# DPMS

The Dynamic Pressure Measurement System (DPMS) is a multi-channel pressure measurement system that provides simultaneous measurement of both time-averaged (mean) and time-varying (fluctuating) pressure measurements in real-time. This pressure measurement system extends the capabilities of other existing systems by providing time-accurate measurements of even rapidly fluctuating pressures up to high frequencies.

The system is capable of a linearised frequency response from 0 Hz to several kHz and is available in various full-scale ranges. The measurement, or Dynamic Pressure (DP), modules are supplied fully calibrated and ready to use.

*32-channel Dynamic Pressure (DP) module*

TFI's Windows-based *Device Control* software provides a powerful, easy-to-use interface for operating the DPMS. Data processing is performed in real-time so results may be viewed while data are being acquired, or replayed and analysed afterwards.

The DPMS also incorporates TFI's *Real-Time Animated Contouring* (*R-TAC*) software, for overlaying dynamic pressure contours, in real-time, on an imported image of the measurement situation. This allows the user to see the fluctuating pressure contours directly on the object where measurements are taken. *R-TAC* provides a very fast and powerful method of analysing pressure measurements.



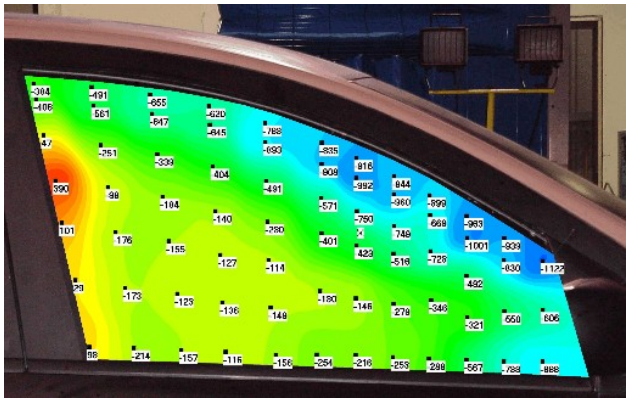
## How it works

As with other similar systems, the DPMS measures pressure using separate pressure transducers for each channel located in the DP modules. However, the DPMS also corrects the signals for amplitude and phase distortions of fluctuating pressures that occur in the tubing used to connect the measurement points (pressure taps) to the modules. This process is termed 'linearisation'. Linearisation allows the DPMS to provide accurate pressure measurements from 0 Hz (mean pressure) to several kHz, depending on tube dimensions. The linearisation is performed automatically as data is acquired by the included *Device Control* software after the user has entered details of the tubing. Results can then be displayed in real-time, as time traces of the pressure signals or overlaid on an image of the measurement situation using *R-TAC*.

## Capabilities

The DPMS and *Device Control* software provide a complete data acquisition and processing system that perform the following functions:

- Time-averaged (mean) and time-varying (fluctuating) pressure measurement
- Measurement of up to 1024 channels (pressure taps) simultaneously
- Frequency response from 0 Hz (mean pressure) to several kHz
- Real-time data processing and display
- Real-time frequency analysis of any pressure signal
- Real-time pressure contour display, overlayed on an image of the measurement situation



*Pressure contours displayed over the side window of a vehicle by the R-TAC software*

## Uses and Applications

The DPMS can be used to take pressure measurements in a variety of situations. Desktop computers are supported for use in wind tunnels and other fixed location testing. Alternatively, a laptop computer can be used for mobile pressure measurement, such as on-road testing or other fieldwork. The system is very compact and low channel count versions draw their required power from the computer, allowing easy transportation.

*Lightweight 15-channel DP module, with the 16th channel used for a temperature sensor*

A DPMS can be used wherever simultaneous multi-channel pressure measurements are required (see Table 1). It is especially useful for real-time mapping of pressure contours without waiting for post-processing and visualisation. This allows on-the-spot decisions to be made about data integrity and saves considerable time during testing. All data can be saved to file for later viewing and *R-TAC* output can be saved in video file format for use in analyses and presentations.

