TR2 Electronics Module [Catalogue]

CAN Bus Communications Specification

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Document History

Rev.	Date	Author	Details of change
A	05-Dec-18	Terry Gooding	Initial release. This document was based on *Generic Scale CAN Bus Communication Specification* document 0074994.docm Rev D.

1. Purpose

The purpose of this document is to define the CAN bus interface of the TR2 Scale ECU. It defines both the details and implementation as well as the message identifiers needed to access the data and functions of the ECU.

2. Scope

This document is applicable only to the TR2 Scale ECU firmware. Refer to the ECU's Software Release Notes **[1]** for details of the document revision on which a particular firmware release is based.
This specification defined 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 module 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 step size of 1 (1 gramme, 1 kg, 1 lb etc.)
- The TR2 will output all weight measurements in grammes to a precision of one decimal place - in normal use, the number following the decimal point will always be zero

5. CAN Bus Protocol settings

The TR2 will operate the CAN bus at a default speed of 500 kBd, though the user can change this speed if required. It fully conforms to the CAN 2.0B standard and uses 29-bit identifiers for all communications but can tolerate 11-bit message identifiers on the bus if they are used by other modules.

6. CAN Bus Communications Implementation

The TR2 sends no periodic messages on the CAN bus and will never transmit an unsolicited message. All CAN bus transmissions from the TR2 are event-driven in response to requests received on the bus.
Any message actioned by the TR2 may be thought of as being one of the following types:

- A 'read' command; to request current (latest) data from the ECU.
- A 'write' command; to change specific data held in the ECUs internal ***(volatile***) memory.
- An 'execute' command; to perform specific functions within the ECU.

The sections below detail how each of these message types is implemented on the CAN bus.

6.1. CAN Bus implementation for 'read' commands (RTR bit Set)

To read a data value from the TR2, a node will transmit the appropriate message identifier with the remote transmit request (RTR) bit set. The data length code (DLC) will not be validated and may contain any value, but the response length will always be fixed for the specific message ID, as described in the Section 8 below. The ECU will respond by sending a data message with the same ID as the request, containing the current value of the requested data.

6.2. CAN Bus implementation for 'write' commands (RTR bit Clear)

To write a value to the TR2's internal (***volatile***) memory, a node must transmit a standard data message (RTR=0) with the appropriate message ID as detailed in Section 8 below. The data to be written is sent in the data field and must be of the specified length.
The TR2 will respond by sending an 'ECU General Status' message as detailed in Section 7.1.4 below.

6.3. CAN Bus implementation for 'execute' commands (RTR bit Clear)

To execute a specific function of the TR2, a node must transmit a standard data message (RTR=0) with the appropriate message ID as detailed in Section 8 below. The data length code (DLC) must be set to zero.

The TR2 will respond by sending an 'ECU General Status' message as detailed in Section 7.1.4 below.

6.4. Error handling

As described above, each message received by the TR2 will elicit a response on the CAN Bus.

Note that messages are hardware-filtered on both message ID and RTR bit before they are sent to the CPU, so invalid messages and invalid read requests are never actually received.

In the case of 'write' and 'execute' messages, the response message will include a status code describing the success or failure of the requested message. In this way, the requesting ECU does not need to check the success of the message by sending a 'read' command after a write; the content of the response message will indicate the outcome of the request.
The full list of valid status codes is show in Table 2 below.

Status code	Error type	Description
0x00	None - success	A valid request was received and executed.
0x02	Conditions not correct	The message ID / command code is valid, but the command cannot be executed at the time (e.g. the user is not authorised to make the request).
0x04	Out of range	Data for a 'write' command is outside of the legal range for the parameter being written.
0x05	Message length	The data length code (DLC) does not match that specified for the message ID or command.

Table 2 - List of valid status codes

7. Message Identifiers

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

7.1. Identifiers for data transmitted by the ECU – 'read' commands

The following commands are those which request current data from the TR2 Scale ECU.

