Digital Wheel Pressure Measurement System WSMSD

Complete Lift and Drag Measurement System

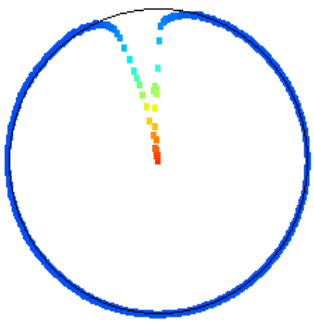
- ***Fully integrated digital system for measuring the pressure profile on a rotating model wheel .***
- ***On-wheel data acquisition, processing and storage.***
- ***Continuous power and Ethernet communications through high quality slip rings.***
- ***Full software provided to control the wheel, display profile and calculate lift and drag.***
- ***Light weight flexible PCB design, 32 or 64 pressure transducers***
- ***Better than 1° angular resolution***

Chell Instruments has developed its wheel measurement system into a fully digital on-board design. This coupled with the use of slip rings leads to a highly functional, low weight system.

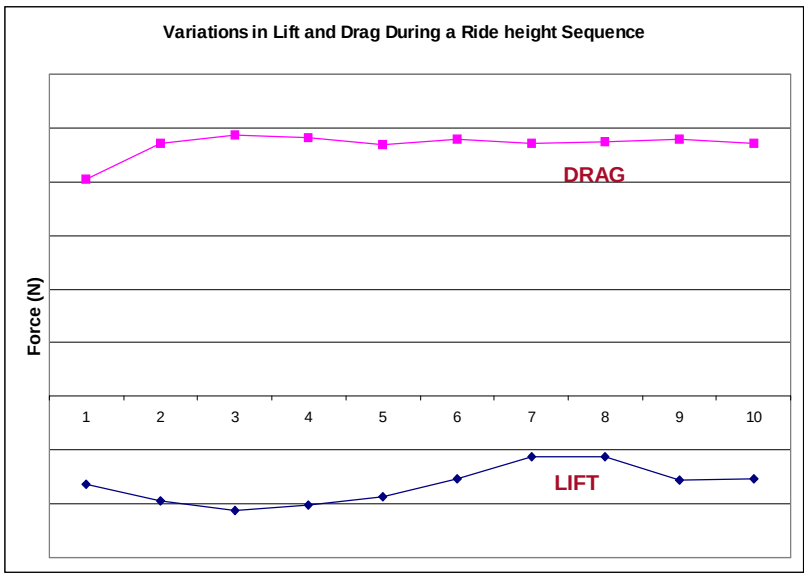
The system will measure 32 or 64 pressures anywhere on a rotating wheel. These pressure can be averaged over any number of revolutions. Once the average is complete, the data is down loaded to a PC via Ethernet where the pressure profile of the wheel can be plotted and the corresponding life and drag calculated.

The WSMSD system is designed on a series of flexible PCB's. This removes the mass and inconvenience of cabling inside the wheel. The main PCB performs all the acquisition tasks and stores the data. The system usually consists of two or three addition flexible PCB's that make all the connections to the transducers.