*Table 1: Sample uses and applications of the TFI DPMS*

| | |
|---|---|
| General uses in all applications | |
| | - Pressure contouring over surfaces<br>- Determination of mean, RMS and peak pressure distributions<br>- Most applications requiring multi-channel pressure measurement |
| Aircraft aerodynamics | |
| | - Measurement and visualisation of pressure distributions<br>- Investigation of pressure fluctuations, e.g. due to stall & flow separations<br>- Investigation of fatigue due to aerodynamic buffeting |
| Industrial/environmental aerodynamics | |
| | - Pressure measurements on scale models of buildings and other structures<br>- Quantification of pressure loading and distribution on structures<br>- Determination of instantaneous peak pressures |
| Vehicle aerodynamics | |
| | - Investigation of pressure distributions and flow separations on vehicles<br>- Quantification of flow through heat exchangers<br>- Measurements on-road, at test tracks or in wind tunnel facilities<br>- Measurements on model-scale or full-scale vehicles |

## Operating Requirements

The following standard components are supplied when you order a DPMS: Dynamic Pressure (DP) modules; all necessary cabling; TFI's *Device Control* and *R-TAC* software; and on-going technical support. You will need to supplement these components with the following:

- Windows-based computer – desktop or laptop (500 MHz processor minimum, faster preferred for channel counts greater than 128)
- Supported A/D card or other suitable data acquisition system (16 bit, 100 kHz preferred). Supported cards include:
  - IOtech DaqBoard/2000 series for desktop computers
  - National Instruments M-series and E-series for desktop and laptop computers


*DP module*

The listed A/D are available from their respective distributors or can be packaged with the DPMS. Contact TFI to enquire about support for other A/D cards and data acquisition systems.

## Calibration Requirements

DP modules are supplied fully calibrated and ready to use - full calibration of the DPMS is performed by TFI before delivery to customers. Occasional (6-monthly) transducer checks are recommended (these checks are quickly and easily performed by the user by applying known pressures to the DP modules).

## Configurations

The DP modules output raw voltage data that are transferred to computer via supported A/D cards (see *Operating Requirements*) or another suitable data acquisition system. The raw data are then processed into fluctuating pressure data by the *TFI Device Control* software by linearisation and other signal processing techniques. There are several different DPMS configurations available, depending on the total number of channels required, DP module size and your preferred data acquisition system. Custom configurations are available and every system is designed with future expansion potential.

### *Stand-alone configurations*

The stand-alone configurations use the A/D cards directly supported by the *Device* Control software as the data acquisition device. These configurations fall into two main categories:

- direct connection configurations, and;
- interfaced configurations.

Direct connection involves directly connecting DP modules to one or more A/D cards in the computer, i.e. one DP module per A/D card (Figure 1). Direct connection is suited to applications utilising a small number of DP modules and not requiring other inputs. Configurations using interface boxes (Figure 2) are termed interface connections, and are used when a large number of DP modules with small channel counts are required, e.g. where small modules are preferred due to space constraints in the test set up. Interface boxes are also used to provide optional user inputs, such as those from other sensors. Figure 1 and Figure 2 detail some of the common stand-alone configurations.

DP modules can be produced in 16-, 32-, 64-, 128- and 256-channel versions, depending on customer requirements. Other channel counts may also be specified if required. With either configuration type, up to 256 channels may be used per installed A/D card. With simultaneous use of up to 4 A/D cards, this allows a total channel count of 1024. Channel counts beyond 1024 are possible (contact TFI for further details). Thermally regulated enclosures are optional.

DP modules can also be used with laptop computers, providing a lightweight, portable system for testing in various locations. Systems with an interface box can be supplied with additional inputs for other sensors, such as temperature and accelerometer, and external data-acquisition timing signals (note that each additional input means the loss of one available pressure transducer channel). Power for low channel count systems can be provided directly from the computer. Larger channel count systems require the use of a supplied power adaptor.

The DP modules should be located close to the measurement points in order to minimise the length of tubing between the DP module and the pressure taps. Reducing the length of tubing increases the available frequency response. For applications where space is limited, the use of multiple low channel count systems may be preferable1. Where space is not an issue, larger channel count modules simplify the system and may be more convenient. Therefore the choice of configuration, direct connection or interface box, will depend on the preferred DP module size and the total number of channels required. TFI will assist in determining the best configuration to meet your requirements.

