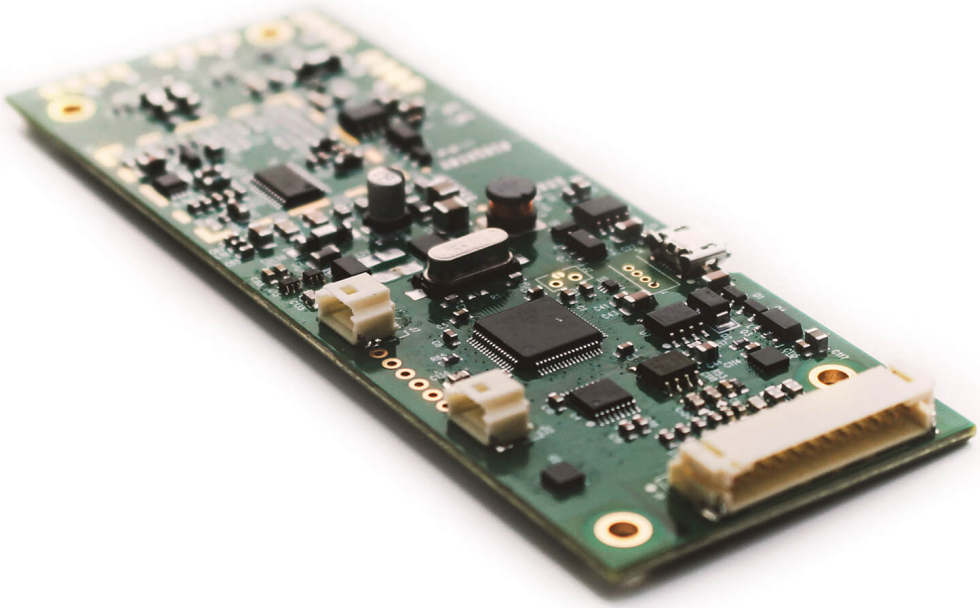
User Manual



TR2 Catalogue

V1.0 March 2019

Table of Contents

1. TR2 Catalogue 4
1.1. Introduction 4
1.2. Key features 4
1.3. Future features 4
1.4. Disclaimer 5
1.5. Safety Instructions 6
1.6. Document History 6
2. Specifications 7
3. References 8
4. TR2-A and TR2-B Hardware differences 9
5. TR2 Connections 9
5.1. Load-Cells (J8, J9, J10 and J11) 9
5.2. Power, RS232 and CAN (J6) 10
5.3. Micro USB Socket (J4) 11
5.3.1. Normal Operation – USB-CDC (Communications Device Class) 11
5.3.2. Reflash Operation – USB DFU mode (Device Firmware Upgrade) 11
5.4. I2C Slave (J7) 11
6. TR2 Serial RS232 12
6.1. The basics 12
6.2. Master/Slave 12
7. TR2 USB-CDC (USB Communications Device Class) 12
8. First connection - Connecting TR2 to a PC 12
8.1. Installing drivers 13
9. Password-protected Commands 13
10. Calibrate the TR2 with a PC running FDC (Flintec Device Configurator) 14
10.1. Start up the FDC 15
10.2. Connect to the TR2 using ComPort or USB-CDC 16
10.3. Calibrate using the TR2 Set-up Tab 16
10.4. Calibrate the Zero Point 17
10.5. Calibrate the Gain / Span Point 18
10.6. Set the Minimum and Maximum limits 19
11. Calibrate the TR2 manually using Terminal 21
11.1. Manual calibration breakdown 22
12. TR2 CAN 23
12.1. TR2 CAN Overview 23

12.2. CAN Commands 23
12.3. CAN Write and Execute Command – Status bytes returned. 23
12.4. CAN Command breakdown 24
12.4.1. Read Command - Get Calibration Counter 24
12.4.2. Write Command - Set Calibration Mode Register (Password) 24
12.4.3. Execute Command - Calibrate System Zero 25
12.5. Connect PC to TR2 using PCAN-USB 25
12.6. Using Flintec Device Configurator (FDC) and TR2 CAN 25
12.6.1. TR2 CAN Tabs 26
12.7. FDC CAN Terminal 27
12.8. Manually calibrate TR2 over CAN 28
12.8.1. Record the calibration process 28
12.8.2. Decode the commands, data and response 29
12.9. Using PCAN-View 30
12.9.1. PCAN-View Man-in-the-Middle Mode (MitM) 30
12.9.2. Read command 0x10000006 – Get Calibration Counter 31
12.9.3. Write command 0x1000040 - Set Calibration Mode Register (Password) 31
12.9.4. Execute command 0x10000087 - Calibrate System Zero 31
13. TR2 I2C 32
13.1. TR2 I2C Overview 32
14. Engineering Mode 33
14.1. Engineering Mode Commands 33
15. TR2 Tilt Sensing 34
15.1. Overview 34
15.2. Example 34
15.3. Tilt Commands 35
15.4. Recording the Tilt Sensor baseline 35
15.5. Using the FDC to see the Tilt Sensing in action 35
15.6. Accelerometer – NXP MMA8452Q 36
16. TR2 Gravity Compensation 37
16.1. Overview 37
16.2. Gravity Compensation commands 37
16.3. Display Gravity Compensation values in FDC 37
17. TR2 Communication Commands 38
17.1. Serial Text-Based Commands 38
17.2. CAN Commands 40
17.3. I2C Commands 42

1. TR2 Catalogue

1.1. Introduction

The TR2 is a precision scale PCB assembly with integral 24-bit sigma-delta analogue-to-digital converter, accelerometer for tilt detection, and microcontroller with OIML compliant functionality.

- Designed for OIML Class III approval as part of a complete scale.
- Low cost, high precision instrument, designed for use in OIML approved weighing systems.
- Communication with the PCB is available using a variety of serial interfaces –
- CAN bus, RS-232, I2C – making it easy to connect to a PC,
- PLC or other devices with standard serial ports or CAN network.
- The inclusion of a USB port (Micro-B) is available for parameter configuration and firmware upgrade.

There are two variants, to cater for different supply voltages:
TR2-A (5V) and TR2-B (10-24V).

Setup of the module is simple using a terminal emulation program or FDC application software (*available from Flintec.com*).

1.2. Key features

- CAN Interface
- RS-232 Serial Interface
- I2C Interface
- USB interface (for USB-CDC or USB-DFU operation)
- Up to 4x load cells (350Ω or 1,000Ω) summed, up to ±3mV/V
- +5V DC excitation
- Accelerometer for tilt detection

1.3. Future features

- RS-485 Serial Interface
- SPI & UART Serial Interfaces

1.4. Disclaimer

All rights reserved.

No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, mechanical, photocopying, recording, or otherwise, without the prior written permission of Flintec.

No patent liability is assumed with respect to the use of the information contained herein. While every precaution has been taken in the preparation of this book, Flintec assumes no responsibility for errors or omissions. Neither is any liability assumed for damages resulting from the use of the information contained herein.

The information herein is believed to be both accurate and reliable. Flintec, however, would be obliged to be informed if any errors occur. Flintec cannot accept any liability for direct or indirect damages resulting from the use of this manual.

Flintec reserves the right to revise this manual and alter its content without notification at any time. Neither Flintec nor its affiliates shall be liable to the purchaser of this product or third parties for damages, losses, costs, or expenses incurred by purchaser or third parties as a result of: accident, misuse, or abuse of this product or unauthorized modifications, repairs, or alterations to this product, or failure to strictly comply with Flintec operating and maintenance instructions.

Flintec shall not be liable against any damages or problems arising from the use of any options or any consumable products other than those designated as Original Flintec Products.

NOTICE: The contents of this manual are subject to change without notice.

1.5. Safety Instructions

CAUTION: READ this manual BEFORE operating or servicing this equipment. FOLLOW these instructions carefully. SAVE this manual for future reference. DO NOT allow untrained personnel to operate, clean, inspect, maintain, service, or tamper with this equipment. ALWAYS DISCONNECT this equipment from the power source before cleaning or performing maintenance.

CALL Flintec for parts, information, and service.

WARNING: Only permit qualified personnel to service this equipment. Exercise care when making checks, tests and adjustments that must be made with power on. Failing to observe these precautions can result in bodily harm.

WARNING: For continued protection against shock hazard connect to properly grounded outlet only. Do not remove the ground prong.

WARNING: Disconnect all power to this unit before removing the fuse or servicing.

WARNING: Before connecting/disconnecting any internal electronic components or interconnecting wiring between electronic equipment always remove power and wait at least thirty (30) seconds before any connections or disconnections are made. Failure to observe these precautions could result in damage to or destruction of the equipment or bodily harm.

CAUTION: Observe precautions for handling electrostatic sensitive devices.

1.6. Document History

Rev.	Date	Author	Details of change
A			Initial release.

2. Specifications

Specification	
Application	Medical scales, Retail scales and General weighing equipment.
Bridge Excitation	$5V_{DC}$
Sensor Configuration	Up to four 4-wire load cells, with parallel summation on the PCB
Accuracy Class	Designed for OIML Class III scales
Verification Scale Intervals	10,000
Minimum Input Sensitivity	0.5µV/d (TBC)
Weighing Range	Single Interval
Resolution	±240,000 counts (non-approved)
Analogue Input Range	±15mV (±3mV/V @ $5V_{DC}$ Excitation)
Minimum Load Cell Impedance	75Ω (e.g. 4 x 350Ω)
Maximum Load Cell Impedance	1100Ω
Programmable Sampling Rate	5 Hz to 50 Hz
Calibration	Test weights or load-cell simulator
Digital Filtering	None / 8 or 32 Moving Average / Flintec Baby Scale
Weighing Functions	Zero; Gross; Tare; Net; Filter; Zero-tracking etc.
Programmable Parameters	Stability criteria, zero range, initial zero, min/max weight output, gravity compensation, 32-byte user-definable non-volatile memory area
Passcode Protection	Calibration and User data
Tilt detection resolution	10-bit (0.06° up to 30° tilt)

CAN bus Interface (CAN 2.0B)	
Baud-rate	20 / 50 / 125 / 250 / 500 / 800 / 1000 kbps (default = 500)
Frame Format	29 bit

RS232 Interface	
Protocol	Simple text-based command set
Baud-rate	115,200 bps (fixed)
Format	8 Data bits, No Parity, 1 Stop bit

I2C Slave Interface	
Protocol	ASCII Characters
Baud-rate	Defined by Master (e.g. 20kHz)

USB	
Class	Normal Operation: USB-CDC Firmware Upgrade: USB-DFU
Baud-rate	Auto-detected

General	
Power Supply: TR2-A (5V)	4.5V to 5.5V @ 500mA (max)
Power Supply: TR2-B (10-24V)	9.5V to 28V @ 200mA (max)
Operating Temperature Range	-15°C to +55°C
Storage Temperature Range	-30°C to +85°C
Weight	30g approx.
Dimensions (L x W)	125 x 45mm

3. References

#	Doc. Number	Rev.	Title
1	0084789.docm		TR2 Catalogue Text-Based Communications Specification
2	0087289.docm		TR2 Catalogue CAN Bus Communications Specification
3	0087552.docm		TR2 Catalogue I2C Bus Communications Specification
4	0088642.docm		Flintec Device Configurator (FDC) Quick Start Guide.

4. TR2-A and TR2-B Hardware differences

The only difference between TR2-A and TR2-B is the supply voltage required.

