Inductive Short-Range Communication Channel

Bachelorthesis

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Demo

Introduction

Goals

The goal of the thesis was to create a communication channel that utilizes magnetic induction with the help of readily available components.

Magnetic Induction

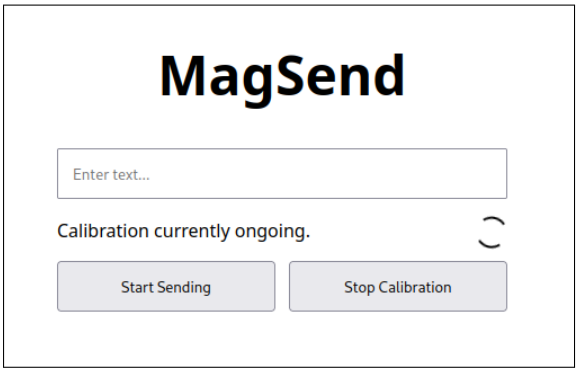
Magnetic Induction (MI), also known as magnetic flux density or simply the magnetic field, is a physical quantity measured in Tesla T. The movement of electric charges in a conductor produces a magnetic field around the conductor.

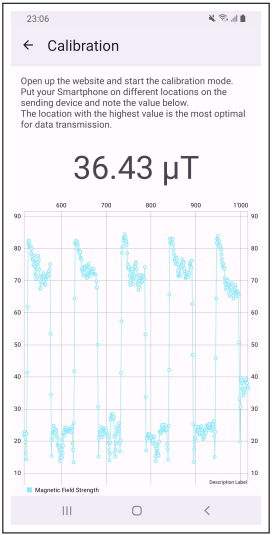
Solution

MagSend

- Uses two devices
- A laptop as sender
- A phone as receiver
- Laptop modifies a magnetic field
- The phone measures the field

