Portfolio

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Design and realization of a control and measurement station for the frame structure

Project Objective and Scope

The purpose of this position is to monitor the technical condition of the frame structure to increase safety and efficiency of its use.

- The aim of this work is:
- comprehensive design,
- implementation of the electronic system,
- implementation of the frame structure
- device validation.

Project Assumptions:

The project was developed according to the following assumptions:

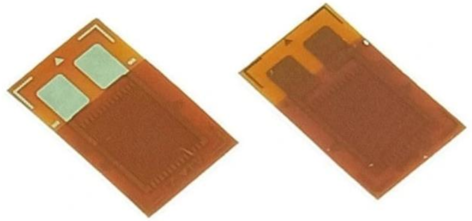
- Strain gauge stress sensors,
- Analog-to-digital converter,
- Microcontroller,
- LCD display,
- Truss with dimensions up to 50cm in height and 110cm in width.

Selection of Electronic Components

The control is implemented using the ATmega328P microcontroller.

The analog-to-digital converter used is the AD7794.

Two strain gauges arranged in a Wheatstone bridge configuration are used for stress monitoring.

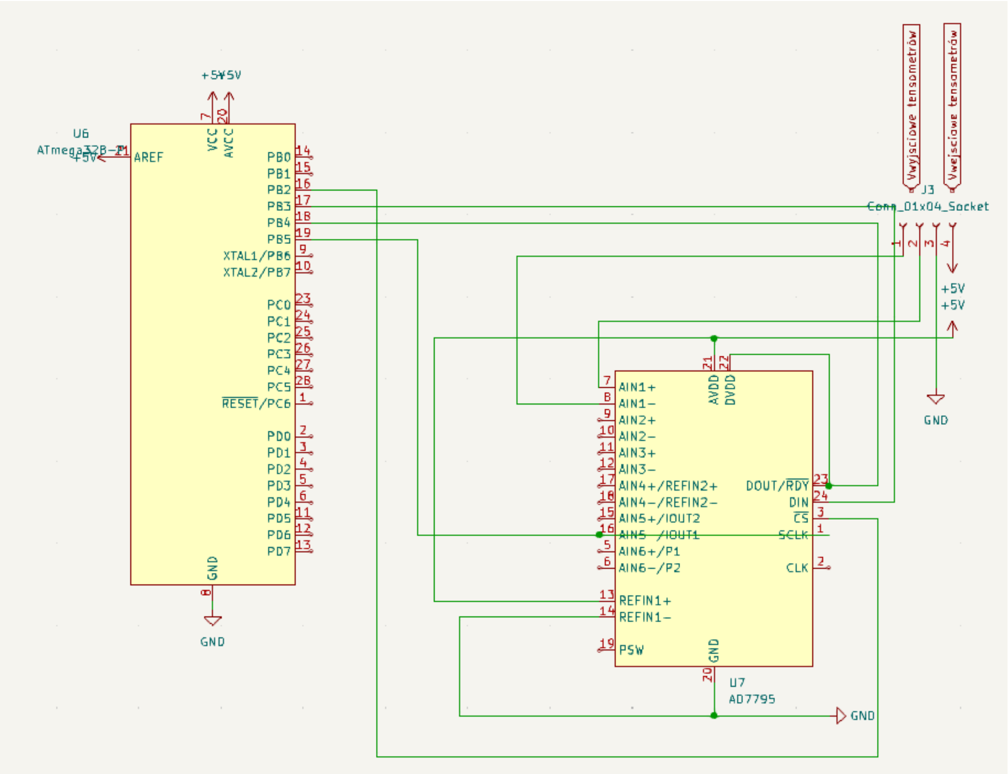


Selection of Electronic Components

LCD display is used for reading measurements.

RGB LED is used as a light indicator.

