mbed

mbed - der schnellste Einstieg in Web-basierte Steuerung und Regelung

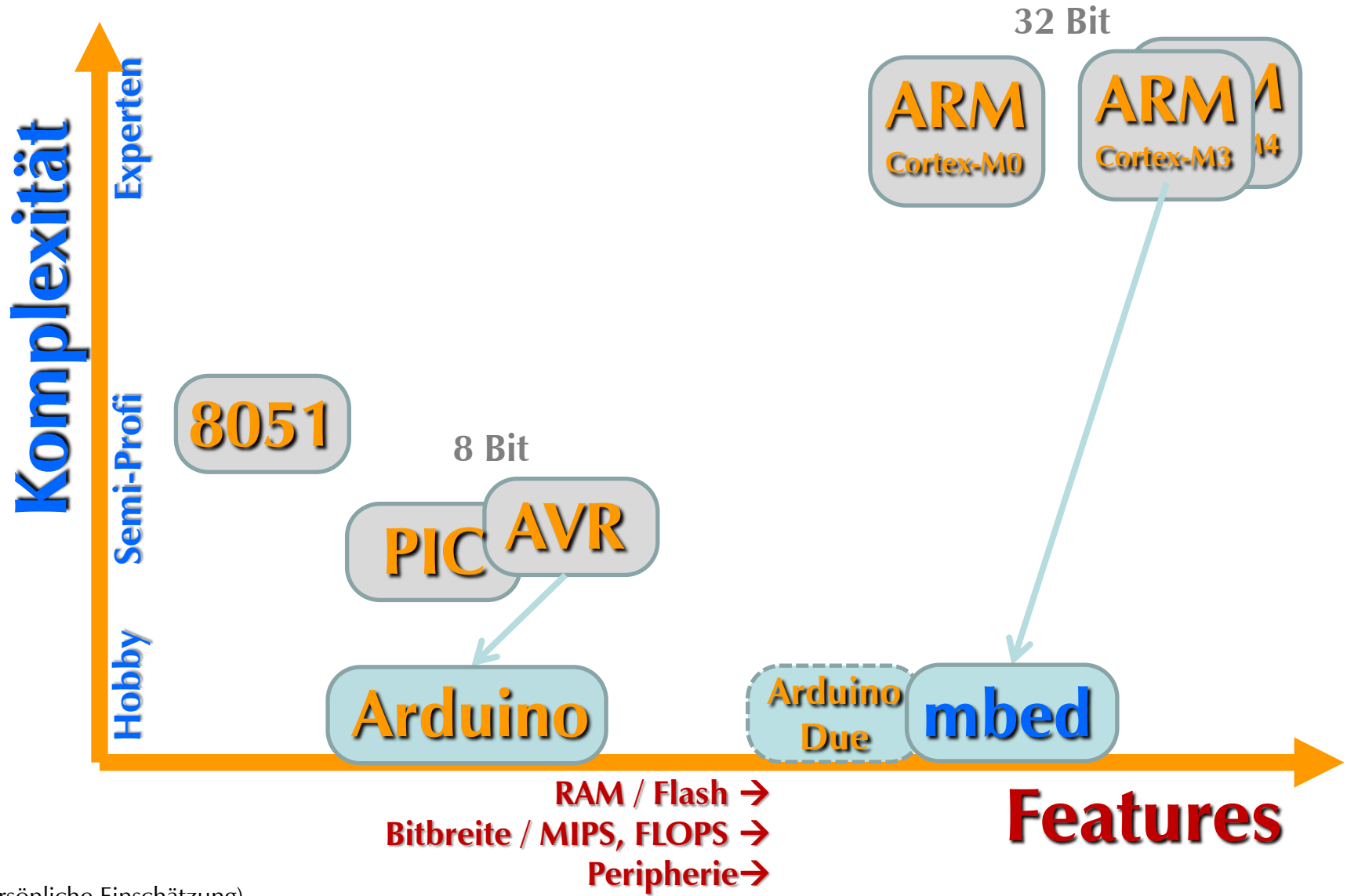
KNF-Kongress 2012 - Jochen Krapf

Agenda

- mbed ?!
- Typische Anwendungen
- Entwicklungsumgebung
- Libraries
- Mit mbed ins Netz
- Referenzen

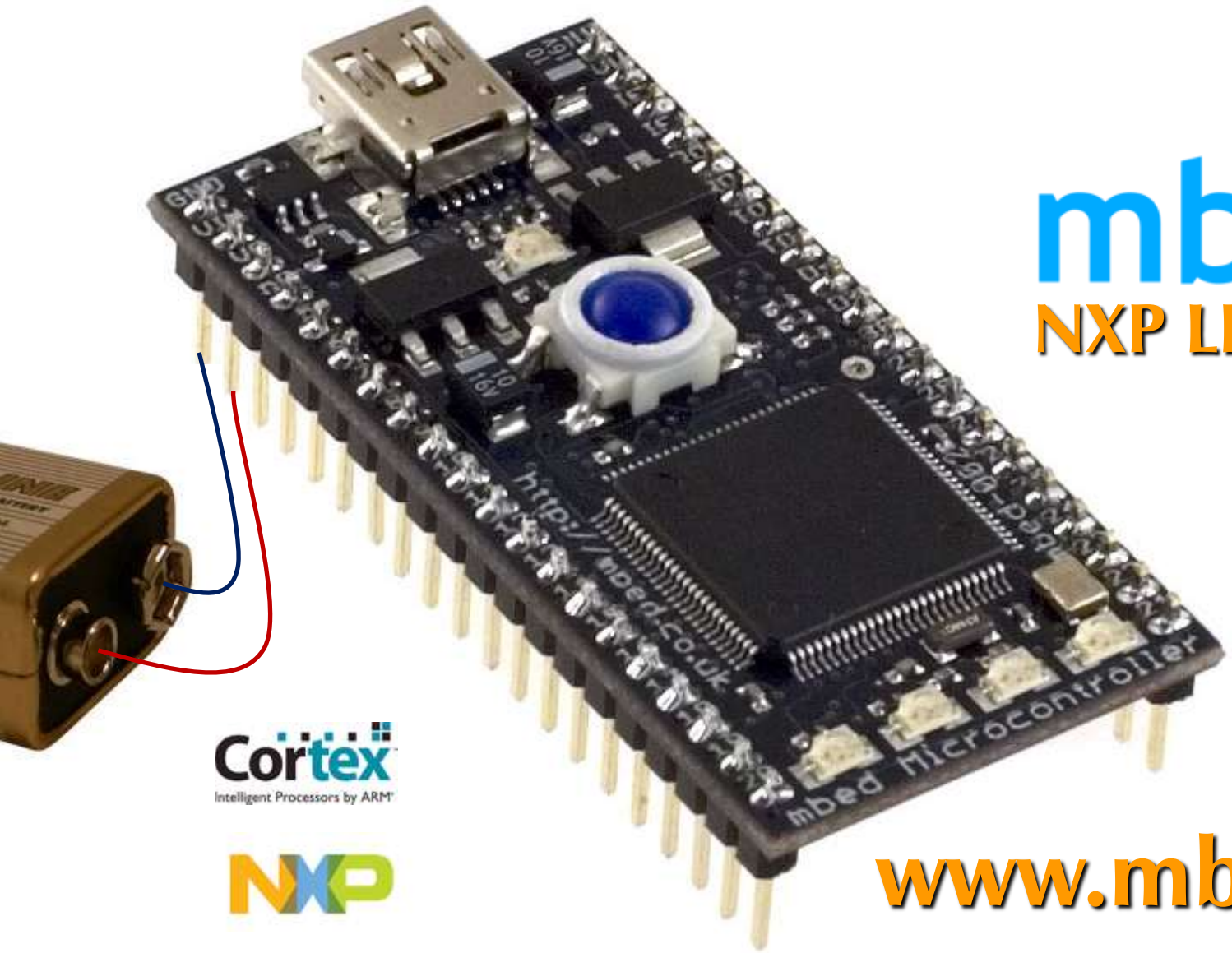
- Internet of Things (2. Teil)

mbed → System-Auswahl



(persönliche Einschätzung)

mbed → Modul



mbed

NXP LPC1768

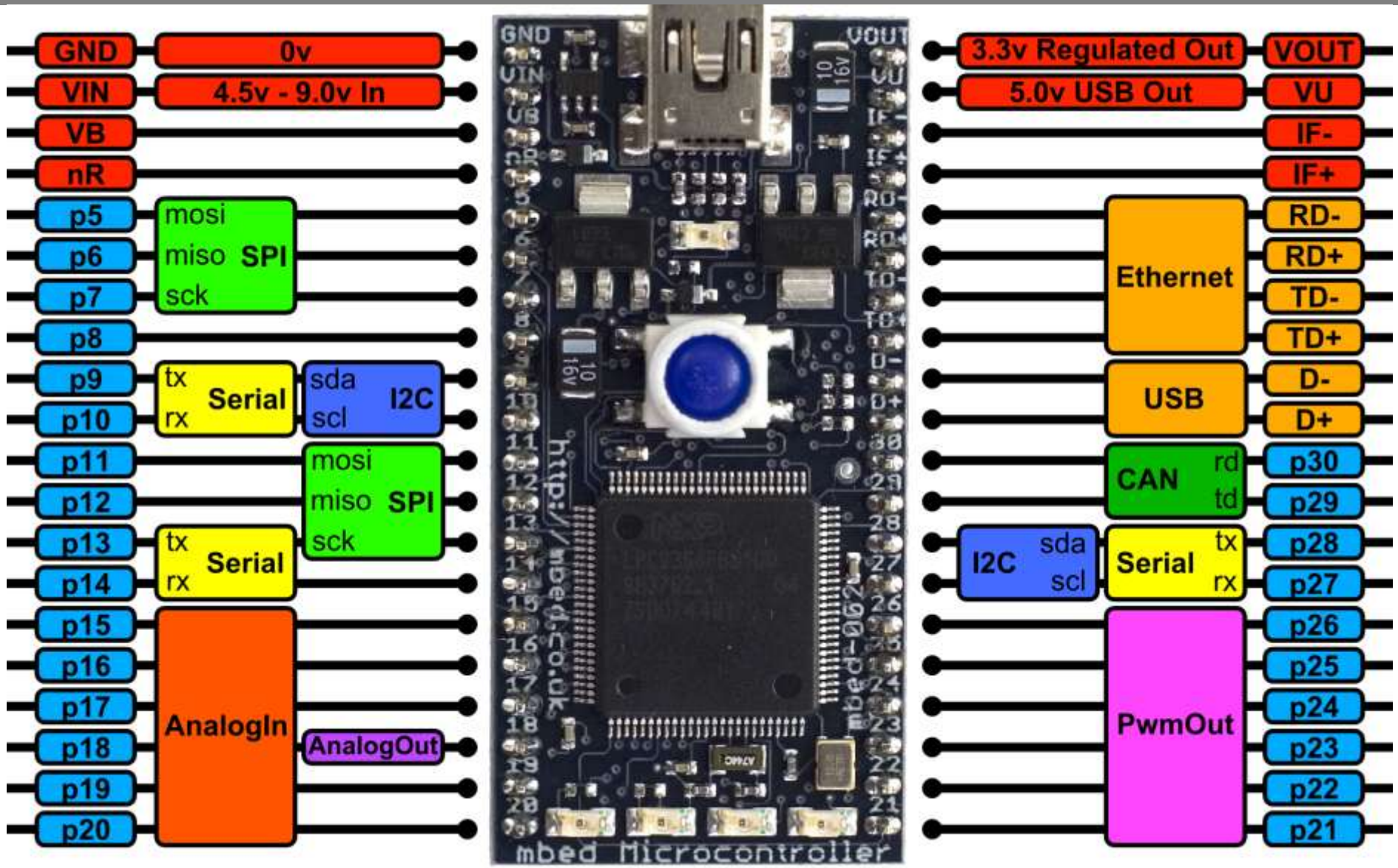
Cortex

Intelligent Processors by ARM

NXP

www.mbed.org

Mbed → Pinout


GND
0v
VIN
4.5v - 9.0v In
VB
nR
p5
mosi
p6
miso SPI
p7
sck
p8
p9
tx
p10
rx Serial
sda
scl I2C
p11
mosi
p12
miso SPI
p13
sck
tx
p14
rx Serial
p15
p16
p17
AnalogIn
p18
AnalogOut
p19
p20
3.3v Regulated Out
VOUT
5.0v USB Out
VU
IF-
IF+
RD-
Ethernet
RD+
TD-
TD+
D-
USB
D+
p30
CAN rd
td
p29
p28
I2C sda
scl
Serial tx
rx
p27
p26
p25
PwmOut
p24
p23
p22
p21
http://mbed.co.uk
mbed-0021
mbed Microcontroller

mbed → Features HW

Feature	mbed	Arduino Uno
CPU	ARM Cortex-M3	ATmega328
Takt	96MHz	16MHz
RAM	32kB	2kB
FLASH	512kB	32kB
I/O	3,3V (5V tol.) mit 40mA	
Analog-In	0…3,3V	=
On-Board	Eth.Phy, RTC, CAN, DC/DC…	
Pinout	Raster 2,54mm	Proprietär

mbed → Features SW

Feature	mbed	Arduino Uno
Code	C++	ähnlich C
Compiler	Online	Java-Prog.
Ext.Compiler	ja (Keil, IAR, GCC)	-
SdtLib…	ja	-
RTOS	ja	
…		
…		
Community	ja	ja

mbed → Konzept CMSIS

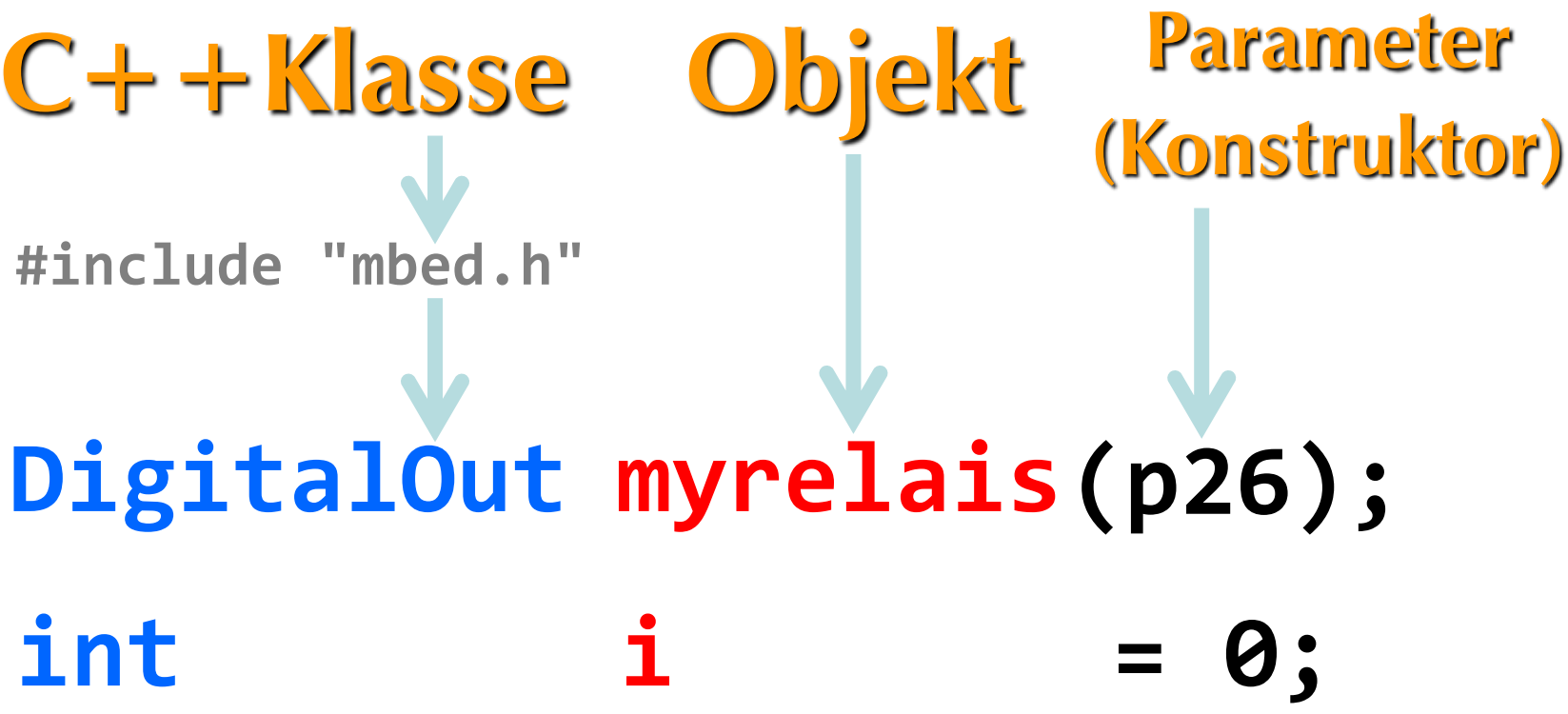
(CMSIS = Cortex Microcontroller Software Interface Standard)

```
void setPWM(int width, int period){
    LPC_SC->PCONP |= (1 << 6); // PWM1 power on
    LPC_SC->PCLKSEL0 |= (1 << 12); // Divide CCLK by 1 for PWM1
    LPC_PINCON->PINSEL4  |= 1; // DIP26 = pin P2.0, set to PWM1.1
    LPC_PINCON->PINMODE4 |= 2; // enable neither pull up nor pull down.
    LPC_PWM1->TCR = 0; // reset PWM
    LPC_PWM1->MCR = 0; // no interrupts (set for no interrupts by default)
    LPC_PWM1->MR0 = period; // set pulse period in clock cycles
    LPC_PWM1->MCR |= 1 << 1; // Reset timer on Match0
    LPC_PWM1->MR1 = width; // set pulse width in clock cycles
    LPC_PWM1->LER = 3; // make match register writes effective for MR0+MR1
    LPC_PWM1->PCR |= (1 << 9); // enable PWM1 output, single edge mode
    LPC_PWM1->TC = 0; // clear timer counter
    LPC_PWM1->PC = 0; // clear prescale counter
    LPC_PWM1->PR = 0; // clear prescale register
    LPC_PWM1->TCR = 8+1; // enable PWM mode and PWM timer counter
}
```

Nur für Experten!

mbed → Konzept C++

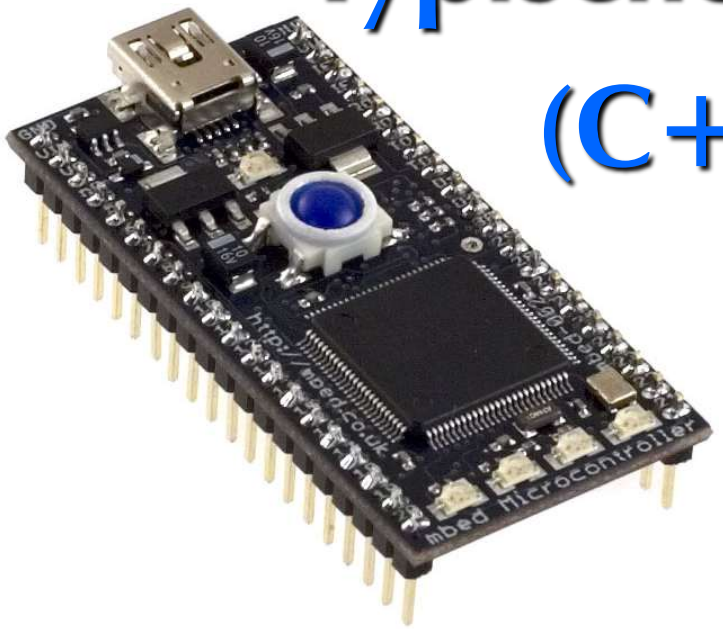
Für ALLES gibt es eine Klasse...



mbed → Konzept C++

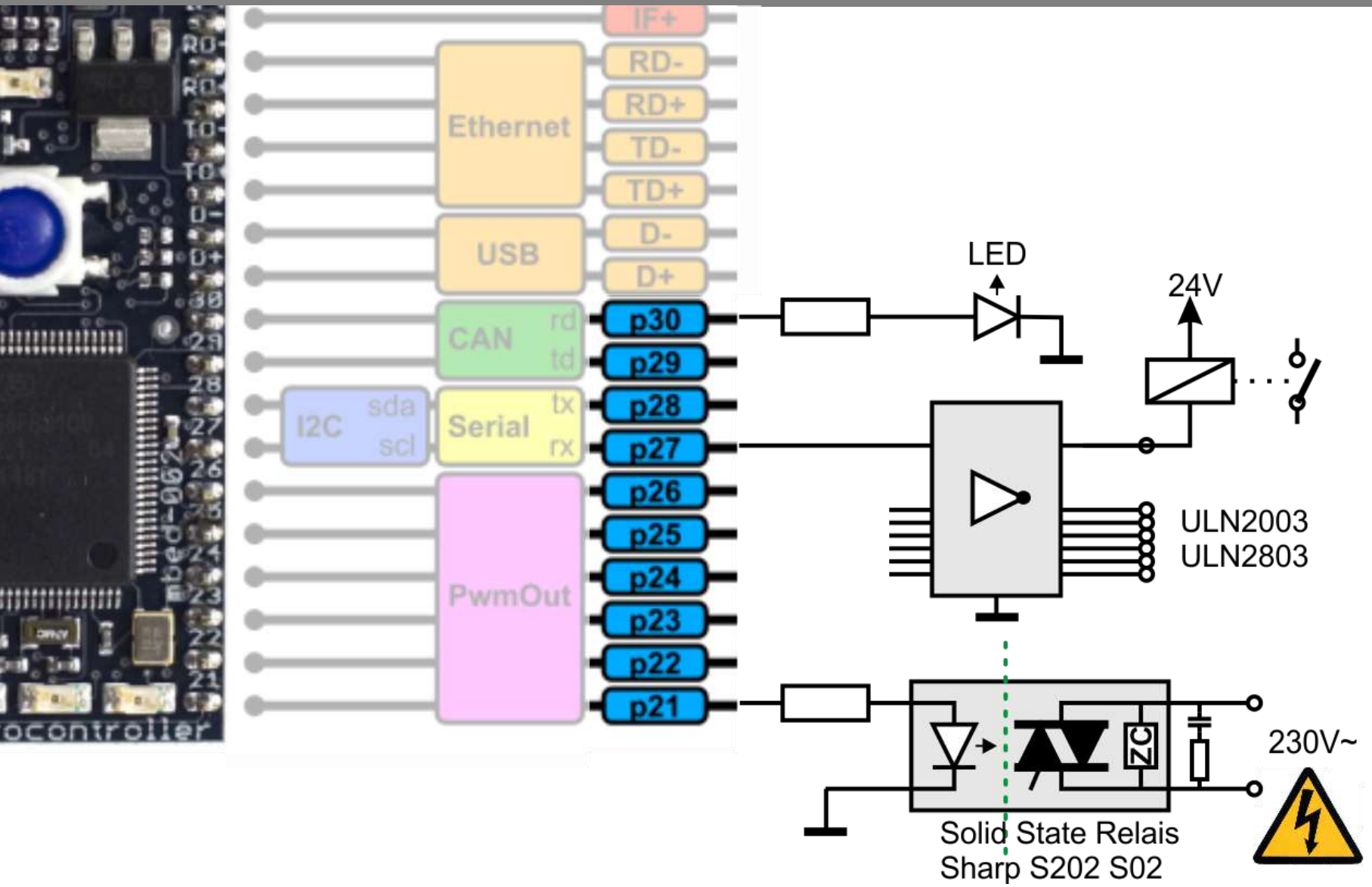
```
#include "mbed.h"
int main() {

//  <Class>    <Object>(<Parameter>);
    DigitalOut myrelais(p26);

//  <Object>.<Method>(<Parameter>);
    myrelais.write(1);

//  <Object> = <Value>;
    myrelais = 1;                  // operator=() ---> .write(1)

//  <Variable> = <Object>.<Method>(<Parameter>);
    i          = myrelais.read();

//  <Variable> = <Object>;
    i          = myrelais;         // int operator() ---> .read()
}
```