7.1.1. Get ECU Serial Number

Description:	The ECU serial number is stored as a 24-byte null-terminated ASCII string. Given the 8-byte limit on the data length of a CAN message, three message identifiers are required to read the full 24 bytes. If the ECU serial number is less than 24 characters long, all subsequent characters will be null (0x00). If the ECU serial number is 24-characters long, the null terminator will not be sent.
Message ID:	0x10000000 (bytes 0-7) 0x10000001 (bytes 8-15) 0x10000002 (bytes 16-23).
Data:	ID 0x10000000: Bytes 0-7 of the ECU serial number string. ID 0x10000001: Bytes 8-15 of the ECU serial number string. ID 0x10000002: Bytes 16-23 of the ECU serial number string.
Special access:	None.

7.1.2. Get ECU Part Number

Description:	The ECU part number is stored as an 8-byte null-terminated ASCII string. If the ECU part number is less than 8 characters long, the data frame will be padded with null bytes. If the ECU Part number is 8 characters long, the null-terminator will not be sent.
Message ID:	0x10000003
Data:	Bytes 0-7 of the ECU part number string.
Special access:	None.

7.1.3. Get ECU Firmware Version

Description:	The ECU's firmware revision number is given as a 2-byte value containing the major and minor firmware revision numbers.
Message ID:	0x10000004
Data:	Byte 0: Major firmware version number. Byte 1: Minor firmware revision.
Special access:	None.

7.1.4. ECU General Status

Description:	The status of the ECU is given as a 2-byte value containing the current state of the ECU and the result of the last 'write' / 'execute' command.

	The system status register is returned as bit-mapped data with the following bit values: 0x01: Measurement is stable (no motion). 0x02: Zero action performed. 0x04: Tare is active. 0x08: ECU is in calibration mode. 0x10: Gravity compensation is active. 0x20: Tilt sensor detects scale is not flat. 0x40: TR2 warm-up is in progress.
Message ID:	0x10000005
Data:	Byte 0: System Status, as detailed above. Byte 1: Status of last 'write' / 'execute' command (see Table 2 above)
Special access:	None.

7.1.5. Get Calibration Counter

Description:	The calibration counter tracks changes made to the ECU's calibration values. 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.
Message ID:	0x10000006
Data:	Byte 0: Calibration counter LSB. Byte 1: Calibration counter MSB.
Special access:	None.

7.1.6. Get Gross Weight

Description:	Gross weight is returned as a 32-bit signed integer, representing the current gross weight on the scale in units of 0.1 intervals. If the gross weight is below the Minimum Output Value (see section 7.1.18 below), the value 0x80000000 will be returned (the smallest value of a 32-bit signed number). If the gross weight is above the Maximum Output Value (see section 7.1.19 below), the value 0x7FFFFFFF will be returned (the largest value of a 32-bit signed number).
Message ID:	0x10000007
Data:	Byte 0: Gross weight byte 0 (LSB). Byte 1: Gross weight byte 1. Byte 2: Gross weight byte 2. Byte 3: Gross weight byte 3 (MSB).
Special access:	None.

7.1.7. Get Net Weight

Description:	Net weight is returned as a 32-bit signed integer, representing the current net weight on the scale in units of 0.1 intervals. If the net weight is below the Minimum Output Value (see section 7.1.18 below), the value 0x80000000 will be returned (the smallest value of a 32-bit signed number). If the net weight is above the Maximum Output Value (see section 7.1.19 below), the value 0x7FFFFFFF will be returned (the largest value of a 32-bit signed number).
Message ID:	0x10000008
Data:	Byte 0: Net weight byte 0 (LSB). Byte 1: Net weight byte 1. Byte 2: Net weight byte 2. Byte 3: Net weight byte 3 (MSB).
Special access:	None.

7.1.8. Get Tare Weight

Description:	Tare weight is returned as a 32-bit signed integer, representing the current tare weight, in units of 0.1 intervals, stored in the ECU's internal register.
Message ID:	0x10000009
Data:	Byte 0: Tare weight byte 0 (LSB). Byte 1: Tare weight byte 1. Byte 2: Tare weight byte 2. Byte 3: Tare weight byte 3 (MSB).
Special access:	None.

