WaveSculptor Wiring & Connections

Engineering Reference

31 March 2007

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1 INTRODUCTION

This document describes the connections and support components required to connect a WaveSculptor motor controller into a vehicle electrical system.

2 CAN BUS COMMUNICATIONS

2.1 TOPOLOGY

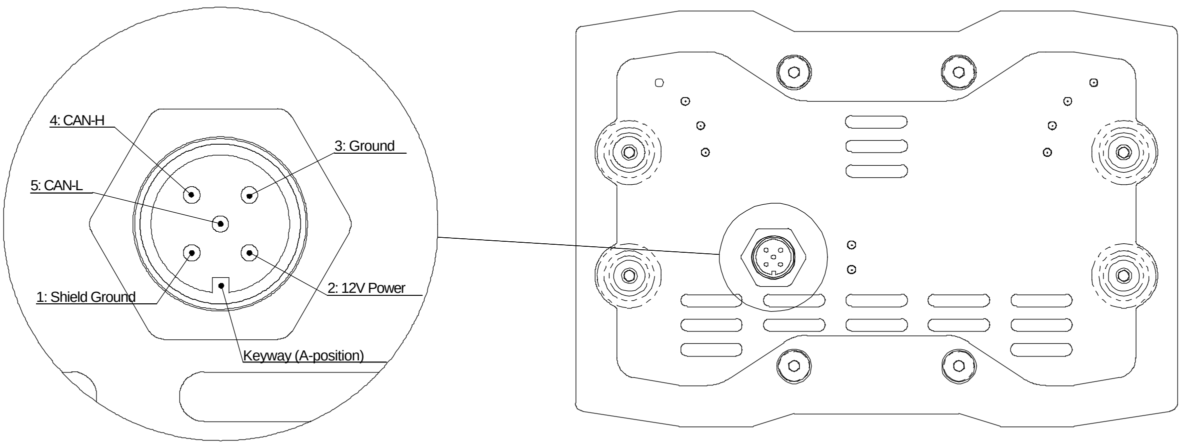
The CAN bus is structured as a linear network, with short stubs from the main bus backbone to each device. This allows disconnecting a device from the bus without disturbing communications on the rest of the network.

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.

For more detailed information on the CAN bus, please refer to the CAN bus engineering reference document, TRI50.012, available on the Tritium website.

2.2 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.

For more detailed information on CAN bus cabling and connectors, please refer to the CAN bus engineering reference document, TRI50.012, available on the Tritium website.

3 MOTOR POSITION & TEMPERATURE SENSING

3.1 POSITION

For operating Brushless DC (BLDC) and Permanent Magnet Synchronous (PMSM) type motors, the WaveSculptor requires three motor position sensing inputs, commonly provided using Hall-effect switches embedded in the motor.

Please note that the relation between each Hall-effect input and a motor output phase, as well as the polarity of the Hall-effect input signal, does not matter. The WaveSculptor will detect these relationships when running it's initial setup and configuration routine (Phasorsense). The only requirement for these signals is that they have a fixed alignment (ideally, a 0° offset) with the zero-crossing point of the back-EMF waveform of the motor, and that the signals are offset from each other by 120°. This is where most motors will be configured by default.

The WaveSculptor provides an isolated approximately +15V DC supply to operate these sensors, and this is also selectable as a +5V supply if desired, as a factory option.

The WaveSculptor provides internal pullup resistors to the selected supply voltage, to accommodate open-collector Hall-effect switches.

3.2 TEMPERATURE

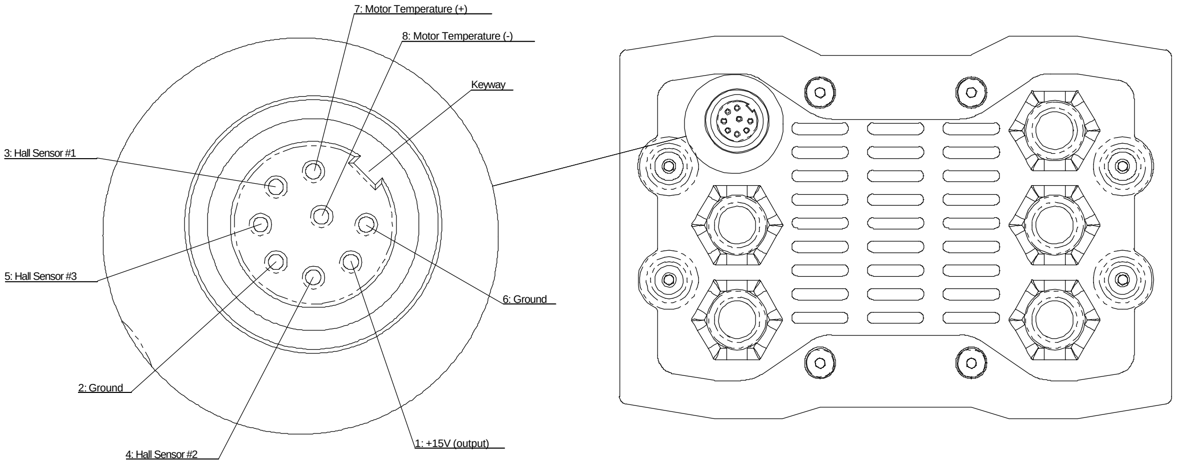
Motor temperature can be sensed by the WaveSculptor using a 10k (at 25°C) NTC thermistor bead embedded in the windings of the motor. The beta and logarithmic fit curves for the thermistor can be set using the Windows PC config program to match the thermistor that is present in your motor.

