TR2 [Catalogue] Firmware

I^2C Communication Specification

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Document History

Rev.	Date	Author	Details of change
A	2019-11-12	Ian Chalinder	First release, for firmware V1.0

1. Purpose

The purpose of this document is to define the I^2C serial interface of the TR2 electronics module. It defines both the details and implementation of the I^2C protocol and the command codes needed to access the data and functions of the TR2.

2. Scope

This document is applicable only to the Flintec TR2 catalogue part firmware (Flintec part number 0087549. Refer to the TR2's Software Release Notes **[1]** for details of the document revision on which a particular firmware release is based.
This specification defines only the software layers of the communication bus; the physical layer implementation is not defined here and is outside the scope of this document.

3. References

This document should be read in conjunction with those detailed in the table below:

#	Doc. Number	Rev.	Title
1	0087550	All	TR2 [Catalogue] Firmware Release Note

Table 1 - References

4. Fixed Functions and Values

As well as a number of factory-changeable and user-changeable parameters, there are a number of values and functions which are set in the firmware and cannot be altered. These form the basis of the operation of the TR2 and customers' software must work within these parameters to achieve their own required functionality.
The following aspects of the TR2 are fixed as described below:

- The TR2 is single interval, single range
- The TR2 has a fixed display step size of 1 interval (1 gramme, 1 kg, 1 lb etc. relative to the defined calibration weight)

5. I^2C Protocol Settings

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.

6. I²C Communications Implementation

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.

6.1. I²C implementation for 'read' commands

To read a data value from the TR2, the master node first writes the command code into the slave followed by a checksum byte. The master node then uses the repeated start mechanism of I²C to begin the read part of the transaction to clock out the response, the requested data and a checksum (as described in section 6.4 below).
During the transaction, the slave may use clock stretching at any time in order to decode the request and prepare the data response.
All 'read' commands must adhere to the following format:

Byte number	Data	Description
0	0x06	Slave address 0x03 and R/W set to 'write'.
1	Command code	See section 7 below.
2	Checksum	Checksum for the command code (see section 6.4 below).
		Repeated start bit
3	0x07	Slave address 0x03 and R/W set to 'read'.
4	Response code	See Table 5 below.
5 ... N-1	Data	Master drives the clock. Slave transmits the requested data.
N	Checksum	Master drives the clock. Slave transmits the checksum (see section 6.4 below).

Table 2 - Command format for a read request

6.2. I²C implementation for 'execute' commands

To execute a TR2 command, the master node first writes the command code into the slave followed by a checksum byte. The master node then uses the repeated start mechanism of I²C to begin the read part of the transaction to clock out a response code.
All command execution requests must adhere to the following data format:

Byte number	Data	Description
0	0x06	Slave address 0x03 and R/W set to 'write'.
1	Command code	See section 7 below.
2	Checksum	See section 6.4 below.
		Repeated start bit
3	0x07	Slave address 0x03 and R/W set to 'read'.
4	Response code	Master drives the clock. Slave transmits response code (see Table 5 below).
5	Checksum	Master drives the clock. Slave transmits the checksum (see section 6.4 below).

Table 3 - Command format for an execute request

6.3. I²C implementation for 'write' commands

To write a value to the TR2's internal (***volatile***) memory, the master node first writes the command code into the slave followed by the data to be written and a checksum byte. The master node then uses the repeated start mechanism of I²C to begin the read part of the transaction to clock out a response code and checksum.
All 'write' commands must adhere to the following format:

Byte number	Data	Description
0	0x06	Slave address 0x03 and R/W set to 'write'.
1	Command code	See section 7 below.
2 … N	Data to write	
N + 1	Checksum	See section 6.4 below.
		Repeated start bit

Byte number	Data	Description
N + 2	0x07	Slave address 0x03 and R/W set to 'read'.
N + 3	Response code	Master drives the clock. Slave transmits response code (see Table 5 below).
N + 4	Checksum	Master drives the clock. Slave transmits the checksum (see section 6.4 below).