1 A small 16-channel DP module could be situated inside a wind-tunnel model close to the pressure taps, thereby reducing tubing length and maximising the frequency response.

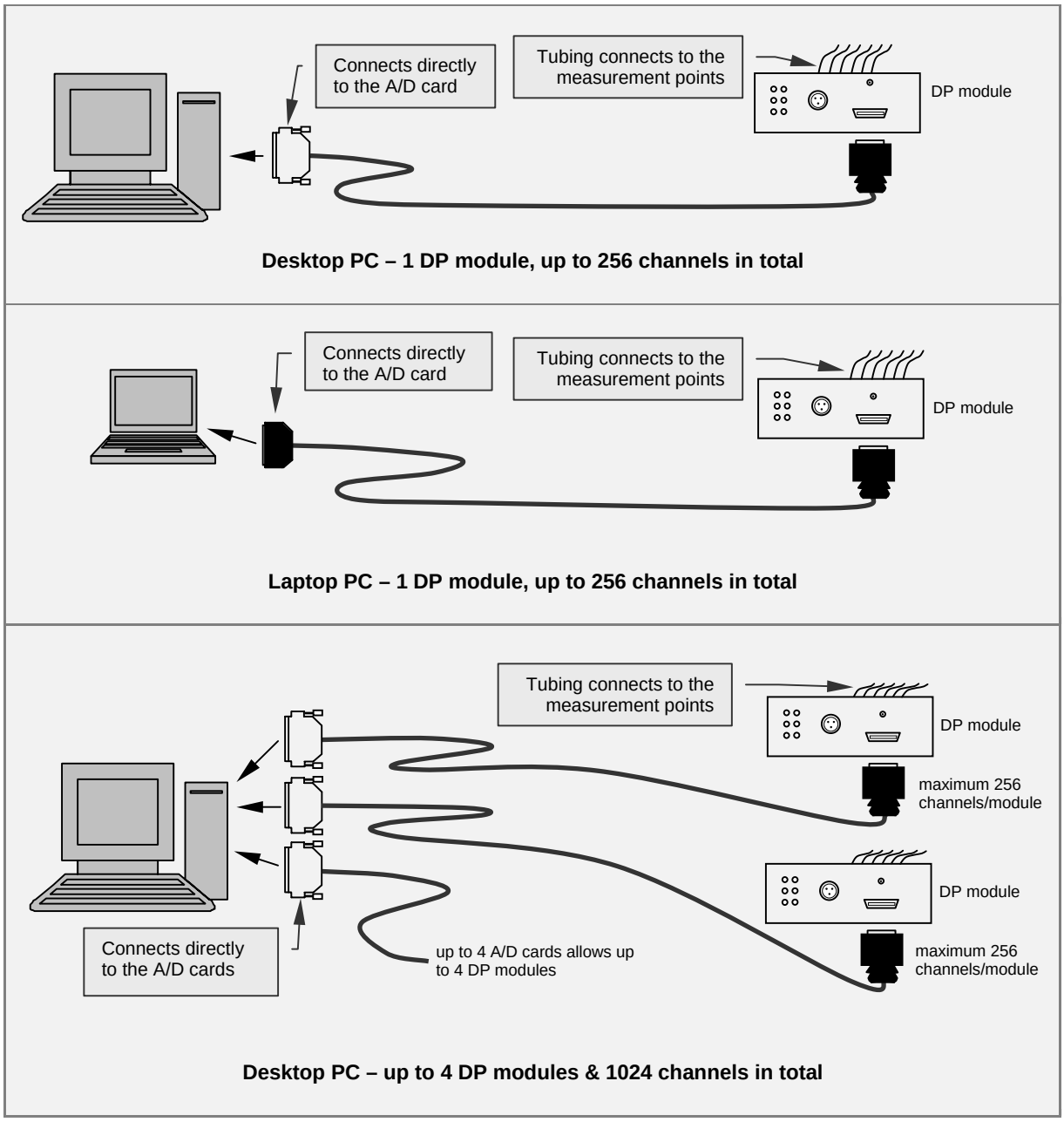



*Figure 1: Direct connection configurations for the DPMS (minimum number of DP modules for total channel count)*

