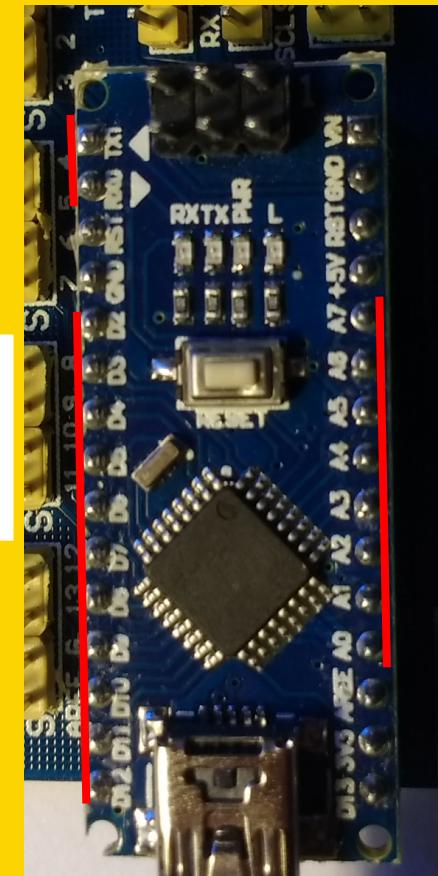
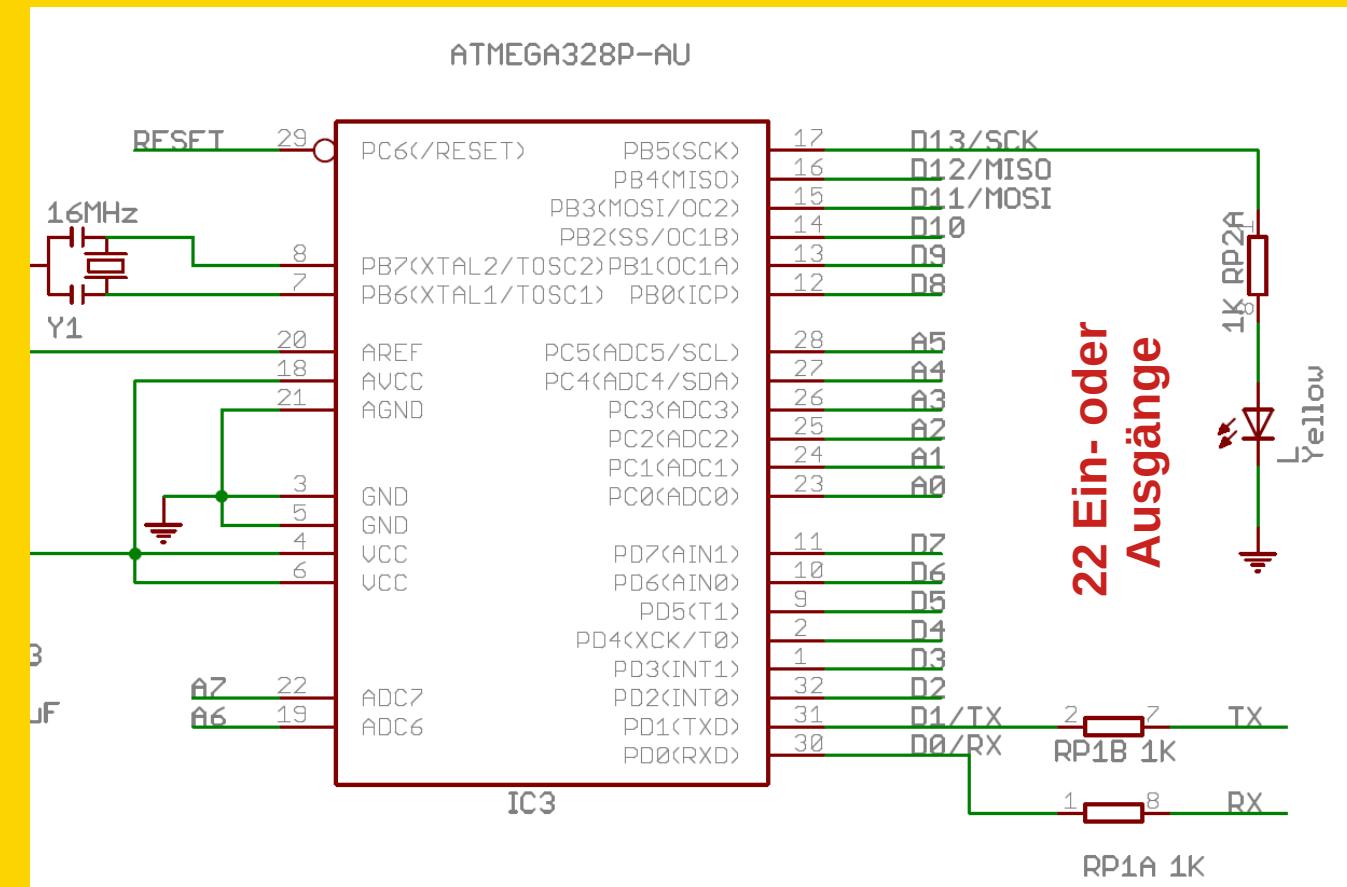


Montage und Programmierung eines Roboters für den Hessen SolarCup Disziplin: SolaRobot Teil 2.0: Hello World