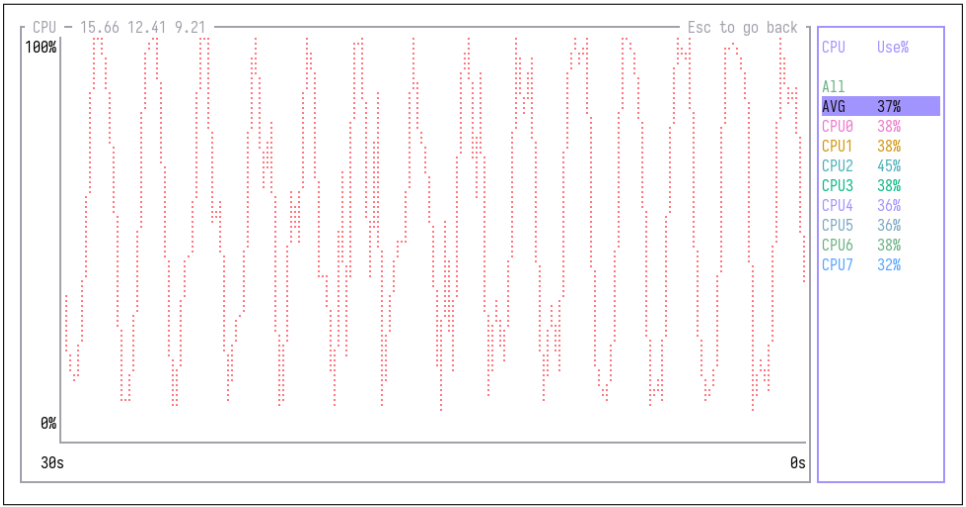
Calibration



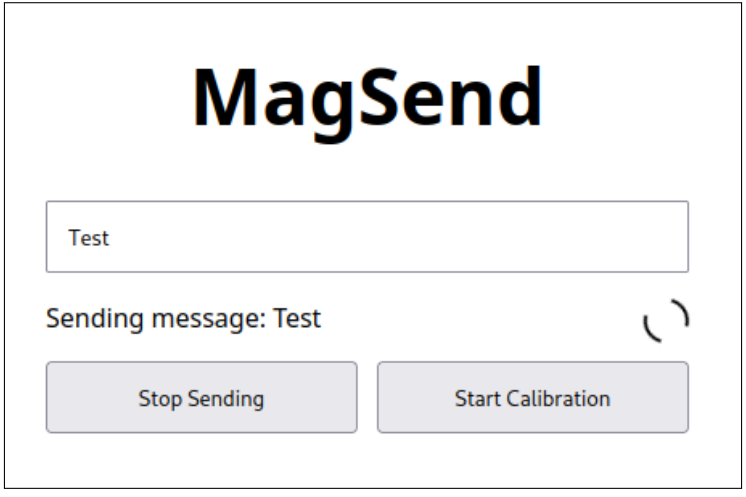


Calibration

CPU Load



Sending


MagSend
Test
Sending message: Test
Stop Sending
Start Calibration

Packet Format

- Header
  - 4 Bit
  - Payload Length; Up to 16 bytes
- Payload
  - Bit stream of the ASCII Text
  - Up to 16 characters
- Checksum
  - CRC-8-AUTOSAR

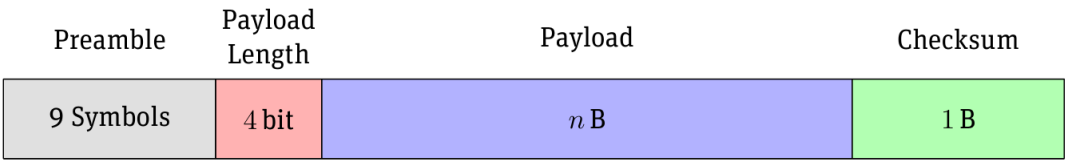
Packet Format

CRC-8-AUTOSAR

- Created by AUTOSAR
- Single, and double bit errors
- Burst errors of up to 8-bits
- Errors with an odd number of bits
- Up to 4 single bit errors in a message length up to 119 bits

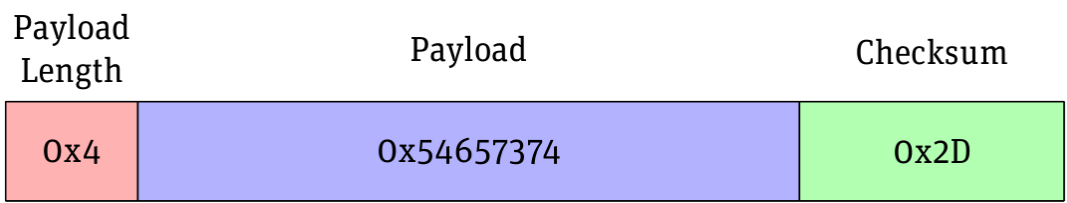
Packet Format

Structure



Packet Format

Example for Text: "Test"

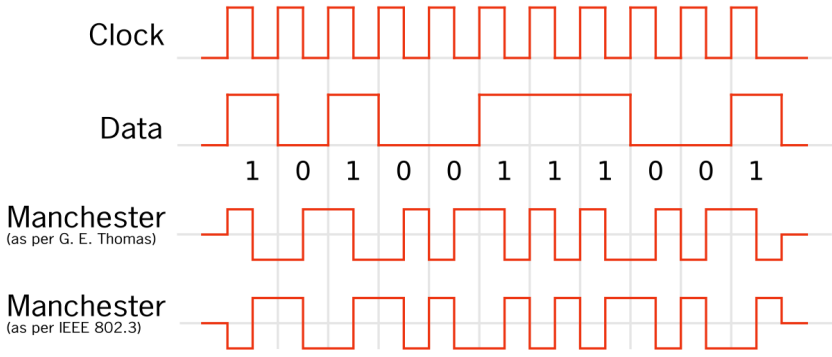


Transmission

- Depending on the text, the website puts load on the CPU in a controlled way
- High signals are 1, and low signals are 0
- Packet is encoded using manchester encoding
- Preamble to indicate the start of a packet

