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Indoor Air Quality Monitoring with WSN-based CO2 Sensors

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- Problem statement
- CO2
- ZigBee
- System setup
- CO2 Sensor
- I²C circuit
- Fan circuit

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- CO2 measurements using ...
  - … ZigBee nodes
  - … I²C CO2 Sensor
  - … monitoring Software on PC

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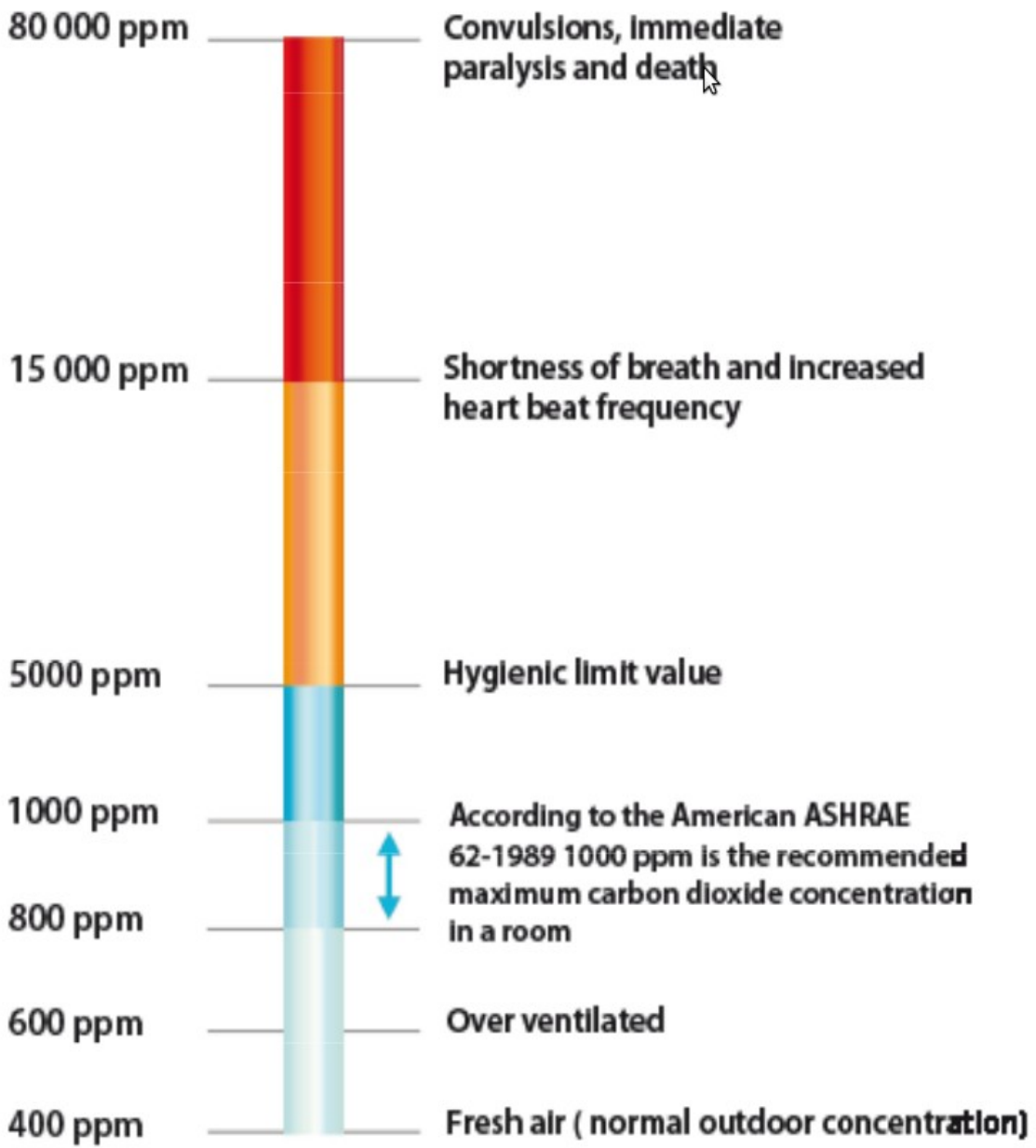
- CO2 occurs in ...
  - … combustion processes
  - … natural metabolism of organisms
- Quantity
  - Exhaled air: 3,8% (38000ppm)
  - Indoors: 400-1200 ppm
  - Outdoors: 350-450 ppm
- FH-Kiel Laboratory: ~600-700ppm