- TR2-A requires 5V
- TR2-B requires 10V to 24V

A resistor fitted to the board can be interrogated by the software to determine if it's a TR2-A or TR2-B configuration. When an external PC issues the "FPN" command the reply will be TR2-A or TR2-B

5. TR2 Connections

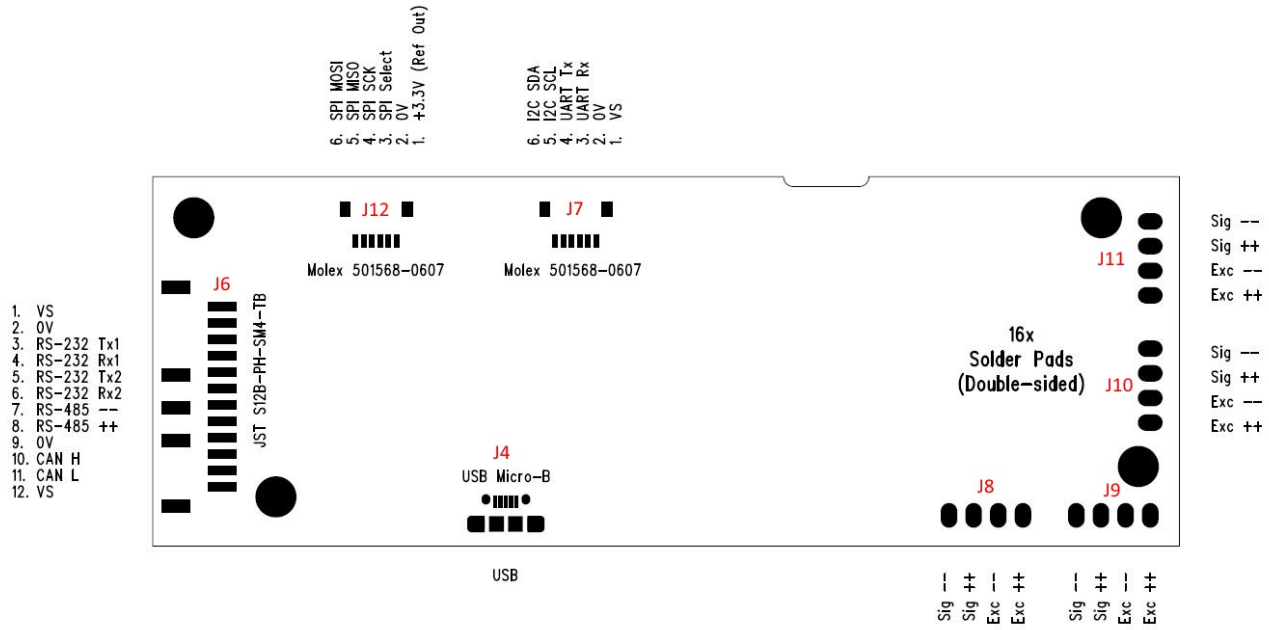


Figure 1- TR2 Connections and signal

5.1. Load-Cells (J8, J9, J10 and J11)

The TR2 has only one analogue input measuring channel but can physically accommodate up to 4 load-cells being soldered on pad connectors J8, J9, J10 and J11.

Note: On the PCB J8, J9, J10 and J11 are all wired in parallel, so the calculated weight is the average measurement of the load-cells in parallel.

Connect the input using the colour coding for load-cell connections:

J8, J9, J10 and J11 Load-Cell Pin-Out	Function
A	Excitation+.
B	Excitation-.
C	Signal+.
D	Signal-.

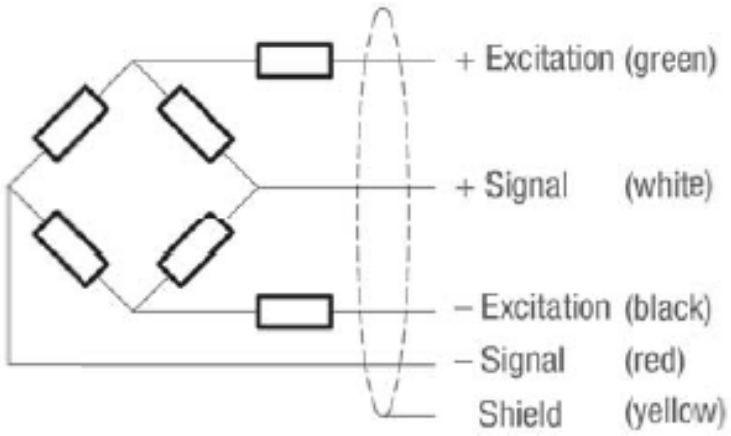


Figure 2- 4-Wire Connection

5.2. Power, RS232 and CAN (J6)

The power supply depends on the model.

RS232 and CAN interfaces are available through this connector.

J6 Pin Number	Pin Name	Notes
1	VS	TR2-A (5V Version) TR2-B (10V to 24V Version)
2	GND	
3	RS232 – Tx1	
4	RS232 – Rx1	
5	RS232 – Tx2	Not implemented
6	RS232 – Rx2	Not implemented
7	-485	Not implemented
8	+485	Not implemented
9	GND	
10	CAN H	
11	CAN L	
12	VS	TR2-A (5V Version) TR2-B (10V to 24V Version)

5.3. Micro USB Socket (J4)

The USB connection has 2 functions depending on jumper J2:-

5.3.1. Normal Operation – USB-CDC (Communications Device Class)

J2 not made – The USB port functions as a USB-CDC device and appears to the PC as a Serial Com Port

(in Device Manager – Ports (Com and LPT) appears as STMicroelectronics Virtual COM Port (COM3)

5.3.2. Reflash Operation – USB DFU mode (Device Firmware Upgrade)

J2 made – At switch on the USB port functions as a USB-DFU device allowing the firmware to be upgraded

5.4. I2C Slave (J7)

The TR2 can be used as an I2C Slave device on J7

J7 I2C Pin-Out	Function
1	TR2-A (5V Version) TR2-B (10V to 24V Version)
2	GND
3	UART Rx (not implemented)
4	UART Tx (not implemented)
5	SCL
6	SDA

Note: The I2C protocol is intended for transmitting data on a PCB between various chips, where the distance is small. If this interface is used, then it is advisable to keep the length between the TR2 (Slave) and the Master as short as possible.

J6 pin1, J6 pin12 and J7 pin1 are all connected together, so the supply voltage VS only needs to be connected to any one of these pins.

6. TR2 Serial RS232

Please note:

There is comprehensive coverage of text-based serial comms in document:-

0084789.docm - TR2 Catalogue Text-Based Communications Specification

6.1. The basics

- TR2 can communicate over RS232 at a fixed baud-rate of 115200, 8 data bits, No Parity and 1 stop bit.
- All commands are text-based (mainly 2 characters such as “PW” or “NT”) and are terminated with a **Carriage Return** (ASCII code 0x0D).
- In this document Carriage Return (ASCII code 0x0D) will be denoted by **<CR>**.
- By using text-based commands, communication with a PC is simple since any of the common terminal applications such as HyperTerm, TeraTerm or PuTTY will do.

6.2. Master/Slave

All communication is initiated by the Master – usually a PC or PLC.

The TR2 acts as a slave device.

The only time this is not the case is when the TR2 receives a Stream Gross Weight (“SG”) command.

In this situation the TR2 will send a gross weight value at the value set by the Sample Rate (“UR”).

If “UR” = 40 then the TR2 will stream 40 Samples Per Second (SPS).

To stop streaming send any command to the TR2.

7. TR2 USB-CDC (USB Communications Device Class)

USB-CDC is essentially Serial Port operation over USB. When USB-CDC is operational it appears in the Device Manager Ports (COM and LPT) section as a Virtual COM Port.

It obviously uses USB signals instead of RS232.

What applies to TR2 Serial RS232 above regarding text-based coms and Master/Slave operation also applies to USB-CDC.

8. First connection - Connecting TR2 to a PC

Ensure you have the following:-

- PC/Laptop with USB or Serial Port.

- If using **TR2-A** – a PSU capable of delivering +5V_{DC} at 500mA.
- If using **TR2-B** – a PSU capable of delivering +10V_{DC} to +24V_{DC} at 200mA.
- Load-cell with test weights or a load-cell simulator connected to J8 (or J9/J10/J11)

If connecting by:

- **USB (USB-CDC)** – A USB 'A' Male to Micro 'B' cable.

- **Serial Port RS232** – Cable with 9-way D female for connecting to PC Serial Port or USB-RS232 adaptor and the means to connect to J6 RS232 Tx, Rx and Gnd.

- **CAN** – a PEAK PCAN-USB opto-decoupled (IPEH-002022) and the means to connect to J6 CAN H, CAN L and GND.

For CAN you can use your preferred CAN controller. The PCAN-USB is quoted here as it is the only CAN device that will work with the Flintec Device Configurator App (FDC).

The easiest connection is by USB-CDC as it uses a standard cable.

8.1. Installing drivers

If using CAN (PCAN-USB) or USB-CDC you may need to install drivers.
See document *0088642.docm - Flintec Device Configurator (FDC) Quick Start Guide* for instructions.

9. Password-protected Commands

Several of the calibration and configuration commands are protected by a password.
The password-protected commands are listed in section 17.1. These mainly concern scale calibration, gravity compensation and configuration settings, e.g. scale ranges, scale limits, etc.

The default password is 632111

The password command is PW, so the password is entered by the command:
PW 632111<CR>
Successful password entry elicits the response:
OK

To exit the password protected mode, either try to enter an incorrect password or power the scale off and on again.

10. Calibrate the TR2 with a PC running FDC (Flintec Device Configurator)

The Flintec Device Configurator is an application that allows the user to set-up and calibrate the TR2 with a user-friendly graphical user interface (GUI).

Whether connected to the TR2 by R232, USB-CDC or CAN the GUI looks the same.

The FDC can be downloaded from the Flintec website at
https://www.flintec.com/uk/electronics/digitising-units/tr2

See also document *0088642.docm - Flintec Device Configurator (FDC) Quick Start Guide* for more info on getting the FDC installed and up and running.

This exercise is going to calibrate using a 2000g weight and set a minimum to maximum range of -10g to +2020g

The steps of this exercise will be:

- Connect the TR2 to the FDC and establish communication
- On the TR2 Set-up tab - Enable the Calibration controls
- With load-cell unloaded, set the zero point
- Enter the calibration weight (2000 in this case)
- With 2000g on load-cell, set the span point
- Save the calibration settings
- Set the Minimum Output (-10 in this case)
- Set the Maximum Output (2020 in this case)
- Show the effects of this calibration using the Weighing tab

10.1. Start up the FDC

The screen shot shows the FDC Connection screen with no connections made.

Note: The FDC supports the Flintec EM100 as well as the TR2.