7.1.9. Get Hold (Net) Weight

Description:	Hold weight is returned as a 32-bit signed integer, representing the current net hold weight, in units of 0.1 intervals, stored in the ECU's internal register. If the hold weight is below the Minimum Output Value (see section 7.1.18 below), the value 0x80000000 will be returned (the smallest value of a 32-bit signed number). If the hold weight is above the Maximum Output Value (see section 7.1.19 below), the value 0x7FFFFFFF will be returned (the largest value of a 32-bit signed number).
Message ID:	0x1000000A
Data:	Byte 0: Hold weight byte 0 (LSB). Byte 1: Hold weight byte 1.

	Byte 2: Hold weight byte 2. Byte 3: Hold weight byte 3 (MSB).
Special access:	None.

7.1.10. Get Current A/D Converter Sample

Description:	This current (latest) A/D converter sample value is returned as a 24-bit unsigned integer.
Message ID:	0x1000000B
Data:	Byte 0: ADC Sample byte 0 (LSB). Byte 1: ADC Sample byte 1 Byte 2: ADC sample byte 2 (MSB).
Special access:	None.

7.1.11. Get Zero Point A/D Converter Sample

Description:	This is the A/D converter value that was used to calibrate the system's zero point. It is returned as a 24-bit unsigned integer.
Message ID:	0x1000000C
Data:	Byte 0: Zero-point ADC value byte 0 (LSB). Byte 1: Zero-point ADC value byte 1. Byte 2: Zero-point ADC value byte 2 (MSB).
Special access:	None.

7.1.12. Get Gain Point A/D Converter Sample

Description:	This is the A/D converter value that was used to calibrate the system's gain (span) point. It is returned as a 24-bit unsigned integer.
Message ID:	0x1000000D
Data:	Byte 0: Gain-point ADC value byte 0 (LSB). Byte 1: Gain-point ADC value byte 1. Byte 2: Gain-point ADC value byte 2 (MSB).
Special access:	None.

7.1.13. Get No-Motion Range

Description:	The no-motion range is 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).

	It is returned as a 32-bit signed integer, representing the no-motion range in units of 0.1 intervals.
Message ID:	0x1000000F
Data:	Byte 0: No-motion range byte 0 (LSB). Byte 1: No-motion range byte 1. Byte 2: No-motion range byte 2. Byte 3: No-motion range byte 3 (MSB).
Special access:	None.

7.1.14. Get No-Motion Time

Description:	This request returns the no-motion time in milliseconds. See the description in section 7.1.13 above for the 'no-motion' definition.
Message ID:	0x10000010
Data:	Byte 0: No-motion time LSB. Byte 1: No-motion time MSB.
Special access:	None.

7.1.15. Get Calibration Gain Weight

Description:	The calibration gain weight is the weight that was (or will be) used to calibrate the gain (span) of the scale. It is returned as a 32-bit signed integer, representing the calibration gain weight in units of 0.1 intervals.
Message ID:	0x10000011
Data:	Byte 0: Calibration span weight byte 0 (LSB). Byte 1: Calibration span weight byte 1. Byte 2: Calibration span weight byte 2. Byte 3: Calibration span weight byte 3 (MSB).
Special access:	None.

7.1.16. Get Calibration Gravity Value

Description:	The calibration gravity value is the gravity value that was present during calibration of the scale. It is returned as a 32-bit unsigned integer representing the value of g in $ms^{-2} * 10^6$.
Message ID:	0x10000012
Data:	Byte 0: Calibration gravity value byte 0 (LSB). Byte 1: Calibration gravity value byte 1. Byte 2: Calibration gravity value byte 2. Byte 3: Calibration gravity value byte 3 (MSB).
Special access:	None.

7.1.17. Get User Gravity Value

Description:	The user gravity value is the gravity value that is to be used in the current location when gravity compensation is enabled. It is returned as a 32-bit unsigned integer representing the value of g in $ms^{-2} * 10^6$.
Message ID:	0x10000013
Data:	Byte 0: User gravity value byte 0 (LSB). Byte 1: User gravity value byte 1. Byte 2: User gravity value byte 2. Byte 3: User gravity value byte 3 (MSB).
Special access:	None.

7.1.18. Get Minimum Output Value

Description:	The minimum output value is the weight at which the gross, net and hold weight output changes to show the under-range error value of 0x80000000. It is returned as a 32-bit signed integer, representing the minimum output weight in units of 0.1 intervals.
Message ID:	0x10000014
Data:	Byte 0: Minimum output value byte 0 (LSB). Byte 1: Minimum output value byte 1. Byte 2: Minimum output value byte 2. Byte 3: Minimum output value byte 3 (MSB).
Special access:	None.