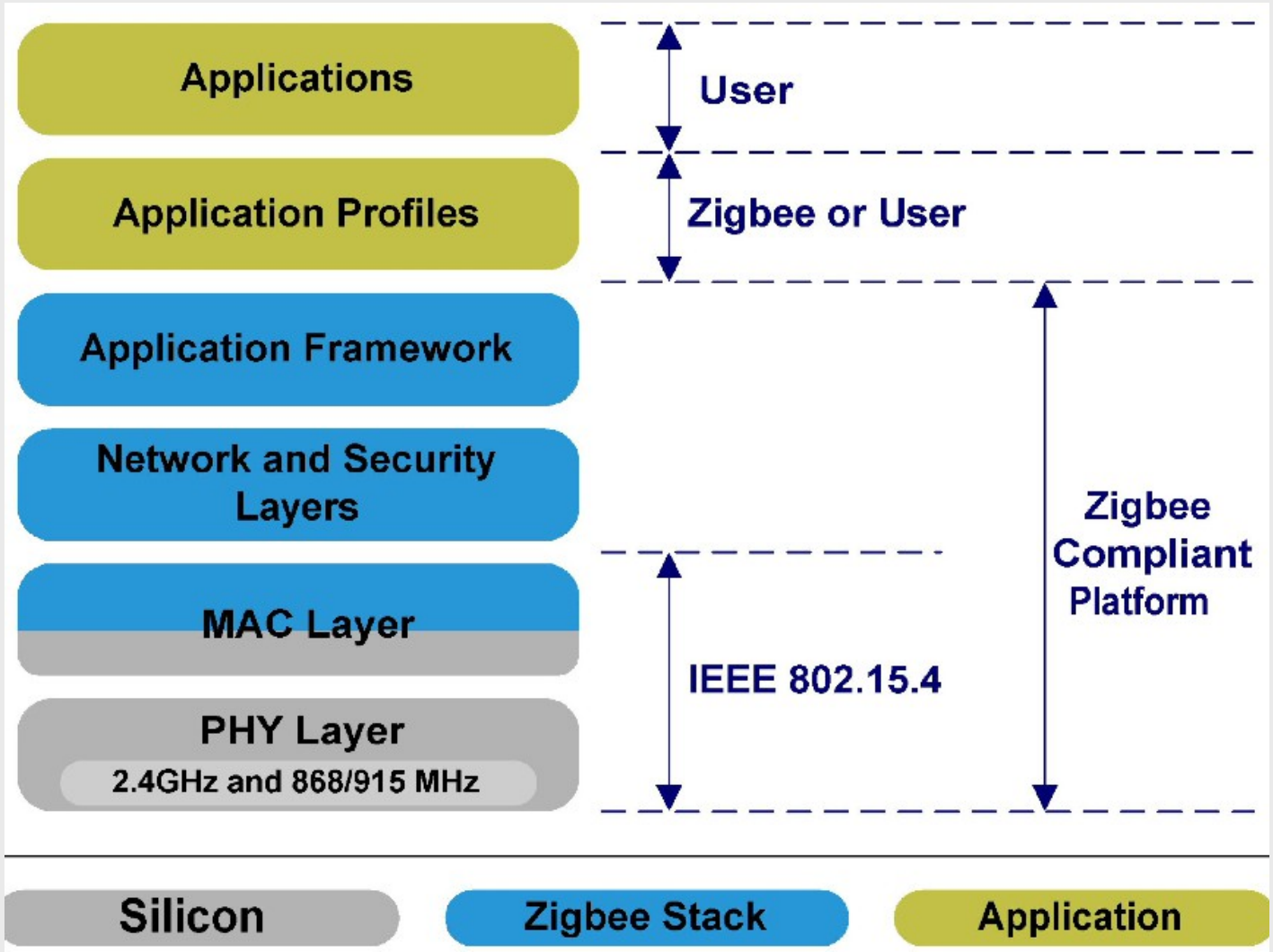
How does CO_2 affect the human body?

[www.senseair.com]



- Standard for wireless control and sensor networks with a low data rate
- Created by the Zigbee alliance (Philips, Motorola, Intel,..)
- Characteristics
  - low power consumption designed for long battery life
  - low manufacturing costs