Von Charlotte und Andreas

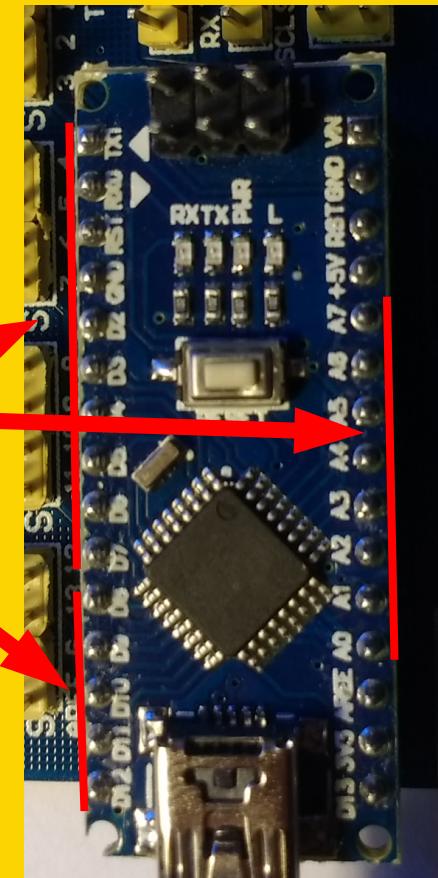
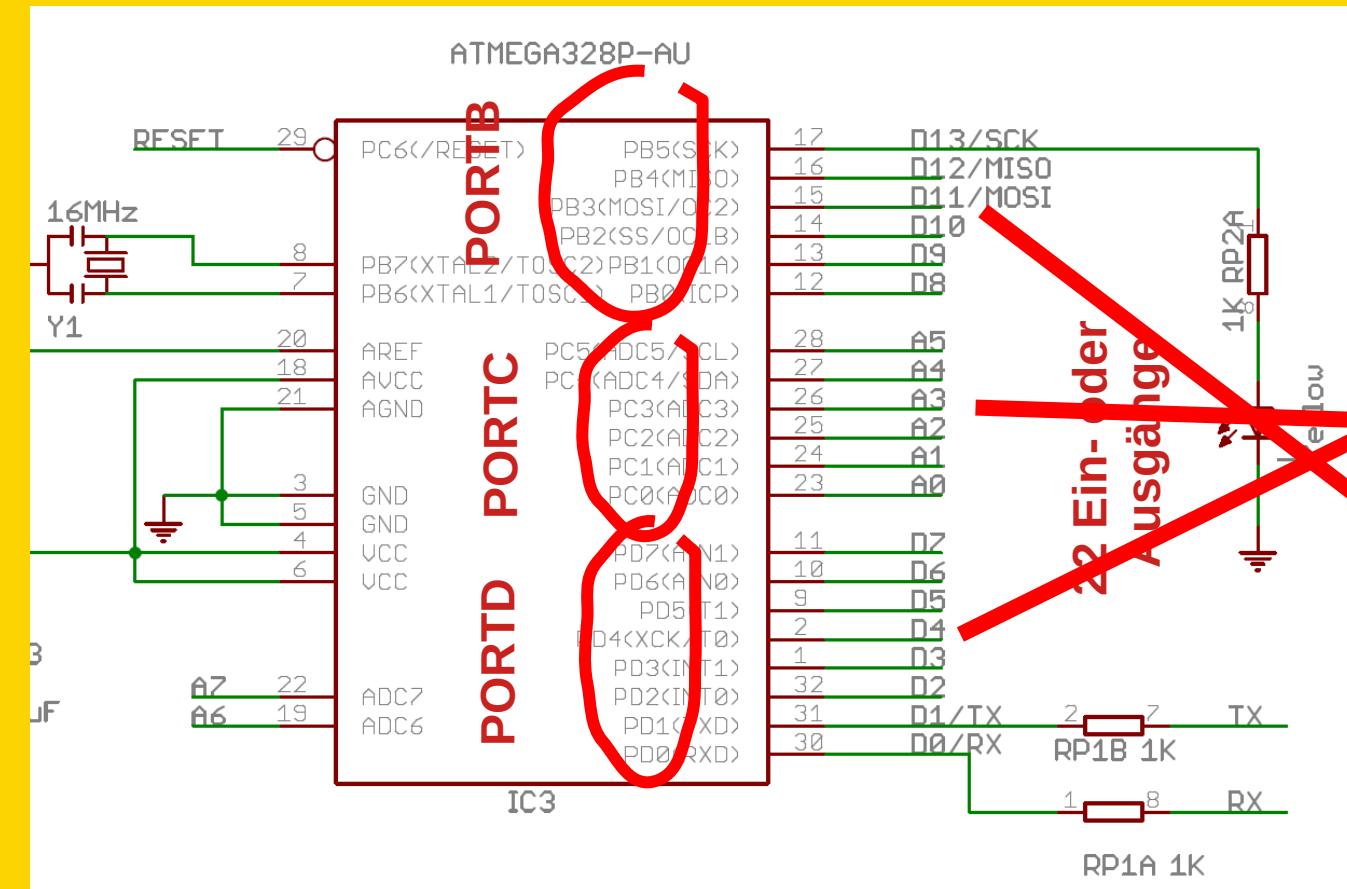
PORTS am Atmega328P