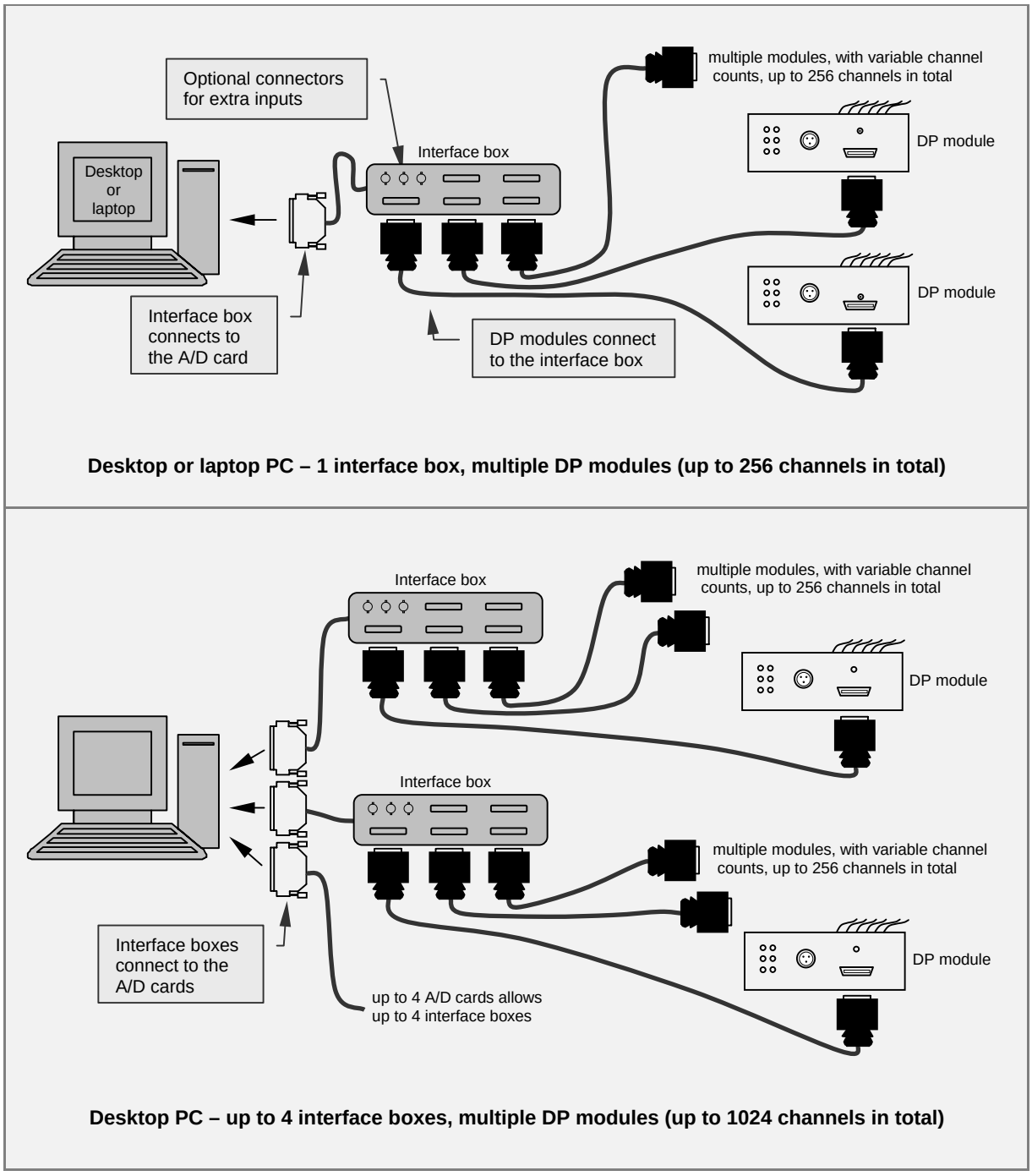



*Figure 2: Interfaced connection configurations for the DPMS (for multiple DP modules with small channel counts)*