Beispiele



Typische Anwendungen (C++ Klassen)

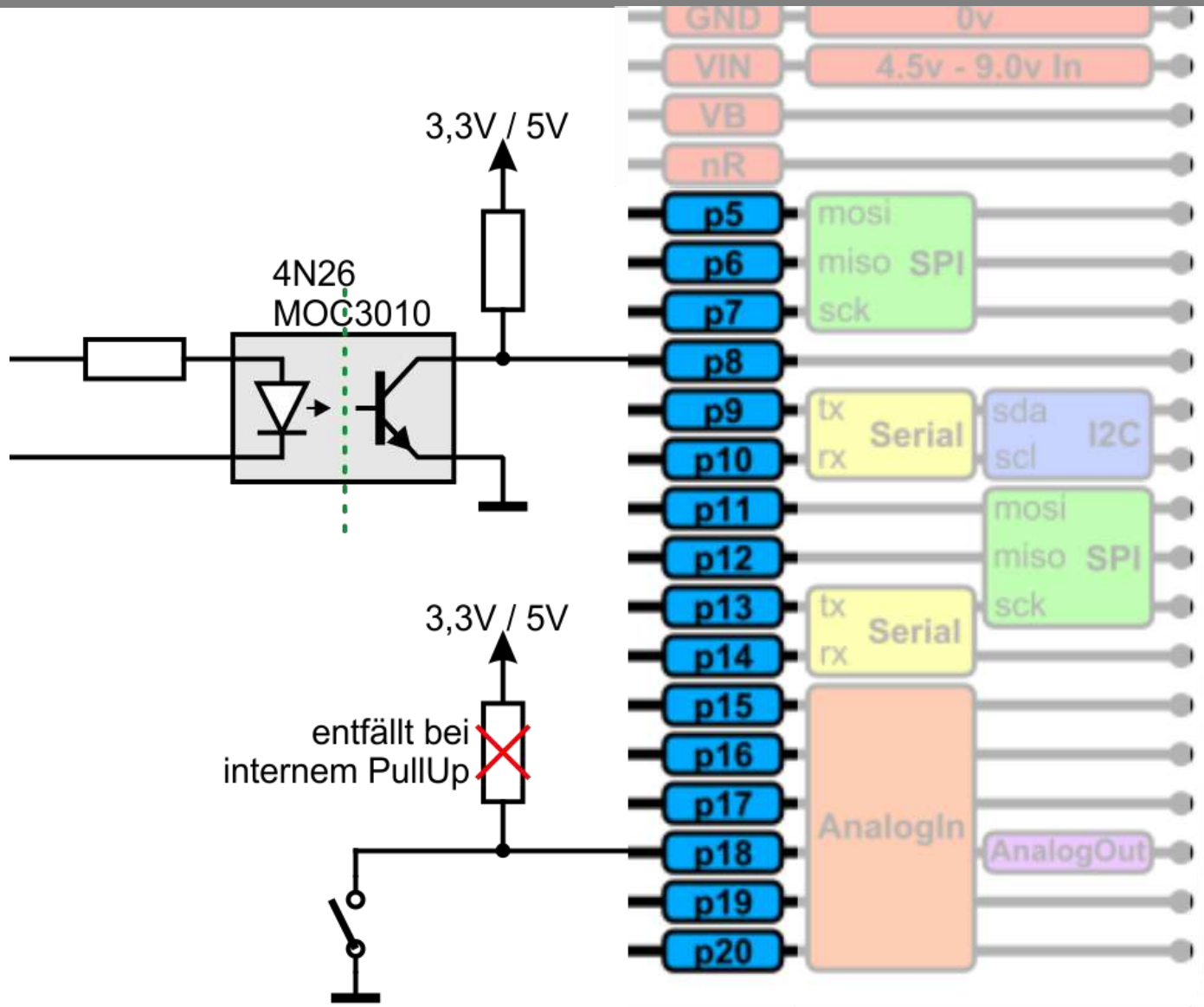
Beispiele → Digital-Out

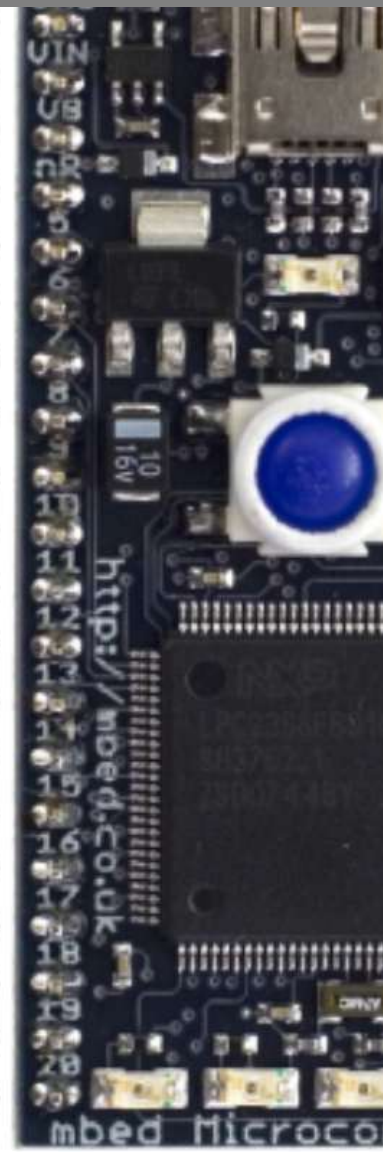


Beispiele → Digital Out C++

```
1  #include "mbed.h"
2  int main() {
3      // Relais und Solid-State-Relais
4      DigitalOut relais(p27);
5      DigitalOut SSR(p21);
6
7      relais.write(1);              // oder auch   relais = 1;
8      SSR = 0;                      // entspricht  SSR.write(0);
9
10     // Blink-LED
11     DigitalOut led(p30);
12
13     while(1) {
14         led = !led;               // entspricht  led.write( !led.read() );
15         wait(0.5);
16         }
17 }
18
19
```

Beispiele → Digital-In





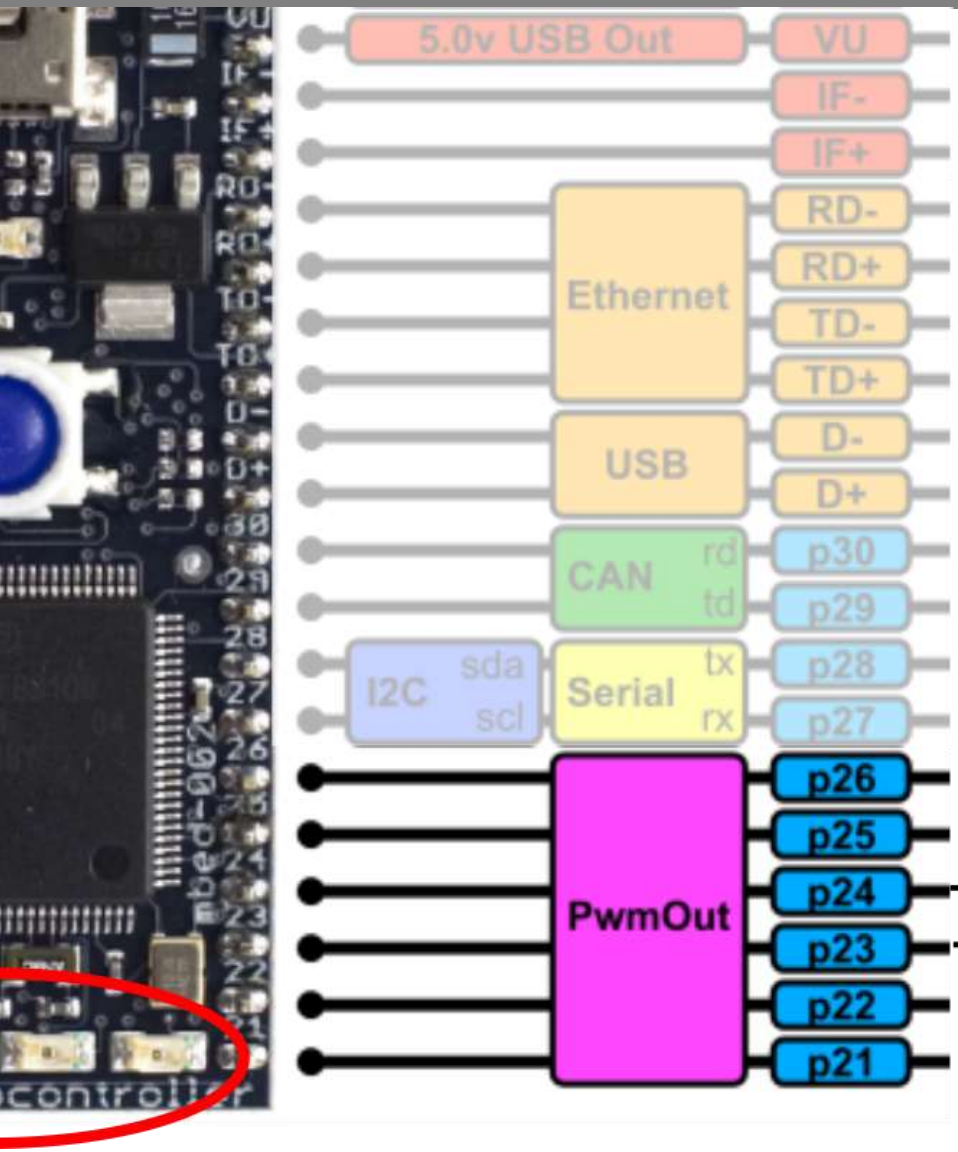
Beispiele → Digital In C++

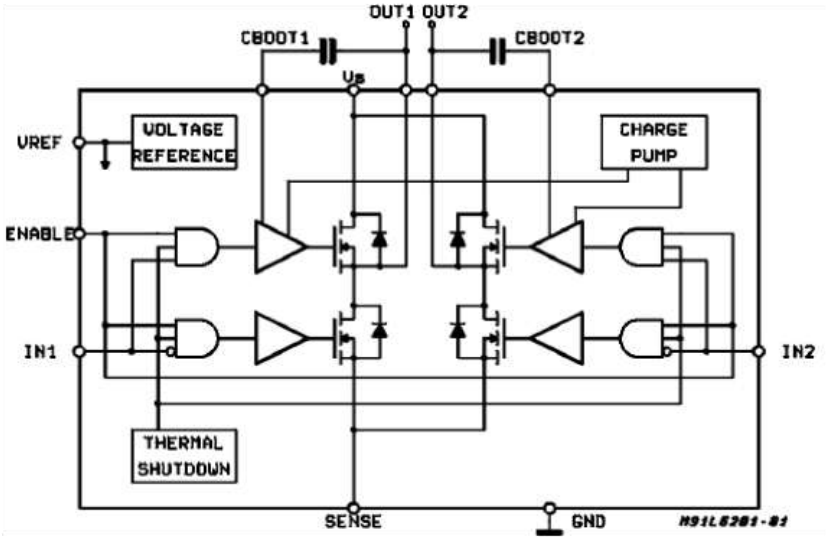
```
1  #include "mbed.h"
2  int main() {
3
4  // Taster
5      DigitalIn taster(p18);
6
7      taster.mode ( PullUp );
8
9      int i = taster;              // entspricht  taster.read();
10
11     if ( taster == 0 )
12     {
13         // ...
14     }
15
16     funktion_abc ( taster );
17 }
18
19
```

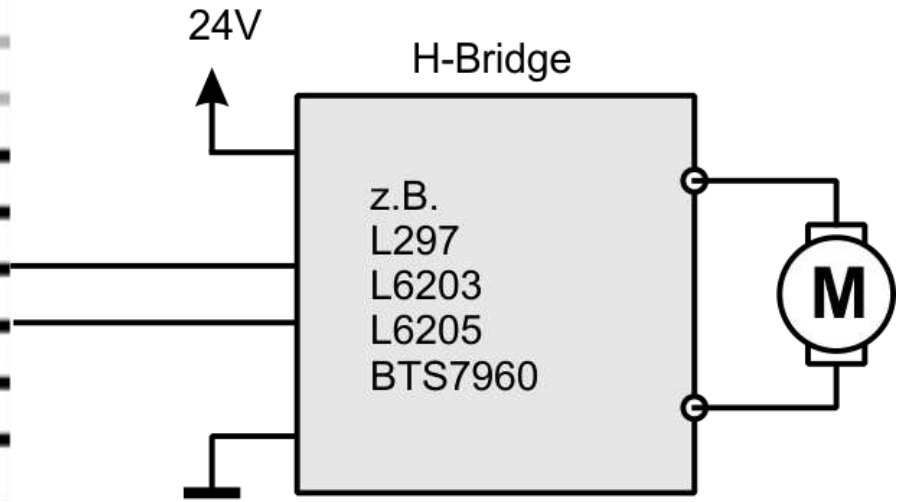
Beispiele → Digital In C++

```
1  #include "mbed.h"
2
3  // Taster
4  InterruptIn taster(p26);
5
6  // ISR (Interrupt Service Routine)
7  void callback() {
8      // ...
9  }
10
11 int main() {
12
13     taster.mode ( PullUp );
14     taster.fall ( &callback );          // attach ISR
15
16     while(1) {}   //Endlosschleife
17 }
18
19
```

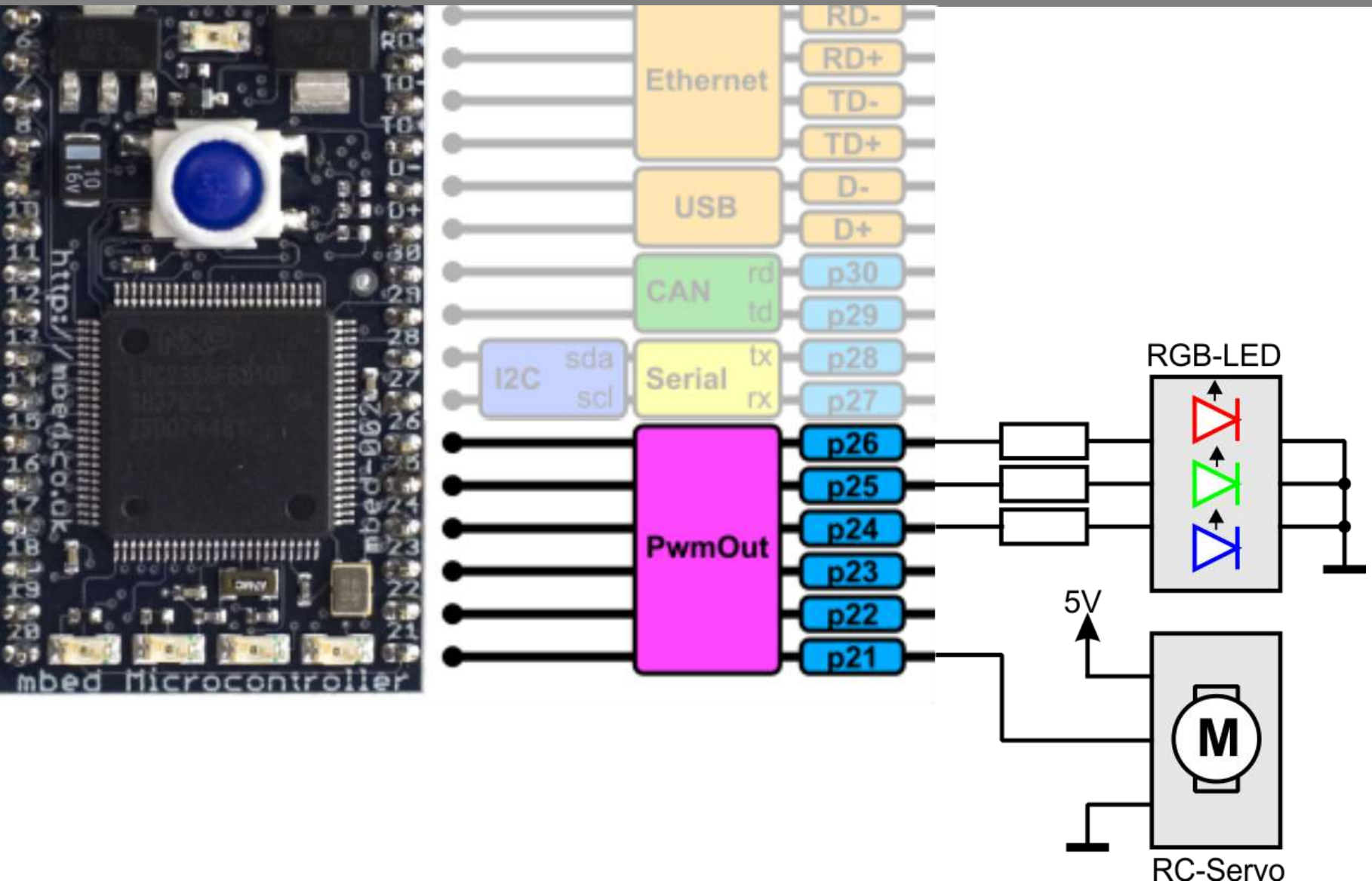
Beispiele → PWM (Pulsweiten-Modulation)







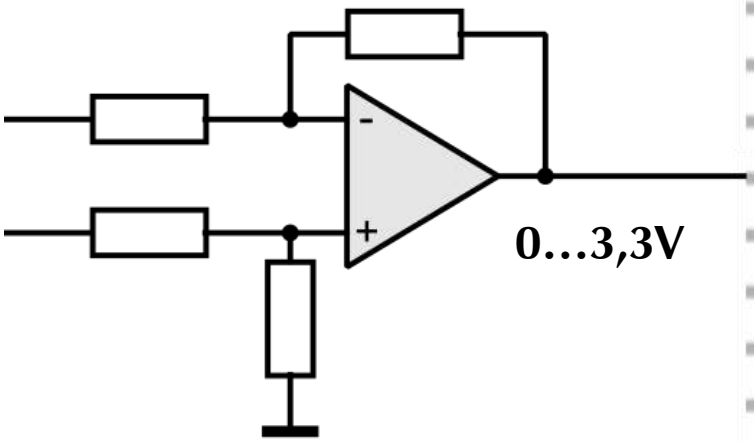
Beispiele → PWM (Pulsweiten-Modulation)