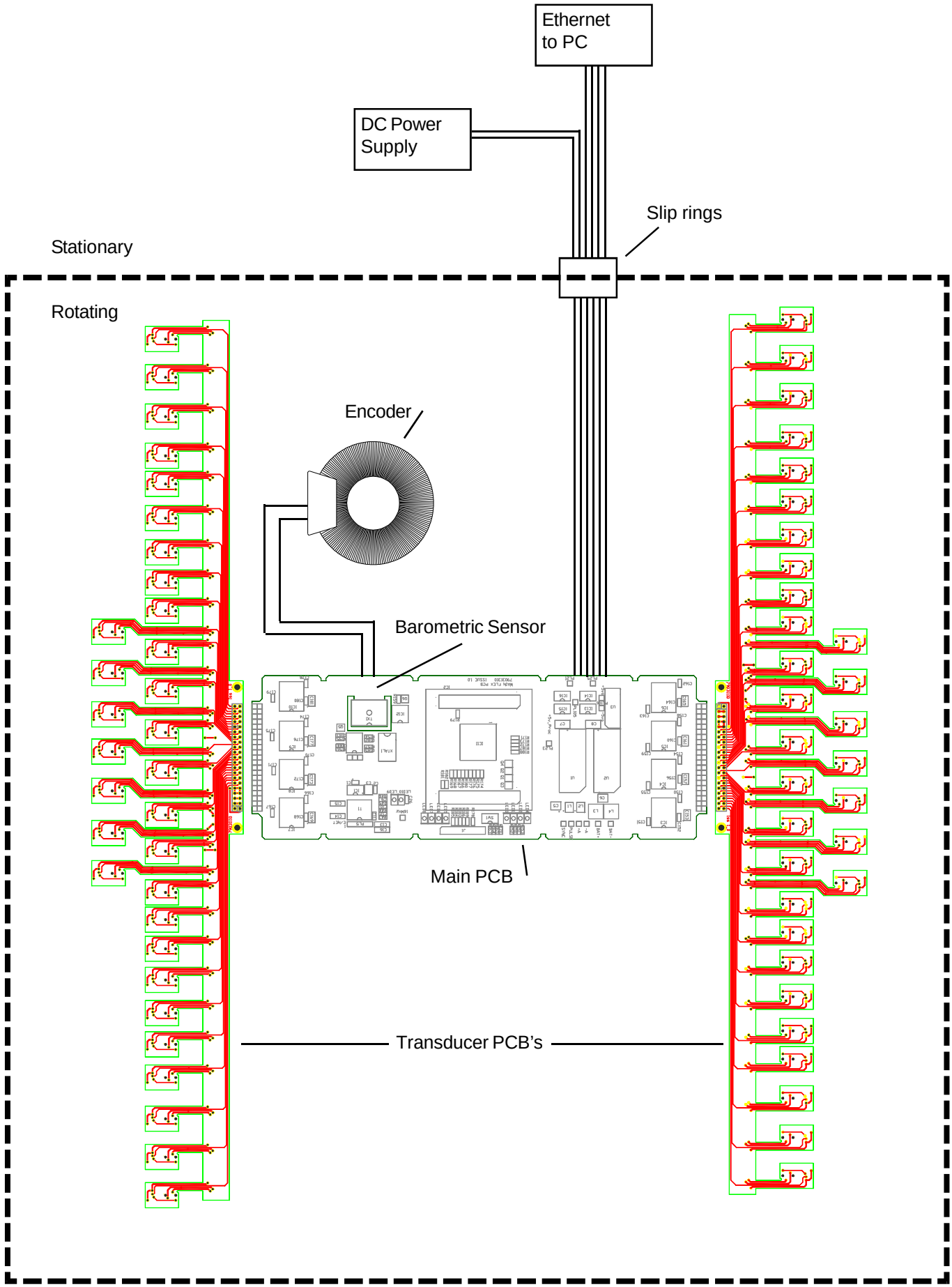
The system can be delivered calibrated with either 32 or 64 channels using miniature surface mount transducers.



An example of one of the various methods of displaying the pressure plot.



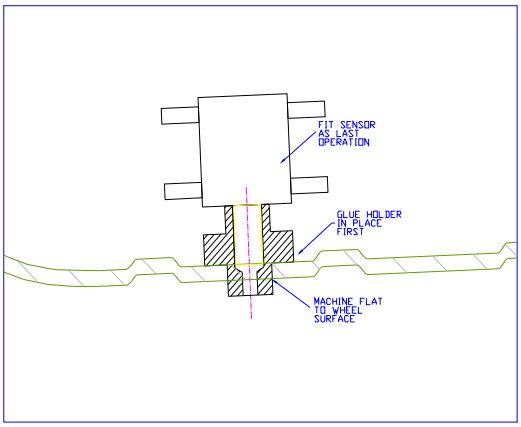
Block Diagram



Transducers

The transducers have been selected for their small size, light weight and excellent thermal characteristics. Another important aspect is the position of the sensing diaphragm. This is parallel to the pressure port so the transducer can be mounted with the diaphragm normal to the surface of the wheel. Tests have shown that there is a negligible effect by the g loading on the transducer.

The transducers have a fast response time and the small pneumatic length between the outside surface of the wheel and the diaphragm of approximately 5mm. This gives a natural frequency of 17KHz.

