CAN Bus System & Topology

Engineering Reference

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1 INTRODUCTION

This document describes the overall system structure for the Controller Area Network (CAN) bus used by the Tritium WaveSculptor motor controller and it's associated peripheral devices.

CAN is a serial bus network, originally developed by Bosch for automotive applications such as anti-lock braking and other high-reliability uses. The protocol was standardized as ISO 11898-1 in 1993 and specifies the first two layers of the 7-layer OSI model.

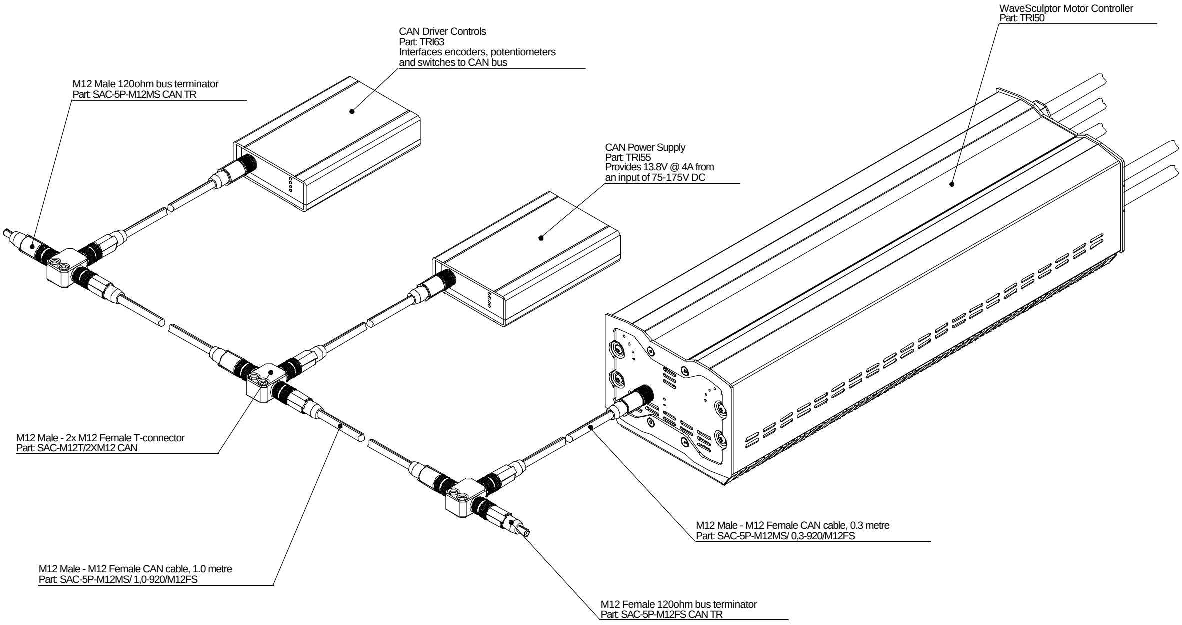
CAN automatically takes care of issues such as collision detection, error detection, and retransmission, as well as prioritized message delivery and requests. It is implemented as a multi-master system using a producer-consumer message model, rather than the client-server model typically seen in other communications systems. The main effect of this is that message addresses (IDs) show where a message has been *sent from*, rather than where it is *going to*.

Electrically, data transmission is implemented on a single twisted pair cable, using differential signaling (two wires, called 'CAN-H' and 'CAN-L'). Two states are used on the bus, 'Dominant' and 'Recessive'. A dominant bit from one device will override a recessive bit from another, resulting in the second device detecting a collision and backing off from the bus.

CAN messages contain an 11-bit identifier (address), a data payload of between 0 and 8 bytes, a CRC error correction value, and several status bits. Messages can be sent autonomously by a device at fixed intervals or on a change of state, or they can be requested at any time by other devices. The CAN standard does not specify any higher-level message protocols.

2 SYSTEM FUNCTIONALITY

2.1 BASIC SYSTEM



2.2 OVERVIEW

The WaveSculptor motor controller uses the CAN bus to receive commands and transmit telemetry, as well as to provide low-voltage DC power to operate the controller electronics.