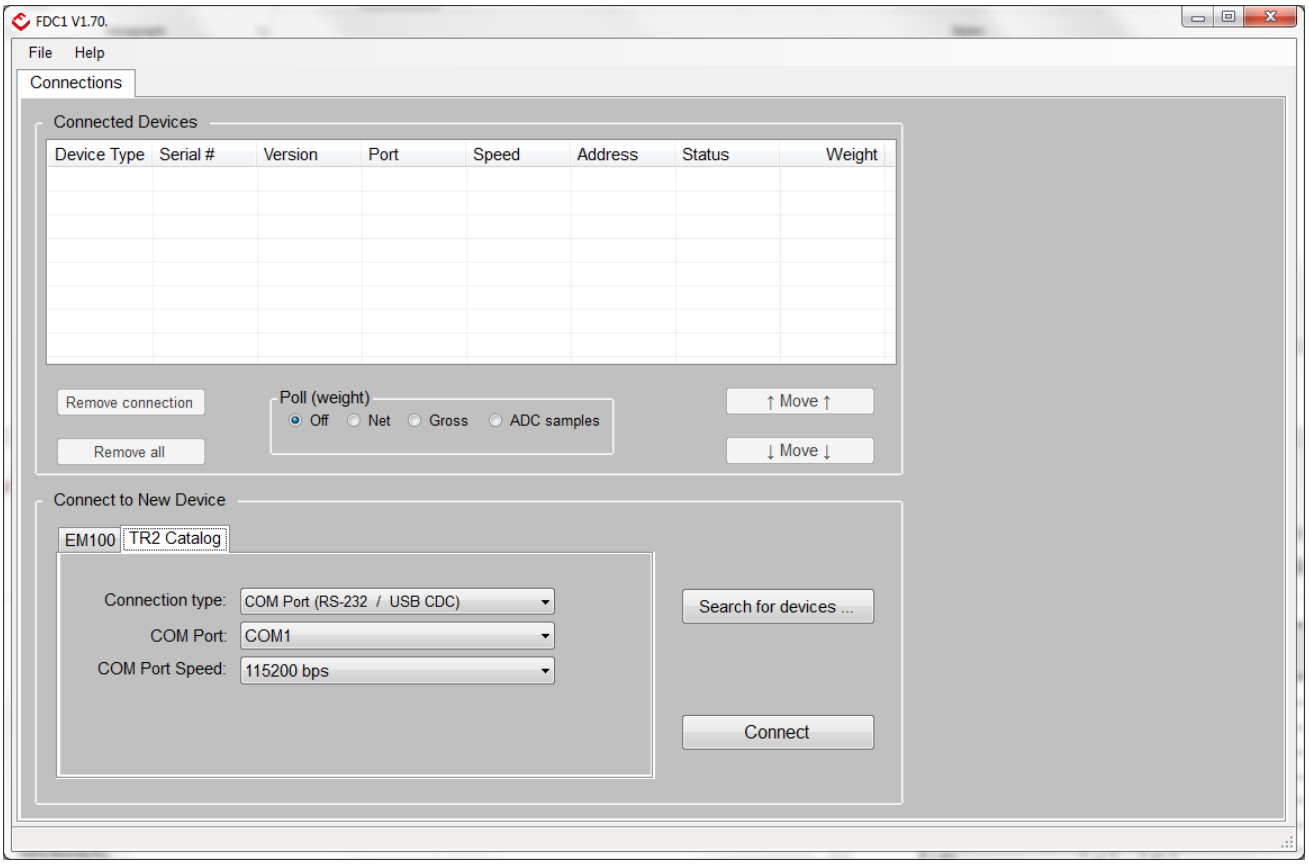


Figure 3 - FDC started and TR2 Catalog tab selected

10.2. Connect to the TR2 using ComPort or USB-CDC

Select the COM Port to which the TR2 is connected and press [Connect]

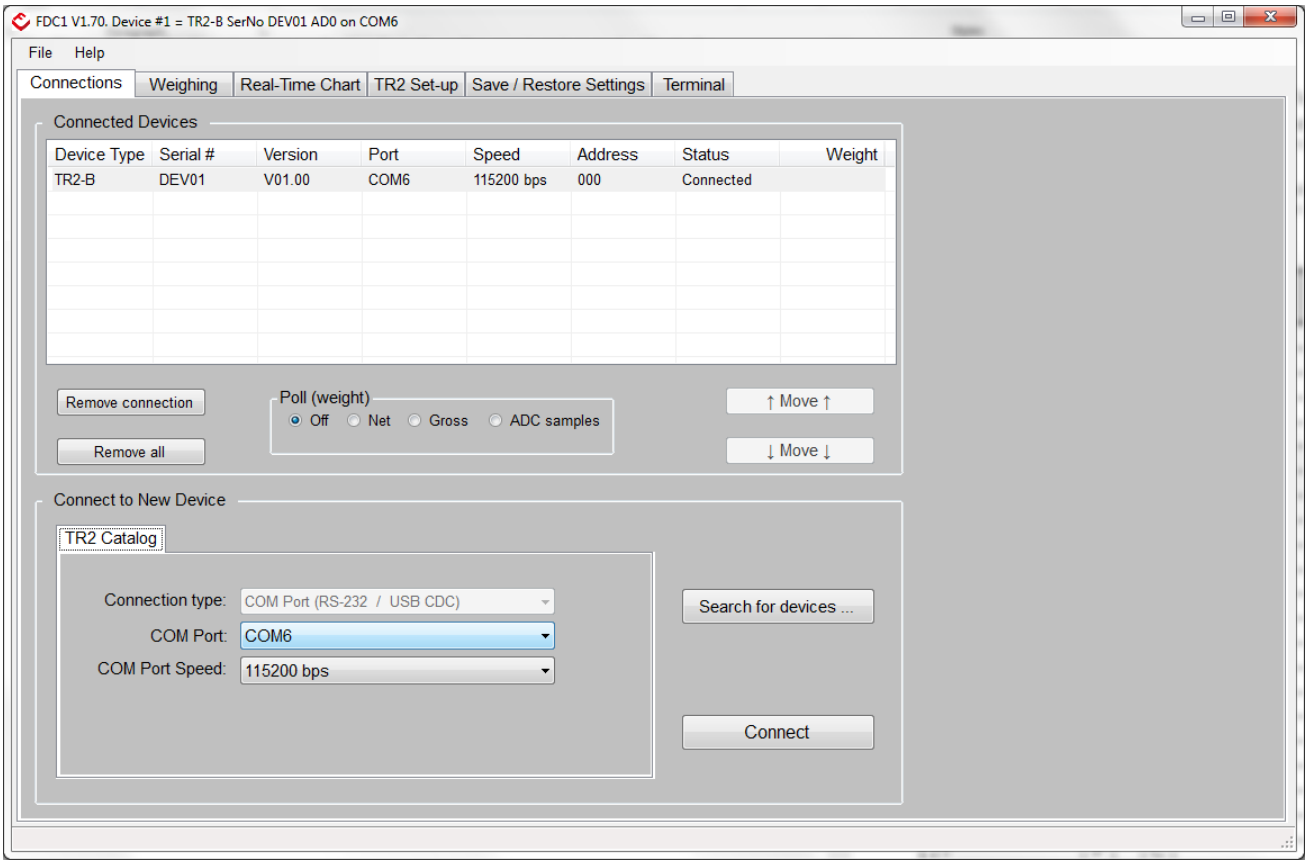


Figure 4 - TR2 connected to FDC

- Notice that on connecting to the TR2 the Weighing, Real-Time Chart, TR2 Set-up, Save/Restore Settings and Terminal tabs have become active.
- Up to 4 TR2's can be attached to the FDC. The TR2 that will be set-up / calibrated will be the one highlighted and appears at the top of the form.
- The connection data is saved to the Windows registry so when the FDC starts at a later date it will try to connect to this TR2 automatically.

10.3. Calibrate using the TR2 Set-up Tab

Calibration is on the TR2 Set-up tab so select this tab.

Useful information: Whatever the connection to the TR2 (RS232, USB-CDC or CAN) the GUI almost looks the same.

There are some differences, for instance, CAN does not support streaming so the Real-Time Chart is not available.

10.4. Calibrate the Zero Point

With the load-cell unloaded (zero load), check the *[Enable Calibration]* checkbox to enable the Calibration controls.

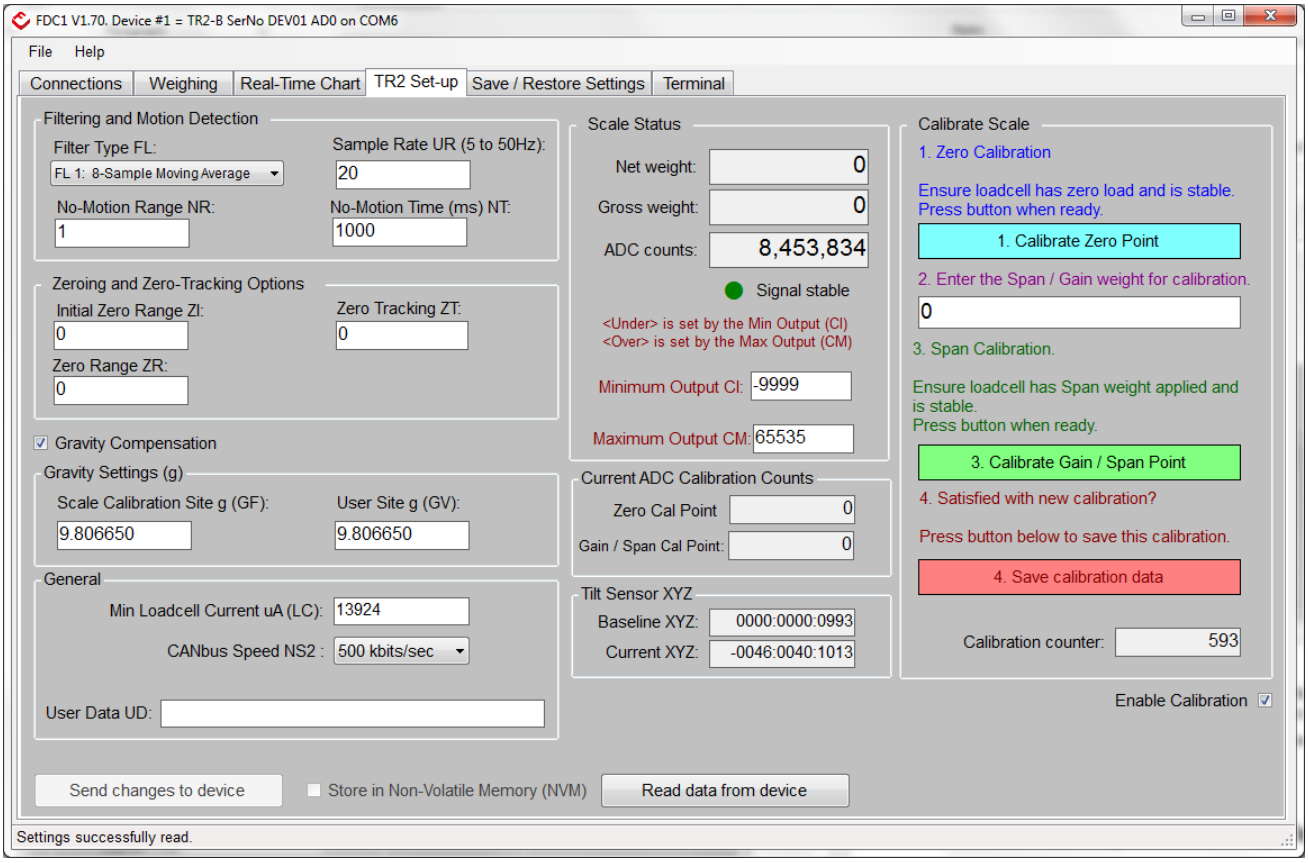


Figure 5 - Calibration controls now active

- Useful tip 1: Make sure the *[ADC counts]* is reading correctly by pressing down on the load-cell and observing that the ADC counts change.
- Useful tip 2: Make a note of the *[Calibration counter]* before starting calibration.

When the load-cell is stable press the *[1. Calibrate Zero Point]* button to calibrate the zero point.