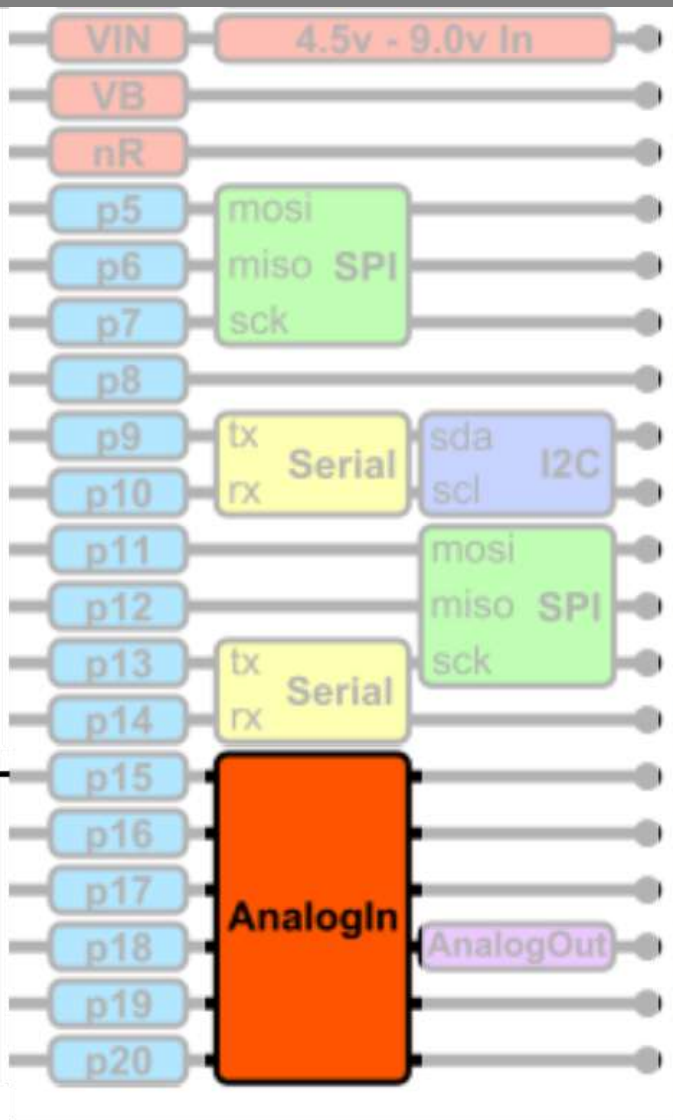


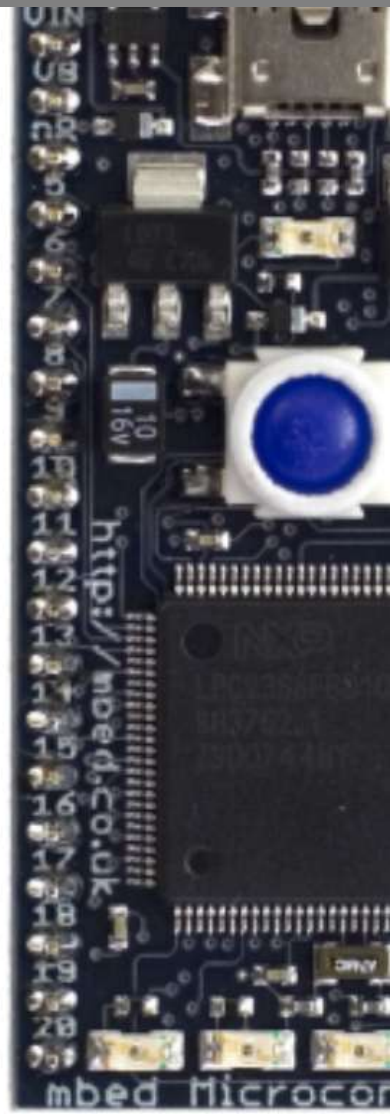
Beispiele → PWM C++

```
1  #include "mbed.h"
2  int main() {
3  // RGB-LED auf orange
4      PwmOut ledR(p26), ledG(p25), ledB(p24);
5
6      ledR = 1.0; // 100%          // == ledR.write(1.0);
7      ledG = 0.7; //  70%
8      ledB = 0.0; //   0%
9
10 // RC-Servo
11     PwmOut servoRC(p21);
12
13     servoRC.period_ms(20);       // == servoRC.period(0.020);
14
15     // RC-Servo in Mittelstellung
16     float value = 0.5;           // 0...1
17     servoRC.pulsewidth(0.001 + 0.001*value);
18 }
19
```

Beispiele → Analog-In



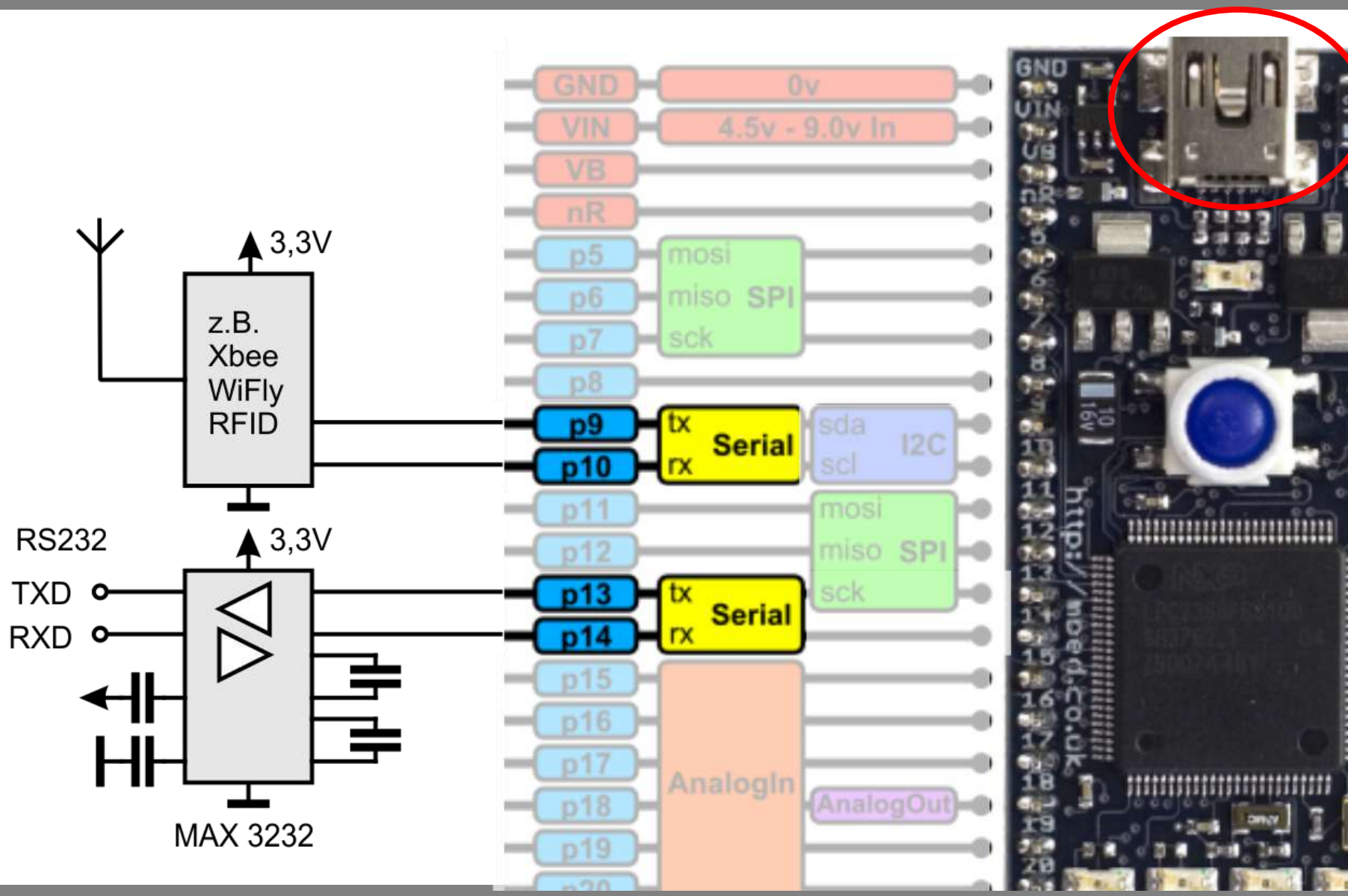




Beispiele → Analog In C++

```
1  #include "mbed.h"
2  int main() {
3  // Analog In
4      AnalogIn ain1(p18), ain2(p19);
5
6      float value = ain1.read();
7
8      PwmOut pwm(p21);
9      while (1) {
10         pwm = pow(ain1, 1.2f) + ain2;
11     }
12
13     unsigned short samples[1024];
14     for(int i=0; i<1024; i++) {
15         samples[i] = ain1.read_u16();
16         wait_ms(0.1);
17     }
18 }
19
```

Beispiele → Serielle (RS232, V24)



Beispiele → Serielle C++

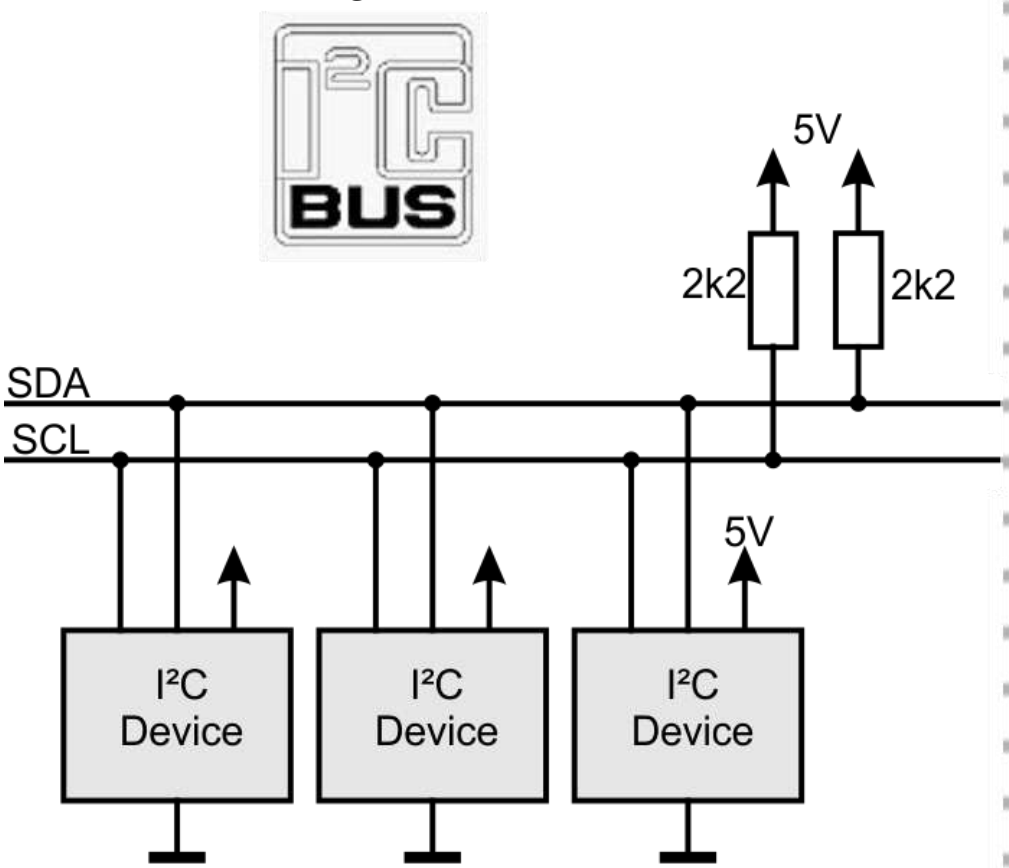
```
1  #include "mbed.h"
2  int main() {
3  // Virtuelle Serielle
4      Serial pc(USBTX, USBRX); // tx, rx
5
6      pc.printf("Hello World!");
7
8  // Serielle zu Device
9      Serial sensor(p9, p10); // tx, rx
10
11     sensor.baud(19200);
12     sensor.format(8, Serial::Odd, 1);
13
14     sensor.putc('X');
15     while ( sensor.readable() ) {
16         int i = sensor.getc();
17     }
18 }
19
```

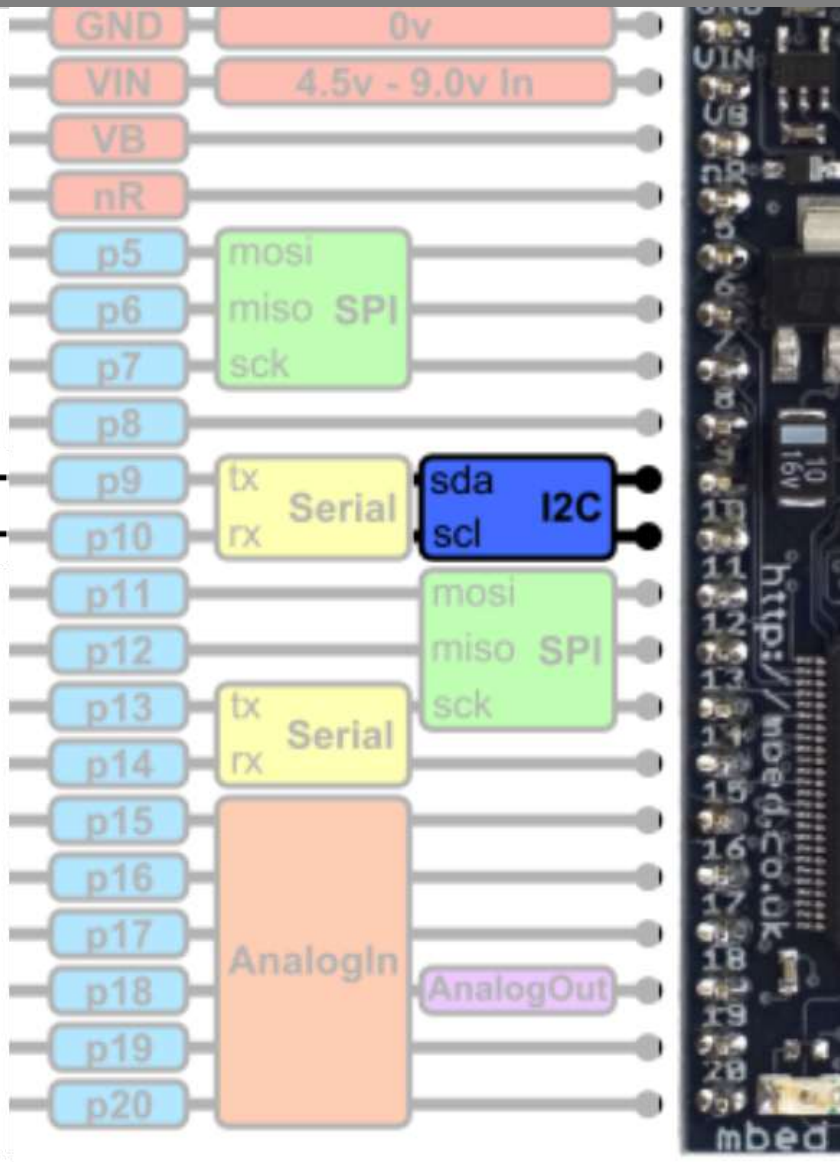
Beispiele → Serielle C++

```
1  #include "mbed.h"
2
3  // Serielle zu Device
4  Serial sensor(p9, p10); // tx, rx
5
6  void callback() {
7      int i = sensor.getc();
8      // ...
9  }
10
11 int main() {
12
13     sensor.baud(19200);
14     sensor.attach(&callback);
15
16     sensor.putc('X');
17
18     while(1) {}   //Endlosschleife
19 }
```

Beispiele → I²C (IIC, I2C, Two-Wire)

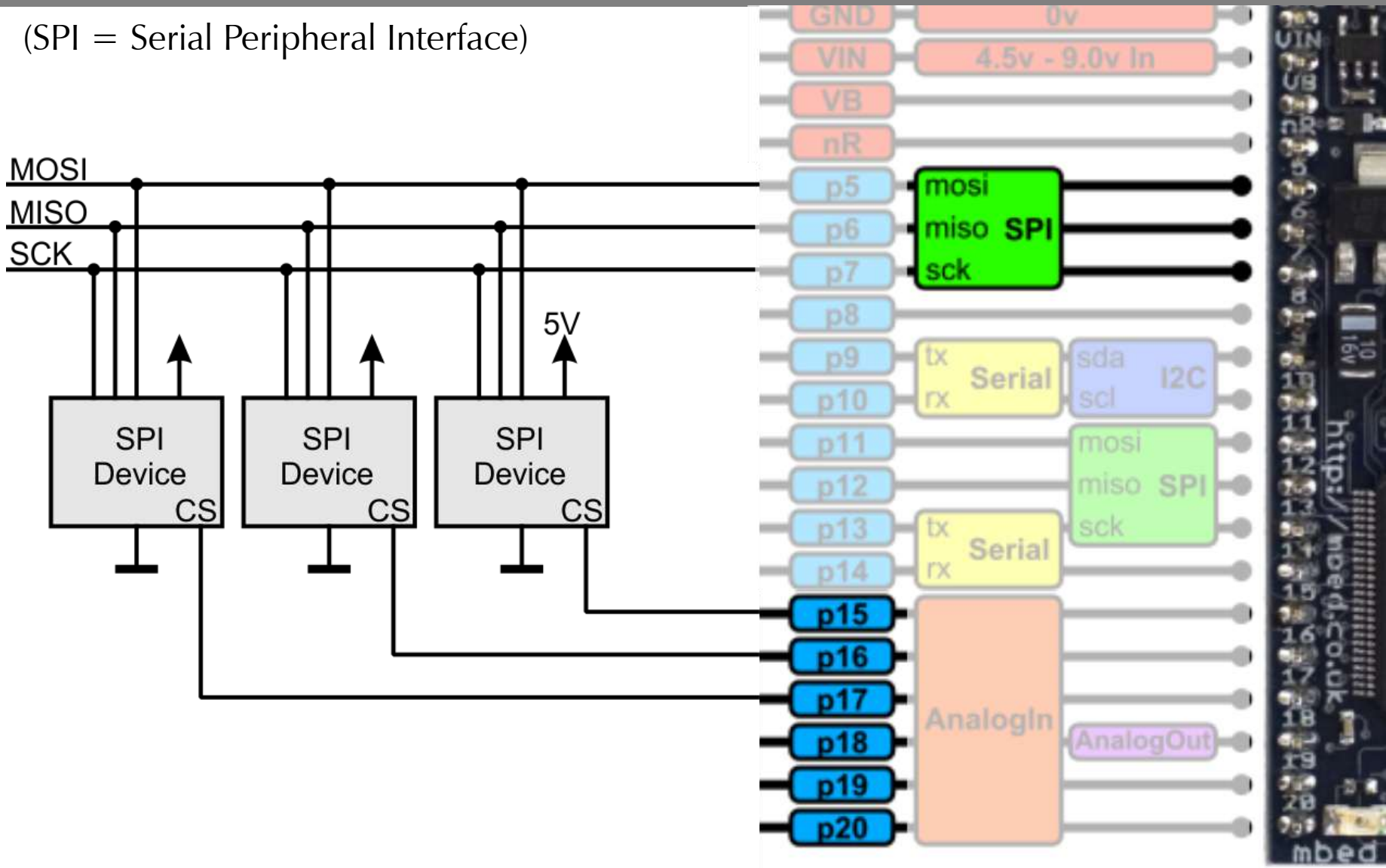
(IIC = Inter-Integrated Circuit)





Beispiele → SPI

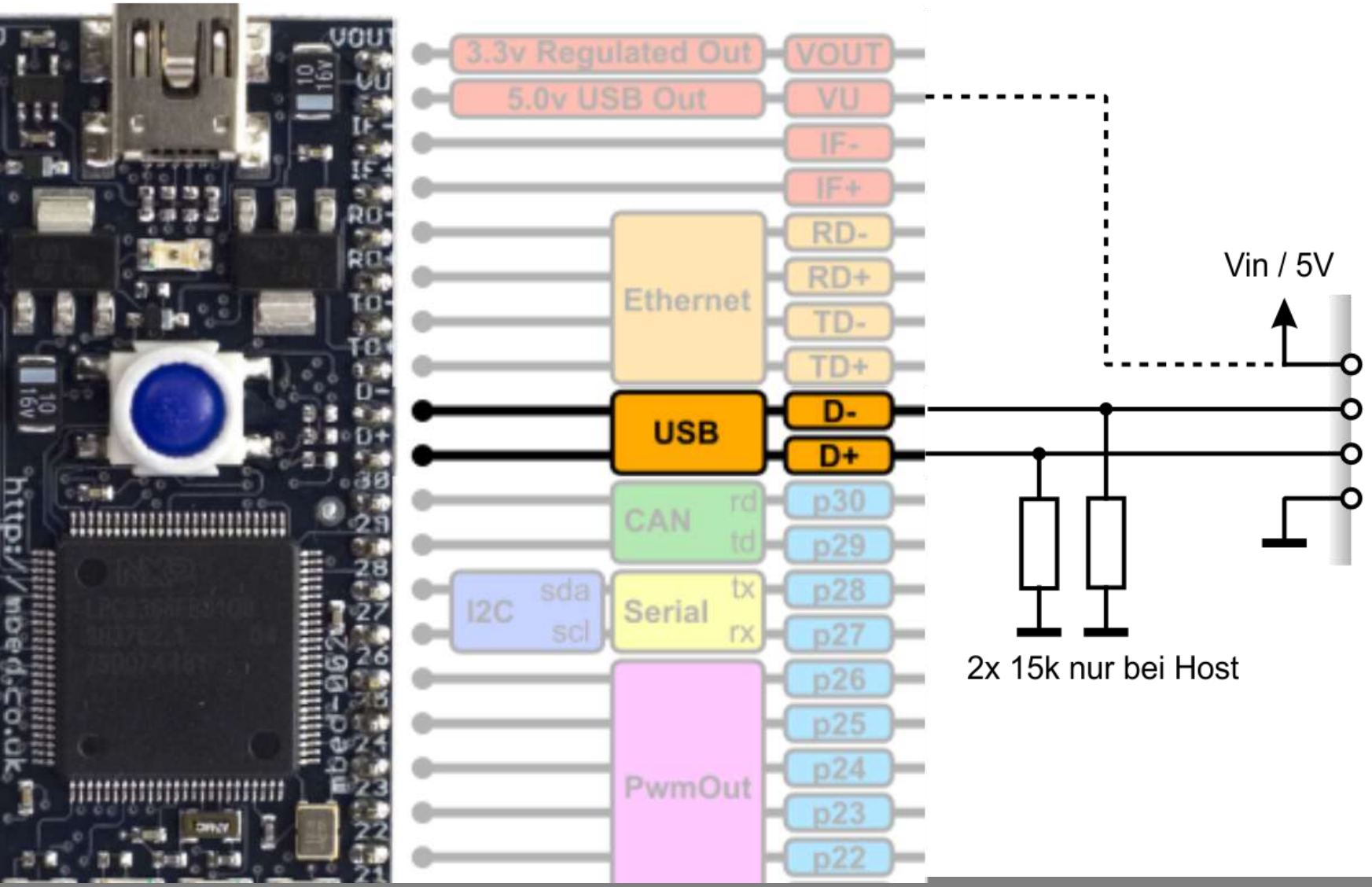
(SPI = Serial Peripheral Interface)