Therefore, as basic system consists of three major components:

1) WaveSculptor motor controller
2) Driver controls interface to potentiometers, encoders and switches
3) Power supply (nominally 12V DC) to operate the system

Other components can also be added to the network. Items typically found in a solar vehicle would include:

4) LCD and other driver information displays
5) Lighting (indicators, brakes, headlights, etc) output control
6) Solar peak-power trackers
7) Battery management system
8) Multiple motor controllers
9) Redundant power supplies

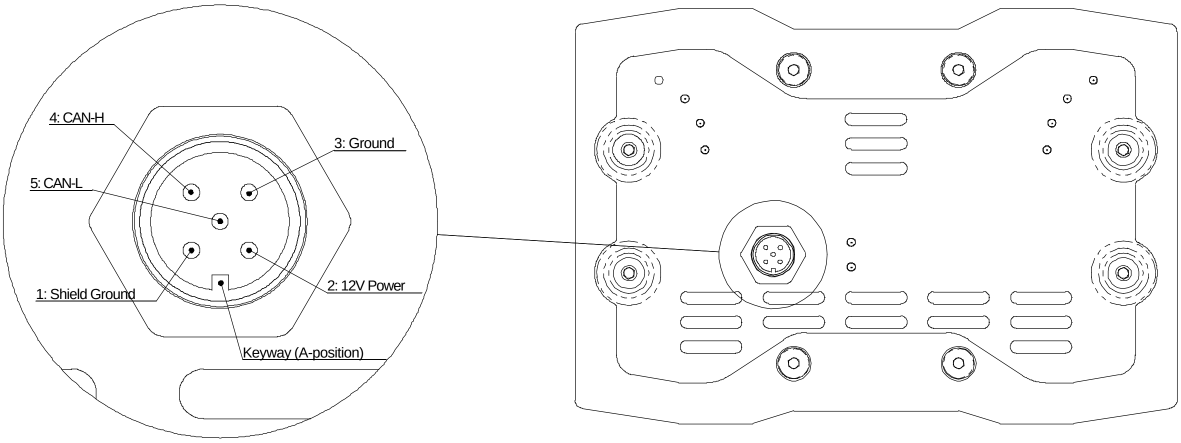
2.3 TOPOLOGY

The CAN bus is structured as a linear network, with short stubs from the main bus backbone to each device. This allows disconnecting a device from the bus without disturbing communications on the rest of the network.

The CAN bus data lines must be terminated at each end of the main bus with 120 ohm resistors between the CAN-H and CAN-L signal lines.

2.4 CONNECTORS & CABLES

The WaveSculptor and other Tritium peripheral devices use the common industrial standard 5-pin M12 screw-locking connectors, designed for use with CanOpen and DeviceNET standards. These connectors are available from several manufacturers. The part numbers detailed in this document are from Phoenix Contact.



The connector on the WaveSculptor and other Tritium devices is Male, M12, A-coded. The pinout follows the DeviceNET specification, and the diagram above shows the connector on the WaveSculptor as viewed from the front of the controller.

Reliable, robust pre-made cables are also available, with waterproof connectors permanently moulded onto each end. These cables are shielded, have a twisted pair for the CAN signals, and a heavier gauge twisted pair for power and ground. They provide a perfect solution for quickly and easily connecting up your system.

The following table provides part numbers for cabling used in the Tritium system. Please contact Tritium about small volume supplies of these parts, as the minimum order quantity from Phoenix Contact for some items will be 5 or 10 pieces.

Part Number	Description
SAC-M12T/2XM12 CAN	M12 male to 2x M12 female T-connector
SAC-5P-M12MS/ 5,0-920/M12FS	M12 male to M12 female cable, 5.0 metre
SAC-5P-M12MS/ 3,0-920/M12FS	M12 male to M12 female cable, 3.0 metre
SAC-5P-M12MS/ 2,0-920/M12FS	M12 male to M12 female cable, 2.0 metre
SAC-5P-M12MS/ 1,0-920/M12FS	M12 male to M12 female cable, 1.0 metre
SAC-5P-M12MS/ 0,3-920/M12FS	M12 male to M12 female cable, 0.3 metre
SAC-5P-M12MS CAN TR	M12 male 120 ohm CAN bus terminator
SAC-5P-M12FS CAN TR	M12 female 120 ohm CAN bus terminator

2.5 COMMUNICATIONS

The CAN standard does not specify high-level message protocols. Tritium devices use a custom protocol, outlined in the communication specification document for each device.

By default, each device operates at the maximum possible data rate of 1 Mbit/second, and comes programmed from the factory with a CAN base address that will allow it to work without problems with other Tritium devices. Using the Windows PC interface program and a simple low-cost USB to CAN adapter (http://www.canusb.com), both the data rate and the base address can be programmed to suit your network.

WaveSculptor controllers also have a second programmable base address that they watch for command messages. This should be set to whatever base address is used by the driver controls node on the network.