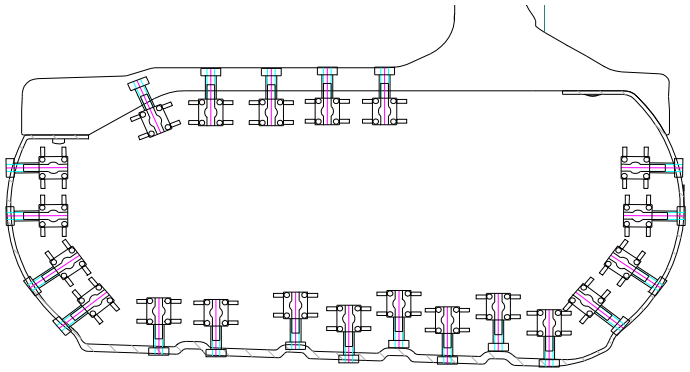


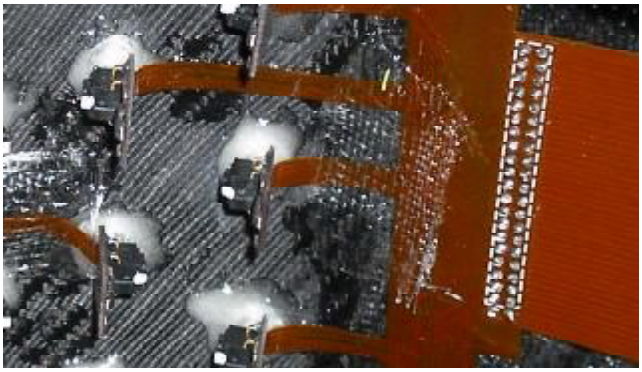
The transducers are bonded to the inside surface of the tyre and then finished flush with the outside surface. Chell recommends fitting an intermediate pressure tapping into which the transducers can be mounted. This enables the outside surface of the tapping to be finished flush with the wheel before the transducer is fitted.

Each transducer is mounted on a PCB which contains its amplification electronics. This improves the noise immunity of the system.

The transducers are arranged in a number of rows. They can be located in any part of the tyre / rim and can monitor side wall forces together with the internal rim pressures.

The transducers are mounted on the opposite side of the wheel to the main PCB thus providing balancing for the main PCB.

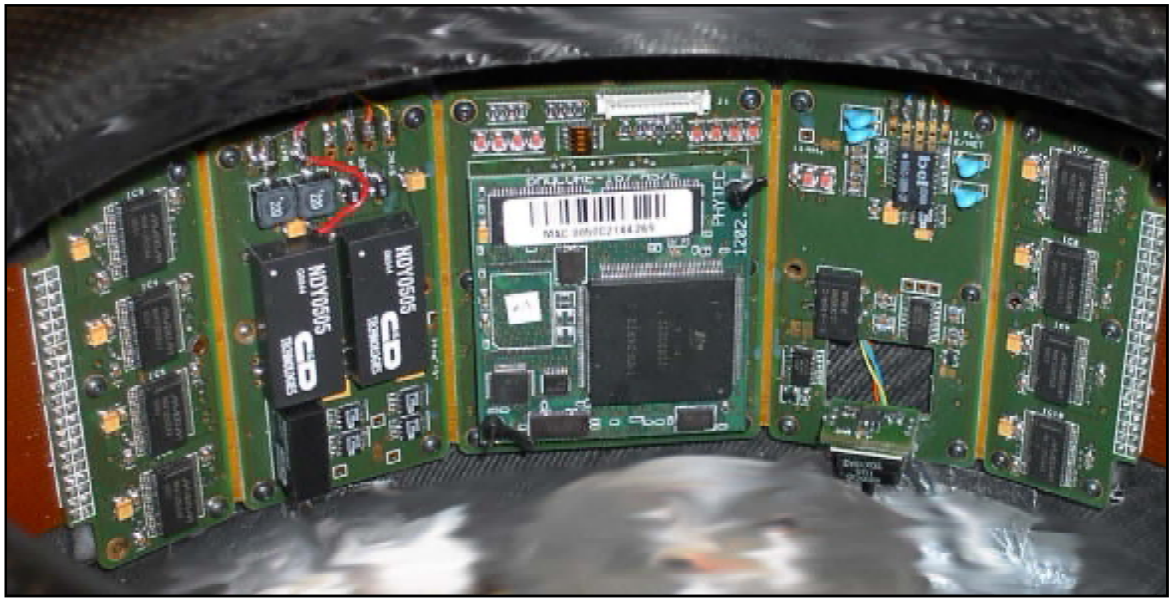




The transducers are connected to a flexible PCB which is in turn connected to the main PCB. Once the installation is complete, the flexible PCB can be bonded into the wheel to prevent any movement under g loads.

