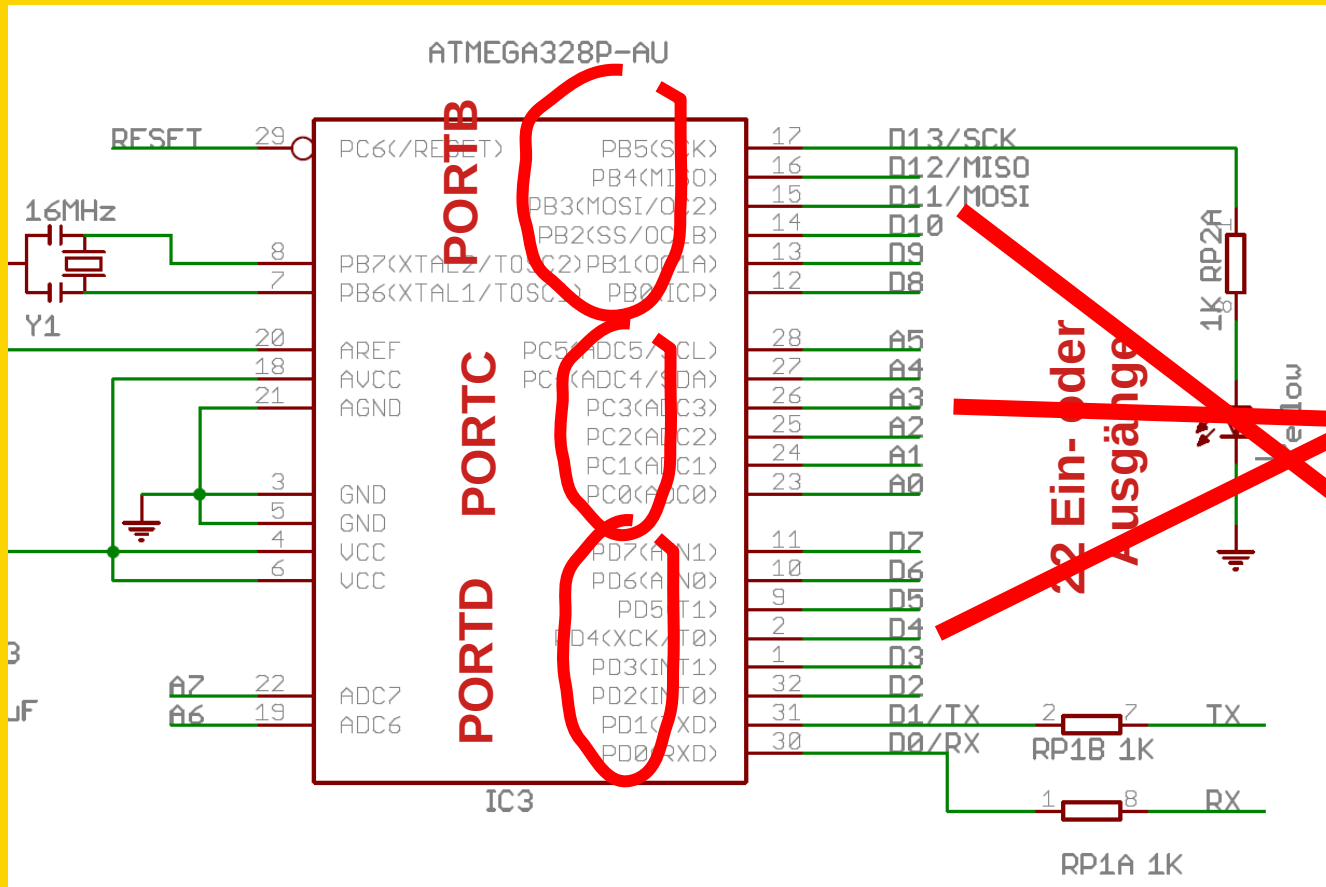
# PORTS am Atmega328P



14 Pins

8 Pins

# PORTS am Atmega328P



# Pinbelegung

D0 und D1 werden für Datenübertragungen gebraucht

D2 Echo vom Ultraschall links

D3 Echo vom Ultraschall rechts

D4 Ultraschall links Triggerleitung

D5 PWM B

D6 PWM ANicht belegt

D7 Ultraschall rechts Triggerleitung

D8 Motorausgang B

D9 Motorausgang A

D10 Liniensensor LEDs on/off

D11 Nicht belegt

D12 Nicht belegt

D13 LED am Nano

A0 Liniensensor links drei

A1 Liniensensor links zwei

A2 Liniensensor links eins

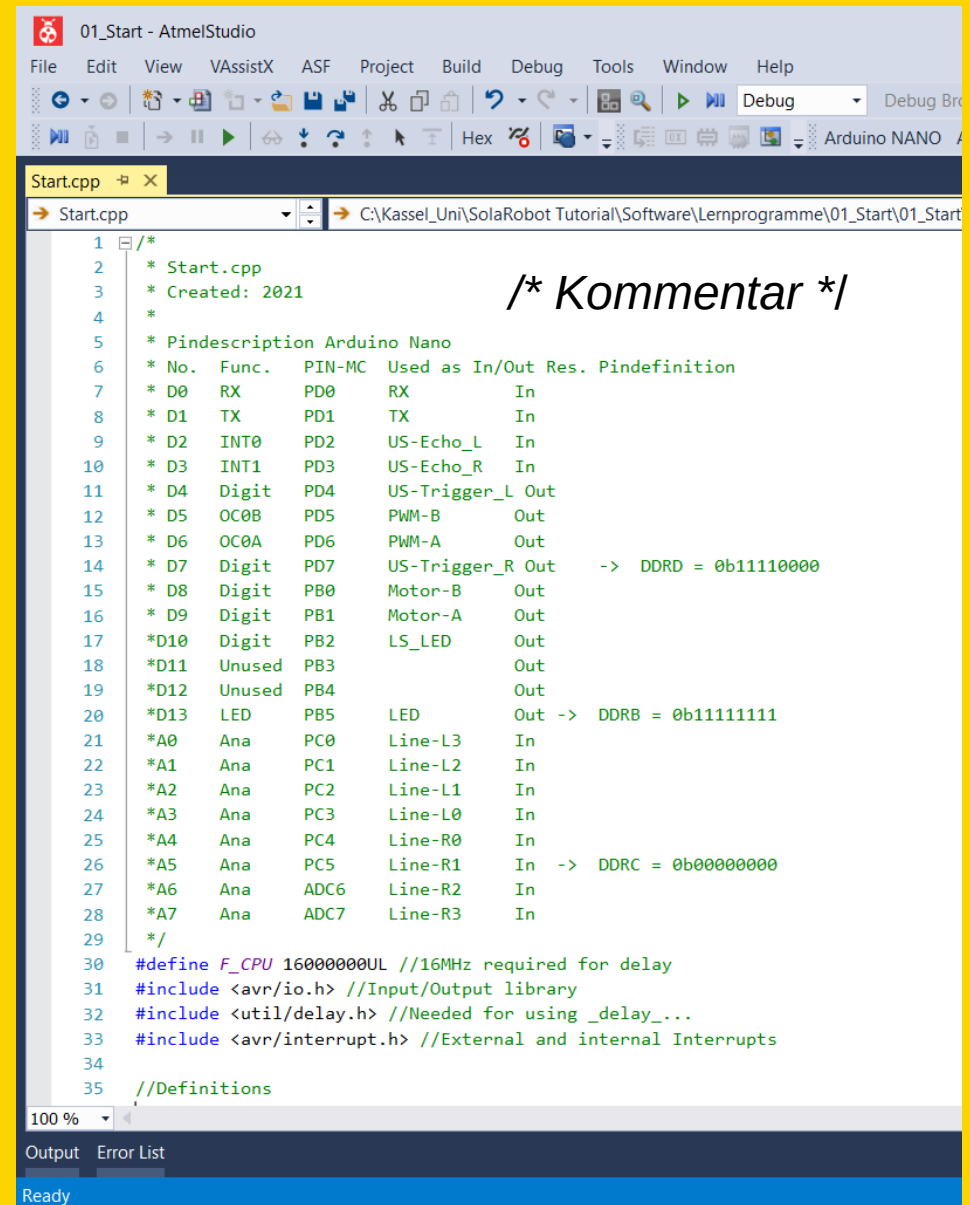
A3 Liniensensor links null

A4 Liniensensor rechts null

A5 Liniensensor rechts eins

A6 Liniensensor rechts zwei

A7 Liniensensor rechts drei



```
01_Start - AtmelStudio
File Edit View VAssistX ASF Project Build Debug Tools Window Help
Start.cpp
Start.cpp C:\Kassel_Uni\SolaRobot Tutorial\Software\Lernprogramme\01_Start\01_Start
1 /*
2  * Start.cpp
3  * Created: 2021
4  *
5  * Pindescription Arduino Nano
6  * No. Func. PIN-MC Used as In/Out Res. Pindefinition
7  * D0 RX PD0 RX In