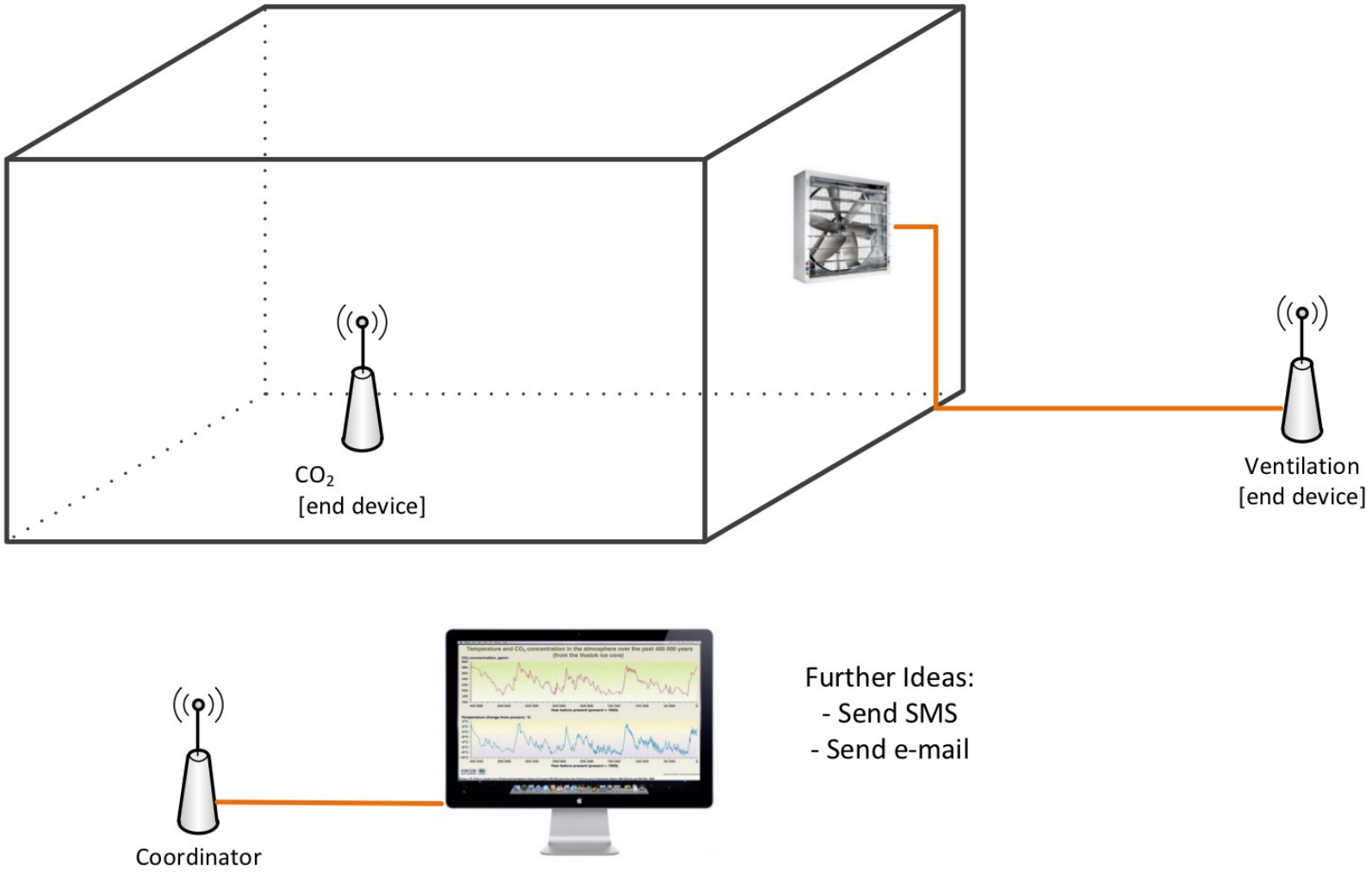
ZigBee


Applications
Application Profiles
Application Framework
Network and Security Layers
MAC Layer
PHY Layer
2.4GHz and 868/915 MHz
User
Zigbee or User
IEEE 802.15.4
Zigbee Compliant Platform
Silicon
Zigbee Stack
Application

- Device types
  - Full functional device (FFD)
  - Reduced functional device (RFD)
- Roles
  - ZigBee end device (RFD)
  - ZigBee router (FFD)
  - ZigBee coordinator (FFD)

- Network topologies
  - Star
  - Mesh
  - Cluster
- Addressing
  - 64 bit and 16 bit address
  - 255 endpoints per device to address services
  - Direct and indirect communication