Table 4 - Command format for a write request

6.4. Checksum transmission

Both commands and responses include a checksum byte to help guard against data corruption during transmission. In all cases, the data included in the checksum will be all bytes *between* (but not including) the last slave address transmitted and the checksum byte itself.
A checksum is calculated by starting with a seed byte of 0x1C and performing a running bitwise exclusive-OR calculation on each byte of data. Consequently, if the same calculation is performed on the data range and the checksum itself, the resulting value will be zero.

6.5. Error handling

As described above, each request from the master node will elicit a response from the slave node (assuming there is no corruption of the slave address during transmission). Each response sent from the slave node will include a response code to indicate whether the command has been received and executed successfully. The full list of valid response codes is given below.
Given that the master node always drives the clock signal and that it will clock in data for every clock pulse sent, data clocked in by the master following any failure response code from the slave must be considered as invalid and should be discarded. Similarly, any data clocked in as a result of 'extra' clock pulses at the end of a valid command will also be invalid, even though a success response has already been returned.
The following table shows the list of valid response codes that will be sent by the TR2 during the 'read' phase of each I^2C transaction.

Command code	Error type	Description
0x00	None - success	A valid request was received and executed.
0x01	Illegal command	The command code received is unrecognised.

Command code	Error type	Description
0x02	Conditions not correct	The command code is recognised, but the command cannot be executed at the time (e.g. the user is not authorised to make the request).
0x03	Checksum error	The received checksum does not match that calculated internally for the received data.
0x04	Out of range	Data for a write command is outside of the legal range for the parameter being written.

Table 5 - List of valid response codes

7. I²C Command Codes

The following is a list of command codes that can be used to access the data and functions of the TR2. Where a request can only be executed in calibration mode, this is shown in the 'Special access' field of the command definition.

7.1. 'Read' commands

The following commands are those which read data from the TR2. They should be sent in the format described in section 6.1 above.

7.1.1. Read Serial Number

Description:	This command returns the unique serial number of the TR2. The serial number is returned as a 24-byte ASCII string. If the serial number is less than 24 characters long, it will be padded with null characters.
Command code:	0x00
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1 … Byte 24: See description above. Byte 25: Checksum.
Special access:	None.

7.1.2. Read Firmware Version

Description:	This command returns the TR2's major and minor firmware revision numbers.
Command code:	0x01
Command parameters:	Byte 0: Checksum.

Response parameters:	Byte 0: Response code. Byte 1: Major firmware version number. Byte 2: Minor firmware revision. Byte 3: Checksum.
Special access:	None.

7.1.3. Read General Status

Description:	This command returns information about the current state of the TR2. The status is returned as a 1-byte bit-mapped data with the following bit values: 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: Tilt sensor detects scale is not flat. 0x40: The TR2 warm-up period is in progress.
Command code:	0x02
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: TR2 Status, as detailed above. Byte 2: Checksum.
Special access:	None.

7.1.4. Read Calibration Counter

Description:	This command returns the current value of the TR2's calibration counter. The value of the calibration counter cannot be changed manually but will be automatically incremented each time the 'Save Calibration Data' or 'Restore Factory Defaults' command is executed.
Command code:	0x03
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Calibration counter LSB. Byte 2: Calibration counter MSB. Byte 3: Checksum.
Special access:	None.

7.1.5. Read Gross Weight

Description:	This command returns the gross weight as an 8-byte, fixed-format string of ASCII characters representing the weight on the scale in intervals. The string will be of the following format: [+,-]00000.0 If the gross weight is below the Minimum Output Value (see section 7.1.15 below), the ASCII string “uuuuuuuu” will be returned. If the gross weight is above the Maximum Output Value (see section 7.1.16 below), the ASCII string “oooooooo” will be returned. Note that there is no null-terminator at the end of these strings.
Command code:	0x04
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1 … Byte 8: See description above. Byte 9: Checksum.
Special access:	None.

