Hochschule Osnabrück
University of Applied Sciences

**Faculty**
**Engineering and Informatics**

# Summer University 2013 - Sundsvall

Report about the group-work

**Smoke detector as a hand-held device**

Mittuniversitetet
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# 1 Introduction

## 1.1 Motivation

As i first heard about the summer university in the lecture of Measurement here in Germany, i thought of being pushed to speak English and have a look on how a semester outside Germany will be. This was my point of interest in the Summer University and i applied to it.

## 1.2 Ambition

The target to get in touch with other students of other countries and working together on technical projects to further the language and learning from each other was set.

# 2 Sustainability with the mobile device

## 2.1 Mobile protection against fire

The use of our device to secure you from the fire is the most usually. Imagine, if you where at a camping tour and the fire is far away but it lasts around you, maybe this device got the needed accuracy to give an alarm when the particle number is increasing. When something is burning it gives a lot of smoke and dust to the air. So, now you hold a little device with great capabilities in your tent, which gives you an alarm early enough to get in a secure area.

## 2.2 Measure fine dust

Nowadays most common diesel motors and even the laser printers in the offices are producing fine dust. It is an fact that these fine dusts are causing cancer. If you breath these dusts in most great offices or on the street its significant bad for you. So the idea is to get our handy device with you and you can check the values around you. Maybe you are able to change the desk to a lesser polluted area in your working place. Or if you are living near a motorway, you can check if its okay to open the windows.

## 2.3 Smog warning

Another interesting use of our device is, to give an alarm if you are living in the big metropolis. The big industrial shaped countries got big problems with the smog. Air pollution is overwhelming. With our device you can check if its okay to go outside, or if you wait until the rush hour is over.

## 2.4 Fine Dust Map

If the capability of writing the values of dust in the SD-card will bring another idea of the group on the table. If we are going to save the values together with the geographical position of the sensor, it will be possible to create a fine dust map. So we can find the areas of the most pollution.

# 3 Module Overview

## 3.1 Display 3000 Module

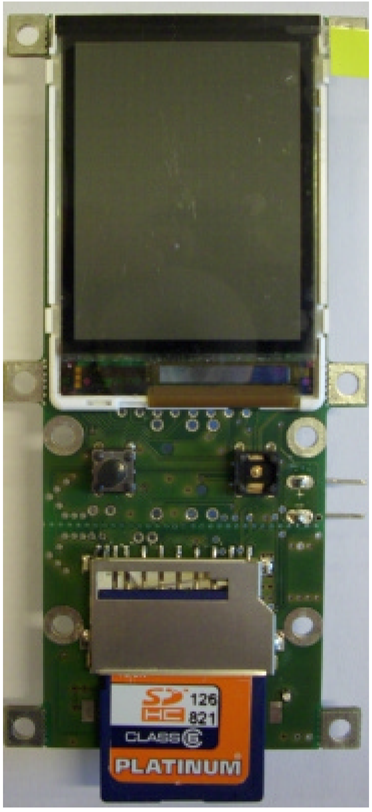


Figure 1: :Display 3000 - DO74x Module

The display 3000 module with the model Number: D074x is based on an ATMega 2561 micro controller, and the information can be read on a 2,1" TFT-Color-Display. Further the board got different interfaces, like the ISP-Interface which can be used to burn in the program, JTAG, and simple general purpose input output pins. A digital-analog-converter is over the controller usable.

## 3.2 Sharp Dust Sensor Module

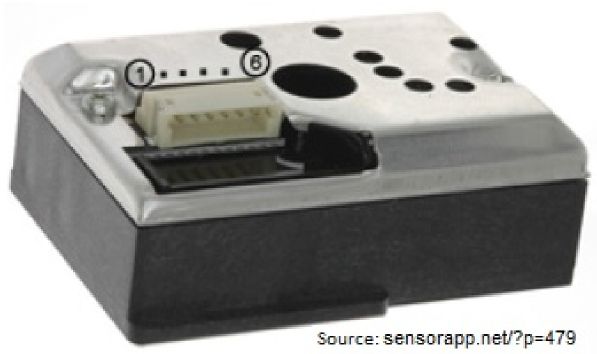


Figure 2: Sharp Dust Sensor

The Sharp dust sensor is generally based on a infrared diode and a photo diode. The infrared diode is controlled via the signal pulse. If particles are in the light of that diode, they will reflect the light in the the direction of the photo diode and it will detect it. The more particles are in the sight of that infrared diode the more Voltage you got at the resulting peak after the falling edge.