10.5. Calibrate the Gain / Span Point

Enter 2000 in the *[2. Enter the Span / Gain weight for calibration*] and place a 2000g weight on the load-cell. Press the *[3. Calibrate Gain / Span Point]* to set this as the span.

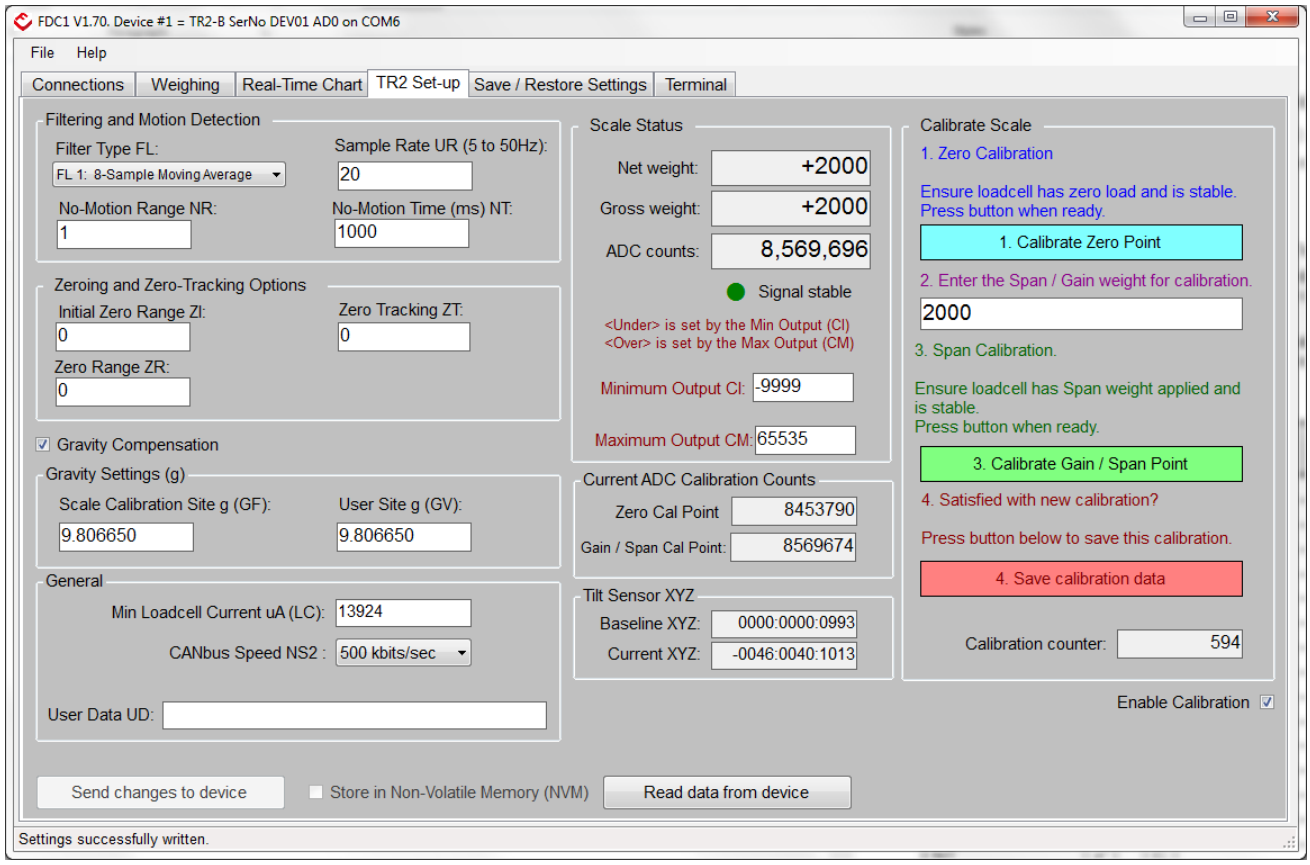


Figure 6- Calibration done and successfully saved

With Zero and Span calibration done press the *[4. Save calibration data]* button to save this calibration.

On completion of calibration observe the following:-

- Net and Gross weight now showing +2000(g)
- The current ADC calibration counts for zero and span are displayed.
- The Calibration counter has incremented from 593 to 594 to indicate a calibration has taken place.

10.6. Set the Minimum and Maximum limits

This is not part of the calibration but if you wish to restrict the weighing range transmitted then enter the following:-

- [Minimum Output CI] = -20
- [Maximum Output CI] = 2020
- Check the [Store in Non-Volatile Memory (NVM)] checkbox
- Press [Send changes to device]

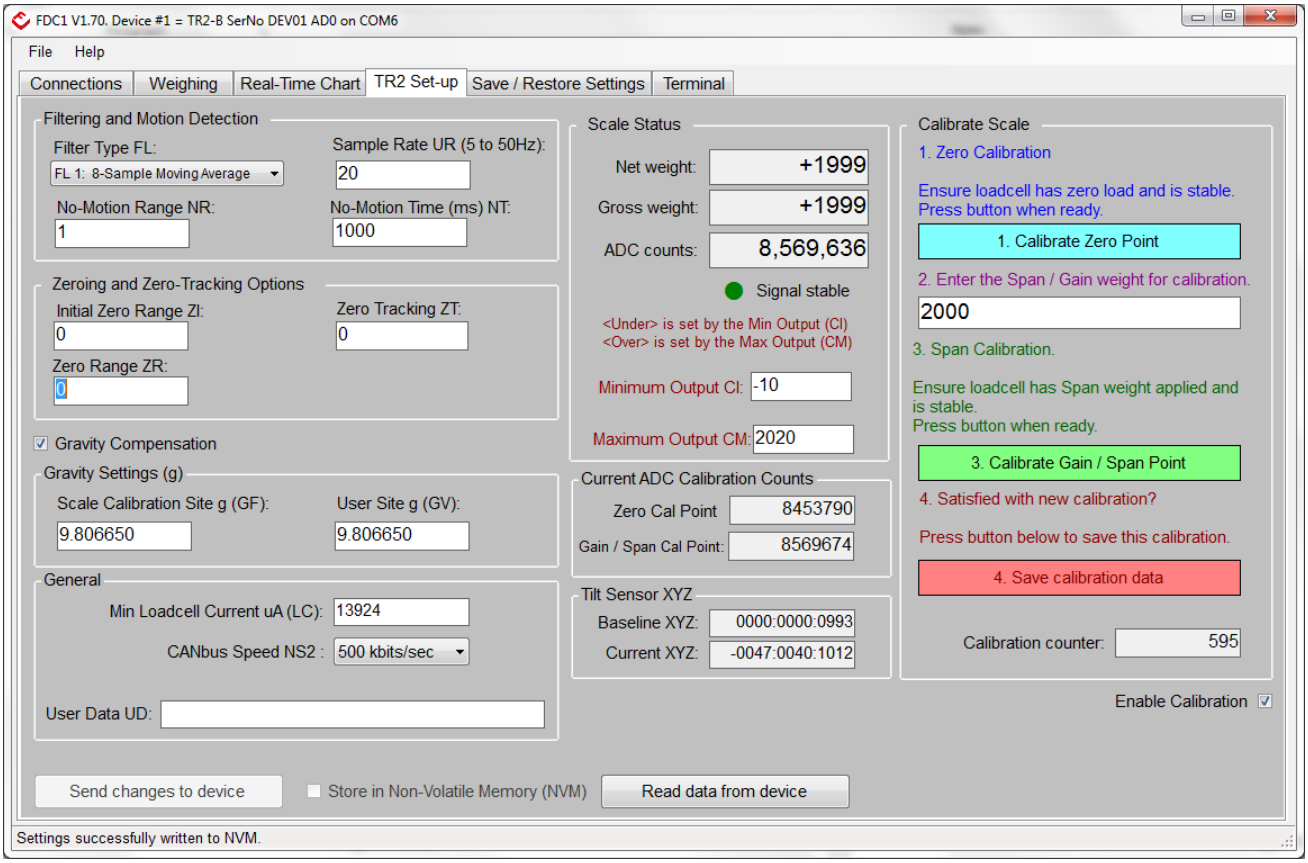


Figure 7- Minimum and Maximum Outputs successfully set

Text-based commands such as Get Gross (GG) and Get Net (GN) which return the weight will return an Over or Under weight message if the weight <-10 or >2020