7.1.6. Read Net Weight

Description:	This command returns the net weight as an 8-byte, fixed-format string of ASCII characters representing the weight on the scale in intervals. The string will be of the following format: [+,-]00000.0 If the gross weight is below the Minimum Output Value (see section 7.1.15 below), the ASCII string “uuuuuuuu” will be returned. If the gross weight is above the Maximum Output Value (see section 7.1.16 below), the ASCII string “oooooooo” will be returned. Note that there is no null-terminator at the end of these strings.
Command code:	0x05
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1 … Byte 8: See description above. Byte 9: Checksum.
Special access:	None.

7.1.7. Read Tare Weight

Description:	This command returns the tare weight as an 8-byte, fixed-format string of ASCII characters representing the tare weight in intervals. The string will be of the following format:

	[+,-]00000.0 If the tare function is not currently active, the tare weight will be zero.
Command code:	0x06
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1 … Byte 8: See description above. Byte 9: Checksum.
Special access:	None.

7.1.8. Read Hold Weight

Description:	This request returns the net weight that was stored in the TR2 the last time the 'Set Hold Weight' command was executed. The hold weight is returned as an 8-byte, fixed-format string of ASCII characters in the following format: [+,-]00000.0 If the 'Set Hold Weight' command has not been executed since the TR2 was powered on or reset, the hold weight will be zero. If the hold weight is below the Minimum Output Value (see section 7.1.15 below), the ASCII string "uuuuuuuu" will be returned. If the hold weight is above the Maximum Output Value (see section 7.1.16 below), the ASCII string "oooooooo" will be returned. Note that there is no null-terminator at the end of these strings.
Command code:	0x07
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1 … Byte 8: See description above. Byte 9: Checksum.
Special access:	None.

7.1.9. Read current A/D Converter Sample

Description:	This command returns the current A/D converter sample value as a 24-bit unsigned integer.
Command code:	0x08
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: ADC Sample byte 0 (LSB). Byte 2: ADC Sample byte 1. Byte 3: ADC sample byte 2 (MSB). Byte 4: Checksum.

Special access:	None.

7.1.10. Read Zero Point A/D Converter Sample

Description:	This request returns the A/D converter value that was used to calibrate the system's zero point. It is given as a 24-bit unsigned integer.
Command code:	0x09
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: ADC Sample byte 0 (LSB). Byte 2: ADC Sample byte 1. Byte 3: ADC sample byte 2 (MSB). Byte 4: Checksum.
Special access:	None.

7.1.11. Read Gain Point A/D Converter Sample

Description:	This request returns the A/D converter value that was used to calibrate the system's gain (span) point. It is given as a 24-bit unsigned integer.
Command code:	0x0A
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: ADC Sample byte 0 (LSB). Byte 2: ADC Sample byte 1. Byte 3: ADC sample byte 2 (MSB). Byte 4: Checksum.
Special access:	None.

7.1.12. Read No-Motion Range

Description:	This command returns the weight range inside which the weight signal may be considered as stable. If the weight does not fluctuate by more than this value during the time period specified by 'No-motion Time', the weight is considered to be stable (and the appropriate bit is set in the system status byte).
Command code:	0x0C
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: No-motion range LSB.

	Byte 2: No-motion range MSB. Byte 3: Checksum.
Special access:	None.

7.1.13. Read No-Motion Time

Description:	This command returns the no-motion time in milliseconds. See the description in section 7.1.12 above for details of the no-motion definition).
Command code:	0x0D
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: No-motion time LSB. Byte 2: No-motion time MSB. Byte 3: Checksum.
Special access:	None.

7.1.14. Read Calibration Span / Gain weight

Description:	This command returns the weight (in intervals) that was (or will be) used to calibrate the gain (span) of the scale.
Command code:	0x0E
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Calibration span weight LSB. Byte 2: Calibration span weight MSB. Byte 3: Checksum.
Special access:	None.