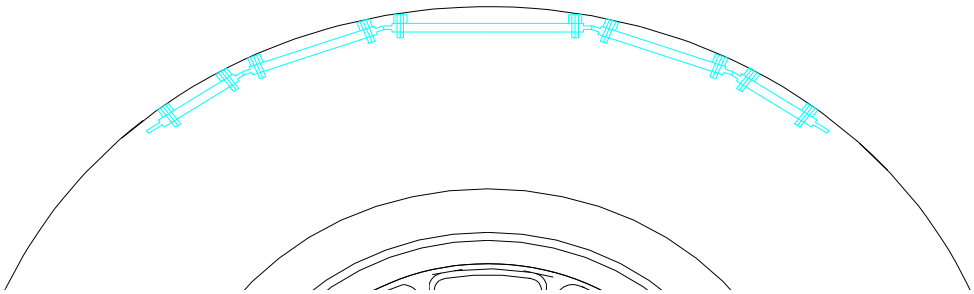
The main PCB carries out all the data acquisition, processing and storage. The PCB is of a hybrid flexible / rigid multilayer construction. This enables it to be curved and fitted into the internal diameter of the tyre. The use of both flexible and rigid PCB's removed any cable interconnections and provides a rigid mounting for the components.

The system features a number of high speed ADC converters, a processor, memory and Ethernet drivers. The ADC's are driven directly from the encoder signals to ensures that each measurement is taken at precisely the right angle during rotation. During acquisition, the ADC's are bused directly to the RAM which enables the acquisition to run at the speeds necessary. When the system is running at 4000 rpm (with 32 channels) ***each*** transducer will be measured at 33KHz!



The on-board software runs out of a flash memory and can be updated via a programming header. The software configures the acquisition and averages together any number of revolutions to improve the signal to noise. Once the acquisition is complete, the data can be transmitted to the PC via the Ethernet link.

The main PCB is mounted into the wheel as below. A number of tapped standoffs are first bonded into the wheel and the PCB is then bolted to these. This allows the PCB (the single highest cost part of the system) to be removed and transferred to another wheel.



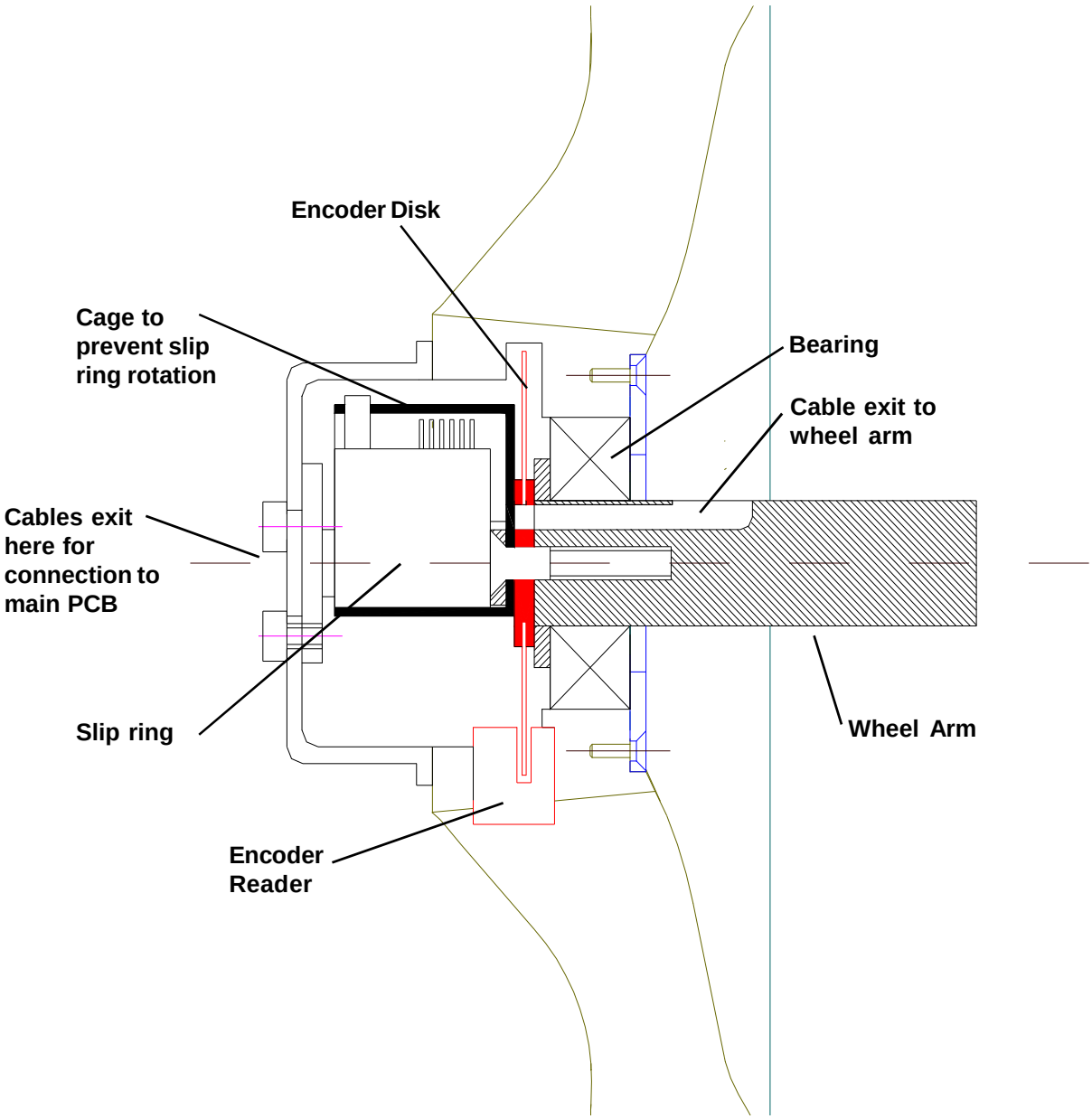
The slip ring forms the interface with the stationary parts of the system. We have selected a miniature, high performance slip ring and tested it fir noise transmission and suitability for Ethernet communications.