7.1.19. Get Maximum Output Value

Description:	The maximum output value is the weight at which the gross, net and hold weight output changes to show the over-range error value of 0x7FFFFFFF. It is returned as a 32-bit signed integer, representing the maximum output weight in units of 0.1 intervals.
Message ID:	0x10000015
Data:	Byte 0: Maximum output value byte 0 (LSB). Byte 1: Maximum output value byte 1. Byte 2: Maximum output value byte 2. Byte 3: Maximum output value byte 3 (MSB).
Special access:	None.

7.1.20. Get Zero Range

Description:	Zero range is the weight range within which the scale can be manually zeroed using the ‘Set System Zero’ command.

	It is returned as a 32-bit signed integer, representing the zero range in units of 0.1 intervals.
Message ID:	0x10000016
Data:	Byte 0: Zero range value byte 0 (LSB). Byte 1: Zero range value byte 1. Byte 2: Zero range value byte 2. Byte 3: Zero range value byte 3 (MSB).
Special access:	None.

7.1.21. Get Initial Zero Range

Description:	Initial zero range is the weight range within which the scale will perform an automatic 'Set System Zero' after power-up or reset. It is returned as a 32-bit signed integer, representing the initial zero range in 0.1 gramme units.
Message ID:	0x10000017
Data:	Byte 0: Initial zero value byte 0 (LSB). Byte 1: Initial zero value byte 1. Byte 2: Initial zero value byte 2. Byte 3: Initial zero value byte 3 (MSB).
Special access:	None

7.1.22. Get CAN Bus Speed

Description:	The speed of the CAN bus is determined by the value of the prescaler byte in the CAN bus control register of the microcontroller, and can be calculated as follows: CAN Bus speed = ($4*10^6$ / prescaler) The prescaler value is returned as an 8-bit unsigned integer.
Message ID:	0x10000018
Data:	Byte 0: CAN Bus prescaler value.
Special access:	None

7.1.23. Get Filter Type

Description:	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.

Message ID:	0x10000019
Data:	Byte 0: Filter type.
Special access:	None

7.1.24. Get Sample Rate

Description:	The sample rate of the ECU's A/D converter is returned as an 8-bit unsigned integer representing the number of A/D samples taken every second.
Message ID:	0x1000001A
Data:	Byte 0: ADC sample rate in Hertz.
Special access:	None

7.1.25. Get Tilt Sensor Baseline

Description:	The tilt sensor baseline values are the x-, y- and z-axis values read from the tilt sensor (accelerometer) when factory calibration took place. These values are the references used to determine whether the scale is currently detecting a tilt. The x-, y- and z-axis acceleration data is specified in 1g/1024 per bit.
Message ID:	0x1000001B
Data:	Byte 0: X-axis baseline value LSB. Byte 1: X-axis baseline value MSB. Byte 2: Y-axis baseline value LSB. Byte 3: Y-axis baseline value MSB. Byte 4: Z-axis baseline value LSB. Byte 5: Z-axis baseline value MSB.
Special access:	None

7.1.26. Get Tilt Sensor Data

Description:	The tilt sensor data values are the current (most recent) x-, y- and z-axis values read from the tilt sensor (accelerometer). The x-, y- and z-axis acceleration data is specified in 1g/1024 per bit.
Message ID:	0x1000001C
Data:	Byte 0: X-axis current value LSB. Byte 1: X-axis current value MSB. Byte 2: Y-axis current value LSB. Byte 3: Y-axis current value MSB. Byte 4: Z-axis current value LSB. Byte 5: Z-axis current value MSB.
Special access:	None

7.1.27. Get User Data

Description:	The user data area is a 32-byte space for general purpose non-volatile storage. It has no function within the operation of the ECU itself. The user data is stored as a 32-byte ASCII string. Given the 8-byte limit on the data length of a CAN message, four message identifiers are required to read the full 32 bytes.
Message ID:	0x1000001D (bytes 0-7) 0x1000001E (bytes 8-15) 0x1000001F (bytes 16-23) 0x10000020 (bytes 24-31).
Data:	ID 0x1000001D: Bytes 0-7 of the user data. ID 0x1000001E: Bytes 8-15 of the user data. ID 0x1000001F: Bytes 16-23 of the user data. ID 0x10000020: Bytes 24-31 of the user data.
Special access:	None.