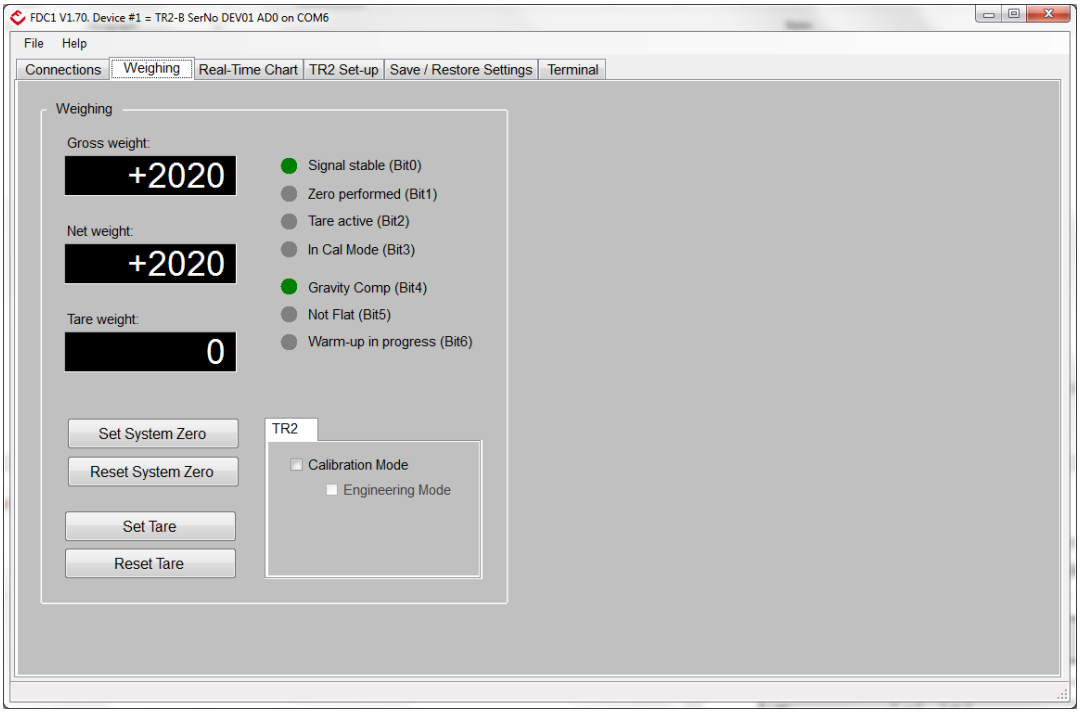


Figure 8 – Weighing tab showing load-cell with 2020g - reading still valid

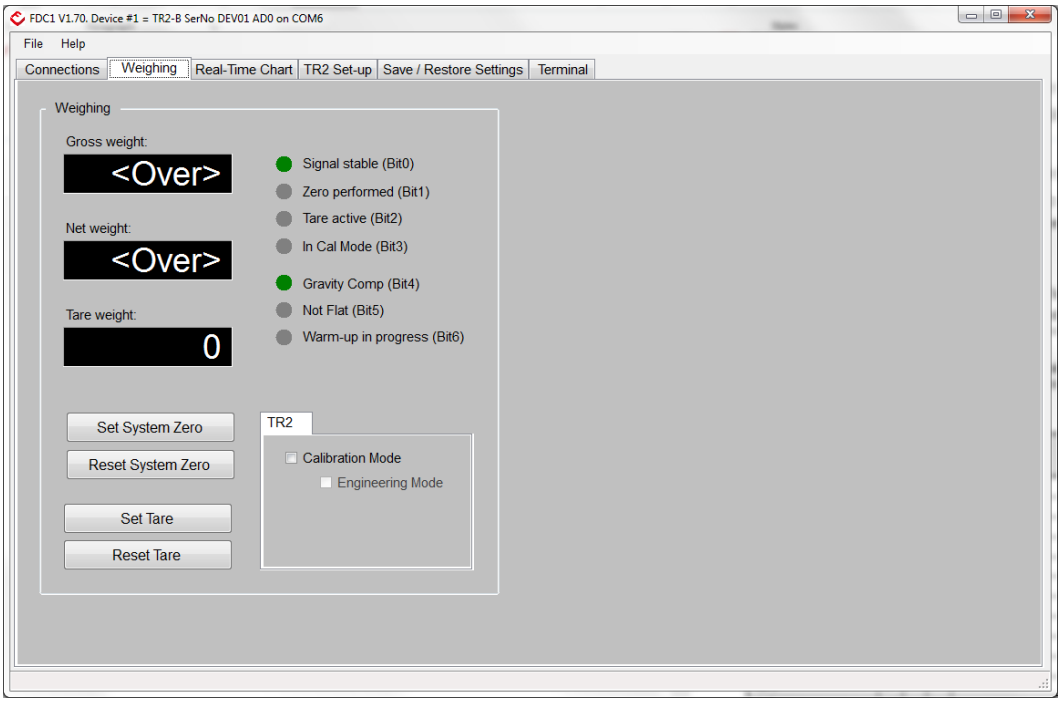


Figure 9 – Weighing tab showing load-cell with weight >2020g - returns Over status

11. Calibrate the TR2 manually using Terminal

When performing the previous calibration, the FDC hides all of what is going on “under the bonnet”.

Here we are going to use a Terminal and the text-based commands to perform the same calibration.

Though PC Terminal programs such as HyperTerm, TeraTerm and PuTTY can do the job the FDC has a handy ‘Terminal’ tab that allows for communicating with the TR2.

Note: If connecting to the TR2 by CAN then a CAN Terminal screen is displayed instead.

Using the FDC Terminal also saves having to mess around with getting the correct serial parameters and text terminator right.

Below is a screen-shot from the FDC Terminal of what was essentially done using the TR2 Calibration GUI

```
PW 632111
OK
CE
E+00595
CZ
OK
CW 2000
OK
CG
OK
CS
OK
CE
E+00596
CI -10
OK
CM 2020
OK
CS
OK
CE
E+00597
GG
G+02000.0
GG
Goooooooo
```

Figure 10- TR2 calibrated manually using text-based command set

11.1. Manual calibration breakdown

Here is a breakdown of the screenshot

Command	Response	Description
Load-cell unloaded (Zero)		
PW 632111<CR>	OK	Password – needed to allow calibration
CE<CR>	E+00595	Get Calibration counter = 595
CZ<CR>	OK	Calibrate System Zero (Zero Point)
CW 2000<CR>	OK	Set the calibration weight.
Load-cell loaded with 2000g		
CG<CR>	OK	Calibrate System Gain Point (Span)
CS<CR>	OK	Save Calibration Data (auto increments calibration counter)
CE<CR>	E+00596	Get Calibration counter = 596
CI -10<CR>	OK	Set the Minimum Output Value = -10g
CM 2020<CR>	OK	Set the Maximum Output Value = 2020g
CS<CR>	OK	Save Calibration Data
CE<CR>	E+00597	Get Calibration counter = 597
GG<CR>	G+02000.0	Get Gross Weight = 2000g (Calibration weight left on load-cell)
Load-cell loaded with > 2020g		
GG<CR>	Gooooooo	Get Gross Weight = weight exceeds Max (Weight exceeds Max Weight Value CM)

12. TR2 CAN

12.1. TR2 CAN Overview

- TR2 works to CAN 2.0B standard and uses 29-bit identifiers for all communications. Default speed = 500 kbps
- Only one TR2 can be on the bus. (The CAN ID is treated as a command and not an address.)
- The TR2 sends no periodic messages on the CAN bus and will never transmit an unsolicited message.
- Messages sent to the TR2 can be thought of as Read, Write or Execute commands.
- Read Command – RTR bit set.
- Write / Execute Command RTR bit clear.

RTR bit = Remote Transmit Request.

12.2. CAN Commands

A comprehensive list of TR2 CAN commands and information can be found in document:-

0087289.docm - TR2 Catalogue CAN Bus Communications Specification.

Further down this document is a list of CAN commands and the number of data bytes they write or read.

One thing to note is that setting and getting a parameter are 2 different commands.

For instance, the text-based command

"NR" (No-Motion Range) is used to get and set the NR parameter

whereas in CAN the command

0x1000000F = Get No-Motion Range
0x10000041 = Set No-Motion Range

12.3. CAN Write and Execute Command – Status bytes returned.

The CAN equivalent of the text-based General Status "IS" command is 0x10000005.

This returns 2 status bytes shown below.

However, CAN 'write' and 'execute' commands also return the same 2 status bytes which saves having to send a second command to get this status.

The reason for showing this is to aid the disassembly of the CAN write and execute messages.

10000005 [0][1] Status Bytes	Function
Byte [0] = System Status	
0x01	Measurement is stable (no motion).
0x02	Zero action performed.
0x04	Tare is active.
0x08	TR2 is in calibration mode.
0x10	Gravity compensation is active.
0x20	
0x40	TR2 warm-up is in progress.
Byte [1] = Status of last 'write' / 'execute' command	
0x00	None - success
0x02	Conditions not correct
0x04	Out of range
0x05	Message length

12.4. CAN Command breakdown

Here we show the breakdown of the read, write and execute commands. This data has been derived from using the FDC CAN Terminal further down.

12.4.1. Read Command - Get Calibration Counter

Get Calibration Counter is command 10000006 ("CE" text-based command).

FDC sends - 10000006 RTR

TR2 replies - 10000006 56 02

The read command requires the RTR bit set.

The CAN command table shows that this command returns 2 bytes.

The reply of 56 02 = 0x0256 (598 decimal).

12.4.2. Write Command - Set Calibration Mode Register (Password)

Set Cal Mode Register is command 10000040 ("PW 632111" text-based command).

FDC sends - 1000040 2F A5 09 00

TR2 replies - 100000005 09 00

The write command requires the RTR bit clear.

The CAN command table shows that this command writes 4 bytes.

2F A5 09 00 = 0x0009A52F (632111 decimal).

As it's a write command the 2 bytes returned are the 2 status bytes.

09 00 = In Cal Mode, Stable, No errors.

12.4.3. Execute Command - Calibrate System Zero

Calibrate System Zero is command 10000087 (“CZ” text-based command).

FDC sends - 10000087

TR2 replies - 10000005 09 00

The execute command requires the RTR bit clear.

As it’s an execute command the 2 bytes returned are the 2 status bytes.

09 00 = In Cal Mode, Stable, No errors.

12.5. Connect PC to TR2 using PCAN-USB

CAN communication between PC and TR2 has been successfully achieved using the PCAN-USB adaptor from PEAK-Systems.

Details on how to set up this adaptor and install the FDC program can be found in document:-

0088642.docm - Flintec Device Configurator (FDC) Quick Start Guide.

Before going any further ensure:-

- The PCAN-USB driver is installed.
- The PCAN-USB adaptor is connected to the TR2
- FDC is installed and opened.

12.6. Using Flintec Device Configurator (FDC) and TR2 CAN

With the FDC opened on the Connections tab, select the *[TR2 Catalog] tab.*

If the PCAN-USB driver and adaptor are all working the PCAN (PEAK-Systems PCAN-USB) option can be selected in the *[Connection type:]* (see below)

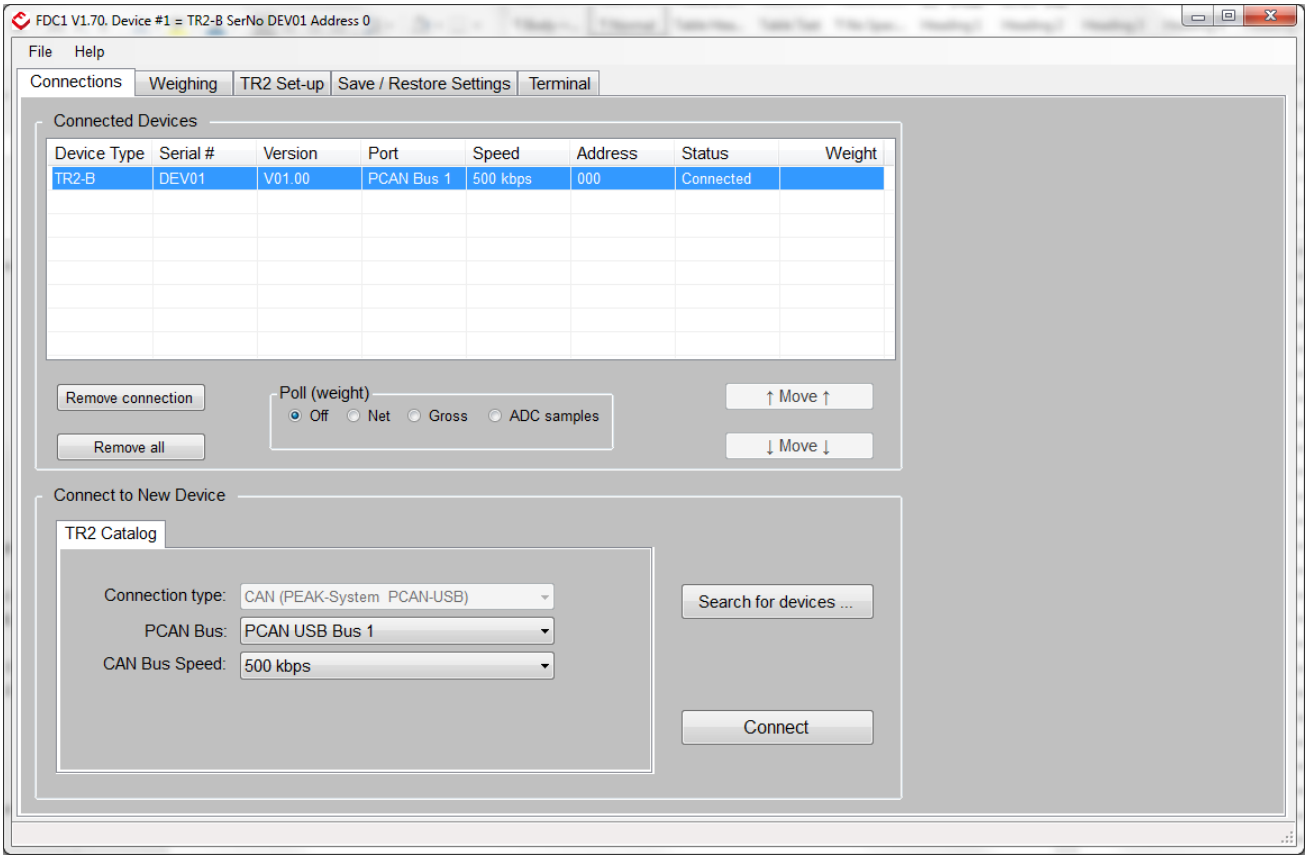


Figure 11- TR2 selected for CAN operation

Note: To connect another TR2 using CAN would require another PCAN-USB adaptor.

