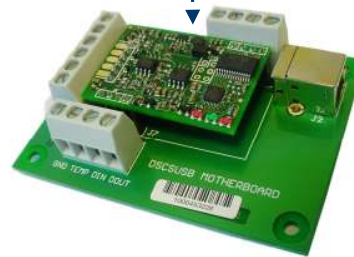




Cased version



OEM PCB



DSJ2 OEM Module

## DSCUSBS and DSCUSBH USB Strain Gauge or Load Cell Digitiser Modules



*User Manual*  
[www.mantracourt.co.uk](http://www.mantracourt.co.uk)

**ME** mantracourt

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# Chapter 1 Introduction

This chapter provides an introduction to the DSCUSB products, describing the product range, main features and application possibilities.

## Overview

The DSCUSB products are miniature, high-precision Strain Gauge Converters; converting a strain gauge sensor input to a **digital** USB serial output. They allow high precision measurements to be made and communicated directly to a PC. With the appropriate drivers installed, the DSCUSB appears as a virtual communication port to the PC .

## Key Features

### Three Form factors:

The product is available in three formats depending on how it is to be integrated:

**PCB Only:** for OEM integration into the customer's own products. This can include fitting into a load cell body if space allows.

**OEM Field Connector Module:** the DSJ2 provides field terminals and a USB Type B connector.

**Cased:** supplied in a desk mounting case (approx 86 x 57 x 25mm) with 1.4m of USB cable terminating in a type A plug and a 9 way D-Type socket for the strain gauge connections.

### High Stability`

25ppm/°C basic accuracy (equates to 16 bit resolution)

### Adjustable sensitivity

Supplied pre-configured for standard 2.5mV/V full-scale strain gauges.

A single additional resistor re-configures the input between 0.5 and 100 mV/V full-scale.

### Temperature sensing and compensation (optional)

An optional temperature sensor module (DTEMP) is available which will enable an advanced 5-point temperature-compensation of measurements.

### Linearity compensation

Advanced 7-point linearity compensation available as standard.

### USB

Uses a simple 'Virtual Communications Port' as its connection method to a PC.

Device addressing allows up to 127 devices.

ASCII version allows for continuous output stream.

### Low current

Functions as a 'Low Power Device' i.e. draws less than 100mA (one unit load) when connected to a 350 Ohm Bridge.

### Digital calibration

Completely drift-free, adjustable in-system and/or in-situ via standard communications link.

Two independent calibration stages for load cell and system-specific adjustments.

Programmable compensation for non-linearity and temperature corrections.

Calibration data is transferable between devices for in-service replacement.

### Self-diagnostics

Continuous monitoring for faults such as strain overload, over/under-temperature, broken sensors or unexpected power failure.

All fault warnings are retained on power-fail.

### Multiple output options

Choice of three different protocols for ease of integration: ASCII, MODBUS or MANTRABUS

All variants provide identical features and performance.

## ***Special Facilities***

### **Output Capture Synchronisation**

A single command instructs all devices on a bus to sample their inputs simultaneously, for synchronised data capture.

### **Output Tare Value**

An internal control allows the removal of an arbitrary output offset, enabling independent readings of net and gross measurement values.

### **Dynamic Filtering**

Gives higher accuracy on stable inputs, without increasing settling time.

### **Programmable Output Modes**

Output rate control enables speed/accuracy trade-off.

ASCII output version provides a decimal format control and continuous output mode for 'dumb terminal' output.

### **Unique Device Identifier**

Every unit carries a unique serial-number tag, readable over the communications link.

### **External Temperature Sensing (optional)**

An external temperature module is available for improved accuracy (especially tracking changing temperature conditions).

### **Software Reset**

A special communications command forces a device reboot as a failsafe to ensure correct operation.

## The Product Range

The DSCUSBS and DSCUSBH modules are available in three physical formats:

### OEM PCB



### Description and dimensions

OEM PCB with plated through holes for cable connections.

Dimensions:

PCB: 43 x 28 x 4mm (1.6929 x 1.1024 x 0.4724 inches)

### DSJ2 OEM Module



OEM PCB fitted to DSJ2 motherboard providing screw-type field connections for load cell, temperature, digital I/O and USB plus 'B' type 4-pole USB connector.

Dimensions:

Module: 82 x 60 x 20mm (3.2283 x 2.3622 x 0.7874 inches)

### Cased version



Free-standing module fitted with 9-way 'D' type socket for load cell, temperature and digital I/O connections. Integral USB lead with type 'A' connector.

Dimensions:

Case: 86 x 57 x 26.5mm excluding connector (95mm (3.740") including 9-way 'D' type socket) with 136cm (4.462 feet) USB cable.



## Chapter 2 Getting Started

This chapter explains how to connect up a DSCUSB for the first time and how to get it working.

If you have an ASCII device we supply a simple DSC Toolkit software application that is simple to use. If you have any other type of device you must use Instrument Explorer to configure the device. Note that Instrument Explorer can be used with ASCII devices as well, so if you need more complex configuration than DSC Toolkit offers you can use Instrument Explorer.

For simplicity, this chapter is based on the standard DSCUSB OEM Evaluation Kit, which contains everything needed to communicate with a PC.

It is advised that first time users wishing to familiarise themselves with the product, use the Mantracourt Evaluation Kit. This provides a low cost, easy way to get started.

If you do not have an Evaluation Kit, the instructions in this chapter mostly still apply, but you will need to wire up the device and have some means of communicating with it.

- The OEM Evaluation Kit
  - A 6 way screw connector for the strain gauge
  - A 4 way screw connector for a temperature sensor and the digital I/O
  - A 4 way USB screw connector
  - A type 'B' USB connector to interface to a computer
  - An Evaluation DSCUSB with the Comms protocol of your choice
- A CD ROM containing Instrument Explorer software and USB drivers
- A USB lead
- A DTEMP temperature sensor



Other Things you will need:

- A PC running Windows XP or above, with a spare USB port and 45Mb free disk space
- and, ideally -
- A strain gauge, load cell or simulator typically 350-5000 ohms impedance. (Refer to specifications Chapter 12)

### Communications Interface Information

DSCUSB devices can connect to a PC by plugging into a USB port and do not require an external power supply as they appear as a 'single unit load' i.e. they draw <100mA.

Appropriate drivers must be installed which are bundled with **Instrument Explorer** and **DSC Toolkit**. These create a virtual serial port allowing the DSCUSB to appear to the PC as a normal COM port device.

## Checking the Device Protocol Type

Before running the communications application, you will need to know both the protocol to use and the Com Port number allocated to the USB DSC (see the section 'Establishing the Assigned COM Port' later in this chapter).

| DSCUSB Order Codes | Description                                           | Can Use Instrument Explorer | Can Use DSC Toolkit |
|--------------------|-------------------------------------------------------|-----------------------------|---------------------|
| DSCSUASC           | ASCII Protocol USB Industrial Stability               | Yes                         | Yes                 |
| DSCSUEASC          | Cased version ASCII Protocol USB Industrial Stability | Yes                         | Yes                 |
| DSCHUASC           | ASCII Protocol USB High Stability                     | Yes                         | Yes                 |
| DSCHUEASC          | Cased version ASCII Protocol USB High Stability       | Yes                         | Yes                 |
| DSJ2               | Motherboard PCB with field terminals for uncased      | -                           | -                   |

## Instrument Explorer

Instrument Explorer is Mantracourt's own communication interface for our range of standard products. It provides communications drivers for the DCell/DSC/DSCUSB products. A complimentary copy is provided on CD-ROM with the DSCUSB Evaluation Kit. Instrument Explorer can also be downloaded from Mantracourt's website [www.mantracourt.co.uk/products\\_software.html](http://www.mantracourt.co.uk/products_software.html)

Instrument Explorer is a software application that enables communication with Mantracourt Electronics' instrumentation for configuration, calibration, acquisition and testing purposes.

The clean, contemporary interface allows full customisation to enable your Instrument Explorer to be moulded to your individual requirements.

### What Can Instrument Explorer Do?

- Save and restore customisable user workspace
- Read and Write individual instrument parameters
- Save and restore parameter configurations
- Log data to a window or file
- Perform calibration and compensation

### Installing Instrument Explorer

Install the Instrument Explorer software by inserting the CD in the CD ROM drive. This should start the 'AutoRun' process, unless this is disabled on your computer.

(If the install program does not start of its own accord, run SETUP.EXE on the CD by selecting 'Run' from the 'Start Menu' and then entering *D:\SETUP*, where *D* is the drive letter of your CD-ROM drive).

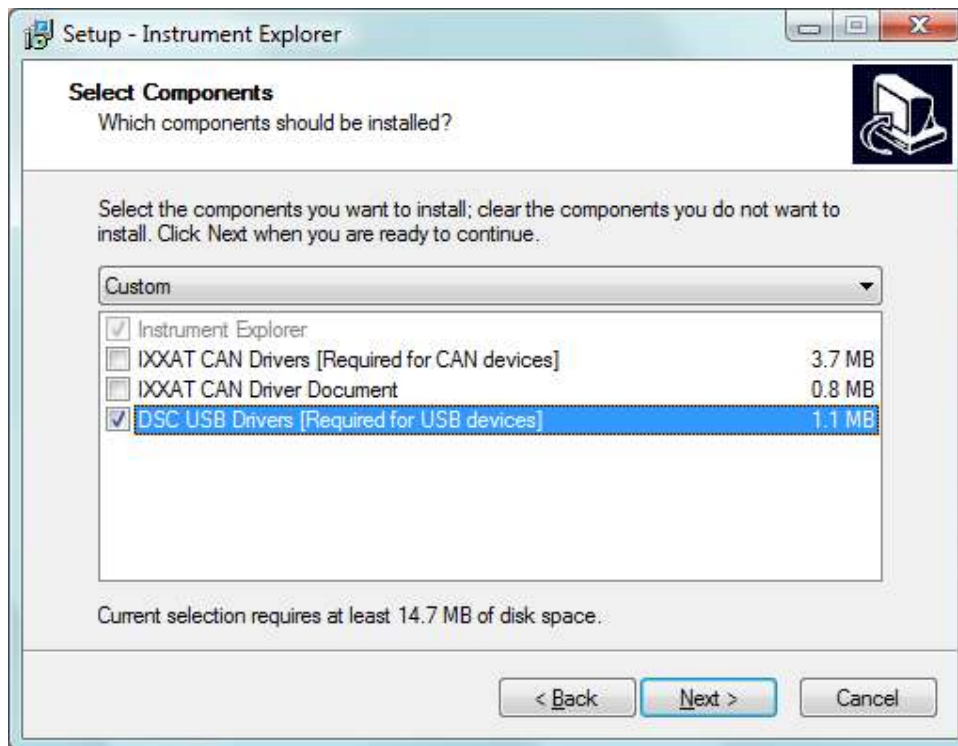
The install program provides step-by-step instructions. The software will install into a folder called *InstrumentExplorer* inside the *Program Files* folder. You may change this destination if required.

Shortcut icons can be created on your desktop and shortcut bar. After installation you may be asked to restart the computer. This should be done before proceeding with communications.

This section deals with using Instrument Explorer to communicate with the DSCUSB device and the drivers are installed during Instrument Explorer setup. If you are planning to communicate with the DSC with your own software contact Mantracourt for information on where to get a stand alone set of drivers.

## Installation

Install **Instrument Explorer** (Version 1 build 6.4 or higher) ensuring that the option for installing the DSC USB drivers is selected.



If you already have an older version of **Instrument Explorer** installed or did not select this option when you installed the newer version you can safely install again without uninstalling first.

In the above example the CAN drivers have not been selected as they are not required.

The installation software is trying to pre-install the required drivers so that they can be automatically found when the hardware is plugged in later on.

This will appear twice during the installation.

After installing the software you can connect the DSCUSB device to the computer.

The new hardware will be detected and the computer may display a dialog window asking whether to use Windows Update or the Internet to search for software.

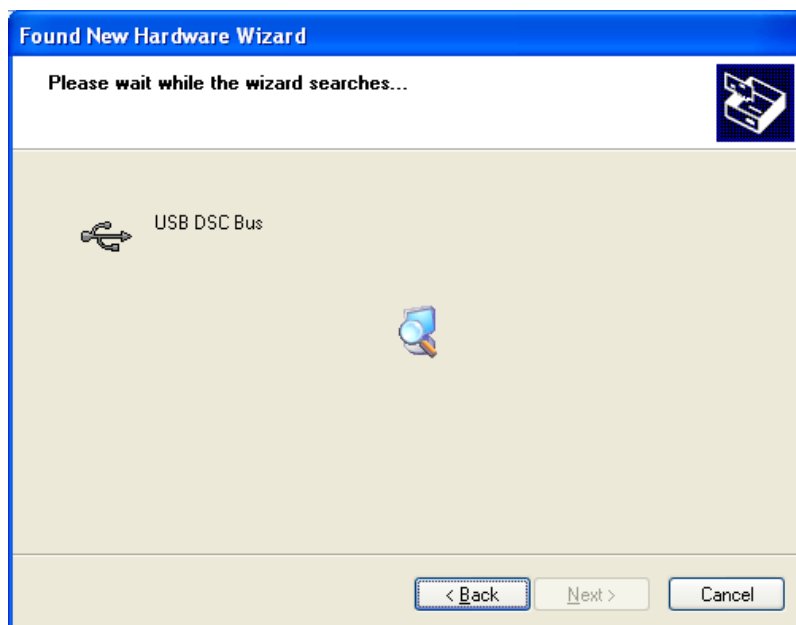
### ***Found New Hardware Wizard***

Once the software has been installed you can plug in the hardware. The '**Found New Hardware Wizard**' should now appear.

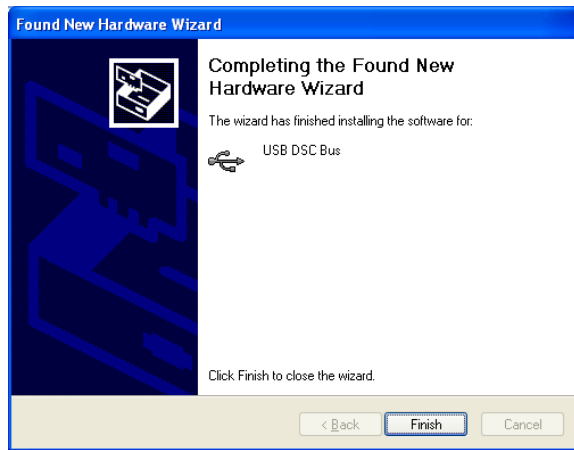
Select '**No, not at this time**' so that the wizard does not try searching online for a driver. Click '**Next**'.



Select 'Install the software automatically (Recommended)' and click 'Next'. Now the wizard will start searching for the drivers.



The wizard should then proceed with installing the software drivers.



Please note that there are two interfaces to the hardware so that there are two drivers that will be installed  
The **USB DSC Port** and the **USB DSC Bus**.

So the next dialog box you will see will be for the USB DSC Port and the steps will be repeated from step 2.



## ***Connecting up the Evaluation Kit***

Simply connect to a spare USB port on the PC using the lead provided in the kit.

## ***Initial Checks***

With no load cell connected the LED on the DSCUSB should flash OFF for 100ms every 0.5, 1 or 2 seconds depending on the protocol according to the following table:

| Protocol | LED Flash Period |
|----------|------------------|
| ASCII    | 0.5 seconds      |

Connect a load cell to the six-way screw connector following the labelling on the DSJ2 PCB

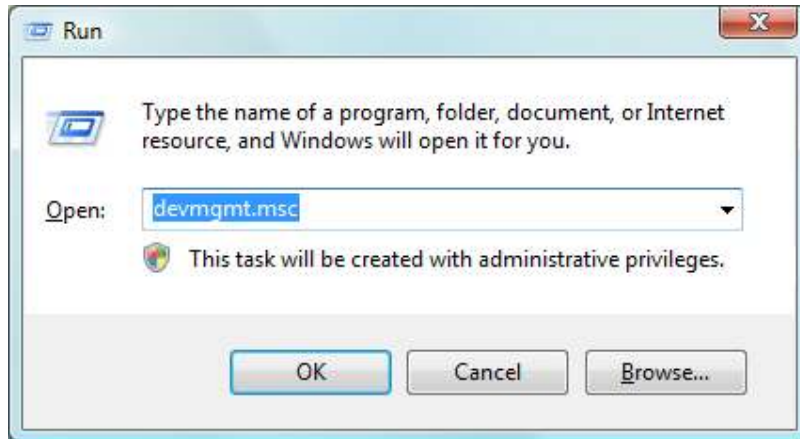
Note: If there are no errors the LED will Flash ON for 100mS then OFF for the above period. This is the normal 'healthy' state.

## ***Establishing the Assigned COM Port***

The DSCUSB device actually creates a virtual serial port (COM port) even though it is plugged into a USB port. This allows the PC software to communicate with the devices as if they were connected to a serial port. Unfortunately the PC will allocate a COM port to each device over which we have no control. Therefore we need to perform the next step to establish which COM port has been assigned to the DSC device. Instrument Explorer only supports COM ports 1 to 8 so if a COM port greater than this has been assigned it will need to be changed as follows:

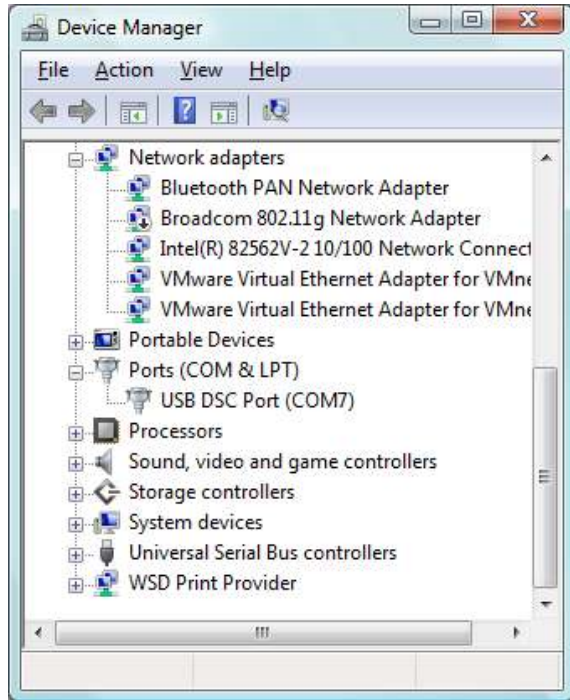
## ***Open the Device Manager***

Click the **Start** button and select **Run...**  
Type `devmgmt.msc` into the box and click **OK**.



This will open the **Device Manager** window

## Device Manager



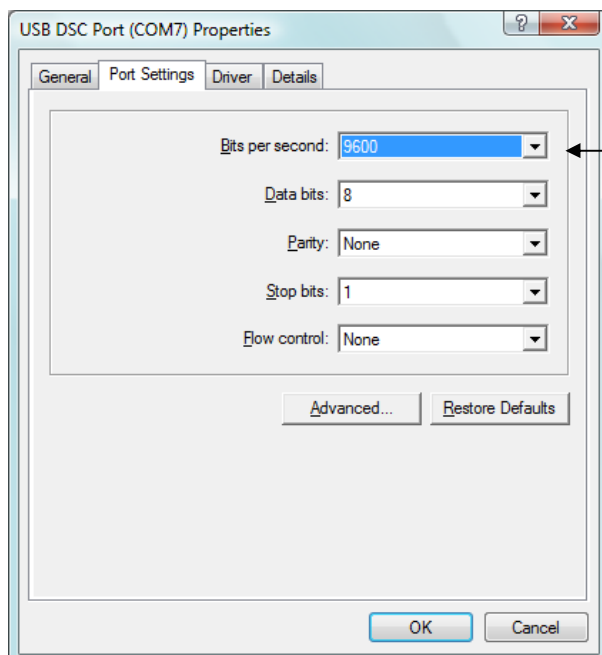
Select the **Ports (COM & LPT)** item and expand it.

If the DSC USB device has been installed correctly you should see an item named **USB DSC Port (COMx)** where the COM port assigned is shown in brackets.

If this COM port is between 1 and 8 then note the number as it will be needed when **Instrument Explorer** is used to connect to the device.

If the COM port is greater than 8 then it must be changed as follows:

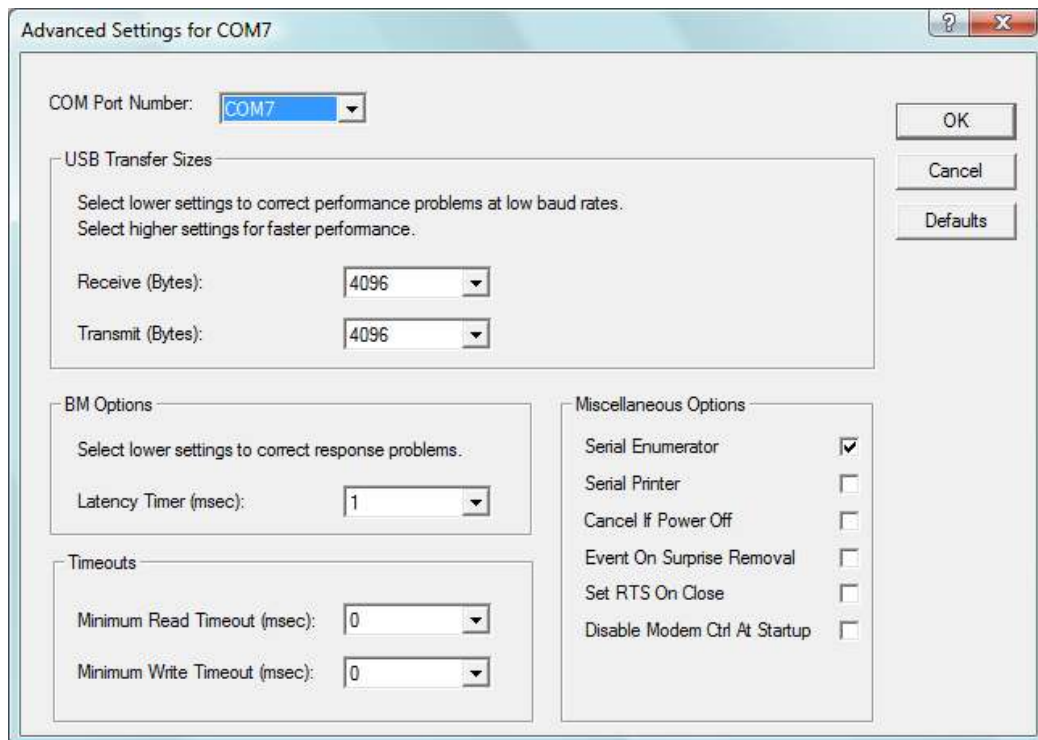
Right click the device and select **Properties** from the pop-up menu.



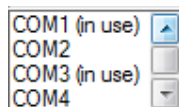
Please Note: The **BAUD** rate of 9600 is displayed in the dialog box but is not the actual **BAUD** rate of the device and does not need changing at this point.

Select the **Port Settings** Tab from the window that appears.

Click the **Advanced** button.



You can now select a new **COM Port Number** from the dropdown list at the top of this dialog. When you drop the list you may find that next to some of the listed COM ports there is an '(in use)' note.



Unless you have physical COM ports at the destination you wish to use then you can ignore this. The 'in use' note will be shown against any COM port that has, at some time, ever been allocated as a virtual COM port.

Once changed, select **OK** on all dialogs until they are closed.

You have now established which COM port your DSC device is 'connected' to.