8  * D1 TX PD1 TX In
9  * D2 INT0 PD2 US-Echo_L In
10 * D3 INT1 PD3 US-Echo_R In
11 * D4 Digit PD4 US-Trigger_L Out
12 * D5 OC0B PD5 PWM-B Out
13 * D6 OC0A PD6 PWM-A Out
14 * D7 Digit PD7 US-Trigger_R Out -> DDRD = 0b11110000
15 * D8 Digit PB0 Motor-B Out
16 * D9 Digit PB1 Motor-A Out
17 *D10 Digit PB2 LS_LED Out
18 *D11 Unused PB3 Out
19 *D12 Unused PB4 Out
20 *D13 LED PB5 LED Out -> DDRB = 0b11111111
21 *A0 Ana PC0 Line-L3 In
22 *A1 Ana PC1 Line-L2 In
23 *A2 Ana PC2 Line-L1 In
24 *A3 Ana PC3 Line-L0 In
25 *A4 Ana PC4 Line-R0 In
26 *A5 Ana PC5 Line-R1 In -> DDRC = 0b00000000
27 *A6 Ana ADC6 Line-R2 In
28 *A7 Ana ADC7 Line-R3 In
29 */
30 #define F_CPU 16000000UL //16MHz required for delay
31 #include <avr/io.h> //Input/Output library
32 #include <util/delay.h> //Needed for using _delay...
33 #include <avr/interrupt.h> //External and internal Interrupts
34
35 //Definitions
100 %
Output Error List
Ready
```

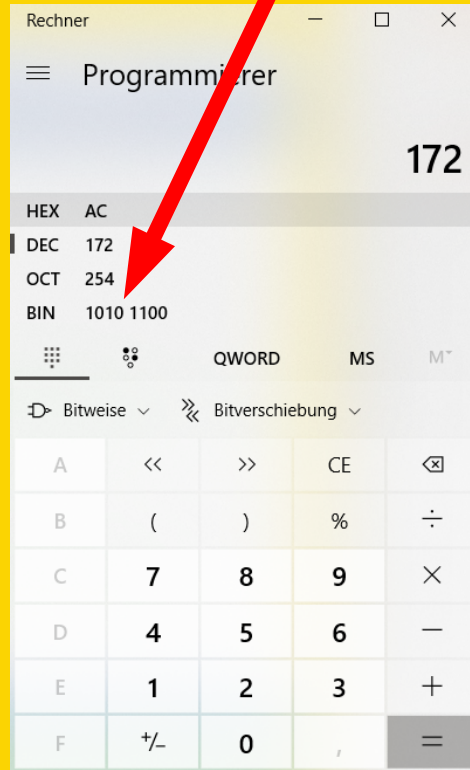


## unsigned char

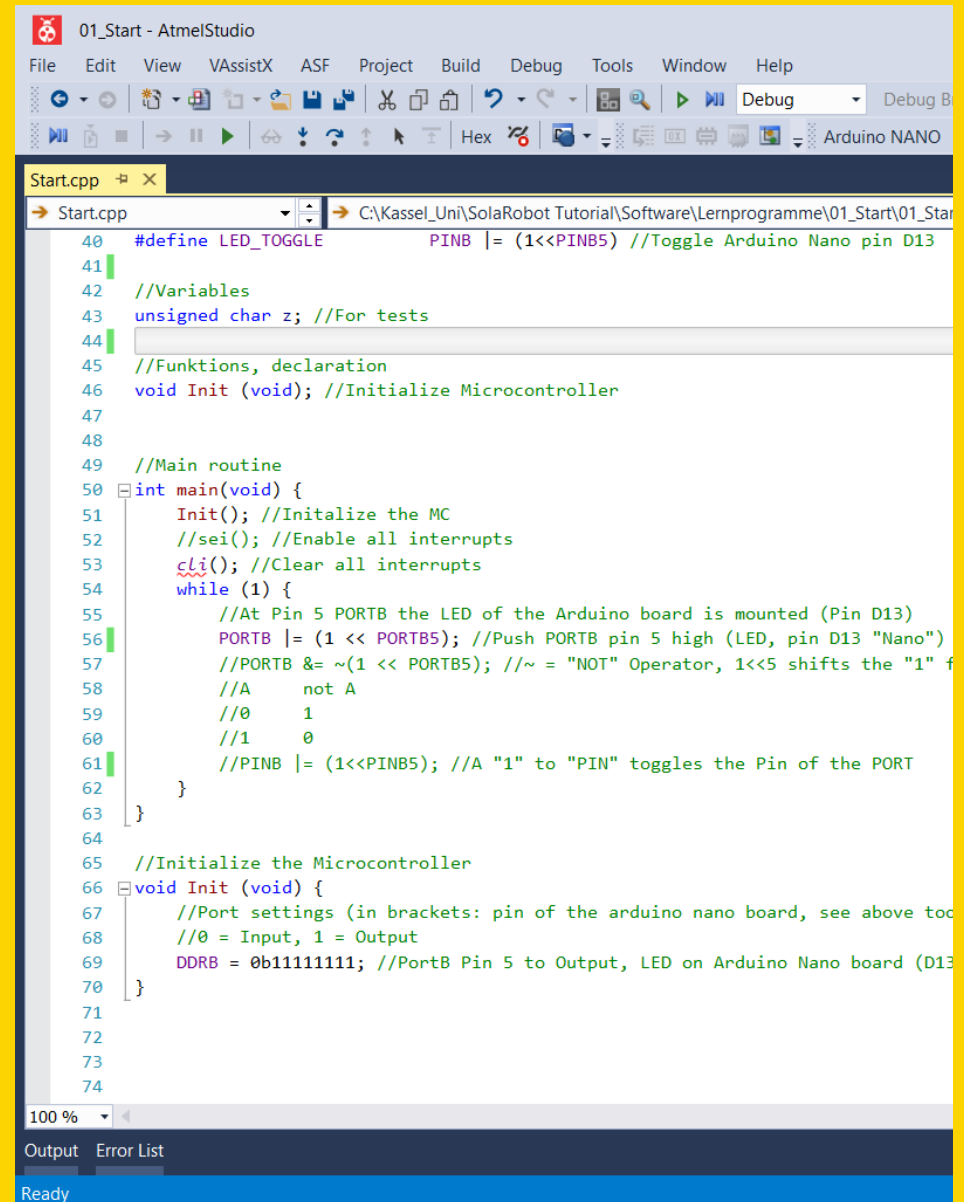
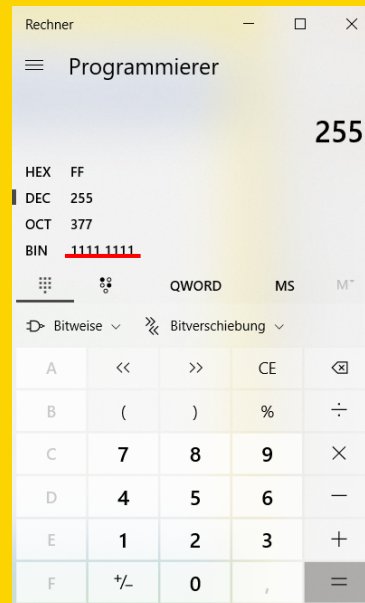
1 Byte bestehend aus 8 Bit