7.1.15. Read Minimum Output Value

Description:	This command returns the minimum weight (in intervals) at which the gross weight output changes to show the under-range error value of 'uuuuuuuu'.
Command code:	0x0F
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Minimum output value LSB. Byte 2: Minimum output value MSB. Byte 3: Checksum.
Special access:	None.

7.1.16. Read Maximum Output Value

Description:	This command returns the maximum weight (in intervals) at which the gross weight output changes to show the over-range error value of 'ooooooo'.
Command code:	0x10
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Maximum output value LSB. Byte 2: Maximum output value MSB. Byte 3: Checksum.
Special access:	None.

7.1.17. Read Zero Range

Description:	This command returns the weight (in intervals) within which the scale can be manually zeroed using the 'Set System Zero' command.
Command code:	0x11
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Zero range value LSB. Byte 2: Zero range value MSB. Byte 3: Checksum.
Special access:	None.

7.1.18. Read Initial Zero Range

Description:	This command returns the weight (in intervals) within which the scale will perform an automatic 'Set System Zero' after power-up or reset.
Command code:	0x12
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Initial zero range value LSB. Byte 2: Initial zero range value MSB. Byte 3: Checksum.
Special access:	None.

7.1.19. Read Part Number

Description:	This command returns the Flintec part number of the TR2 electronics module. The part number is returned as an 8-byte ASCII string. If the

	part number is less than 8 characters long, it will be padded with null characters.
Command code:	0x13
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1 … Byte 8: See description above. Byte 9: Checksum.
Special access:	None.

7.1.20. Read Calibration Gravity Value

Description:	This command returns the gravity value that was present during calibration of the TR2 module. The calibration value of g is specified in $ms^{-2} * 10^6$ and is returned as a 32-bit unsigned integer.
Command code:	0x14
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Calibration gravity value byte 0 (LSB). Byte 2: Calibration gravity value byte 1. Byte 3: Calibration gravity value byte 2. Byte 4: Calibration gravity value byte 3 (MSB). Byte 5: Checksum.
Special access:	None.

7.1.21. Read User Gravity Value

Description:	This request returns the gravity value that is to be used in the current location when gravity compensation is enabled. The user value of g is specified in $ms^{-2} * 10^6$ and is returned as a 32-bit unsigned integer.
Command code:	0x15
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: User gravity value byte 0 (LSB). Byte 2: User gravity value byte 1. Byte 3: User gravity value byte 2. Byte 4: User gravity value byte 3 (MSB). Byte 5: Checksum.
Special access:	None.

7.1.22. Read Filter Type

Description:	This command returns the current filter setting of the TR2. The filter type is represented as an enumerated data type and has one of the following values: 0: No filtering (uses latest ADC sample only) 1: An 8-sample moving average 2: A 32-sample moving average 3: The Flintec 'baby' algorithm The filter type is returned as an 8-bit unsigned integer.
Command code:	0x16
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Filter type. Byte 2: Checksum.
Special access:	None.

7.1.23. Read Sample Rate

Description:	This command returns the current ADC sample rate of the TR2 in Hertz (samples per second). The valid range is from 5 Hz to 50 Hz.
Command code:	0x17
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: TR2 sample rate in Hz. Byte 2: Checksum.
Special access:	None.

7.1.24. Read Tilt Sensor Baseline

Description:	This command returns the x-, y- and z-axis data values that were read from the tilt sensor (accelerometer) at the time the factory calibration took place. These values are the references used to determine whether the TR2 is currently detecting a tilt. The x-, y- and z-axis acceleration data is specified in 1g/1024 per bit.
Command code:	0x18
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: X-axis baseline value LSB. Byte 2: X-axis baseline value MSB. Byte 3: Y-axis baseline value LSB. Byte 4: Y-axis baseline value MSB.

	Byte 5: Z-axis baseline value LSB. Byte 6: Z-axis baseline value MSB. Byte 7: Checksum.
Special access:	None.