System setup



System setup

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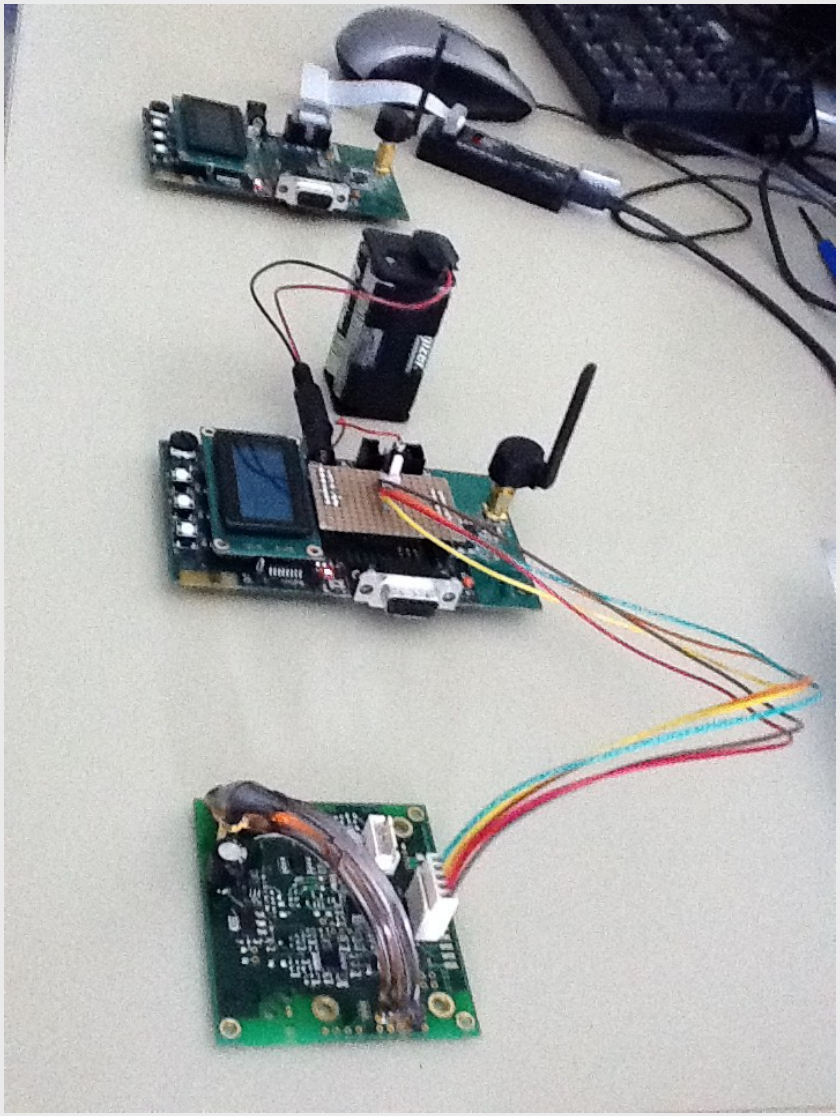