z.B.:

1	0	1	0	1	1	0	0
---	---	---	---	---	---	---	---

 = 172

0 bis 255



## void Funktionsname (void)

z.B.: void Init (void)

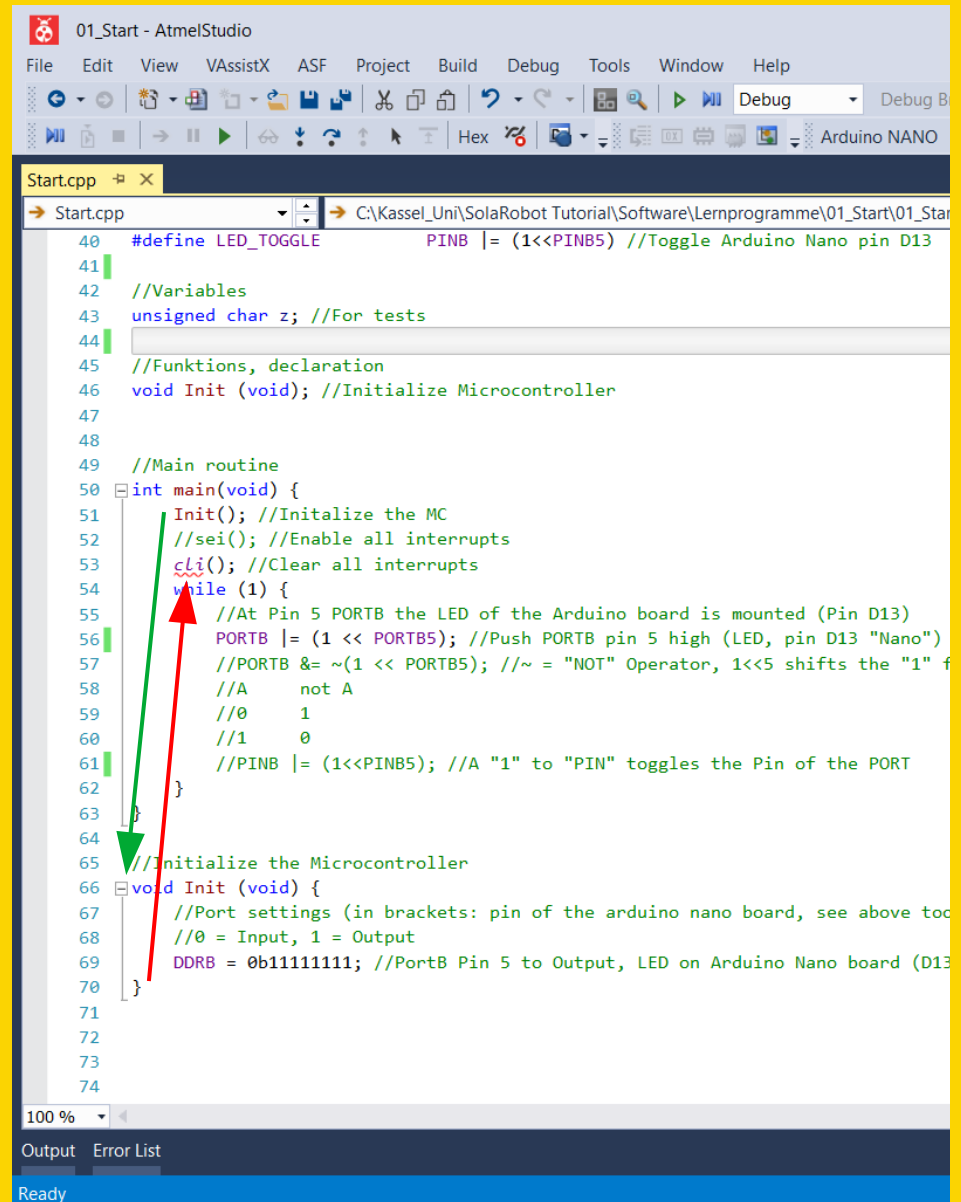
Deklaration für den Compiler im oberen Teil, vor der Hauptfunktion(main). Bekanntmachung der Funktion für den Compiler.

Aufruf im Hauptprogramm (oder woanders)

Definition im unteren Teil

Wenn die Funktion aufgerufen wird Init();  
springt der Mikrocontroller dort hin, arbeitet die Funktion ab und springt an die Ausgangsstelle zurück.

void → nichts



```
01_Start - AtmelStudio
File Edit View VAssistX ASF Project Build Debug Tools Window Help
Start.cpp
Start.cpp C:\Kassel_Uni\SolaRobot Tutorial\Software\Lernprogramme\01_Start\01_Start
40 #define LED_TOGGLE PINB |= (1<<PINB5) //Toggle Arduino Nano pin D13
41
42 //Variables
43 unsigned char z; //For tests
44
45 //Funktions, declaration
46 void Init (void); //Initialize Microcontroller
47
48
49 //Main routine
50 int main(void) {
51     Init(); //Initialize the MC
52     //sei(); //Enable all interrupts
53     cli(); //Clear all interrupts
54     while (1) {
55         //At Pin 5 PORTB the LED of the Arduino board is mounted (Pin D13)
56         PORTB |= (1 << PORTB5); //Push PORTB pin 5 high (LED, pin D13 "Nano")
57         //PORTB &= ~(1 << PORTB5); //~ = "NOT" Operator, 1<<5 shifts the "1" f
58         //A not A
59         //0 1
60         //1 0
61         //PINB |= (1<<PINB5); //A "1" to "PIN" toggles the Pin of the PORT
62     }
63 }
64
65 //Initialize the Microcontroller
66 void Init (void) {
67     //Port settings (in brackets: pin of the arduino nano board, see above too
68     //0 = Input, 1 = Output
69     DDRB = 0b11111111; //PortB Pin 5 to Output, LED on Arduino Nano board (D13
70 }
71
72
73
74
100 %
Output Error List
Ready
```