## 3.3 Self-made Sensor Interface

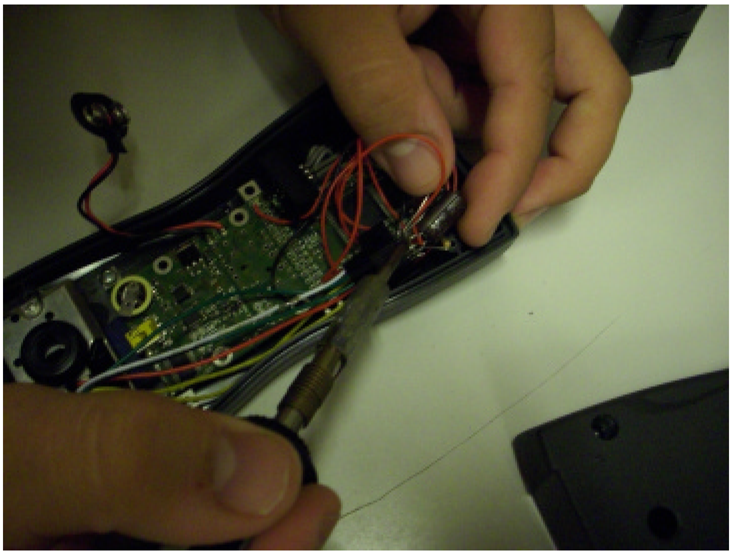

Figure 3: Self-made Sensor Interface

After we read in the data sheet of the Sharp dust sensor, it was clear that we have to develop a little interface to fit the sensor to the D074x-Board. So we decided to use some wires and a capacitor and a MOSFET-Transistor to build a little driver interface to get the sensor working.

## 3.4 Case

Figure 4: Case

Finally the whole device has to fit an case which was bought before. So we got room limits to fulfill.

# 4 Signal and processing overview

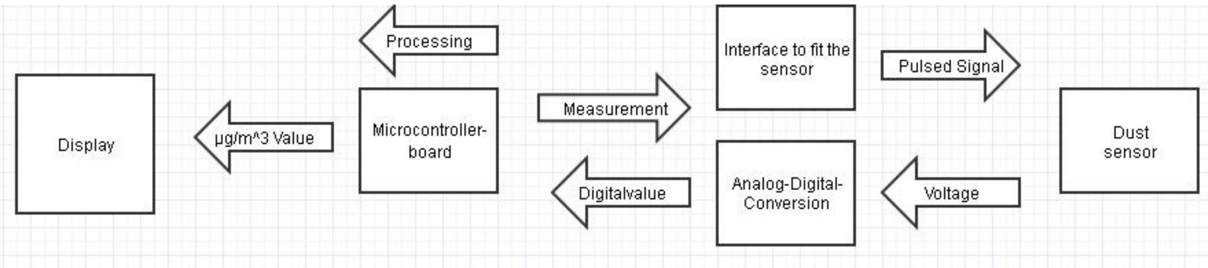


Figure 5: Signal Process Chart

## 4.1 Signals from the Display 3000 Module to the Sensor

The micro controller sends a pulsed signal to the interface and after this interface the sensor is connected. At the falling edge of the signal the measuring process in the sensor is started.