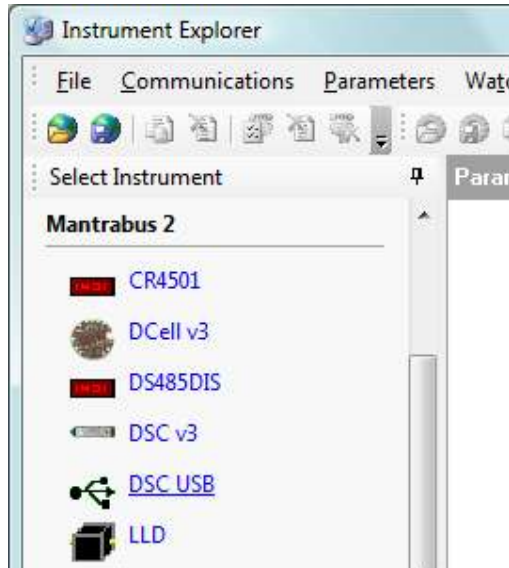
**NOTE:** The selected COM port should now remain with the DSC device regardless of which USB port it is plugged into. However, plugging the device into a different USB port may, depending on operating system, result in a request for drivers again. If this occurs follow the above procedure from the 'Found New Hardware Wizard' section.

Plugging in a new DSC device will also result in a driver request on Windows XP. Again, follow the above procedure from the 'Found New Hardware Wizard' section.



## Instrument Explorer

Launch Instrument Explorer and select the appropriate **DSC USB** device from the instrument list in the left hand pane. You need to know whether you have a Mantrabus, ModBus or ASCII device.



After clicking on the device name the following dialog will appear:



As can be seen in the above screenshot, the dialog message will indicate whether a device was detected and at what COM Port. In this example it is at COM7 so select Port 7 from the drop-down list.

Clicking **OK** will start communications with the device.

NOTE: The screenshots have been taken from a computer running Vista so you may see windows that appear slightly different depending on your operating system.

## Running the Instrument Explorer Software

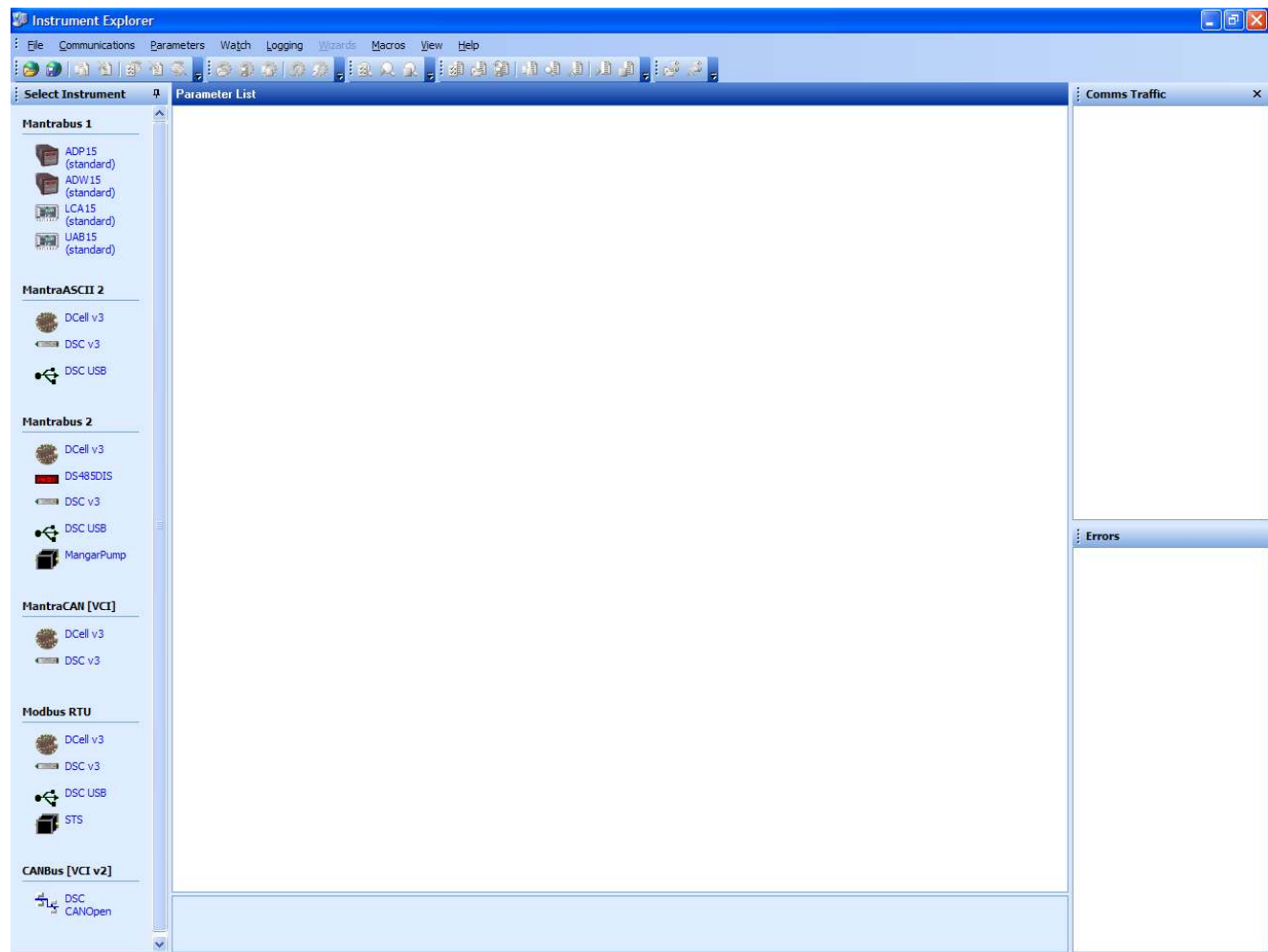
Having installed Instrument Explorer you can now run the application which the rest of this chapter is based on. From the Windows 'Start' button, select *Programs*, then *Instrument Explorer* or double-click on the shortcut on your desktop.

### Instrument Explorer Icon



The application should open and look like the following screen shot.

### Instrument Explorer Window



The layout of Instrument Explorer's window and child windows allows the user full customisation to their requirements. If the application show a different arrangement of child windows than the above screen shot, then load one of the default workspaces as follows:

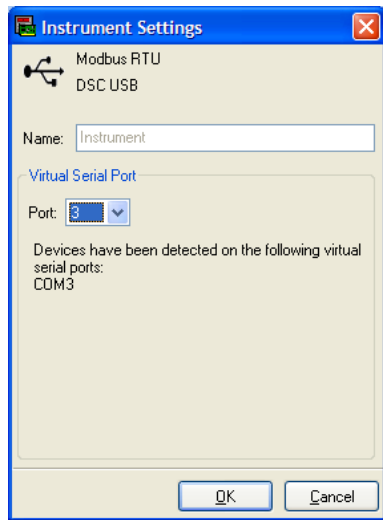
Click **File** on the menu and select **Open Workspace**. From the file dialogue window select **Layout - Standard.iew**. This will ensure your application layout matches this document.

A list of available instruments is displayed in the **Select Instrument** pane of Instrument Explorer. Select the relevant device and protocol to match the device you are working with, by clicking on the device icon.

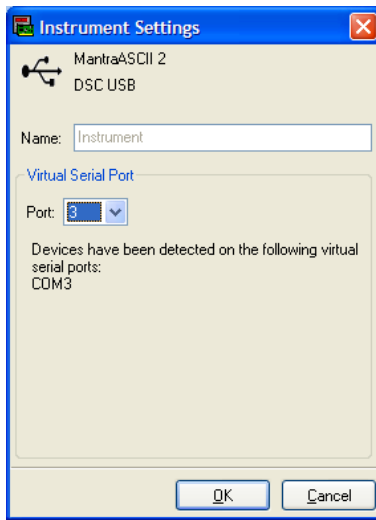
## Instrument Settings

One of the following dialogue windows will be displayed:

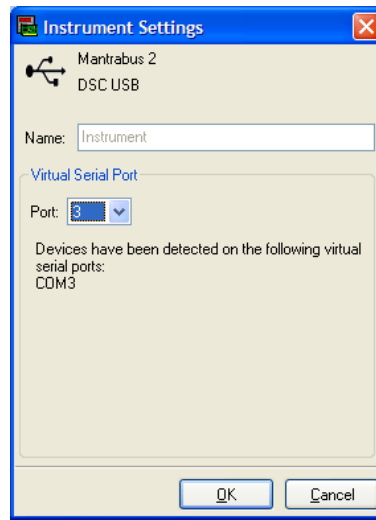
### Modbus



### MantraASCII



### MantraBus

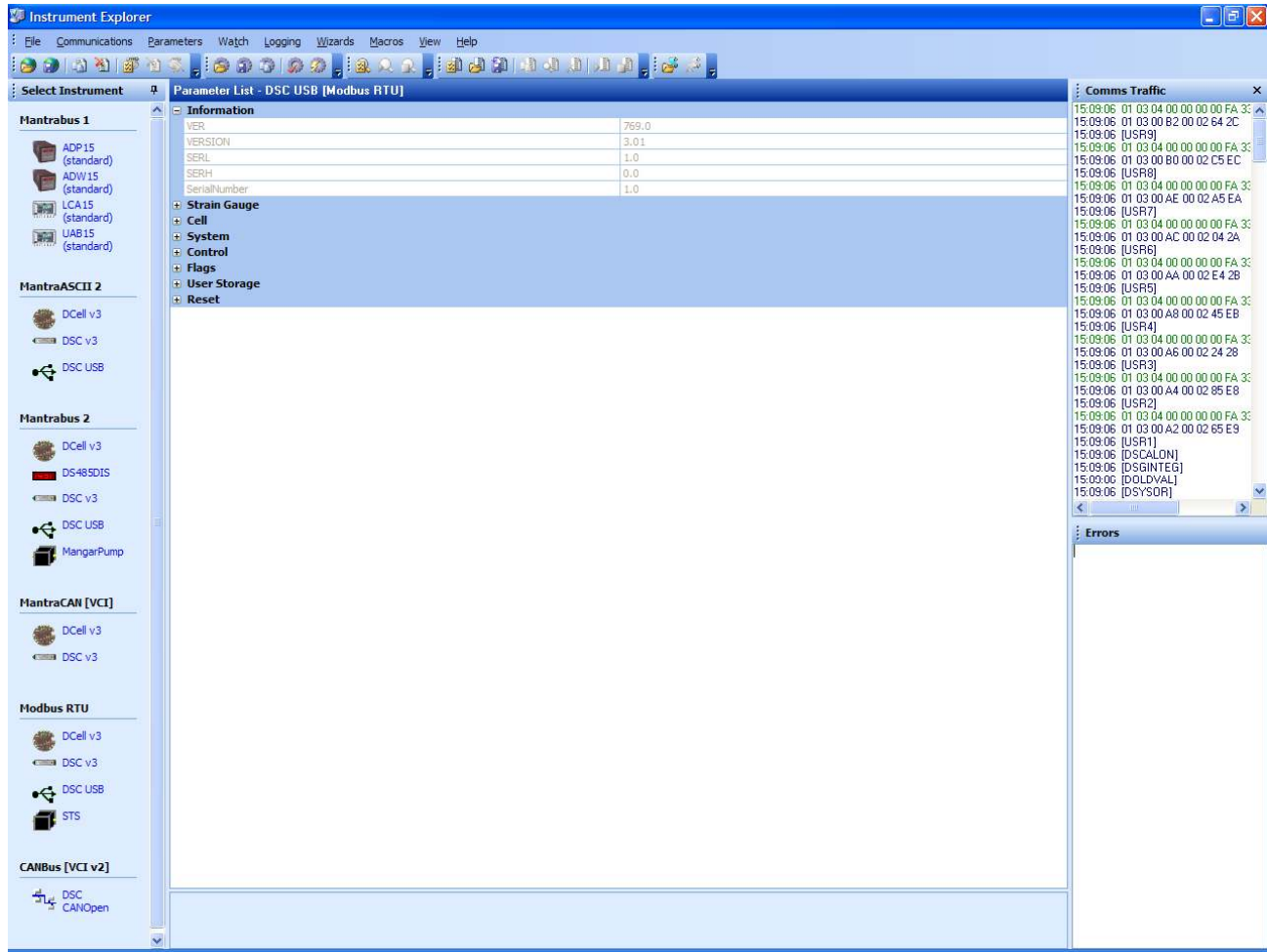


Select the serial port to which the device is connected from the drop-down list and click the 'OK' button.



## Viewing Device Data

The following main parameter list should now appear in the central pane.

### Instrument Explorer Parameter List



When an instrument has been selected from the Select Instrument window this parameter list window will become populated.

The parameters and commands which are available for the selected device will appear in this list in a structured hierarchic manner enabling the user to expand or contract categories by clicking the  and  buttons on the left of the list.

There are four types of parameters and commands:

**Read/write Numeric** - These parameter values are displayed in the right hand column and can be edited by clicking the value.

The value can then be changed and pressing the Enter key or moving away from the edited value will cause the new value to be written to the device. There are no checks on the data entered and it is up to the user to enter the correct data.

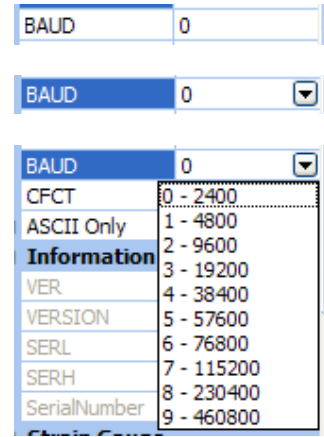
NMVV 234.5

NMVV 0.0

**Read-Only** - These parameter values are displayed 'greyed out' and cannot be changed.

SerialNumber 0.0

**Read/write Enumerated** - These parameters can only be changed by selecting the new value from a drop down list. Clicking in the right hand column will display a down arrow button which when clicked will display the parameter value options in a list. Note that all enumerated data (apart from on/off) will be displayed with a numeric value, hyphen then the description of the value. The numeric value is the value of the parameter and the description is just there to help.



**Commands** - These commands have 'Click to execute...' displayed in the right hand column. Clicking here will display a button. Click this to issue the command to the device.



As parameters are changed the communications traffic is displayed in the 'Comms Traffic' pane. If any errors occur they will be shown in red in the 'Errors' pane. Once an error occurs it will need to be reset before any more communications can take place. Reset errors by either right-clicking the 'Errors' pane and selecting **Reset Errors** from the pop-up menu or select the **Communications** menu and click the **Reset Errors** item.

To manually refresh the parameter list click the button on the toolbar or select **Sync Now** from the **Parameters** menu.

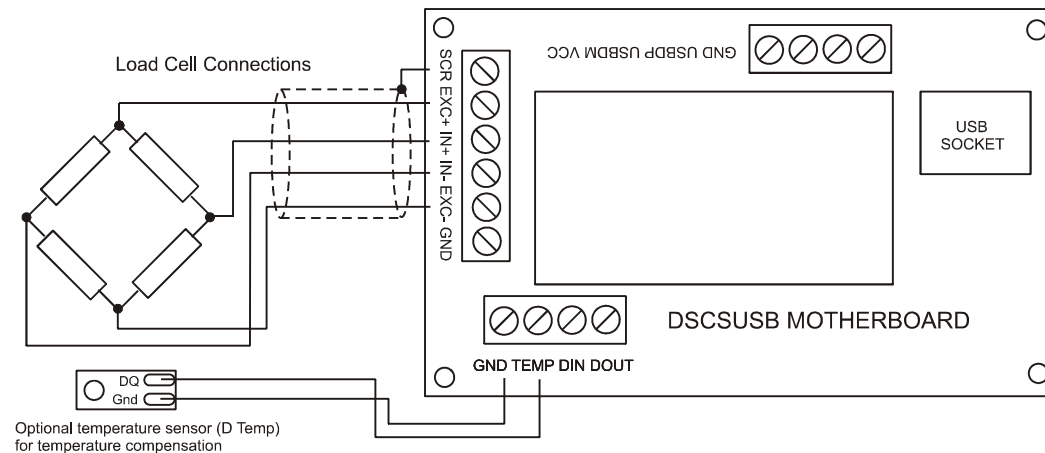
Now you have successfully established communications with your evaluation device the next step is to perform a simple calibration.

## Connecting a Load Cell

You can now connect a strain gauge bridge, load cell or simulator to the DSCUSB.


A suitable strain gauge should have an impedance of 350-5000 Ohms and (at least for now) a nominal output of around 2.5mV/V.




## DSJ2 Evaluation Board Sensor Connections







Next, we will set Instrument Explorer to automatically update dynamic parameters from the device so that we can see values such as SYS changing on the screen. To do this either click the button on the toolbar or click on the **Parameters** menu and select the **Auto Sync** item. Note that these options toggle so be sure to leave your selection in the active state.



From the Parameter List click the  next to the **System** heading to expand this level. The Parameter List should look as follows:

| <b>System</b>                                                                                   |                     |
|-------------------------------------------------------------------------------------------------|---------------------|
|  Scaling       |                     |
|  Limits        |                     |
| SRAW                                                                                            | -2.000592           |
| SZ                                                                                              | 0.0                 |
| SYS                                                                                             | -2.000592           |
| SOUT                                                                                            | -2.000592           |
| SNAP                                                                                            | Click to execute... |
| SYSN                                                                                            | 0.0                 |
|  Peak + Trough |                     |



This now exposes more levels that can be expanded as required by clicking the  next to the heading name.

| <b>System</b>                                                                                    |                     |
|--------------------------------------------------------------------------------------------------|---------------------|
|  Scaling        |                     |
| SGAI                                                                                             | 1.0                 |
| SOFS                                                                                             | 0.0                 |
|  Limits         |                     |
| SMIN                                                                                             | -100.0              |
| SMAX                                                                                             | 100.0               |
| SRAW                                                                                             | -2.000592           |
| SZ                                                                                               | 0.0                 |
| SYS                                                                                              | -2.000592           |
| SOUT                                                                                             | -2.000592           |
| SNAP                                                                                             | Click to execute... |
| SYSN                                                                                             | 0.0                 |
|  Peak + Trough |                     |
| PEAK                                                                                             | -2.000592           |
| TROF                                                                                             | -2.000719           |
| RSPT                                                                                             | Click to execute... |

Dynamic values (such as SYS and SRAW) will now be updating in real-time from the device.

Once you have connected the load cell the 'SYS' parameter should display 'realistic' values in the parameter list pane. These values should correspond to mV/V assuming the device is in its factory default state.

For diagnostics, the device has two sets of flags, one being latched and held within the device's non volatile memory (FLAG parameter) and the other being dynamic and volatile (STAT parameter).

| <b>Flags</b>                                                                                |  |
|---------------------------------------------------------------------------------------------|--|
|  Latched |  |
|  Dynamic |  |

Instrument Explorer provides a simple method of displaying and resetting individual flags although these are held within the device in FLAG and STAT parameters.

| Flags    |     |
|----------|-----|
| Latched  |     |
| FLAG     | 0.0 |
| TEMPUR   | Off |
| TEMPOR   | Off |
| ECOMUR   | Off |
| ECOMOR   | Off |
| CRAWUR   | Off |
| CRAWOR   | Off |
| SYSUR    | Off |
| SYSOR    | Off |
| SGINTEG  | Off |
| WDRST    | Off |
| REBOOT   | Off |
| Reset    |     |
| Dynamic  |     |
| STAT     | 0.0 |
| DOOUTPUT | Off |
| DINPUT   | Off |
| DTEMPUR  | Off |
| DTEMPOR  | Off |

To quickly clear all the flags simply write zero to the FLAG parameter. If no problems exist, all flags should remain in their off state.

If any flags remain on then refer to Chapter 8 for flag definitions.

## Performing a System Calibration

The values obtained so far are in mV/V units, these are factory calibrated and fixed to within 0.1% accuracy.

The device also contains two separate user-adjustable calibration parameter groups termed 'Cell' and 'System'. 'Cell' is used to convert from mV/V to a calibration value and 'System' to convert this calibration value to the required engineering units. The use of 'CELL' is optional. We shall be using 'System' for the following exercise where we rescale the output value to read in units of your choice, and to calibrate precisely to your load cell / system hardware.

Instrument Explorer provides Wizards to allow quick and simple calibration operations to be undertaken without the use of a calculator. Wizards can be activated by simply selecting the required item from the Wizard menu. Since we are now calibrating at system level we have a choice of two calibration methods:

**Sys Calibration Table** - This technique is used when a manufacturer's calibration document is available for the connected strain gauge. This normally gives mV/V to engineering unit values.

**Sys Calibration Auto** - This technique is used when the input can be stimulated with real input values i.e. test weights or forces can be applied.

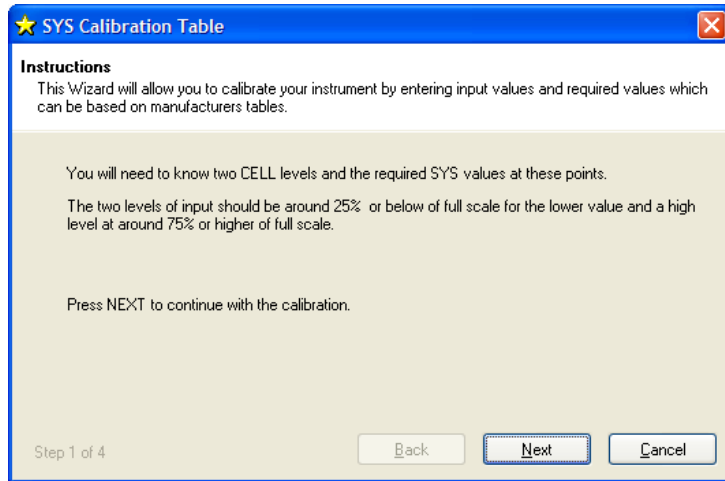
We will now describe each of these techniques with an example.

### Sys Calibration, Table method

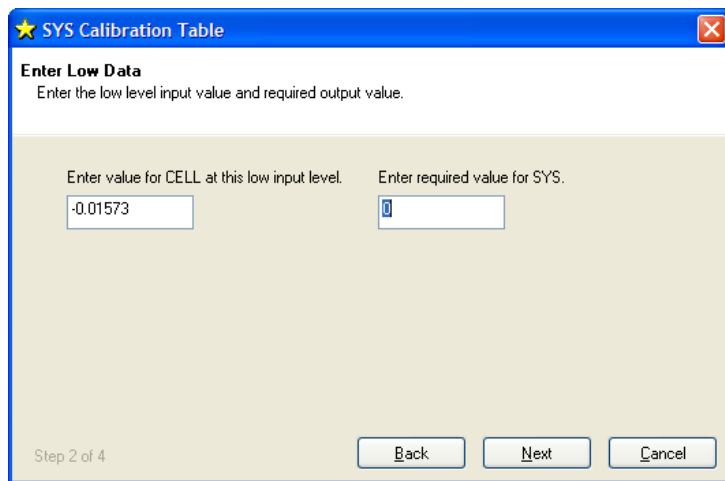
A 10 tonne load cell manufacturer gives the following data:

| mV/V output | Force    |
|-------------|----------|
| 2.19053     | 10 tonne |
| -0.01573    | 0 tonne  |

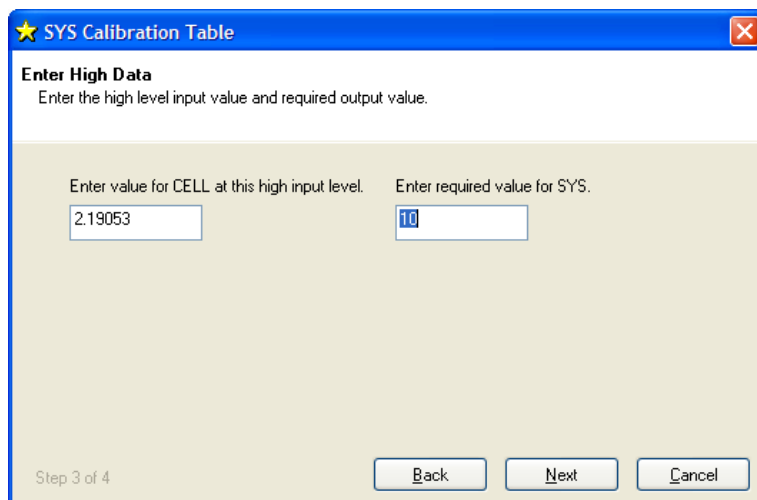
Start the wizard by selecting **Sys Calibration Table** from the **Wizard** menu



Click the **Next** button and enter the low values as shown below.