The WaveSculptor motor controller expects regular messages from the driver controls device. If a message is not received within a set timeout period (refer to the communications specification for the exact value) then the controller will change to a safe mode and will stop driving the motor. This protects against faults where either a connector is loose or broken, the cable has been damaged, or the driver controls have failed.

2.6 POWER

Each Tritium device expects a DC supply on the CAN bus connection of between 9 and 15V. 13.8V from a supply that is backed up by a small lead-acid battery (for redundancy) is ideal. The maximum current allowable in any segment of CAN cable depends on the manufacturer of the cable and associated connectors, but somewhere between 3 and 4 Amps is typical. Refer to each device's datasheet for CAN bus current consumption values.

2.7 DRIVER CONTROLS

Tritium can provide a CAN bus driver controls device. This interfaces between several potentiometers, encoders and switches to provide the messages required to operate a WaveSculptor controller. The firmware for this device is open-source, allowing it to be easily customized to suit your vehicle.

As the communications specification is open, the WaveSculptor can also be operated from custom driver controls hardware specific to your vehicle, or from a Windows PC running either the provided Tritium software, or custom software of your choice.

Please refer to the driver controls specification and other documents on our website for further details.

3 SYSTEM EXPANSION

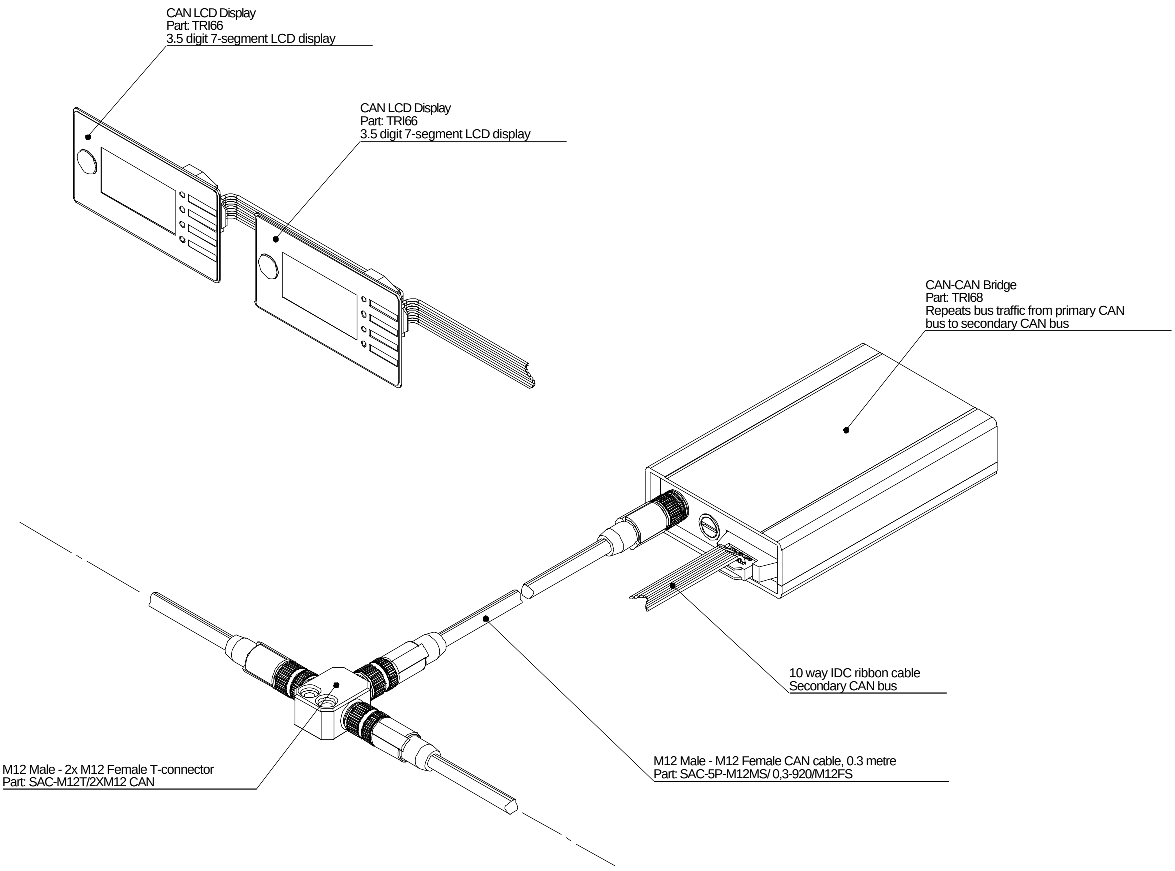
3.1 LCD DISPLAYS

Tritium can provide a CAN bus LCD display capable of showing up to four different telemetry values (one at a time) on a 3.5 digit sunlight-readable screen. Due to size and cost reasons, this device does not use the M12 connector that the rest of the Tritium system uses, instead being fitted with a latching 10-way IDC ribbon cable connector. This connection allows multiple displays to be chained up along one ribbon cable, which can be easily threaded through the confined spaces usually present in most vehicle dashboards and display areas.