12.6.1. TR2 CAN Tabs

Once connected the Weighing, TR2 Set-up, Save/Restore Settings and Terminal tabs are active.

If you are familiar with using TR2 over Serial you will notice that apart from the Terminal tab, all the controls on the tabs are the same and the GUI is very familiar.

If you are not familiar with the FDC and just want to use the GUI to set-up and calibrate the TR2 check out the Serial set-up earlier in the document.

12.7. FDC CAN Terminal

Whilst it is easy to set up and calibrate the TR2 from the TR2 Set-up tab, we are going to use the TR2 CAN Terminal tab to calibrate the TR2.

The reason for this is so the user can get a good idea of the data that goes back and fore. Not all TR2 users are going to use the TR2 connected to a PC or require the FDC for their project.

Below is the TR2 CAN Terminal Tab. It consists of:-

Shortcuts – Assign your commonly used commands to a button.

Command [Message ID] – Highlight the command. Press Read or Write as required.

Select Target Device – If more than one TR2 connected select TR2 that requires set-up.

Manual Send – craft your own commands and data if they're not supported elsewhere in the FDC.

Response – See the command/data sent to the TR2 and its response.

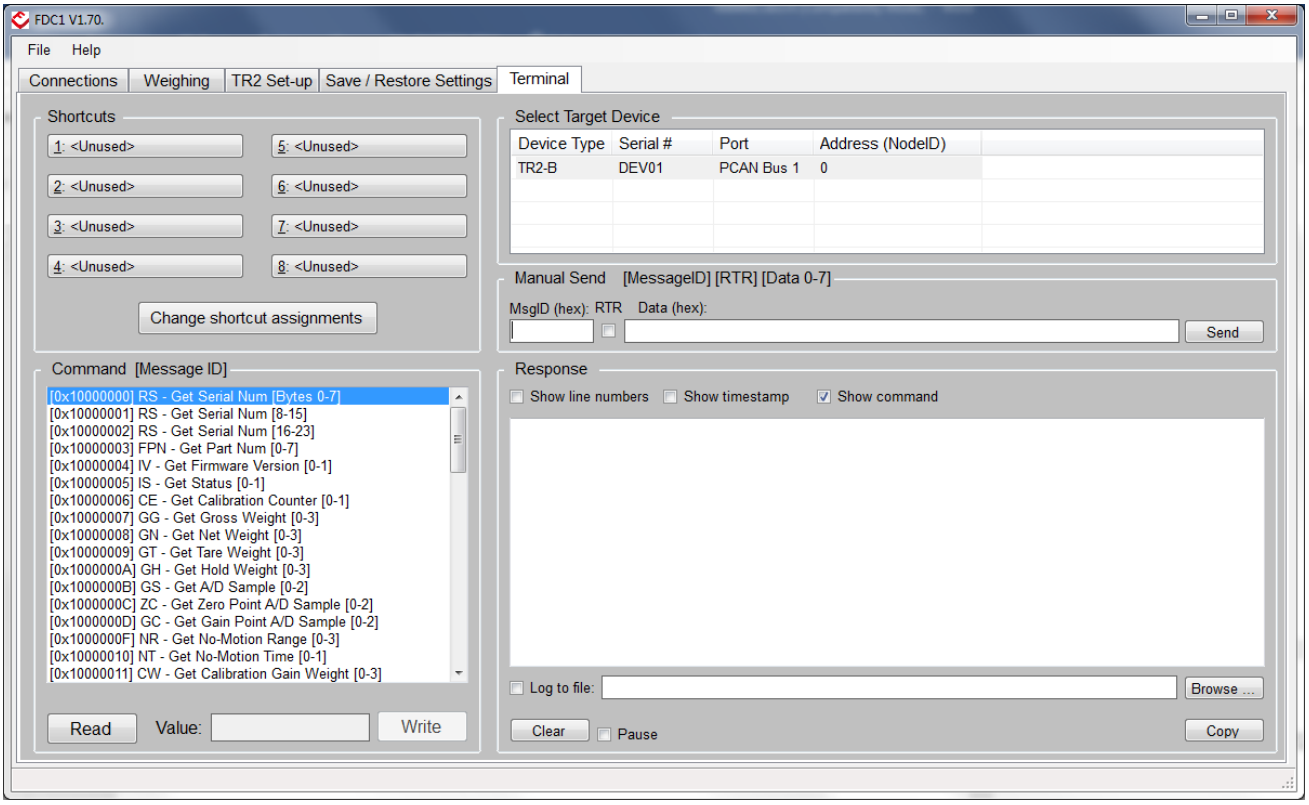


Figure 12 - TR2 CAN Terminal tab

12.8. Manually calibrate TR2 over CAN

This is similar to what was done earlier in the document where we used the Serial Terminal to manually calibrate the TR2 with a 2000g weight.

The steps of this exercise will be:

- Send the password to allow calibration
- Read the Calibration Counter (note the value)
- With load-cell unloaded - set the zero point
- Set the calibration weight (2000 in this case)
- With 2000g on load-cell, set the span point
- Save the calibration settings
- Read the Calibration Counter (should have advanced by 1)
- Set the Minimum Output (-10 in this case)
- Set the Maximum Output (2020 in this case)
- Save the calibration settings
- Read the Gross weight – should be 2000
- Add weight >2020g (> Max Output)
- Read the Gross Weight – check weight == 0x7FFFFFFF == Over Weight

12.8.1. Record the calibration process

```
10000040 2F A5 09 00
10000005 09 00
10000006 RTR
10000006 56 02
10000087
10000005 09 00
10000043 D0 07
10000005 09 00
10000088
10000005 09 00
10000089
10000005 09 00
10000006 RTR
10000006 57 02
10000045 F6 FF
10000005 09 00
10000046 E4 07
10000005 09 00
10000089
10000005 09 00
10000007 RTR
10000007 20 4E 00 00
10000007 RTR
10000007 FF FF FF 7F
```

Figure 13 - Screenshot of manually calibrating TR2 over CAN

12.8.2. Decode the commands, data and response

This shows the commands, data and response recorded in the screenshot and their meaning.

Command	Response	Description
Load-cell unloaded (Zero)		
1000040 2F A5 09 00	100000005 09 00	Cmd = Set Password = 0x09A52F (632111 decimal) Resp = In Cal Mode, Stable, No errors.
10000006 RTR	10000006 56 02	Cmd = Get Calibration Counter Resp = 0x0256 (598 decimal)
10000087	10000005 09 00	Cmd = Calibrate System Zero (Zero Point) Resp = In Cal Mode, Stable, No errors.
10000043 D0 07	10000005 09 00	Cmd = Set Calibration Gain Weight = 0x07D0 (2000g decimal) Resp = In Cal Mode, Stable, No errors.
Load-cell loaded with 2000g		
10000088	10000005 09 00	Cmd = Calibrate System Gain Point (Span) Resp = In Cal Mode, Stable, No errors.
10000089	10000005 09 00	Cmd = Save Calibration Data. Resp = In Cal Mode, Stable, No errors.
10000006 RTR	10000006 57 02	Cmd = Get Calibration counter Resp = 0x0257 (599 decimal)
10000045 F6 FF	10000005 09 00	Cmd = Set Minimum Output Value = 0xFFF6 (-10g decimal) Resp = In Cal Mode, Stable, No errors.
10000046 E4 07	10000005 09 00	Cmd = Set Maximum Output Value = 0x07E4 (2020g decimal Resp = In Cal Mode, Stable, No errors.
10000089	10000005 09 00	Cmd = Save Calibration Data Resp = In Cal Mode, Stable, No errors.
10000007 RTR	10000007 20 4E 00 00	Cmd = Get Gross Weight Resp = 0x00004E20 (20000 decimal)
Load-cell loaded with > 2020g		
10000007 RTR	10000007 FF FF FF 7F	Cmd = Get Gross Weight Resp = 0x7FFFFFFF (gross weight > max output value)

12.9. Using PCAN-View

If you decide to use the PCAN-USB adaptor from PEAK-Systems, then it is useful to know about their PCAN-View PC application for doing lower level work or debugging.

We've used PCAN-View in 2 scenarios:-

1. Where PCAN-View is the Master.
   Commands are entered into PCAN-View and sent to the CAN device and their response observed. (These commands can be saved so saving having to re-enter them.)

2. Where PCAN-View acts as a Man-in-the-Middle, where it monitors and displays traffic going back and fore between the PC and TR2

Here we are showing scenario 2 – Man-in-the-Middle

12.9.1. PCAN-View Man-in-the-Middle Mode (MitM)

- Ensure the FDC and TR2 are already communicating over CAN.
- Open up PCAN-View. It detects that the hardware is already in use so will act as a MitM.
- Ensure Extended is selected then press OK.

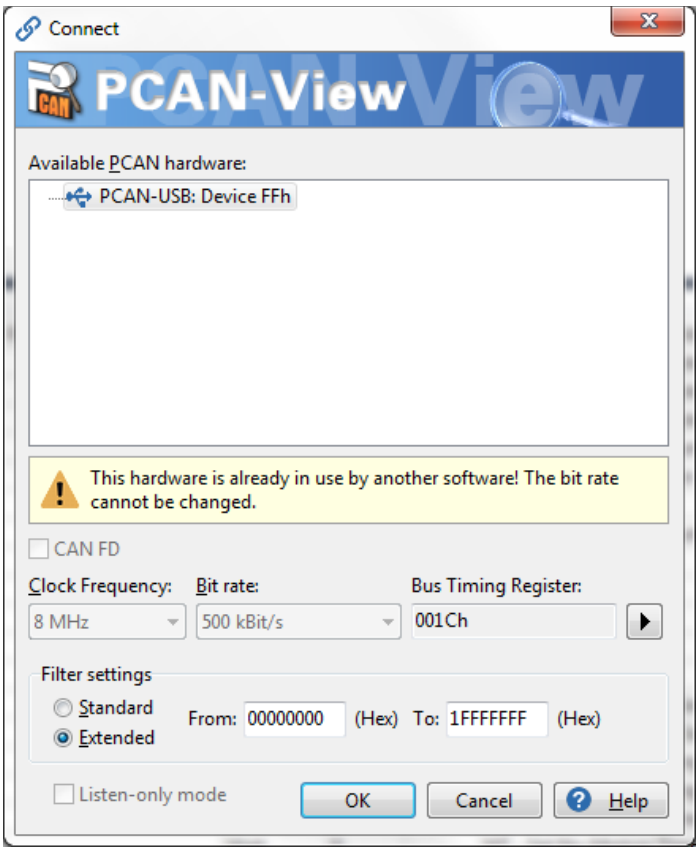


Figure 14 - PCAN-View ready to be used as a Man in the Middle

Earlier we showed and dissected a read, write and execute command. These were :-

- Read command – 0x10000006 – Get Calibration Counter

- Write command – 0x1000040 - Set Calibration Mode Register (Password)
- Execute command – 0x10000087 - Calibrate System Zero

We are going to send these commands from FDC to TR2 and allow PCAN-View to record the data. The screenshots below show the command/data transmitted and the command/data received.

