Labor Windkanal/Strömungsmesstechnik

OSTBAYERISCHE TECHNISCHE HOCHSCHULE REGENSBURG
MASCHINENBAU

Mobile anemometer for wind velocities from 5 m/s to 50 m/s in connection with a telemetric system

Mobiles Anemometer für Windgeschwindigkeiten von 5 m/s bis 50 m/s mit Anbindung an Telemetrie

Stephan Lehmann

Mechanical Engineering, Galgenbergstr. 30, D-93053 Regensburg, Head: Prof. Dr.-Ing. Stephan Lämmlein

https://hps.hs-regensburg.de/las39261/

1. Outline

The classical way to measure the wind speed involves the problem that the measured signals are quite low at velocities about or lower than 5 $\frac{m}{s}$. In case of a mobile application like an unmanned aerial vehicle, it can lead to an uncertain measurement of the wind velocity and flight operations like automatic landing can be dangerous. Therefore, it is necessary to develop new probes or use measuring principles which are more sensitive at lower wind speeds.

The goal is to develop a new probe or measuring principle to measure reliable wind speeds at low velocities. This new probe shall be mounted on a flight model to determine the true air speed. Furthermore, the measured wind velocity and other measured values should be sent down to the pilot's laptop. There, the data is shown on several displays and the flight conditions can be controlled.