To convert the M12 (primary) CAN bus to the IDC (secondary) can bus, Tritium can provide a simple CAN-CAN bridge, which repeats messages from the primary bus onto the secondary bus. This prevents faults on the secondary bus (such as a shorted ribbon cable) from taking down communications on the primary bus and halting the vehicle. Given the unprotected nature of ribbon cable, and the areas in which it is expected to be used, this protection is a highly desirable feature.

The CAN-CAN bridge also provides the 120 ohm termination between CAN-H and CAN-L for one end of the secondary (IDC ribbon) CAN bus. If this cable is short (1 – 2 metres) then it will operate satisfactorily with no termination on the other end of the ribbon.

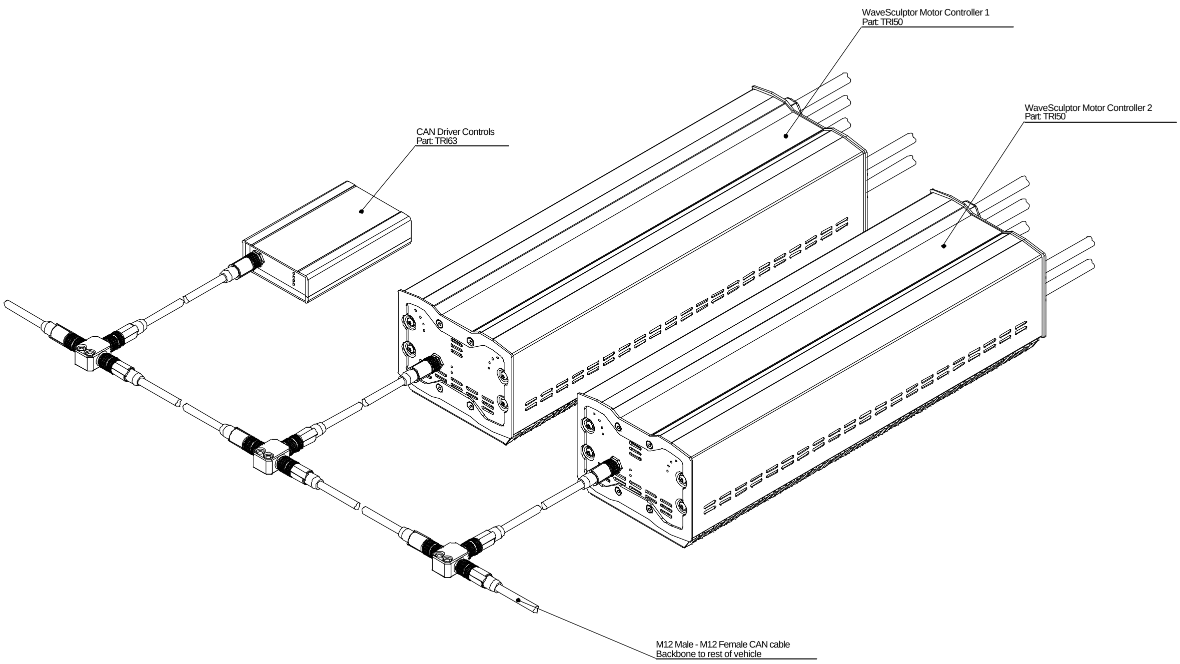
A diagram of this system is shown in the following figure.



3.2 MULTIPLE MOTORS

Multiple motors are accommodated easily with the CAN bus system. All that is required is for each WaveSculptor controller to be programmed to receive messages from the same *driver controls* base address, and then to run the vehicle in current-control mode. Each motor will now operate at the same current, thus giving automatic wheel speed differences for cornering, with the system acting as an electronic differential.

The base address of *each WaveSculptor controller* should be programmed to a different value. This allows viewing of separate telemetry data from each controller on the LCD displays or other telemetry systems in the vehicle.



4 REVISION HISTORY

Version	Date	Description
1	29 November, 2006	Document creation (JMK)