## 4.2 Signals from the Sensor to the Display 3000 Module

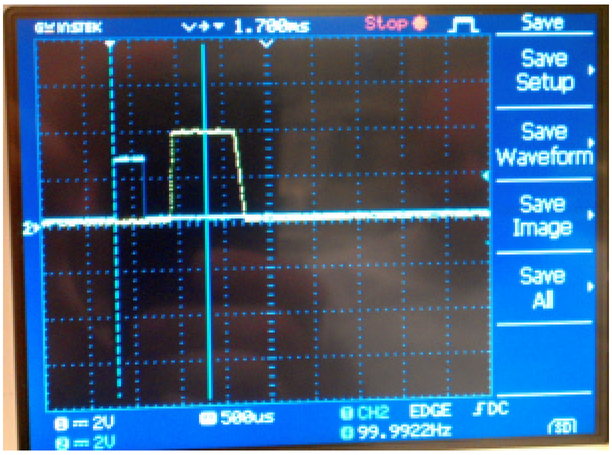


Figure 6: The Signals (Sent Pulse is Blue, Peak Value from Sensor is Yellow)

## 4.3 Signals from the Display 3000 Module to the Sensor

After a time of approximately 13 microseconds the Sensor responses with a Peak. This Voltage value is significant to the measured particles between the measurement hole. back at the micro controller the Digital-Analog-converter converts the Voltage in a integer Number of 0 to 1023 like 0 Volt - 5 Volt. With this value the micro controller is operating.

## 4.4 Processing at the micro-controller

In the micro controller the digital integer value is used to compute the actual particle value.

## 4.5 Output on the Display


Figure 7: Layout

Then the micro controller brings the Value on the TFT-Screen via JTAG-Interface.

# 5 Programming the Display 3000 Module

## 5.1 Software prerequisites

The properly software was difficult to find. It was very hard the first days to get something working on the board, because we were the first. But the following Packages have to be installed to get the programming process working: (right in that order)

- AVR-Studio Version 4.19
- AVR-Studio Version 4 Toolchain
- AVR-Studio Version 4 USB-Driver
- AVR-Studio Version 6.1 with Service Pack 1

All needed Software is placed in the Folder Programming-software on this DVD.

## 5.2 Hardware prerequisites

The Hardware is simple, you need a JTAG-Programmer connected to the ISP-Interface.

## 5.3 Sample programs

We got some sample programs from the manufacturer, to test if the board is working. We spend the first days of project work with only transfer a display Sample code on the device, cause using the newest AVR-Studio will end in burning the .elf-file on the board and the display ist only white after reboot the device. So we tested some other configurations but still got the problem. One of the bigger sample codes was only a Version 6 project. So we decided to program on AVR-Studio 6 and find a way to burn only the .hex-file with the AVR-Studio 4. So with this configuration it works. It is nessesary to use the old USB-Driver which come with AVR-Studio 4. The sample codes got a wide spectrum from simple display tests with images to great code with SD-card functions.

## 5.4 The programming line

- Start AVR-Studio Version 6.1 with Service Pack 1
- Open the project-file
- Make the changes you want
- Build the solution (generate the .hex-file)
- Start AVR-Studio Version 4
- Connect to the programming device
- Connect via programming device on the ATmega2561 microprocessor

- Burn the .hex-File (NOT THE ELF) (located in the folder project/release or project/debug)

## 5.5 The modifications in the Source code

The sample code we used as basis was the RTCDemo.atsln-Project. It has a build in SD-card test and the most usual Display-codes included. To get the sensor working we had to generate pulsed voltage with the micro controller. We had to modify the General Pin-Layout to do that. We had to build our own Display Layout and figure out how to Display the value. Also we had to generate code to get the analog-digital conversion. Then from the digital value the right conversion to get the particle value. The preconfigured source code only supported the data-format "string". But in the computing process out of the Digital value comes a 16Bit-Integer value. So we had to "cast" the data format. Then we had several tests to cache the values to get a smoother value at the display.

# 6 Connecting the Sensor Module

## 6.1 Developing the Interface

The Interface was needed because the sensor does not got Direct-Current-Voltage output which were very easy to use. The data sheet tells us, to use a pulsed signal to drive the sensor and trigger the measure time. With the capacitor we realize a very simple sort of a "Sample and hold circuit". The transistor is needed to drive the transmitting diode. Also we needed the Interface to fasten change the Sensor and secure the transmitting diode in the Sensor-Chamber. The used PINs at the DO74x-Board are the following:

- PORT A0 - Used to send the pulsed Signal to the Sensor
- PORT F1 - Used to read the Sensor as analog value