Beispiele → I²C, SPI C++

```
1  #include "mbed.h"
2  int main() {
3  // SPI
4      SPI spi(p5, p6, p7);          // mosi, miso, sclk
5
6      spi.format(8,3);              // 8 Bits (4-16), Mode 3
7      spi.frequency(1000000);       // default 1MHz
8
9      int ret = spi.write(0x12);
10
11 // I²C (Two-Wire)
12     I2C i2c(p9, p10);             // sda, scl
13
14     const int addr = 0x70;        // define the I2C Address
15     char cmd[2] = { 0x00, 0x51 };
16
17     i2c.write(addr, cmd, 2);
18     i2c.read(addr, cmd, 2);
19 }
```

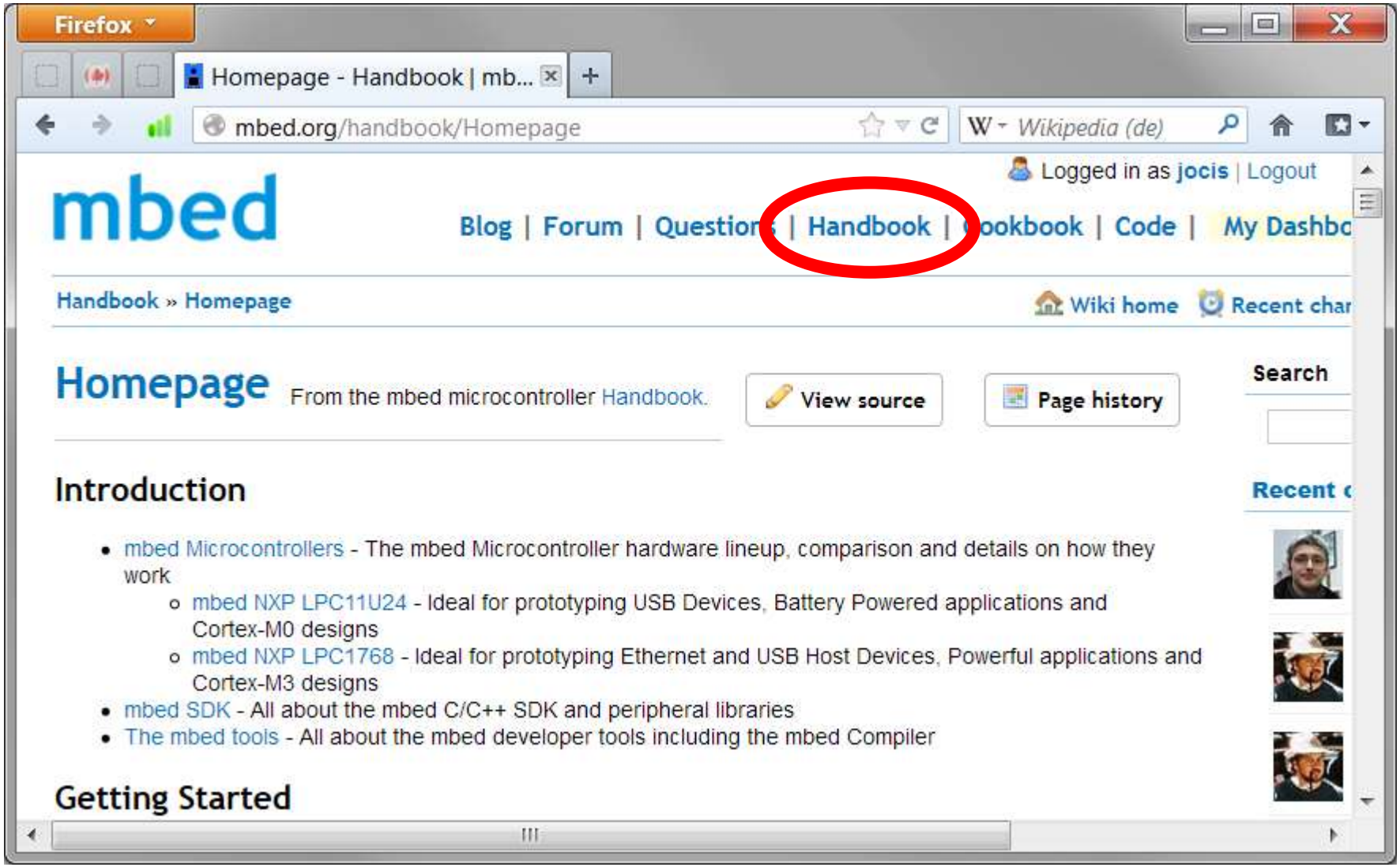
Beispiele → USB Device/Host



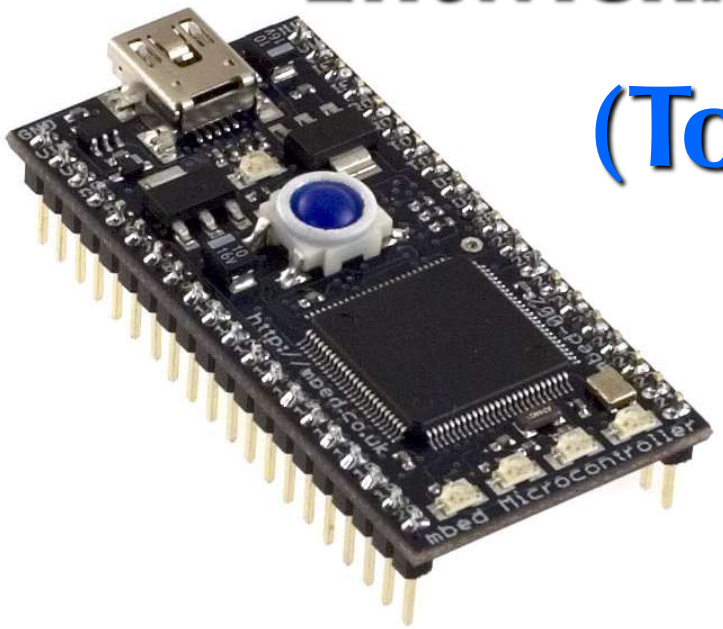
Beispiele → USB-Mouse C++

```
1  #include "mbed.h"
2  #include "USBMouse.h"
3
4  USBMouse mouse(ABS_MOUSE);
5
6  int main() {
7      int16_t x, y;
8      float radius = 5000;
9      float angle = 0;
10
11     while (1) {
12         x = 10000 + cos(angle*3.14f/180.0f)*radius;
13         y = 10000 + sin(angle*3.14f/180.0f)*radius;
14         mouse.move(x, y);
15         angle += 3.0f;
16         wait(0.01);
17     }
18 }
19
```

Beispiele → Handbook



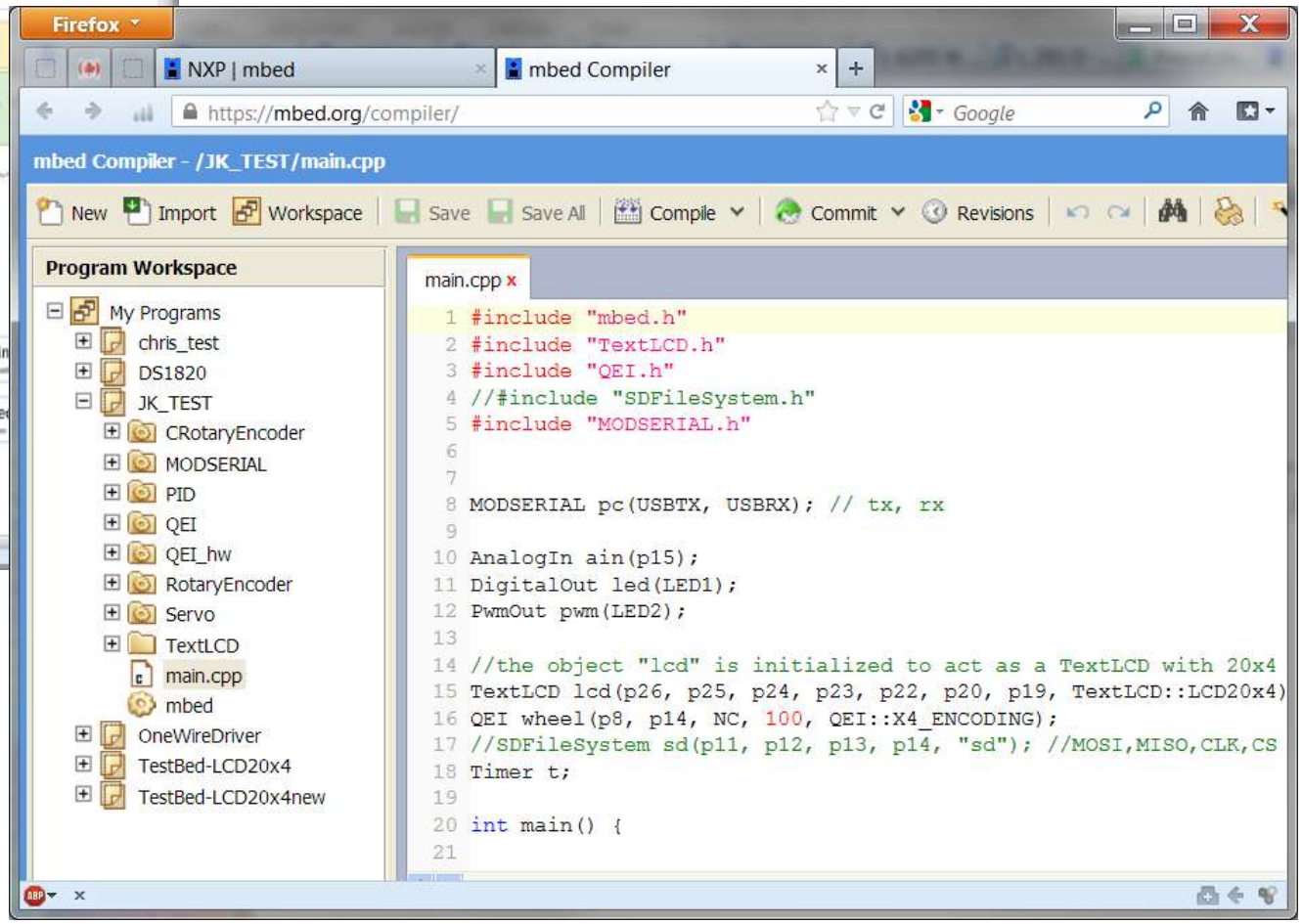
Entwicklungsumgebung (Tool-Chain)



IDE → Online

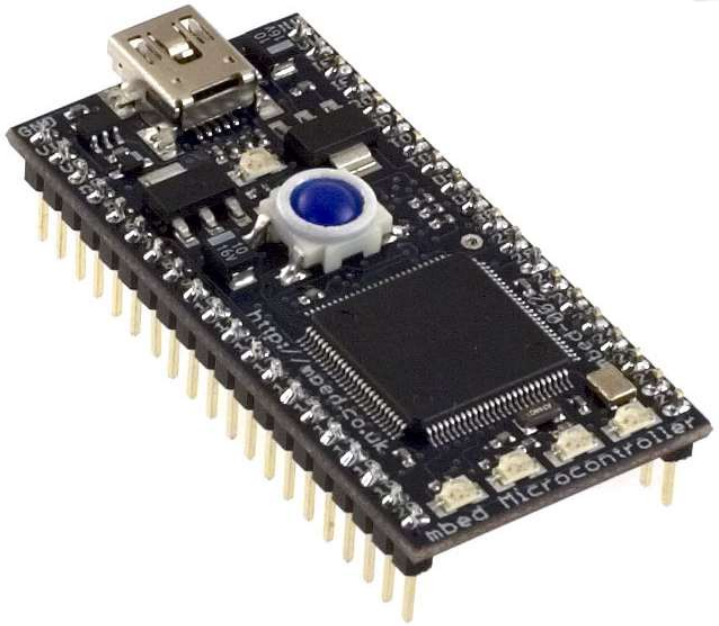
(IDE = Integrated Development Environment)

→ LIVE



Libs

Libraries



Libs → Selber machen…

main.cpp (vorher)

```
1  #include "mbed.h"
2  int main() {
3
4  // RC-Servo
5      PwmOut servoRC(p21);
6
7      // RC-Servo Init
8      servoRC.period_ms(20);
9
10     // RC-Servo in Mittelstellung
11     float value = 0.5;
12     servoRC.pulsewidth(0.001 + 0.001*value);
13
14     // RC-Servo nach links
15     value = 0.1;
16     servoRC.pulsewidth(0.001 + 0.001*value);
17 }
18
19
```

Libs → Selber machen…

ServoRC.h

```
1  #include "mbed.h"
2
3  /** Interface to control a RC-servo ... */
4  class ServoRC {
5  protected:
6      PwmOut _pwm;                          // Class Member
7
8  public:
9      /** Create an instance of ... */
10     ServoRC(PinName pwmpin);              // Constructor
11     ~ServoRC()                            // Destructor
12         { _pwm=0; }
13
14     void write ( float value );           // Method
15
16     float operator= ( float value )       // Assign-Operator
17         { write(value); return value; }
18 }
19
```

Libs → Selber machen…

ServoRC.cpp

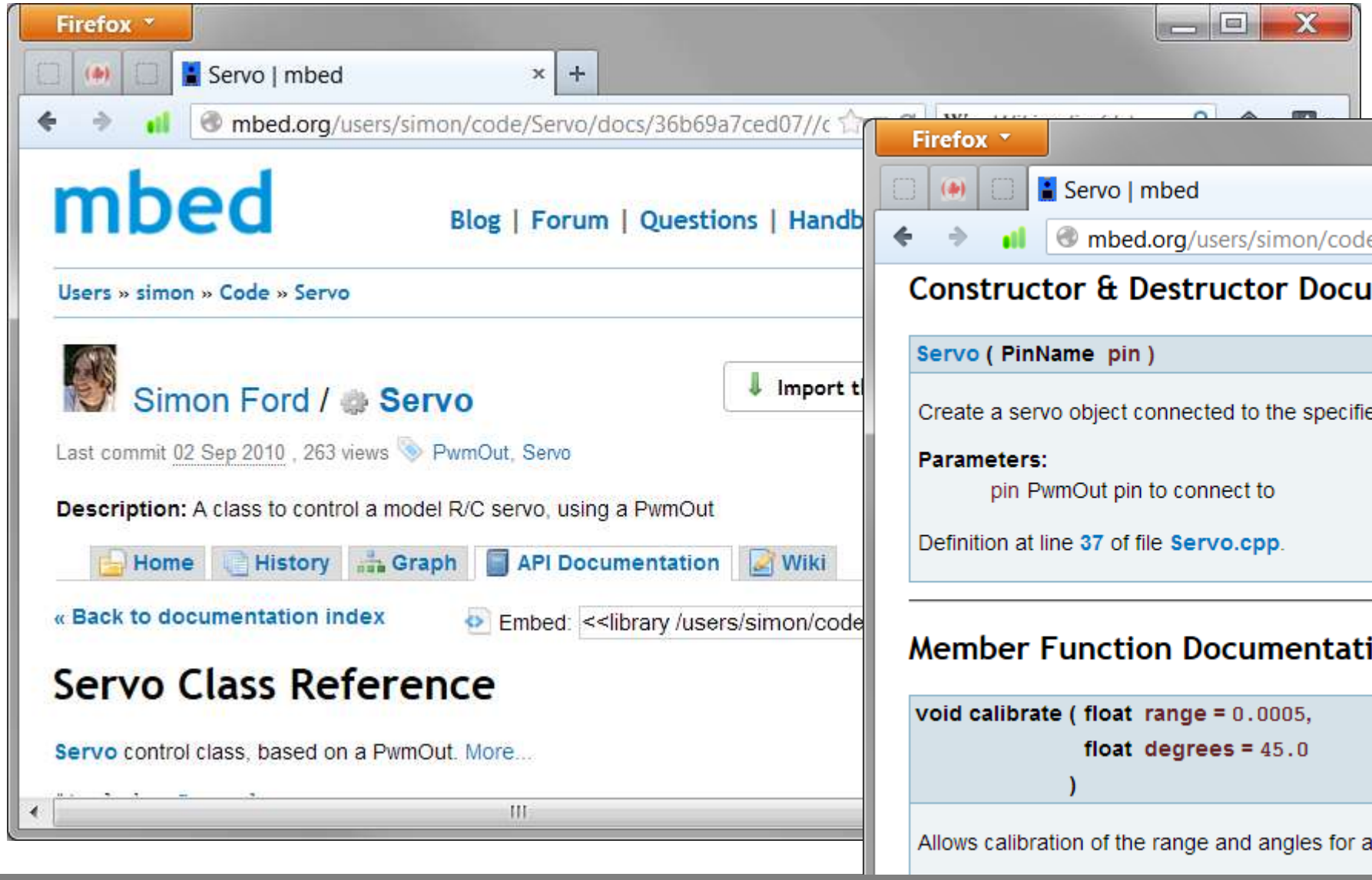
```
1  #include <ServoRC.h>
2
3  // Constructor
4  ServoRC::ServoRC(PinName pwmpin) : _pwm(pwmpin)
5  {
6      _pwm.period_ms(20);
7  }
8
9
10 // Method write()
11 void ServoRC::write(float value)
12 {
13     if ( value<0.0 ) value = 0.0;
14     if ( value>1.0 ) value = 1.0;
15     _pwm.pulsewidth(0.001 + 0.001*value);
16 }
17
18
19
```

Libs → Selber machen…

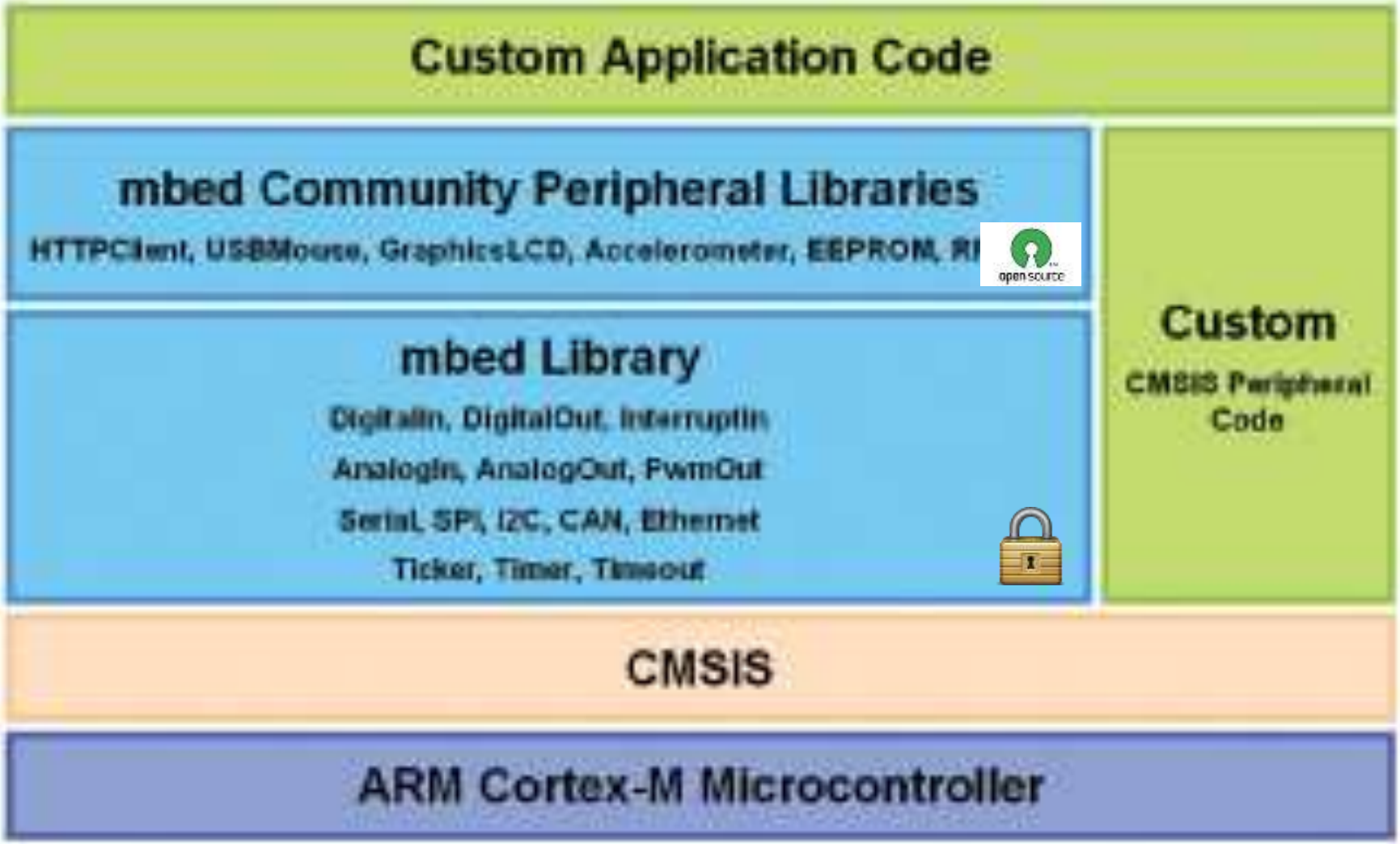
main.cpp (nachher)

```
1  #include "mbed.h"
2
3  #include <ServoRC.h>
4
5  ServoRC myServo(p21);
6
7  int main() {
8
9      // RC-Servo in Mittelstellung
10     myServo = 0.5;
11
12     // RC-Servo nach links
13     myServo = 0.1;
14 }
15
16
17
18
19
```