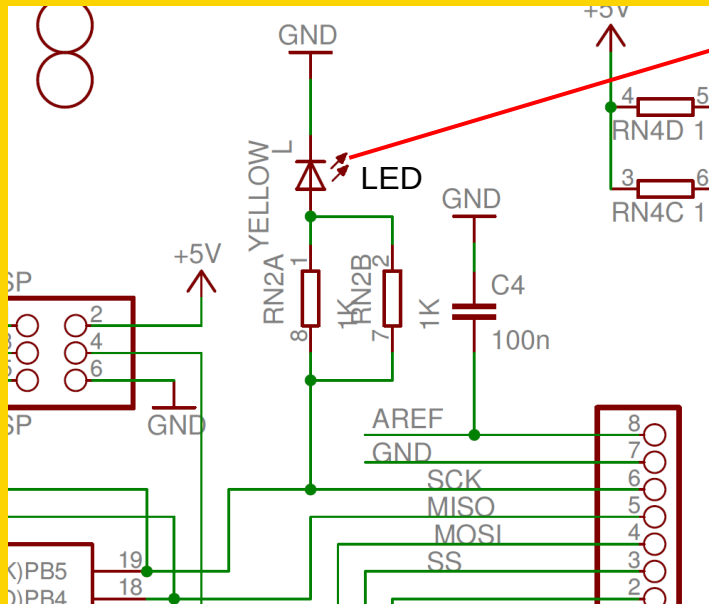
## DDRB:

Data Direction Register für PORTB  
0b... Die folgende Ziffernfolge gibt  
eine Binärzahl wieder.

0b 1 1 1 1 1 1 1 1

Bit 5

Bit 0



01\_Start - AtmelStudio

File Edit View VASistX ASF Project Build Debug

Start.cpp

```
40 #define LED_TOGGLE PINB |= (1<<P
41
42 //Variables
43 unsigned char z; //For tests
44
45 //Funktions, declaration
46 void Init (void); //Initialize Microcontr
47
48
49 //Main routine
50 int main(void) {
51     Init(); //Inititalize the MC
52     //sei(); //Enable all interrupts
53     cli(); //Clear all interrupts
54     while (1) {
55         //At Pin 5 PORTB the LED of the Arduino board is mounted (Pin D13)
56         PORTB |= (1 << PORTB5); //Push PORTB pin 5 high (LED, pin D13 "Nano")
57         //PORTB &= ~(1 << PORTB5); //~ = "NOT" Operator, 1<<5 shifts the "1" f
58         //A      not A
59         //0      1
60         //1      0
61         //PINB |= (1<<PINB5); //A "1" to "PIN" toggles the Pin of the PORT
62     }
63 }
64
65 //Initialize the Microcontroller
66 void Init (void) {
67     //Port settings (in brackets: pin of the arduino nano board, see above too
68     //0 = Input, 1 = Output
69     DDRB = 0b11111111; //PortB Pin 5 to Output, LED on Arduino Nano board (D13
70 }
71
72
73
74
```

Bit 5

## Int main (void):

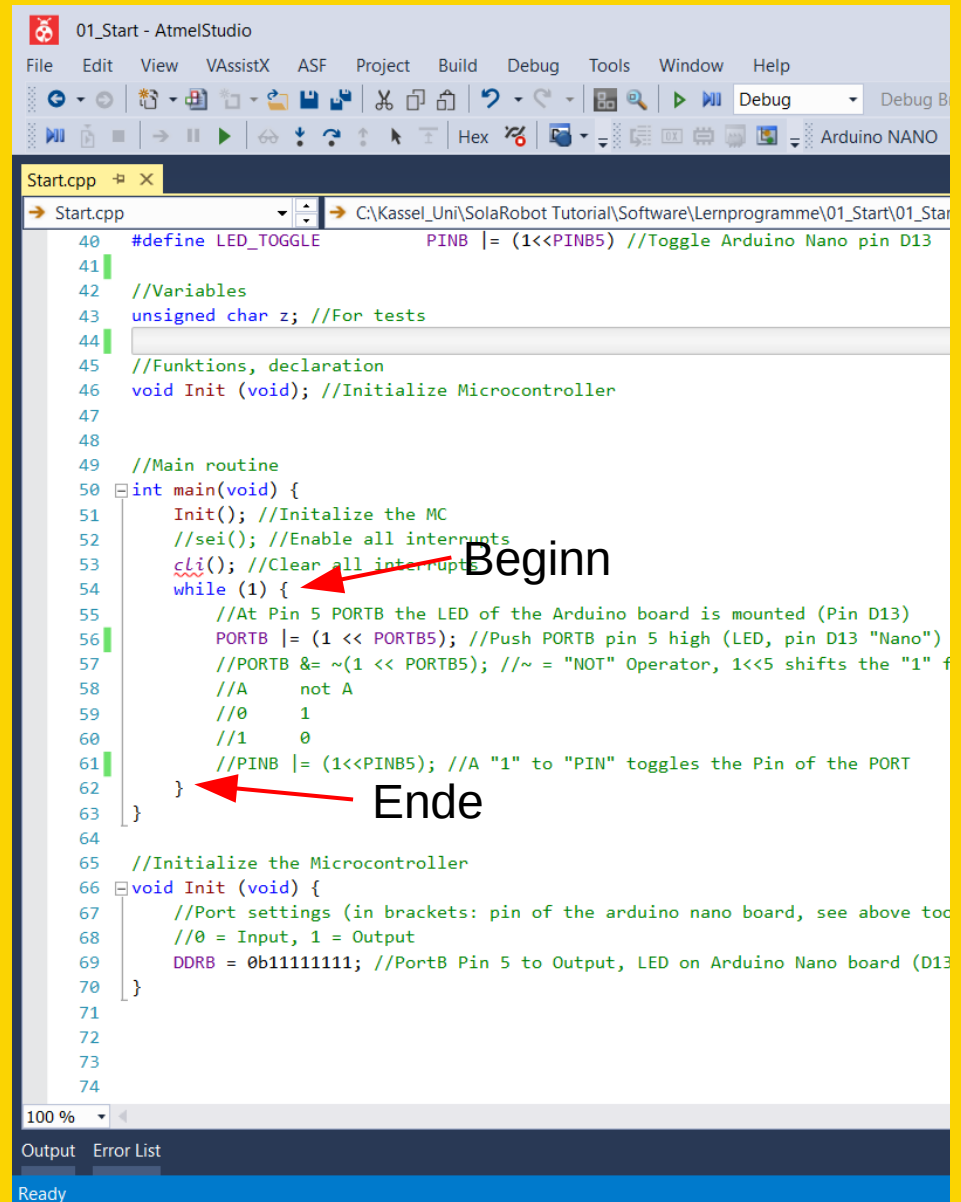
Der MC beginnt immer mit der main-Funktion

## while:

Solange die Bedingung in den nachfolgenden runden Klammern erfüllt ist, wiederhole die Anweisungen zwischen den geschweiften Klammern der „while-Schleife“.