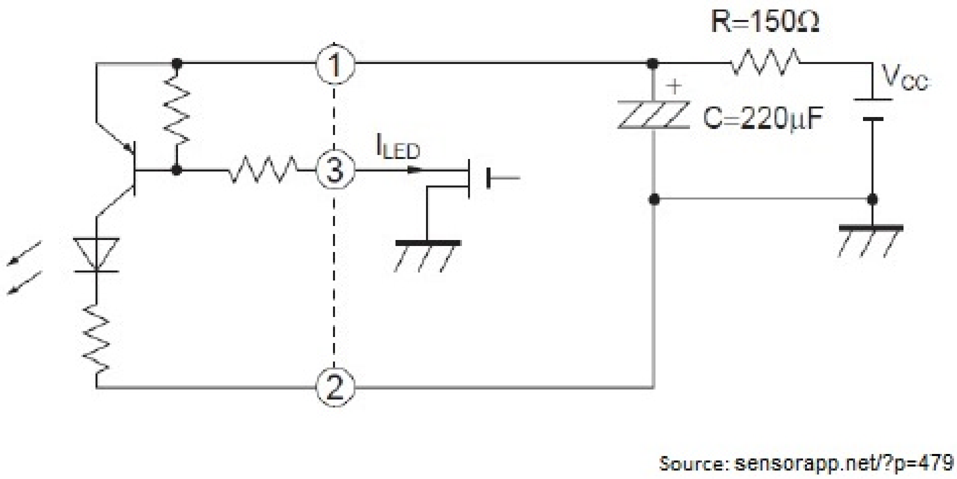


Figure 8: Sheme

## 6.2 Modifying the Sensor connections

As you can see in figure 2, the professional Sharp dust sensor is made to use in industrial manufactured devices. This devices are build by large industrial machines and in large quantities. It got a very small socket to fit a industrial made connector. We decided to solder some wires on the contacts available in the PCB. So you can use a usable connector if you find the right one.