### *Interfacing with existing systems*

As well as the stand-alone configurations, TFI can provide a configuration that will interface with a customer's existing data acquisition system (Figure 3). DP modules are connected to the existing data acquisition system using compatible connectors, and can include connecting the DP module channels via separate cables for each input (e.g. using BNC connectors). Specialised software interface routines supplied by TFI can then be accessed by the customer's existing data acquisition software in order to produce the processed fluctuating pressure information and to take advantage of powerful features such as *R-TAC*. The software routines are compatible with C++, LabVIEW® and other programming languages.

Due to the variety of possibilities with data acquisition systems and data processing options, you should contact TFI to determine the set up that best meets your needs.

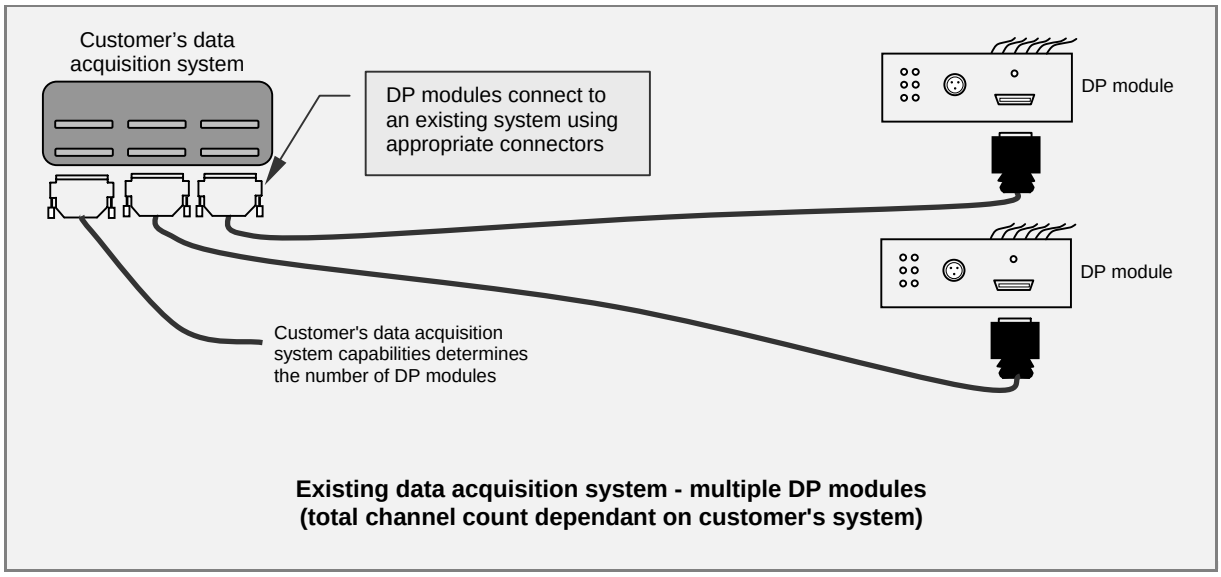
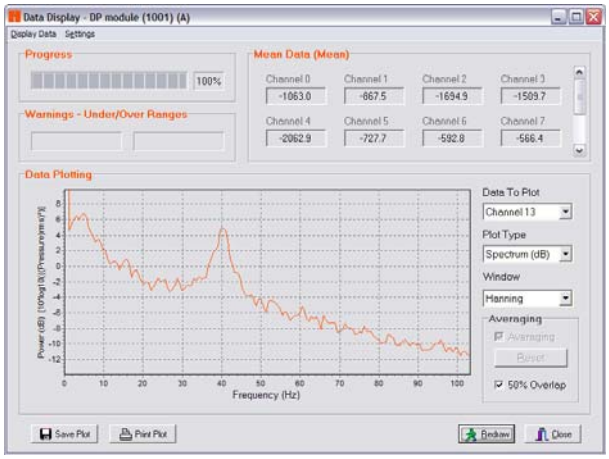