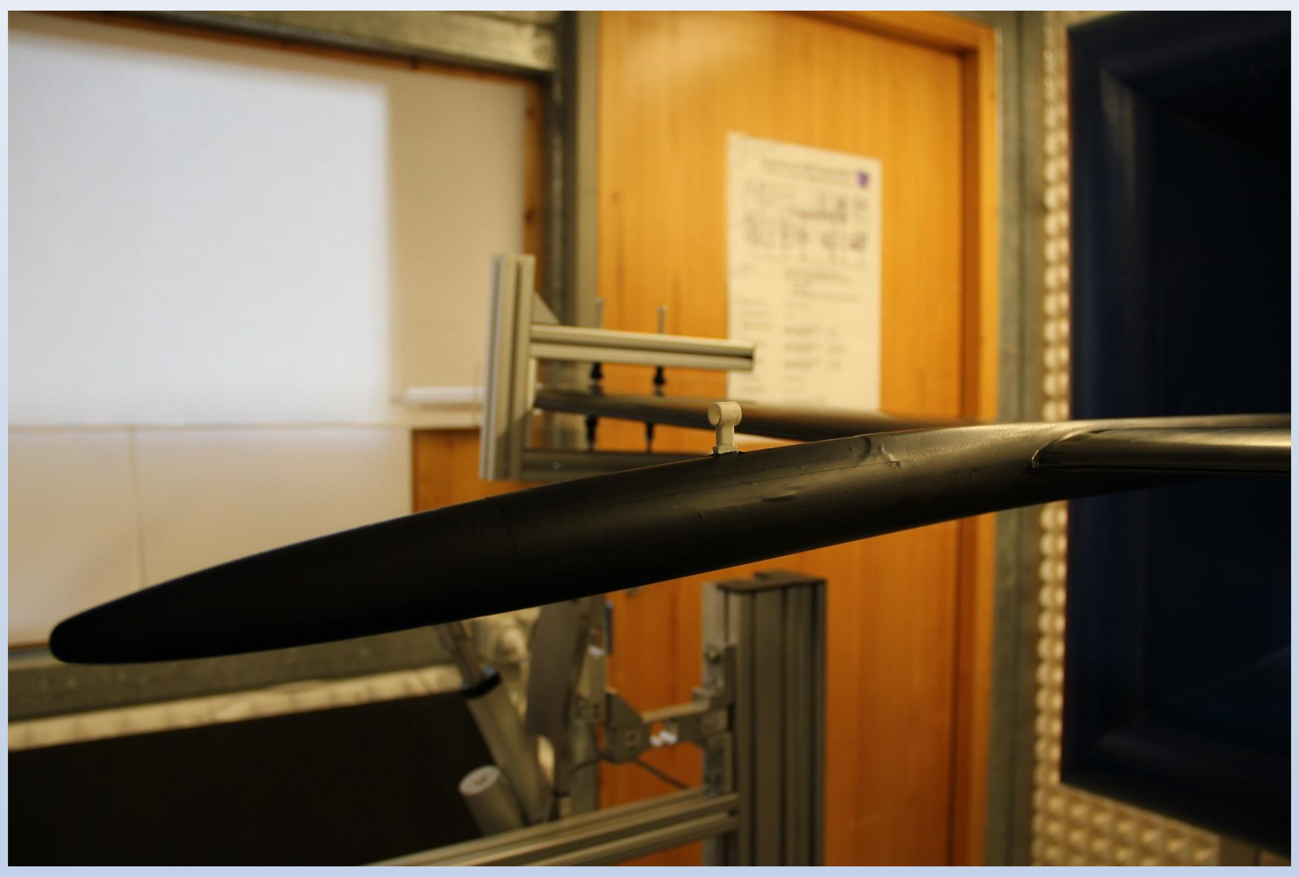

Fig. 1: The mounted differential pressure probe on top of the aircraft.

2. Development of different probes

There are three different probes and one sensor which are examined. The three probes uses the differential pressure as measuring principle. The sensor is a mass flow sensor (MAF) from the automotive industry and uses the hot film technology as measuring principle.

Fig. 2: The investigated MAF.

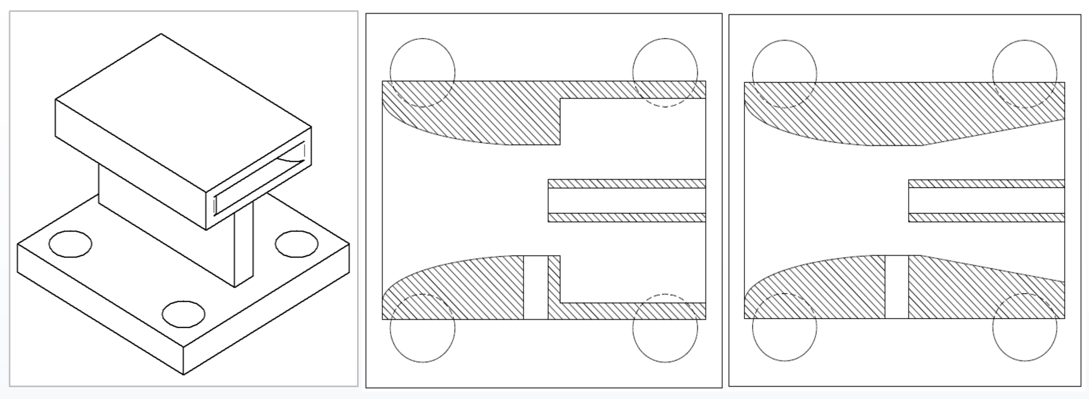

Fig. 3: The rectangular shaped nozzle with both inner shapes.

The differential pressure tubes are divided in two different outer shapes: a circular and a rectangular shape. The rectangular shaped probe also has two variations of the inner shape. The soft ending of the inner shape regains the pressure inside the nozzle and the produced pressure difference is higher and the signal quality is better compared to the sharp inner contour.

The development of the circular shaped nozzle is inspired by the DIN EN ISO 5167, the norm for orifice plates. Due to the big cross section area reduction, the pressure difference between the pressure ports is higher compared to the Prandtl tube.

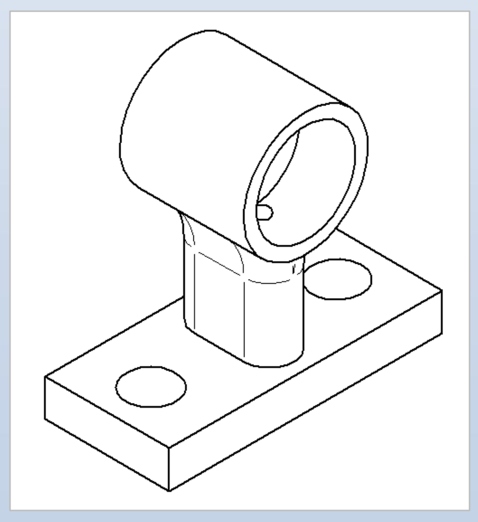

Fig. 4: The tested orifice plate.

3. Measurement results

The testing parameters for the test have been:

- Wind velocities from 0 m/s to 30 m/s
- Angle of yaw from -90° to 90°
- Weight of the nozzle and additional equipment
- Dimensions
- Signal quality
- Amount of additional pieces to connect to the telemetric system

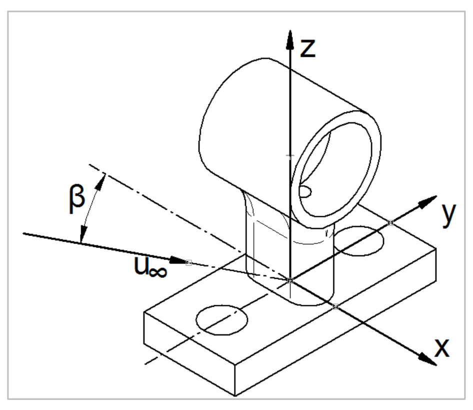

Fig. 4: Definition of the angle of yaw.