7.1.25. Read Tilt Sensor Data

Description:	This command returns the current (most recent) x-, y- and z-axis data values read from the tilt sensor (accelerometer). The x-, y- and z-axis acceleration data is specified in 1g/1024 per bit.
Command code:	0x19
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: X-axis current value LSB. Byte 2: X-axis current value MSB. Byte 3: Y-axis current value LSB. Byte 4: Y-axis current value MSB. Byte 5: Z-axis current value LSB. Byte 6: Z-axis current value MSB. Byte 7: Checksum.
Special access:	None.

7.1.26. Read User Data

Description:	This command returns the contents of the user data area. The user data area is a 32-byte space for general purpose non-volatile storage. It has no function within the operation of the TR2 itself.
Command code:	0x1A
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1 … Byte 32: User data. Byte 33: Checksum.
Special access:	None.

7.1.27. Read Error Status

Description:	This command returns information about the current error / diagnostic state of the TR2. The error status is returned as a 2-byte bit-mapped data with the following bit values: 0x0001: TR2 is not calibrated. 0x0002: A non-volatile memory error checksum has been detected. 0x0004: A broken load cell excitation wire has been detected.

	0x0008: An A/D converter result was not received as expected. Bit values 0x0010 to 0x8000 are currently unused.
Command code:	0x1B
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Error Status, as detailed above. Byte 2: 0x00 Byte 33: Checksum.
Special access:	None.

7.1.28. Read Minimum Expected Load Cell Current

Description:	This command returns the minimum combined current (in µA) expected to be consumed by all load cells in the system. The total load cell current is continually monitored by the TR2 diagnostic firmware. If the current consumption of the loadcells falls below this minimum expected value, the broken load cell excitation wire flag is set in the Error Status word, as described above.
Command code:	0x1C
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Minimum expected load cell current in microamps LSB. Byte 2: Minimum expected load cell current in microamps MSB. Byte 3: Checksum.
Special access:	None.

7.1.29. Read Zero-Tracking Value

Description:	This command returns the weight within which the scale will continually perform **automatic** 'Set System Zero' operations when weighing. The result is returned in units of 0.5 intervals. A value of 0 shows that the zero-tracking function is disabled.
Command code:	0x1D
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Zero-tracking setting. Byte 2: Checksum.
Special access:	None.

Description:	Get Zero Tracking value. A value of 0x00 == Zero Tracking Off
Message ID:	0x10000024
Data:	Byte 0: Zero tracking value
Special access:	None.

7.2. ‘Execute’ commands

The following commands are those which execute internal functions of theTR2. They should be sent in the format described in section 6.2 above.

7.2.1. Set Hold Weight

Description:	This command stores the current net weight value in an internal register. The hold weight can be read by issuing the ‘Read Hold Weight’ command, as described in Section 7.1.8 above.
Command code:	0x80
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Checksum.
Special access:	None.

7.2.2. Set Tare Value

Description:	This request stores the current gross weight value in an internal register and uses it as the tare value. Subsequent operations will use this tare value as the basis for net weight calculation until a new ‘Set Tare Value’ command or ‘Reset Tare Value’ command is executed. An error will be returned if this command is issued while the signal is not stable, as defined by the no-motion parameters.
Command code:	0x81
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Checksum.
Special access:	None.

7.2.3. Reset Tare Value

Description:	This request cancels the ‘Set Tare Value’ command above, and the tare value is set to zero.

Command code:	0x82
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Checksum.
Special access:	None.

7.2.4. Set System Zero

Description:	This request sets a new “current zero” which is then the basis of all weight values until further updated by another ‘Set System Zero’ command or the ‘Reset System Zero’ command. An error will be returned if the new system zero point is more than 2% of the Maximum Output value. An error will be returned if this command is issued while the signal is not stable, as defined by the no-motion parameters.
Command code:	0x83
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Checksum.
Special access:	None.

7.2.5. Reset System Zero

Description:	This request cancels the ‘Set System Zero’ command above, and the zero reading reverts to that set by the Calibrate System Zero command.
Command code:	0x84
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Checksum.
Special access:	None.