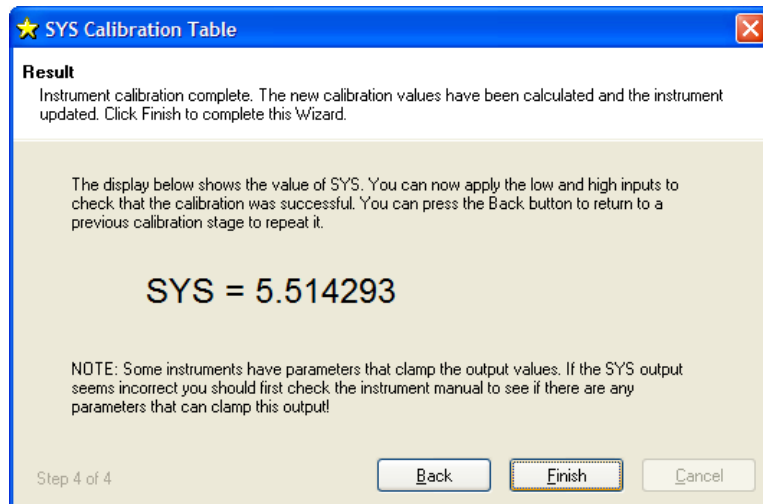


Click the **Next** button and enter the high values as shown below.



Click **Next** the following window will be displayed showing the calibrated SYS value which is dependent on the current input values.

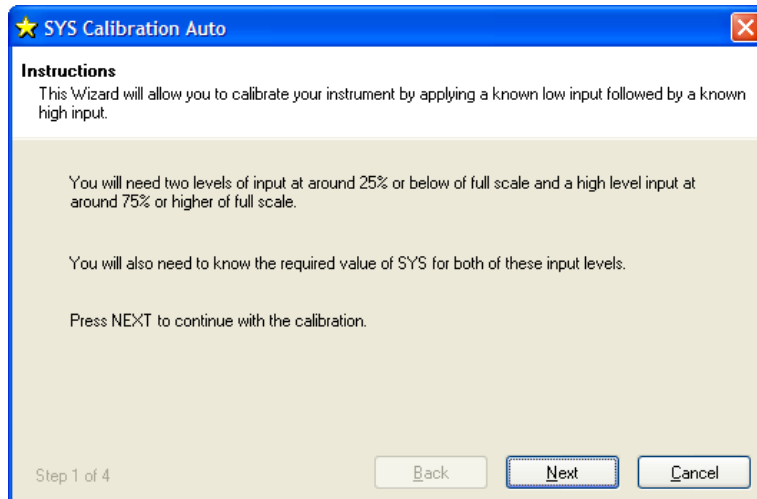




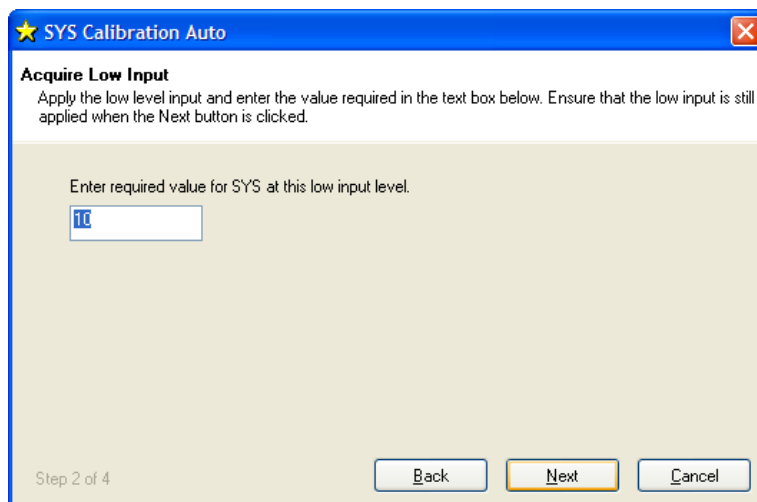
The device is now calibrated. However you may find SYS has been 'clamped' if the resultant SYS is greater than SMAX or less than SMIN. If this is the case then change these values to suitable limits. In this example we may set SMIN to -0.5 (tonne) and SMAX to 12.0 (tonne). This would then provide clamping of SYS to these values and also a flags being set in FLAG and STAT.

## Sys Calibration, Auto Method

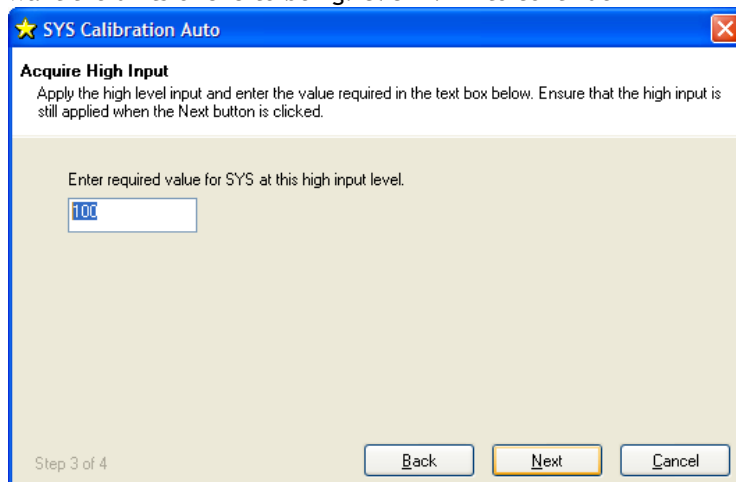
Assume we need to calibrate for kg output and we have available accurate 10 kg and 100 kg test weights. Start the wizard by selecting **Sys Calibration Auto** from the **Wizard** menu



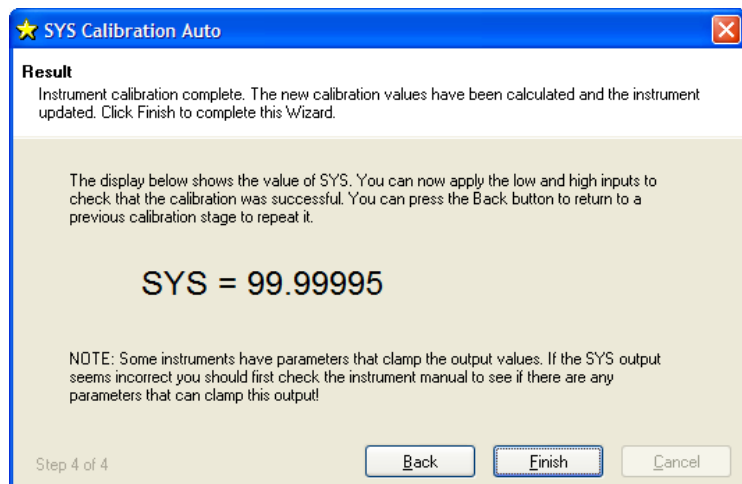
Click Next.



Apply the low known test weight and enter the required SYS value for this weight. In this case it will be 10 as we want the units of SYS to be kg. Click **Next** to continue



Apply the high known test weight and enter the required SYS value for this weight. In this case it will be 100. Click **Next** to continue.



The device is now calibrated. However you may find SYS has been ‘clamped’ if the resultant SYS is greater than SMAX or less than SMIN. If this is the case then change these values to suitable limits. In this example we may set SMIN to -0.5 (Kg) and SMAX to 110.0 (Kg). This would then provide clamping of SYS to these values and also a flags being set in FLAG and STAT.

For detailed information about calibration calculations please refer to chapter 3.

## Chapter 3 Explanation of Category Items

Instrument Explorer shows the categories to which parameters and generated variables belong. This provides a convenient method for describing the functionality and purpose of each. The categories can be seen from Instrument Explorer's Parameter List pane and are as follows.

### Communications

For the ASCII protocol there are **DP** and **DPB** controls which set the format of the ASCII string returned by the device (see Chapter 12).

Care should be taken when changing the station number or baud rate as communications can be lost with the host. Also note that some commands require the reset (**RST**) command to be sent or a power cycle before the new values take effect. **STN**, **BAUD**, **DP** and **DPB** are such commands.

When using Instrument Explorer to change either the **STN** or **BAUD** parameter, communications with the device will be lost after the **RST** command has been issued as the software will be using the previous settings. In this case you need to change the device settings in Instrument Explorer by selecting **Change Settings** from the **Communications** menu.

### Output Format Controls, DP and DPB (ASCII ONLY)

The parameters **DP** and **DPB** are used to control the formatting of floating-point values in the ASCII protocol.

**DP** controls the number of decimal places after the point and **DPB** controls the number of decimal places before the point. Values of 1..8 are appropriate in both cases.

All output values are then transmitted in this same format. As values are limited to a normal 4-byte accuracy, about 7 digits, it may sometimes be necessary to alter the formatting for best accuracy in reading/writing values.

eg. if **DP=5** and **DPB=2**, the value 1.257 is output as '+01.25700'

The new value of **DP** and **DPB** does not take effect until the **RST** command is issued or the device is power cycled.

### Information

The 'Information' heading in the parameter list reports the current version of the device's software and the device's unique serial number. Note that 'VERSION' is the readable item derived from the device's internal value of **VER** and 'SerialNumber' is derived from **SERL** and **SERH**.

### Software Version, VER

The 'VER' parameter (read-only byte) returns a value identifying the software release number, coded as 256\*(major-release) + (minor-release).

eg. current version 3.1 returns VER=769

### Serial Number, SERL and SERH

**SERL** and **SERH** are read-only integer parameters returning the device's serial-number.

This is decoded as = 65536\***SERH** + **SERL**.

The VisualLink/Instrument Explorer drivers include a convenience 'Serial Number' property that automatically calculates this.

### Strain Gauge

This is where the measurement process starts. If the optional temperature module is fitted then **TEMP** will display actual temperature in °C. Otherwise **TEMP** will display 125 °C.

**RATE** is the parameter that selects the measurement cycle update rate.

## ***mV/V output, MVV***

**MVV** is the factory calibrated mV/V output and it is this value that all other measurement output values are derived from. Factory calibration is within 0.05%.

## ***Nominal mV/V level, NMVV***

This is used to represent the nominal mV/V value representing 100% of full scale. This value is used solely for the generation of **ELEC**. It is factory set for 2.5mV/V. If the electronic gain is adjusted by changing the gain resistor then if **ELEC** is used **NMVV** value must be changed to represent the new nominal mV/V.

## ***mV/V Output In Percentage Terms, ELEC***

This is mainly for backwards compatibility with Version 2. It is the mV/V value represented in percentage terms, 100% being the value set by **NMVV**.

## ***Temperature Value, TEMP***

If the optional temperature module **DTEMP** is fitted, then **TEMP** will display actual temperature in °C. Otherwise **TEMP** will display 125 °C. **TEMP** is used by the temperature compensation. See chapter 5

## ***Output Rate Control, RATE***

The **RATE** parameter is used to select the output update rate, according to the following table of values -

| <b>RATE</b> value                 | 0 | 1 | 2 | 3  | 4  | 5  | 6  | 7   | 8   | 9   | 10  |
|-----------------------------------|---|---|---|----|----|----|----|-----|-----|-----|-----|
| update rate (readings per second) | 1 | 2 | 5 | 10 | 20 | 50 | 60 | 100 | 200 | 300 | 500 |

The default rate is 10Hz (**RATE**=3): The other settings give a different speed/accuracy trade-off. Invalid **RATE** values default to 3 (10Hz).

The underlying analogue to digital conversion rate is 4.8kHz. These results are block averaged to produce the required output rate.

### **To Change the Output Rate**

1. Set **RATE** to the new value
2. Click on the '**RST**' button to reboot the device
3. Wait for one second for the reset procedure to complete and measurement cycle to start

With **RATE** set to 0, you should be able to see the **SYS** update rate slow down to once a second and the noise level should also noticeably decrease.

All the main-reading output values are updated at this rate. **Rate** does not change the rate at which temperature output **TEMP** is updated.

## ***Dynamic Filtering, FFST and FFLV***

The Dynamic filter is basically a recursive filter and therefore behaves like an 'RC' circuit. It has two user settings, a level set in mV/V by **FFLV** and the maximum number of steps (up to 255) set by **FFST**.

Instead of outputting every new value, a fraction of the *difference* between the new input value (**RMVV**) and the current filtered value (**MVV**) is added to the current filtered value (**MVV**) to produce the filtering action.

If this difference is less than the value set in **FFLV** then the fractional amount added each time is decremented until it reaches the minimum level set by **FFST** i.e. **FFST** is the *limit* of the divisor.

e.g. if **FFST** = 10 the fractional part of the difference between the new value (**RMVV**) and the current filtered value (**MVV**) will be decremented as follows: 1/1, 1/2, 1/3, 1/4, 1/5, 1/6 . . . 1/10, 1/10, 1/10 before being added to the current filtered value (**MVV**).

If a rapidly changing or step input occurs and the difference between the new input value (**RMVV**) and the current filtered value (**MVV**) is greater than the value set in **FFLV** then the output of the filter will be made equal to the new input reading i.e. the fractional amount of the new reading added to the current reading is reset to 1. This allows the Filter to respond rapidly to fast moving input signals.

When a step change occurs which does not exceed **FFLV**, the new filtered value is calculated as follows:

$$\text{New Filter Output value} = \text{Current Filter Output Value} + ((\text{Input Value} - \text{Current Filter Output Value}) / \text{FFST})$$

The time taken to reach 63% of a step change input (which is less than **FFLV**) is the frequency at which values are passed to the dynamic filter, set in **RATE**, multiplied by **FFST**.

The table below gives an indication of the response to a step input which is less than **FFLV**.  
**Update Rate** = 1/**RATE** see 'Output Rate Control' above.

| % Of Final Value | Time To settle         |
|------------------|------------------------|
| 63%              | Update Rate * FFST     |
| 99%              | Update Rate * FFST * 5 |
| 99.9%            | Update Rate * FFST * 7 |

For example, If **RATE** is set to 7 = 100Hz = 0.01s and **FFST** is set to 30 then the time taken to reach a % of step change value is as follows.

| % Of Final Value | Time To settle              |
|------------------|-----------------------------|
| 63%              | 0.01 x 30 = 0.3 seconds     |
| 99%              | 0.01 x 30 x 5 = 1.5 seconds |
| 99.9%            | 0.01 x 30 x 7 = 2.1 seconds |

The following table shows the number of updates '**x FFST**' and the '**% Error**' that the **Filtered Output value** will differ from the constant **Input Value**.

| x FFST | % Error     |
|--------|-------------|
| 1      | 36.78794412 |
| 2      | 13.53352832 |
| 3      | 4.97870684  |
| 4      | 1.83156389  |
| 5      | 0.67379470  |
| 6      | 0.24787522  |
| 7      | 0.09118820  |
| 8      | 0.03354626  |
| 9      | 0.01234098  |
| 10     | 0.00453999  |
| 11     | 0.00167017  |
| 12     | 0.00061442  |
| 13     | 0.00022603  |
| 14     | 0.00008315  |
| 15     | 0.00003059  |
| 16     | 0.00001125  |
| 17     | 0.00000414  |
| 18     | 0.00000152  |
| 19     | 0.00000056  |
| 20     | 0.00000021  |

Remember: if the step change in mV/V is greater than the value set in **FFLV** then:

**New Filter Output value = New Input Value** i.e. the output jumps to the new input value and the internal working value of **FFST** is reset to 1. This is then incremented each update (set by **RATE**) until it reaches the user set value of **FFST**.

## **Cell**

This is the level where integration between the DSCUSB and the strain gauge bridge takes place (see Chapter 4 for more details).

Features include:

- A 5-point compensation to produce a temperature compensated value **CMVV** when the optional temperature module, D Temp is fitted.
- Scaling, using a gain and offset, **CGAI** and **COFS** respectively, producing the value **CRAW**.
- Linearisation, using up to 7-points, producing the final output from this section known as **CELL**.
- Over load and under load values can be set in **CMIN** & **CMAx** to alert the user to forces outside the intended or safe operating area.

These features allow the output **CELL** to be in force units which can be used by 'System' to convert to units of weight.

Temperature compensation and Linearisation are covered in detail in their own chapters.

### **Temperature Compensation in brief**

When the optional temperature hardware module DTEMP is connected temperature compensation is available.

This facility can remove the need for fitting compensation resistors to strain gauges. The compensation can apply for both gain and offset with up to 5 temperature points.

The input for the temperature compensation is **MVV** and the output from the process is **CMVV**. If no temperature compensation is invoked, **CMVV** is equal to **MVV**

A detailed explanation is given in chapter 5

### **Cell Scaling, CGAI, COFS**

The temperature compensated value **CMVV** is scaled with gain and offset using **CGAI** and **COFS** respectively. The gain is applied first and the offset then subtracted. This would be used to produce a force output in the chosen units, this output being termed **CRAW**.

$$\mathbf{CRAW} = (\mathbf{CMVV} \times \mathbf{CGAI}) - \mathbf{COFS}$$

### **Two Point Calibration Calculations and Examples**

Examples are given here for two point calibration, as this is by far the most common method.

#### **Cell Calibration**

The scaling parameters are **CGAI** and **COFS**

**CGAI** is in cell-units per mV/V'

**COFS** is in cell units

The cell output calculation is (in the absence of temperature and linearity corrections) -

$$\mathbf{CRAW} = (\mathbf{CMVV} \times \mathbf{CGAI}) - \mathbf{COFS}$$

If we have two electrical-output (**MVV**) readings for two known force loads, **fA** and **fB**, we can convert the output to the required range. So if -

$$\text{test load} = fA \rightarrow \mathbf{CMVV} \text{ reading} = cA$$

$$\text{test load} = fB \rightarrow \mathbf{CMVV} \text{ reading} = cB$$

- then calculate the following gain value

$$\mathbf{CGAI} = (fB - fA) / (cB - cA)$$

and the offset is

$$\text{COFS} = (\text{cA} \times \text{CGAI}) - \text{fA}$$

The outputs, CELL should then be the true forces applied.

### **Calibration Methods**

There are a number of ways of establishing the correct control values.

#### **Method 1 - Nominal (data sheet) Performance Values**

This is the simplest method, where the given nominal mV/V sensor output is used to calculate an approximate value for CGAI.

##### **Example.**

A 50 kN load cell has nominal sensitivity of 2.2mV/V full-scale.

To get 50.0 for an input of 2.2mV/V, set CGAI to  $50/2.2 \approx 22.7273$ . This assumes the output for 0kN is 0mV/V.

#### **Method 2 - Device Standard (Calibration) Values**

With some load cells you may have a manufacturer's calibration document. This gives precise cell-output gain and offset specifications for the individual cell. These values can be used to calculate CGAI and COFS.

##### **Example.**

A 10 tonne load cell has a calibration sheet specifying 2.19053mV/V full-scale output, and -0.01573mV/V output offset.

CGAI is set to  $10 / (2.19053 - -0.01573) \approx 4.532557$ .

COFS is set to  $-0.01573 \times 4.532557 \approx -0.0071297$

#### **NOTE:**

Methods 1 and 2 require no load tests. This means that systematic installation errors cannot be removed, such as cells not being mounted exactly vertically. The accuracy is also limited by the DSCUSB electrical calibration accuracy, which is about 0.1%.

The remaining methods require testing with known loads, but are therefore inherently more reliable in practice, as they can remove unexpected complicating factors relating to installation.

#### **Method 3 - Two-Point Calibration Method**

This is a simple in-system calibration procedure, and probably the commonest method in practice (as in the previous example).

Two known loads are applied to the system, and reading results noted, then calibration parameters are set to provide exactly correct readings for these two conditions.

eg. a 10kN (1-tonne) load cell has a CELL reading of +0.120721mV/V with no load, and -2.21854mV/V with a known 100kg test-weight.

To calibrate this to read in a -1.0 to +1.0 tonne range,

Calculate CGAI as  $0.1 / (2.21854 - +0.120721) = 0.047669$ .

Set COFS =  $0.120721 \times 0.047669 = 0.005755$ .

#### **Method 4 - Multi-point Calibration Test**

For ultimate accuracy, a whole series of point measurements may be taken to determine the best linear scaling of input to output: Effectively, a 'best line' through the data is then chosen, and the calibration is set up to follow the line.

Testing of this sort is also used to establish linearity corrections, and similar tests at different temperatures are used to set up temperature compensation (see Chapters on Temperature Compensation and Linearity Compensation).

**Note:** Instrument Explorer provides wizards for easy calibration of the Cell stage. There are two wizards, 'Cell Calibration Auto' and 'Cell Calibration Table', these can be found under the menu item 'Wizards'.



## **Cell Limits, CMIN, CMAX**

These are used to indicate that the desired maximum and minimum value of **CRAW** have been exceeded. They are set in Force units. If **CRAW** exceeds the value set in **CMAX** the **CRAWOR** flag is set in both **FLAG** and **STAT**, the value of **CRAW** is also clamped to this value. If **CRAW** is less than the value set in **CMIN** the **CRAWUR** flag is set in both **FLAG** and **STAT**, the value of **CRAW** is also clamped to this value.

## **Linearisation In Brief**

Linearisation allows for any non-linearity in the strain gauge measurement to be removed. Up to 7 points can be set using **CLN**. The principle of operation is that the table holds a value at which an offset is added. The point in the table that refer to **CRAW** are named **CLX1..CLX7**. The offsets added at these point are named **CLK1.. CLK7** and are set in thousandths of a cell unit. The output from the Linearisation function is **CELL**. If no Linearisation is used (**CLN** < 2) the **CELL** is equal to **CRAW**.

A Detailed explanation is given in chapter 6

## **System**

'System' is where the 'Force' output, **CELL**, is converted to weight when installed into a system (see Chapter 4 for more details). Other features such as **SZ** offers a means of zeroing the system output **SYS**. Peak and Trough values are also recorded against the value of **SYS**, these are volatile and reset on power up. A command **SNAP** records the next **SYS** value and stores in **SYSN**, this is useful where there is more than 1 device in a system and to prevent measurement skew across the system the **SNAP** command can be broadcast to all devices ready for polling their individual **SYSN** values.

## **System Scaling, SGAI, SOFS**

The cell output value **CELL** is scaled with gain and offset using **SGAI** and **SOFS** respectively. The gain is applied first and the offset the subtracted. This would be used to give a force output in the chosen units, this output being termed **SRAW**.

$$\text{SRAW} = (\text{CELL} \times \text{SGAI}) - \text{SOFS}$$

If we have two cell-output (**CELL**) readings for two known test loads, **xA** and **xB**, we can convert the output to the required range. So if -

Test load = **xA** → **CELL** reading = **cA**

Test load = **xB** → **CELL** reading = **cB**

Then we calculate the following gain value

$$\text{SGAI} = (\text{xB} - \text{xA}) / (\text{cB} - \text{cA})$$

And then the offset

$$\text{SOFS} = (\text{cA} \times \text{SGAI}) - \text{xA}$$

**SRAW** now indicates the true load applied.

## **Example of calculations for SGAI and SOFS**

### **Example:**

A 2500kgf load cell installation is to be calibrated by means of test weights.

The cell calibration gives an output in kgf ranging 0-2000.

A system calibration is required to give an output reading in the range 0-1.0 tonnes.