# 7 Modifying the case

## 7.1 General Layout

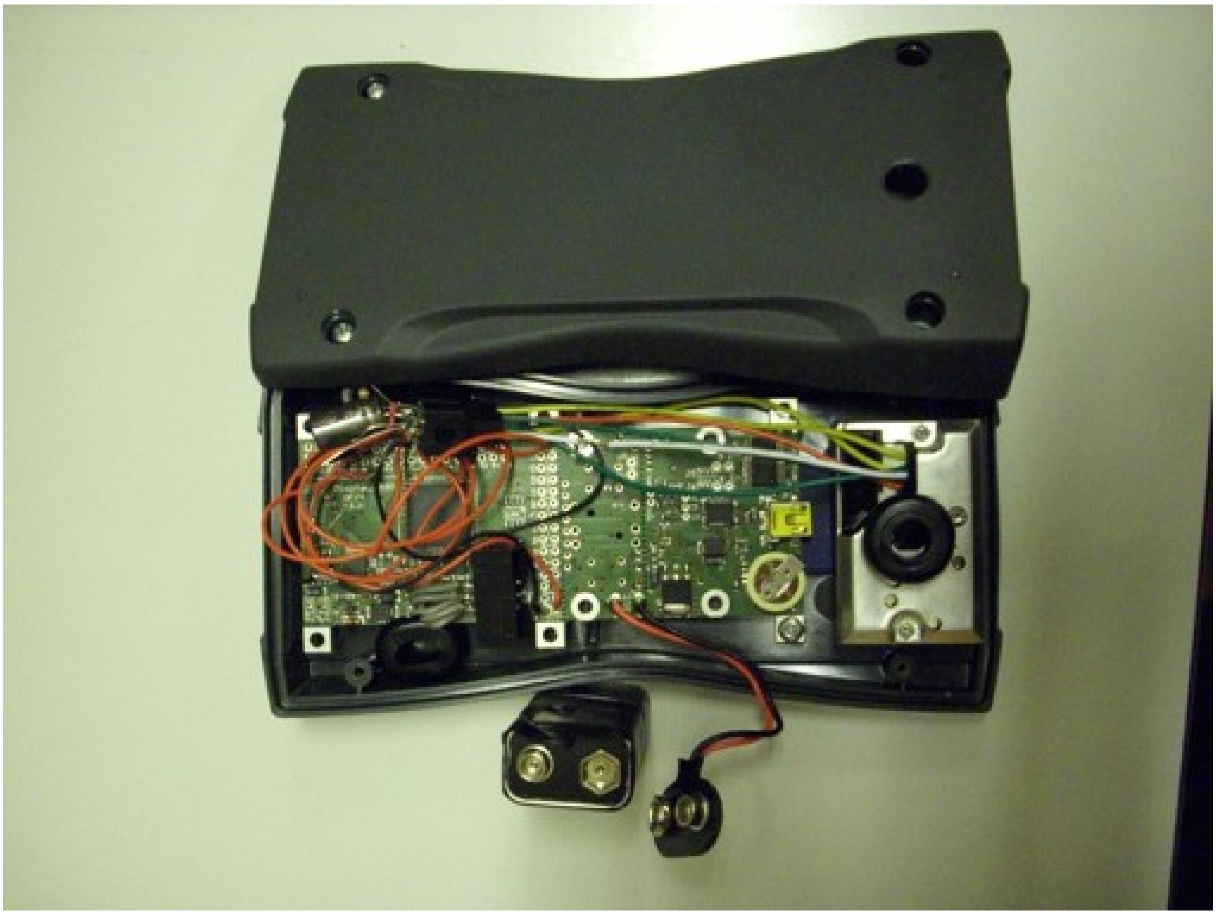

Figure 9: Hand held particle detector

The case is very small. The whole Board fits nearly in it. At the front is a square hole to fit the display. Inside are some mounting holes, but only one of them seems to be usable. It was probably made for an other model of the board. We glued a security glass on the display hole, and mounted the display with the board in the case. The dust sensor has only enough space in the lower part of the case. So we drilled a hole big enough to get the air trough the sensor chamber and glued it in. The sensor interface got enough space beside the Board-PCB. Only the 9 volt battery, our power source has to to placed on the PCB. To prevent any short circuits we decided to isolate it with isolating band. After all, we get everything needed in the case. But there is no more room left inside.

# 8 Present Status


Figure 10: Case with everything inside

The present status is like the following:

- Programming is working
- Power source is working
- Case is working
- Display Layout is working
- Analog-Digital conversion is working
- Dust sensor is working with external pulsed Voltage
- Pulsed Signal generation by micro controller is working
- Triggering the right Peak-Value of the measurement is not working
- SD-card function is not working
- Power consumption is much to high. (e.g.

The main problems during developing were the lot of time bringing the programming process up, to find out how to program the device was the biggest time part. After that we thought the sensor gives back a easy DC Signal and spent much time to find the "distorting" part. But then with the interface development it goes further. The last part which was missing is the timing problem in driving the sensor. If we had the idea and a few days more in Sundsvall we would find the solution.

# 9 Future Work

## 9.1 Energy saving functions

As i mentioned in the Status report, i think the power consumption is much to high to use the device as a hand held module. The consumption of 300mA lasts approx. 1 hour with the 9 Volt battery. So i guess it is possible to save energy with deactivating the display illumination use the powersaving functions on the micro controller and maybe use less measurements per second. Also it can be possible to use a lower controller working frequency.

## 9.2 Data logging on a SD-Card

The function to write the values on the SD-card would be the most interesting part after getting the other problems solved. There are many other further applications with would be possible then. Like a long term measurement, or the fine dust map.

## 9.3 Keyboard

To get a user interaction a keybord, or joystick like one of the sample boards got, would be perfect if we try to navigate through a diagram or menus.

## 9.4 Alarm function

A loudspeaker, or something like that would be great to have to signal danger.

## 9.5 Output in a diagram

The possibility to get the values as diagram on the display would be usefull to get a look at the changes per time. To see how much the particle number is rising and other time depending values.

## 9.6 Level function

The level function would be great to have together with the alarm. To know after this value as border you have to leave the office, to preserve cancer.