7.1.28. Get Error Status

Description:	This command returns information about the current error / diagnostic state of the ECU. The error status is returned as a 16-bit unsigned integer representing a 4-bit bitmapped nibble with the following bit values: 0x01: ECU is not calibrated. (Bit0) 0x02: A non-volatile memory error checksum has been detected. (Bit1) 0x04: A broken load cell excitation wire has been detected. (Bit2) 0x08: An A/D converter result was not received as expected. (Bit3)
Message ID:	0x10000021
Data:	Byte 0: Error Status, as detailed above. Byte 1: 0x00
Special access:	None.

7.1.29. Get Minimum Expected Loadcell Current

Description:	This command returns the minimum combined current (in µA) expected to be consumed by all load cells in the system as a 16-bit unsigned integer. The total load cell current is continually monitored by the TR2 diagnostic firmware. If the current consumption of the loadcells falls below the minimum expected value, the broken load cell excitation wire flag (Bit2) is set in the Error Status word.
Message ID:	0x10000022
Data:	Byte 0: Min Expected Loadcell Current LSB

	Byte 1: Min Expected Loadcell Current MSB
Special access:	None.

7.1.30. Get Engineering Mode

Description:	If Engineering mode is enabled, weight outputs are given to 0.1 gramme resolution rather than 1.0 grammes. Cycling the power switches Engineering Mode off.
Message ID:	0x10000023
Data:	Byte 0: Engineering Mode Status where 0x00=OFF, 0x01=ON
Special access:	None.

7.1.31. Get Zero Tracking

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. Identifiers for setting data values in the ECU – 'write' commands

The following commands are those which write user data to the TR2 Scale ECU.

7.2.1. 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 (default value 0x0009A52F) in order to change any calibration mode data or execute any ECU functions. If the ECU is in calibration mode when the contents of this register are changed, this command will return the success response and the ECU will exit calibration mode. If the ECU is not in calibration mode and an incorrect code is entered, an error will be logged and this command will become unavailable for a period of around 5000 ms. The ECU will timeout of calibration mode if no calibration commands are executed for a period of 10 minutes. The ECU will respond with an ECU General Status message as detailed in Section 7.1.4 above.
Message ID:	0x10000040
Data:	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).
Special access:	None.

7.2.2. Set No-Motion Range

Description:	This requests the ECU to set the value of the no-motion range. See the description in section 7.1.13 above for the definition of 'no-motion'). The value is sent as a 16-bit unsigned integer representing the no-motion weight range in grammes. The ECU will respond with an ECU General Status message as detailed in Section 7.1.4 above.
Message ID:	0x10000041
Data:	Byte 0: No-motion range LSB. Byte 1: No-motion range MS). Valid range: TBD.
Special access:	The ECU must be in calibration mode to execute this request.

7.2.3. Set No-Motion Time

Description:	This requests the ECU to set the value of the no-motion time. See the description in section 7.1.13 above for the definition of 'no-motion'). The value is sent as a 16-bit unsigned integer representing the no-motion time in milliseconds. The ECU will respond with an ECU General Status message as detailed in Section 7.1.4 above.
Message ID:	0x10000042
Data:	Byte 0: No-motion time LSB. Byte 1: No-motion time MSB.
Special access:	The ECU must be in calibration mode to execute this request.

7.2.4. Set Calibration Gain Weight

Description:	This requests the ECU to set the weight that was (or will be) used to calibrate the gain (span) of the scale. The value is sent as a 16-bit unsigned integer, representing the calibration gain weight in grammes. The ECU will respond with an ECU General Status message as detailed in Section 7.1.4 above.
Message ID:	0x10000043

Data:	Byte 0: Calibration gain weight LSB. Byte 1: Calibration gain weight MSB. Valid range: TBD.
Special access:	The ECU must be in calibration mode to execute this request.