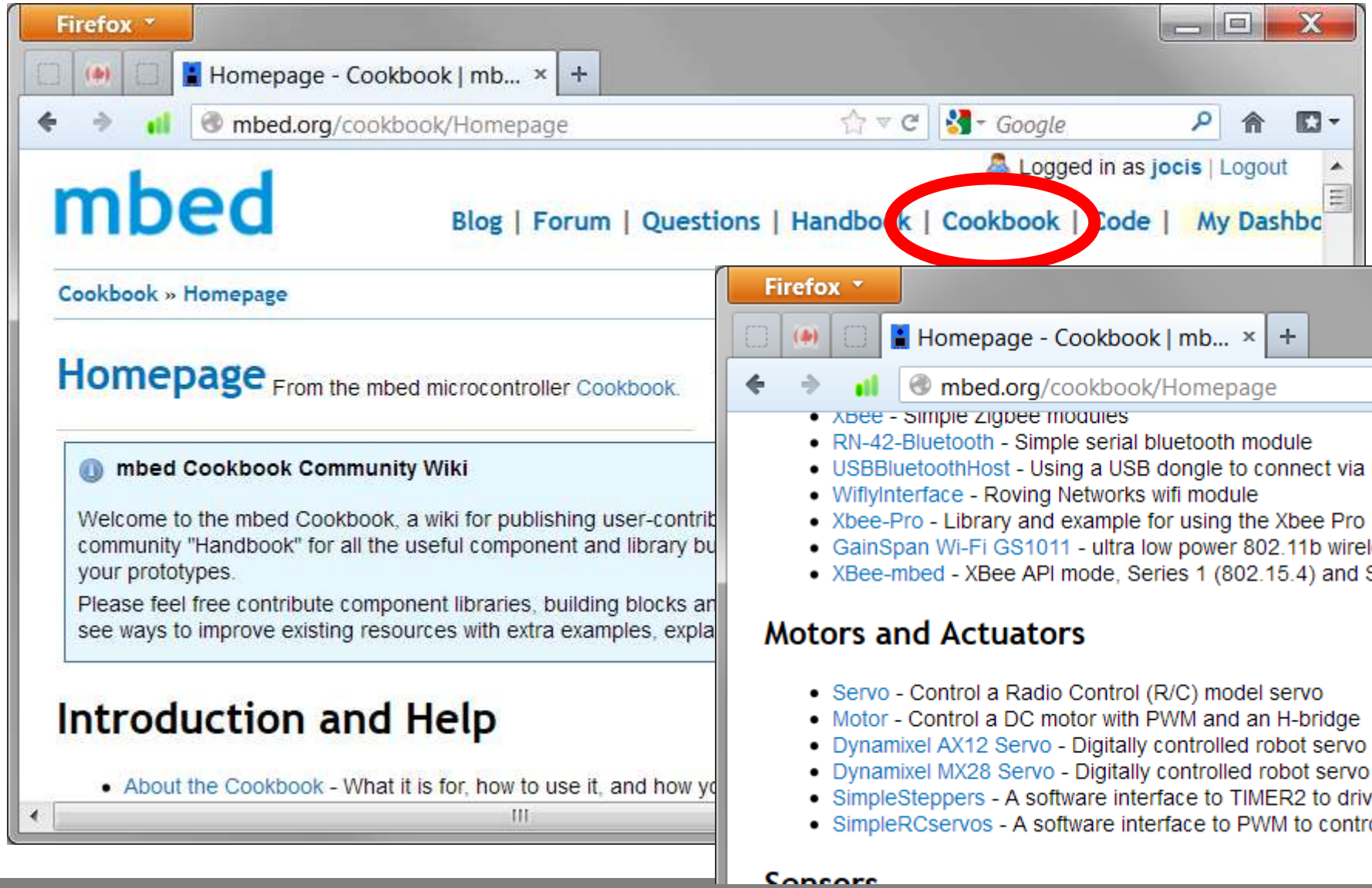
Libs → Selber machen…



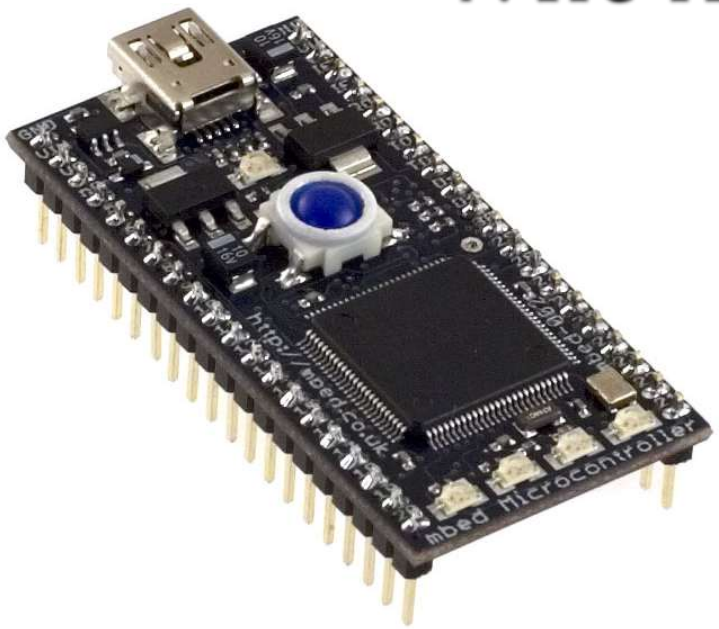
Libs → Architektur



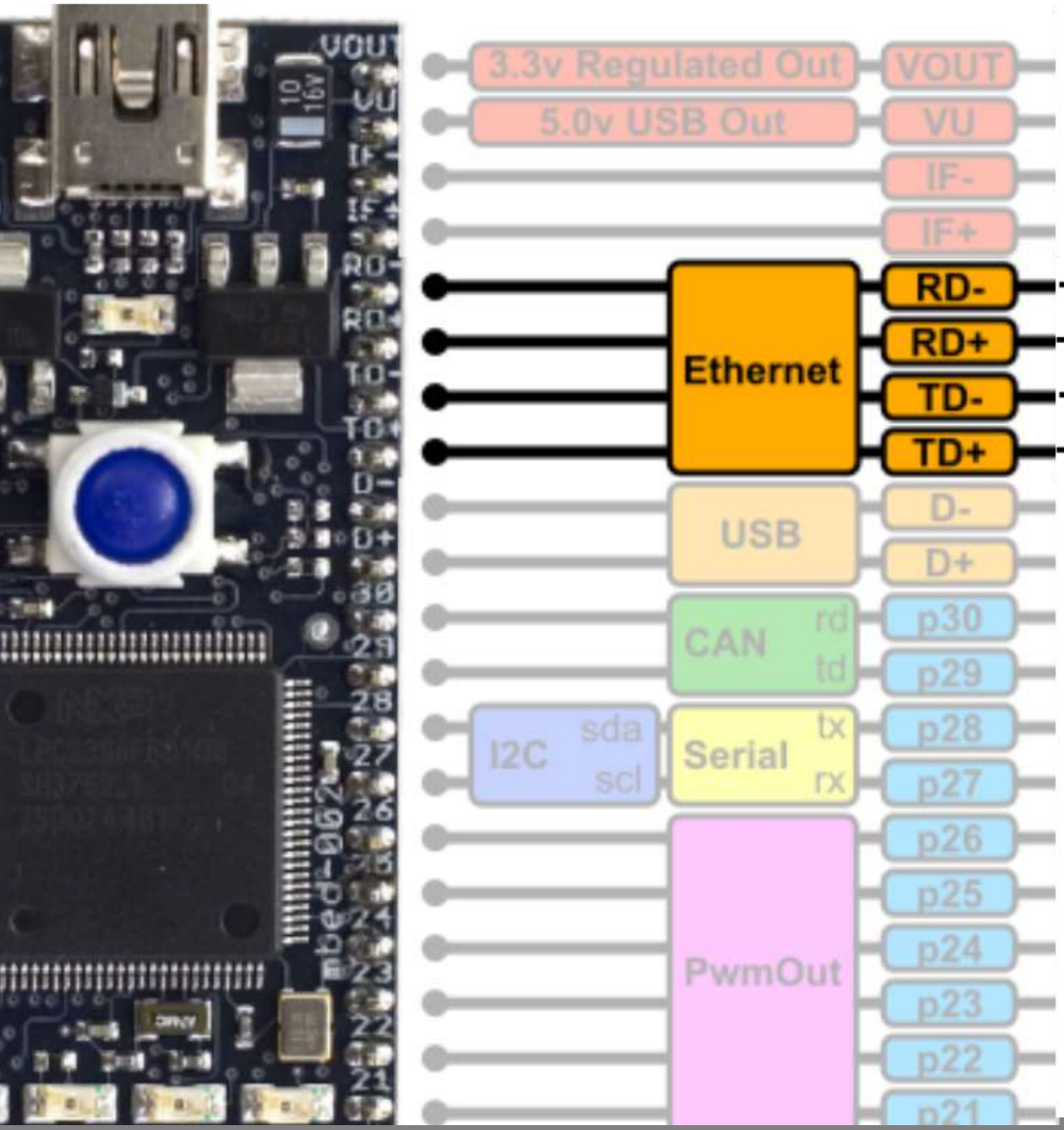
Libs → Community

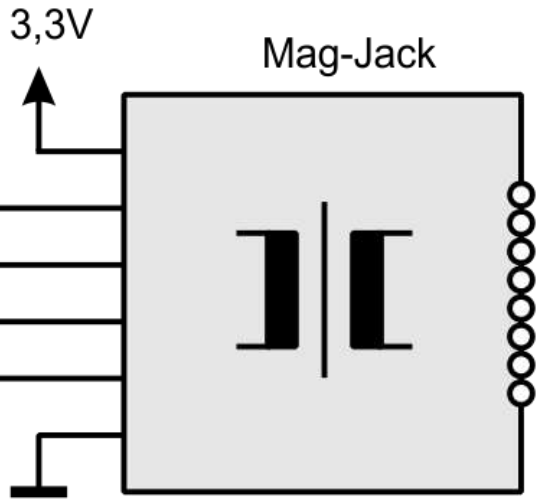


Mit mbed in Netz

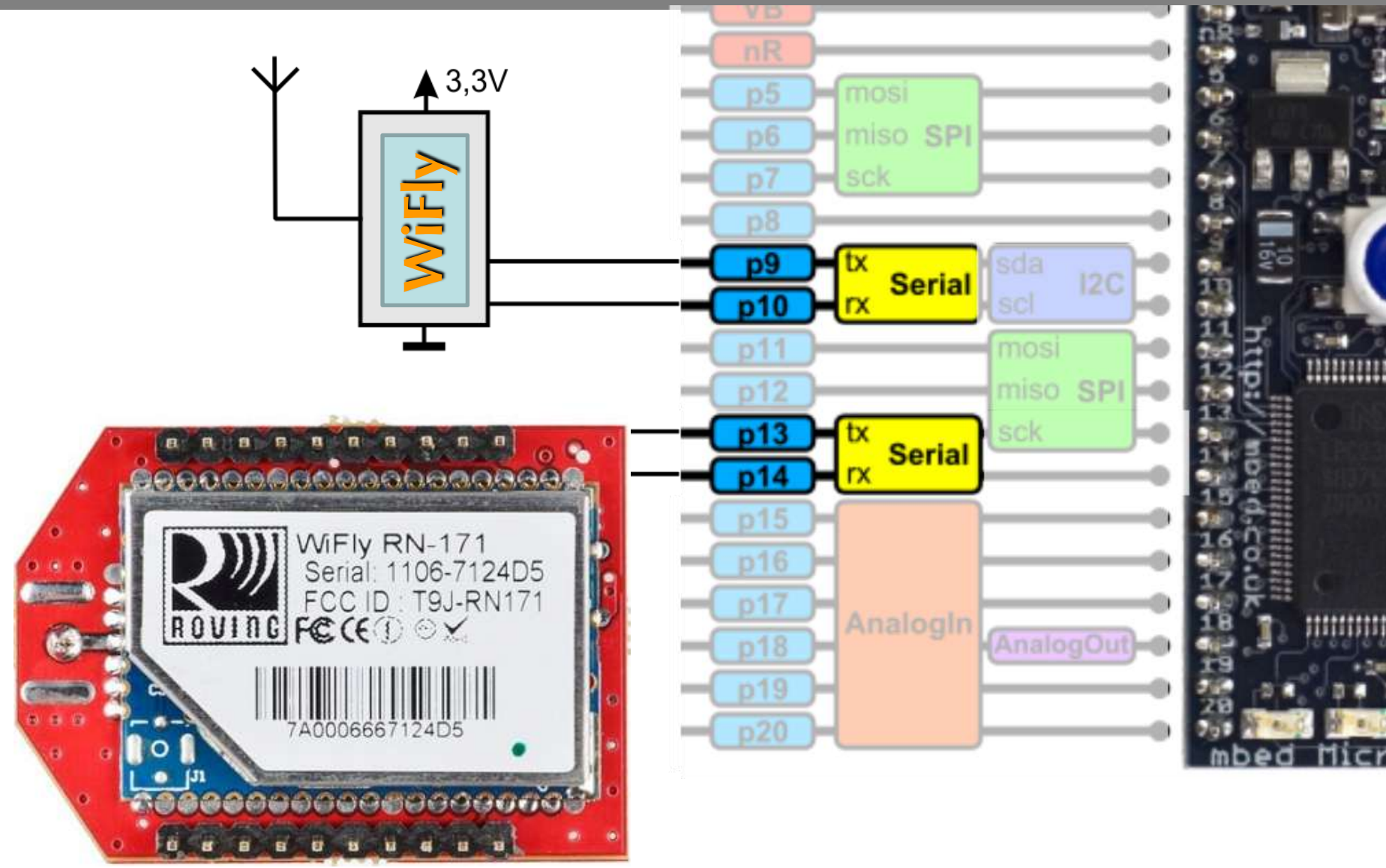


Web → Ethernet (10/100Mbit)

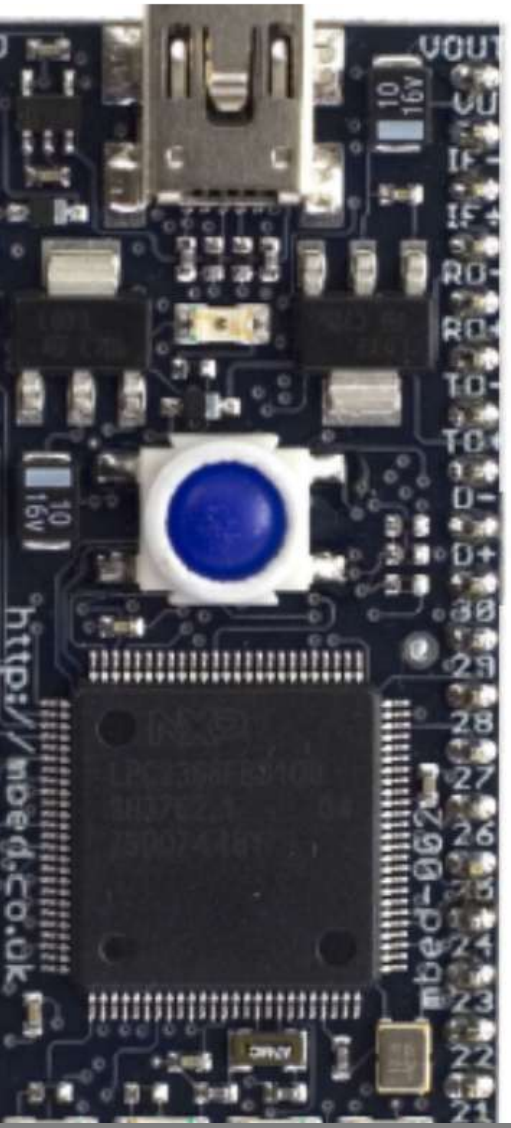


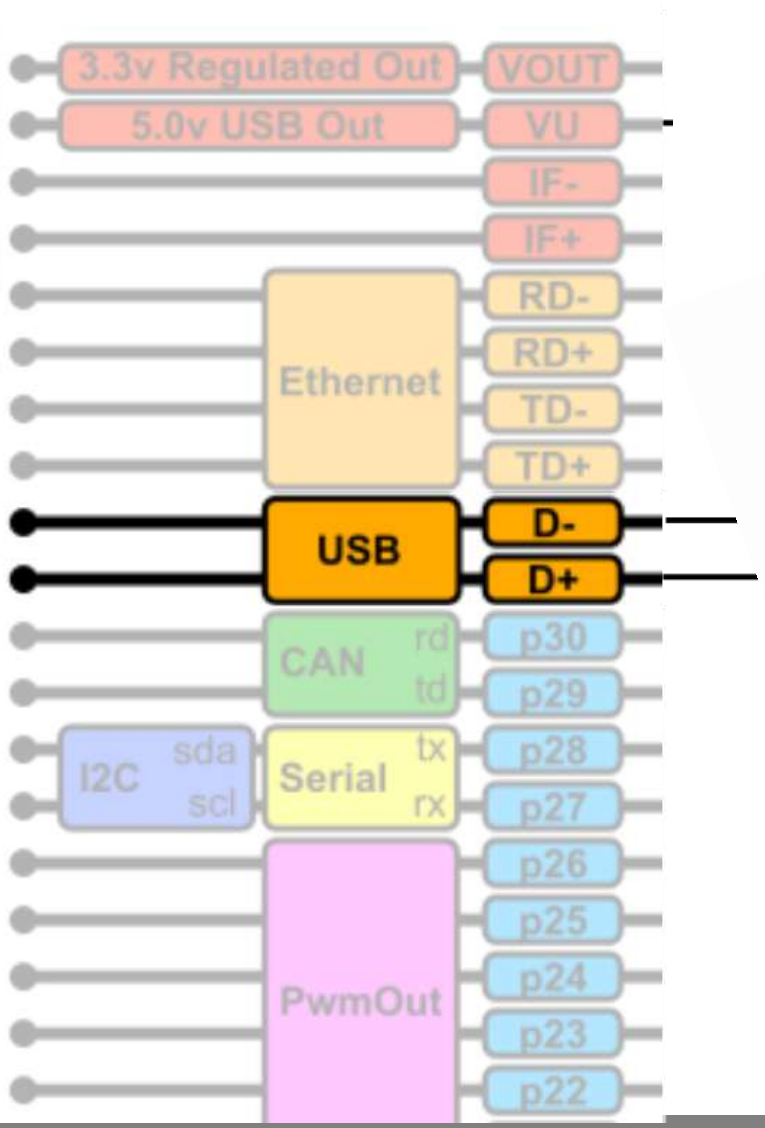


Web → WLAN 802.11*b*/*g* (WiFly)



Web → UMTS (SurfStick)





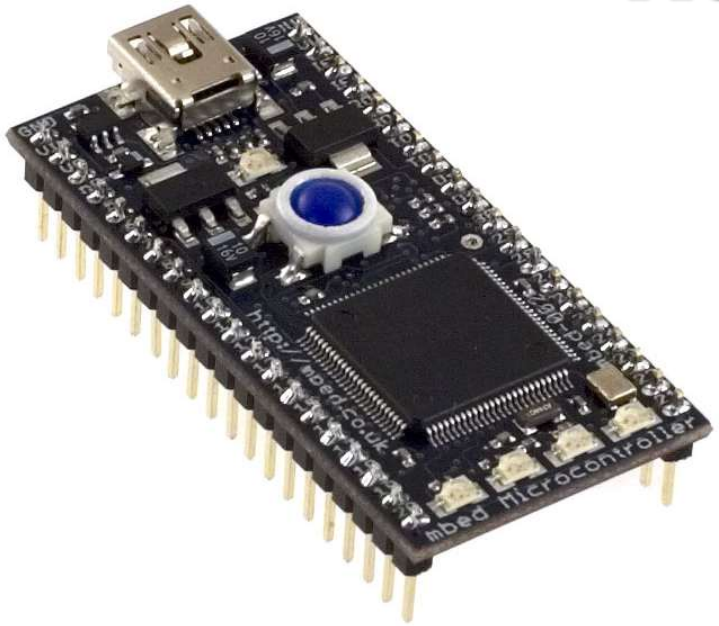
Web → Ethernet C++

```
1  #include "mbed.h„
2  #include "EthernetInterface.h"
3  int main() {
4      EthernetInterface eth;
5      eth.init();                    //Use DHCP
6      eth.connect();
7
8      TCPSocketConnection sock;
9      sock.connect(„www.franken.de", 80);
10     char http_cmd[] = "GET /index.htm HTTP/1.0\n\n";
11     sock.send_all(http_cmd, sizeof(http_cmd)-1);
12
13     char buffer[300];   int ret;
14     do {
15         ret = sock.receive(buffer, sizeof(buffer));
16         // ... buffer[]
17     } while (ret>0);
18     sock.close();   eth.disconnect();
19 }
```

Web → Ethernet NTP C++

```
1  #include "mbed.h„
2  #include "EthernetInterface.h"
3  #include „NTPClient.h"
4  int main() {
5      EthernetInterface eth;
6      eth.init();                    //Use DHCP
7      eth.connect();
8
9      NTPClient ntp;
10
11     if ( ntp.setTime("0.pool.ntp.org") != 0 ) {
12       // Fehler ...
13     }
14
15     eth.disconnect();
16 }
17
18
19
```

Referenzen



mbed ☹

Vachteil	
Preis	56…60…70 €
IDE	nur Online
Code	im Netz (mbed.org)
Anleitungen	*only in english*
…	
Weniger Features als direkt in CMSIS	
…	
Bezugsquellen	nur wenige…