Electronic Design of the Control and Measurement Instrument

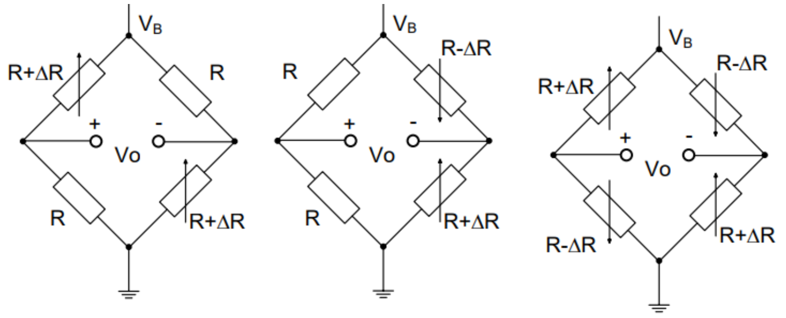


The chosen reference voltage for the applied converter is 1.17 V. The gain is set to 64 times. The maximum input voltage is calculated as 1.17 V / 64 = 18.281 mV. This means that at a stress of 220 MPa (11 x 20), which corresponds to the tensile strength of aluminum PA6, the full measurement range of the device will be utilized.

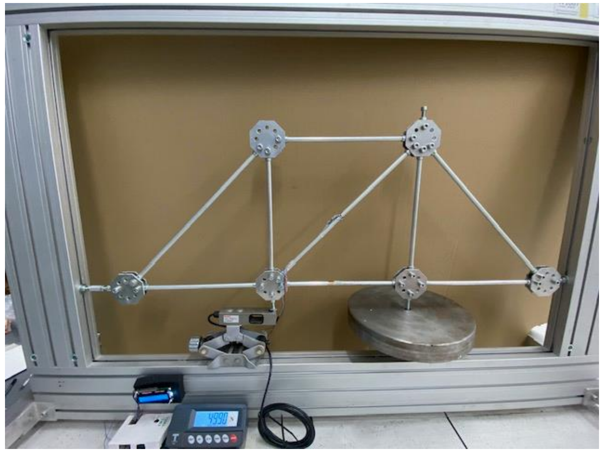
In this setup, the resolution is calculated as 18.281 mV / 2^15 = 0.558 µV.

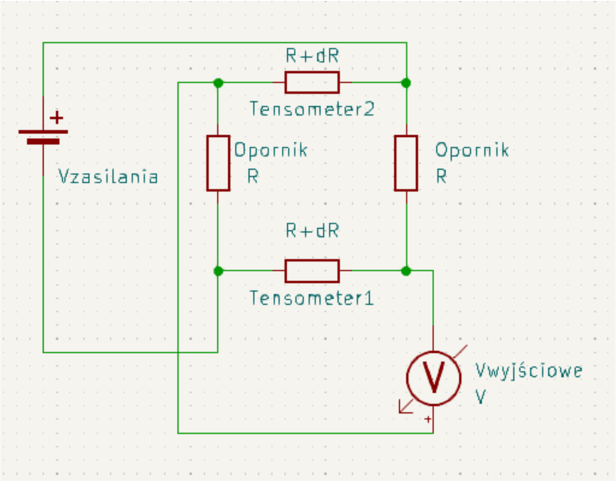
Where 2^15 =32,768

Electronic Design of the Control and Measurement Instrument



$$Vo=\frac{V_B}{2}\left(\frac{\Delta R}{R+\frac{\Delta R}{2}}\right) \qquad Vo=\frac{V_B}{2}\left(\frac{\Delta R}{R}\right) \qquad Vo=V_B\left(\frac{\Delta R}{R}\right)$$





The normal force in the rod for load 2 (500 N) and load 1 (220 N) is 339 N.

$$V_{out}=\frac{V_{in}}{2}\left(\frac{\Delta R}{R+\frac{\Delta R}{2}}\right)$$

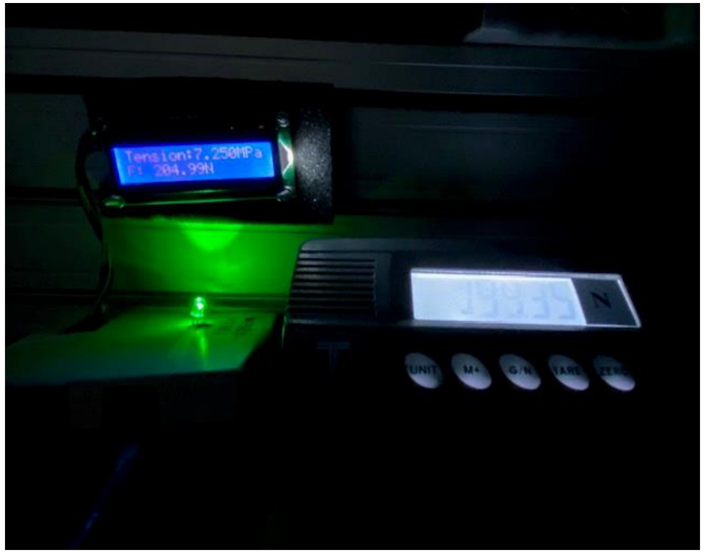
we should expect a voltage change at the output of the bridge of 0.92 mV.