- Senseair LO K22

CO2 Sensor

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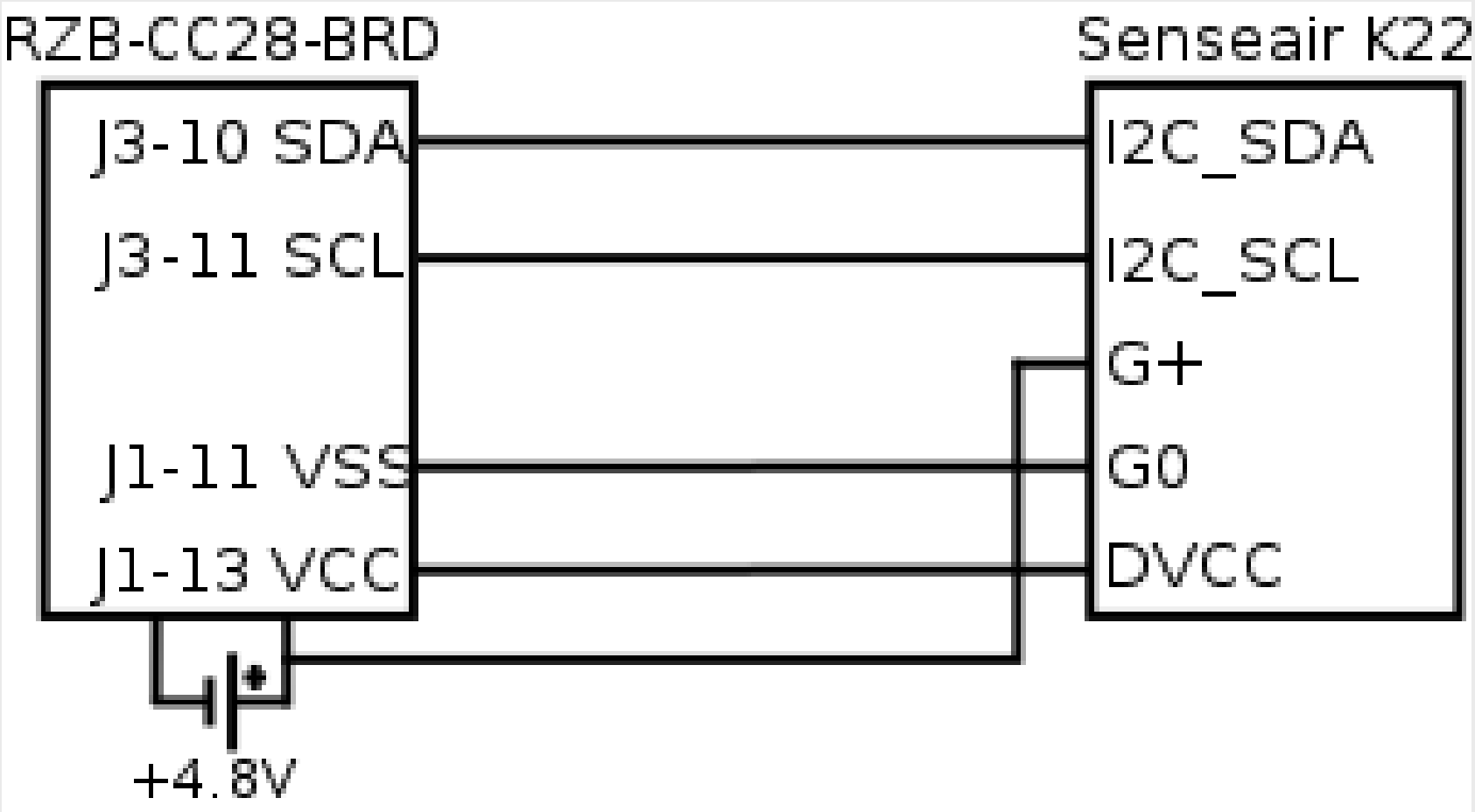
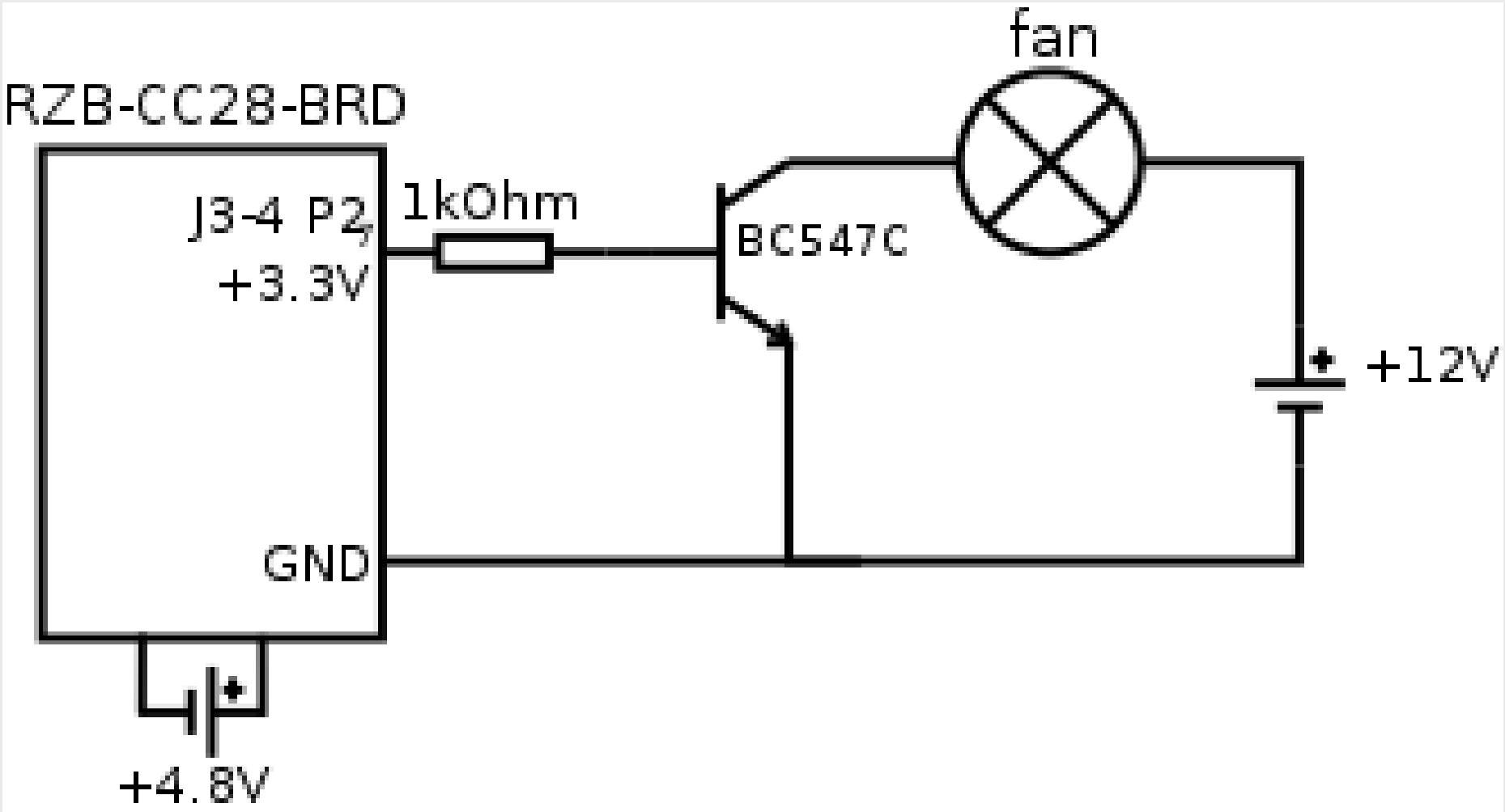
	Technical specification	Values
Electrical Data	Power input	4.5 to 12 VDC
	Current consumption	40 mA, 300 mA (peak)
CO_2 measurement	Measurement interval	2 seconds
	Measurement range	0-2000 ppm
	Extended measurement range	2000 – 10000 ppm
	Calibration adjustment switch	Fresh air (400 ppm)
	Accuracy	(+/-) 75 ppm