14 Pins

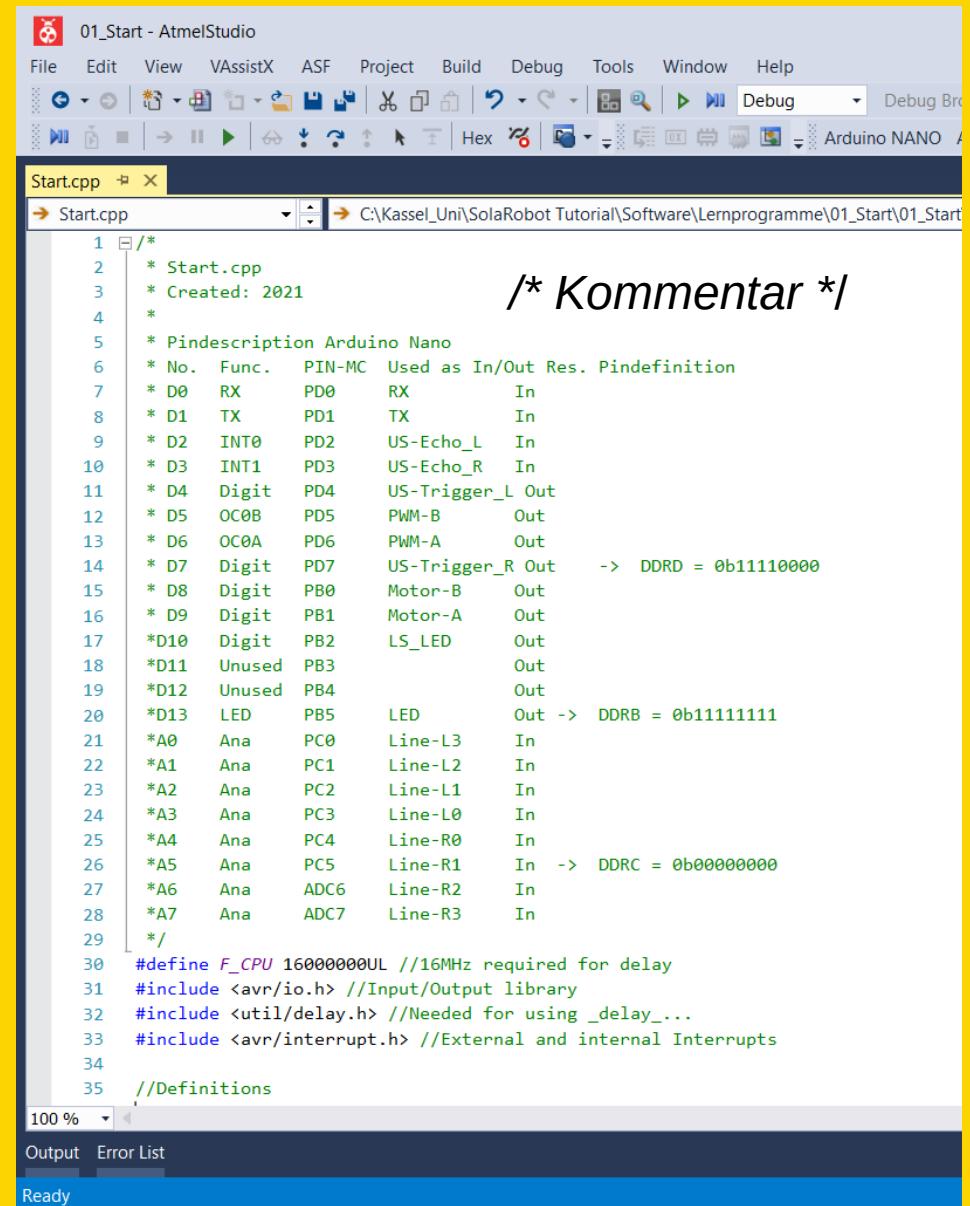
8 Pins

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



The screenshot shows the Atmel Studio interface with the project '01_Start' open. The code editor displays 'Start.cpp' with the following content:

```
01_Start - AtmelStudio
File Edit View VAssistX ASF Project Build Debug Tools Window Help
Debug
Start.cpp  x  C:\Kassel_Uni\SolaRobot Tutorial\Software\Lernprogramme\01_Start\01_Start
Start.cpp  C:\Kassel_Uni\SolaRobot Tutorial\Software\Lernprogramme\01_Start\01_Start
1  /*
2   * Start.cpp
3   * Created: 2021
4   *
5   * Pin description Arduino Nano
6   * No. Func. PIN-MC Used as In/Out Res. Pin definition
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
```

The code is a pin description for an Arduino Nano, defining pin mappings for various digital and analog pins, including the pins used for ultrasonic sensors, PWM outputs, and line sensors.

unsigned char

1 Byte bestehend aus 8 Bit

z.B.:

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

= 172

Rechner

Programmierer

0 bis 255

172

HEX AC

DEC 172

OCT 254

BIN 1010 1100

Rechner

Programmierer

255

HEX FF

DEC 255

OCT 377

BIN 1111 1111

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 tool
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

void Funktionsname (void)

z.B.: void Init (void)