7.2.6. Enable Gravity Compensation

Description:	This request switches on gravity compensation mode. Subsequent calculations of gross weight, net weight and tare weight will be adjusted for the difference in the value of g specified for calibration and at the user location.
Command code:	0x85
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Checksum.

Special access:	The TR2 must be in calibration mode to execute this request.

7.2.7. Disable Gravity Compensation

Description:	This request switches off gravity compensation mode.
Command code:	0x86
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Checksum.
Special access:	The TR2 must be in calibration mode to execute this request.

7.2.8. Calibrate System Zero

Description:	This request stores the current 24-bit A/D converter value into the TR2's internal (***volatile***) memory as the zero-calibration value. This command should be executed when the scale is unloaded (empty). An error will be returned if this command is issued while the signal is not stable, as defined by the no-motion parameters.
Command code:	0x87
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Checksum.
Special access:	The TR2 must be in calibration mode to execute this request.

7.2.9. Calibrate System Gain Point

Description:	This request stores the current 24-bit A/D converter value into the TR2's internal (***volatile***) memory as the gain (span) calibration value. An error will be returned if this command is issued while the signal is not stable, as defined by the no-motion parameters.
Command code:	0x88
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Checksum.
Special access:	The TR2 must be in calibration mode to execute this request.

7.2.10. Save Calibration Data

Description:	This request transfers the current values of all calibration data from the TR2's volatile memory to its non-volatile memory. Until this command is successfully executed, any unsaved calibration data will be lost if a power-off or reset occurs.

	The calibration counter will be incremented on successful execution of this command. In this instance, 'calibration data' refers to any values which require calibration mode to be active to change their value. **Note that the data transfer to non-volatile memory may take up to 50 ms to complete. A success response to this request signifies only that the request was valid, and that the memory transfer has been scheduled to begin. Any further communication to the TR2 within 50 ms of this command may be lost, as all CPU activity is halted during the memory transfer process.**
Command code:	0x89
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Checksum.
Special access:	The TR2 must be in calibration mode to execute this request.

7.2.11. Restore Factory Defaults

Description:	This request causes all volatile and non-volatile memory contents to be over-written with factory default settings. All saved and unsaved calibration values will be lost. The calibration counter will be incremented on successful execution of this command. **Note that the data transfer to non-volatile memory may take up to 50 ms to complete. A success response to this request signifies only that the request was valid, and that the memory transfer has been scheduled to begin. Any further communication to the TR2) within 50 ms of this command may be lost, as all CPU activity is halted during the memory transfer process.**
Command code:	0x8A
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Checksum.
Special access:	The TR2 must be in calibration mode to execute this request.

7.2.12. Reset Firmware

Description:	This request performs a full firmware reset (warm start). All unsaved calibration values will be lost, as values are re-loaded from non-volatile memory. The TR2 will exit calibration mode, the tare value will be zeroed and the system zero point will be reset to the zero-calibration point (though an automatic 'Set System Zero' command

	may occur if calibration settings and conditions allow). If successfully executed, the success response will be returned before the TR2 is reset (typically within 50ms).
Command code:	0x8B
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Checksum.
Special access:	None.

7.2.13. Set Tilt-Sensor Baseline

Description:	This request stores the current values from the tilt sensor and uses these values as the zero-baseline for all subsequent readings.
Command code:	0xD3
Command parameters:	Byte 0: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Checksum.
Special access:	The TR2 must be in calibration mode to execute this request.

7.3. 'Write' commands

The following commands are those which write data to the TR2's internal (***volatile***) memory. They should be sent in the format described in section 6.3 above.

7.3.1. Set No-Motion Range

Description:	This request specifies the no-motion weight range in intervals. See the description in section 7.1.12 above for details of the no-motion definition).
Command code:	0xC0
Command parameters:	Byte 0: No-motion range LSB. Byte 1: No-motion range MSB. Byte 2: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Checksum.
Special access:	The TR2 must be in calibration mode to execute this request.