The use of a slip ring has removed the requirement for batteries which added considerable mass to the system. They would also require recharging periodically, making the system unsuitable for continuous testing.

This slip ring also made the use of Ethernet communications possible which enables the data to be down loaded in a few seconds. This means that the system can acquire and down load data without extending a standard ride height sequence.

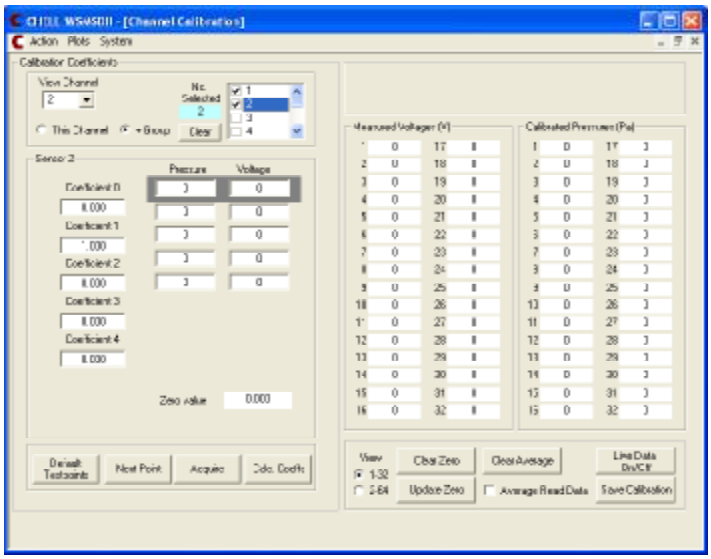
The slip ring is mounted in the central part of the wheel as below (here shown as a wheels off configuration). Six cables then connect to the stationary part of the slip ring and exit via the wheel arm. These are then in turn connected to a power supply and PC (or network hub).