### **Calculations**

Take readings with two known applied loads, such as -

For test load of  $x_A = 99.88\text{Kg}$  : CELL reading  $c_A = 100.0112$

For test load of  $x_B = 500.07\text{Kg}$ : CELL reading  $c_B = 498.7735$

Calculate gain value. In this case put  $SGAI = (x_B - x_A) / (c_B - c_A)$

$$= (0.50007 - 0.09988) / (498.7735 - 100.0112)$$

$$\approx 0.001003580 = 1.003580 \times 10^{-3}$$

Calculate offset value. In this case  $SOFS = (c_A \times SGAI) - x_A$

$$= (100.0112 \times 1.003580 \times 10^{-3}) - 0.09988$$

$$\approx 0.00048924$$

Check

Putting the values back into the equation, results for the two test loads should then be –

For  $x = 99.88\text{Kg}$ , CELL = 100.0112, so

$$SRAW \approx (100.0112 \times 1.003580 \times 10^{-3}) - 0.00048924 \approx 0.09988$$

For  $x = 500.07\text{Kg}$ , CELL = 498.7735, so

$$SRAW \approx (498.7735 \times 1.003580 \times 10^{-3}) - 0.00048924 \approx 0.5006987$$

The remaining errors are due to rounding the parameters to 7 figures.

Internal parameter storage is only accurate to about 7 figures, so errors of about this size can be expected in practice.

### ***System Limits, SMIN, SMAX***

These are used to indicate that the desired maximum and minimum value of **SRAW** have been exceeded. They are set in weight units. On **SRAW** being greater than the value set in **SMAX** the **SRAWOR** flag is set in both **FLAG** and **STAT**, the value of **SRAW** is also clamped to this value. On **SRAW** being less than the value set in **SMIN** the **SRAWUR** flag is set in both **FLAG** and **STAT**, the value of **SRAW** is also clamped to this value.

### ***System Zero, SZ***

**SZ** provides a means of applying a zero to **SYS** and **SOUT**. This could be used to generate a Net value making **SRAW** in effect a gross value.

$$SYS = SRAW - SZ$$

Care should be taken on how often **SZ** is written to, see ‘WARNING: Finite Non-Volatile Memory Life’ later in this chapter.

### ***System Outputs, SYS, SOUT***

**SYS** is considered to be the main output value and it is this value that would be mainly used by the master. **SOUT** is for backwards compatibility with Version 2

### ***Reading Snapshot, SNAP, SYSN***

The action command **SNAP** samples the selected output by copying **SYS** to the special result parameter **SYSN**. The main use of this is where a number of different inputs need to be sampled at the same instant.

Normally, multiple readings are staggered in time because of the need to read back results from separate devices in sequence: By broadcasting a **SNAP** command at the required time, all devices on the bus will sample their inputs within a few milliseconds. The resulting values can then be read back in the normal way from all the devices **SYSN** parameters.

**Note:** Instrument Explorer provides ‘wizards’ for easy calibration of the System stage. There are two wizards, ‘Sys Calibration Auto’ and ‘Sys Calibration Table’ these can be found under the menu item ‘Wizards’.

## Control

### Shunt Calibration Commands, **SCON** and **SCOF**

The Device is fitted with a ‘Shunt’ calibration resistor whose value is 100K. This can be switched across the bridge, using **SCON**, giving an approximate change of 0.8mV/V at nominal 2.5mV/V. The command **SCOF** removes the resistor from across the bridge. It is important for the user to remember to switch out the shunt calibration resistor after calibration has been confirmed.

## Digital I/O

### Digital input

The state of the digital input pin is interrogated via bit 1, IPSTAT, of the Dynamic Status Flags (**STAT**). The digital input is a volt-free contact type (10k pull-up resistor to +5V) and will accept switch or relay contacts etc.

### Digital Output, **OPON** and **OPOF**

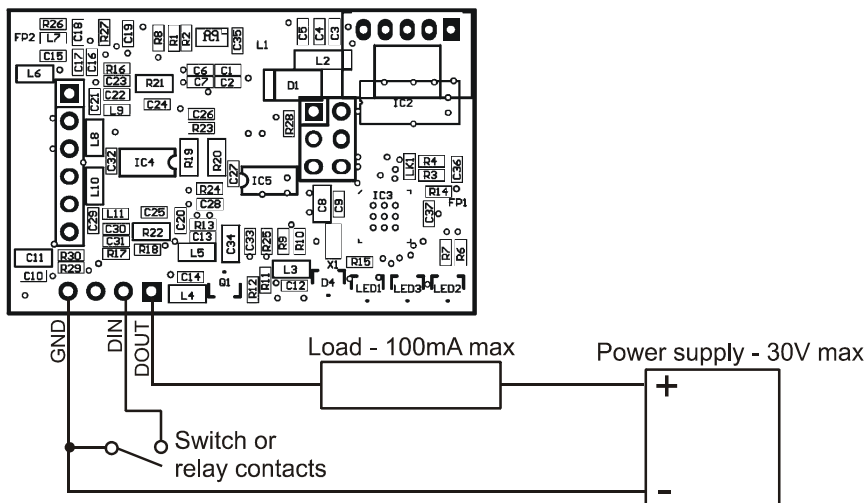
The OEM PCB and OEM Module versions feature a digital input and a digital output. As supplied, the cased version only provides a digital output due to the insufficient number of spare pins on the 9 way ‘D’ type connector. This can be changed to a digital input instead by removing and fitting 0603 surface-mount resistors (see below for details).

The digital output is an open collector transistor rated at 100mA/30V maximum. **Care must be taken to limit the current to this value.**

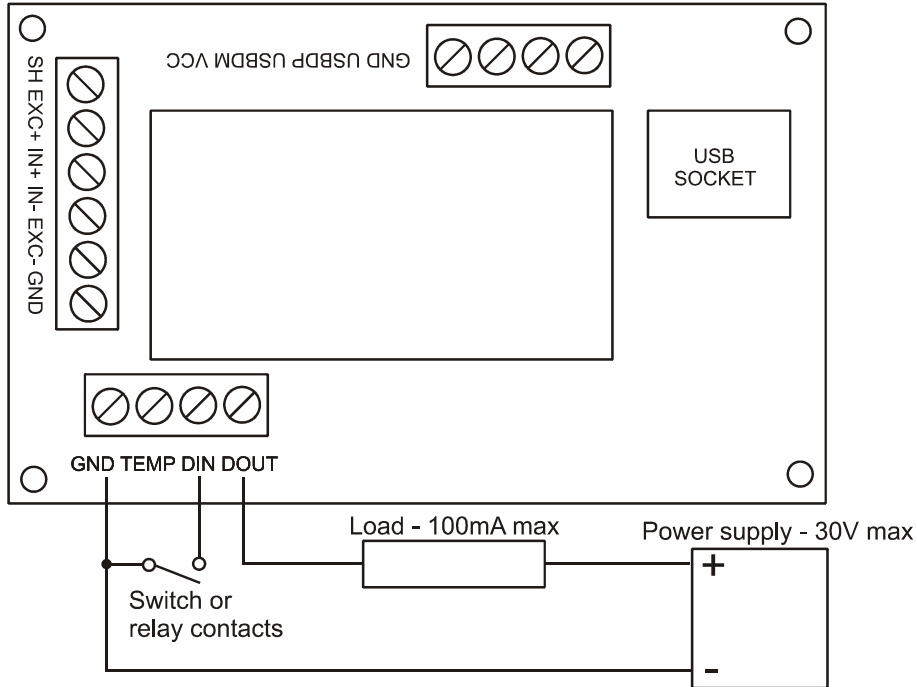
The output can be switched on and off using the commands **OPON** and **OPOF** respectively.

## Digital I/O connection Details

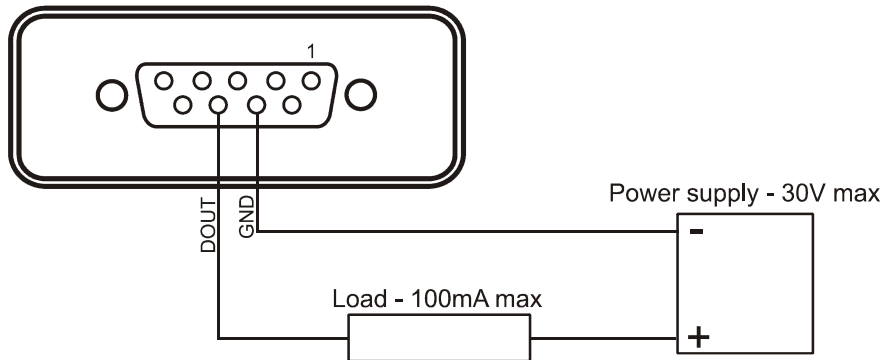
### OEM PCB:



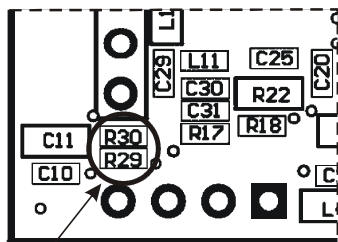
**OEM Module:**



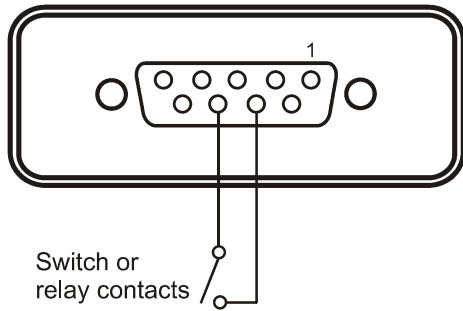
**Cased version Digital Output**



To change the cased version to accept a digital input the PCB must be modified. This requires removing one 0603 SM zero Ohm resistor and re-fitting it in another location. The PCB must be removed from its housing by unscrewing the four screws and withdrawing the PCB from the case. A fine-tipped temperature controlled soldering iron should be used to avoid damage to the PCB and surrounding components:



Remove R30 (zero Ohm link) - re-fit in position R29 or link across R29



## **Flags**

### **Diagnostics Flags, FLAG and STAT**

All the self-diagnostics rely on the **FLAG** & **STAT** parameters, which are 16-bit integer register in which different bits of the value represent different diagnostic warnings. **FLAG** is stored in EEPROM and is therefore non-volatile; **STAT** is stored in RAM and reset on power-up to 0. **FLAG** is latching and needs to be reset by the user whereas **STAT** is non-latching showing the current error status.

### **Latched Warning Flags (FLAG)**

The flags are normally used as follows:-

**FLAG** is read at regular intervals by the host (like the main output value, but generally at longer intervals)

If some warnings are active, i.e. **FLAG** is non-zero, then the host tries to cancel the warnings found by writing

**FLAG= 0**

The host then notes whether the error then either remains (i.e. couldn't be cancelled), or if it disappears, or if it re-occurs within a short time, and will take action accordingly.

The warning flags are generally latched indicators of transient error events: by resetting the register, the host both signals that it has seen the warning, and readies the system to detect any re-occurrence (i.e. it resets the latch).

What the host should actually do with warnings depends on the type and the application: sometimes a complete log is kept, sometimes no checking at all is needed.

Often, some warnings can be ignored unless they recur within a short time.

Warning flags survive power-down, i.e. they are backed up in non-volatile (EEPROM) storage.

Though useful, this means that repeatedly cancelling errors which then shortly recur can wear out the device's non-volatile storage - see Chapter 3 Basic Set-up and Calibration.

## Meaning and Operation of Flags

The various bits in the FLAG value are as follows

| Bit | Value | Description                         | Name    |
|-----|-------|-------------------------------------|---------|
| 0   | 1     | (unused - reserved)                 | Unused  |
| 1   | 2     | (unused - reserved)                 | Unused  |
| 2   | 4     | Temperature under range ( TEMP)     | TEMPUR  |
| 3   | 8     | Temperature over-range (TEMP)       | TEMPOR  |
| 4   | 16    | Strain gauge input under-range      | ECOMUR  |
| 5   | 32    | Strain gauge input over-range       | ECOMOR  |
| 6   | 64    | Cell under-range (CRAW)             | CRAWUR  |
| 7   | 128   | Cell over-range (CRAW)              | CRAWOR  |
| 8   | 256   | System under-range (SRAW)           | SYSUR   |
| 9   | 512   | System over-range (SRAW)            | SYSOR   |
| 10  | 1024  | (unused - reserved)                 | Unused  |
| 11  | 2048  | Load Cell Integrity Error (LCINTEG) | LCINTEG |
| 12  | 4096  | Watchdog Reset                      | WDRST   |
| 11  | 8192  | (unused - reserved)                 | Unused  |
| 14  | 16384 | Brown-Out Reset                     | BRWNOUT |
| 15  | 32768 | Reboot warning (Normal Power up)    | REBOOT  |

### NOTE:

The mnemonic names are used by convenience properties in Instrument Explorer, but are otherwise for reference only -the flags can only be accessed via the FLAG parameter.

The various warning flags have the following meanings

**TEMPUR** and **TEMPOR** indicate temperature under and over-range. The temperature minimum and maximum settings are part of the temperature calibration, fixed at -50.0 and +90.0 °C. These flags are only active when the optional temperature module, DTEMP is fitted.

**ECOMUR** and **ECOMOR** are the basic electrical output range warnings. These are tripped when the electrical reading goes outside fixed  $\pm 120\%$  limits: This indicates a possible overload of the input circuitry, i.e. the input is too big to measure.

The tested value, ECOM is an un-filtered precursor of ELEC

**CRAWUR** and **CRAWOR** are the cell output range warnings. These are tripped when the cell value goes outside programmable limits CMIN or CMAX.

The tested value, CRAW is the cell output prior to linearity compensation.

**SYSUR** and **SYSOR** are the system output range warnings. These are triggered if the SYS value goes outside the SMIN or SMAX limits.

**LCINTEG** indicates a missing or a problem with the Load cell. It is based on the common mode of the -SIG being correct. NOTE: this flag will also be set when the shunt calibration has been switched on.

**WDRST** indicates that the Watchdog has caused the device to re-boot. If this error continually occurs consult the factory.

**BRWNOUT** indicates that the device has re-booted due to the supply voltage falling below 4.1V, the minimum spec for supply voltage is 5.6V and this must include any troughs in the AC element of this supply.

**REBOOT** is set whenever the DSCUSB is powered up and is normal for a power up condition. This flag can be used to warn of power loss to device.

## Dynamic Status Flags (STAT)

Status flags are 'live' flags, indicating current status of the device. Some of these flags have the same bit value & description as 'FLAG'.

### Meaning and Operation of Flags

The various bits in the STAT value are as follows

| Bit | Value | Description                          | Name    |
|-----|-------|--------------------------------------|---------|
| 0   | 1     | Setpoint output status               | SPSTAT  |
| 1   | 2     | Digital Input status                 | IPSTAT  |
| 2   | 4     | Temperature under range (TEMP)       | TEMPUR  |
| 3   | 8     | Temperature over-range (TEMP)        | TEMPOR  |
| 4   | 16    | Strain gauge input under-range       | ECOMUR  |
| 5   | 32    | Strain gauge input over-range        | ECOMOR  |
| 6   | 64    | Cell under-range (CRAW)              | CRAWUR  |
| 7   | 128   | Cell over-range (CRAW)               | CRAWOR  |
| 8   | 256   | System under-range (SRAW)            | SYSUR   |
| 9   | 512   | System over-range (SRAW)             | SYSOR   |
| 10  | 1024  | (unused - reserved)                  | Unused  |
| 11  | 2048  | Load Cell Integrity Error (LCINTEG)  | LCINTEG |
| 12  | 4096  | Shunt Calibration Resistor ON        | SCALON  |
| 11  | 8192  | Stale output value (previously read) | OLDVAL  |
| 14  | 16384 | (unused - reserved)                  | Unused  |
| 15  | 32768 | (unused - reserved)                  | Unused  |

SPSTAT indicates the state of the Open collector output, 1 being output on, 0 being output off.

IPSTAT indicates the state of the digital input. If the bit is set it indicates input is 'closed' to 0V (-V or GND).

**SCALON** Used to indicate that the Shunt Calibration command, **SCON**, has been issued & therefore the shuntcal resistor is now in circuit with the strain gauge bridge. **SCOF** command resets this bit. Note that when Shunt Calibration is active the 'Load Cell Integrity Error' will also be generated.

**OLDVAL** is set when the device is read via the communications. Thus indicating this value has already been sampled. It is reset when a new result has been made available.

### Output Update Tracking

The **OLDVAL** flag can be used for output update tracking

This allows sampling each result exactly once: To achieve this poll, the **STAT** value until **OLDVAL** is cleared to indicate a new output is ready, then read **SYS**, this reading will set the **OLDVAL** flag in **STAT**.

This scheme works as long as the communications speed is fast enough to keep up. With faster update rates and slower baud rates, it may not be possible to read out the data fast enough.

## User Storage

### USR1...USR9

There are nine storage locations **USR1** to **USR9**. These are floating point numbers which can be used for storage of data. This data could be calibration time and date, operator number, customer number etc.

This data is not used in any way by the DSCUSB.

## **Reset**

### ***The Reset command, RST***

This command is used to reset the device. This command **MUST** be issued if the following parameters are changed before the change will take effect: **RATE, STN, BAUD, DP & DPB**. Alternatively the power maybe cycled.

The reset action may take up to about a second to take effect, followed by the normal start-up pause of 1 second.

### ***WARNING: Finite Non-Volatile Memory Life***

The DSCUSB uses EEPROM-type memory as the storage for non-volatile controls (i.e. all the settings that are retained even when powered down).

The device EEPROM itself is specified for 100,000 write cycles (for any one storage location), although typically this is 1,000,000. Therefore -

When automatic procedures may write to stored control parameters, it is important to make sure this does not happen too frequently.

So you should not, for example, *on a regular basis* adjust an offset calibration parameter to zero the output value. However, it *is* reasonable to use this if the zeroing process is initiated by the operator, and won't normally be used repeatedly.

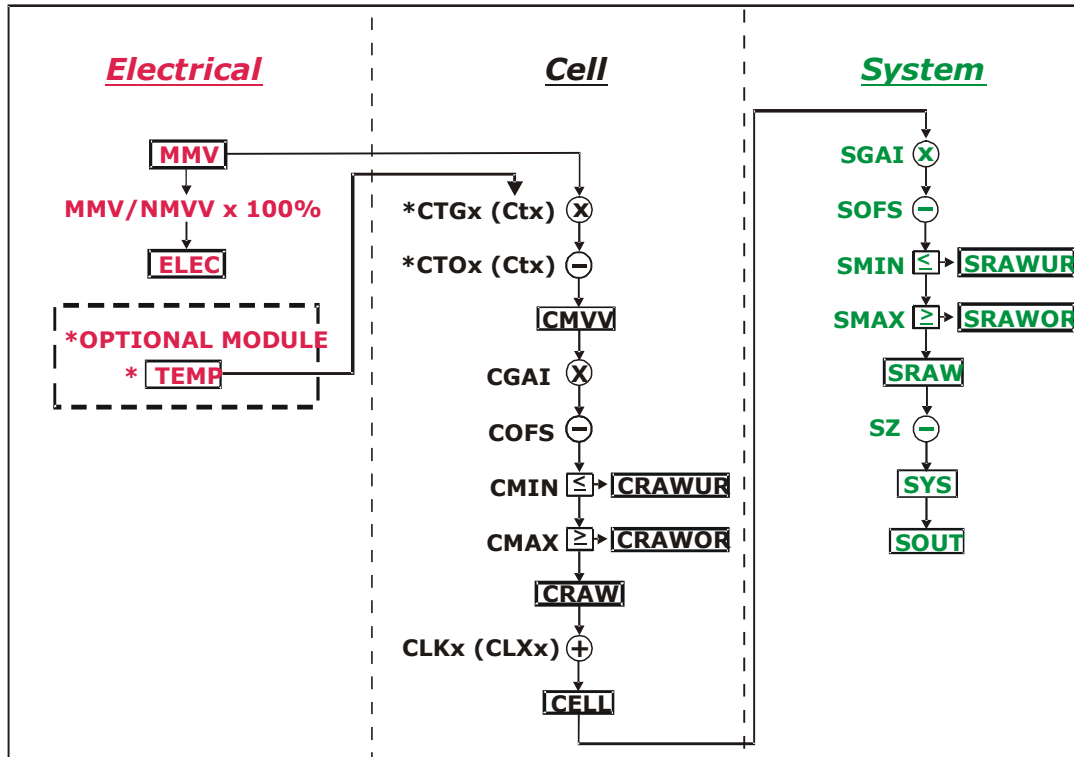
For the same reason, automatically cancelling warning flags must also be implemented with caution: It is okay as long as you are not getting an error recurring *repeatedly*, and resetting it every few seconds.



## Chapter 4 The Reading Process

This chapter gives an account of the reading process *except* for the linearity-and temperature-compensation processes (which have their own chapters later on).

### Flow diagram



The underlying analogue to digital conversion rate is 4.8kHz. These results are block averaged to produce the required output rate set by the **RATE** control. This block averaged result is then passed through the dynamic filter at the same rate and then into the 'chain' of above calculations.

The named values shown in the boxes are all output parameters, which can be read back over the comms link. The diagram shows *three separate calibration stages*, called the 'Electrical', 'Cell' and 'System'. This allows independent calibrations to be stored for the device itself, the load cell and the installed system characteristics -

#### Electrical

The 'Electrical' calibration produces corrected electrical readings from the internal measurements. This is factory-set by Mantracourt during the production process.

The main outputs from this are:

- **MMV** is the factory calibrated output, in mV/V units.
- **ELEC** is the mV/V in % terms. Where the 100% value is set using **NMMV**. This is for backwards compatibility only.
- **TEMP** is a device temperature measurement, in °C and requires an optional module.

There are also two flags, **ECOMUR** and **ECOMOR** (not shown on the diagram), which indicate an input electrical under or over-range.

## Cell

The 'Cell' calibration converts the mV/V output into a cell-force reading.

This can be used by an OEM sensor manufacturer to provide a standard, calibrated output in force units, which could be based on either typical or device-specific calibration data.

(This stage also includes the temperature and linearity-corrections, not covered here)

The outputs from this are:

- **CMVV** is the temperature compensated mV/V (**MVV**).
- **CRAW** is the scaled temperature compensated value **CMVV**
- **CELL** is a load cell force reading in 'Force' units (e.g. kN)
- **CRAWUR** and **CRAWOR** are two flags indicating under or, over range for the force measurement.

## System

The 'System' calibration converts the Cell output into a final output value, in the required engineering units.

This is normally be set up by a systems installer or end user, to provide whatever kind of output is needed, independently of device-specific information in the Cell calibration.

(Making this split allows in-service replacement without re calibration).

The outputs from this are:

- **SRAW** is a re-scaled and offset adjusted output derived from **CELL**
- **SYS** is the final output value, after removing a final user output offset value (**SZ**) from **SRAW**
- **SRAWUR** and **SRAWOR** are output warning limit flags.

In practice, **SRAW** and **SYS** can be used to represent something like gross and net values.

## Cell and System Scaling

Both the Cell and System calibrations are simply linear rescaling calculations -i.e. they apply a gain and offset.