*Figure 3: Interfacing a DPMS with an existing data acquisition system*

## Device Control and R-TAC software

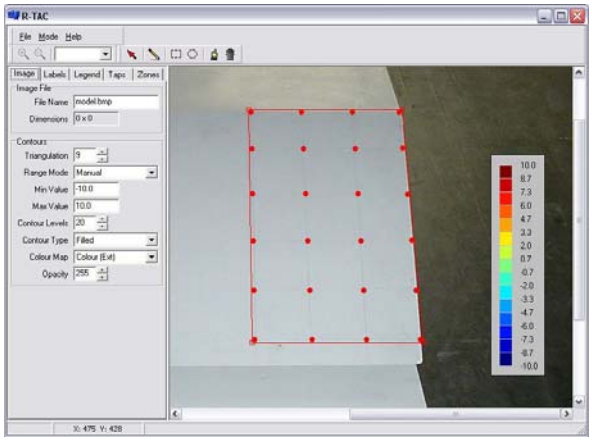
An integral part of the DPMS is the software that controls and processes the pressure data. The *Device Control* software includes all functions required to operate the DPMS, including data acquisition, processing, visualisation and storage. Mean, RMS, minimum and maximum pressures from each transducer can be displayed in real-time.

By entering dimensions of the tubing that is used to connect the measurement points (pressure taps) to the DP modules, the software will linearise data to correct for tubing response, thus providing accurate measurement of fluctuating pressures. Real-time frequency spectra from any pressure tap can be displayed using this data. Software correction of the phase lag between channels also provides quasi-simultaneous sampling without the need for a true simultaneous-sampling data acquisition system, which would add significant cost.

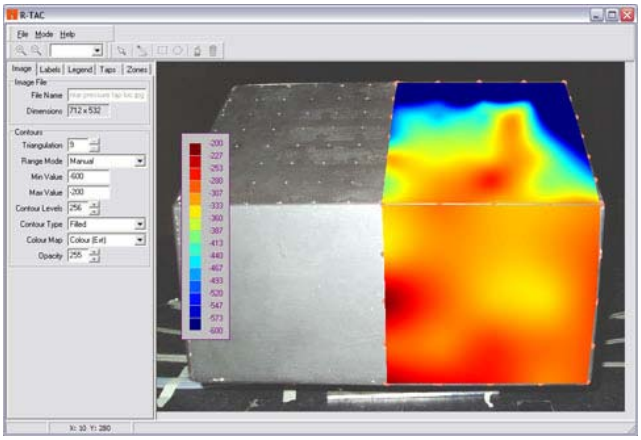



*Real-time frequency spectrum of a pressure signal by the Data Display form in the Device Control software*

The *Device Control* software for the DPMS incorporates *R-TAC* (*Real-Time Animated Contouring*), which provides real-time contouring of the linearised pressure signals. This feature enables you to import a photo or other image of the item under test and indicate the location of the pressure taps. The software then provides real-time display of the pressure distribution contours superimposed on the photo of the test article. The images can be saved to produce video of the dynamic pressure distribution, thus providing a very valuable tool for understanding flow structures.




*The R-TAC main form where pressure tap locations and other settings are specified (the image shown is that of a geometrical wind-tunnel model)*




*Pressure contours over another geometrical wind-tunnel model shown by the R-TAC software*

## Specifications

The following sections provide some details of DPMS specifications. They should be treated as a guide only, due to the wide variety of applications, possible test scenarios and custom configurations. More specific advice will be provided by TFI when discussing your particular application.

DP modules can optionally be supplied with thermal regulation that maintains a constant temperature within the module, thus reducing drift in the transducer signals due to temperature variation. This is beneficial when significant temperature fluctuations are expected during the course of a measurement. For situations where the temperature variation is expected to be small, thermal regulation is not required due to the use of temperature compensated pressure transducers.

Smaller DP modules are supplied with power directly from the connected computer, however modules with more than 32 channels or thermal regulation require an external power source that is supplied. Typical module dimensions are given in Table 2 and a schematic diagram of a module is shown in Figure 4 below. Custom packaging is also possible – contact TFI to discuss your requirements.