12.9.2. Read command 0x10000006 – Get Calibration Counter

Receive / Transmit | Trace | PCAN-USB

CAN-ID	Type	Length	Data	Cycle Time	Count
10000006h	RTR	0			1
10000006h		2	58 02		1

As it's a read command the RTR bit is set.

The data = 0x0258 = 600 decimal.

12.9.3. Write command 0x1000040 - Set Calibration Mode Register (Password)

Receive / Transmit | Trace | PCAN-USB

CAN-ID	Type	Length	Data	Cycle Time	Count
10000040h		4	2F A5 09 00		1
10000005h		2	09 00		1

The data sent = 0x0009A52F = 632111 decimal.

Write commands always reply with the 2-byte General Status bytes.

09 00 = In Cal Mode, Stable, No errors.

12.9.4. Execute command 0x10000087 - Calibrate System Zero

Receive / Transmit | Trace | PCAN-USB

CAN-ID	Type	Length	Data	Cycle Time	Count
10000087h		0			1
10000005h		2	09 00		1

Execute commands do not supply any data but always reply with the 2-byte General Status bytes.

09 00 = In Cal Mode, Stable, No errors.

.

13. TR2 I2C

See document *0087552.docm - TR2 Catalogue I2C Bus Communications Specification* for a fuller description of using TR2 over I2C.

13.1. TR2 I2C Overview

- The TR2 will operate in slave mode, meaning that the master ECU will define the clock speed, though it is assumed that this will be around 20 kHz.
- The TR2 will operate in 7-bit addressing mode with a slave address of 0x03.

All communication on the I2C bus is driven by the master ECU and thus operates in a request/response format. The command set is broadly split into three command types: read commands, write commands and execute commands:

- Read commands are those which simply request data from the TR2.
- Execute commands are those which execute specific functions within the TR2.
- Write commands are those which store system data in the TR2's internal (***volatile***) memory.

14. Engineering Mode

When requesting Net, Gross or Tare Weight the reading is to 1 decimal place, but with the decimal place always set to 0.

Therefore a TR2 calibrated to weigh grams with 108.1g on the load-cell will show 108.0.

However, if Engineering Mode is activated the decimal place becomes valid, as shown below.

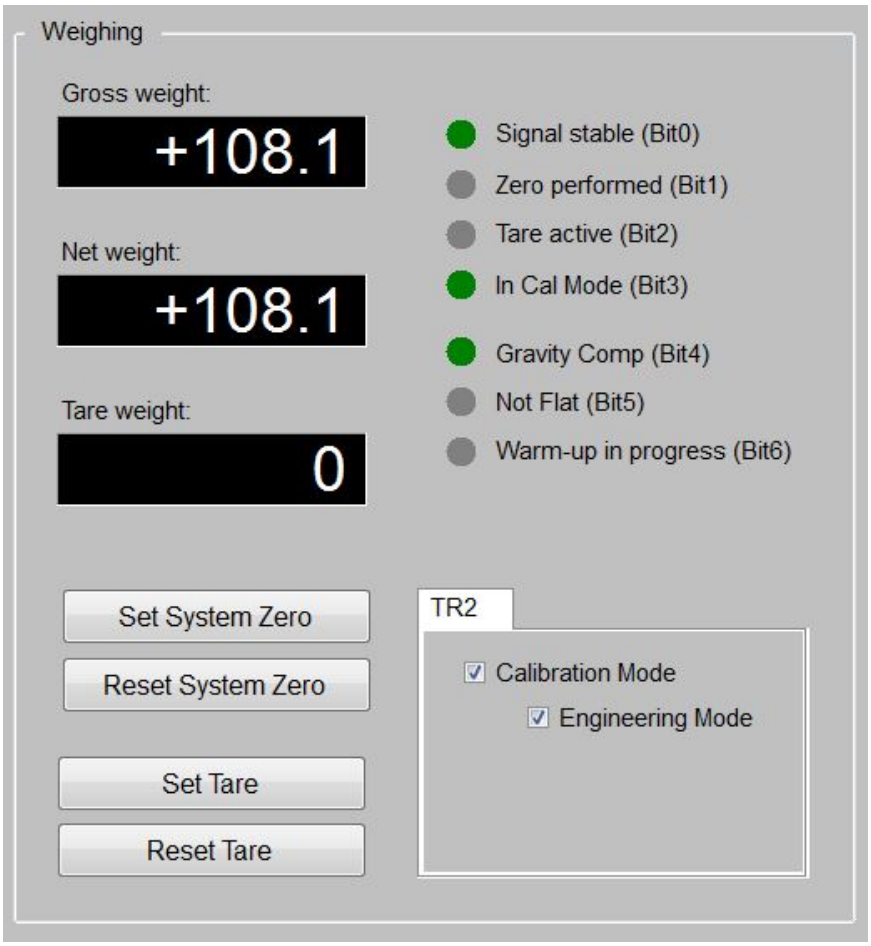


Figure 15 - FDC Weighing Tab showing Engineering Mode

14.1. Engineering Mode Commands

Text-Based	CAN	Notes
EM 0<CR> EM 1<CR>	0x1000004D	Disable / Enable Engineering Mode

15. TR2 Tilt Sensing

15.1. Overview

When weighing with a load-cell it is important that the load-cell is kept level so that the reading is accurate.

If the load-cell is tilted then the weight registered will not be as accurate. This may not be a problem for small angles of tilt but for larger angles it could give unacceptable readings.

The TR2 is fitted with an accelerometer chip that provides tilt information about the XYZ axes of the PCB.

If the TR2 and load-cell are fitted so that during operation they experience the same level of tilt then the tilt information supplied by the TR2 can be useful.

Note: The TR2 makes no tilt compensation of the weight or indication that its tilted. It is down to the user to inspect the XYZ reported by the TR2 and take the necessary action.

Each axis ranges from -1023 to +1023 counts, depending on its orientation to the earth's gravitational field.

Below shows how the axes line up with the PCB.

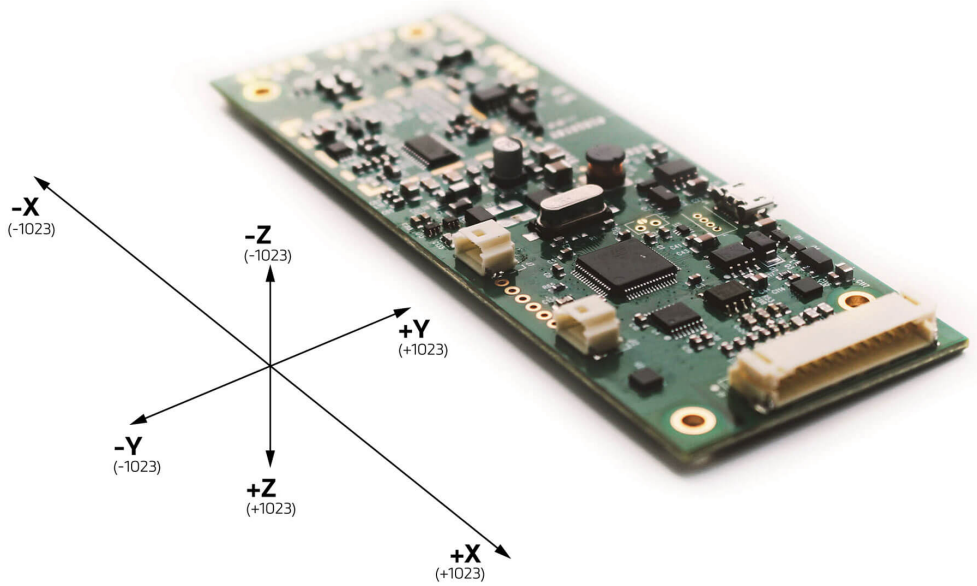


Figure 16 - TR2 showing accelerometer XYZ axes

15.2. Example

The simplest way to show the tilt sensor in action is an example.

Consider the PCB on a flat level surface. When the PCB is in this orientation the full gravitational effect is through the Z axis, with the X and Y axis seeing little to no gravitational component.

In an ideal situation we would see:

- X and Y axis showing approx. 0 counts
- Z axis is approx. +1023 counts.
- PCB now placed upside down. Z axis is approx. -1023 counts.

The best way to see the tilt feature in action is using the FDC application on the TR2 Set-up Tab.

15.3. Tilt Commands

Text-Based	CAN	Notes
CT<CR>	0x10008030	Record / Calibrate the Tilt baseline. (must be in Calibration Mode i.e. Password sent)
TC<CR>	0x1000001B	Get Tilt Sensor Baseline XYZ
TV<CR>	0x1000001C	Get Tilt Sensor Data XYZ

Full details of these command can be found in the relevant TR2 Text-based / CAN Communication Specification documents listed earlier.

15.4. Recording the Tilt Sensor baseline

Once the TR2 PCB is in its desired location, the tilt sensor baseline can be recorded.

Before issuing the CT or 0x10008030 make sure it is in Calibration Mode by sending the Password.

Note: At this time the FDC (V1.70) does not have a user-friendly control for setting the Tilt Baseline so will have to be done using the Terminal and sending the commands manually.

Even though the TR2 is in Calibration Mode there is no need to send the 'Save Calibration Data' command to save the baseline.

15.5. Using the FDC to see the Tilt Sensing in action

Open up the FDC TR2 Set-up tab and locate the Tilt Sensor XYZ readings.

For this particular TR2 the baseline has been set with the PCB on a horizontal surface. Notice the X and Y axes are closer to 0 counts whereas the Z axes is nearer +1023 counts.

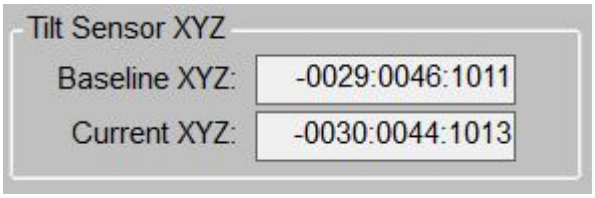


Figure 17 - Tilt Sensor on flattish surface

The TR2 long edge (on the left in the diagram) was then slightly raised and the readings recorded.

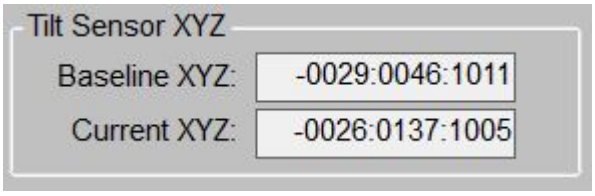


Figure 18- Tilt Sensor with nearest long edge slightly raised

This time the X and Z axes are still near their baseline values, but the Y axes has increased by nearly 100 counts.

15.6. Accelerometer – NXP MMA8452Q

The accelerometer used on the TR2 is the NXP MMA8452Q.

It is configured so that 1 count = 1g/1024 (g = gravity not grams)

Note: The relationship between the counts off the accelerometer and the tilt angle (degrees) is not linear. It is not correct to say that at 1024 / 2 = 512counts that the tilt angle is 45degs.

A useful document on this subject can be found at

https://www.nxp.com/files-static/sensors/doc/app_note/AN3107.pdf

16. TR2 Gravity Compensation

16.1. Overview

Gravity Compensation is usually required when a scale is calibrated in one location (say the factory where it was manufactured) and then moved to the customer location.

If the gravity values between the factory and customer location are different then the weight seen on the scale maybe higher or lower than expected.

To address this problem, the gravity at the factory is entered into the scale at calibration. When the scale moves to the customer site, the gravity value at the customer site is entered. The gravity differential between the 2 sites is then used to adjust the weight so that the reading is still accurate.

