BACHELOR THESIS

for obtaining an academic degree

„Bachelor of Science in Engineering“ in the degree program

Electronics and Business

**Working title**

Working title

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Vienna, 2020-02-11

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Abstract

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**Keywords:** smoke detector, Keyword2, Keyword3, Keyword4, Tessel 2

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# Introduction

With the introduction of smoke alarm detectors for commercial use in the early 1950’s [1] and for residential use around the 1970’s this market is still growing and interesting market to date [2]. First smoke detectors were used for the military facilities, warehouses or public buildings from the government in order to meet prevalent safety standards. They were not sold to the public until a significant price drop of smoke detectors due to technical developments were achieved. One of the most important developments was the introduction of solid-state electronics [3]. Namely diodes, transistors and integrated circuits, which replaced the previous technology with its cold cathode tubes or vacuum tubes. This allowed manufactures to reduce manufacturing and resource costs, to mass-produce these devices and sell them at reasonable prices to customers. From that moment on, this whole industry started to gain momentum and further developments in terms of detection of smoke, size of the detectors, energy efficiency or to connect multiple detectors to fire alarm systems with steady connections to fire brigades. These allowed for a faster and reliable detection of fire and a prompt alerting of people in the building or structure these fire alarm systems were installed. For consumers smoke detectors which operated by batteries were introduced for easier installment and without the necessity of an expensive fire alarm system.

According to a survey of National Fire Protection Association (NFPA) almost every private household, at around 96 Percent, in the United States of America (USA)has smoke detectors installed in their homes [4] [5]. All these smoke detectors have one major disadvantage: the battery. These must be exchanged at certain intervals are renewal of the whole detector is advised according to manufacturer’s manuals to ensure proper functioning of the detector. In the European Union (EU) however, there is not such a dense distribution of smoke detectors in private households. This is due to higher and more uniform building codes across the EU and which focus heavily on fire prevention then fire detection. Every building according to its designated use must withstand a certain time against fire or fire safety facilities are implemented, whereas standards in the USA are lower or the they are not even adopted all [6]. This means a barely minimum fire safety requirements for new or existing buildings are met in the USA (most houses are built from wood because it is the cheapest resource in the USA). Fire safety regulations in Austria or Germany overachieve minimum fire safety standards of the EU. In Austria they are applied through several guidelines, e.g. “Österreichisches Institut für Bautechnik” (OIB) OIB Richtlinie 2 [7] and “Technische Richtlinie Vorbeugender Brandschutz” (TRVB) TRVB 122S [8]. In Germany there are similar guidelines, e.g. “Deutsches Institut für Normung“ (DIN) DIN 4102-1 and “European Norm” (EN)  
EN 13 501-1 [9].

Although there are many regulations to prevent fire, it is not totally impossible that fire occurs or ignites. If it does, annual statics [9] show around 400 people die from fire worldwide, but only one third dies in the consequence to fire, the other two thirds die in the case of smoke intoxication. 4000 people worldwide suffer long-term damage from burnings and around 1 Billion Euro of fire loss is accumulated worldwide in private households. These figures tell us most people die from smoke not from the actual fire itself. Many of these victims are surprised at night and do not recognize the smoke or fire while sleeping. To reduce the casualties of smoke intoxication almost every manufacturer of home smoke detectors has integrated or combined sensors for smoke / heat or carbon monoxide (CO), acoustic beepers or smart home implementations to receive notifications or ease maintenance [10]. For example, when there are several smoke detectors in every room of a house are installed, they create a mesh network. If there is an alarm, the detecting smoke detector transmits this signal to every other detector in the network and all acoustic beepers trigger at the same time to alert everyone in every room [11]. In Austria it is mandatory to install smoke detectors in habitable rooms or on exit paths in new or refurbished buildings since 2008 [7]. This does not imply that the latest and greatest smart home detectors installed in this new or refurbished buildings.

## Problem Definition

Ideally, every private household should install smoke detectors in their homes, to protect themselves from fire and the even more dangerous smoke caused by fire. But most people think they are rather expensive, unreliable or are annoyed from changing batteries. This could lead to:

* losing their lifes from smoke intoxication
* damaging or losing their property in the case of fire without insurance covering it
* or treat safety or fire prevention slightly and do not care

Today’s home smoke detectors are well-engineered, reliable, more user friendly then people would think of.

## Aim of this work

The aim of this bachelor thesis is, to show how state of the art smoke detectors work and to point out the principles of different detections for smoke and fire. A comparison amongst these detectors builds a foundation to decide which type of detection is suited best for a prototype using the Tessel 2 microcontroller. A detection function for this prototype is implemented to detect smoke and fire reliably. Furthermore, a website displays relevant information and the current status of the associated sensor of the microcontroller.