7.2.5. Set User Gravity Value

Description:	This requests the ECU to set the gravity value that is to be used for the current location when gravity compensation is enabled. The value is sent as a 32-bit unsigned integer representing the value of g in $ms^{-2} * 10^6$. The ECU will respond with an ECU General Status message as detailed in Section 7.1.4 above.
Message ID:	0x10000044
Data:	Byte 0: User gravity value byte 0 (LSB). Byte 1: User gravity value byte 1. Byte 2: User gravity value byte 2. Byte 3: User gravity value byte 3 (MSB). Valid range: 9700000_{10} to 9900000_{10}.
Special access:	The ECU must be in calibration mode to execute this request.

7.2.6. Set Minimum Output Value

Description:	This requests the ECU to set the output value at which the gross, net and hold weight outputs change to show the under-range error value of 0x80000000. The value is sent as a 16-bit signed integer, representing the minimum output value in grammes. The ECU will respond with an ECU General Status message as detailed in Section 7.1.4 above.
Message ID:	0x10000045
Data:	Byte 0: Minimum output value LSB. Byte 1: Minimum output value MSB. Valid range: TBD.
Special access:	The ECU must be in calibration mode to execute this request.

7.2.7. Set Maximum Output Value

Description:	This requests the ECU to set the output value at which the gross, net and hold weight outputs change to show the over-range error value of 0x7FFFFFFF. The value is sent as a 16-bit unsigned integer, representing the maximum

	output value in grammes. The ECU will respond with an ECU General Status message as detailed in Section 7.1.4 above.
Message ID:	0x10000046
Data:	Byte 0: Maximum output value LSB. Byte 1: Maximum output value MSB. Valid range: TBD.
Special access:	The ECU must be in calibration mode to execute this request.

7.2.8. Set Zero Range

Description:	This requests the ECU to set the weight range within which the scale can be manually zeroed using the 'Set System Zero' command. If this value is set to zero, the system uses the default value of 2% of the scale's maximum output value. The value is sent as a 16-bit unsigned integer, representing the zero range in grammes. The ECU will respond with an ECU General Status message as detailed in Section 7.1.4 above.
Message ID:	0x10000047
Data:	Byte 0: Zero range value LSB. Byte 1: Zero range value MSB. Valid range: TBD.
Special access:	The ECU must be in calibration mode to execute this request.

7.2.9. Set Initial Zero Range

Description:	This requests the ECU to set the weight range within which the scale will perform an automatic 'Set System Zero' after power-up or reset. 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. The value is sent as a 16-bit unsigned integer, representing the initial zero range in grammes. The ECU will respond with an ECU General Status message as detailed in Section 7.1.4 above.
Message ID:	0x10000048
Data:	Byte 0: Initial zero range value LSB. Byte 1: Initial zero range value MSB. Valid range: TBD.
Special access:	The ECU must be in calibration mode to execute this request.

7.2.10. Set CAN Bus Speed

Description:	This requests the ECU to set the prescaler value in the microcontroller's CAN bus control register. The required value of the prescaler register can be calculated as follows: prescaler = ($4*10^6$ /CAN Bus speed) Valid values for the prescaler are $4 \leq p \leq 255$, giving a maximum bus speed of 1MBd. The specified bus speed will be used following the next ECU power cycle or reset sequence. The ECU will respond with an ECU General Status message as detailed in Section 7.1.4 above.
Message ID:	0x10000049
Data:	Byte 0: CAN Bus prescaler value.
Special access:	The ECU must be in calibration mode to execute this request.

7.2.11. Set Filter Type

Description:	This requests the ECU to set the type of filtering used by the A/D capture function. The filter type is sent as an enumerated data type with 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 ECU will respond with an ECU General Status message as detailed in Section 7.1.4 above.
Message ID:	0x1000004A
Data:	Byte 0: Filter type.
Special access:	The ECU must be in calibration mode to execute this request.

7.2.12. Set Sample Rate

Description:	This requests the ECU to set the ADC sample rate of the ECU in Hertz (samples per second). The valid range is 5 Hz to 50 Hz. The specified sample rate will be used following the next ECU power cycle or reset sequence. The ECU will respond with an ECU General Status message as detailed in Section 7.1.4 above.
Message ID:	0x1000004B
Data:	Byte 0: Sample rate in Hz.
Special access:	The ECU must be in calibration mode to execute this request.