I²C Circuit


RZB-CC28-BRD
J3-10 SDA
J3-11 SCL
J1-11 VSS
J1-13 VCC
+4.8V
Senseair K22
I2C_SDA
I2C_SCL
G+
G0
DVCC

Fan circuit



CO2 monitor desktop application

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- .NET 2.0
- Uses graph component
- Listens to RS232
  → event-driven
- Logs CO2-Data to csv file

CO2 monitor desktop application

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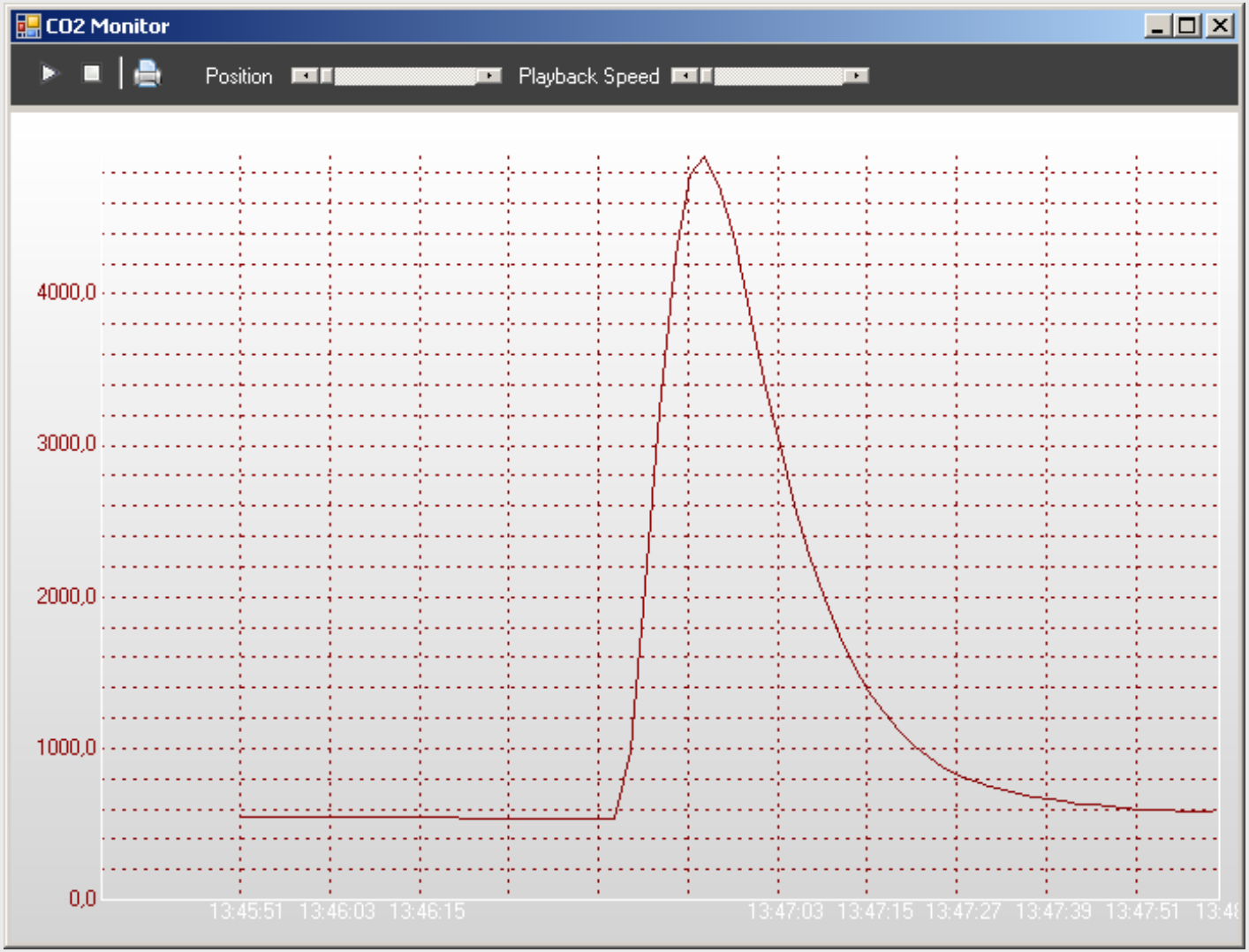