The measurements show that only the orifice plate produces a higher differential pressure than the Prandtl tube. It is also the lightest probe and the signal quality is good too. Due to this fact, it is the selected probe to be mounted on the top of the aircraft.

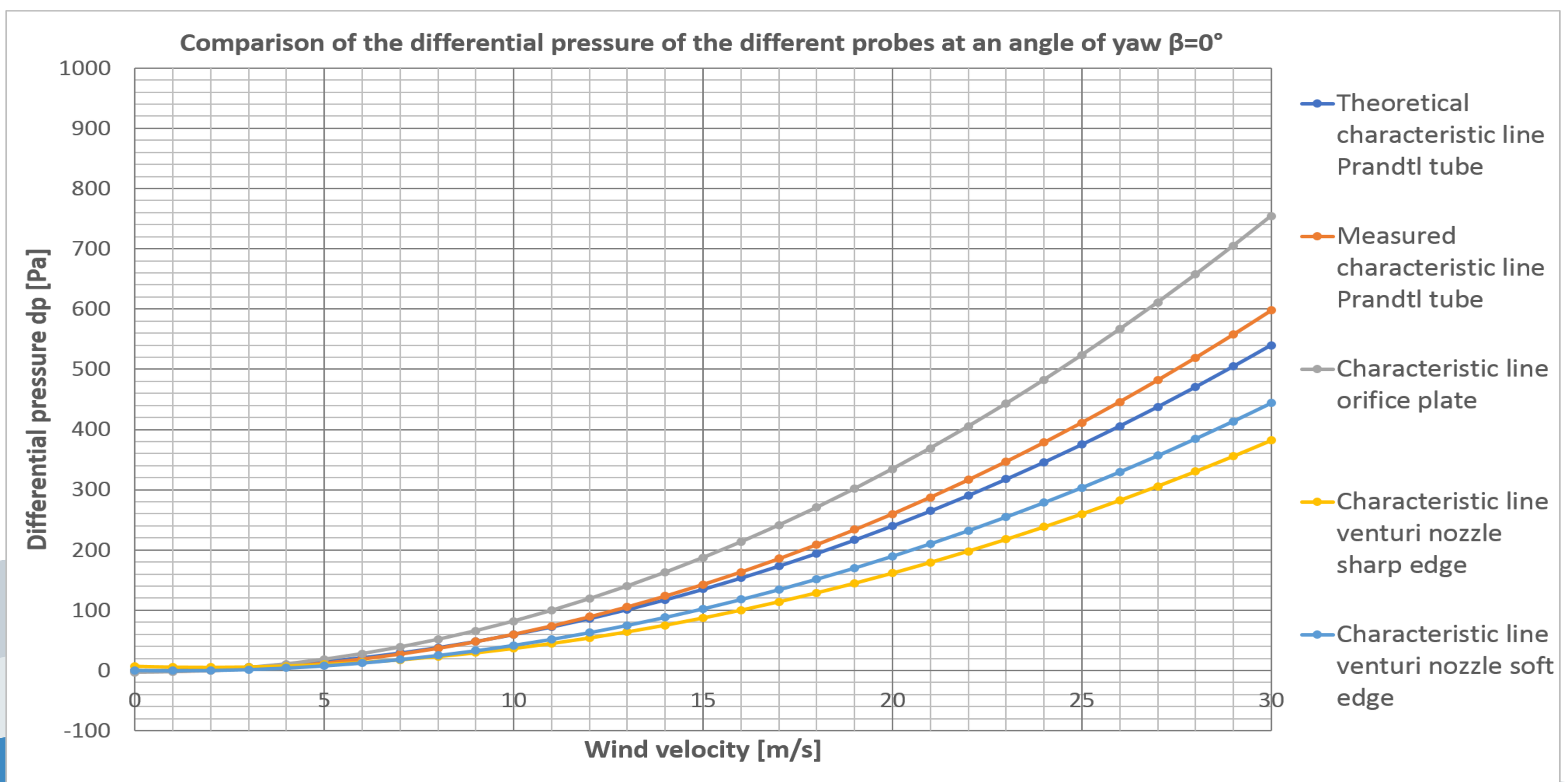

Fig. 5: The characteristic lines of the different probes are compared to each other. Additionally, the trend line of the theoretical curve of the Prandtl tube is shown.