In both cases, four parameters define the scaling, offset and min and max limit values. These calculations are applied in the following way:

Output = (Input × **GAI**) - **OFS**

Output = min (output, **MAX**)

Output = max (output, **MIN**)

(In addition, if the value exceeds either limit, one of two dedicated error flags is set)

The control parameters thus have the following characteristics: -

- **GAI** is the multiplying factor, set in 'output-units per input-unit'
- **OFS** is the value that gives zero output, set in 'output units'
- **MAX** and **MIN** are output limit values, set in 'output units'

The units and functions of the main scaling controls can thus be summarised as -

### Cell Calibration

|      |            |                               |
|------|------------|-------------------------------|
| CGAI | Force/mV/V | mV/V gain factor              |
| COFS | Force      | <b>CELL</b> Offset Value      |
| CMIN | Force      | Minimum value for <b>CRAW</b> |
| CMAX | Force      | Maximum value for <b>CRAW</b> |

### System Calibration

|      |            |                               |
|------|------------|-------------------------------|
| SGAI | Eng/ Force | <b>SYS/CELL</b> gain factor   |
| SOFS | Eng        | <b>SRAW</b> value offset      |
| SMIN | Eng        | Minimum value for <b>SRAW</b> |
| SMAX | Eng        | Maximum value for <b>SRAW</b> |
| SZ   | Eng        | <b>SYS</b> value offset       |

(**MVV** is mV/V, 'Force' is force units, and 'Eng' is engineering units)

## Calibration Parameters Summary and Defaults

The various control parameters are listed for each stage.

This also includes the compensation parameters, not covered in this chapter, but shown in the flow diagram

The 'Default' values shown set the device back to its nominal default calibration (mV/V)

### Cell Control Defaults

| Command | Action                     | Default Values        |
|---------|----------------------------|-----------------------|
| FFLV    | Filter dynamic level       | 0.001                 |
| FFST    | Filter Steps (max)         | 100                   |
| NMMV    | Nominal 2.5mV/V            | 2.5                   |
| RATE    | Rate 10Hz                  | 3                     |
| CGAI    | basic cell gain            | 1.0                   |
| COFS    | basic cell offset          | 0.0                   |
| CTN     | number of temp points      | 0                     |
| CT1..5  | temp points (Deg C)        | 0.0, 0.0, 0,0...      |
| CTO1..5 | offset adjusts             | 0.0, 0.0, 0,0...      |
| CTG1..5 | gain adjusts               | 1.0, 1.0, 1.0, 1.0... |
| CMIN    | <b>CRAW</b> min limit      | -3.0                  |
| CMAX    | <b>CRAW</b> max limit      | +3.0                  |
| CLN     | number of linearity points | 0                     |
| CLX1..7 | linearity raw-value points | 0.0, 0.0, 0,0...      |
| CLK1..7 | linearity adjusts          | 0.0, 0.0, 0,0...      |

### System Control Defaults

| Command | Action                | Default Values |
|---------|-----------------------|----------------|
| SGAI    | basic gain            | 1.0            |
| SOFS    | basic offset          | 0.0            |
| SMIN    | <b>SRAW</b> min limit | -100.0         |
| SMAX    | <b>SRAW</b> max limit | +100.0         |
| SZ      | output zero offset    | 0.0            |

## Chapter 5 Temperature Compensation

This chapter explains how to use the Temperature Compensation facilities, to compensate for changes in the measurement with ambient temperature.

Temperature compensation is only provided when an optional module (DTEMP) comprising a digital temperature sensor is wired to the DSCUSB.

### Purpose and Method of Temperature Compensation

Most measurement methods are affected by changes in temperature, and (uncompensated) load cells are especially sensitive, having a large overall temperature coefficient.

Temperature compensation adjusts the measured value in a way that depends on a temperature measurement, so that (ideally) the output is independent of the current temperature.

In practice, it is usual to refer to a calibration 'reference' temperature: The ideal output value is then what the reading 'would have been' if made at the reference temperature.

The DSCUSB temperature compensation facilities make adjustments to the 'Cell' calibration parameters (i.e. gain and offset) which depend on temperature, according to a digitally programmed curve.

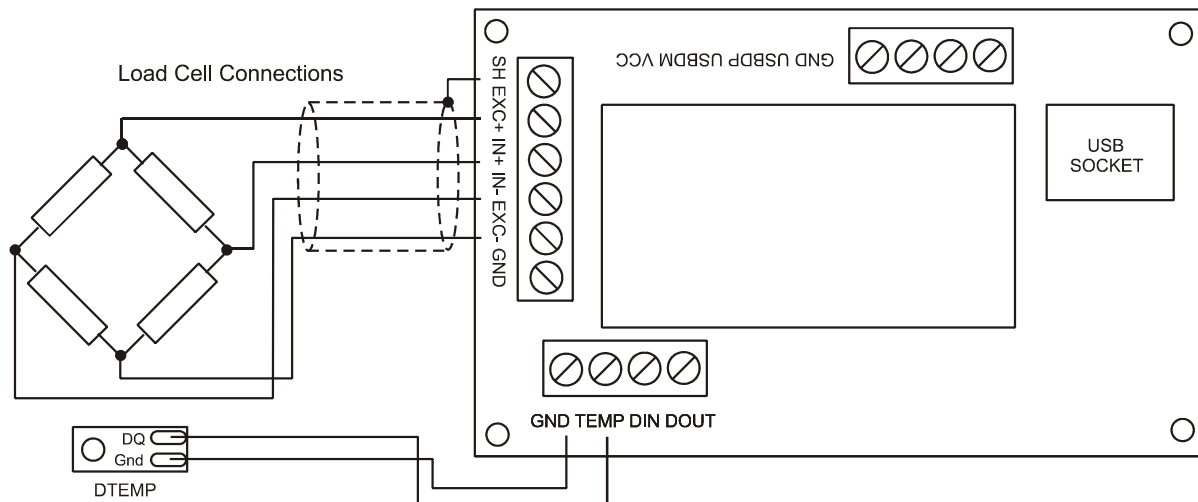
These adjustments are automatically applied, based on the current device temperature measurement. With some care, this can remove the need for the usual electrical compensation components altogether.

Note that the temperature compensation will also remove the temperature drift of the DSCUSB itself if the temperature compensation data is collected when the DSCUSB and strain gauges are tested together as a system.

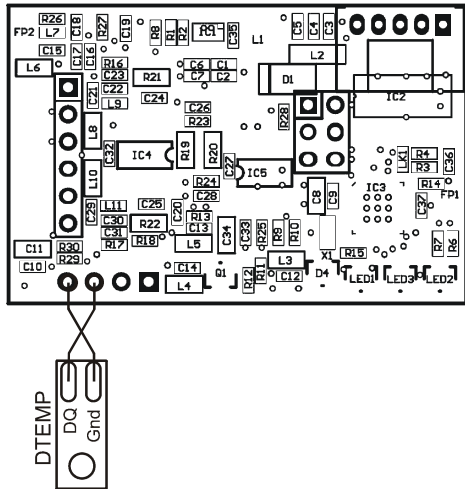
### Temperature Module Connections and Mounting (DTEMP)

The temperature module is connected using only two wires. The temperature sensor is the Dallas '1-Wire' digital device DS18S20. One connection is ground, the other is the 1 wire 'DQ' connection which provides the bi-directional data line.

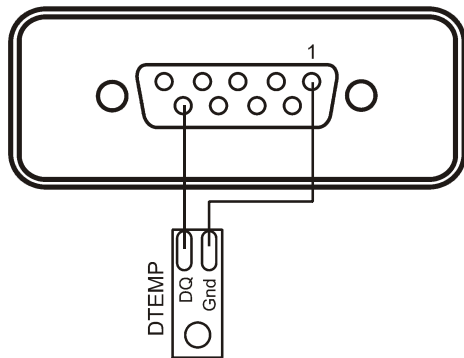
#### OEM Module DTEMP Connections:



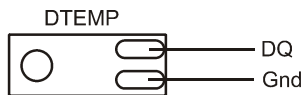
## OEM PCB DTEMP Connections:



## Cased Version DTEMP Connections:



The temperature module is a small double sided PCB with an 8 pin SOIC integrated circuit mounted to it. The dimensions are 10.5 x 7.6 x 2.5mm (0.413 x 0.299 x 0.098"). There are two solder pads for connection to the DSCUSB. A 2mm hole is used for fixing the temperature module to the body of the load cell. The module should, ideally, be positioned as close as possible to the strain gauges. The IC on the temperature module must also be in good thermal contact with the load cell body so the strain gauges and temperature sensor see the same temperature.



## Control Parameters

The temperature compensation parameters define a pair of lookup tables that contain adjustments to the cell calibration gain and offset over temperature.

The parameters concerned are the following:

|             |      |                                                                  |
|-------------|------|------------------------------------------------------------------|
| CTN         | [-]  | Number of temperature table points                               |
| CT1...CT5   | [°C] | Indicated TEMP value at table point N                            |
| CTO1...CTO5 | mV/V | MV/V ( $\times 10^4$ ) Offset adjustment at Offset table point N |
| CTG1...CTG5 | ppm  | Gain ( $\times 10^6$ ) at Gain table point N                     |

CTN sets the number of points in the gain & offset tables. A CTN value of less than two effectively switches off temperature compensation. The maximum number of point is 5, values greater than 5 reset CTN to 0 switching off temperature compensation.

CT1 to CT5 sets the temperature in °C of the correction points. The table must be filled from CT1 up to & including CT(CTN) and must be entered in order of increasing temperature value.

CTO1 to CTO5 provide the offset adjustment in mV/V x10<sup>4</sup>. The reason for the multiplication is due to the limitation set by the ASCII protocol of only being able to enter up to 6 decimal places. The CTOx value is subtracted from the uncompensated value.

CTG1 to CTG5 provide the gain adjustment in ppm terms. The actual gain value used is calculated as  $1 + CTG_n \times 10^{-6}$

## ***Internal Calculation***

The temperature compensation calculation is described as follows:-

The GAIN correction is applied first. The current measured temperature is checked against the table values CT1 to CT(CTN) to establish an index value if the measured temperature is below that of CT1 then CT1 is used as the index, If the temperature is above CT(CTN-1) then CT(CTN-1) is used.

This can be represented as follows:-

A working table index, i, is derived from the current measured temperature, T, as follows: –

(n = number of points used, as set by CTN)

When (T < CT1) then i = 1

When (T > CTn-1) then i = (n-1)

Otherwise i is chosen so that  $T_i \leq T \leq T_{i+1}$

Once an index into the table has been established the gain value to be used is extrapolated between the index value and the value above. If the temperature is above CT(CTN) or below CT1 then the calculated temperature gain value is extrapolated from CT(CTN-1) to CT(CTN) or CT1 to CT2 respectively.

This can be represented mathematically as follows:-

$$\text{CALC\_CTG} = \text{CTG}_i + (\text{CTG}_{i+1} - \text{CTG}_i) \times (T - \text{CT}_i) / (\text{CT}_{i+1} - \text{CT}_i)$$

The actual gain value used is  $1 + \text{CALC\_CTGO} \times 10^{-6}$  and is multiplied by the uncompensated value MVV.

The offset correction is then applied using the same temperature index ‘i’ as found for the GAIN index above.

The Offset value is extrapolated between the same two temperature points.

This can be represented mathematically as follows:-

$$\text{CALC\_CTO} = \text{CTO}_i + (\text{CTO}_{i+1} - \text{CTO}_i) \times (T - \text{CT}_i) / (\text{CT}_{i+1} - \text{CT}_i)$$

The actual offset value used is  $\text{CALC\_CTO} \times 10^{-4}$  and is subtracted from the above gain adjusted value.

The output from the temperature compensation (CMVV) is then calculated as

$$\text{CMVV} = \text{MVV} \times (1 + \text{CALC\_CTGO} \times 10^{-6}) - (\text{CALC\_CTO} \times 10^{-4})$$

## ***The Temperature Measurement***

The temperature sensor used is a Dallas (MAXIM) DS18S20 Digital Thermometer using the ‘1-Wire’ bus technology. This gives a temperature measurement accuracy of +/-0.5°C over the temperature range -10 to +85°C and +/-2.0°C over temp range -55 to +125°C. The resolution of the measurement is 0.0625°C. The temperature is sampled and the TEMP variable updated every 5 seconds.

## ***How to Set Up a Temperature Compensation***

There are a number of ways of obtaining a temperature compensation curve.

The best possible compensation for a given piece of physical hardware can only be achieved by performing experiments on that particular unit (DSCUSB and associated strain gauges), to characterise the measurement output at a variety of different, stable temperatures in the required operating range.

The basic choice of methods depends on trading off ideal accuracy against the complexity of the calibration procedure.

### **Method 1**

Apply a simple linear drift correction (i.e. for known constant gain and offset changes per degree), by specifying zero correction at the calibration temperature, and appropriately adjusted correction values at extreme temperatures above and below this.

This can be used when the measurement or sensor has known temperature coefficients.

### **Method 2**

Where the temperature characteristics of the measurement are known, but not linear, a similar scheme to Method 1 can be used, with a multi-point table defining an approximation to the known, ideal temperature curves of offset and gain variations.

**NOTE:** Both of the above methods are based on ‘known’ characteristics, which could come from datasheets but these methods would not compensate for the DSCUSB.

### **Method 3**

Do a series of measurements at different temperatures and install the appropriate correction values to give exactly correct results at those same temperatures -i.e. calculate ideal gain and offset corrections at the tested temperatures.

*(This method is the most common).* There is a ‘wizard’ available in Instrument Explorer which will enable this method to be easily completed by calculating the gain and offset corrections for you.

### **Method 4**

Use a set of test results to plan a ‘best correction’ curve (not necessarily perfect at test temperatures, but slightly better overall).

### **NOTES:**

All of these methods can be applied *either* to data from individual devices *or* to an ‘average’ correction for a particular type of sensor hardware.

During testing, temperatures should be measured using the internal TEMP measurement, as this is the measurement used to do the corrections.

For in-system tests, the environment of the DSCUSB must always be as near as possible to the exact conditions of the eventual in-system use.

## ***Parameter Calculations***

Instrument Explorer provides a ‘Wizard’ for the calculation of the parameters required by the DSCUSB. This is based on Method 3 where data is collected. The wizard allows for small changes in the sampled temperature point that may occur when taking a set of results for gain and offset. Also taken into account is any variation in the test weights at different temperatures. This is a complex mathematical procedure which is best solved by a PC programme such as the wizard.

## Chapter 6 Linearity Compensation

This chapter describes the Linearity Compensation features and how to use them.

### Purpose and Method of Linearisation

Load cell sensor outputs are never precisely proportional to the input (applied load).

If the graph of the measurement output against the true value shows slight deviations from the ideal straight-line, then slight errors remain even when the basic calibration (offset and gain) is as good as possible.

Linearity compensation adjusts the raw measurement by a small amount that is calculated as a function of the raw measurement value itself. Ideally this will adjust the output response, for any given input load, by exactly the right amount to place the final result onto the ideal straight line.

The DSCUSB non-linearity compensation uses a single 'lookup table', similar to those used for temperature compensation (see previous chapter). This provides a linearly-interpolated compensating value with up to 7 control points, which is then added to the output result.

Generally, linearisation is a finer level of compensation than temperature compensation.

It should only be applied after the basic Cell calibration and temperature compensation (if any) have been set up. Although the tests are generally simpler than testing over temperature, the accuracy requirement is often greater. See below for notes of possible difficulties to be avoided.

### Control Parameters

Refer to Chapter 9 for command numbers

The lookup table (based on parameters **CLXi**, **CLKi**) defines an offset adjustment based on the **CRAW** value, which is then added in to give the final **CELL** output.

(N.B. linearity correction is applied after any temperature compensation.)

#### The Parameters Involved Are :

|                |                                                             |
|----------------|-------------------------------------------------------------|
| <b>CLN</b>     | Sets the number of linearisation points (from 2 up to 7)    |
| <b>CLX1..7</b> | Raw input ( <b>CRAW</b> ) value points                      |
| <b>CLK1..7</b> | Output ( <b>CELL</b> ) adjustments to apply at these points |

#### They are used like this:

- The number of calibration points is set by CLN (from 2 up to 7)
- Raw input value points are set by CLX1, CLX2 .. CLX7 (or up to the number set by CLN)  
These *must* be arranged in order of increasing input value.
- The output corrections at these points are set by CLK1, CLK2 .. CLK7
- **Corrections are specified in 'thousandths of a cell unit'** i.e. a CLKi value of 1.0 actually adds 0.001 to the CELL output. This due to a limitation in the ASCII conversion to floating point numbers.

### Internal Calculation

This uses the same basic 'interpolated table lookup' method as for temperature compensation.

First, a working table index, *i*, is derived from the current raw input **CRAW**=*x*, as follows :

(*n* = number of points used, as set by **CLN**)

When (*x* < CLX<sub>1</sub>)      then *i* = 1

When (*x* > CLX<sub>*n*-1</sub>)      then *i* = (*n*-1)

Otherwise      *i* is chosen so that CLX<sub>*i*</sub> ≤ *x* ≤ CLX<sub>*i*+1</sub>

The resulting interpolated adjustment value is then calculated as -

$$\text{ofs} = \text{CLK}_i + (\text{CLK}_{i+1} - \text{CLK}_i) \times (x - \text{CLX}_i) / (\text{CLX}_{i+1} - \text{CLX}_i)$$

The compensated cell value is then calculated as:-

$$\text{CELL} = \text{CRAW} + \text{ofs}$$



## How to Set Up Linearity Compensation

A linearity correction can be set up either from sensor specification, calibration data, or more commonly from in-system testing results.

Assuming we do not have any prior information on linearity errors, the usual approach is to do a series of controlled tests with accurately known test loads.

Just as with temperature compensation, it is possible to obtain a detailed graph of linearity error and then choose a 'best-fit' piecewise linear curve for the compensation table.

However, it is generally good enough, and much simpler, to simply test at several different points and then apply an exact correction at those points. If the error curve is reasonably smooth, this should give exact results at the test points, and reasonably accurate values in between.

### NOTES:

Linearisation tests should only be done *after* the cell calibration is set, because the correction values are dependent on the cell calibration.

Similarly, linearisation testing should only be done at the calibration 'reference' temperature, or after temperature compensation is installed, to avoid temperature effects from distorting the results.

The linearisation tests should not reveal any significant remaining linear trend in the errors.

If errors do appear to lie on a definite line, this could drastically reduce the accuracy of the correction.

If this does happen, it shows that the cell calibration is wrong and should be redone.

The table points must always cover more-or-less the whole range of output values to be used, because corrections are extrapolated outward beyond the first and last points.

It is always worthwhile including more test-points than will be used in the correction table, because this gives confidence that no regions of rapidly changing error have been missed.

Tests should be done both with steadily increasing *and* decreasing load values, as hysteresis effects (for load cells) are often of a similar size to non-linearities.

## Parameter Calculations and Example

Based on the simple method outlined above, we suppose that we have obtained test results for a series of precisely known load values -

test loads  $X_i$  give readings of CRAW =  $C_i$ , for ( $i = 1..n$ )

Then calculate the errors that need to be removed at these points -

$$E_i = X_i - C_i$$

Now just enter these values into the correction table, remembering to scale the errors -

$$CLN = n$$

$$CLX_i = X_i$$

$$CLK_i = 1000 \cdot E_i$$

### Example

Suppose we have a load cell and Cell calibration giving a result in the range 0-500 kgF.

The following test results were obtained using a series of known test loads -

For test load of  $x_1 = 0\text{kg}$  : CELL reading  $c_1 = 0.0010$

For test load of  $x_2 = 100.13\text{kg}$  : CELL reading  $c_2 = 100.44$

For test load of  $x_3 = 199.72\text{kg}$  : CELL reading  $c_3 = 200.57$

For test load of  $x_4 = 349.97\text{kg}$  : CELL reading  $c_4 = 349.75$

For test load of  $x_5 = 450.03\text{kg}$  : CELL reading  $c_5 = 449.98$

We choose these precise test points as our linearisation reference points, so

$$CLN = 5$$

$$CLX_1 = 0.0010$$

$$CLX_2 = 100.44$$

$$CLX_3 = 200.57$$

$$CLX_4 = 349.75$$

CLX5 = 449.98

(Note that these are the raw reading values, not the known true values.)

Now calculate all the residual errors, and set up the correction factors -

$$\text{CLK1} = 10^3 \times (x_1 - c_1) \approx 1000 \times (000.00 - 0.0010) = -1.0$$

$$\text{CLK2} = 10^3 \times (x_2 - c_2) \approx 1000 \times (100.13 - 100.44) = -310.0$$

$$\text{CLK3} = 10^3 \times (x_3 - c_3) \approx 1000 \times (199.72 - 200.57) = -850.0$$

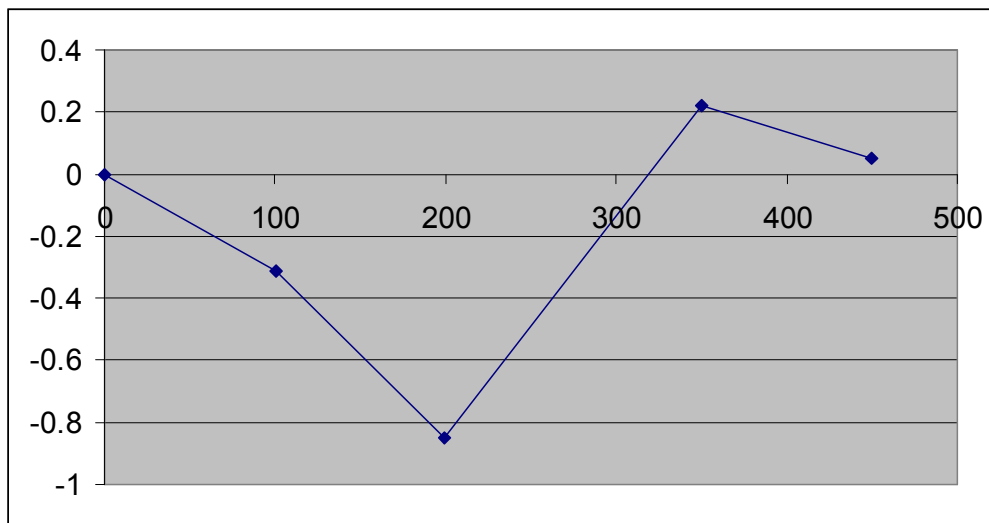
$$\text{CLK4} = 10^3 \times (x_4 - c_4) \approx 1000 \times (349.97 - 349.75) = +220.0$$

$$\text{CLK5} = 10^3 \times (x_5 - c_5) \approx 1000 \times (450.03 - 449.98) = +320.0$$

The CELL output values will now have the required values at all these 5 points.

**Note on the example:**

If you graph the errors from the above example, the results look like this



This doesn't show any very definite linear trend, so the calibration is okay.

However there *is* a big jump between points 3 and 4, which might be worth a more detailed investigation: Some important features of the error curve could have been missed by the test.

# Chapter 7 Self-Diagnostics

## Diagnostics Flags

The main diagnostics facilities are by means of the flags. See ‘Flags’ in chapter 3 for a full description of the flags and their meaning.

The flags are normally used in the following way:

**FLAG** is read at regular intervals by the host (like the main output value, but generally at longer intervals).

If some warnings are active, i.e. **FLAG** is non-zero, then the host tries to cancel the warnings found by writing **FLAG= 0**

The host then notes whether the error then either remains (i.e. couldn’t be cancelled), or if it disappears, or if it re-occurs within a short time, and will take action accordingly.

The warning flags are latched indicators of transient error events. By resetting the register, the host both signals that it has seen the warning, and readies the system to detect any re-occurrence (i.e. it resets the latch).

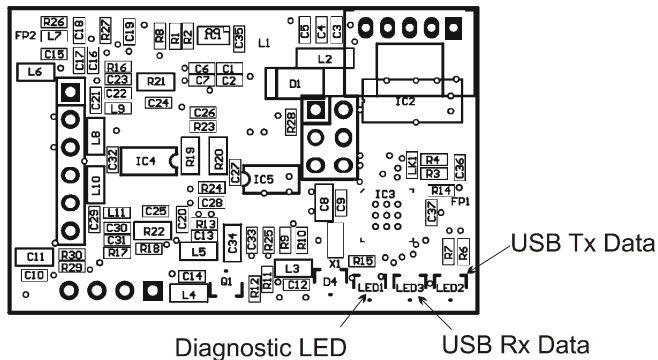
What the host should actually do with warnings depends on the type and the application: Sometimes a complete log is kept; sometimes no checking at all is needed.