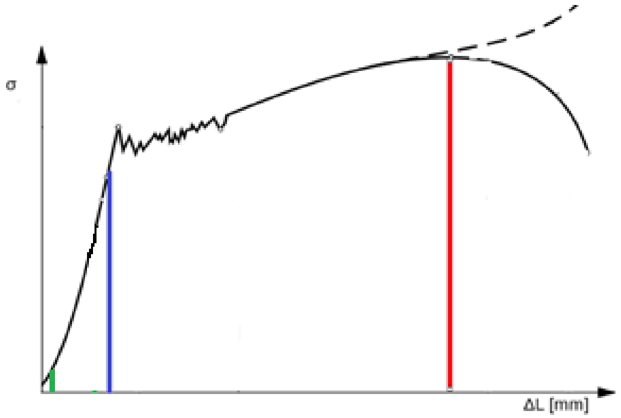
Safety element of the structure monitoring system

- The red color will light up when half of the tensile strength Rmmin = 130 MPa is exceeded, which is 65 MPa.

- The blue color will light up when half of the yield strength Rp02 min = 65 MPa is exceeded, which is 37.5 MPa.

- The green color will light up when the program is activated and the stress reaches б = 0.001 MPa.





Programing

- I used the C/C++ language for communication between the strain gauge, ADC converter, and strain gauges.

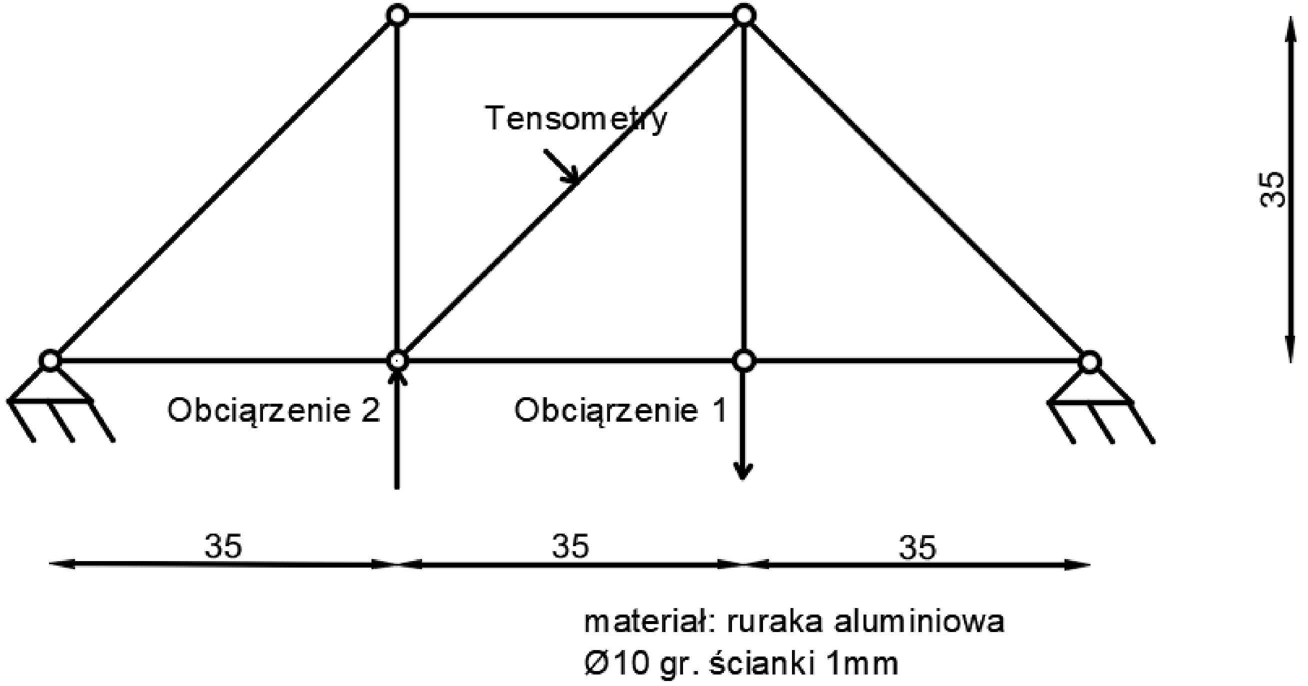
```
AD7794 adc(AD7794_CS, 4000000, 2.50);

float readings[8]; //6 channels + temp and AVDD monitor

void setup() {

   Serial.begin(115200);


  while(!Serial);
  adc.begin();
  delay(100);
  adc.setUpdateRate(470);

  for(int i=0; i < 6; i++){
    adc.setBipolar(i,true);
    adc.setGain(i, 128);
    adc.setEnabled(i,true);
  }
  delay(100);
}

void loop() {

  unsigned long dt;
  unsigned long startTime = millis();

  adc.read(readings,6);

  dt = millis() - startTime;
```