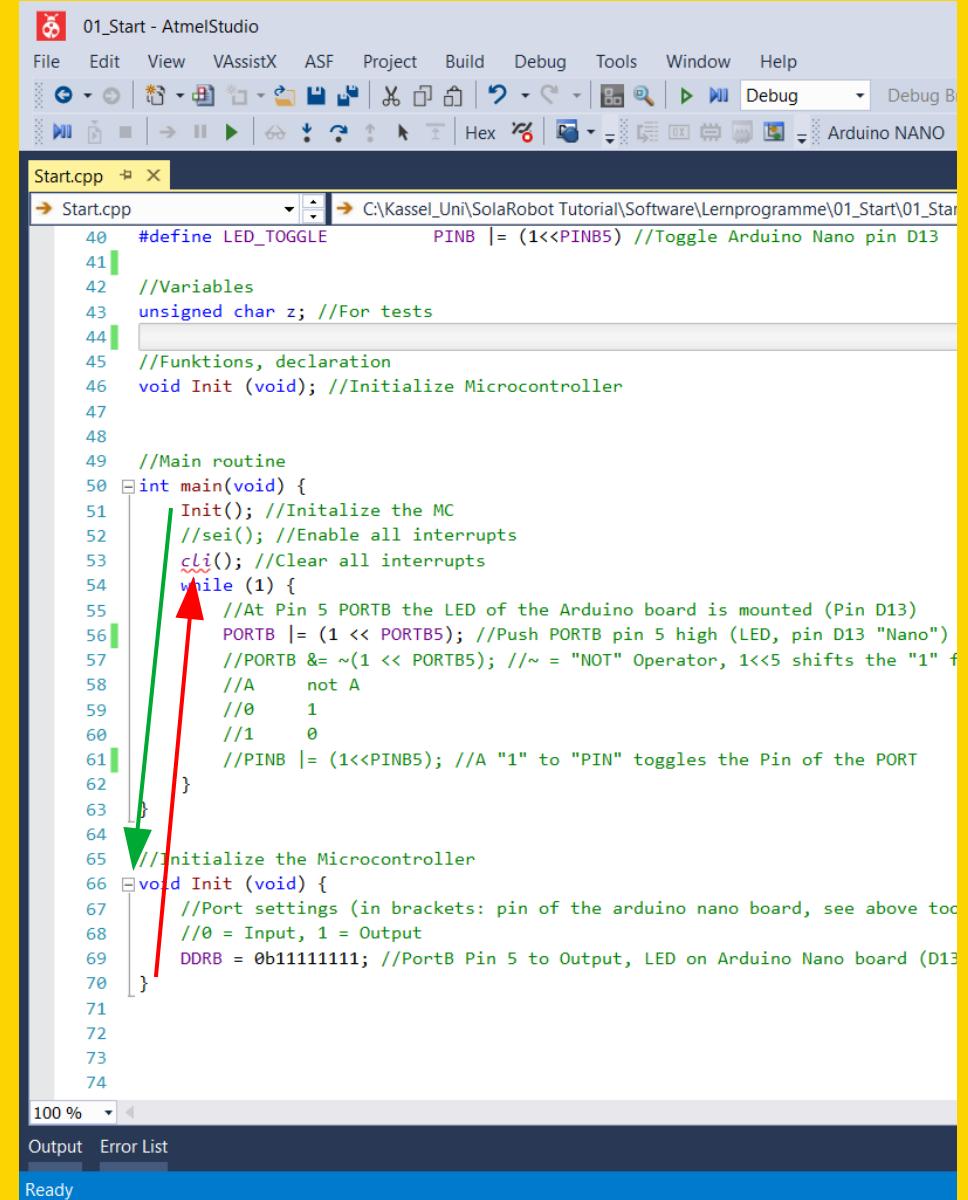
Deklaration für den Compiler im oberen Teil, vor der Hauptfunktion(main). Bekanntmachung der Funktion für den Compiler.

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 x
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 tool
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:

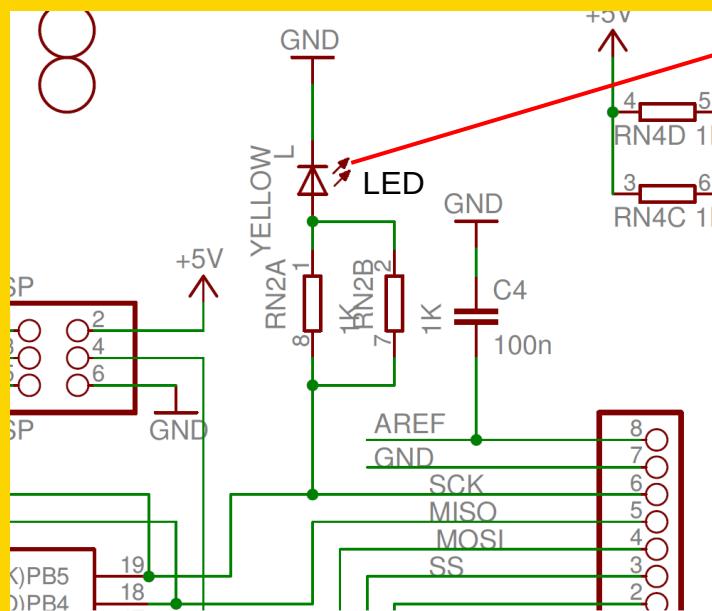
Data Direction Register für PORTB

Ob... Die folgende Ziffernfolge gibt eine Binärzahl wieder.

0b 1 1 1 1 1 1 1 1 1

Bit 5

Bit 0



```
01_Start - AtmelStudio
File Edit View VAssistX ASF Project Build Debug
Start.cpp x
Start.cpp C:\Kassel_Uni\SolaRobotT...
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 toc
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
```

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(); //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 tool
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

Beginn

Ende

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“.

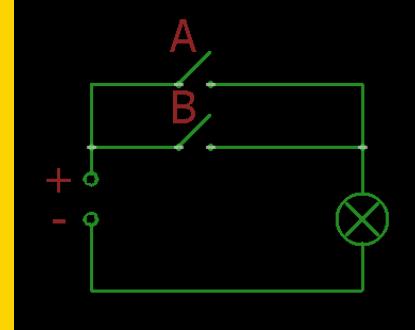
Eine Bedingung gilt dann als erfüllt, wenn sie

NICHT NULL
ist.

Wahrheitstabelle:

Oder (Or |)