### *Module Dimensions*

*Table 2: Sample DP Module dimensions*

| Module size | Length | Width | Height (excl ports) |
|---|---|---|---|
| 16 channels | 110 | 65 | 30 |
| 32 channels | 115 | 100 | 32 |
| 64 channels | 220 | 100 | 32 |
| 128 channels | 220 | 190 | 32 |
| 256 channels | 440 | 190 | 32 |

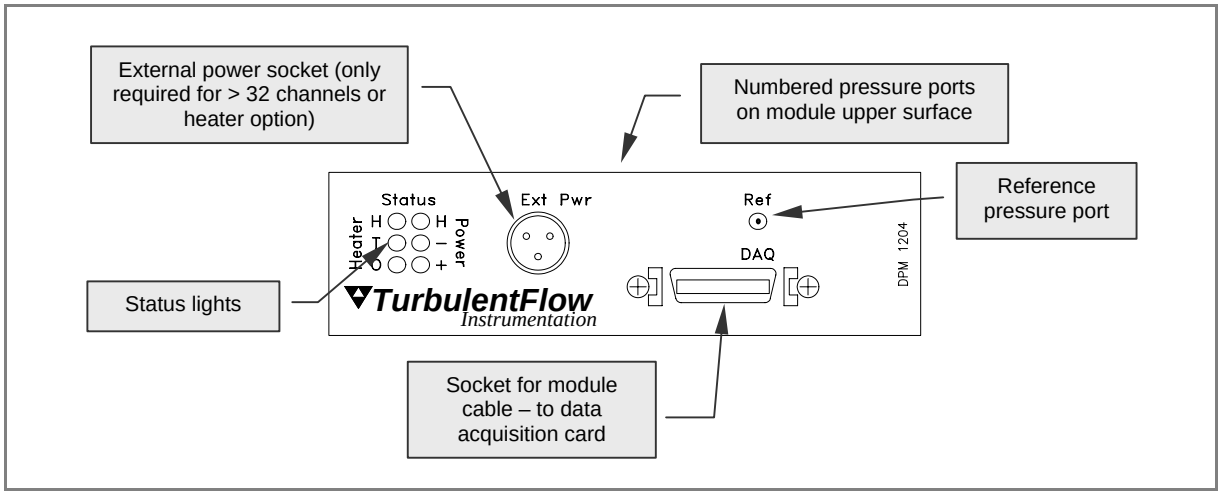



*Figure 4: Schematic diagram of a DP module front panel*

### *Pressure ports & reference pressure*

DP modules can be supplied with pressure ports to suit any tubing size (up to what will physically fit on the module). For example, pressure ports are often produced to accept tubing with an inner diameter ranging from 0.8 – 2.0 mm.

The reference pressure port (see Figure 4) provides the common reference pressure for the transducers. Pressures measured by the DPMS are relative to the pressure present at the reference port. Therefore, the reference port is normally vented to the wind tunnel control room or another suitable location.


*A 32-channel DP module showing the pressure ports on the top surface*

### *Performance*

*Table 3: DPMS Performance*

| Pressure ranges | Frequency response | Accuracy (typical) | |
|---|---|---|---|
| | | Pressure (linearity & temperature) | Frequency response amplitude |
| 1 kPa (4" $H_2O$)<br>2.5 kPa (10" $H_2O$)<br>7 kPa (1 psi) | 0 Hz (DC) to several kHz<br>(limited only by tube dimensions and data acquisition capabilities) | ±0.3% FS<br>(from 0° - 50°C) | ±2%<br>(dependant on tube dimensions) |

The accuracy of fluctuating pressures is mostly dependent on the known accuracy of the pressure tubing dimensions (length and internal diameter); knowing tube dimensions more accurately will produce more accurate linearisation. Experimental calibrations of particular tubing may also be performed, but this is generally not required.

## Customisation

TFI can customise the DPMS to suit your particular requirements. Items commonly customised include channel count and configuration, additional inputs, and integrating the DPMS with existing equipment. Contact TFI to discuss your requirements.