Often, some warnings can be ignored unless they recur within a short time.

Warning flags survive power-down, i.e. they are backed up in non-volatile (EEPROM) storage.

Though useful, this means that repeatedly cancelling errors which then shortly re-occur can wear out the device’s non-volatile storage - see *WARNING: Finite Non-Volatile Memory Life* in chapter 3.

## Diagnostics LEDs



The Diagnostic LED indicates the current status of the device and also its protocol. If all is healthy the LED should flash ON for a period of 100ms. The rate at which the LED flashes is used to indicate the protocol as indicated in the table below.

| Protocol     | LED Flash Period |
|--------------|------------------|
| ASCII        | 0.5 seconds      |
| MODBUS       | 1 second         |
| MANTRABUS II | 2 seconds        |

If an error conditions occurs which is based on any of the following error flags being set then the operation of the LED will invert, i.e. the LED will flash off for 100mS at the rate set in the table above.

The flags in question are: TEMPUR, TEMPOR, ECOMUR, ECOMOR, CRAWUR, CRAWOR, SYSUR, SYSOR & LCINTEG.

The USB Rx and Tx LEDs indicate the presence of USB traffic. N.B. due to the nature of the USB waveform these LEDs are not very bright but do serve as diagnostic indicators.

## Chapter 8 Communication Protocols

This chapter gives details of communication protocols and bus connections.

There are effectively three 'layers' involved in communicating with the DSCUSB:

1. Internally, all devices support the same 'command set', as described in earlier sections.
2. Command-accesses are coded into actual byte sequences according to the communications protocol used. Three protocols, ASCII, Mantrabus and Modbus are available.
3. Serial communications are carried out via a 'Virtual COM Port' assigned by the PC.

The protocol type is fixed for a given device during production.

The communications baud rate and station number (the 'bus address') are configured for each device by the control parameters **STN** and **BAUD** (see *Chapter 2 Getting Started*).

### Bus Standards

#### Serial Data Format

Serial data formatting is the same for all the protocols and is fixed to

- one start-bit
- one stop-bit
- 8 data bits
- no parity

#### Communications Flow Control

Bus flow control is managed as part of the protocol (managed differently by each).

No hardware or software flow control signals are to be used for any of the bus standards.

#### Communications Errors

Serial data which does not conform to the expected format causes a 'serial framing error' to be registered, which increments the Communication Failure Counter **CFCT**.

What this actually means is that, following a start bit (1 to 0 transition), a 'stop' (1) bit was not seen in the expected place. This is obviously baud rate dependent; the commonest cause being data transmitted at a lower baud rate than the unit was configured for.

#### Choosing a Protocol

The current choices are:

|                     |                                                                            |
|---------------------|----------------------------------------------------------------------------|
| <b>ASCII</b>        | Printable characters, easy to drive, direct output to printers/displays    |
| <b>MODBUS RTU</b>   | Binary industry standard, inter-compatible with other devices such as PLCs |
| <b>MANTRABUS-II</b> | Efficient binary protocol, checksums give better security than ASCII       |

#### Communications Software for the Different Protocols

To access a DSCUSB, you will need a communications application running on your PC or PLC in addition to the appropriate hardware connections.

The simplest approach for initial experiments is to use the 'Instrument Explorer' evaluation application.

Instrument Explorer can provide a 'window' into intended parameters and variables. This is supplied on a CD with the DSCUSB Evaluation kit or can be downloaded from our website:

[http://www.mantracourt.co.uk/software/Instrument\\_Explorer](http://www.mantracourt.co.uk/software/Instrument_Explorer)

A full version of Mantracourt's VisualLink (SCADA) toolkit can be used for much more complex control and monitoring applications. Contact our sales office for details.

**Other simple ways of using the different protocols are as follows :**

1. The ASCII protocol only uses basic printable characters, and so can be accessed with a simple terminal program like Windows 'HyperTerminal'.

2. The MODBUS protocol can be accessed via a proprietary generic MODBUS application.  
For evaluation purposes, we suggest the free shareware demo of 'ModScan32' from Win-Tech software (visit [www.win-tech.com](http://www.win-tech.com)).
3. MANTRABUS needs a purpose-designed program to handle full 8-bit data bytes and the proprietary checksum calculations. Instrument Explorer and VisualLink provide this.

## ***Common Features of All Protocols***

The communications protocols are all of the master/slave type: A central 'host' device (normally a PC or PLC) acts as a bus master in control of all communications.

Communications consist of the master transmitting **command messages** addressed to particular DSCUSB 'slave' devices. The target slave may then transmit a 'response message' back to the master.

Because there is only one bus master, and slaves never initiate communications, the master is in control of all communications. This enables multi-drop operation, i.e. a single master can control any number of slave devices at a time.

In practice, the master usually 'polls' the attached slaves, interrogating them in a fixed rotation.

### **Command Types**

A single command sent to a device can instruct it to read from or write to an internal 'parameter' value, or to execute a 'Control Action'.

The device responds by returning data (for a parameter read) or a simple acknowledge (for write or action). Precise details depend on the protocol in use.

### **Each Command Message Contains the Following Information:**

1. The intended slave address (or broadcast)
2. The command to access
3. The access type, one of read / write / execute
4. (For write accesses only) the write value

### **The Command Response will then be one of the following three types:**

1. An error indication
2. A simple acknowledge
3. A read data-value (implicit acknowledge)

The various protocols differ quite a lot in the available types of error and acknowledgements. The distinction between different access types is also protocol-dependent, in that some use a dummy read or write command to execute access.

### **Slave Addressing and Broadcast**

Every slave device on the bus is identified by a unique address value, known variously as its 'station number', 'node id' etc. depending on the protocol.

Each command message contains an address specifying to which slave device it is directed. A slave will ignore all communications that are not addressed to it.

All the protocols also define a special address value (normally 0) which is reserved for broadcast commands, which all slaves act on.

No response is allowed to broadcast commands, as multiple replies would collide with one another.

### **Parameters**

Parameters are the values used for all control settings and output values. They have an associated storage type (byte, integer or real-value), and may be either read/write, read-only or write-only.

Output or 'result' values are mostly read-only.

Configurable parameters are held in non-volatile storage, so control settings are retained permanently even when power is removed.

## Data Type Conversions and Rounding

### Type Conversion

Depending on the protocol, an integer/byte parameter may need to be converted to or from a floating-point representation for reading or writing.

The rules are as follows

For reading, integer and byte parameters are treated as unsigned, and never read negative

- i.e. read value ranges are 0 to 65535.0 and 0 to 255.0

For writing, values written to integer and byte parameters are truncated to the nearest integer, and negative or positive values are acceptable

**NOTE:** Floating-point data is not always exact, even when reading integral data

e.g. could get 3.999974 instead of 4

e.g. for a byte write, 240, 240.1 and 239.66 are all the same value

### Rounding

Although rounding is applied when writing to integral values, data read from a device is *not* rounded off.

## The ASCII Protocol

The ASCII protocol uses only printable characters and carriage-return ('<CR>'), which allows a 'dumb' terminal device or a PC programme like Hyper-Terminal to interrogate the device - Host Command Message Format

The basic command request structure is shown in the following example, illustrating the message: '!001:SGAI=123.456<CR>', meaning write 123.456 to parameter SGAI on station 1:

| Framing Character | Station Address | Separator | Command Identifier | Access Code | Data    | End of frame |
|-------------------|-----------------|-----------|--------------------|-------------|---------|--------------|
| !                 | 001             | :         | SGAI               | =           | 123.456 | <CR>         |

An Explanation of Each Field is as Follows:

- **Framing Character:** a '!' character is used to signal the start of a new message. This character is only ever transmitted by the host, for framing purposes.
- **Station Address:** a three-digit ASCII decimal number (0-999) determines which slave device(s) the command is intended for. All three digits must be sent. Address 000 is reserved for broadcast addressing.
- **Separator:** always present. As no checksum or message verification technique is used, slaves use this as an extra check on message validity.
- **Command Identifier:** up to 4 alpha-numeric characters, case insensitive, giving the name of the required command.
- **Access Code:** Defines what sort of response is expected :-
  - '=' means write data is expected to follow
  - '?' means the host is expecting to receive read data back
  - <CR> (i.e. nothing more before end) means the command is an action type (execute)
- **Data:** an ASCII decimal-formatted number, can include 0-9, '+', '-', '.', and spaces. This field can have a maximum length of 15 characters.
- **End of frame:** a <CR> is always present to indicate the end of the message.

### Summary

- A command message begins with '!', followed by a three-digit station address, then a ':', and finishes with a <CR>.
- The '!' and <CR> *only* appear at the beginning and end of commands respectively
- From the ':' to the final <CR> is the command 'instruction' (of read, write or execute type)
- All instructions begin with an alphanumeric command identifier of up to 4 characters, and end with a non-alphanumeric (which may be the final <CR>).

### Slave Response Message Formats

Each slave monitors the bus for command messages. It responds to any message that is addressed to it by sending a response message.

To be accepted by a slave device, a message must start with '!', the correct three-digit slave address and ':', and end with <CR>, with no intervening extra '!'.  
The slave will then *always* respond.

**There are three possible types of response: acknowledge (ACK), acknowledge with data (for a read), and not-acknowledge (NAK)**

ACK is a single <CR> character. This confirms an execute or write command.

ACK-with-data is a decimal number, followed by <CR>. This confirms a read and returns the data value.

NAK is an '?' <CR> sequence. The device rejected the command.

**There are several possible reasons for a NAK response:**

Command identifier not recognised

Badly formatted command: Missing command identifier, unrecognised access-code character, or unexpected character somewhere else

Access attempted not supported by this command.

#### NOTES:

- The maximum time from receipt of the host's terminating <CR> to a response from the device (if any) will be 50mS. After this time it can be assumed there is no response.
- There is no value-checking: A slave *cannot* NAK a command because a write data value is 'unsuitable' in some way, only if write access itself is disallowed.

For the Ack-with-data (i.e. a successful read command), the returned value consists of printable ASCII characters finishing with a <CR>, formatted according to the DP and DPB settings as follows

#### Write Command

If the device accepts the command then a <CR> is transmitted. There is no error checking on the data received by the device.

#### Example:

A command to set the BAUD parameter to 3 on station 1 could look like this -

```
!001:BAUD=3<CR>
```

assuming a device with STN=1 is present, it will respond with -

```
<CR>
```

#### Read Command

Returns the requested value specified by the command.

The returned value is formatted according to the DP and DPB values: The response consists of a sign character (±), DPB decimal digits before a decimal point, DP digits after the point and a terminating <CR>:

The length of the response is thus fixed at DP+DPB+3 characters.

#### Example:

A command to read the SOUT output could look like this -

```
!001:SOUT?<CR>
```

if the value=32.1, and format settings are DP=3 and DPB=5, the response string will be -

```
+00032.100<CR>
```

#### Action Command

If the device accepts the command then a <CR> is transmitted.

#### Example:

A command to reset device 14 would look like -

```
!014:RST<CR>
```

the response string will be solely <CR>

### Broadcast Commands

If the station address in a command message is '000', this means a broadcast command.

All slaves act as normal on a broadcast command, but do not respond.

#### Example:

A command to all devices on the bus to sample their inputs would look like this -

```
!000:SNAP<CR>
```

- no response

### Bad Commands

If any command is not understood by the device then a '?' is transmitted followed by a <CR>.

#### Example:

A unrecognised command, correctly addressed to station 173 -

```
!173:XYWR?<CR>
```

produces the general error response -

```
?<CR>
```

## Continuous Output Stream (ASCII ONLY)

For the ASCII protocol only, there is a 'continuous output' mode:

The SOUT value is continually broadcast at intervals set by the RATE parameter (see Chapter 3). The maximum output rate is 300Hz with the baud rate set to a minimum of 115200.

This feature is intended for outputting data to a single simple serial device such as a display or printer.

There are two continuous output streaming modes which are determined by the station number being set to either 998 or 999 (see below for how to change the station number).

- When set to 999 streaming does not start automatically, a ctrl/Q (0x11) character must be sent to initiate it. This means that if there is, for example, a brief power interruption then streaming will stop even when power is restored. A further ctrl-Q character must be sent to re-start streaming.
- When STN is set to 998 the continuous output stream will start automatically from power up. The streaming can be switched on and off by sending the standard ASCII 'XON/XOFF' control bytes (ctrl/Q = 0x11 and ctrl/S = 0x13).

## Station Number, STN

The STN parameter controls the 'station number', which specifies the device address for bus communications. Historically this was introduced to allow multi-dropping on RS485 versions of other DSC and DCell products in Mantracourt's product range.

As supplied, devices have the station-number factory set to 001

**Please note:** because the DSCUSB communicates through a virtual comm port (VCP), its unique identity is determined by the assigned Comm Port number rather than its station number, STN. For this reason the station number can be left at its default setting of 001 unless the continuous streaming feature described above is required (STN = 998 or 999). Two DSCUSB devices with the same station number can co-exist without any conflicts when connected to a single PC via separate USB sockets or a hub.

**Please note:** The new value of STN does not take effect until the RST command is issued or the device is power cycled.



To Change the Station Number of your device:

1. First set STN to the new value.

```
!001:STN=999<CR>
```

assuming a device with STN=1 is present, it will respond with -

```
<CR>
```

2. Send a RST command or power cycle the device for the change to take place. If using Hyper Terminal or similar applications it may be necessary to 'Disconnect' then 'Call' (disconnect then re-connect) after cycling the power in order to re-establish communications.

```
!001:RST<CR>
```

- no response

The station number will now be set to 999. Subsequent commands should be addressed to !999:

**Please note:** if using Hyper Terminal or similar applications it may be necessary to 'Disconnect' then 'Call' (disconnect then re-connect) after cycling the power in order to re-establish communications.

#### NOTES:

- The valid range of STN for the ASCII protocol is 1-999
- If STN is set outside the valid range, it behaves as if set to a default of 1.
- Ctrl/Q will cause the DSCUSB to start streaming its data. Ctrl/S will stop the streaming.

### ***Baud rate Control, BAUD***

The BAUD parameter is a read/write byte value specifying a standard communications baud rate according to the following table -

| BAUD value      | 0    | 1    | 2    | 3    | 4    | 5    | 6    | 7     | 8     | 9     |
|-----------------|------|------|------|------|------|------|------|-------|-------|-------|
| baud rate (bps) | 2400 | 4800 | 9600 | 19k2 | 38k4 | 57k6 | 76k8 | 115k2 | 230k4 | 460k8 |

- **Default setting value 7 for BAUD rate 115200**
- BAUD can only take the values shown above. If set <0 or >9, the baud rate reverts to default of 115200

**Warning:** When changing this setting it is possible to lose communication with the device. As well as keeping track of the correct baud rate, it is also essential in this case to be sure that your hardware supports the rate you are changing to.

The evaluation kit supports all possible DSCUSB baud rates.

The new value of BAUD does not take effect until the RST command is issued or the device is power cycled.

To Change the Baud Rate, follow a similar sequence to changing the STN value:

1. First set Baud to the new value.

```
!001:BAUD=4<CR>
```

assuming a device with STN=1 is present, it will respond with -

```
<CR>
```

2. Send a RST command or power cycle the device for the change to take place. If using Hyper Terminal or similar applications it may be necessary to 'Disconnect' then 'Call' (disconnect then re-connect) after cycling the power in order to re-establish communications.

```
!001:RST<CR>
```

- no response

1. Change the device settings in Instrument Explorer by selecting **Change Settings** from the **Communications** menu. Select new baud rate.

## ***The MODBUS-RTU Protocol***

MODBUS is a proprietary standard of Modicom Inc.

The full specification is quite complex, including a timeout-based framing strategy and polynomial CRC calculation, so full details are not given here. Refer to Modicom documentation. Knowledge of the MODBUS protocol is therefore assumed.

The MODBUS protocol is a partial implementation of the 'RTU' (binary) form of the MODBUS standard, sufficient to allow DSCUSB units to coexist on a serial bus with other MODBUS-compliant devices.

### **NOTE:**

Third-party applications for MODBUS communications are readily available (e.g. ModScan from Win-Tech software, [www.win-tech.com](http://www.win-tech.com), who offer a free trial version).

### **Modbus Messages**

All messages and responses are formatted and check summed according to the normal RTU rules. The slave number is the device station number: Slave '0' may also be used for broadcast writes.

The device command-set is mapped into the MODBUS 'Output' or 'Holding Registers' -

**Parameters** (read or write) are mapped onto a pair of registers containing a 4-byte floating-point value

**Action Commands** are implemented as dummy parameters: Writing activates the command and reading returns a dummy value (with no action)

### **Only two valid Message Function Codes are supported**

Function 03 'Read Holding Registers' - to read a register-pair  
Function 16 'Preset Multiple Registers' - to write a register-pair

The start address must always be a valid parameter address, which is always an odd number (see the following).

The **only** permitted data length is two registers, i.e. 4 bytes.

Registers **cannot** be read or written singularly, in larger groups or using other addresses (i.e. even-numbered registers cannot be addressed directly).

### **Parameter Addresses**

All MODBUS parameter addresses are derived from the equivalent MANTRABUS register number by a simple 'times 2 plus 1' calculation.

For example, the 'FLAG' parameter is Mantrabus register#14, so this occupies MODBUS holding registers 29 and 30 (i.e.  $2 \times 14 + 1 = 29$ ).

See the command table in Chapter 9 for the starting register numbers.

### **Parameter Values**

All exchanged values (read and write parameters) are in the standard IEEE 4-byte floating-point format:

### **The 32 Bits of the number are distributed as follows:**

|     |       |            |                                 |
|-----|-------|------------|---------------------------------|
| MSB | 31    | Sign bit , | 1=negate                        |
|     | 30-23 | Exponent,  | 7-bit excess-127                |
| LSB | 22-0  | Mantissa,  | 23-bit fraction with implicit 1 |

The value of the number is thus

$$\{ (-1)^{\text{Sign}} * 2^{(\text{Exponent}-127)} * 1.\text{Mantissa} \},$$

Note the 'assumed 1' before the mantissa. The exception to this is the special value 0.0, which is represented as 4 zeroes.

**e.g. a floating point number of -12345.678 is represented as - [hex] C6 40 E6 B6**

These 32 bits are mapped onto a register pair in the following way: The lower register holds bits 15-0 and the upper register bits 31-16.

These values are coded according to normal Modbus conventions, so the actual byte sequence in a read/write message is thus -

R1<sub>hi</sub>, R1<sub>lo</sub>, R2<sub>hi</sub>, R2<sub>lo</sub>

- Which in terms of bits is-

15:8, 7:0, 31:24, 23:16

#### Error Codes

Only three Modbus Error Codes are supported, which are used as follows:

- 01 'Illegal Function' request for function other than 3 or 16
- 02 'Illegal Data Address' attempt to read an unsupported register address
- 03 'Illegal Data Value' attempt to write a read-only parameter, or message too long for buffer (valid messages have a known maximum length)

#### Write Command Example:

Write value 1.23 (represents as hex 3F9D70A4) to registers 57,58 on slave#4 by sending:

```
[hex] 04 station address
      10 function code (write)
      00 38 start-reg hi,lo (N.B. h38=56 addresses register 57)
      00 02 quantity = 2 registers
      04 byte-count = 4
      70 A4 first=lower register (17) value = hi,lo
      3F 9D second=upper register (18) value = hi,lo
      6B AB checksum = hi,lo
```

A correct response would then be:

```
[hex] 04 station address
      10 function code (write)
      00 38 the Data Address of the first register
      00 02 the number of registers written
      C0 50 checksum = hi,lo
```

#### Read Command Example:

Read a value from registers 13,14 on slave#52 by sending:

```
[hex] 34 station address
      03 function code (read)
      00 0C start-reg hi,lo
      00 02 quantity = 2 registers
      01 AD checksum = hi,lo
```

A correct response with a value of -55.2317 (Hex C25CED51) would then be:

```
[hex] 34 station response
      03 function code (read)
      04 byte-count
      ED 51 C2 5C data
      AA D4 checksum = hi,lo
```

#### Execute Command Example:

Execute command 101 on slave#17 by sending:

```
[hex] 11 station address
      10 function code (write)
      00 64 start-addr h64=100 → register 101
      00 02 quantity = 2 registers
```

```

04    byte-count
00 00 00 00 data (value irrelevant)
A0 B4 checksum = hi,lo

```

The Acknowledge response is then:

```

[hex] 11    station response
      10    function code (write)
      00 64 the Data Address of the first register
      00 02 the number of registers written
      02 87 checksum = hi,lo

```

## The Mantrabus-II Protocol

Mantrabus-II is a two-wire system where data is transmitted & received over a common pair of wires. Comms traffic is synchronised by using a unique 8 bit framing character. For this reason the framing character must not appear as data in a command or reply from the responding DSCUSB. The protocol ensures this does not occur by splitting data bytes into 4 bit nibbles while the framing character & station number remain as 8 bits.

### Framing Character

The framing character for Mantrabus-II is FEh, (this being different from the older Mantrabus-I FFh to allow the two protocols to be mixed on one bus).

### Checksum

Both Host & Device send their EXOR checksum of all data sent, excluding framing character, in nibble format with the MS nibble being first.

e.g. EXOR Checksum of data is A7h. Checksum characters sent = 0Ah, 07h

### Data Transfer

Data is both sent and received as 4 bytes split into 8 nibbles following the station number, plus two nibbles of checksum.

### Floating-Point Data Format

All data sent & received in Mantrabus-II is in the IEEE floating-point format, this being a 4-byte floating-point number. The byte containing the sign & exponent is sent first, with the LS byte of the mantissa being last.

The memory layout of the 4-byte floating-point numbers is:

```

MSB   31    Sign bit ,      1=negate
      30-23  Exponent,      7-bit excess-127
LSB   22-0  Mantissa,      23-bit fraction with implicit 1

```

The value of the number is thus

$$\{ (-1)^{\text{Sign}} * 2^{(\text{Exponent}-127)} * 1.\text{Mantissa} \},$$

Note the 'assumed 1' before the mantissa. The exception to this is the special value 0.0, which is represented as 4 zeroes.

e.g. a floating-point number of -12345.678 is represented as - [hex] C6, 40, E6, B6  
This is transmitted in nibble format as - [hex] 0C, 06, 04, 00, 0E, 06, 0B, 06.

### End of Data Identifier

As the protocol has no fixed length or length identifiers the *last* nibble of *data* sent to the device has its *MS nibble set*. This indicates to the device that all data has been received & the next two bytes will be checksum data. This does not apply to the response from the remote device as the master knows how many bytes to expect in the reply to each of its commands.

### ACK & NAK

Mantrabus-II supports ACK & NAK, sending ACK (06h) at the end of a successful operation, and NAK (15h) for an unknown command or failed operation. These are always preceded by the station number (see examples below). N.B. Mantrabus-II will *not* transmit a NAK for invalid checksum data, but instead remains silent. (This is different from the behaviour of the older Mantrabus-I).

### Writing to Variables

Station number and command number are followed by 8 bytes of nibble data (the last having its MS bit set), followed by the two checksum nibbles.

e.g. To write the value 100.0 (Floating point 100.0 = 42h, C8h, 00h, 00h) to variable CGAI (command number 40) at station 20, send the following

|                    |                   |      |                                         |                            |
|--------------------|-------------------|------|-----------------------------------------|----------------------------|
| FEh,               | 14h,              | 28h, | 04h, 02h, 0Ch, 08h, 00h, 00h, 00h, 80h, | 0Bh, 0Eh                   |
|                    |                   |      | [ DATA ]                                | [EXOR CS]                  |
| Frame<br>character | Station<br>number | Cmd  |                                         | MS bit<br>of last Byte set |

The response is then -

14h, 06h i.e. 'station number' + 'ACK'.