Bezugsquellen mbed

Für Privatkunden

www.watterott.com

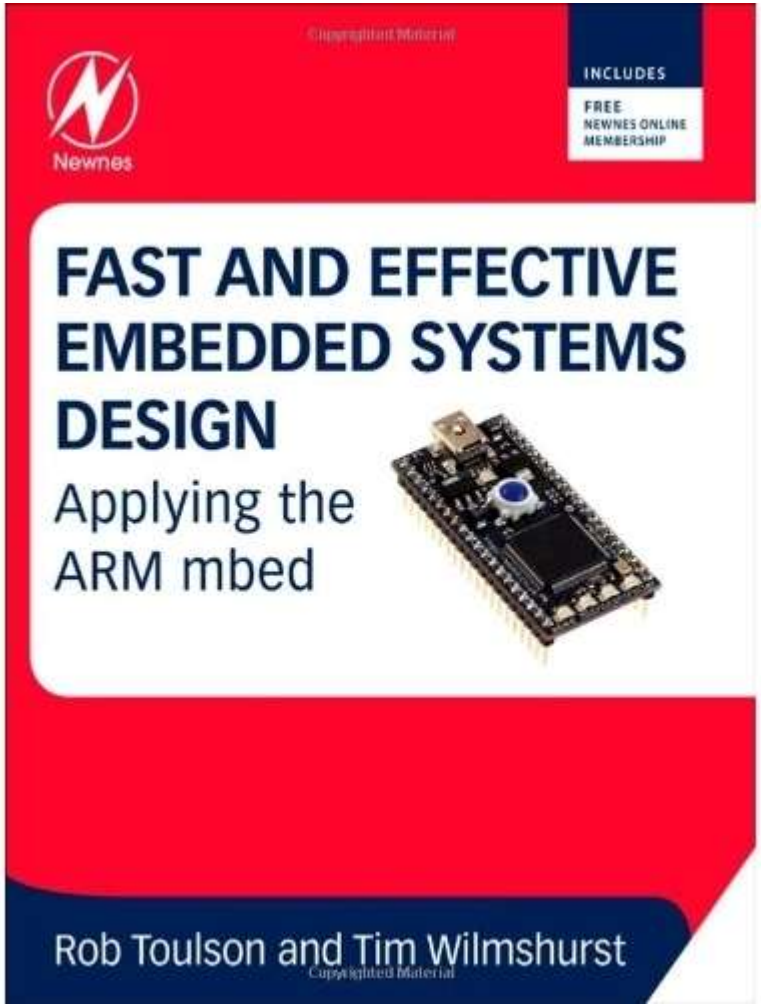
www.amazon.de

Nur gewerbliche Kunden

www.elmicro.com

www.farnell.de

Bücher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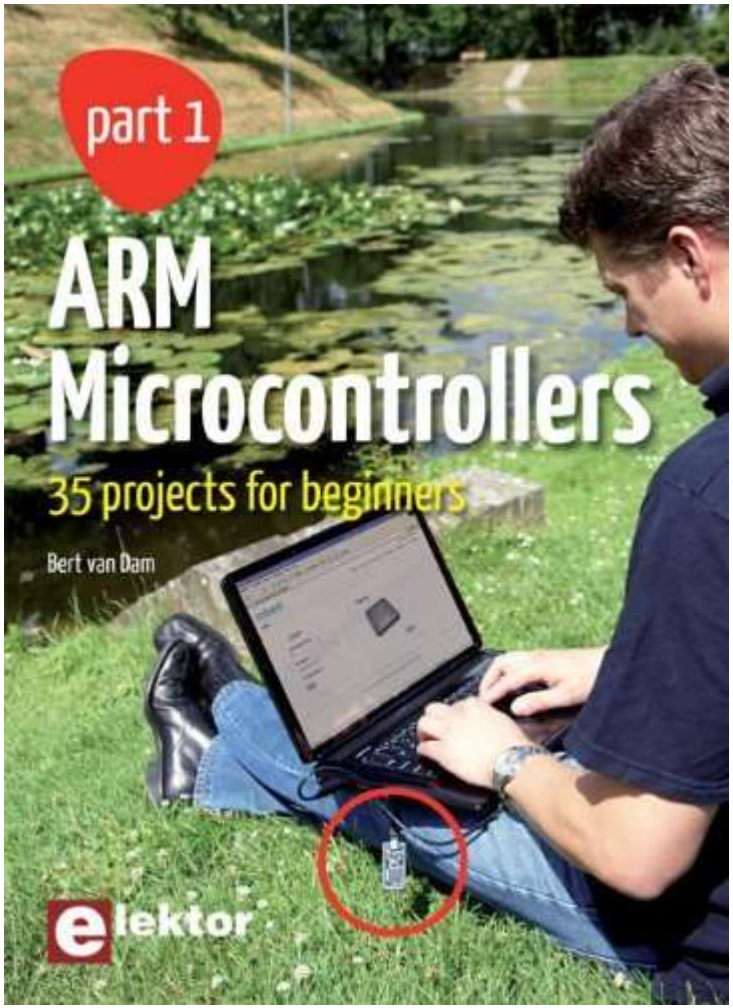
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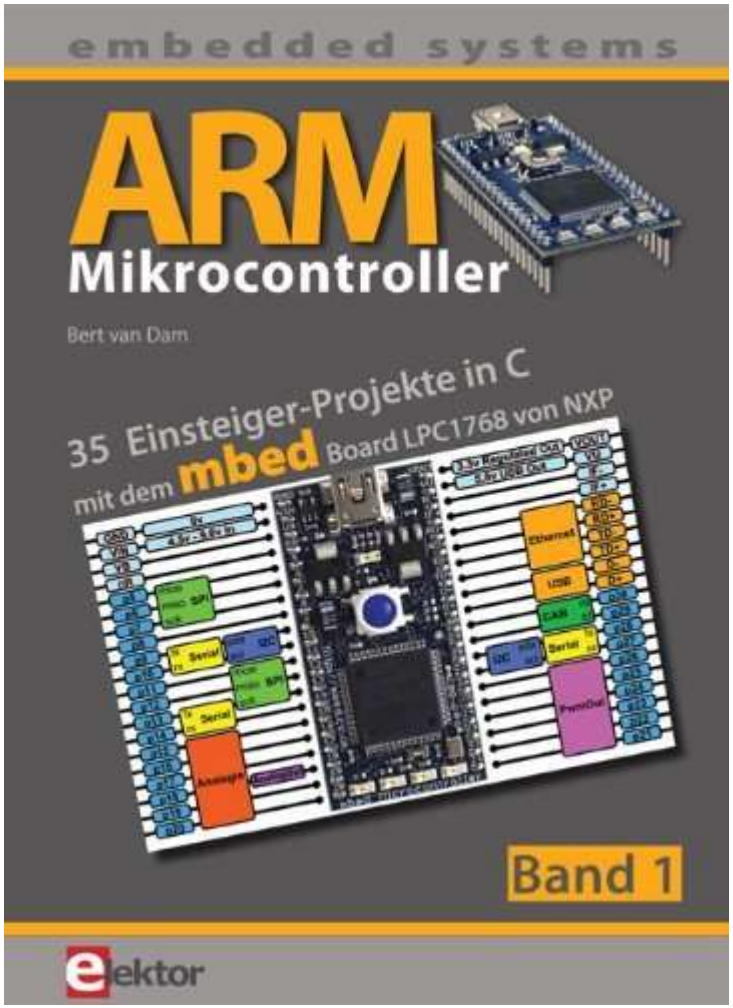
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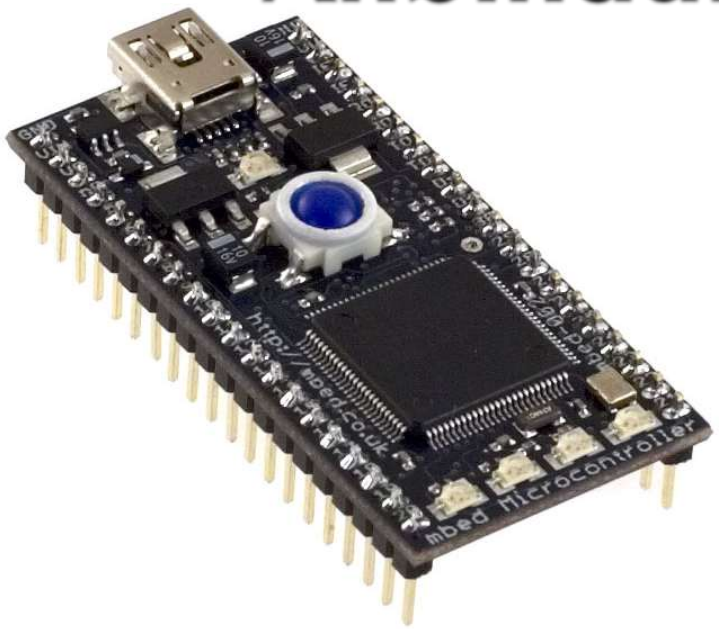
Alle Logos, Marken und Namen sind Eigentum der jeweiligen Firmen

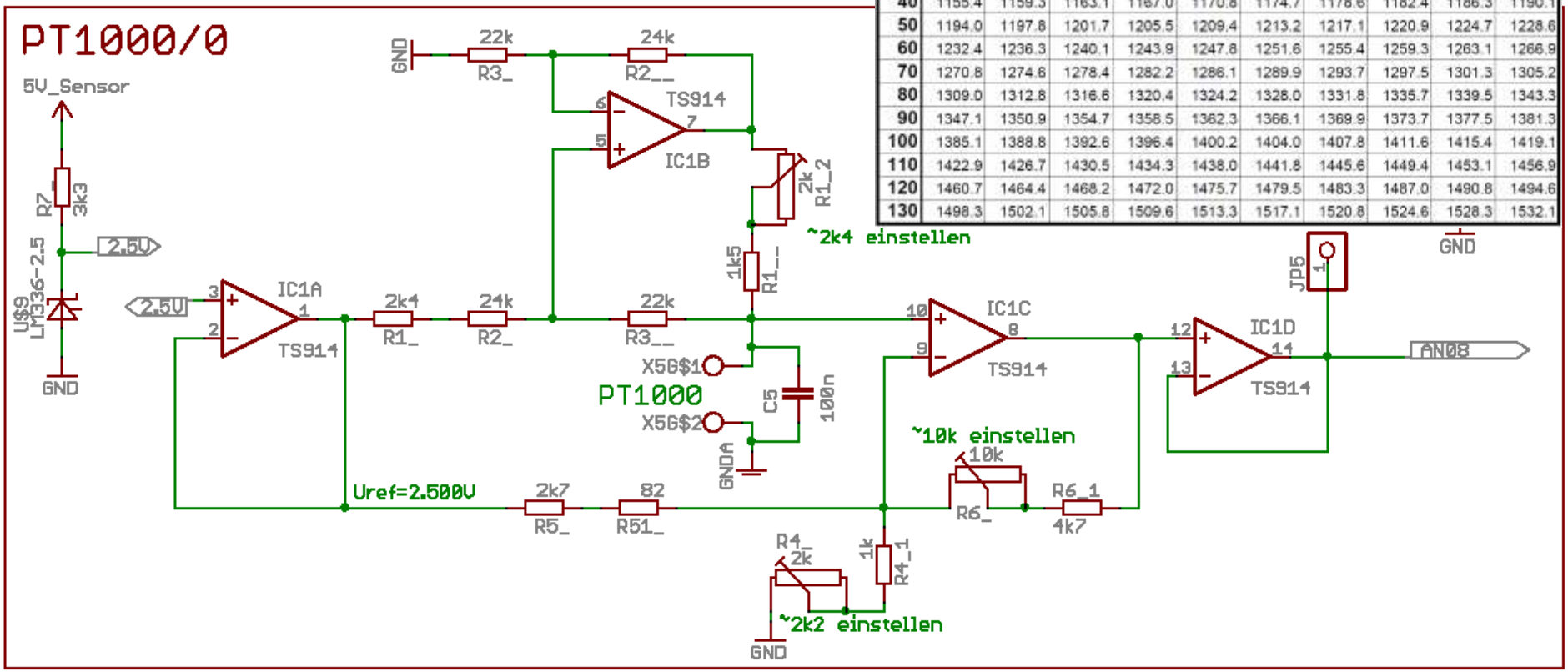
Anbindung von Sensoren



Sensoren → Temperatur analog

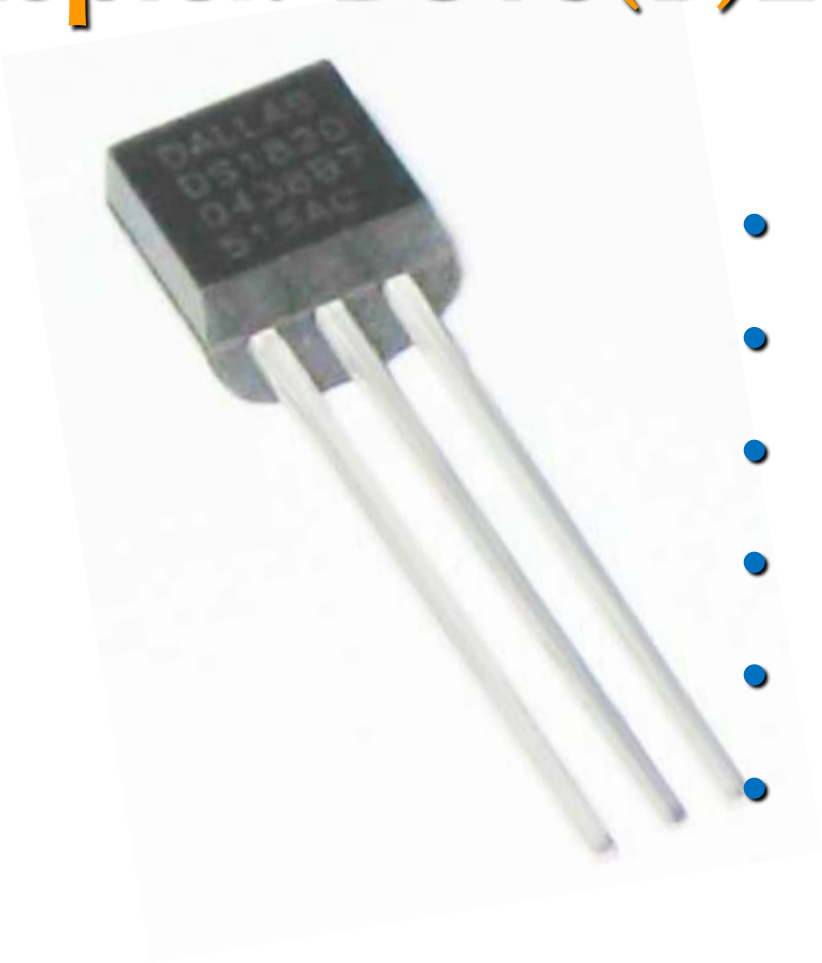
Beispiel: PT1000

°C	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
-50	803.1	807.0	811.0	815.0	818.9	822.9	826.9	830.8	834.8	838.7
-40	842.7	846.7	850.6	854.6	858.5	862.5	866.4	870.4	874.3	878.3
-30	882.2	886.2	890.1	894.0	898.0	901.9	905.9	909.8	913.7	917.7
-20	921.6	925.5	929.5	933.4	937.3	941.2	945.2	949.1	953.0	956.9
-10	960.9	964.8	968.7	972.6	976.5	980.4	984.4	988.3	992.2	996.1
0	1000.0	1003.9	1007.8	1011.7	1015.6	1019.5	1023.4	1027.3	1031.2	1035.1
10	1039.0	1042.9	1046.8	1050.7	1054.6	1058.5	1062.4	1066.3	1070.2	1074.0
20	1077.9	1081.8	1085.7	1089.6	1093.5	1097.3	1101.2	1105.1	1109.0	1112.9
30	1116.7	1120.6	1124.5	1128.3	1132.2	1136.1	1140.0	1143.8	1147.7	1151.5
40	1155.4	1159.3	1163.1	1167.0	1170.8	1174.7	1178.6	1182.4	1186.3	1190.1
50	1194.0	1197.8	1201.7	1205.5	1209.4	1213.2	1217.1	1220.9	1224.7	1228.6
60	1232.4	1236.3	1240.1	1243.9	1247.8	1251.6	1255.4	1259.3	1263.1	1266.9
70	1270.8	1274.6	1278.4	1282.2	1286.1	1289.9	1293.7	1297.5	1301.3	1305.2
80	1309.0	1312.8	1316.6	1320.4	1324.2	1328.0	1331.8	1335.7	1339.5	1343.3
90	1347.1	1350.9	1354.7	1358.5	1362.3	1366.1	1369.9	1373.7	1377.5	1381.3
100	1385.1	1388.8	1392.6	1396.4	1400.2	1404.0	1407.8	1411.6	1415.4	1419.1
110	1422.9	1426.7	1430.5	1434.3	1438.0	1441.8	1445.6	1449.4	1453.1	1456.9
120	1460.7	1464.4	1468.2	1472.0	1475.7	1479.5	1483.3	1487.0	1490.8	1494.6
130	1498.3	1502.1	1505.8	1509.6	1513.3	1517.1	1520.8	1524.6	1528.3	1532.1



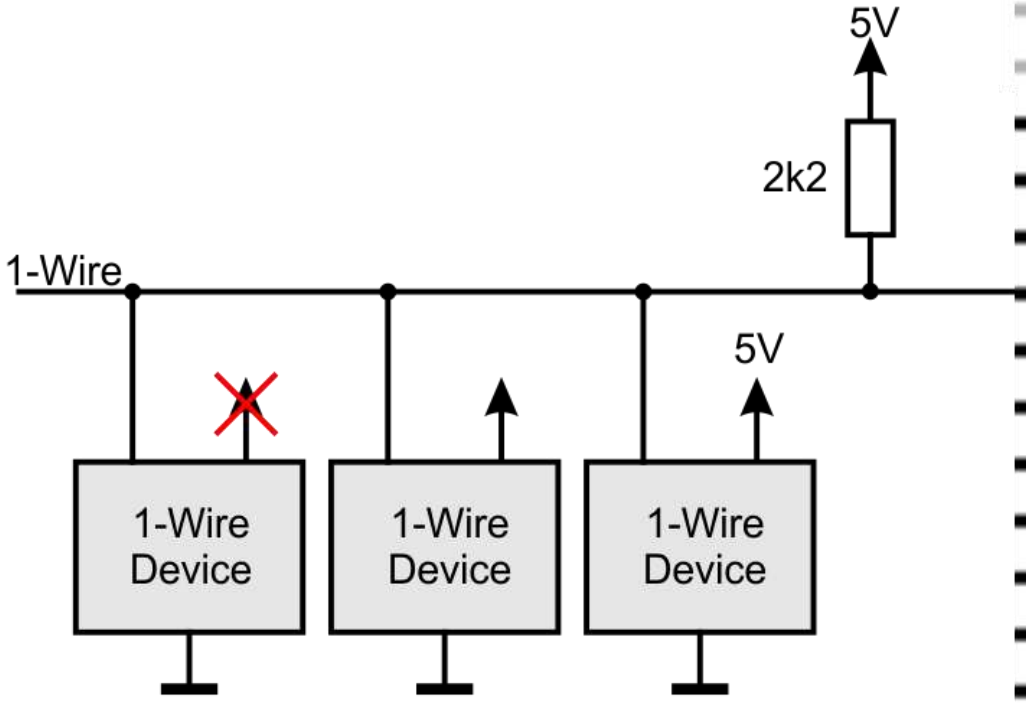
Sensoren → Temperatur digital

Beispiel: DS18(B)20

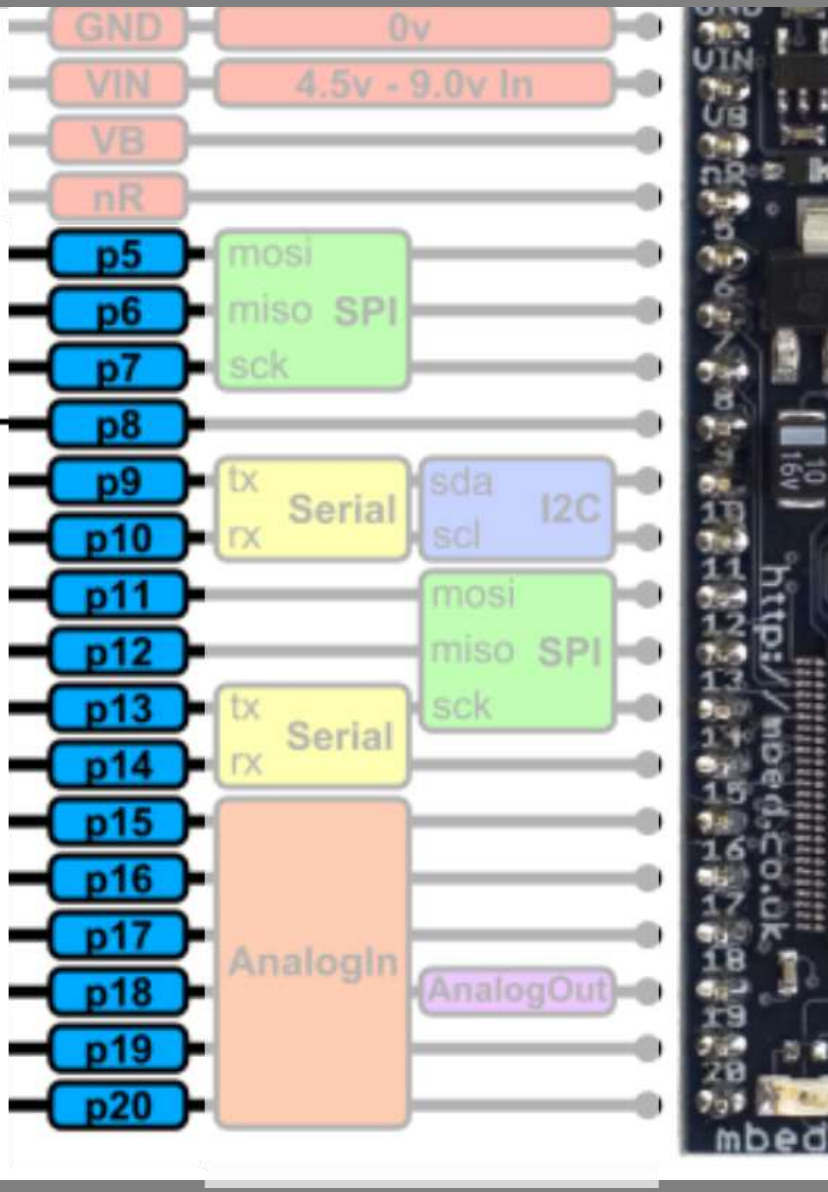


- 1-Wire-Bus
- -55…125°C
- Genauigkeit ±0,5°C
- 3…5,5V oder pars.
- Eindeutige ID
- 2,15 € (Reichelt.de)