The LCD display was used to read the values of stress and normal force.

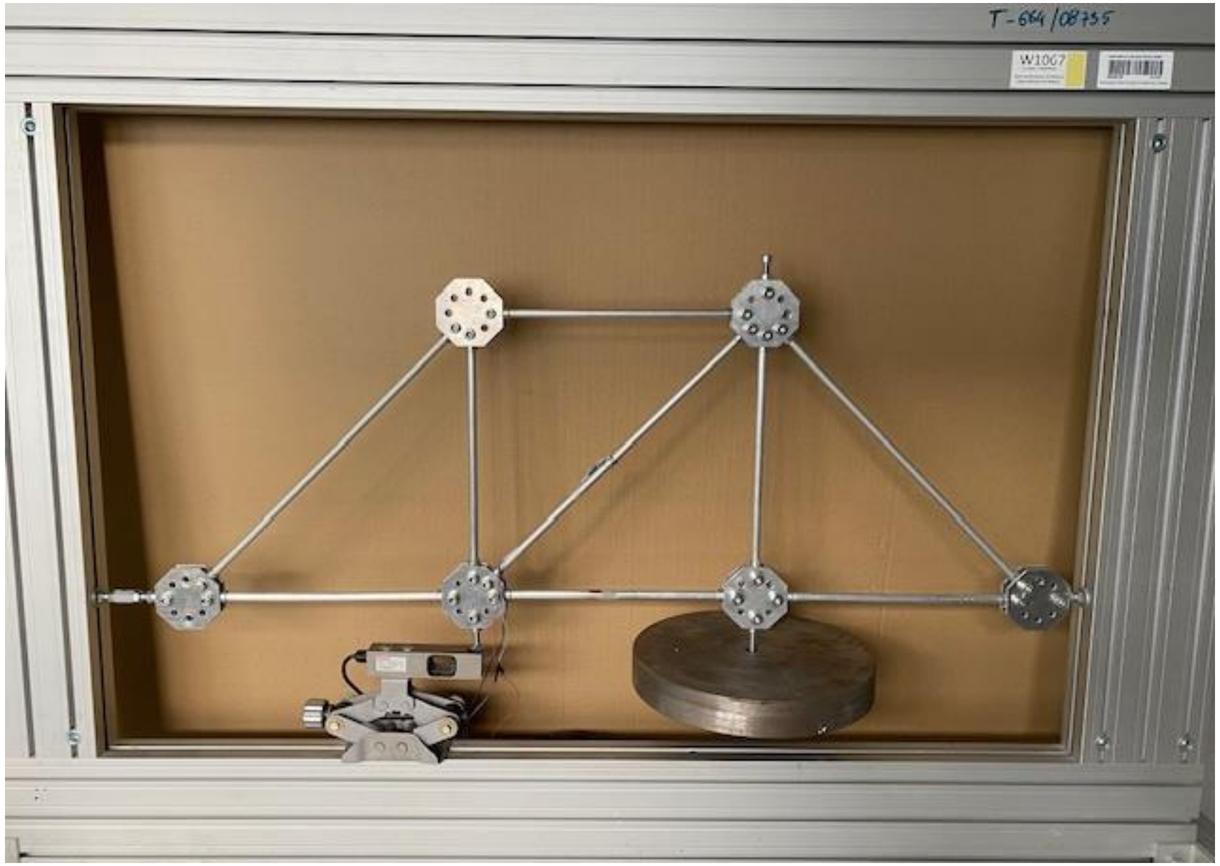
Stanowisko kontrolno-pomiarowe

Schemat kratownicy na którym była prowadzona walidacja