Eine Bedingung gilt dann als erfüllt, wenn sie

**NICHT NULL**  
ist.

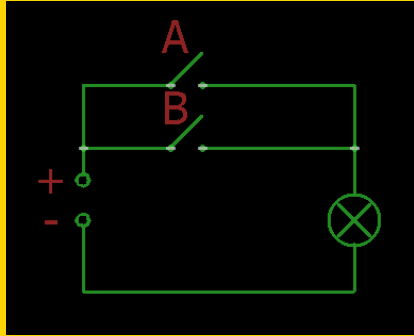


```
01_Start - AtmelStudio
File Edit View VAssistX ASF Project Build Debug Tools Window Help
Start.cpp
Start.cpp C:\Kassel_Uni\SolaRobot Tutorial\Software\Lernprogramme\01_Start\01_Start
40 #define LED_TOGGLE PINB |= (1<<PINB5) //Toggle Arduino Nano pin D13
41
42 //Variables
43 unsigned char z; //For tests
44
45 //Funktions, declaration
46 void Init (void); //Initialize Microcontroller
47
48
49 //Main routine
50 int main(void) {
51     Init(); //Inititalize the MC
52     //sei(); //Enable all interrupts
53     cli(); //Clear all interrupts
54     while (1) {
55         //At Pin 5 PORTB the LED of the Arduino board is mounted (Pin D13)
56         PORTB |= (1 << PORTB5); //Push PORTB pin 5 high (LED, pin D13 "Nano")
57         //PORTB &= ~(1 << PORTB5); //~ = "NOT" Operator, 1<<5 shifts the "1" f
58         //A not A
59         //0 1
60         //1 0
61         //PINB |= (1<<PINB5); //A "1" to "PIN" toggles the Pin of the PORT
62     }
63 }
64
65 //Initialize the Microcontroller
66 void Init (void) {
67     //Port settings (in brackets: pin of the arduino nano board, see above too
68     //0 = Input, 1 = Output
69     DDRB = 0b11111111; //PortB Pin 5 to Output, LED on Arduino Nano board (D13
70 }
71
72
73
74
100 %
Output Error List
Ready
```

## Wahrheitstabelle:

Oder (Or | )

A	B	A   B
0	0	0
0	1	1
1	0	1
1	1	1



0 0 0 0 0 0 0 0 = 0

oder

0 0 0 1 0 0 0 0 = 16

ergibt

0 0 0 1 0 0 0 0 = 16

oder

0 0 0 0 0 0 1 1 = 3

ergibt

0 0 0 1 0 0 1 1 = 19

01\_Start - AtmelStudio

File Edit View VAssistX ASF Project Build Debug Tools Window Help

Start.cpp

```

40 #define LED_
41
42 //Variables
43 unsigned char
44
45 //Funktionen, declaration
46 void Init (void); //Initialize Microcontroller
47
48
49 //Main routine
50 int main(void) {
51     Init(); //Initialize the MC
52     //sei(); //Enable all interrupts
53     cli(); //Clear all interrupts
54     while (1) {
55         //At Pin 5 PORTB the LED of the Arduino board is mounted (Pin D13)
56         PORTB |= (1 << PORTB5); //Push PORTB pin 5 high (LED pin D13 "Nano")
57         //PORTB &= ~(1 << PORTB5); //Push PORTB pin 5 low (LED pin D13 "Nano")
58         //A not A
59         //0 1
60         //1 0
61         //PINB |= (1<<PINB5);
62     }
63 }
64
65 //Initialize the Microcontroller
66 void Init (void) {
67     //Port settings (in brackets)
68     //0 = Input, 1 = Output
69     DDRB = 0b11111111; //PortB
70 }
71
72
73
74

```

Rechner

Programmierer

0 OR 16 OR 3 = 19

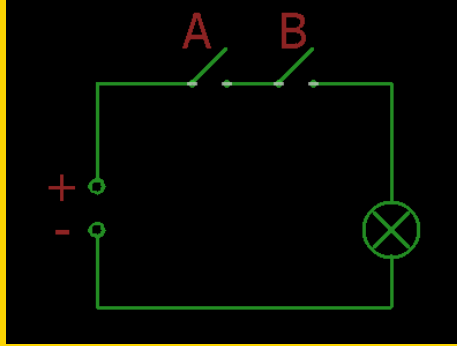
HEX 13  
DEC 19  
OCT 23  
BIN 0001 0011

QWORD MS M\*

Bitweise Bitverschiebung

Wahrheitstabelle:  
Und (And & )

A	B	A & B
0	0	0
0	1	0
1	0	0
1	1	1



0 0 0 1 0 0 1 1 = 19

und

1 1 1 0 1 1 1 0 = 238

gleich

0 0 0 0 0 0 1 0 = 2

01\_Start - AtmelStudio

File Edit View VAssistX ASF Project Build Debug Tools Window Help

Start.cpp

```

40 #define LED_TOGGLE PINB |= (1<<PINB5) //Toggle Arduino Nano pin D13
41
42 //Variables
43 unsigned char z; //For tests
44
45 //Funktions, declaration
46 void Init (void); //Initialize Microcontroller
47
48
49 //Main routine
50 int main(void) {
51     Init(); //Inititalize the MC
52     //sei(); //Enable all interrupts
53     cli(); //Clear all interrupts
54     while (1) {
55         //At Pin 5 PORTB the LED of the Arduino board is mounted (Pin D13)
56         PORTB |= (1 << PORTB5); //Push PORTB pin 5 high (LED, pin D13 "Nano")
57         //PORTB &= ~(1 << PORTB5); //~ = "NOT" Operator, 1<<5 shifts the "1" f
58         //A not A
59         //0 1
60         //1 0
61         //PINB |= (1<<PINB5); //A "1" to "PIN" toggles the Pin of the PORT
62     }
63 }
64
65 //Initialize the Microcontroller
66 void Init (void) {
67     //Port settings (in brackets: pin of the arduino nano board, see above too
68     //0 = Input, 1 = Output
69     DDRB = 0b11111111; //PortB Pin 5 to Output, LED on Arduino Nano board (D13
70 }
71
72
73
74