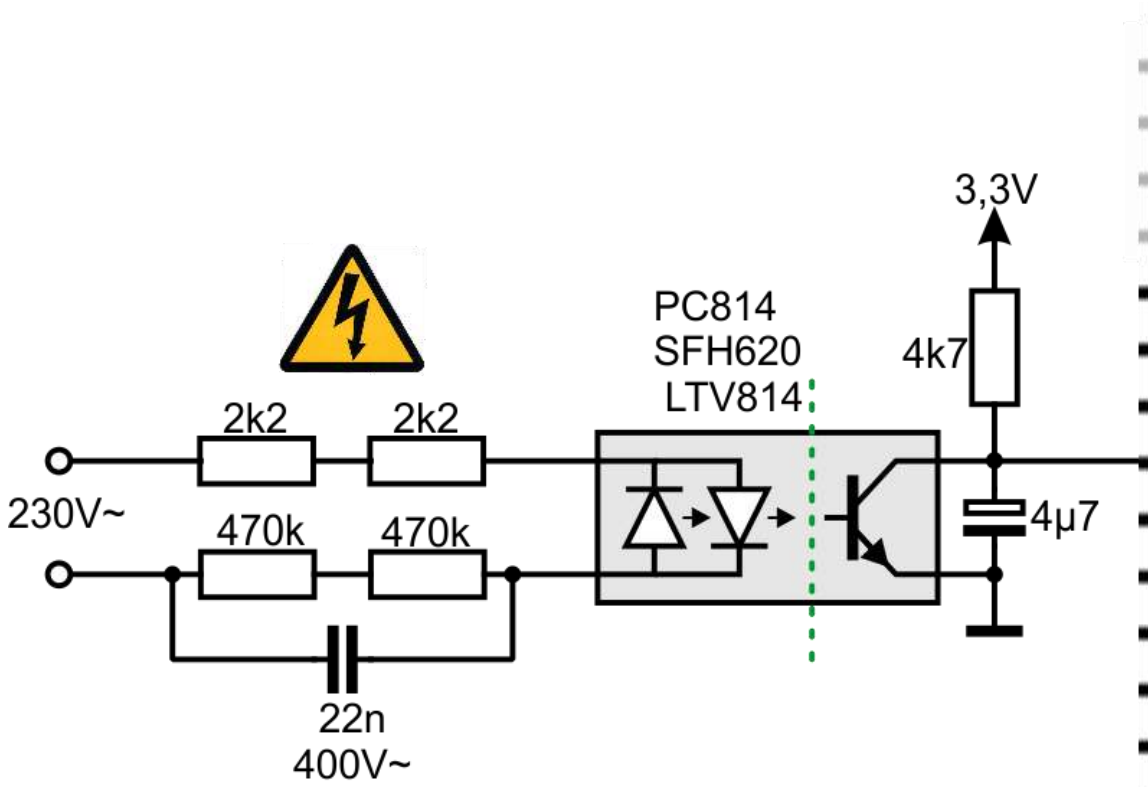
Sensoren → 1-Wire

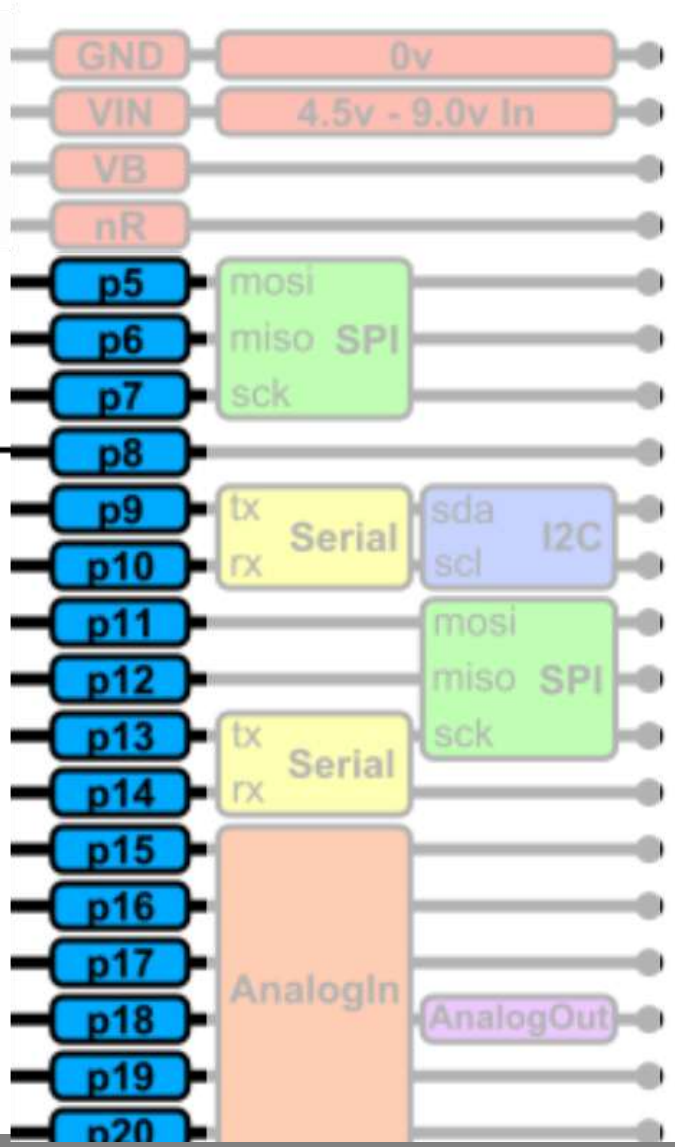


MSB	64-bit 'Registration' ROM number	LSB
8-bit CRC	48-bit Serial Number	8-bit Family Code
MSB LSB	MSB LSB	MSB LSB

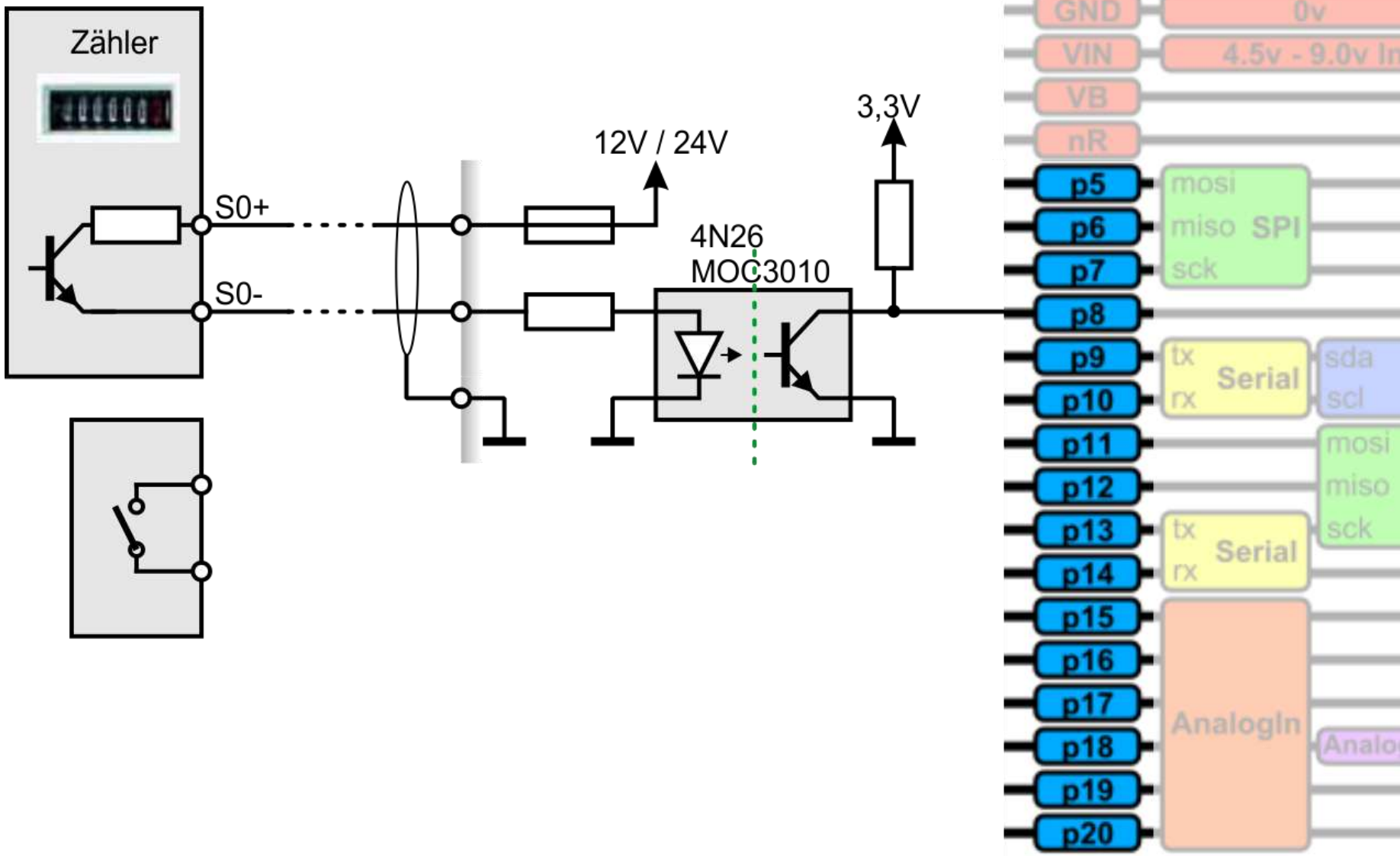


Sensoren → 230V-Erkennung

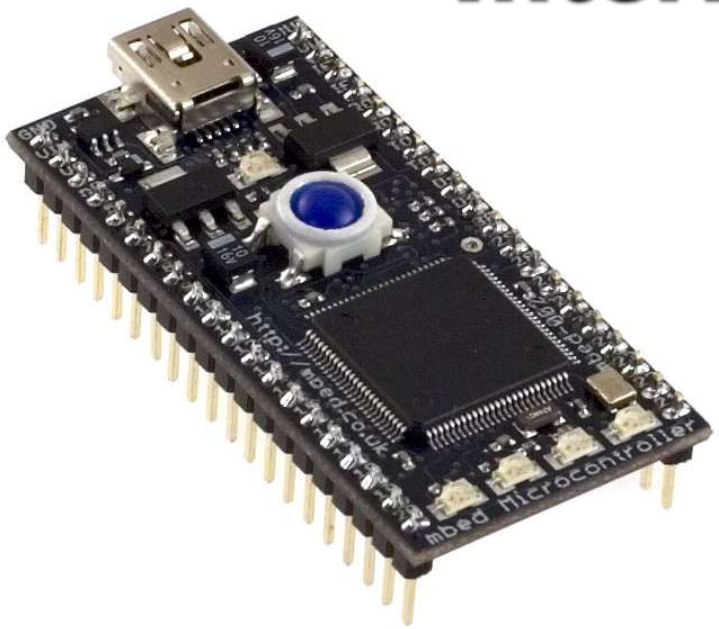




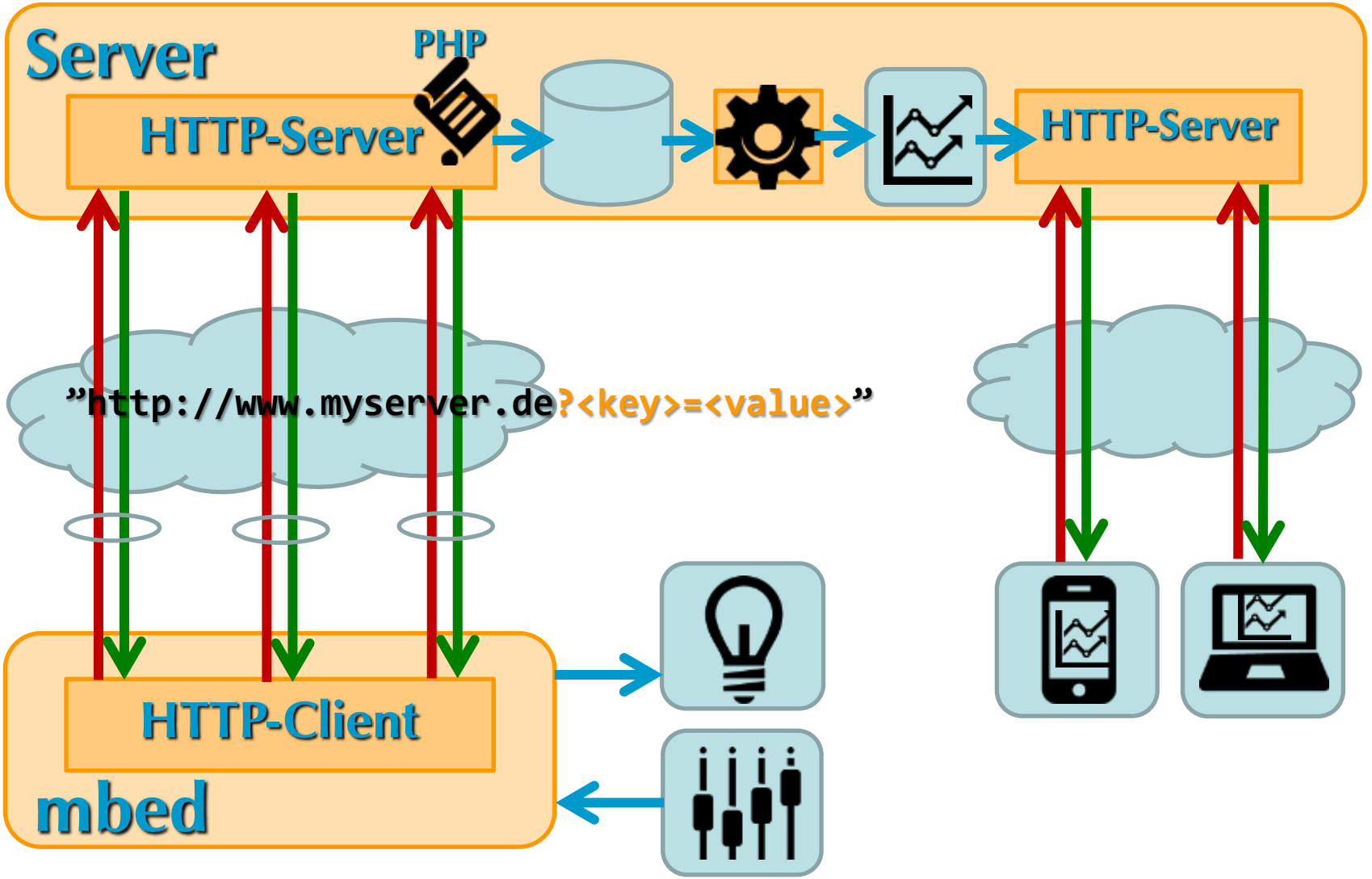
Sensoren → S0-Bus



Internet of Things



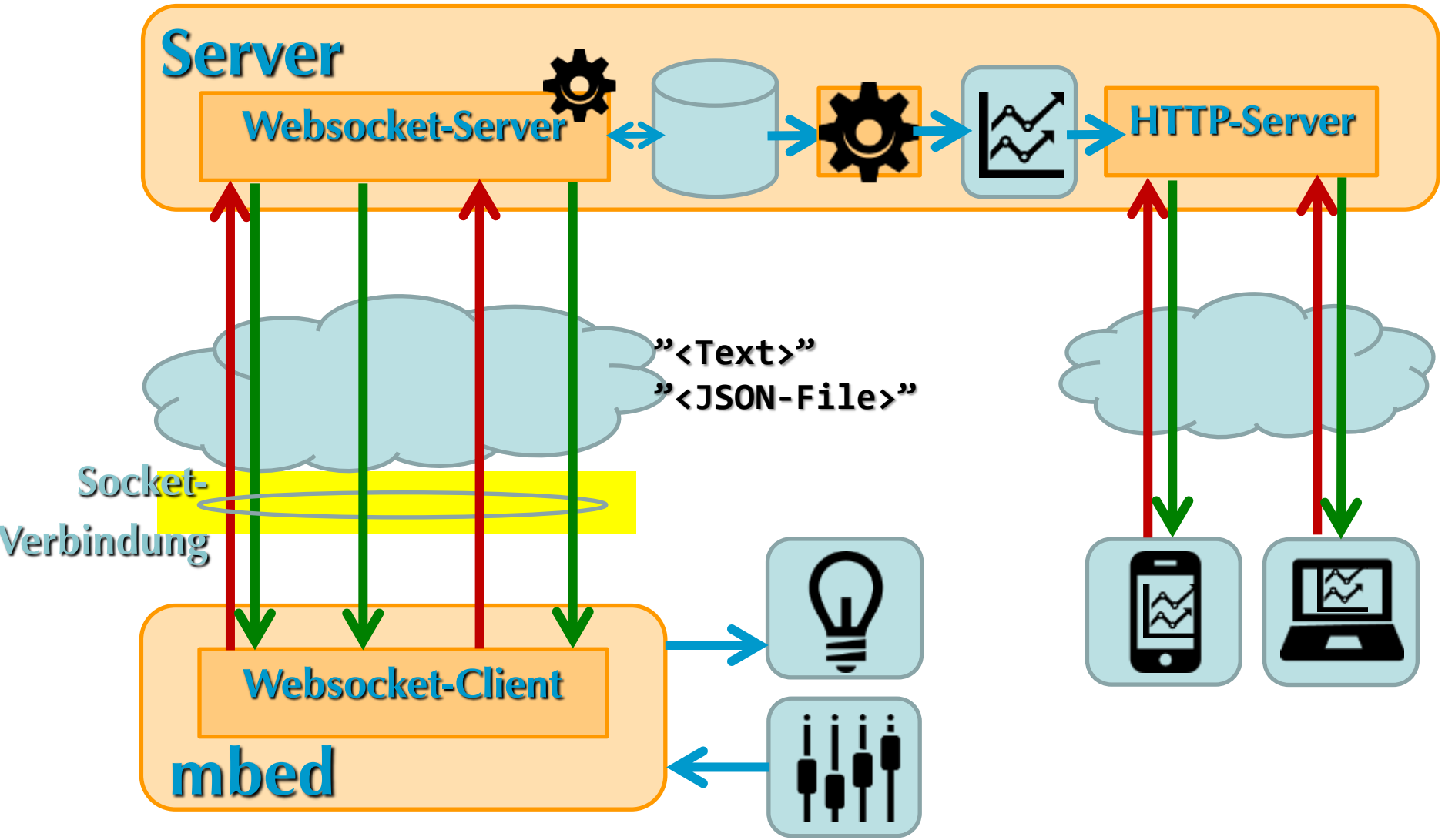
IOT → mbed als HTTP-Client



IOT → mbed als HTTP-Client

```
1  #include "mbed.h„
2  #include "EthernetInterface.h„
3  #include "HTTClient.h"
4  int main() {
5      EthernetInterface eth;
6      eth.init();                    //Use DHCP
7      eth.connect();
8
9      HTTPClient http;
10     char str[512];
11     int ret = http.get(”http://www.myserver.de?<key>=<value>", str, 512);
12
13     ret = http.post(...
14
15     eth.disconnect();
16 }
17
18
19
```