7.3.2. Set No-Motion Time

Description:	This request specifies the no-motion time in milliseconds. See the description in section 7.1.12 above for details of the no-motion definition).

Command code:	0xC1
Command parameters:	Byte 0: No-motion time LSB. Byte 1: No-motion time MSB. Byte 2: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Checksum.
Special access:	The TR2 must be in calibration mode to execute this request.

7.3.3. Set Calibration Gain Weight

Description:	This request specifies the weight (in intervals) that was (or will be) used to calibrate the gain (span) of the scale.
Command code:	0xC2
Command parameters:	Byte 0: Calibration gain weight LSB. Byte 1: Calibration gain weight MSB. Byte 2: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Checksum.
Special access:	The TR2 must be in calibration mode to execute this request.

7.3.4. Set User Gravity Value

Description:	This request specifies the gravity value that is to be used for the current location when gravity compensation is enabled. The value of g is specified in $ms^{-2} * 10^{6,}$ as a 32-bit unsigned integer. The valid range for this command is 9700000 to 9900000.
Command code:	0xC3
Command parameters:	Byte 0: User gravity value LSB Byte 1: User gravity value Byte 2: User gravity value Byte 3: User gravity value MSB Byte 4: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Checksum.
Special access:	The TR2 must be in calibration mode to execute this request.

7.3.5. Set Minimum Output Value

Description:	This request specifies the minimum weight (in intervals) at which the gross, net, tare or hold weight output changes to show the under-range error value of ‘uuuuuuuu’.
Command code:	0xC4

Command parameters:	Byte 0: Minimum output value LSB. Byte 1: Minimum output value MSB. Byte 2: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Checksum.
Special access:	The TR2 must be in calibration mode to execute this request.

7.3.6. Set Maximum Output Value

Description:	This request specifies the maximum weight (in intervals) at which the gross, net, tare or hold weight output changes to show the over-range error value of ‘ooooooo’.
Command code:	0xC5
Command parameters:	Byte 0: Maximum output value LSB. Byte 1: Maximum output value MSB. Byte 2: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Checksum.
Special access:	The TR2 must be in calibration mode to execute this request.

7.3.7. Set Zero Range

Description:	This request specifies the weight (in intervals) within which the scale can be manually zeroed using the ‘Set System Zero’ command.
Command code:	0xC6
Command parameters:	Byte 0: Zero range value LSB. Byte 1: Zero range value MSB. Byte 2: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Checksum.
Special access:	The TR2 must be in calibration mode to execute this request.

7.3.8. Set Initial Zero Range

Description:	This request specifies the weight (in intervals) of the Initial Zero range. If this value is non-zero, the device will execute an automatic ‘Set System Zero’ command after power-up or reset when the weight stabilizes (using the current no-motion settings) and the weight is within this Initial Zero range.
Command code:	0xC7

Command parameters:	Byte 0: Initial zero range value LSB. Byte 1: Initial zero range value MSB. Byte 2: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Checksum.
Special access:	The TR2 must be in calibration mode to execute this request.

7.3.9. Set Calibration Mode Register

Description:	The calibration mode register holds a 32-bit unsigned integer representing a passcode to grant access to calibration mode. The contents of this register must match the system passcode (value 0x0009A52F) in order to change any calibration mode data or access any restricted functions. If the TR2 is in calibration mode when the contents of this register are changed, this command will return the success response and the TR2 will exit calibration mode. If the TR2 is not in calibration mode and an incorrect code is entered, an error will be returned and this command will become unavailable for a period of around 5000 ms. The TR2 will timeout of calibration mode if no calibration commands are executed for a period of 10 minutes.
Command code:	0xC8
Command parameters:	Byte 0: Calibration mode register byte 0 (LSB). Byte 1: Calibration mode register byte 1. Byte 2: Calibration mode register byte 2. Byte 3: Calibration mode register byte 3 (MSB). Byte 4: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Checksum.
Special access:	The TR2 must be in calibration mode to execute this request.

