FPP3 Experiment 1

Flat Plate Surface pressures

The aim of this lab session is to use the low-speed wind tunnel to measure the surface pressure distribution around a flat plate. The flat plate is instrumented with 104 static pressure tappings. To record the pressure data you will need to understand how the raw pressures at each tapping are converted into digital signals for post-processing.

The conversion requires a number of pieces of hardware and software. The Digital Sensor Array (DSA) is the pneumatic pressure acquisition system which measures the raw pressures and outputs digital voltage signals. The DSA is programmed and controlled by a LabVIEW script. Using the DSA you will be able to measure the tunnel reference pressures and surface pressure distribution around the flat plate. Using the tunnel reference pressures you will be able to establish some of the key operating parameters of the wind tunnel.

Part 1: LabVIEW script and DSA

The LabVIEW script is ready for you to use. It records the tunnel reference temperature and the 16 pressure channels from the DSA. The data is saved into a text file.

Each time you run the LabVIEW script it will initialise the DSA and the thermocouple logger. First a *Cal Zero* is performed on the DSA in which all the sensors are re-set to zero. This ensures each sensor records a zero pressure measurement when exposed to a zero pressure level. The main part of the script records the DSA and thermocouple outputs. The number of samples recorded depends on the parameters *# reads at each set* and *# of tapping sets* which you will have set in the VI (script). Once a sweep of measurements is made a prompt will appear on the screen asking you to move to the next set of pressure tappings. In this way an entire sweep of surface pressures can be recorded in one data file. To analyse your data correctly you will need to record the value of atmospheric pressure appropriately and added as an input value. There is a digital manometer on the ground floor.

The DSA will record a number of sequential measurements. You will need to set the value of *# reads at each set* to determine the number of measurements to average over. There are only 16 channels on the DSA. To record a full sweep of pressures around the flat plate (>100 tappings) you will need to record a number of data sets. The number of sets is determined from *# of tapping sets*.

Before operating the tunnel, run the LabVIEW script and look at the output file in WordPad/ Notepad. It will have the following columns:

- Time (seconds since start)
- Tapping set (1 to n) (as set on '# of tapping sets' – input)
- Reading number (1 to m) (as set on '# reads at each set' - input)
- Pressures (x16 – corresponding to the 16 channels of the DSA)
- Temperatures (x2 – the first one is the thermocouple cold junction, the second one is the tunnel inlet temperature)
- Atmospheric pressure (input)

Press CRTL+E to view the LabVIEW block diagram. The pink box labelled *User Settings* contains the DSA settings. AVG sets how many samples are averaged by the DSA before a reading is output to the computer – see Appendix B. Before making any tunnel measurements, change the values of AVG to see its effect on the time it takes the program to run and the difference it makes to the output dataset. If you set AVG outside the range that DSA can accept, it will reset to its default values. It is important that you familiarise yourself with the parameters above and that you understand what the program is doing before making any tunnel measurements. You will need to set the location of the output files on the script.

Part 2: Tunnel flow speed and measurement accuracy

Once you have familiarised yourself with the DSA you can now determine the operating parameters of the tunnel. You will need to calculate the flow speed of the tunnel, the stability of the tunnel operating point over time, and the standard deviation of the reference pressure measurements.

Set up the LabVIEW script to record over a period of several minutes (i.e. by setting *# reads at each set* to larger integers; you should also set AVG to 1 at this point). Set the LabVIEW running and then switch the tunnel on to record the tunnel reference pressures while the tunnel speeds up and settles. Record a long series of data points e.g. 1000 or 10000, and still with AVG set to 1 to determine how the standard deviation of the data varies with the number of samples. Decide what value of standard deviation is acceptable and use this to choose the number of data points needed for the rest of your measurements.

Part 3: Surface static pressures

You can now use the DSA to measure the pressure distribution around the flat plate (including leading and trailing edges). Operate the tunnel at full speed for this first set of measurements. You should apply what you will have learned in Part 2 to decide how many data points to record to achieve an average with a low enough standard deviation. Operate the tunnel at a lower speed and complete a second set of measurements to investigate the effect of the Reynolds number.

NB. YOU MUST KEEP THE TUNNEL REFERENCE PRESSURES CONNECTED AT ALL TIMES OR YOU WILL NOT BE ABLE TO ANALYSE YOUR DATA CORRECTLY.