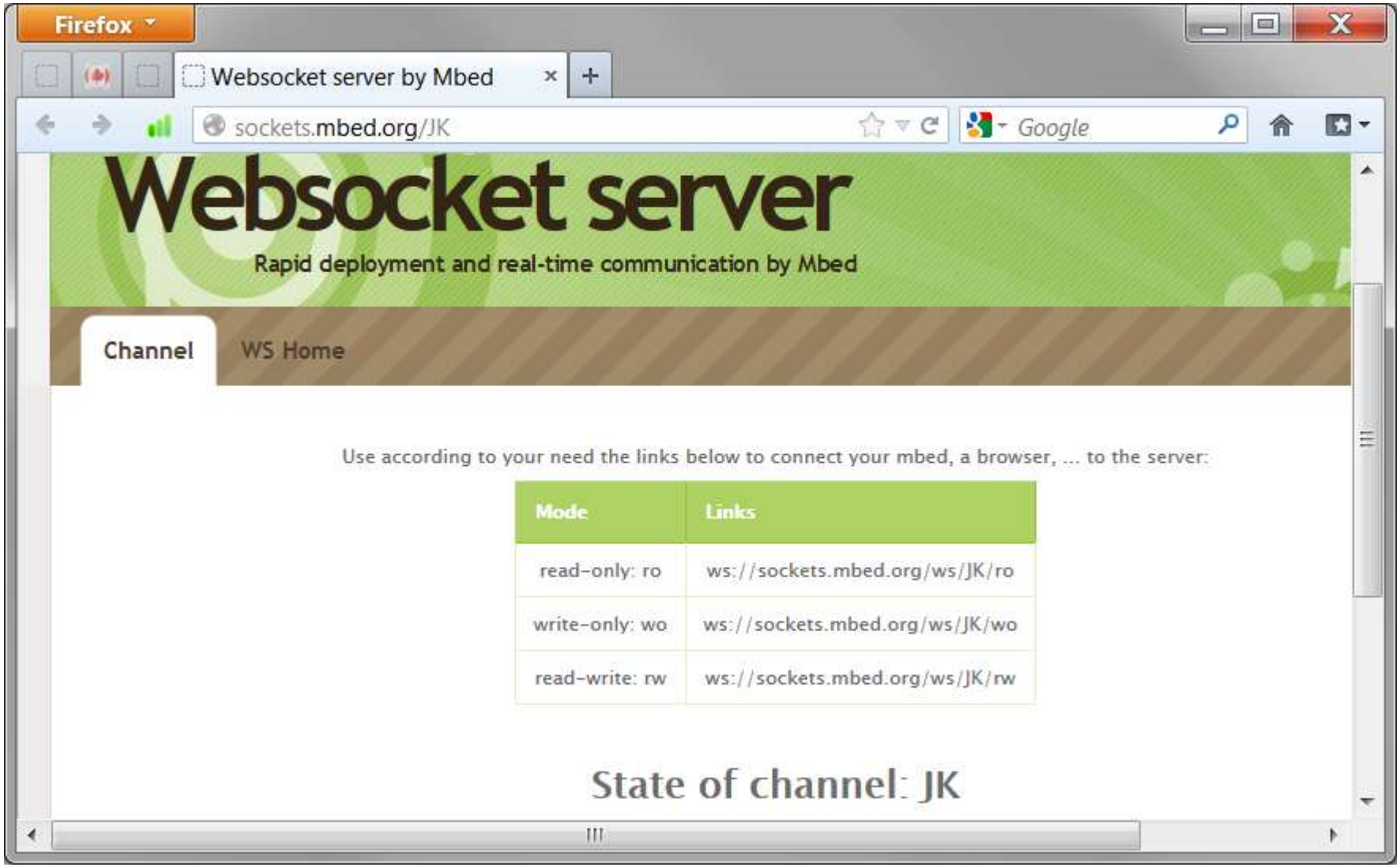
IOT → mbed als Websocket-Client



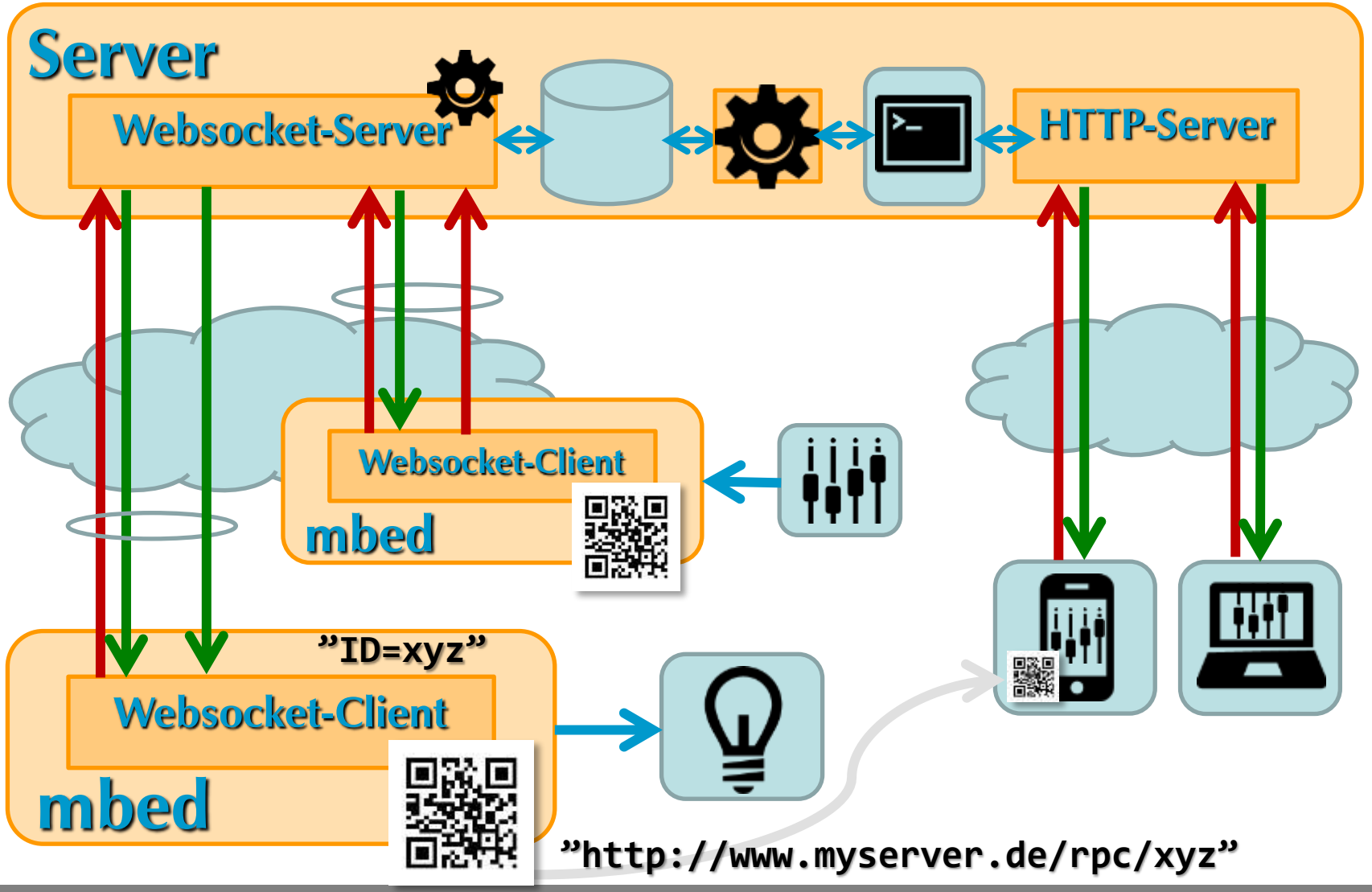
IOT → mbed als Websocket-Client

```
1  #include "mbed.h"
2  #include "EthernetInterface.h"
3  #include "Websocket.h"
4  BusIn taster(p8, p14);   AnalogIn ain(p15);
5  char szData[128];
6
7  int main() {
8      EthernetInterface eth;   eth.init();   eth.connect();
9
10     Websocket ws("ws://sockets.mbed.org:443/ws/JK/rw");
11     ws.connect();
12
13     while (1) {
14         sprintf(szData, "mbed: Poti=%d Taster=%d", (int)(ain*1000),taster);
15         ws.send(szData);
16
17         if (ws.read(szData))    printf("rcv: %s\r\n", szData);
18         wait(1.0);
19     }
```

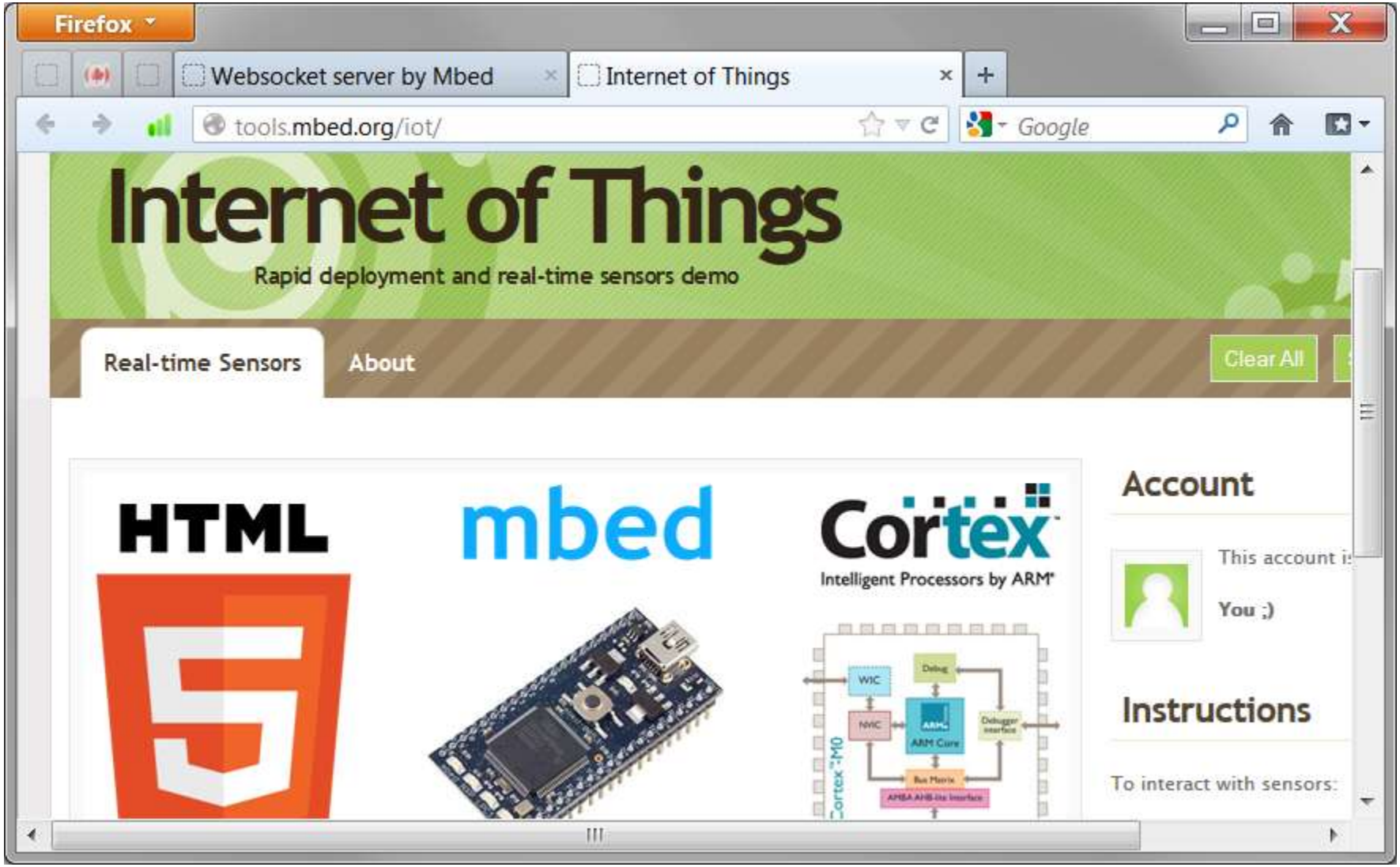
IOT → Websocket-Beispiel: socket.mbed.org



IOT → mbed als Websocket-Client

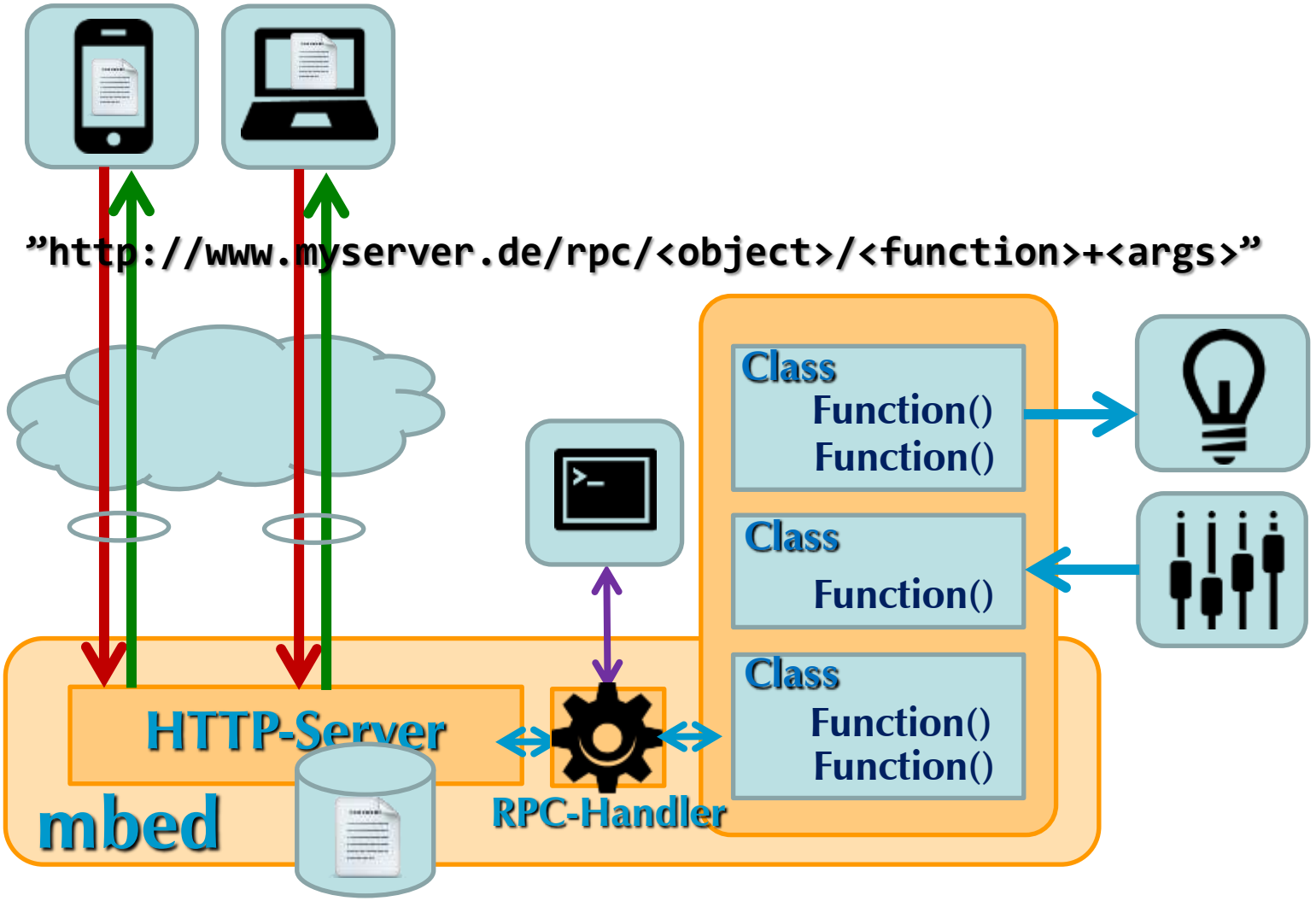


IOT → Websocket-Beispiel: tools.mbed/iot



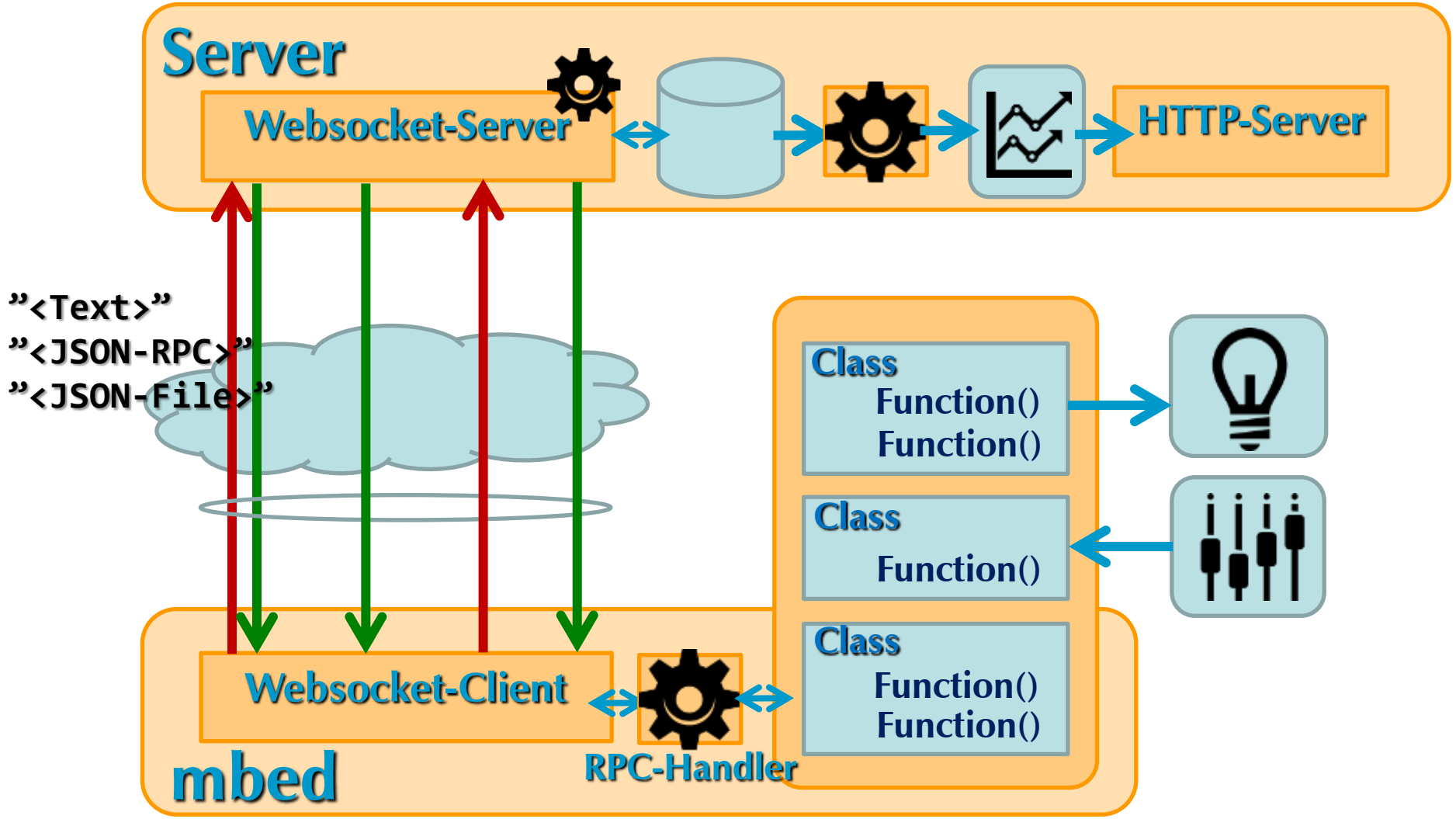
IOT → mbed als HTTP-Server+RPC

(RPC = Remote Procedure Call)



IOT → mbed als Websocket-Client+RPC

(RPC = Remote Procedure Call)



IOT → mbed als Websocket-Client+RPC

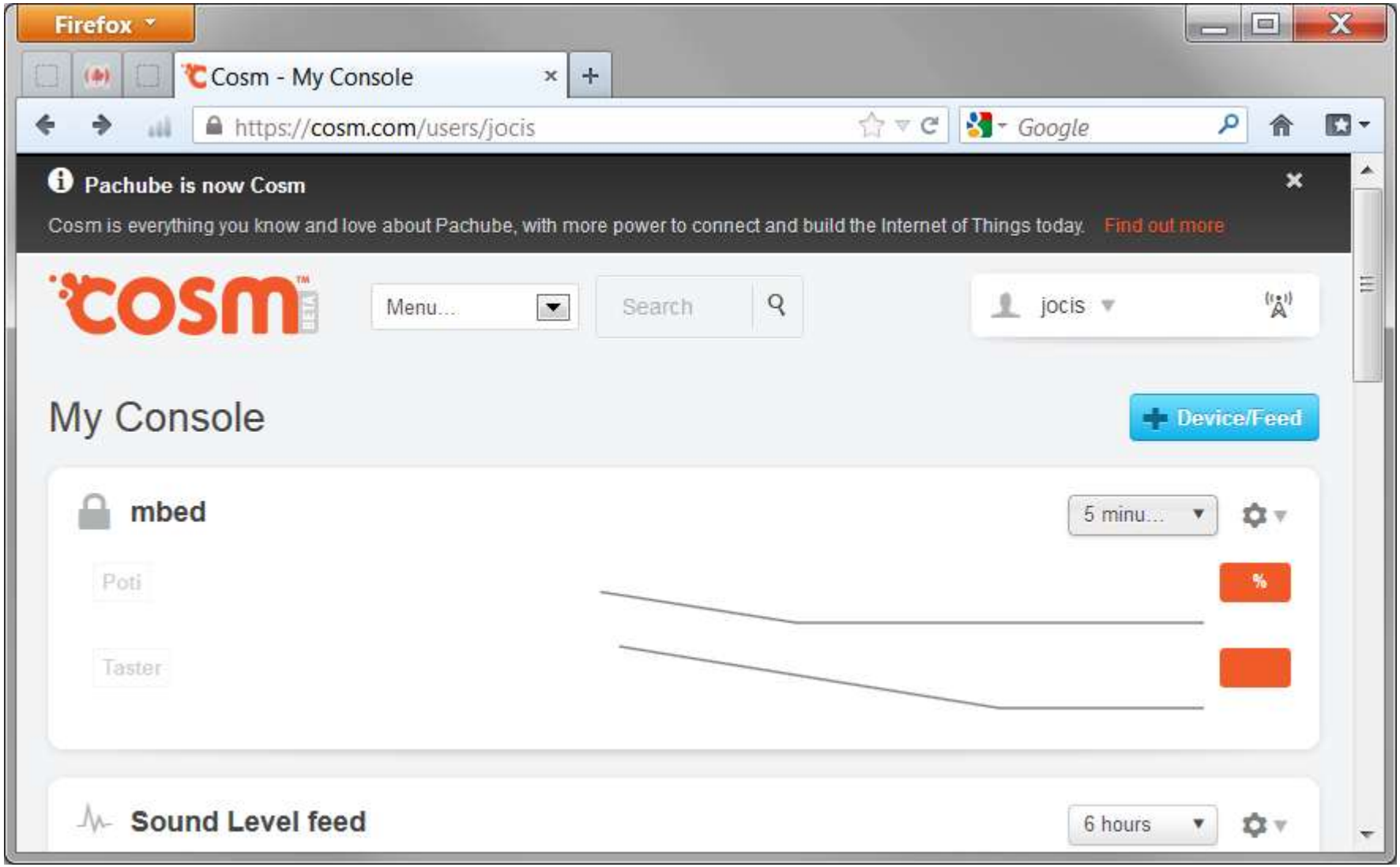
```
1  #include "mbed.h"
   #include "MbedJSONRpc.h"
2  #include "MbedJSONValue.h"
   #include "EthernetInterface.h"
3  #include "Websocket.h"
4  BusOut ledbus(LED1, LED2, LED3, LED4);
5  //websocket: configuration with sub-network = demo and mbed_id = mbed_led
6  Websocket ws("ws://sockets.mbed.org/rpc/KNF/mbed_jk");
7  //RPC object attached to the websocket server
8  MbedJSONRpc rpc(&ws);
9
10 //Test class
11 class MyRPCclass {
12     //...
13     void led(MbedJSONValue& in, MbedJSONValue& out) {
14         ledbus = in[0].get<int>();
15     }
16 };
17
18 MyRPCclass myRPCobject;
19                                                    // to be continued...
```

IOT → mbed als Websocket-Client+RPC

```
1  // ...continued
2
3  int main() {
4      EthernetInterface eth;   eth.init();   eth.connect();
5
6      ws.connect();
7
8      Base::add_rpc_class<AnalogIn>();
9      Base::add_rpc_class<DigitalIn>();
10     Base::add_rpc_class<DigitalOut>();
11     Base::add_rpc_class<BusOut>();
12     Base::add_rpc_class<BusIn>();
13
14     // register „led“
15     rpc.registerMethod("led", &myRPCobject, &MyRPCclass::led));
16
17     // wait for incoming CALL requests
18     rpc.work();
19 }
```

IOT → RPC-Beispiel: tools.mbed/iot/rpc

IOT → RPC-Beispiel: cosm.com



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