Transmission

Encoding



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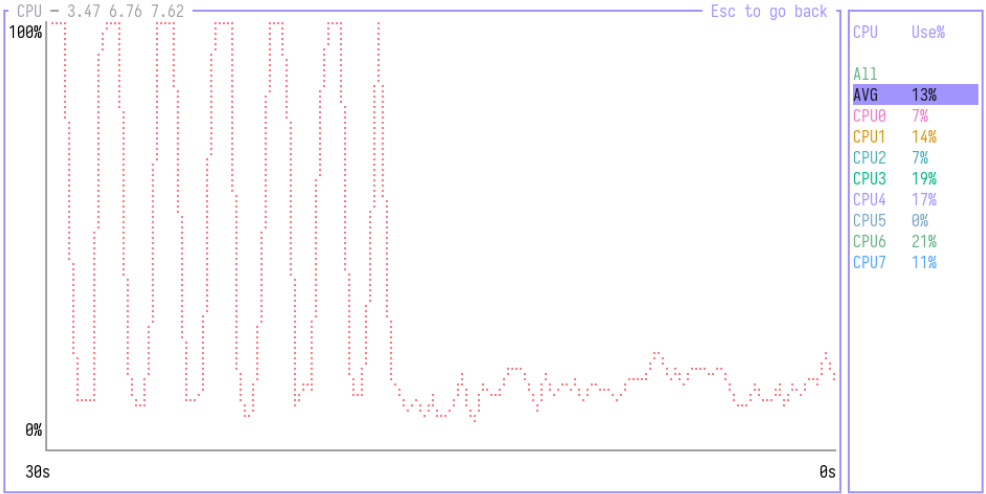
[1] https://commons.wikimedia.org/wiki/File:Manchester_encoding_both_conventions.svg