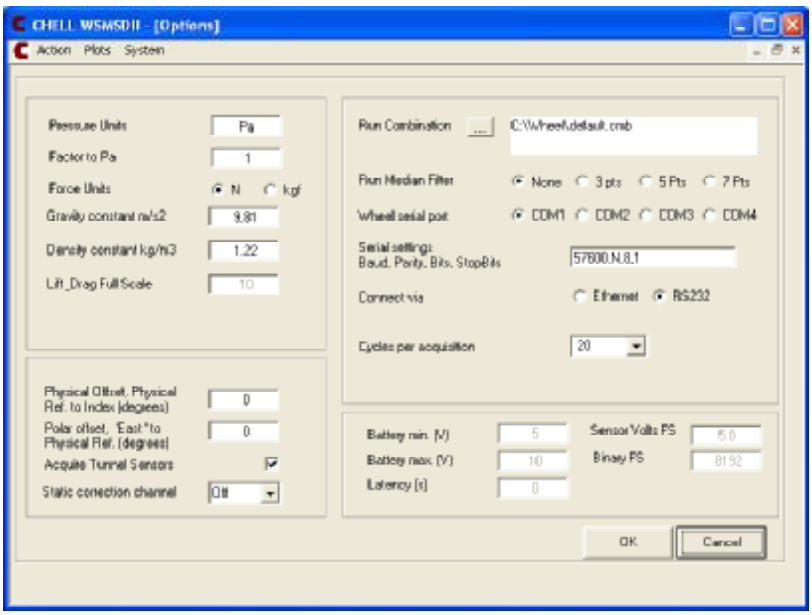
The encoder can also be incorporated into the same assembly as shown. The encoder disk is held stationary be the axle and the reader rotates with the wheel. The encoder is powered by and read by the main PCB.



The WSMSD software communicates directly with the wheel. It allows the user to configure all aspects of the acquisition and to acquire and display data. This is accomplished with the following windows:

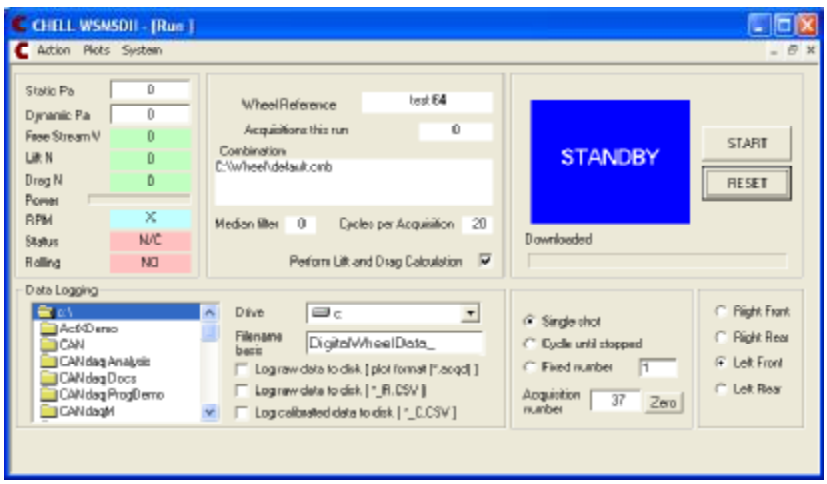
Calibration. Using this window, the user can acquire data from each transducer in volts and calibrate the output in engineering units (usually Pa). This procedure is carried out by Chell prior to delivery but may need repeating every 6 months to 1 year. The wheel can be returned to Chell for recalibration or it can be carried out by the user. This window also provides a re-zero facility for all the transducers.