7.2.13. Set Calibration Gravity Value

Description:	This requests the ECU to set the gravity value that was present during calibration of the scale. The value is sent as a 32-bit unsigned integer representing the value of g in $ms^{-2} * 10^6$. The ECU will respond with an ECU General Status message as detailed in Section 7.1.4 above.
Message ID:	0x1000004C
Data:	Byte 0: Calibration gravity value byte 0 (LSB). Byte 1: Calibration gravity value byte 1. Byte 2: Calibration gravity value byte 2. Byte 3: Calibration gravity value byte 3 (MSB). Valid range: 9700000_{10} to 9900000_{10}.
Special access:	The ECU must be in calibration mode to execute this request.

7.2.14. Set Engineering Mode

Description:	This requests the ECU to enable or disable engineering mode. In engineering mode, weight outputs are given to 0.1 gramme resolution, rather than 1 gramme. The ECU will respond with an ECU General Status message as detailed in Section 7.1.4 above.
Message ID:	0x1000004D
Data:	Byte 0: 1 to enable engineering mode, any other value to disable.
Special access:	The ECU must be in calibration mode to execute this request.

7.2.15. 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 ECU itself. Given the 8-byte limit on the data length of a CAN message, four message identifiers are required to write the full 32 bytes. The ECU will respond with an ECU General Status message as detailed in section 7.1.4 above.
Message ID:	0x1000004E (bytes 0-7) 0x1000004F (bytes 8-15) 0x10000050 (bytes 16-23) 0x10000051 (bytes 24-31).
Data:	ID 0x1000004E: Bytes 0-7 of the user data. ID 0x1000004F: Bytes 8-15 of the user data.

	ID 0x10000050: Bytes 16-23 of the user data. ID 0x10000051: Bytes 24-31 of the user data.
Special access:	The ECU must be in calibration mode to execute this request.

7.2.16. Set Minimum Expected Loadcell Current

Description:	This command sets the minimum combined current (in µA) expected to be consumed by all load cells in the system as a 16-bit unsigned integer. The total load cell current is continually monitored by the TR2 diagnostic firmware. If the current consumption of the loadcells falls below the minimum expected value, the broken load cell excitation wire flag (Bit2) is set in the Error Status word. The ECU will respond with an ECU General Status message as detailed in Section 7.1.4 above.
Message ID:	0x10000052
Data:	Byte 0: Min Expected Loadcell Current LSB Byte 1: Min Expected Loadcell Current MSB
Special access:	The ECU must be in calibration mode to execute this request.

7.2.17. Set Zero Tracking

Description:	Set Zero Tracking value. A value of 0x00 == Zero Tracking Off The ECU will respond with an ECU General Status message as detailed in Section 7.1.4 above.
Message ID:	0x10000053
Data:	Byte 0: Zero tracking value
Special access:	The ECU must be in calibration mode to execute this request.

7.3. Identifiers for executing ECU functions – 'execute' commands

The following commands are those which execute the internal functions of the TR2 Scale ECU.

7.3.1. Set the Hold Weight

Description:	This requests the ECU to store 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 7.1.9 above. The ECU will respond with an ECU General Status message as detailed in Section 7.1.4 above.
Message ID:	0x10000080
Data:	None.
Special access:	None.

7.3.2. Set Tare Value

Description:	This requests the ECU to store 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' command or 'Reset Tare' command is executed. An error will be logged if this command is issued while the signal is not stable, as defined by the no-motion parameters. The ECU will respond with an ECU General Status message as detailed in Section 7.1.4 above.
Message ID:	0x10000081
Data:	None.
Special access:	None.

7.3.3. Reset Tare Value

Description:	This requests the ECU to cancel the 'Set Tare Value' command above, and to set the tare value to zero. The ECU will respond with an ECU General Status message as detailed in Section 7.1.4 above.
Message ID:	0x10000082
Data:	None.
Special access:	None.

7.3.4. Set System Zero

Description:	This requests the ECU to set 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 logged if the new system zero point is more than 2% of the Maximum Output value higher or lower than the "true zero" set during calibration. An error will be logged if this command is issued while the signal is not stable, as defined by the no-motion parameters. The ECU will respond with an ECU General Status message as detailed in Section 7.1.4 above.
Message ID:	0x10000083
Data:	None.
Special access:	None.