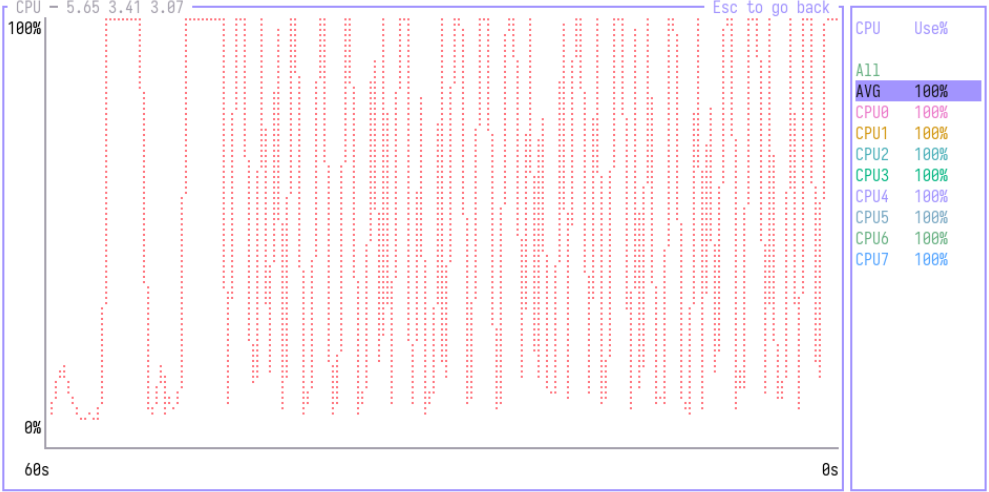
Transmission

CPU Load



Transmission

CPU Load Example for Packet

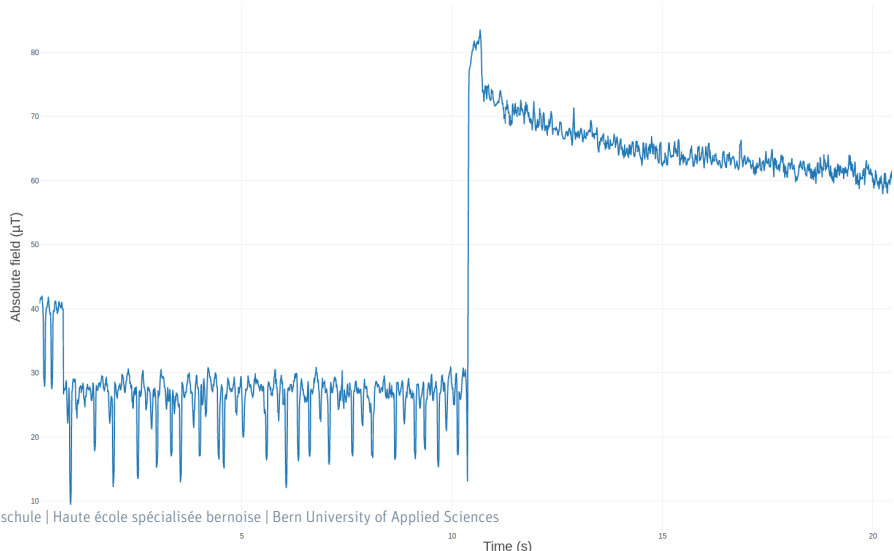


Reception

The phone uses a magnetometer sensor to get the signal from the magnetic field. From that signals it deconstructs the packet to get to the text.