```

100 %

Output Error List

Ready

## << Operator:

Verschiebt ein Bit nach links

0	0	0	0	0	0	0	0
---	---	---	---	---	---	---	---

 = 0

(1 << 1) eine 1 einmal nach links schieben

0	0	0	0	0	0	1	0
---	---	---	---	---	---	---	---

 = 2

(1 << 4) eine 1 viermal nach links schieben

0	0	0	1	0	0	0	0
---	---	---	---	---	---	---	---

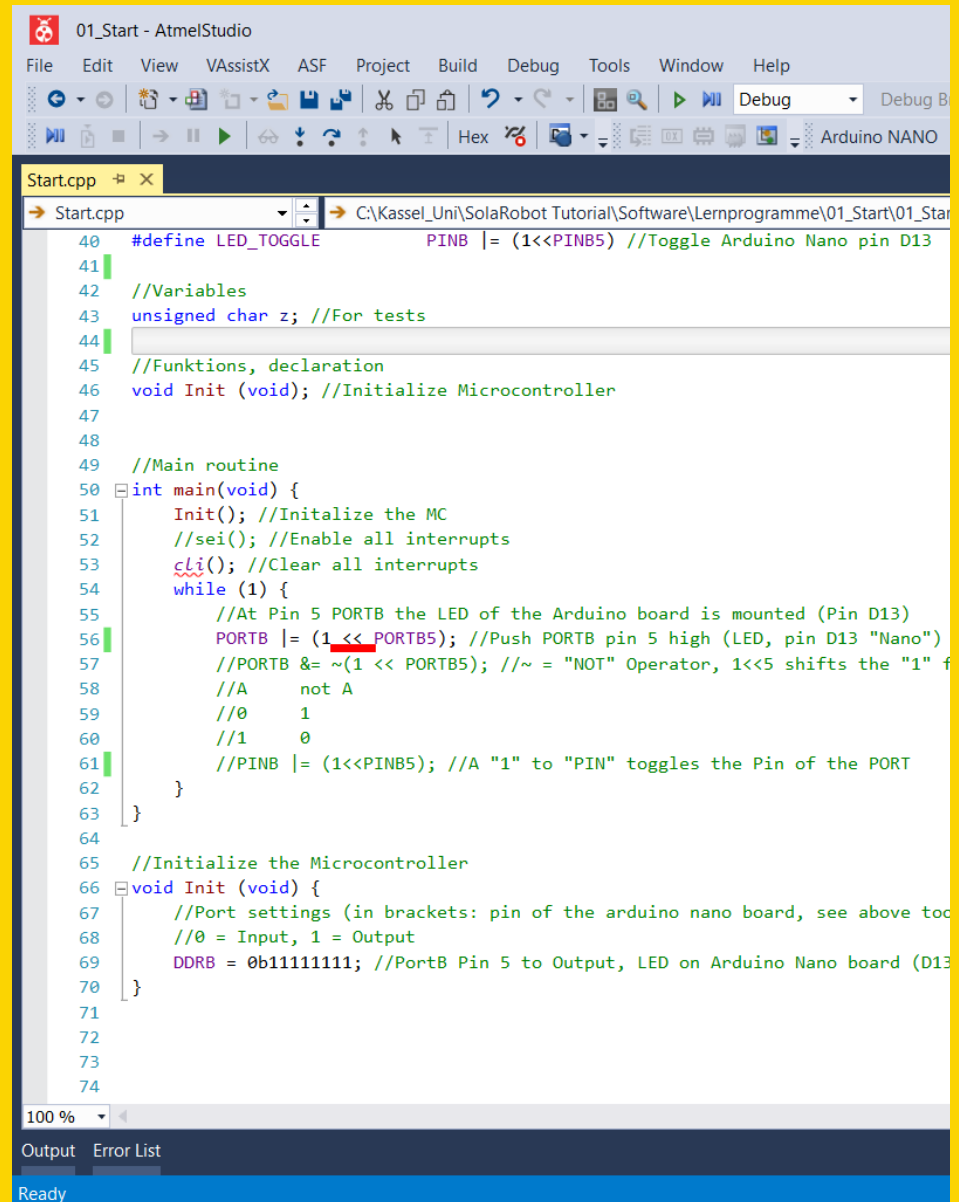
 = 16

| (1 << 6)

0	1	0	1	0	0	0	0
---	---	---	---	---	---	---	---

 = 80

$\text{PORTB} |= (1 \ll \text{PORTB5})$  eine Abkürzung für  
 $\text{PORTB} = \text{PORTB} | (1 \ll \text{PORTB5})$

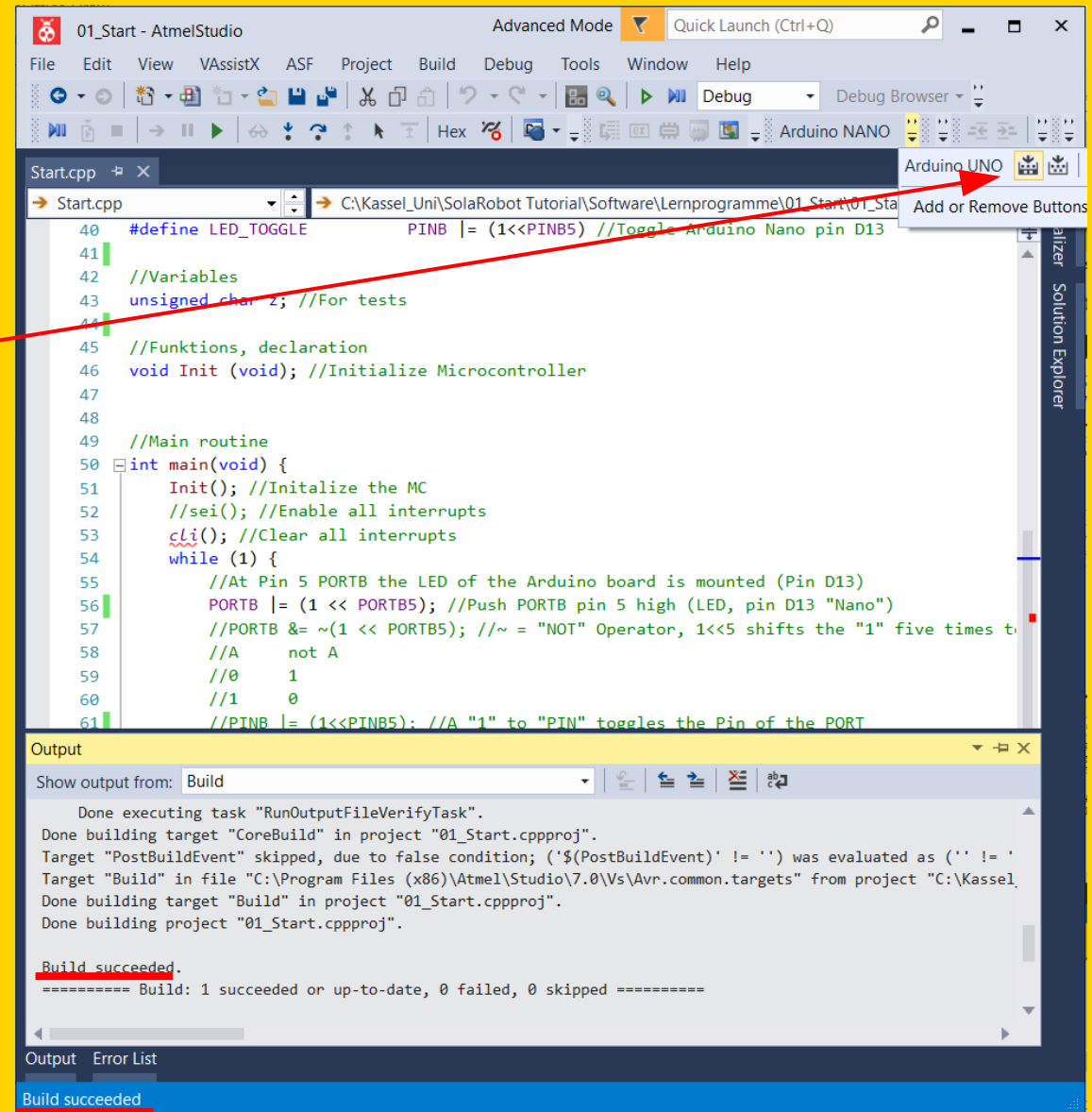


```
01_Start - AtmelStudio
File Edit View VAssistX ASF Project Build Debug Tools Window Help
Start.cpp
Start.cpp C:\Kassel_Uni\SolaRobot Tutorial\Software\Lernprogramme\01_Start\01_Start
40 #define LED_TOGGLE PINB |= (1<<PINB5) //Toggle Arduino Nano pin D13
41
42 //Variables
43 unsigned char z; //For tests
44
45 //Funktions, declaration
46 void Init (void); //Initialize Microcontroller
47
48 //Main routine
49 int main(void) {
50     Init(); //Initialize the MC
51     sei(); //Enable all interrupts
52     cli(); //Clear all interrupts
53     while (1) {
54         //At Pin 5 PORTB the LED of the Arduino board is mounted (Pin D13)
55         PORTB |= (1 << PORTB5); //Push PORTB pin 5 high (LED, pin D13 "Nano")
56         //PORTB &= ~(1 << PORTB5); //~ = "NOT" Operator, 1<<5 shifts the "1" f
57         //A not A
58         //0 1
59         //1 0
60         //PINB |= (1<<PINB5); //A "1" to "PIN" toggles the Pin of the PORT
61     }
62 }
63
64 //Initialize the Microcontroller
65 void Init (void) {
66     //Port settings (in brackets: pin of the arduino nano board, see above too
67     //0 = Input, 1 = Output
68     DDRB = 0b11111111; //PortB Pin 5 to Output, LED on Arduino Nano board (D13
69 }
70
71
72
73
74
100 %
Output Error List
Ready
```



## Compilieren:

das Programm, das wir verstehen,  
wird umgewandelt in ein Programm,  
das der Mikrocontroller versteht.