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



$$\boxed{0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0} = 0$$

oder

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

ergibt

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

 = 16

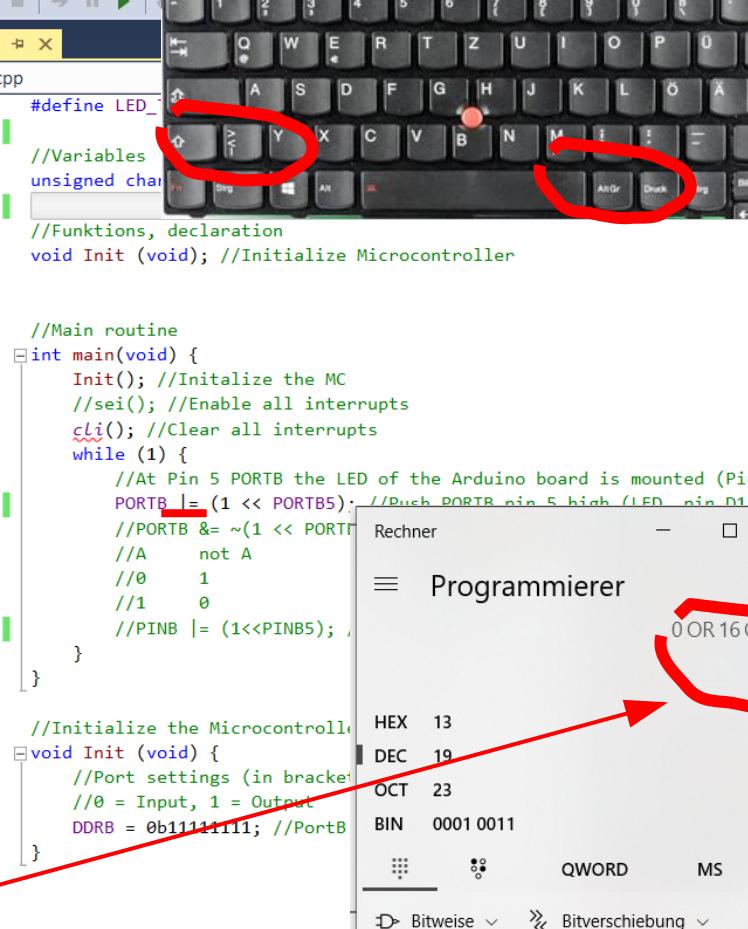
oder

$$\boxed{0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 1 \ 1} = 3$$

ergibt

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

= 19



The screenshot shows the Atmel Studio interface with a code editor displaying a C++ file named `Start.cpp`. The code initializes a microcontroller, setting pin D13 (PORTB5) high to turn on an LED. A floating calculator window titled "Programmierer" is open, showing the binary value 19 (hex 13, decimal 19, octal 23) with the text "0 OR 16 OR 3 = 19" displayed. A red arrow points from the line of code to the calculator window, indicating the result of the bitwise OR operation.

```
40 #define LED_
41 //Variables
42 unsigned char
43 //Funktions, declaration
44 void Init (void); //Initialize Microcontroller
45
46
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);
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

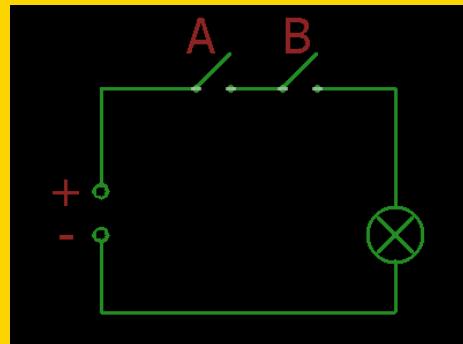
BIN 0001 0011

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(); //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 tool