Wymiary w cm

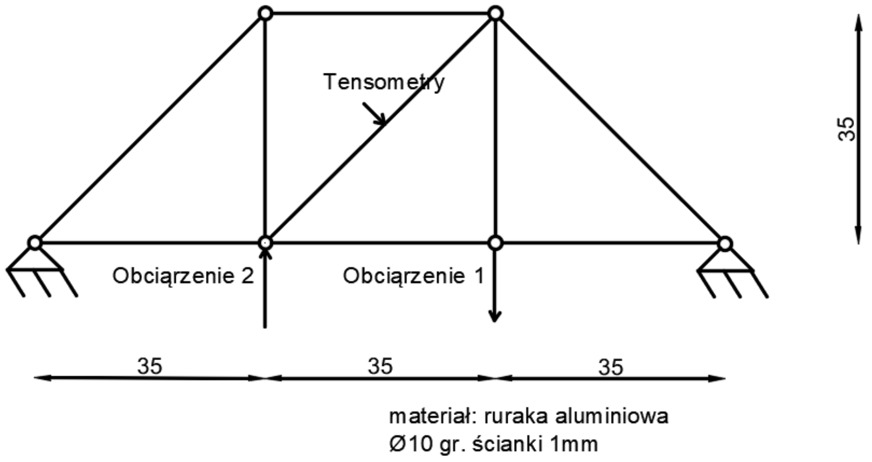


Execution of the validation station



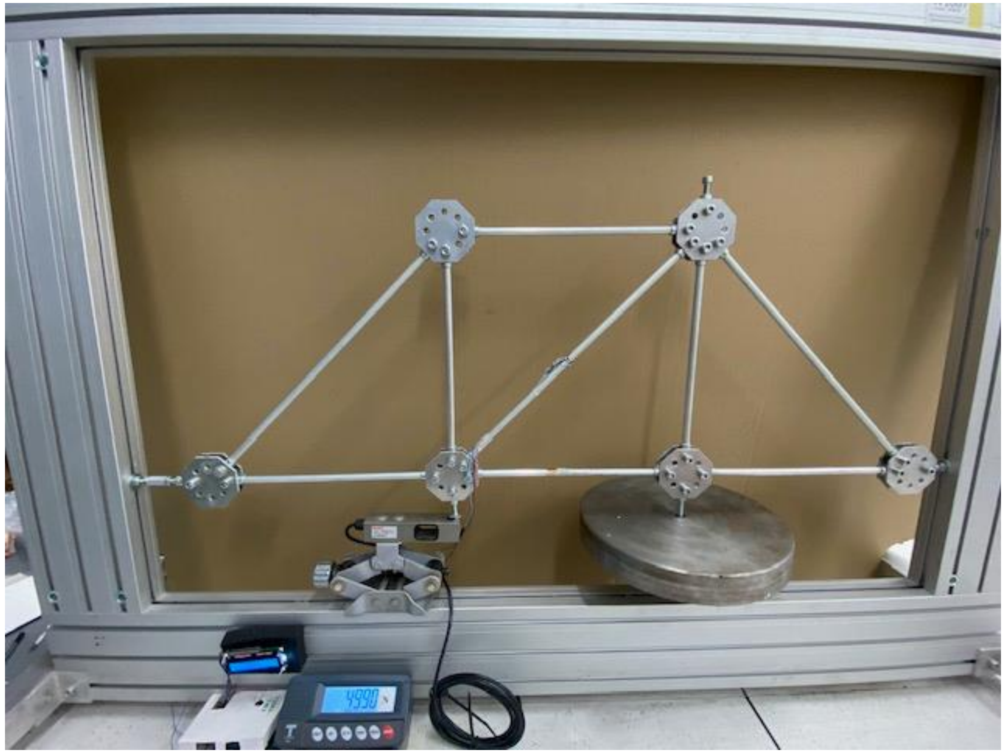
Validation of the control-measurement station