### Reading of Variables

To read an individual variable, the command number is sent with the MS bit set (i.e. no data following).

e.g. To read CGAI (command number 40) from station number 20, send the following -

|               |                   |                        |              |
|---------------|-------------------|------------------------|--------------|
| FEh,          | 14h,              | A8h,                   | 0Bh, 0Ch     |
|               |                   | [   ]                  | [EXOR CS]    |
| Frame<br>char | Station<br>number | Cmd with<br>MS bit set | of last byte |

Assuming the value was -12345.678 (coded as C640E6B6h, representing  $-1 * 2^{13} * 12345.678 / 8192$ ), the response will be -

|                   |                                                                                   |           |
|-------------------|-----------------------------------------------------------------------------------|-----------|
| 14h,              | 0Ch, 06h, 04h, 00h, 0Eh, 06h, 0Bh, 06h,                                           | 01h, 0Fh  |
|                   | [ DATA ]                                                                          | [EXOR CS] |
| Station<br>number | N.B. this is a response, therefore<br>MS bit of last byte does not need to be set |           |

### Action Commands

These are transmitted like read commands, i.e. no data sent. The response is identical to write commands.

eg. To reset station three (command 100), send the following.-

|               |                   |                        |           |
|---------------|-------------------|------------------------|-----------|
| FEh,          | 03h,              | E4h,                   | 0Eh, 07h  |
|               |                   |                        | [EXOR CS] |
| Frame<br>char | Station<br>number | Cmd with<br>MS bit set |           |

The response is then -

03h, 06h i.e. 'station number' + 'ACK'.

## Chapter 9 Software Command Reference

This chapter contains tables of all DSCUSB commands, with brief details of each.

### Commands in Access Order

| ASCII name | description                        | datatype | access | MB reg | MD reg   |
|------------|------------------------------------|----------|--------|--------|----------|
| CMVV       | Temp Compensated mV/V              | float    | RO     | 5      | 11       |
| STAT       | Status                             | int      | RO     | 6      | 13       |
| MVV        | Filtered & factory calibrated mV/V | float    | RO     | 8      | 17       |
| SOUT       | selected output                    | float    | RO     | 9      | 19       |
| SYS        | main output                        | float    | RO     | 10     | 21       |
| TEMP       | temperature                        | float    | RO     | 11     | 23       |
| SRAW       | raw system output                  | float    | RO     | 12     | 25       |
| CELL       | cell output                        | float    | RO     | 13     | 27       |
| FLAG       | error flags                        | int      | RW     | 14     | 29       |
| CRAW       | raw cell output                    | float    | RO     | 15     | 31       |
| ELEC       | electrical output                  | float    | RO     | 16     | 33       |
| SZ         | system zero                        | float    | RW     | 22     | 45       |
| SYSN       | snapshot result                    | float    | RO     | 23     | 47       |
| PEAK       | Peak value                         | Float    | RO     | 24     | 49       |
| TROF       | Trough value                       | Float    | RO     | 25     | 51       |
| CFCT       | Communications failure count       | Float    | RW     | 26     | 53       |
| VER        | software version                   | byte     | RO     | 30     | 61       |
| SERL       | serial number low                  | int      | RO     | 31     | 63       |
| SERH       | serial number high                 | int      | RO     | 32     | 65       |
| STN        | station number                     | int      | RW     | 33     | 67       |
| BAUD       | baud rate select                   | byte     | RW     | 34     | 69       |
| OPCL       | Output Control (Value select)      | byte     | RW     | 35     | 71       |
| RATE       | reading rate select                | byte     | RW     | 36     | 73       |
| DP         | digits after point                 | byte     | RW     | 37     | 75       |
| DPB        | digits before point                | byte     | RW     | 38     | 77       |
| NMVV       | Nominal mV/V for scaling ELEC      | float    | RW     | 39     | 79       |
| CGAI       | cell gain                          | float    | RW     | 40     | 81       |
| COFS       | cell offset                        | float    | RW     | 41     | 83       |
| CMIN       | cell range min                     | float    | RW     | 44     | 89       |
| CMAX       | cell range max                     | float    | RW     | 45     | 91       |
| CLN        | lin n-points                       | byte     | RW     | 50     | 101      |
| CLX1..7    | lin raw-values                     | float    | RW     | 51..57 | 103..115 |
| CLK1..7    | lin corrections                    | float    | RW     | 61..67 | 123..135 |
| SGAI       | system gain                        | float    | RW     | 70     | 141      |
| SOFS       | system offset                      | float    | RW     | 71     | 143      |
| SMIN       | system range min                   | float    | RW     | 74     | 145      |
| SMAX       | system range max                   | float    | RW     | 75     | 151      |
| USR1..9    | g.p. storage values                | float    | RW     | 81..89 | 163..179 |
| FFLV       | Dynamic Filter Level               | Float    | RW     | 92     | 185      |
| FFST       | Dynamic filter steps               | Float    | RW     | 93     | 187      |
| RST        | reboot                             | -        | X      | 100    | 201      |
| SNAP       | take snapshot                      | -        | X      | 103    | 207      |
| RSPT       | Reset peak & trough                | -        | X      | 104    | 209      |
| SCON       | Shunt cal ON                       | -        | X      | 105    | 211      |
| SCOF       | Shunt cal OFF                      | -        | X      | 106    | 213      |
| OPON       | Digital Output on                  | -        | X      | 107    | 215      |
| OPOF       | Digital output off                 | -        | X      | 108    | 217      |

|         |                      |       |    |          |          |
|---------|----------------------|-------|----|----------|----------|
| CTN     | tempco n-points      | byte  | RW | 110      | 221      |
| CT1..5  | tempco Temp points   | float | RW | 111..115 | 223..231 |
| CTG1..5 | tempco gain-adjust   | float | RW | 116..120 | 233..241 |
| CTO1..5 | tempco offset-adjust | float | RW | 121..125 | 243..251 |

**Table Key**

'..' - Denotes a range (e.g. CLK1..7 means 'CLK1' to 'CLK7')

Access RW/RO/WO/X = read-write / read-only / write-only / execute

Datatype float/int/byte/- = 4-byte real / two-byte integer / 1-byte integer / none

MB reg = register number for MANTRABUS protocol

MD reg = start register address (always odd) for MODBUS protocol

**NOTES:**

All Modbus accesses are in register pairs, Modbus addresses are (2\*MANTRABUS)+1

# Chapter 10 Installation

This chapter gives detailed information on integrating the DSCUSB into a production system - including mounting, protection, adjustments, wiring and electrical requirements.

## Before Installation

Carefully remove the DSCUSB device from its shipment box. Check that the device is complete and undamaged. Check the Product Type Code - on the product label is that which you ordered.

The DSCUSB can operate in any industrial environment providing the following limits are not exceeded

|                       |                    |
|-----------------------|--------------------|
| Operating Temperature | -40 °C to +85 °C   |
| Humidity              | 95% non condensing |
| Storage temperature   | -40 °C to +85 °C   |

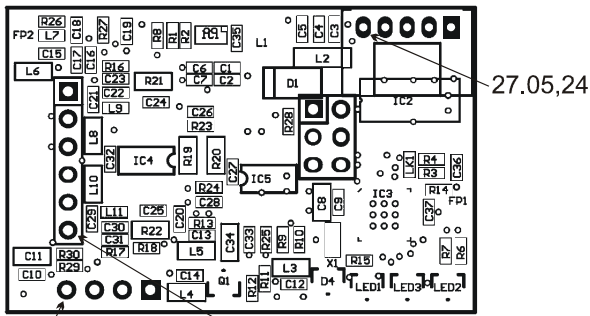
For precise details of Environmental Approvals, see chapter 15.

It is advisable to follow the following installation practices where possible:

- Minimise vibration
- Do not mount next to strong electrical or magnetic fields (transformers, power cables)
- Install electrical protection device as the unit is not internally fused
- Always ensure the package is secure and protected

## Physical Mounting

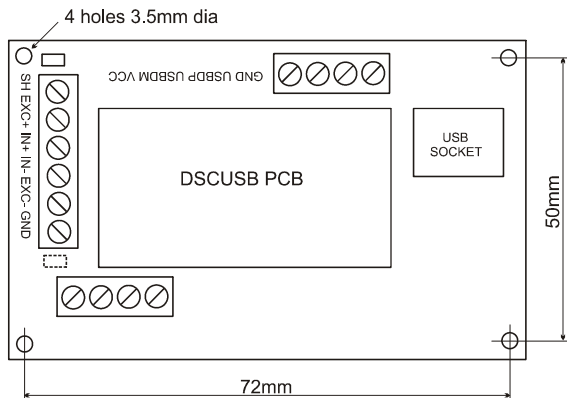
### OEM PCB:



Datum 0,0 (x,y) 0.127,5.46 Dimensions in mm

The PCB can be fitted to a motherboard by fitting in-line pins to the 6-way, 4-way and 5-way rows of holes and plugging them into corresponding sockets on the motherboard or directly soldering through holes. The 6-way and 4-way holes are on a 0.1" pitch, the 5-way holes are on a 2mm pitch.

### OEM Module





The OEM Module can also be DIN rail mounted by means of suitable clips e.g. Wago 209-120 fitted to a separate base plate.

Ideally, the DSCUSB should be installed in a protective enclosure, such as a metal box.

## ***Electrical Protection***

Electrostatic protection is sufficient for installation purposes only.

No over-current or over-voltage protection is provided in case of faults, the supply arrangements should therefore employ adequate power limiting or fusing.

**NOT PROTECTED AGAINST REVERSE POLARITY OF SUPPLY.**

## ***Moisture Protection***

The DSCUSB must only be operated in a dry environment, as moisture can dramatically degrade the measurement performance. Any simple box or enclosure can be used, however, in extreme conditions an enclosure with the appropriate IP rating should be chosen.

If a metal enclosure is used it should be grounded to the 'SH' connection.

## ***Soldering Methods***

Take care when soldering cables to the pads. Use a temperature controlled soldering iron set to a maximum 330°C, for no longer than 2 seconds per pad. Excessive heat or increased soldering time may result in damage to the PCB.

### **NOTES:**

1. Solder with water-soluble flux should not be used (even low-residue), as this can leave a surface film which attracts atmospheric moisture, degrading measurement performance.



## ***Power Supply Requirements***

The DSCUSB is a 'low power' device (<100mA) and normally derives its power from the host machine. It will operate over the worst-case voltage range stated in the USB rev 2.0 specification i.e. 4.35-5.25V.

The OEM-Module version, as supplied with the Evaluation kit, can be operated in 'Self powered' mode i.e. powered by a separate supply (4.25V to 5.5V) connected to pins 1 and 4 of J3 - follow the screen printed legend on the PCB for the polarity. Care should be taken to assure that this supply is not also connected to the host by the USB cable.

A single device consumes typically 70mA with a 350 Ohm gauge connected.

An installation should therefore assume at least 80mA per unit, and allow for extra current being taken at power-on (though supply voltage can safely drop temporarily), and for possible voltage drops in long cables.

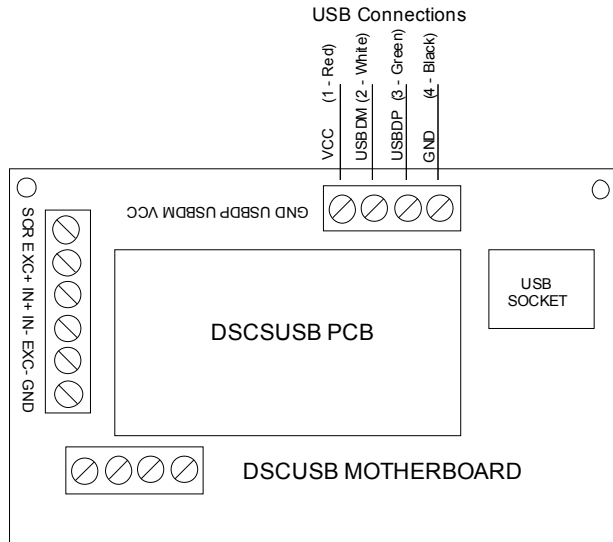
The DSCUSB can supply enough excitation current to drive up to four 350 Ohm gauges connected in parallel. In this case 'Self powered' mode must be used (see note above for the OEM-Module) as the total supply current will rise to approximately 135mA taking it above the USB specification for 'Bus Powered' devices.

Any power-supply ripple should be below 100mV, and supply arrangements should provide current limiting for fault conditions (see *Electrical Protection*, above).

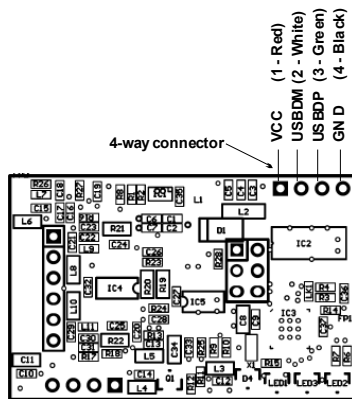
# Cable Requirements

## USB

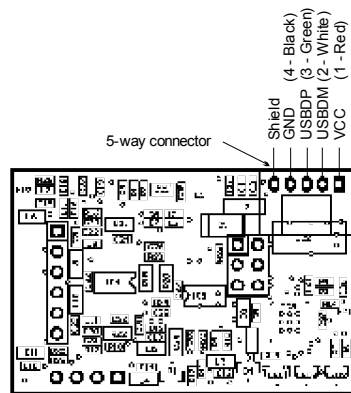
### OEM Module



### OEM PCB



Issue 1 PCB



Issue 2 PCB

### Strain Gauge Input (DSCUSB)

For optimal performance twin twisted pair with individual shields is recommended, this gives good noise immunity. Maximum length should not exceed 20m. Normal 4 core shielded cable can be used in areas of low electromagnetic noise.

### Power and Communication

Standard, good quality USB cables should be used.

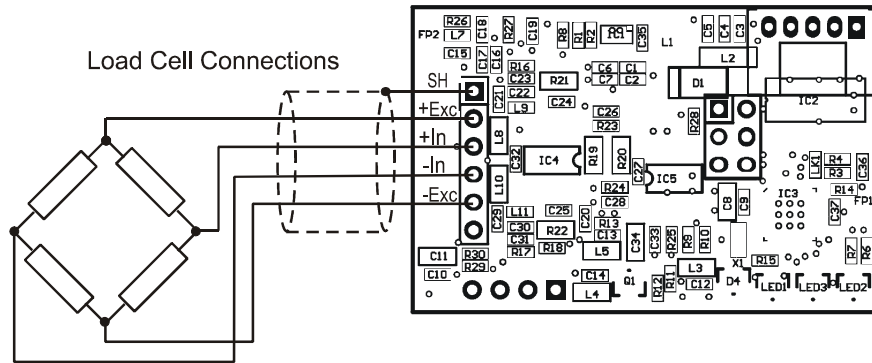
In the case of the 'self-powered' OEM Module described above, use a 'USB type A' to wire tails cable or cut off the 'B type' connector of a standard cable and strip back the outer sheath and connect the 'GND', 'USBDP' and 'USBDM' cores to the 4-way screw connector J3. Leave the Vcc core unconnected. Connect the external 5V supply to 'GND' and 'VCC'. Ensure that the 5V supply stays within the limits 4.25V to 5.5V.

## Temperature Sensor

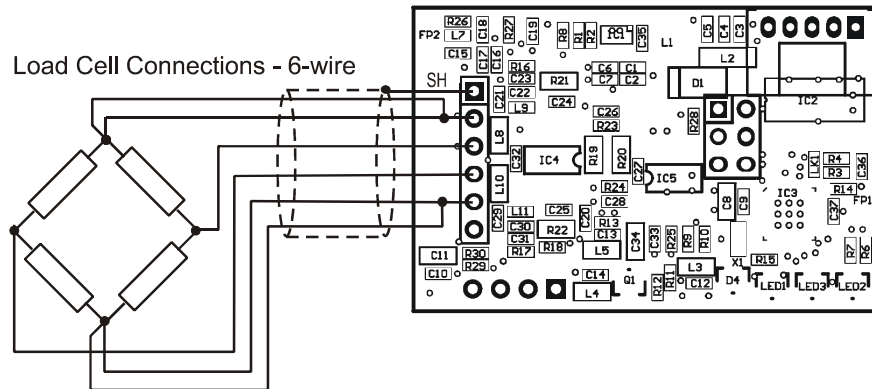
A shielded twisted pair is recommended, with a maximum length of 10m the shield being connected to the load cell body or (SH if DSC). For short lengths (< 2m) in a low noise environment (inside load cell body for example) then normal cable can be used.

## Identifying Strain Gauge Connections

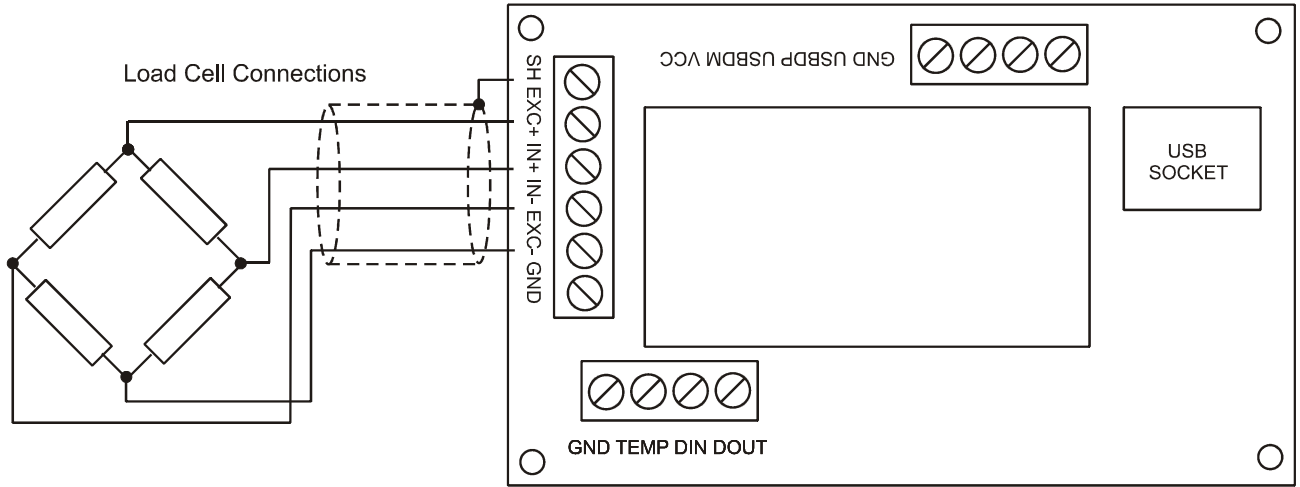
### OEM PCB - 4-wire load cell



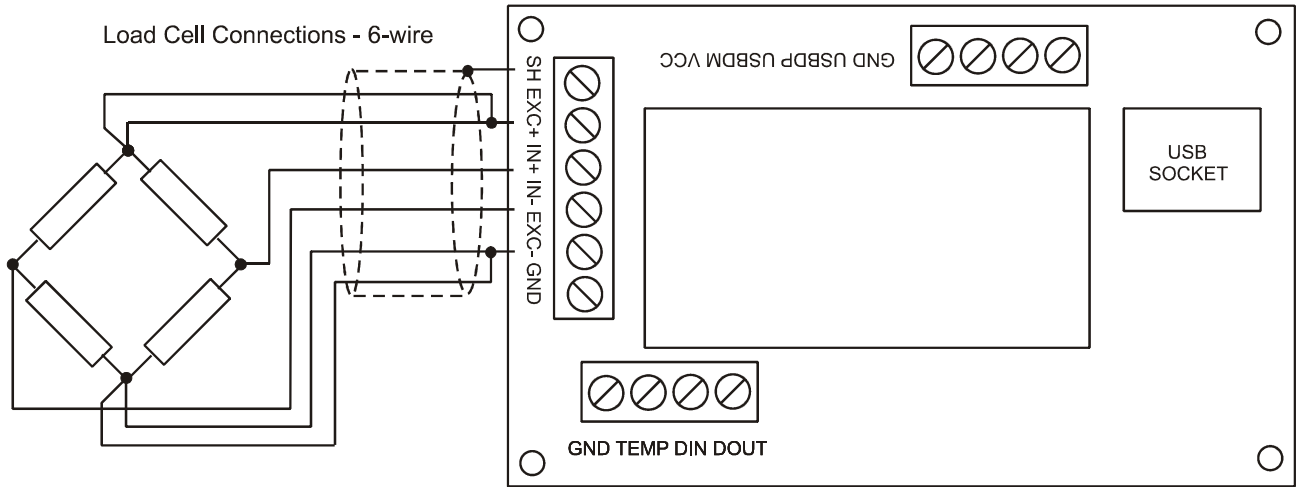
### OEM PCB - 6-wire load cell



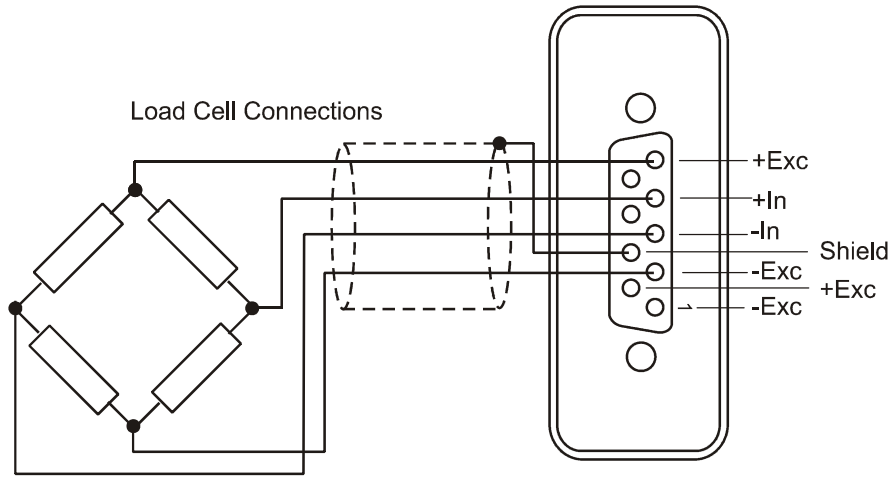
**OEM Module - 4-wire load cell**



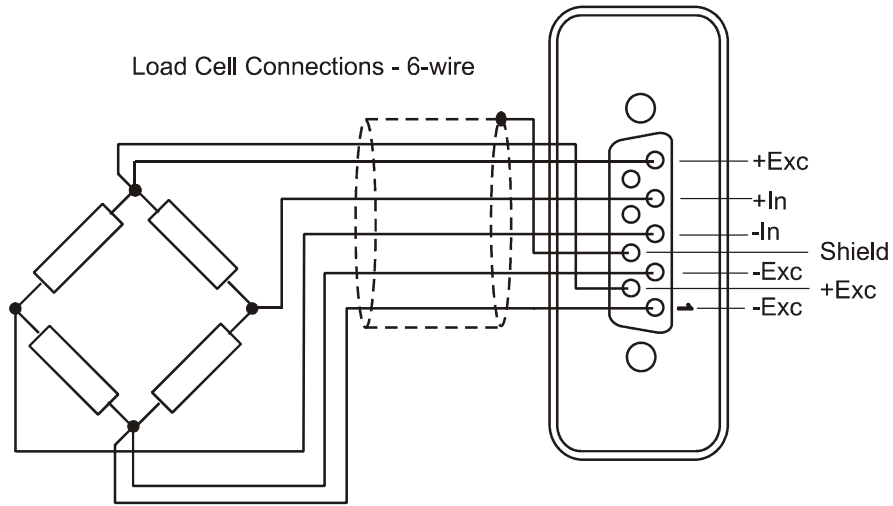
**OEM Module - 6-wire load cell**



**Cased Version - 4-wire load cell**



**Cased Version - 6-wire load cell**



# Strain Gauge Cabling and Grounding Requirements

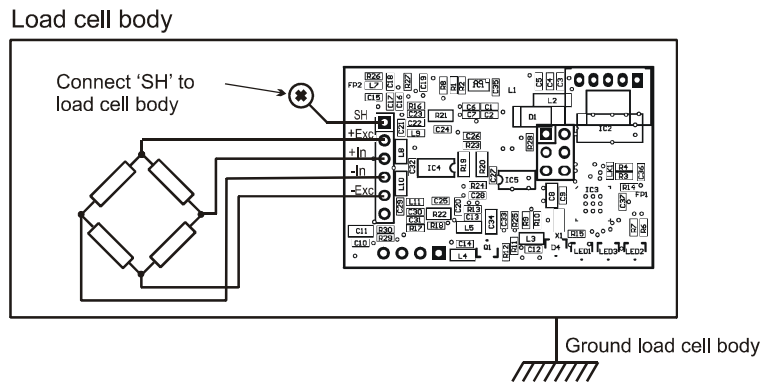
To achieve full performance specifications and conform to environmental approvals, it is important to follow the wiring procedures outlined in this section.