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							

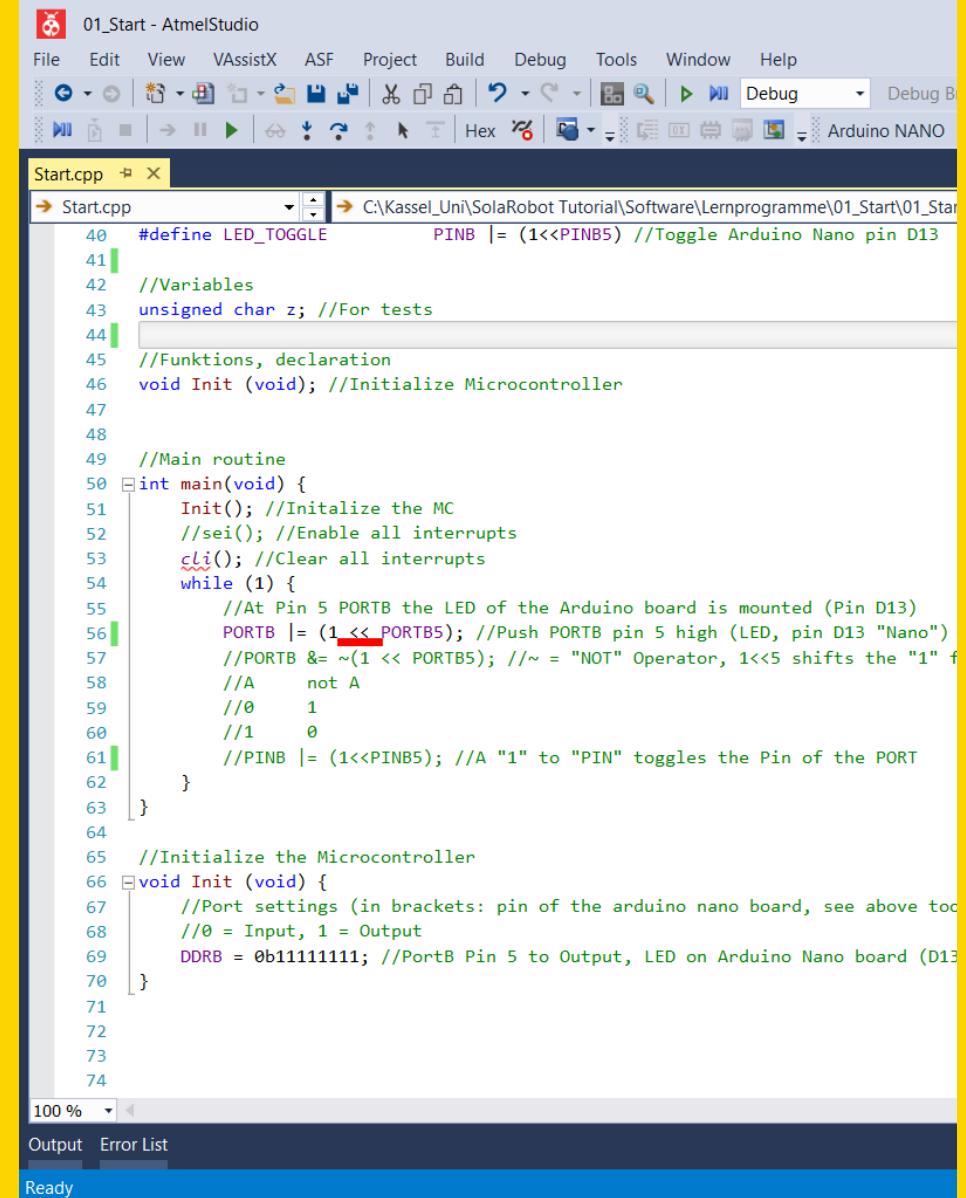
(1 << 4) eine 1 viermal nach links schieben

0	0	0	1	0	0	0	0
= 16							

| (1 << 6)

0	1	0	1	0	0	0	0
= 80							

$\text{PORTB} |= (1 << \text{PORTB}5)$ eine Abkürzung für
 $\text{PORTB} = \text{PORTB} | (1 << \text{PORTB}5)$



The screenshot shows the Atmel Studio IDE with the Start.cpp file open. The code demonstrates the use of the left shift operator (<<) to shift a bit left. The code is as follows:

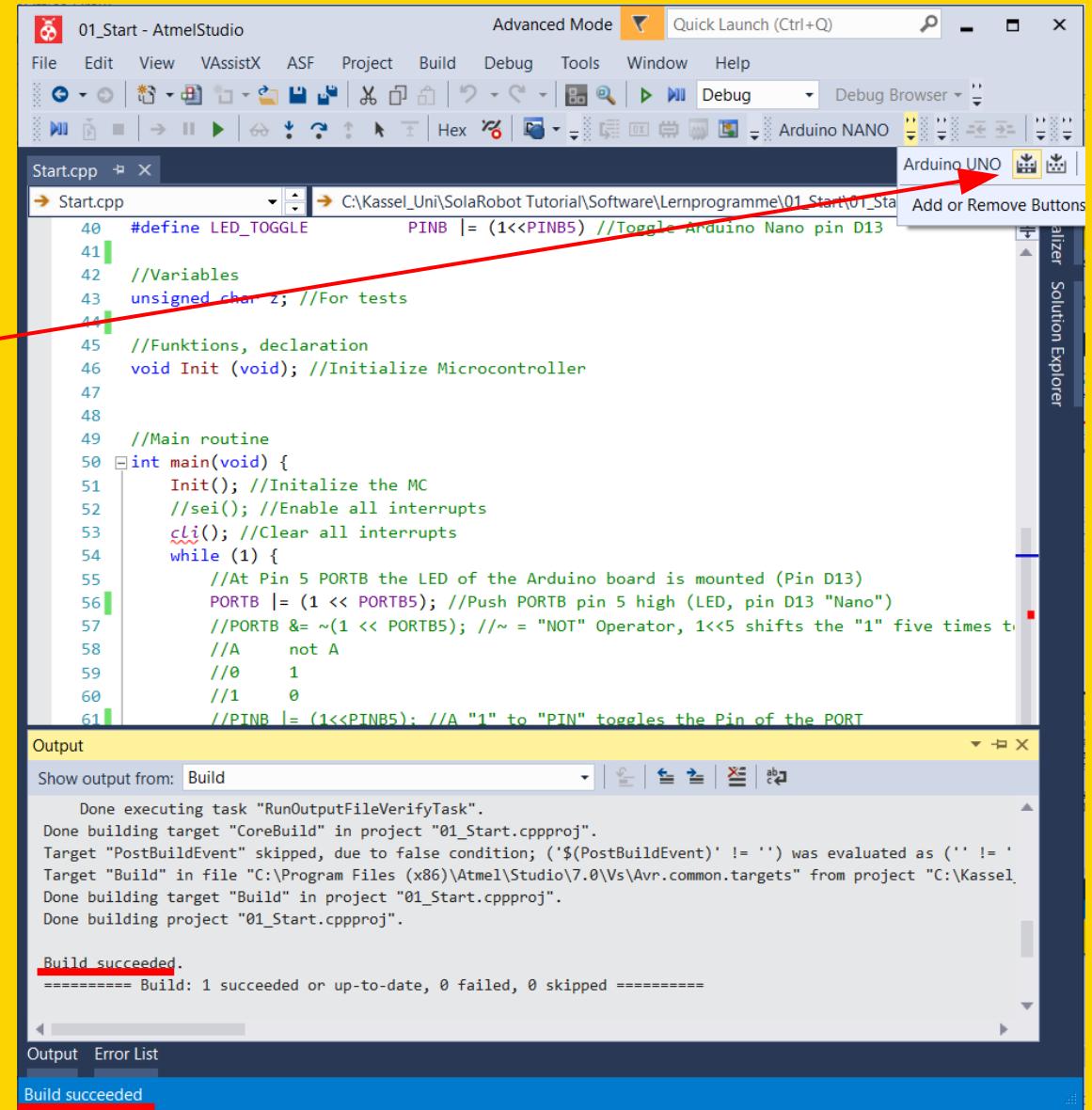
```
#define LED_TOGGLE PORTB |= (1<<PORTB5) //Toggle Arduino Nano pin D13

//Variables
unsigned char z; //For tests

//Funktions, declaration
void Init (void); //Initialize Microcontroller

//Main routine
int main(void) {
    Init(); //Initialize the MC
    sei(); //Enable all interrupts
    cli(); //Clear all interrupts
    while (1) {
        //At Pin 5 PORTB the LED of the Arduino board is mounted (Pin D13)
        PORTB |= (1<<PORTB5); //Push PORTB pin 5 high (LED, pin D13 "Nano")
        //PORTB &= ~(1<<PORTB5); //~ = "NOT" Operator, 1<<5 shifts the "1" f
        //A not A
        //0 1
        //1 0
        //PINB |= (1<<PINB5); //A "1" to "PIN" toggles the Pin of the PORT
    }
}