7.3.5. Reset System Zero

Description:	This requests the ECU to cancel the 'Set System Zero' command above, resetting the zero reading to that set by the zero calibration command. The ECU will respond with an ECU General Status message as detailed in Section 7.1.4 above.
Message ID:	0x10000084
Data:	None.
Special access:	None.

7.3.6. Enable Gravity Compensation

Description:	This requests the ECU to switch on gravity compensation mode. Subsequent calculations of gross weight and net weight will be adjusted for the difference in the value of g specified for calibration and at the user location. The ECU will respond with an ECU General Status message as detailed in Section 7.1.4 above.
Message ID:	0x10000085
Data:	None.
Special access:	The ECU must be in calibration mode to execute this request.

7.3.7. Disable Gravity Compensation

Description:	This requests the ECU to switch off gravity compensation mode. The ECU will respond with an ECU General Status message as detailed in Section 7.1.4 above.
Message ID:	0x10000086
Data:	None.
Special access:	The ECU must be in calibration mode to execute this request.

7.3.8. Calibrate System Zero

Description:	This requests the ECU to store the current 24-bit A/D converter value into the ECU's internal (***volatile***) memory as the zero-calibration value. This command should be executed when the scale is unloaded (empty). An error will be logged if this command is issued while the signal is not stable, as defined by the no-motion parameters. The ECU will respond with an ECU General Status message as detailed in Section 7.1.4 above.
Message ID:	0x10000087
Data:	None.
Special access:	The ECU must be in calibration mode to execute this request.

7.3.9. Calibrate System Gain Point

Description:	This requests the ECU to store the current 24-bit A/D converter value into the ECU's internal (***volatile***) memory as the gain (span) calibration value. An error will be logged if this command is issued while the signal is not stable, as defined by the no-motion parameters. The ECU will respond with an ECU General Status message as detailed in Section 7.1.4 above.
Message ID:	0x10000088
Data:	None.
Special access:	The ECU must be in calibration mode to execute this request.

7.3.10. Save Calibration Data

Description:	This requests the ECU to transfer the current values of all calibration data from the ECU'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 in order 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 ECU within 50 ms of this command may be lost, as all CPU activity is halted during the memory transfer process. The ECU will respond with an ECU General Status message as detailed in Section 7.1.4 above.
Message ID:	0x10000089
Data:	None.
Special access:	The ECU must be in calibration mode to execute this request.

7.3.11. Restore Factory Defaults

Description:	This 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. The ECU will respond with an ECU General Status message as detailed in Section 7.1.4 above.

Message ID:	0x1000008A
Data:	None.
Special access:	The ECU must be in calibration mode to execute this request.

7.3.12. Reset Firmware

Description:	This requests the ECU to perform a full firmware reset (warm start). All unsaved calibration values will be lost, as values are re-loaded from non-volatile memory. The ECU will exit calibration mode, gravity compensation is enabled, 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). The ECU will respond with an ECU General Status message as detailed in Section 7.1.4 above before the ECU is reset (typically within 50ms).
Message ID:	0x1000008B
Data:	None.
Special access:	None.

8. Message ID Summary

The table below shows the full list of the message IDs supported by the TR2 Scale ECU.

Message ID	Data Length	Description
'Read' Messages		
0x10000000	8 bytes	Get ECU Serial Number (bytes 0 - 7)
0x10000001	8 bytes	Get ECU Serial Number (bytes 8 - 15)
0x10000002	8 bytes	Get ECU Serial Number (bytes 16 - 23)
0x10000003	8 bytes	Get ECU Part Number
0x10000004	2 bytes	Get ECU Firmware Version
0x10000005	2 bytes	ECU 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

Message ID	Data Length	Description
0x10000022	2 bytes	Get Minimum Expected Loadcell Current
0x10000023	1 byte	Get Engineering Mode
0x10000024	1 byte	Get Zero Tracking
'Write' Messages		
0x10000040	4 bytes	Set Calibration Mode Register
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		
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

Table 3 - List of valid message identifiers