Nr	Load 1	Load 2	Force read [N]	Calculated force [N]	absolute error %
1	220	99,15	158,00	151,00	4,64%
2	220	149,95	181,01	174,00	4,03%
3	220	199,35	204,99	198,00	3,53%
4	220	250,30	228,99	222,00	3,15%
5	220	300,80	252,01	245,00	2,86%
6	220	360,00	276,01	269,00	2,61%
7	220	400,40	299,00	292,00	2,40%
8	220	450,05	323,01	316,00	2,22%
9	220	499,95	345,99	339,00	2,06%



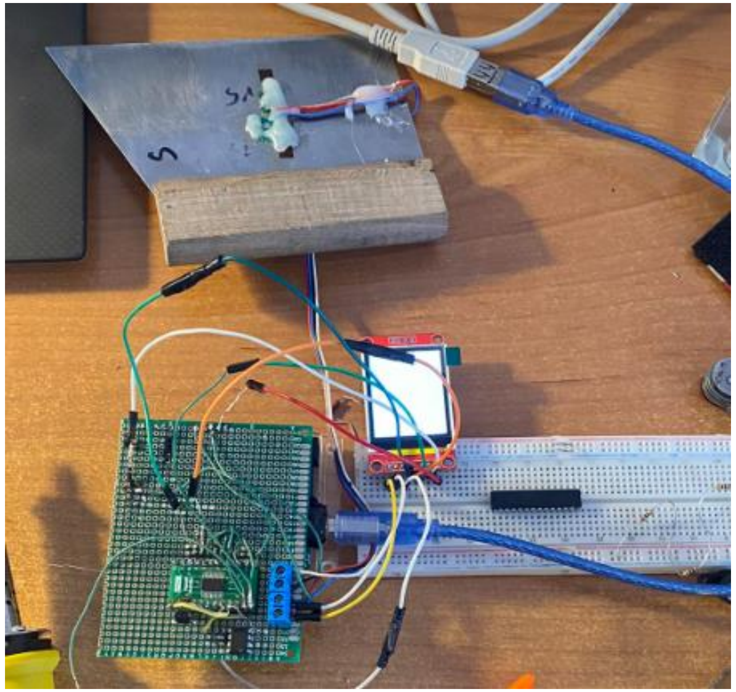
The largest difference between the measured readings and the analytically calculated value is 4.64%, while the smallest difference is 2.06%.