//Initialize the Microcontroller
void Init (void) {
    //Port settings (in brackets: pin of the arduino nano board, see above table)
    //0 = Input, 1 = Output
    DDRB = 0b11111111; //PortB Pin 5 to Output, LED on Arduino Nano board (D13)
}
```



01_Start - AtmelStudio

Advanced Mode Quick Launch (Ctrl+Q)

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.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(); //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`

58 `//A not A`

59 `//0 1`

60 `//1 0`

61 `//PINB |= (1<<PINB5); //A "1" to "PIN" toggles the Pin of the PORT`

Output

Show output from: Build

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_University\SolaRobot Tutorial\Software\Lernprogramme\01_Start\01_Start.cppproj".

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 =====

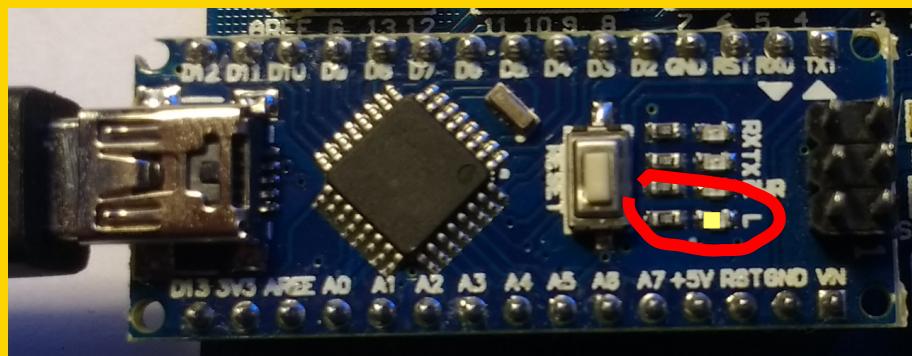
Output Error List

Build succeeded

Compilieren:

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

Flashen:
das Programm auf den
Mikrocontroller
downloaden.



01_Start - AtmelStudio

Advanced Mode Quick Launch (Ctrl+Q) Debug Browser Arduino NANO Go

Start.ape Start.cpp Kassel_Uni\SolaRobot Tutorial\Software\Lernprogramme\01_Start\01_Start\Start.cpp

```
43 //Variables
44 unsigned char z; //For tests
45
46
47 //Funktions, 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 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

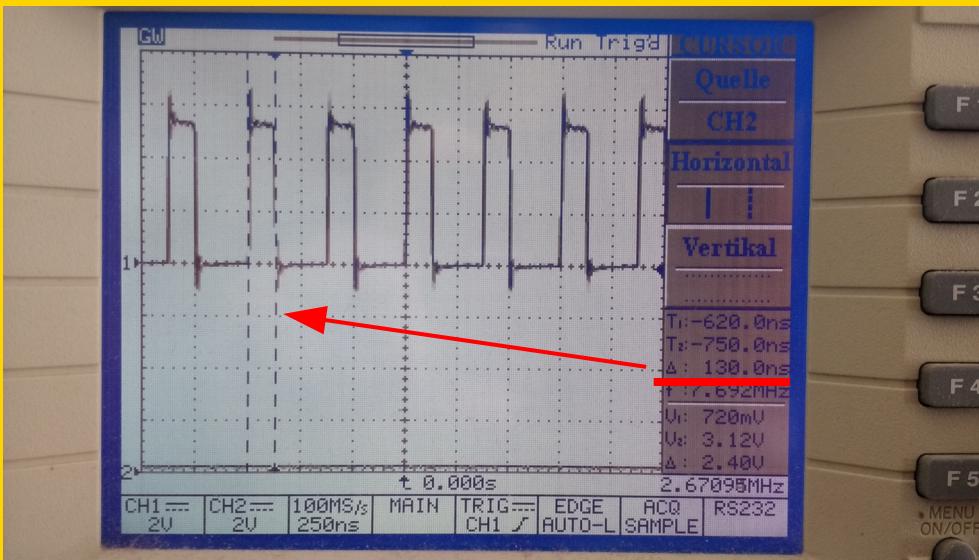
```
avrduke.exe: reading on-chip flash data:
Reading | ##### | 100% 0.05s
avrduke.exe: verifying ...
avrduke.exe: 160 bytes of flash verified
```

avrduke.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

Startcpp x

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 //Funktions, 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 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 }
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

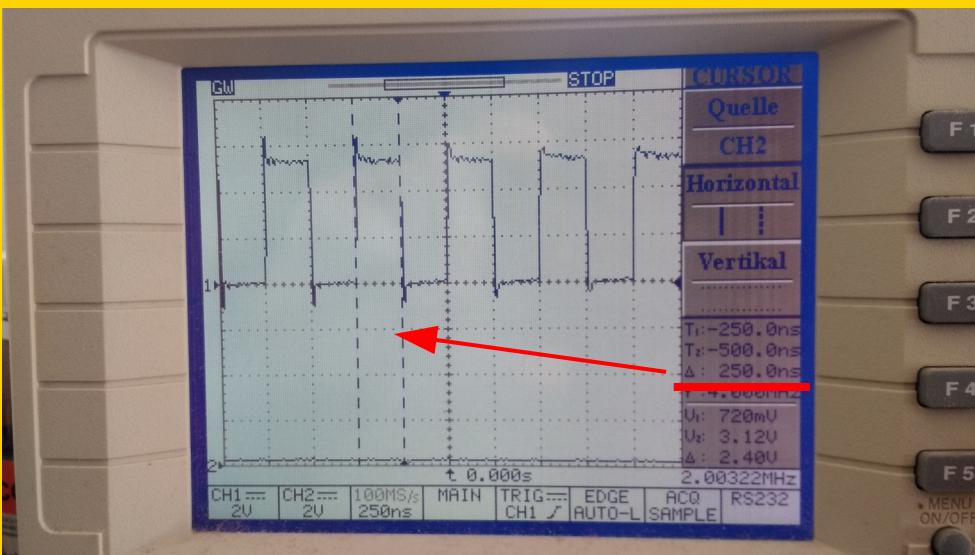
Ready Ln 34 Col 1 Ch 1

Auskommentieren:

Eine Zeile aus dem Programm nehmen.