16.2. Gravity Compensation commands

Text-Based	CAN	Notes
GF<CR>	0x10000012 (Get) 0x1000004C (Set)	Calibration Gravity Value (i.e. Factory site)
GV<CR>	0x10000013 (Get) 0x10000044 (Set)	User Gravity Value (i.e. Customer Site)
EM<CR>	0x10000085	Enable Gravity Compensation
EM<CR>	0x10000086	Disable Gravity Compensation
IS<CR>	0x10000005	General Status Bit4 = Gravity comp is active / not active

Because these commands affect the weight reading they can only be used in Calibration Mode (Password needs to have been entered first) and require the the 'Save Calibration Data' command to save them.

Full details of these command can be found in the relevant TR2 Text-based / CAN Communication Specification documents listed earlier.

16.3. Display Gravity Compensation values in FDC

The FDC fully supports setting Gravity Compensation in the TR2 Set-up Tab.

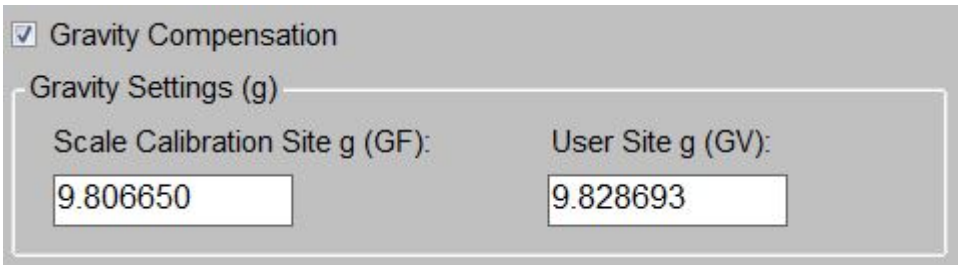


Figure 19 - FDC displaying Gravity Compensation values between 2 different site

17. TR2 Communication Commands

Below are the commands used over Serial (RS232 and USB-CDC), CAN and I2C.

They have been extracted from their respective specification documents which are also listed.

These documents are well detailed, so the contents are not repeated here.

17.1. Serial Text-Based Commands

From document 0084789.docm - TR2 Catalogue Text-Based Communications Specification

The table below shows a summary of the commands available on the RS232 and USB-CDC interfaces, showing which commands read system data (R), write system data (W) or execute TR2 functions(X).

A tick (check) mark shows that the operation is available in all modes, whereas a 'C' entry denotes that the TR2 must be in calibration mode to access the operation (i.e. the correct passcode has been written to the calibration mode register).

Command code	R	X	W	Description
RS	✓			TR2 Serial Number
FPN	✓			TR2 Part Number
FFV	✓			TR2 Firmware Version Number
IS	✓			TR2 General Status
CE	✓			Calibration Counter
PW			✓	Calibration Mode Password
GG	✓			Gross Weight
SG	✓			Stream Gross Weight
GN	✓			Net Weight
GT	✓			Tare Weight
GH	✓			Hold Weight
GS	✓			Current A/D Converter Sample
ZC	✓			Zero-Point A/D Converter Sample
GC	✓			Gain Point A/D Converter Sample
NR	✓		C	No-Motion Range
NT	✓		C	No-Motion Time
CW	✓		C	Calibration Span / Gain weight
CI	✓		C	Minimum Output Value
CM	✓		C	Maximum Output Value
ZR	✓		C	Zero Range
ZI	✓		C	Initial Zero Range
ZT	✓		C	Zero Tracking Value

Command code	R	X	W	Description
GF	✓		C	Calibration Gravity Value
GV	✓		C	User Gravity Value
FL	✓		C	Filter Type
UR	✓		C	Sample Rate
NS2	✓		C	CAN Bus Speed
EM	✓		C	Engineering Mode
TC	✓			Tilt Sensor Baseline
TV	✓			Tilt Sensor Data
UD	✓		C	User Data
ES	✓			Error Status
LC	✓		C	Minimum Expected Load Cell Current
HW		✓		Hold Weight
ST		✓		Set Tare Value
RT		✓		Reset Tare Value
SZ		✓		Set System Zero
RZ		✓		Reset System Zero
EG		C		Enable Gravity Compensation
DG		C		Disable Gravity Compensation
CZ		C		Calibrate System Zero
CG		C		Calibrate System Gain Point
CS		C		Save Calibration Data
FD		C		Restore Factory Defaults
SR		✓		Reset Firmware
FU		✓		Upgrade Firmware

17.2. CAN Commands

From document 0087289.docm - TR2 Catalogue CAN Bus Communications Specification

Message ID	Data Length	Description
'Read' Messages. The RTR bit will be set. (RTR = Remote Transmit Request)		
0x10000000	8 bytes	Get TR2 Serial Number (bytes 0 - 7)
0x10000001	8 bytes	Get TR2 Serial Number (bytes 8 - 15)
0x10000002	8 bytes	Get TR2 Serial Number (bytes 16 - 23)
0x10000003	8 bytes	Get TR2 Part Number
0x10000004	2 bytes	Get TR2 Firmware Version
0x10000005	2 bytes	TR2 General Status
0x10000006	2 bytes	Get Calibration Counter
0x10000007	4 bytes	Get Gross Weight
0x10000008	4 bytes	Get Net Weight
0x10000009	4 bytes	Get Tare Weight
0x1000000A	4 bytes	Get Hold (Net) Weight
0x1000000B	3 bytes	Get Current A/D Converter Sample
0x1000000C	3 bytes	Get Zero Point A/D Converter Sample
0x1000000D	3 bytes	Get Gain Point A/D Converter Sample
0x1000000F	4 bytes	Get No-Motion Range
0x10000010	2 bytes	Get No-Motion Time
0x10000011	4 bytes	Get Calibration Gain Weight
0x10000012	4 bytes	Get Calibration Gravity Value
0x10000013	4 bytes	Get User Gravity Value
0x10000014	4 bytes	Get Minimum Output Value
0x10000015	4 bytes	Get Maximum Output Value
0x10000016	4 bytes	Get Zero Range
0x10000017	4 bytes	Get Initial Zero Range
0x10000018	1 byte	Get CAN Bus Speed
0x10000019	1 byte	Get Filter Type
0x1000001A	1 byte	Get Sample Rate
0x1000001B	6 bytes	Get Tilt Sensor Baseline
0x1000001C	6 bytes	Get Tilt Sensor Data
0x1000001D	8 bytes	Get User Data (bytes 0-7)
0x1000001E	8 bytes	Get User Data (bytes 8-15)
0x1000001F	8 bytes	Get User Data (bytes 16-23)
0x10000020	8 bytes	Get User Data (bytes 24-31)
0x10000021	2 bytes	Get Error Status
0x10000022	2 bytes	Get Minimum Expected Loadcell Current
0x10000023	1 byte	Get Engineering Mode
0x10000024	1 byte	Get Zero Tracking

Message ID	Data Length	Description
'Write' Messages. The RTR bit will be clear.		
0x10000040	4 bytes	Set Calibration Mode Register (Password)
0x10000041	2 bytes	Set No-Motion Range
0x10000042	2 bytes	Set No-Motion Time
0x10000043	2 bytes	Set Calibration Gain Weight
0x10000044	4 bytes	Set User Gravity Value
0x10000045	2 bytes	Set Minimum Output Value
0x10000046	2 bytes	Set Maximum Output Value
0x10000047	2 bytes	Set Zero Range
0x10000048	2 bytes	Set Initial Zero Range
0x10000049	1 byte	Set CAN Bus Speed
0x1000004A	1 byte	Set Filter Type
0x1000004B	1 byte	Set Sample Rate
0x1000004C	4 bytes	Set Calibration Gravity Value
0x1000004D	1 byte	Set Engineering Mode
0x1000004E	8 bytes	Set User Data (bytes 0-7)
0x1000004F	8 bytes	Set User Data (bytes 8-15)
0x10000050	8 bytes	Set User Data (bytes 16-23)
0x10000051	8 bytes	Set User Data (bytes 24-31)
0x10000052	2 bytes	Set Minimum Expected Loadcell Current
0x10000053	1 byte	Set Zero Tracking
'Execute' Messages. The RTR bit will be clear.		
0x10000080	0 bytes	Set the Hold Weight
0x10000081	0 bytes	Set Tare Value
0x10000082	0 bytes	Reset Tare Value
0x10000083	0 bytes	Set System Zero
0x10000084	0 bytes	Reset System Zero
0x10000085	0 bytes	Enable Gravity Compensation
0x10000086	0 bytes	Disable Gravity Compensation
0x10000087	0 bytes	Calibrate System Zero
0x10000088	0 bytes	Calibrate System Gain Point
0x10000089	0 bytes	Save Calibration Data
0x1000008A	0 bytes	Restore Factory Defaults
0x1000008B	0 bytes	Reset Firmware

17.3. I2C Commands

From document 0087552.docm - TR2 Catalogue I2C Bus Communications Specification

Command code	R	X	W	Description
0x00	✓			Read Serial Number
0x01	✓			Read Firmware Version
0x02	✓			Read General Status
0x03	✓			Read Calibration Counter
0x04	✓			Read Gross Weight
0x05	✓			Read Net Weight
0x06	✓			Read Tare Weight
0x07	✓			Read Hold Weight
0x08	✓			Read current A/D Converter Sample
0x09	✓			Read Zero Point A/D Converter Sample
0x0A	✓			Read Gain Point A/D Converter Sample
0x0C	✓			Read No-Motion Range
0x0D	✓			Read No-Motion Time
0x0E	✓			Read Calibration Span / Gain weight
0x0F	✓			Read Minimum Output Value
0x10	✓			Read Maximum Output Value
0x11	✓			Read Zero Range
0x12	✓			Read Initial Zero Range
0x13	✓			Read Part Number
0x14	✓			Read Calibration Gravity Value
0x15	✓			Read User Gravity Value
0x16	✓			Read Filter Type
0x17	✓			Read Sample Rate
0x18	✓			Read Tilt Sensor Baseline
0x19	✓			Read Tilt Sensor Data
0x1A	✓			Read User Data
0x1B	✓			Read Error Status
0x1C	✓			Read Minimum Expected Load Cell Current
				Read Zero Tracking - TBC
0x80		✓		Set Hold Weight
0x81		✓		Set Tare Value
0x82		✓		Reset Tare Value
0x83		✓		Set System Zero
0x84		✓		Reset System Zero
0x85		✓		Enable Gravity Compensation
0x86		✓		Disable Gravity Compensation
0x87		C		Calibrate System Zero
0x88		C		Calibrate System Gain Point

Command code	R	X	W	Description
0x89		C		Save Calibration Data
0x8A		C		Restore Factory Defaults
0x8B		✓		Reset Firmware
0xC0			C	Set No-Motion Range
0xC1			C	Set No-Motion Time
0xC2			C	Set Calibration Gain Weight
0xC3			C	Set User Gravity Value
0xC4			C	Set Minimum Output Value
0xC5			C	Set Maximum Output Value
0xC6			C	Set Zero Range
0xC7			C	Set Initial Zero Range
0xC8			C	Set Calibration Mode Register
0xC9			C	Set Filter Type
0xCA			C	Set Sample Rate
0xCB			C	Set Calibration Gravity Value
0xCC			C	Set Engineering Mode
0xCD			C	Set User Data
0xCE			C	Set Minimum Expected Load Cell Current
				Set Zero Tracking - TBC
				Tilt Calibration - TBC