## DSC Strain Gauge Cabling Arrangement

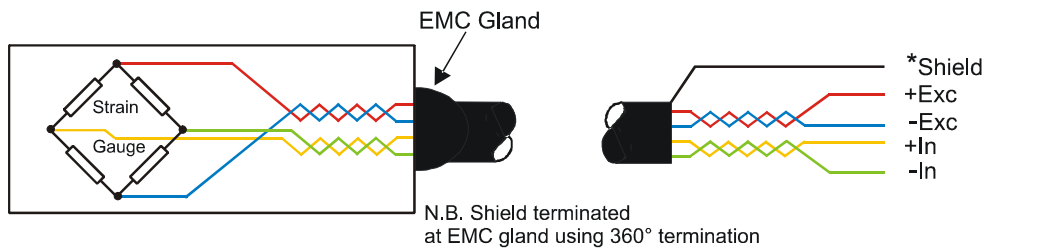
### Key Requirements

If the OEM PCB is fitted within the body of a load cell, the strain gauge wires should be kept as short as possible, at most 20cm. The EXC+/- wires should be twisted together, also the SIG+/- pair, and the two pairs kept apart. It is also recommended to secure the wires from moving due to shock or vibration.

The shield connection 'SH' should be connected to the body of the load cell via a very short length of wire (20mm max).



If the DCell is mounted outside the body of the load cell then, for optimal performance, twin twisted cable should be used, although standard 4 core shielded cable can be used in low noise environments.



N.B. White core shown as yellow in above diagram

\* Shield tail length must be kept to a minimum

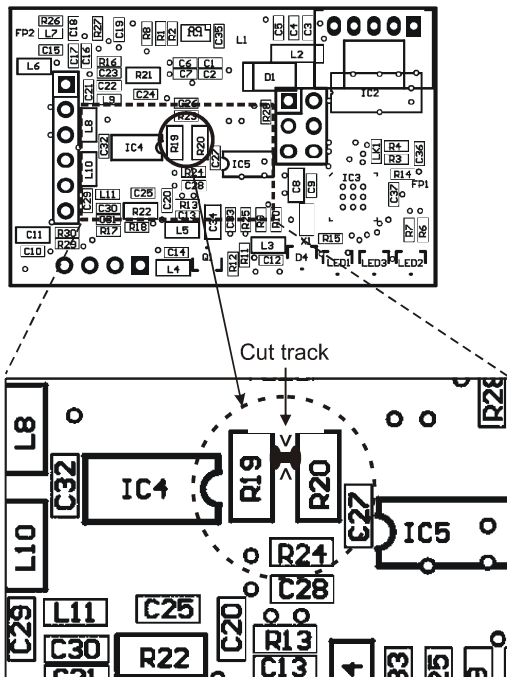
## Strain Gauge Sensitivity Adjustment

The DSCUSB is factory optimised for 2.5mV/V. If your strain gauge does not deliver a 2.5mV/V full scale output, you may want to adjust the sensitivity of the electronics (hardware) and/or the software gain controls.

If an input mV/V setting of *more* than 2.5mV/V is required, the hardware sensitivity must be adjusted to avoid saturating the input.

If the setting is less than 2.5mV/V, you can correct in software alone, but increasing the hardware sensitivity will generally improve accuracy.

There is provision on the DSCUSB PCB for changing the mV/V setting. R20 can be changed, an extra resistor R19 added and/or a track cut as shown below:



The PCB track can be cut as shown above to disconnect the 100 Ohm gain resistor R20 and a suitable value resistor fitted as R19 to change the sensitivity. A high quality 0805 surface-mount resistor 25ppm/°C or better should be used to maintain performance.

### Reducing Sensitivity:

To accommodate a sensor output *larger* than 2.5mV/V, it is necessary to reduce the electrical sensitivity of the input circuitry.

To decrease the sensitivity, the track should be cut to remove R20 from the circuit and resistor R19 fitted as calculated by the following formula:

$$R_{19} = (\text{required mV/V}) \times 40$$

**Example:** for 10mV/V

$$R_{19} = 10 \times 40 = 400 \text{ Ohms}$$

### Increasing Sensitivity

When the full-scale output is *less* than 2.5 mV/V, it may be desired to increase the sensitivity. However, it is often possible instead to compensate partly or entirely in software, by increasing either or both of the software gain controls CGAI or SGAI.

To *increase* the sensitivity, R20 is left in place by leaving the PCB track intact and R19 fitted in parallel. R19 is calculated as:

$$R_{19} = 1 / (( 0.025 / (\text{reqd. mV/V}) ) - 0.01)$$

**Example:** for 1.5mV/V

$$R_{19} = 1 / (( 0.025 / 1.5 ) - 0.01) = 150 \text{ Ohms}$$

**Two effects should be noted:**

1. The purpose of increasing the hardware gain is to reduce reading *noise* which governs the effective resolution. This gives better performance than increasing the gain in software.
2. The sensitivity should, however, not be set greater than typically 1mV/V. Beyond this figure, input noise usually dominates and no extra benefit can be achieved.



# Chapter 11 Troubleshooting

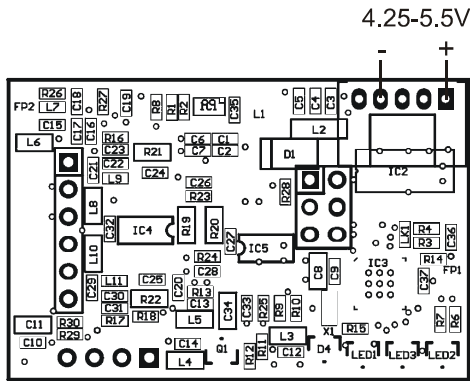
This chapter gives a quick guide to problem solving for DSCUSB devices. Bear in mind that the quickest way to pin down problems is to usually replace items with ‘known good’ alternatives. This also applies to cables, power supplies, devices etc.

## LED Indicator

The LED is used to indicate the protocol selection, the device is powered and the Device is operating. During correct operation the LED should Flash ON for 100mS then repeat at a rate depending on the protocol as shown in the following table. If this is not the case then follow the instructions below.

| Protocol     | LED Flash Period |
|--------------|------------------|
| ASCII        | 0.5 seconds      |
| MODBUS       | 1 second         |
| MANTRABUS II | 2 seconds        |

If the LED is OFF check the power supply polarity & voltage:



If the LED is permanently ON then contact the factory.

If The LED is ON for the majority of time then Flashes OFF for 100mS then a fault exists. This fault can be read back using the communications. Likely causes of this are Strain Gauge Integrity Error or Limits reached for MVV, CRAW, SRAW or TEMP. First check the connections to the strain gauge are correct. Next check the input is not over-range or the limits set for CMIN, CMAX, SMIN or SMAX have not been exceeded.

## No Communications

The majority of problems involve a failure to communicate, as there are a number of optional settings that must be set to the same value at both ends of the link.

For this reason, any communications application should always check command responses, and flag a problem when these responses are not activated.

Possible problems can be categorised according to where in the ‘chain’ of communication the problem may be. The typical chain runs as follows:

- PC software (port connection, baud rate, station number, protocol)
- PC serial port (working)
- USB lead to DSCUSB
- Bus wiring
- DSCUSB device (wiring, station number, baud rate, protocol, working)

A quick checklist elaborates on these areas, if you are using the Instrument Explorer evaluation software (other software may have different requirements at the PC end): Check as follows:

#### **PC End**

1. PC software settings: correct serial port, baud rate and protocol (standard data setup is 1 start bit + 1 stop bit, no flow control).
2. PC serial port okay: check with another serial device, e.g. wire two PCs together with Hyper Terminal running on both.

#### **Evaluation Board or Device**

1. Power reaches the device with correct polarity.
2. USB Connections correct.
3. Device settings: correct station-number, baud rate  
(How do you know these are correct? A substitute device is very useful here!)
4. Device protocol: double-check product label
5. Device running okay: LED is flashing.
6. Devices take 45-55mA supply current without sensor attached, 65-75mA with 350 Ohm gauge.

## ***Bad Readings***

The cause can be either hardware or software related.

#### **Software**

1. Check the MVV reading first and ensure it is correct. This figure is the RAW input and is not affected by the user configurable calibration settings.
2. If MVV looks correct, check the calibration settings step by step.  
Consider resetting all the calibration controls to default values - see *Chapter 4 The Reading Process*. This should make SOUT=MVV at all times.

#### **Hardware**

1. Load Cell problem should be indicated by flags in STAT, LCINTEG
2. Genuine hardware problems usually show up as **total** failure - i.e. unchanging fixed readings, usually either near zero or permanently at full-scale.  
Check wiring, take voltage level readings and again if possible use a known good device and set up.
3. Check the sensor is connected properly, and has some resistance across the excitation leads, output leads and across each arm of the bridge. For a 350 Ohm gauge these readings should be approximately 350 Ohms, 350 Ohms and 262 Ohms respectively (when disconnected from the device).
4. Check for a damaged DSCUSB device by replacement.

## ***Unexpected Warning Flags***

Remember that all warning flags in **FLAG** must be explicitly reset -they do not clear themselves when a problem is resolved.

If a flag cannot be cleared, the cause must be persistent -i.e. it keeps occurring. This can be immediate, regular (every few seconds) or irregular (occasional).

See the 'Flags' section chapter 3 for precise details of how the individual warnings operate.

#### **Bear in mind the following possible problems**

1. REBOOT or an increasing CFCT may indicate intermittent connections.
2. Where ECOMUR/OR or EXCUR/EXCOR are triggered, suspect input wiring.
3. Various 'range' errors (CRAWUR/OR, SRAWUR/OR) are also likely to be set if the excitation was interrupted (EXCUR/OR).
4. For range errors, check the associated limit parameters (CMIN/MAX, SMIN/MAX).
5. Problems are likely if any calibration MIN/MAX parameters are set the wrong side of zero (i.e. MIN>0 or MAX<0).

## ***Problems with Bus Baud Rate***

There are a number of special difficulties to be considered here:

- Systems with very long cabling may not work with higher baud rates
- Always remember, devices need to be rebooted before certain changes take effect

## ***Recovering a 'lost' DSCUSB***

For baud rate problems, see previous section.

If the protocol is unknown e.g. the label has been removed or the diagnostic LED is not visible then try all three protocols (ASCII, MODBUS and MANTRABUS II) until a response is obtained.

If a station number is unknown, it can be reset via *broadcast* command (STN = 0).

**Always remember that a reboot (power-off or RST command) is needed to change STN and BAUD settings!**

# Chapter 12 Specifications

## Technical Specifications DSCUSBS

The DSCUSB is factory set for 2.5mV/V sensitivity.

| Parameter                                                  | Min                                                                                                                                                  | Typical    | Max   | Units         |
|------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|------------|-------|---------------|
| Strain Gauge Excitation System                             | 4 Wire                                                                                                                                               |            |       |               |
| Strain Gauge Excitation Voltage                            | 4.5                                                                                                                                                  | 5          | 5.25  | VDC           |
| Strain Gauge Drive Capability                              | 80                                                                                                                                                   | -          | 5000  | Ohms          |
| Strain Gauge Sensitivity                                   | -3                                                                                                                                                   | 2.5        | 3     | mV/V          |
| Offset Temperature Stability                               |                                                                                                                                                      | 5          | 10    | ppm/C         |
| Gain Temperature Stability                                 |                                                                                                                                                      | 30         | 50    | ppm/C         |
| Offset Stability with Time                                 |                                                                                                                                                      | 35         | 160   | ppm of FR (1) |
| Gain Stability with Time                                   |                                                                                                                                                      |            | 300   | ppm of FR (2) |
| Non Linearity before Linearization                         |                                                                                                                                                      | 5          | 25    | ppm of FR     |
| Internal Resolution                                        |                                                                                                                                                      | 16 Million |       | Counts/divs   |
| Resolution @ 1Hz readings (Noise stable) over 100s         |                                                                                                                                                      | 66,000     |       | Counts/divs   |
| Resolution @ 10Hz readings (Noise stable) over 100s        |                                                                                                                                                      | 40,000     |       | Counts/divs   |
| Resolution @ 100Hz readings (Noise stable) over 100s       |                                                                                                                                                      | 10,000     |       | Counts/divs   |
| Resolution @ 500Hz readings (Noise stable) over 100s       |                                                                                                                                                      | 5,000      |       | Counts/divs   |
| Signal Filter                                              | Dynamic recursive type user programmable                                                                                                             |            |       |               |
| <b>Optional Temperature Resolution (DTEMP)</b>             |                                                                                                                                                      |            |       |               |
| Temperature Measurement Resolution                         |                                                                                                                                                      | 0.0625     |       | Deg C         |
| Temperature Measurement Accuracy (-10 to 85)               |                                                                                                                                                      | 0.5        |       | Deg C         |
| Temperature Measurement Accuracy (-55 to 125)              |                                                                                                                                                      | 2.0        |       | Deg C         |
| Temperature update Speed                                   |                                                                                                                                                      | 5          |       | Seconds       |
| <b>Electrical</b>                                          |                                                                                                                                                      |            |       |               |
| Power Supply voltage                                       | 4.25                                                                                                                                                 | 5          | 5.5   | V dc          |
| Power Supply current (350 Ohm Bridge)                      |                                                                                                                                                      | 68         | 75    | mA            |
| <b>Data transmission</b>                                   |                                                                                                                                                      |            |       |               |
| Data transmission rate                                     | 2.4                                                                                                                                                  | -          | 460.8 | kbps          |
| Output cable length (speed dependant)                      |                                                                                                                                                      |            | 5     | m             |
| <b>Environmental</b>                                       |                                                                                                                                                      |            |       |               |
| Operating temperature range                                | -40                                                                                                                                                  |            | +85   | C             |
| Storage temperature                                        | -40                                                                                                                                                  |            | +85   | C             |
| Humidity                                                   | 0                                                                                                                                                    |            | 95    | %RH           |
| <b>Dimensions</b>                                          |                                                                                                                                                      |            |       |               |
| PCB Dimensions DSCUSB OEM PCB                              | 43 x 28 x 4mm (1.6929 x 1.1024 x 0.472")                                                                                                             |            |       |               |
| PCB Dimensions DSCUSB OEM Module (OEM PCB mounted on DSJ2) | 82 x 60 x 20mm (3.2283 x 2.3622 x 0.7874")                                                                                                           |            |       |               |
| Cased version                                              | 86 x 57 x 26.5mm (3.3465 x 2.2492 x 1.087") excluding connector (95mm 3.740") including 9-way 'D' type connector) with 136 cm 94.462 feet USB cable. |            |       |               |

Notes.

1. From original offset at any time
2. 1st Year

## Technical Specifications DSCUSBH

Set for 2.5mV/V sensitivity.

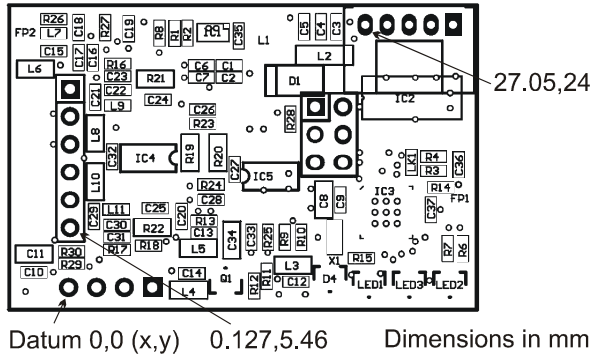
| Parameter                                                  | Min                                                                                                                                                  | Typical    | Max   | Units         |
|------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|------------|-------|---------------|
| Strain Gauge Excitation System                             | 4 Wire                                                                                                                                               |            |       |               |
| Strain Gauge Excitation Voltage                            | 4.5                                                                                                                                                  | 5          | 5.25  | VDC           |
| Strain Gauge Drive Capability                              | 80                                                                                                                                                   | -          | 5000  | Ohms          |
| Strain Gauge Sensitivity                                   | -3                                                                                                                                                   | 2.5        | 3     | mV/V          |
| Offset Temperature Stability                               |                                                                                                                                                      | 5          | 10    | ppm/C         |
| Gain Temperature Stability                                 |                                                                                                                                                      | 30         | 50    | ppm/C         |
| Offset Stability with Time                                 |                                                                                                                                                      | 35         | 160   | ppm of FR (1) |
| Gain Stability with Time                                   |                                                                                                                                                      |            | 300   | ppm of FR (2) |
| Non Linearity before Linearization                         |                                                                                                                                                      | 5          | 25    | ppm of FR     |
| Internal Resolution                                        |                                                                                                                                                      | 16 Million |       | Counts/divs   |
| Resolution @ 1Hz readings (Noise stable) over 100s         |                                                                                                                                                      | 200,000    |       | Counts/divs   |
| Resolution @ 10Hz readings (Noise stable) over 100s        |                                                                                                                                                      | 120,000    |       | Counts/divs   |
| Resolution @ 100Hz readings (Noise stable) over 100s       |                                                                                                                                                      | 50,000     |       | Counts/divs   |
| Resolution @ 500Hz readings (Noise stable) over 100s       |                                                                                                                                                      | 18,000     |       | Counts/divs   |
| Signal Filter                                              | Dynamic recursive type user programmable                                                                                                             |            |       |               |
| <b>Optional Temperature Resolution (DTEMP)</b>             |                                                                                                                                                      |            |       |               |
| Temperature Measurement Resolution                         |                                                                                                                                                      | 0.0625     |       | Deg C         |
| Temperature Measurement Accuracy (-10 to 85)               |                                                                                                                                                      | 0.5        |       | Deg C         |
| Temperature Measurement Accuracy (-55 to 125)              |                                                                                                                                                      | 2.0        |       | Deg C         |
| Temperature update Speed                                   |                                                                                                                                                      | 5          |       | Seconds       |
| <b>Electrical</b>                                          |                                                                                                                                                      |            |       |               |
| Power Supply voltage                                       | 4.25                                                                                                                                                 | 5          | 5.5   | V dc          |
| Power Supply current (350 Ohm Bridge)                      |                                                                                                                                                      | 68         | 75    | mA            |
| <b>Data transmission</b>                                   |                                                                                                                                                      |            |       |               |
| Data transmission rate                                     | 2.4                                                                                                                                                  | -          | 460.8 | kbps          |
| Output cable length (speed dependant)                      |                                                                                                                                                      |            | 5     | m             |
| <b>Environmental</b>                                       |                                                                                                                                                      |            |       |               |
| Operating temperature range                                | -40                                                                                                                                                  |            | +85   | C             |
| Storage temperature                                        | -40                                                                                                                                                  |            | +85   | C             |
| Humidity                                                   | 0                                                                                                                                                    |            | 95    | %RH           |
| <b>Dimensions</b>                                          |                                                                                                                                                      |            |       |               |
| PCB Dimensions DSCUSB OEM PCB                              | 43 x 28 x 4mm (1.6929 x 1.1024 x 0.472")                                                                                                             |            |       |               |
| PCB Dimensions DSCUSB OEM Module (OEM PCB mounted on DSJ2) | 82 x 60 x 20mm (3.2283 x 2.3622 x 0.7874")                                                                                                           |            |       |               |
| Cased version                                              | 86 x 57 x 26.5mm (3.3465 x 2.2492 x 1.087") excluding connector (95mm 3.740") including 9-way 'D' type connector) with 136 cm 94.462 feet USB cable. |            |       |               |

### Notes.

3. From original offset at any time
4. 1st Year

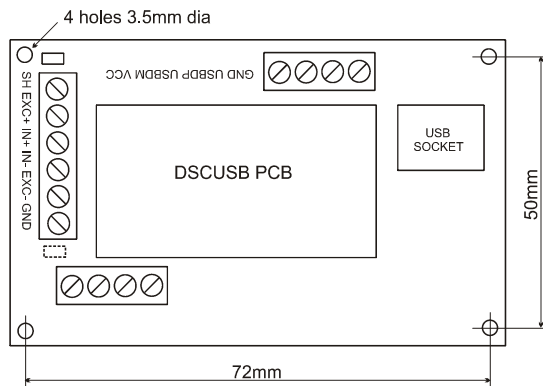
# Mechanical Specification for DSCUSBS and DSCUSBH

## OEM PCB:



The PCB can be fitted to a motherboard by fitting in-line pins to the 6-way, 4-way and 5-way rows of holes and plugging them into corresponding sockets on the motherboard or directly soldering through holes. The 6-way and 4-way holes are on a 0.1" pitch, the 5-way holes are on a 2mm pitch. The diagram shows the x,y coordinates of one hole of each connector.

## OEM Module:



Dimensions: 72 x 50mm with 4 x 3.5mm dia holes (2.8346 x 1.9685" with 4 x 0.1377" dia holes)  
 The OEM Module can also be DIN rail mounted by using suitable clips e.g. Wago 209-120 (below) fitted to a separate base plate.



Ideally, the DSCUSB should be installed in a protective enclosure, such as a metal box.

## Environmental Approvals

### CE Approvals

European EMC Directive      2004/108/EC  
BS EN 61326-1:2006  
BS EN 61326-2-3:2006

Output shall not exceed the sum of uncertainties when subjected to an electric field of 10V/m over the frequency range 80 to 600MHz

## Warranty

All DSC products from Mantracourt Electronics Ltd., ('Mantracourt') are warranted against defective material and workmanship for a period of (3) three years from the date of dispatch.

If the 'Mantracourt' product you purchase appears to have a defect in material or workmanship or fails during normal use within the period, please contact your Distributor, who will assist you in resolving the problem. If it is necessary to return the product to 'Mantracourt' please include a note stating name, company, address, phone number and a detailed description of the problem. Also, please indicate if it is a warranty repair.

The sender is responsible for shipping charges, freight insurance and proper packaging to prevent breakage in transit.

'Mantracourt' warranty does not apply to defects resulting from action of the buyer such as mishandling, improper interfacing, operation outside of design limits, improper repair or unauthorised modification.

No other warranties are expressed or implied. 'Mantracourt' specifically disclaims any implied warranties of merchantability or fitness for a specific purpose. The remedies outlined above are the buyer's only remedies. 'Mantracourt' will not be liable for direct, indirect, special, incidental or consequential damages whether based on the contract, tort or other legal theory.

Any corrective maintenance required after the warranty period should be performed by 'Mantracourt' approved personnel only.



Ⓒ In the interests of continued product development, Mantracourt Electronics Limited reserves the right to alter product specifications without prior notice.

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