## Personal Motivation

The topic fire safety is a vital part of my life, because I work as a field engineer for fire alarm systems for one of Austria’s leading companies. During my working hours I check, maintain, program or install all kinds of smoke detectors or various parts of our fire alarm systems for our diverse customers. Although there is a lot of routine work, because all parts work almost flawless, it is still a challenge for me to retain this high level of quality, our customers rely on. And this high reliability of our products made me curious how different detectors or parts of our fire alarm systems are constructed and work. Therefore, I would like to design an appropriate smoke detector prototype and a corresponding website. This shall help to engage myself even more with the topic fire safety and to gain in-depth knowledge of the technical fundamentals behind it.

## Methodological Approach

At first, a theoretical research of current existing detecting methods, sensors and detectors for smoke and fire is conducted based on relevant literature and from hardware manufactures. In order to choose an appropriate approach for my smoke detector design it is necessary to understand and to highlight all different types of smoke detection. After this, the chosen microcontroller and proprietary modules are assembled and configured to accomplish suitable detection function. Then a website is programmed to showcase the function of the designed smoke detector, both functionally and visually appealing.

## Structure of this thesis

This thesis is structured in five different sections. The first chapter focuses mainly on background information, my personal motivation and the aim of this bachelor thesis. It also gives an overview of my approach to achieve this aim.

In the second chapter technical fundamentals of different smoke detectors are described. Also relevant information for home smoke detectors and regulations how they are used are mentioned. Then, used hardware and software are briefly discussed to show why they were chosen.

The third chapter covers the actual design from the concept to its architecture to its final implementation. ???

In chapter four … ???

The last chapter concludes … ???

# Technical fundamentals

This chapter covers and provides all relevant knowledge needed to understand underlying principles of smoke detection first. Then there is an overview which hardware was used to implement and realize a prototype design. Furthermore, this chapter explains which software, protocols or standards where needed to apprehend interaction of each component for the prototype.

## Smoke detectors

The following chapters illustrate the variety of relevant state of the art smoke detector types and their principles of smoke detection. Based upon their description a suitable smoke detector is used for the prototype.

### Factors affecting smoke detection

There are many different factors to be considered when smoke detectors are in use. But these four key factors [12] determine how well smoke is detected and these factors affect detection the most.

The first factor is smoke itself. Nor the amount of smoke emitted, or composition is not the same, depending which materials burns. Every material burns differently thus meaning the size of particles or smoke density change. Some materials produce larger particles when burned (e.g. plastics) or smoldering fires compared to flaming fires which emit smaller particles.

Another factor is smoke entrance resistance i.e. how easy or hard it is for smoke to permeate into a detection chamber. If this resistance is too high (e.g. geometry or structure of a detector, or filters are to narrow), this will affect the rate of detection.

The rate of smoke buildup is factor three. Some materials burn faster than others based on their chemical structure itself [13]. Or for example smaller objects burn faster than larger objects (same material, same weight considered). Due to their increased surface area, more oxygen contributes to oxidation process leading to an increased combustion process [14].

The last factor to be considered is the low propagation velocity of smoke (unless there are no vents or air supply nearby or active). On one side this eases smoke permeating into a detector chamber. On another side this low velocity smoke could cool down and form larger particles i.e. there are less particles for detection and it takes smoke longer from the fire source to reach the detector.

With this comprehension in mind, smoke detectors have different sensitivities based on their varying detection mechanisms and scopes to detect smoke particles.

### Ionization smoke detectors

Mention commercial use

### Photoelectric smoke detectors

Mention commercial use

### Carbon Monoxide detectors

Mention commercial use

### Multiple sensor detectors

Mention commercial use

### Aspirating smoke detectors

Mention commercial use

### Linear detectors

Relevant???

### Smoke detectors for home use

### Regulations for smoke detectors

Relevant ??? a little is covered in the introduction

## Hardware

### Tessel 2

### IR-Sensor

### IR-Receiver

## Software

### Node.js

### Node package manager

### JavaScript

### HTML5

### CSS

# Design

## Concept

Mention how it is implemented and NTC and CO are not measured due to hardware restrictions on the tessel IO Ports

## Architecture

Block Diagramm

# Results and Discussion

# Summary

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# List of Tables

**Es konnten keine Einträge für ein Abbildungsverzeichnis gefunden werden.**

# List of Abbreviations

|  |  |
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| NFPA | National Fire Protection Association |
| USA | United States of America |
| EU | European Union |
| OIB | Österreichisches Institut für Bautechnik |
| TRVB | Technische Richtline Vorbeugender Brandschutz |
| DIN | Deutsches Institut für Normung |
| EN | European Norm |
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# Appendix A

# Appendix B