7.3.10. Set Filter Type

Description:	This request specifies the current filter setting of the TR2. The filter type is specified as a 1-byte number. The valid values for filter type are: 0: No filtering (uses latest ADC sample only) 1: An 8-sample moving average 2: A 32-sample moving average 3: The Flintec ‘baby’ algorithm
Command code:	0xC9

Command parameters:	Byte 0: filter type. Byte 1: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Checksum.
Special access:	The TR2 must be in calibration mode to execute this request.

7.3.11. Set Sample Rate

Description:	This request specifies the ADC sample rate of the TR2 in Hertz (samples per second). The valid range is 5Hz to 50Hz. The specified sample rate will be used following the next power cycle or reset sequence.
Command code:	0xCA
Command parameters:	Byte 0: Byte 1: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Checksum.
Special access:	The TR2 must be in calibration mode to execute this request.

7.3.12. Set Calibration Gravity Value

Description:	This request specifies the gravity value that was present during calibration of the scale. The calibration value of g is specified in $ms^{-2} * 10^{6,}$ as a 32-bit unsigned integer. The valid range for this command is 9700000 to 9900000.
Command code:	0xCB
Command parameters:	Byte 0: Calibration gravity value LSB Byte 1: Calibration gravity value Byte 2: Calibration gravity value Byte 3: Calibration gravity value MSB Byte 4: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Checksum.
Special access:	The TR2 must be in calibration mode to execute this request.

7.3.13. Set Engineering Mode

Description:	This requests the TR2 to enable or disable engineering mode. In engineering mode, weight outputs are given to 0.1 interval resolution, rather than 1 interval.
Command code:	0xCC
Command parameters:	Byte 0: 1 to enable engineering mode, any other value to disable.

	Byte 1: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Checksum.
Special access:	The TR2 must be in calibration mode to execute this request.

7.3.14. Set User Data

Description:	This command sets the contents of the user data area. The user data area is a 32-byte space for general purpose non-volatile storage. It has no function within the operation of the TR2 itself.
Command code:	0xCD
Command parameters:	Byte 0 … Byte 31: User data. Byte 32: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Checksum.
Special access:	The TR2 must be in calibration mode to execute this request.

7.3.15. Set Minimum Expected Load Cell Current

Description:	This command sets the minimum combined current (in µA) expected to be consumed by all load cells in the system. The total load cell current is continually monitored by the TR2 diagnostic firmware. If the current consumption of the loadcells falls below this minimum expected value, the broken load cell excitation wire flag is set in the Error Status word, as described above.
Command code:	0xCE
Command parameters:	Byte 0: Minimum expected load cell current in microamps LSB. Byte 1: Minimum expected load cell current in microamps MSB. Byte 2: Checksum.
Response parameters:	Byte 0: Response code. Byte 1: Checksum.
Special access:	The TR2 must be in calibration mode to execute this request.

7.3.16. Set Zero-Tracking Value

Description:	This command sets the weight within which the scale will continually perform **automatic** ‘Set System Zero’ operations. The weight is specified in units of 0.5 intervals. A value of 0 disables the zero-tracking function.
Command code:	0xCF
Command parameters:	Byte 0: Zero-tracking value. Byte 1: Checksum.

Response parameters:	Byte 0: Response code. Byte 1: Checksum.
Special access:	The TR2 must be in calibration mode to execute this request.

8. Command summary

The table below shows a summary of the commands available on the I^{2}C bus, showing which commands read system data (R), write system data (W) or execute functions(X). A tick (check) mark shows that the operation is available to 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
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

Command code	R	X	W	Description
0x1B	✓			Read Error Status
0x1C	✓			Read Minimum Expected Load Cell Current
0x1D	✓			Read Zero-Tracking
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
0x89		C		Save Calibration Data
0x8A		C		Restore Factory Defaults
0x8B		✓		Reset Firmware
0xD3		C		Set Tilt-Sensor Baseline
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
0xCF			C	Set Zero-Tracking Value

Table 6 - Command Summary