# 10 Online search - present technologies

Following is a selection of the mass of commercial dust, particle and smoke detectors, mostly hand held, but all of them are very expensive. I would say, that our device is much cheaper then them, maybe 100 to 150 USD. The prices of the commercial models vary between 2000 and 4000 USD! I think that the most of them are the money worth, but i had no idea that measurement of dust and particles is that expensive. I found many more models and technicals to measure dust and particles. Most of them got diagrams on their displays and often got the logging options and things that i would see as future work on our own device.

## 10.1 Met One - Aerosol Mass Monitor 831


http://www.zefon.com/store/aerosol-mass-monitor-met-one-831.html

Figure 11: Aerosol Mass Monitor 831

## 10.2 Met One - AERO CET 531 Handheld Particle Mass Profiler and Counter


Figure 12: AERO CET 531

## 10.3 AIR-AIDE - Airborne Particulate Monitor


Figure 13: AIR-AIDE

## 10.4 Sensidyne Nephelometer Real-Time Handheld Dust Monitor


Source:
http://www.zefon.com/store/dust-monitors/

Figure 14: Sensidyne Nephelometer

## 10.5 HAZ-DUST VDM-7500


Source:
http://www.skcinc.com/prod/770-4004.asp

Figure 15: HAZ-DUST VDM-7500

## 10.6 HAZ-DUST I Real-time Particulate Monitor


Source:
http://www.skcshopping.com/ProductDetails.asp?ProductCode=770-1100

Figure 16: HAZ-DUST I

## 10.7 HAZ-DUST IV Particulate Monitor Personal Monitor


Source:
http://www.skcinc.com/prod/770-4004.asp

Figure 17: HAZ-DUST IV

## 10.8 HAZ-SCANNER EPAS Wireless Environmental Perimeter Air Station


Source:
http://www.skcinc.com/prod/
Haz-Scanner.asp

Figure 18: HAZ-SCANNER EPAS

## 10.9 HAZ-SCANNER IEMS Indoor Environmental Monitoring Station


Source:
http://www.skcinc.com/prod/770-800.
asp

Figure 19: HAZ-SCANNER IEMS

## 10.10 Split2 Real-time Dust Monitor

Figure 20: Split2

## 10.11 EPAM-5000 Electronic Monitor for Measuring EPA PM Criteria


Figure 21: EPAM-5000

## 10.12 EPAM-7500 Portable Direct-reading PM Monitor and Air Station


Figure 22: EPAM-7500

## 10.13 EVM-7 Environmental Monitor 2 Instruments in 1


Figure 23: EVM-7

## 10.14 Versatile 5-channel 3886 OP


Figure 24: Versatile 5-channel 3886 OP

## 10.15 3887 Optical Particle Counter


Source:
http://www.skcinc.com/prod/745-3886.
asp

Figure 25: 3887 Optical Particle Counter

## 10.16 Digital Dust Monitor Model 3443

Source: http://www.kanomax-
usa.com/dust/dust.html

Figure 26: Digital Dust Monitor Model 3443

## 10.17 Con.Tec DustMonit


Source: www.conteng.it

Figure 27: Con.Tec DustMonit

## 10.18 Portable Aerosol Mobility Spectrometer (PAMS)


Source: [illegible]

Figure 28: PAMS

## 10.19 Peak3 TSI 8350 Portable Real-Time Dust Monitor


Figure 29: TSI 8350

## 10.20 Peak3 TSI 8532 Portable Real Time Dust Monitor


Figure 30: TSI 8532

## 10.21 Peak3 TSI 3330 Portable Real Time Dust Particle Profiler

Source: http://www.peak3.com.au/index.php?option=com_content&view=article&id=33&Itemid=8

Figure 31: TSI 3330

## 10.22 Turnkey Osiris


Source: http://www.turnkey-instruments.com/environment.php?id=25

Figure 32: Osiris

## 10.23 Turnkey DustMate

Source: http://www.turnkey-instruments.com/environment.php?id=25

Figure 33: DustMate

# Appendix

The things got bigger than i supposed , so i decided to store the appendix of the Internet search in a separate PDF-File which can be found on this DVD. (Internetsearch.pdf)