Kommentar aufheben:

Eine Zeile ins Programm aufnehmen.

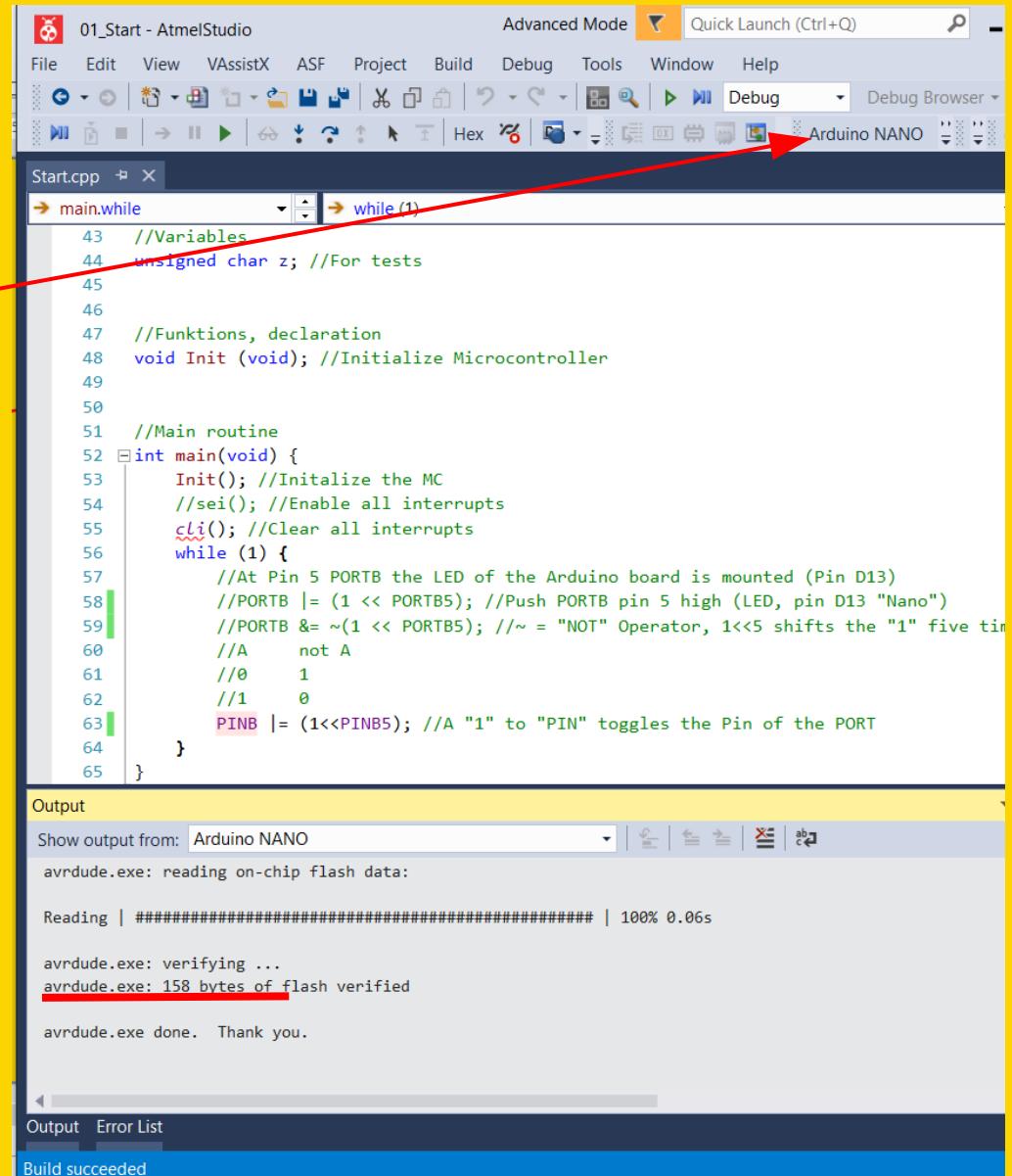


The figure shows the Atmel Studio interface with the file 'Start.cpp' open. The code editor displays the following C++ code:

```
01_Start - AtmelStudio
Advanced Mode Quick Launch (Ctrl+Q)
File Edit View VAssistX ASF Project Build Debug Tools Window Help
Start.cpp* main.while while (1)
43 //Variables
44 unsigned char z; //For tests
45
46
47 //Funktions, 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
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
75
76
```

Two red arrows point to the line of code 'PINB |= (1<<PINB5);' in the code editor. The status bar at the bottom of the Atmel Studio window shows 'Ready'.

Flashen:
das Programm auf den
Mikrocontroller
downloaden.



01_Start - AtmelStudio

File Edit View VAssistX ASF Project Build Debug Tools Window Help

Advanced Mode Quick Launch (Ctrl+Q)

Debug Browser

Start.cpp

main.while

```
43 //Variables
44 unsigned char z; //For tests
45
46 //Funktions, declaration
47 void Init (void); //Initialize Microcontroller
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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

```
avrduke.exe: reading on-chip flash data:
Reading | ##### | 100% 0.06s

avrduke.exe: verifying ...
avrduke.exe: 158 bytes of flash verified

avrduke.exe done. Thank you.
```

Output Error List

Build succeeded

Montage und Programmierung eines Roboters für den Hessen SolarCup Disziplin: SolaRobot Teil 2.1: Hello World_2

Von Charlotte und Andreas