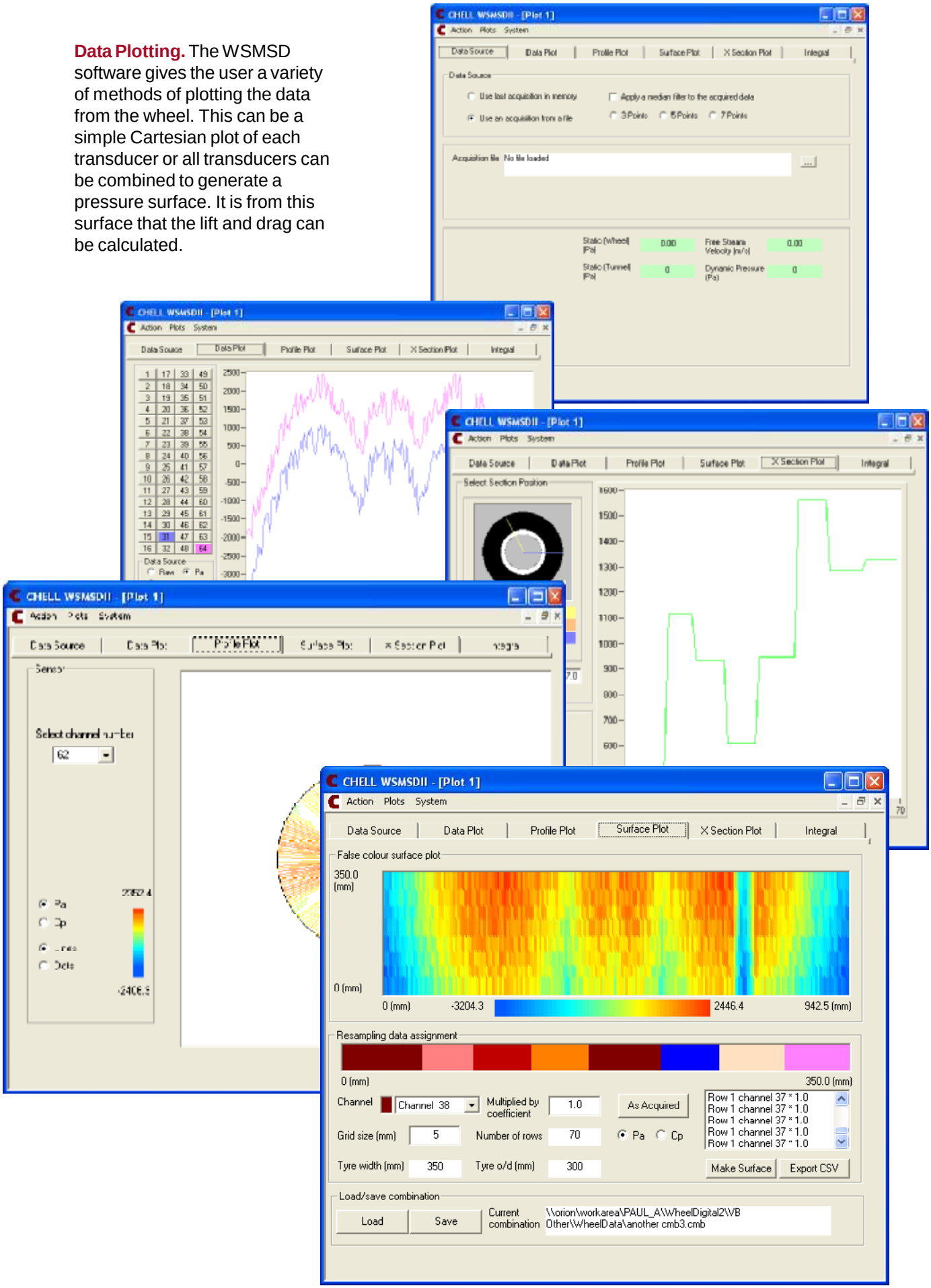


Wheel Options. Each wheel used by the system has its own set of parameters. This mainly consists of the individual transducer positions and angular offsets together with a number of configurable options. The WSMSD software is capable of storing and recalling any number of wheel configurations.

The Run Form. With this form the data is acquired and stored to disk. The form will display the status of the wheel including its rotational speed. The data can be saved for later processing or it can be automatically processed using pre-defined parameters.



Data Plotting. The WSMSD software gives the user a variety of methods of plotting the data from the wheel. This can be a simple Cartesian plot of each transducer or all transducers can be combined to generate a pressure surface. It is from this surface that the lift and drag can be calculated.



Specifications

WSMSD System Specifications	
Repeatability (drag and lift)	Better than +/- 0.1 Newton
Zero Repeatability (drag and lift)	Better than +/- 0.05 Newton
Number of transducers	32 to 64 (one channel is used to monitor the static pressure within the wheel).
Maximum rotational speed	4000 RPM
Acquisition speed	33KHz at 4000 RPM (equivalent to 0.72 Degrees).

WSMSD Interface Specification	
Supply voltage	8 VDC at 1amp
Operating temperature range	+5 to +50 Degrees C (40 to 122 Degrees F)
Warm up time to full accuracy	15 mins
Encoder type	5V TTL encoder, 500 pulses per revolution(for 32 channels, 200 puses for 64 channels) ,1,index pulse. Other types of encoder can be accomodated, please contact Chell for further information

WSMSD Transducer Specifications	
Weight	In the range of 425 to 450g (incuding transducers) depending on diameter.
Operating temperature range	+5 to +50 Degrees C (40 to 122 Degrees F)
Transducer range (wheel surface)	Typically 1 psi (6894Pa)
Transducer accuracy (wheel surface)	0.2%FS
Proof pressure (wheel surface)	20 psi (137Kpa)
Transducer range (barometric)	12 - 16 psi (103Kpa)
Transducer accuracy (Barometric)	0.3%FS
Proof pressure (barometric)	30 psi (206Kpa)
Temperature compensation range	0-50 Degrees C

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