The screenshot shows the Atmel Studio IDE in 'Advanced Mode'. The main window displays the file 'Start.cpp' with the following C code:

```
40 #define LED_TOGGLE PINB |= (1<<PINB5) //Toggle Arduino Nano pin D13
41
42 //Variables
43 unsigned char z; //For tests
44
45 //Funktionen, declaration
46 void Init (void); //Initialize Microcontroller
47
48
49 //Main routine
50 int main(void) {
51     Init(); //Initialize the MC
52     sei(); //Enable all interrupts
53     cli(); //Clear all interrupts
54     while (1) {
55         //At Pin 5 PORTB the LED of the Arduino board is mounted (Pin D13)
56         PORTB |= (1 << PORTB5); //Push PORTB pin 5 high (LED, pin D13 "Nano")
57         //PORTB &= ~(1 << PORTB5); //~ = "NOT" Operator, 1<<5 shifts the "1" five times to the left
58         //A      not A
59         //0      1
60         //1      0
61         //PINB |= (1<<PINB5); //A "1" to "PIN" toggles the Pin of the PORT
```

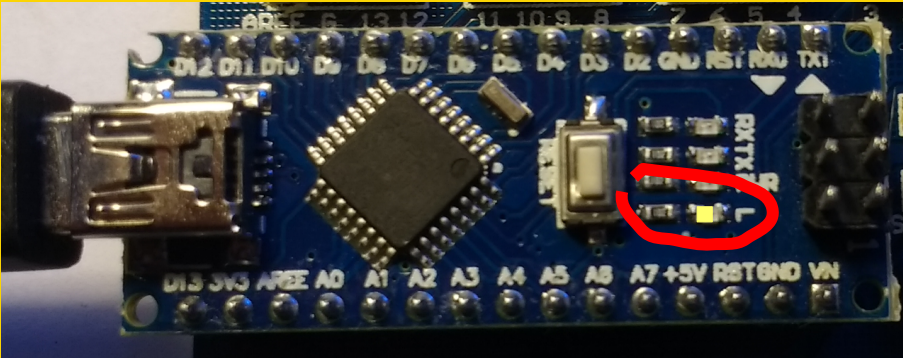
The 'Output' window at the bottom shows the build process:

```
Done executing task "RunOutputFileVerifyTask".
Done building target "CoreBuild" in project "01_Start.cppproj".
Target "PostBuildEvent" skipped, due to false condition; ('$(PostBuildEvent)' != '') was evaluated as ('' != ')
Target "Build" in file "C:\Program Files (x86)\Atmel\Studio\7.0\Vs\Avr.common.targets" from project "C:\Kassel
Done building target "Build" in project "01_Start.cppproj".
Done building project "01_Start.cppproj".

Build succeeded.
===== Build: 1 succeeded or up-to-date, 0 failed, 0 skipped =====
```

At the bottom of the IDE, the status bar indicates 'Build succeeded'.

**Flashen:**  
das Programm auf den  
Mikrocontroller  
downloaden.



01\_Start - AtmelStudio

Advanced Mode Quick Launch (Ctrl+Q)

File Edit View VAssistX ASF Project Build Debug Tools Window Help

Debug Debug Browser

Arduino NANO

Start.cpp

```
43 //Variables
44 unsigned char z; //For tests
45
46
47 //Funktionen, declaration
48 void Init (void); //Initialize Microcontroller
49
50
51 //Main routine
52 int main(void) {
53     Init(); //Inititalize the MC
54     sei(); //Enable all interrupts
55     cli(); //Clear all interrupts
56     while (1) {
57         //At Pin 5 PORTB the LED of the Arduino board is mounted (Pin D13)
58         PORTB |= (1 << PORTB5); //Push PORTB pin 5 high (LED, pin D13 "Nano")
59         PORTB &= ~(1 << PORTB5); //~ = "NOT" Operator, 1<<5 shifts the "1" five times to
60         //A not A
61         //0 1
62         //1 0
63         //PINB |= (1<<PINB5); //A "1" to "PIN" toggles the Pin of the PORT
64     }
65 }
```

Output

Show output from: Arduino NANO

avrdude.exe: reading on-chip flash data:

Reading | ##### | 100% 0.05s

avrdude.exe: verifying ...

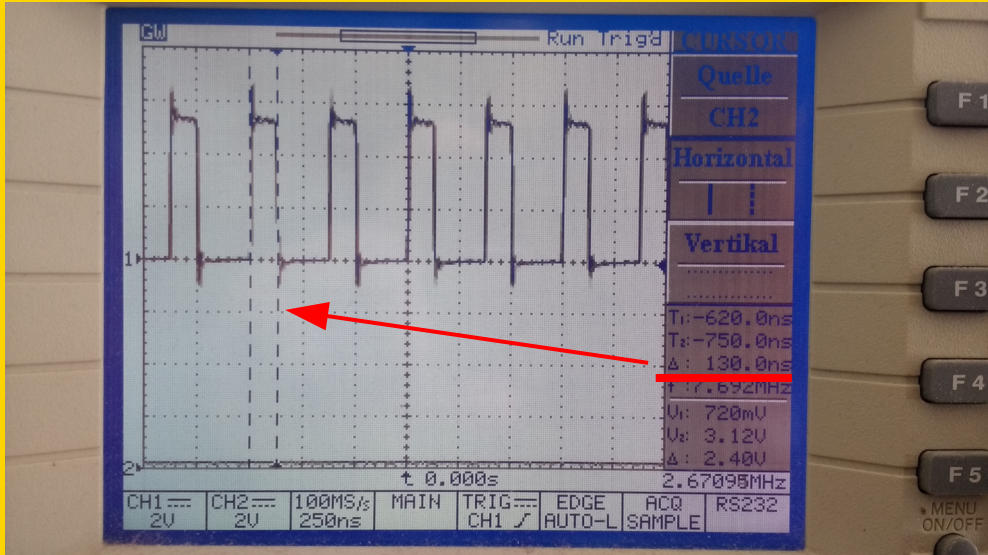
avrdude.exe: 160 bytes of flash verified

avrdude.exe done. Thank you.