Request CO2 Data – Coordinator

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```
/*********************************************************************************
Name        : SendCO2DataRequest()
Parameters  : address where to request the CO2 data
Returns     : nothing
Description: Request new CO2 data  (coordinator only)
*********************************************************************************/
void SendCO2DataRequest(ZbShortAddr destination)
{
    BYTE outPacket[1];
    ZbNsduHandle handle = 20;   // arbitrary value

    // send data to end device
    outPacket[0] = CO2_DATA_REQUEST;
    ZbDataSnd(handle, destination, outPacket, 1, 15, ZB_ROUTE_DISCOVER_ENABLE, FALSE, 0);
}
```

Request CO2 Data – Sensor Node

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```
// read CO2 data
co2_value = SENSOR_READ();

// convert short to byte array
for (i=0; i<2; i++)
{
    tmpPointer = &co2_value.co2_concentration;
    co2_value_in_bytes[1] = *tmpPointer; // lowByte
    tmpPointer++;
    co2_value_in_bytes[0] = *tmpPointer; // highByte
}

// send data to coordinator
outPacket[0] = CO2_DATA_RESPONSE;
outPacket[1] = co2_value_in_bytes[0];
outPacket[2] = co2_value_in_bytes[1];
ZbDataSnd(handle, destination, outPacket, 3, 15, ZB_ROUTE_DISCOVER_ENABLE, FALSE, 0);
```

Fan activation – Coordinator Node

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```
if(sensor_value > 1200  &&  bIsFanOn == 0) //condition for turning fan on
{
    LCD_DisplayString(LCD_LINE2, "fan on"); //Display message on the LCD
    bIsFanOn = 1;
    AlertFanNode();
}
if (sensor_value < 800 &&  bIsFanOn == 1) //condition for turning fan off
{
    LCD_DisplayString(LCD_LINE2, "fan off"); //Display message on the LCD
    bIsFanOn = 0;
    AlertFanNodeOff();
}
```

Fan activation – Coordinator Node

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```
/*****************************************************************************
Name        : AlertFanNode()
Parameters  : nothing
Returns     : nothing
Description: Tell fan node to start fan (coordinator only)
*****************************************************************************/
void AlertFanNode(void)
{
    BYTE outPacket[1];          // will contain the command
    ZbNsduHandle handle = 22;   // arbitrary value

    // send data to end device
    outPacket[0] = ACTIVATE_FAN;
    ZbDataSnd(handle, NODE_FAN, outPacket, 1, 15, ZB_ROUTE_DISCOVER_ENABLE, FALSE, 0);
}
```

Fan activation – Coordinator Node

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```
/*****************************************************************************
Name        : AlertFanNodeOff()
Parameters  : nothing
Returns     : nothing
Description: Tell fan node to stop fan (coordinator only)
*****************************************************************************/
void AlertFanNodeOff(void)
{
    BYTE outPacket[1]; // will contain the command
    ZbNsduHandle handle = 22;   // arbitrary value