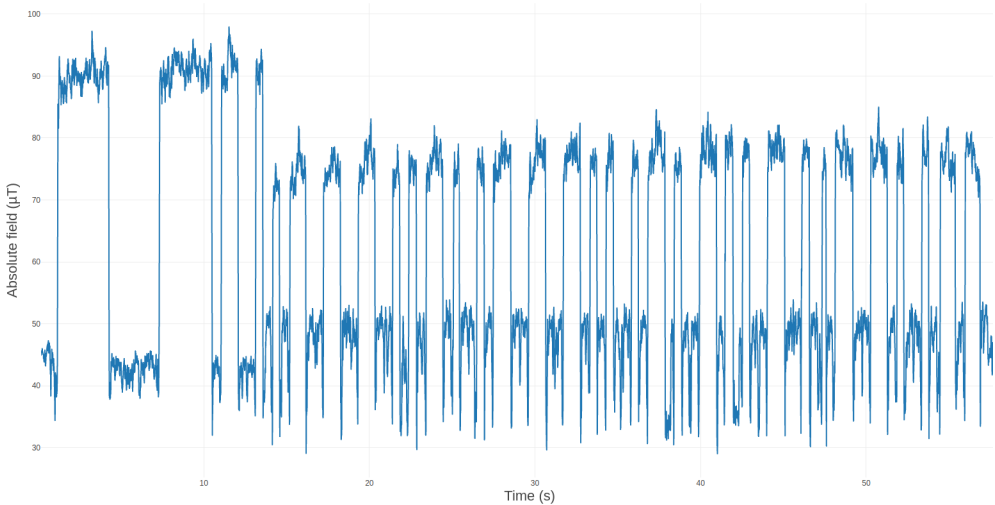
Reception

Sensor Data



Reception

Sensor Data for Packet

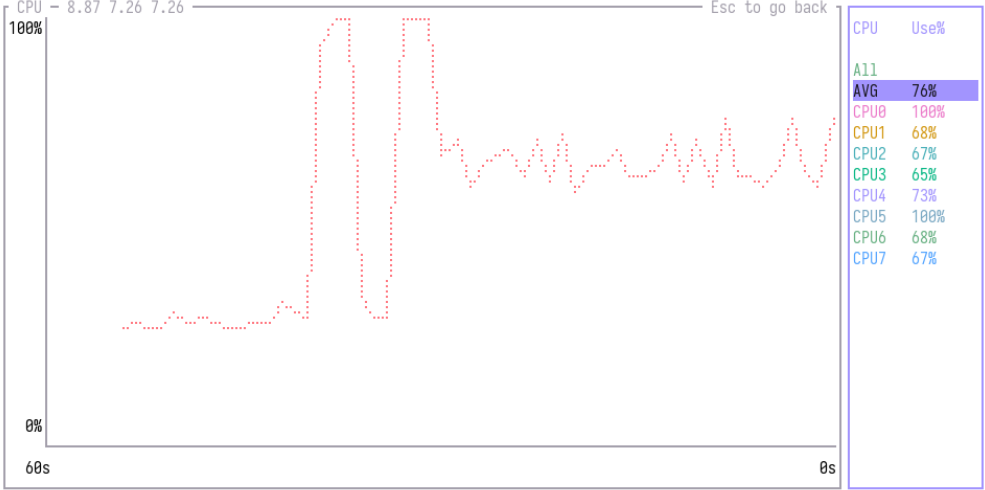


Benchmarking

- Works well at idle CPU load with 1 bit/s
- Problems already with 25% CPU load
- Problems with thermal throttling

Benchmarking

Thermal Throttling



Use Cases

- Works without connectivity e.g. in airplane mode
- Works better under water than radio waves
- Possible applications for small data transmissions: similar to QR codes, 2FA

Future Work

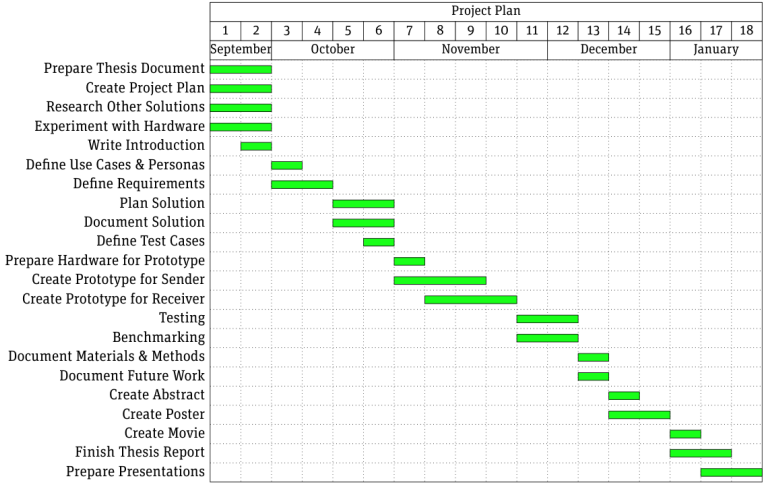
- Enhance the robustness
- Increase transfer speed
- Improve user experience and user interface

Project Management

Organization

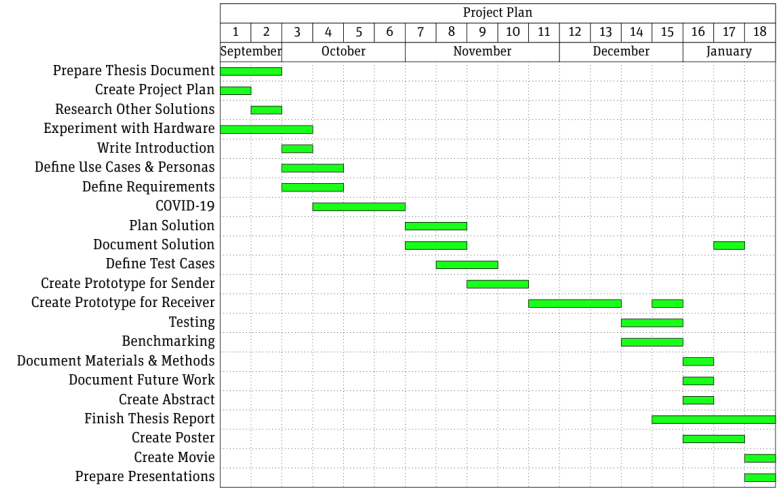
- Git Repository
- Weekly meetings with advisor
- Created plan at the start

Project Plan



Project Plan

Actual Plan



Project Plan

Explanation

- Beginning went well
- COVID-19
- Winter break

Conclusion

- Working prototype
- Better planning
- Better logging

Try It Yourself

https://magsend.kaderli.dev

Questions