Output Error List

Ready Ln 1 Col 1 Ch 1 INS

**Kommentar aufgehoben:**  
Eine Zeile ins Programm  
aufnehmen.



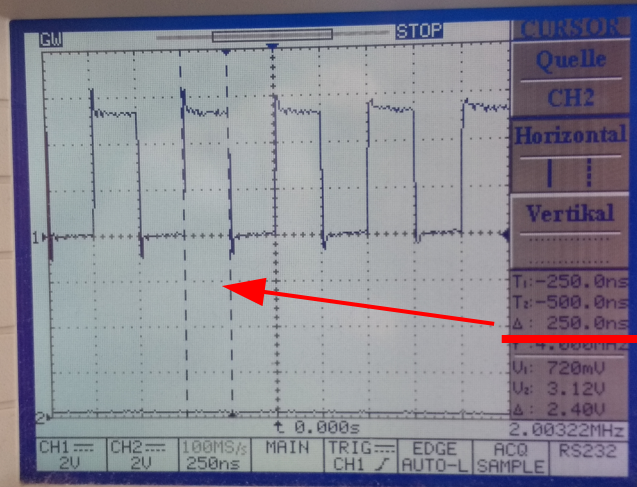
```
01_Start - AtmelStudio Advanced Mode Quick Launch (Ctrl+Q)
File Edit View VAssistX ASF Project Build Debug Tools Window Help
Start.cpp x
Start.cpp Kassel_Uni\SolaRobot Tutorial\Software\Lernprogramme\01_Start\01_Start\Start.cpp
40 #define LED_TOGGLE PINB |= (1<<PINB5) //Toggle Arduino Nano pin D13
41
42
43 //Variables
44 unsigned char z; //For tests
45
46
47 //Funktionen, declaration
48 void Init (void); //Initialize Microcontroller
49
50
51 //Main routine
52 int main(void) {
53     Init(); //Initialize the MC
54     //sei(); //Enable all interrupts
55     cli(); //Clear all interrupts
56     while (1) {
57         //At Pin 5 PORTB the LED of the Arduino board is mounted (Pin D13)
58         PORTB |= (1 << PORTB5); //Push PORTB pin 5 high (LED, pin D13 "Nano")
59         PORTB &= ~(1 << PORTB5); //~ = "NOT" Operator, 1<<5 shifts the "1" five times t
60         //A not A
61         //0 1
62         //1 0
63         //PINB |= (1<<PINB5); //A "1" to "PIN" toggles the Pin of the PORT
64     }
65 }
66
67 //Initialize the Microcontroller
68 void Init (void) {
69     //Port settings (in brackets: pin of the arduino nano board, see above too)
70     //0 = Input, 1 = Output
71     DDRB = 0b11111111; //PortB Pin 5 to Output, LED on Arduino Nano board (D13)
72 }
73
74
100 %
Output Error List
Ready Ln 34 Col 1 Ch 1
```

## Auskommentieren:

Eine Zeile aus dem Programm nehmen.

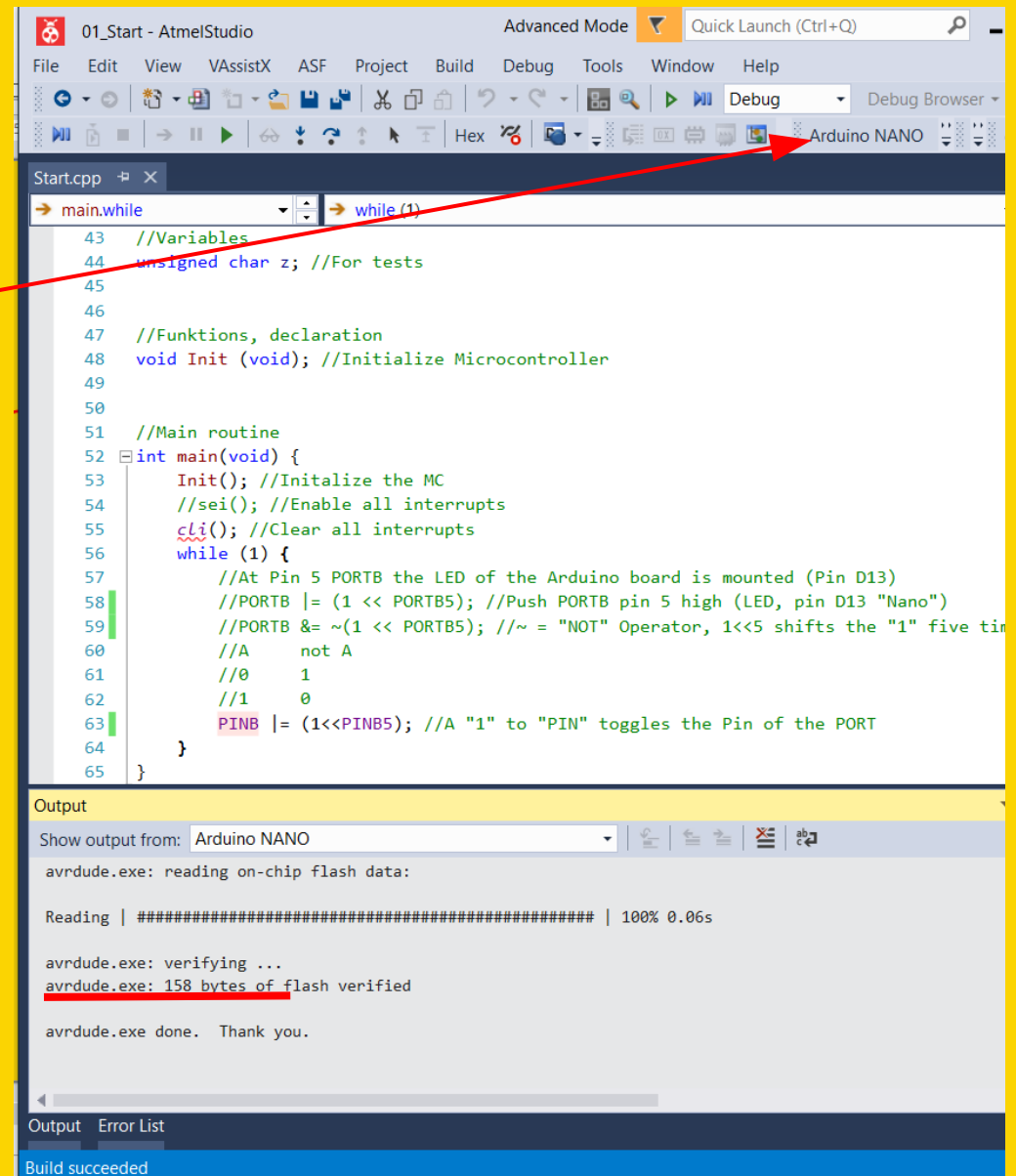
## Kommentar aufheben:

Eine Zeile ins Programm aufnehmen.



```
01_Start - AtmelStudio Advanced Mode Quick Launch (Ctrl+Q)
File Edit View VAssistX ASF Project Build Debug Tools Window Help
Start.cpp* x
main.while while (1)
43 //Variables
44 unsigned char z; //For tests
45
46 //Funktionen, declaration
47 void Init (void); //Initialize Microcontroller
48
49
50 //Main routine
51 int main(void) {
52     Init(); //Initialize the MC
53     //sei(); //Enable all interrupts
54     cli(); //Clear all interrupts
55     while (1) {
56         //At Pin 5 PORTB the LED of the Arduino board is mounted (Pin D13)
57         //PORTB |= (1 << PORTB5); //Push PORTB pin 5 high (LED, pin D13 "Nano")
58         //PORTB &= ~(1 << PORTB5); //~ = "NOT" Operator, 1<<5 shifts the "1" five
59         //A not A
60         //0 1
61         //1 0
62         PINB |= (1<<PINB5); //A "1" to "PIN" toggles the Pin of the PORT
63     }
64 }
65
66 //Initialize the Microcontroller
67 void Init (void) {
68     //Port settings (in brackets: pin of the arduino nano board, see above too)
69     //0 = Input, 1 = Output
70     DDRB = 0b11111111; //PortB Pin 5 to Output, LED on Arduino Nano board (D13)
71 }
72
73
74
75
76
```

**Flashen:**  
das Programm auf den  
Mikrocontroller  
downloaden.



Montage und Programmierung  
eines Roboters für  
den Hessen SolarCup  
Disziplin: SolaRobot  
Teil 2.1: Hello World\_2

Von Charlotte und Andreas