Final Conclusions

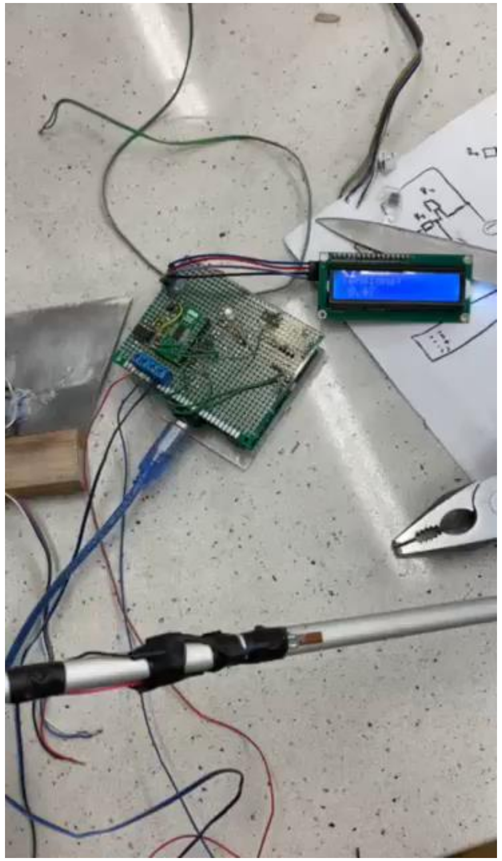


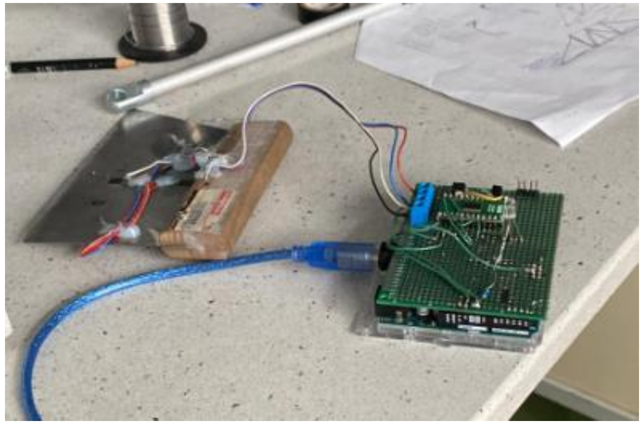
Based on the comparisons of the obtained calculation results and the conducted validation, it can be concluded that the values read from the sensors are at a satisfactory level (average error is 3.05%).

Validation video



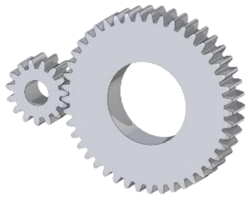
Validation video 2





As an engineer, I designed:

Gear transmissions



The most important tasks I was responsible for during the creation were:

- Functional analysis of gear transmissions in car seats
- Gear ratio selection
- Strength calculations
- Designing using 3D modeling

Seats components

The most important tasks I was responsible for during the creation were:

•Designing seat components in terms of functionality, weight limit, ease of production, and strength of elements as well as the entire structure

•3D modeling design

•Creating 2D drawings with GD&T

Airflow through a car seat

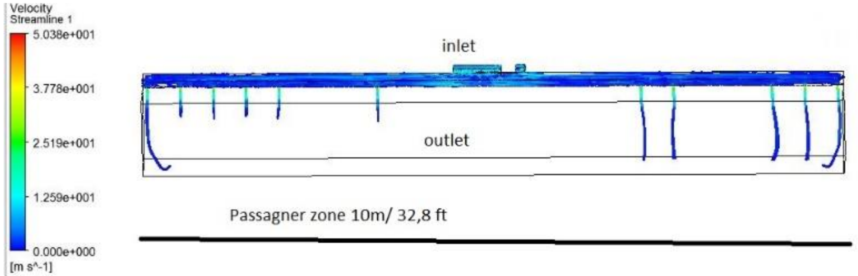
Airflow through a car seat:

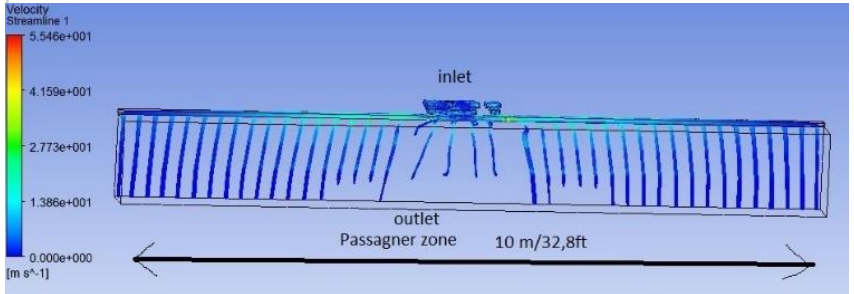
•Optimal flow selection

•Conducting calculations

•Redesigning the rest of the seat to meet airflow requirements

Calculations, optimization, and implementation of channels for air conditioning/ventilation





CFD calculations of the ventilated/air-conditioned zone of buses:

•CFD calculations

•Selection of location, shape, and size of openings

•Creation of templates and prototypes

•Validation went better than anticipated At the top, a view of the ventilation distribution by the predecessor; at the bottom, the airflow distribution based on my calculations.

Bus design

Main tasks:

•Designing floors

•Frame calculations for mass and strenght optimization purposes

•Creating 2D drawings

Model rockets with an impulse of 2.5 Ns

Construction of S6A rockets including:

- Optimal selection of dimensions
- Selection of modern materials
- Development of manufacturing technology
- Production of prototypes