    // send data to end device
    outPacket[0] = DEACTIVATE_FAN;
    ZbDataSnd(handle, NODE_FAN, outPacket, 1, 15, ZB_ROUTE_DISCOVER_ENABLE, FALSE, 0);
}
```

Fan activation – Fan End Device

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```
/*****************************************************************************
Name        : ActivateFan()
Parameters  : nothing
Returns     : nothing
Description: Turn on the fan (fan node only)
*****************************************************************************/
void ActivateFan(void)
{
    ZbHalLed_SetLED(0,1);
    P27_DIR = 1;
    P27 = PIN_STATE_HIGH;
}

/*****************************************************************************
Name        : DeactivateFan()
Parameters  : nothing
Returns     : nothing
Description: Turn off the fan (fan node only)
*****************************************************************************/
void DeactivateFan(void)
{
    ZbHalLed_SetLED(0,1);
    P27_DIR = 1;
    P27 = PIN_STATE_LOW;
}
```

CO2 Experiment

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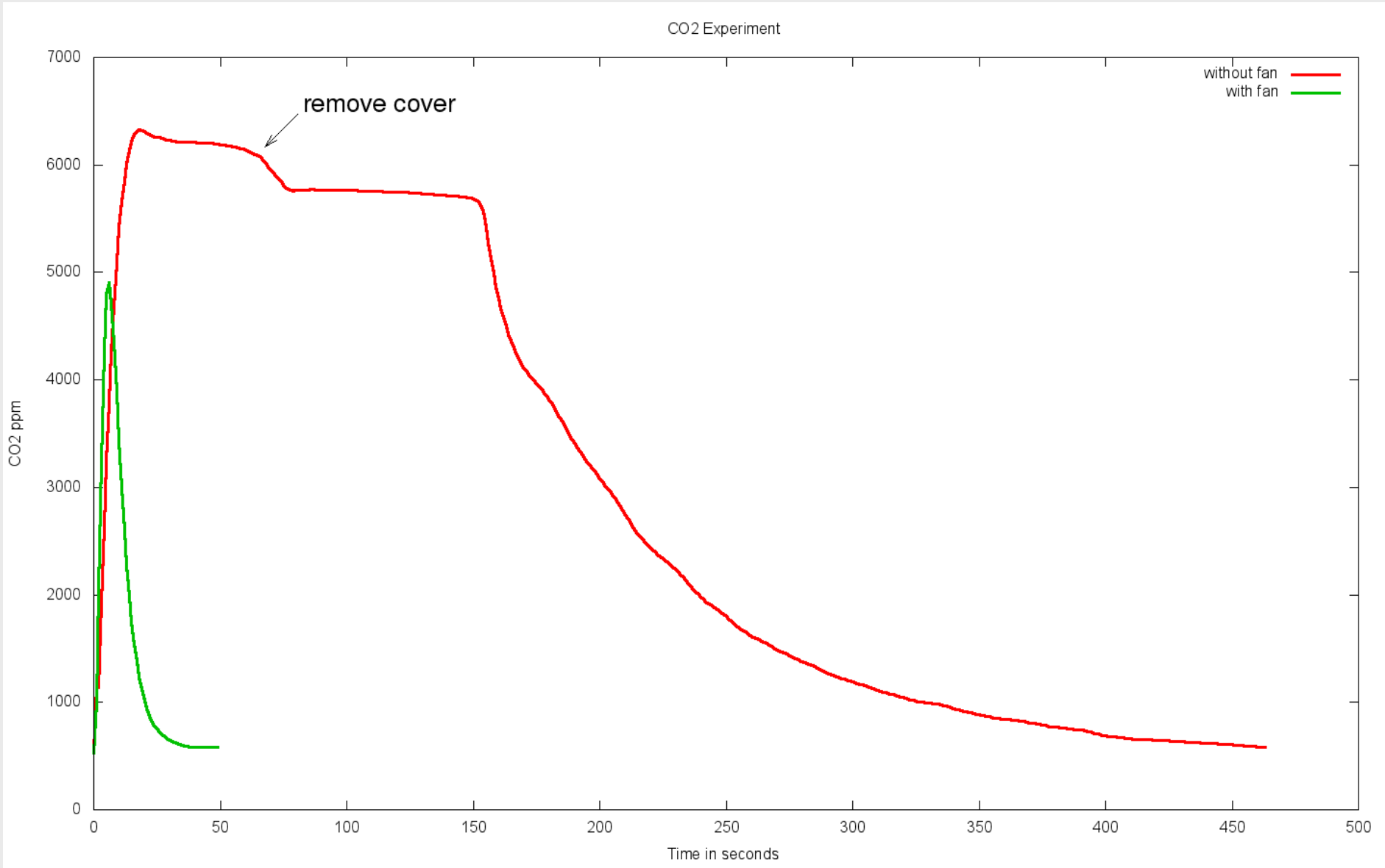

Thank You!