# Master Thesis
# Development of a Pressure Fluctuation Monitoring System

In order to determine the aerodynamic properties of vehicles, scaled models are used in wind tunnels under well controlled conditions. Different boundary conditions and parameters are then responsible for the extent to which these results can be transferred to full scale road or rail vehicles. In order to quantify this transferability, aerodynamic full scale investigations are necessary for comparison. In the framework of Shift2Rail project [1], pressure fluctuations on the surfaces of a full scale container shipped on a freight train need to be measured. In order to do so, a digital measuring unit with reliable data acquisition has to be developed and implemented, recording the pressure fluctuations on the container outer surfaces.

## Goals of the Thesis

A large collection of pressure sensors should be used to gather precisely synchronized ($\pm 10\,\mu s$) measurements at a high frequency ($1\,kHz$). The sensor data should be stored in a central device to enable in detail analysis after the collection. For cost efficiency, a minimal number of sensor nodes should be used to interface with the sensors.
To achieve the goal of the thesis, ESP32 boards are provided to be used as sensor nodes, which are equipped with Ethernet sockets. Honeywell HSCDDRD060MD2A5 sensors are provided for pressure measurements that can be interfaced via $I^2C$ and which do not use clock stretching.


The Pressure Fluctuation Monitoring System will be installed on a container shipped on a freight train to validate wind tunnel measurements of the aerodynamic properties of the depicted model

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| Project type | Master Thesis |
| Duration | 1 Term |
| Language(s) | English, German |
| Field | Computer Science |


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## Task

- Implement PTP support for RIOT [2] using the hardware support of the ESP32 Ethernet MAC
- Develop an API for parallel $I^2C$ transfers of a set of identical sensors and implement it for the ESP32 in RIOT[2]
  - All sensors have the same $I^2C$ address and behave identical
  - A single GPIO pin of the ESP32 should be connected to the `SCL` pin of all sensors connected to the node
  - The `SDA` pin of the sensors are connected to individual GPIO pins of the ESP32 that belong to the same GPIO port
  - A bit-banging $I^2C$ driver should be implemented that makes use of the fact that all GPIO pins on the same GPIO port can be accessed in parallel
- A device driver for RIOT for the pressure sensors has to be implemented, that uses the parallel $I^2C$ API to simultaneously gather measurements
- A RIOT application putting the pieces together should be implemented, that:
  - At boot synchronizes the system clocks using PTP
  - Regularly updates the system clock using PTP in background
  - Gathers measurements from all connected pressure sensors at a frequency of 1 kHz
  - Sends the measurements tagged with a sensor identification and a time step via CoAP over Ethernet to a central device
- The provided implementation should be evaluated, including at least
  - Does the implementation meet the goal of the thesis?
  - The resource requirements of the implemented software
  - The achieved accuracy of the PTP implementation
  - The influence of the PTP synchronization on boot up time

## References


[1] Digitalization and Automation of Freight Rail (FR8RAIL II). Part of the Shit2Rail research project. Funded by European Union's Horizon 2020 Research and Innovation Programme. `https://projects.shift2rail.org/s2r_ip5_n.aspx?p=FR8RAIL%20ii`. 2018.

[2] Emmanuel Baccelli and Oliver Hahm and Mesut Güneş and Matthias Wählisch and Thomas Schmidt. RIOT OS: Towards an OS for the Internet of Things. 32nd IEEE International Conference on Computer Communications (INFOCOM). 2013.


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