4. Telemetric system

Connection between pressure sensor and transmitter

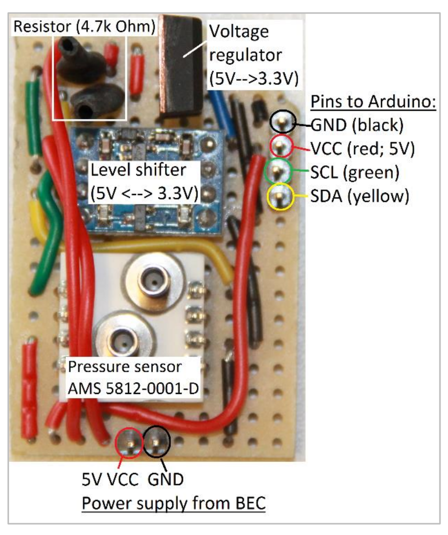

Fig. 6: Circuit board with level shifter and pins to connect the Arduino Pro Mini.

In order to make the pressure sensor values available to the transmitter (GigaScan 9 Vario), the signal level from the pressure sensor (5 V) has to be shifted to a 3.3 V signal level. Therefore, the circuit board in Figure 6 has been developed.

Furthermore, a microcontroller (Arduino Pro Mini) is needed because the communication protocol of the pressure sensor does not fit the protocol of the transmitter. With both components the connection to the transmitter is established.

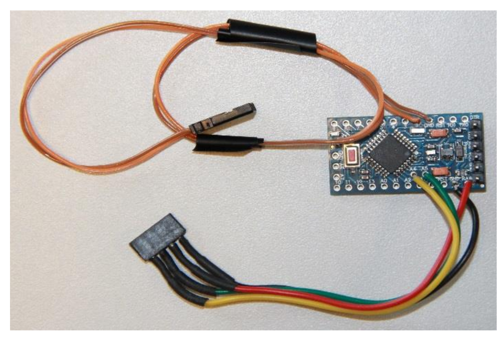

Fig. 7: Arduino Pro Mini with wires to connect the circuit board and the transmitter.

Graphical user interface in LabVIEW

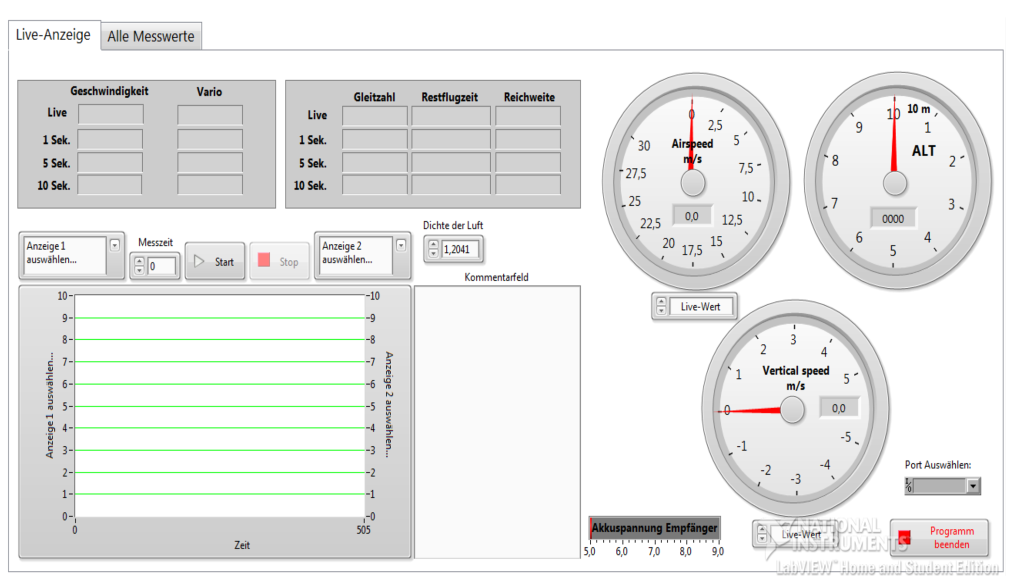

Fig. 8: The main monitor of the graphical user interface.

In order to visualize the received data (air speed, altitude, vertical speed…), a graphical user interface in LabVIEW has been developed. This software also calculates further values like the lift-to-drag ratio, the remaining flight duration and mean values.