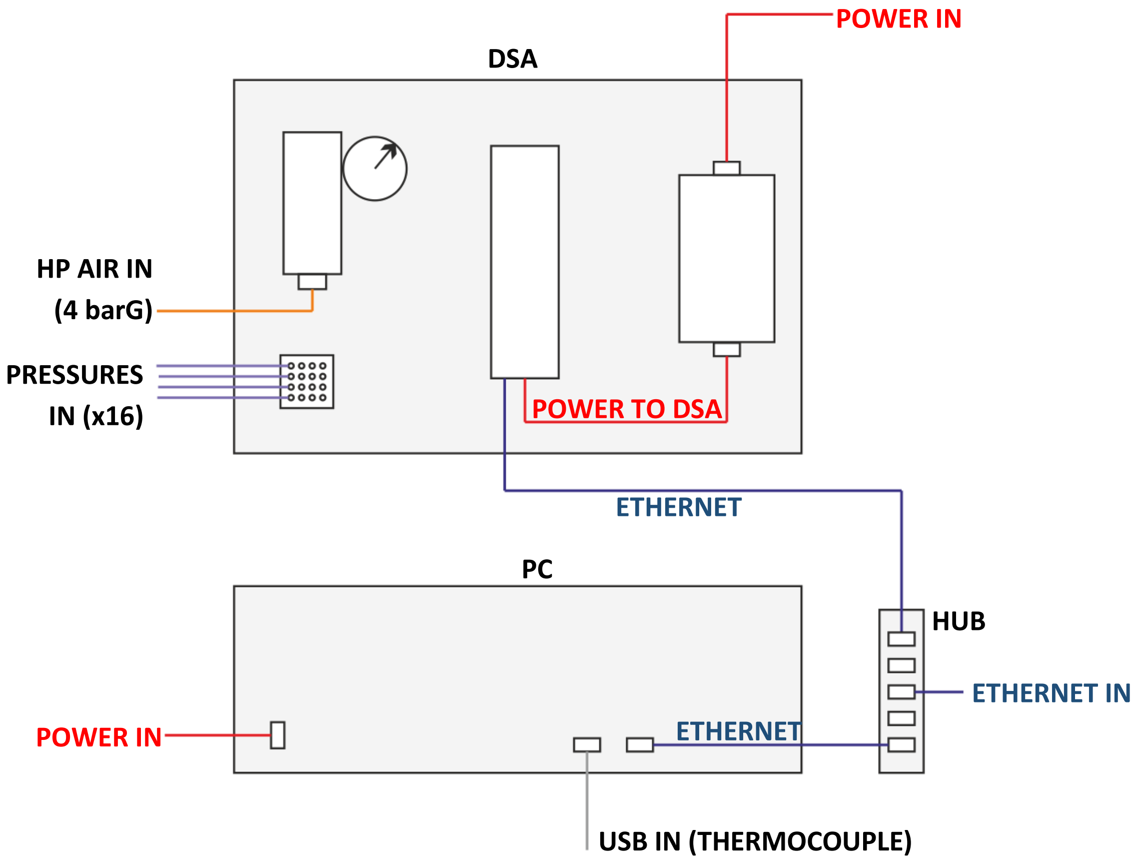
Non-dimensionalise your data appropriately using the tunnel reference pressures. Do you capture any Reynolds’ number effects in your data?

When you write up your report you should discuss:

1. How you handled the errors in your data (including the findings from your standard deviation investigation)
2. The symmetry of the pressure distribution
3. Any Reynolds’ number effects that you may have captured

Appendix A – Data logging block diagram

This appendix illustrates how the DSA interfaces with the rest of the hardware. The DSA communicates via Ethernet with the PC. The PC can communicate with the local network through a lab Ethernet connection. The DSA requires High Pressure (HP) *shop air* to operate and this is supplied from the lab. There are 16 pressure ports on the DSA which are numbered, these numbers correspond to the channels in the LabVIEW script. The digital signal form the thermocouple is read through the USB port on the PC.



Appendix B – Definition of AVG from the DSA manual

AVERAGE (AVG)

Variable	AVG
Valid Values	1 to 240
Default Value	32
Data Type	integer
Group	Scan variables (List S)
Description	This sets the number of raw samples to acquire before producing a averaged output.