This temperature reading is transmitted by the WaveSculptor as a telemetry value, and can also be used to reduce motor operating currents at high temperatures, to protect the motor.

3.3 PINOUT

The motor position and temperature connector is a twist lock 8 pin female DIN connector, Preh part number 71252-080. A mating male plug is provided with the WaveSculptor.

Please refer to the following diagram for the pinout of this connector:

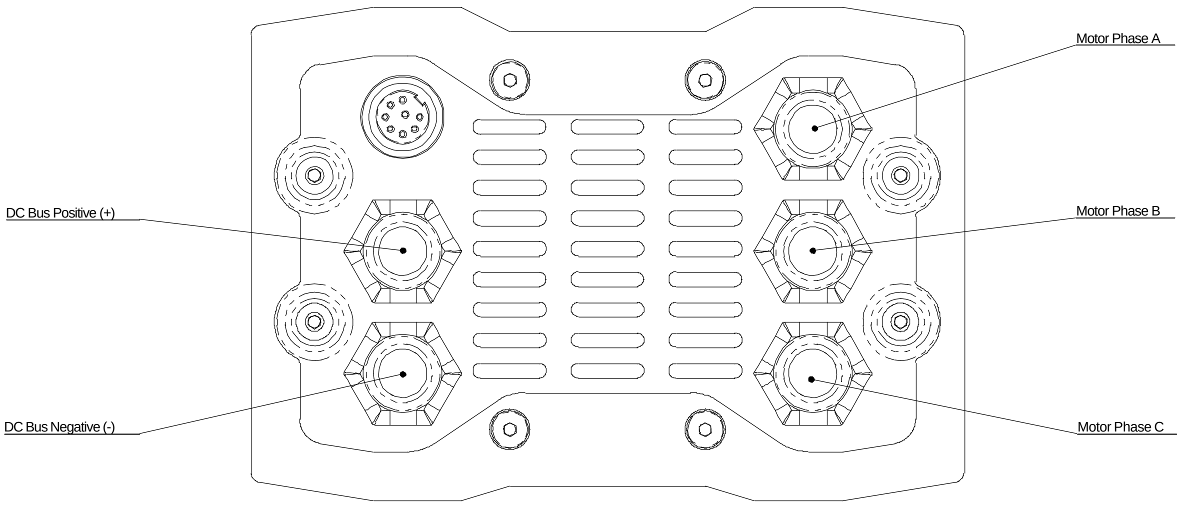


4 MOTOR PHASES

4.1 CONNECTION

The three motor phase connections are provided as 250mm long flying leads from the WaveSculptor using 6 AWG cable, and terminated using Anderson Power Products PP75 Powerpole connectors.

The position of these cables is shown in the following diagram. Please note that the relationship between A, B, C and any particular motor phase does not matter, as long as it remains consistent once the initial setup (Phasorsense) program has been run.



4.2 INDUCTANCE

The WaveSculptor requires a minimum of 50µH inductance (phase – neutral) per phase to operate correctly. Please ensure that sufficient external inductance has been added, if your motor does not have at least this amount of inductance internally.

These external inductors must be rated to the full phase current, ie sqrt(2) x $100A_{rms}$ = 140A, and have windings insulated to the full DC bus voltage (160V max).

It should be noted that CSIRO motors, and most likely any other ironless type motor, do not have sufficient inductance. Tritium can provide a set of appropriately rated inductors on request, if required.

5 HIGH VOLTAGE DC BUS

5.1 CONNECTION

The two DC bus connections are provided as 250mm long flying leads from the WaveSculptor using 6 AWG cable and terminated using an Anderson Power Products SB50 connector. The position of these cables is shown in the diagram in the previous section.

5.2 PRECHARGE

The WaveSculptor has 10,000µF of low-impedance capacitance across the DC bus input connections. An external precharge circuit is mandatory.

When not driving a motor, the WaveSculptor does not draw any power from the DC bus. Therefore, to avoid any high voltages on the bus connector when it is unplugged, an external discharge circuit is recommended. Please note that when operating at the maximum voltage, these capacitors hold over 120 Joules of energy.

5.2.1 Precharge controller

Tritium can provide a circuit to implement these functions, part number TRI72. This precharge / discharge controller can be configured in multiple ways, depending on the safety / cost tradeoff you wish to make with your vehicle. Please refer to the relevant regulations governing this type of circuit in your application.

The Tritium precharge / discharge controller is configured by changing the connections between it and your high-power circuitry. The same controller is used for both of the circuits detailed in the next two sections.

The controller has a 400V isolation barrier between the high-voltage DC bus and battery ground, and the 12V input and vehicle ground.

For more detailed information, please refer to the user's manual for the precharge controller, available on the Tritium website.

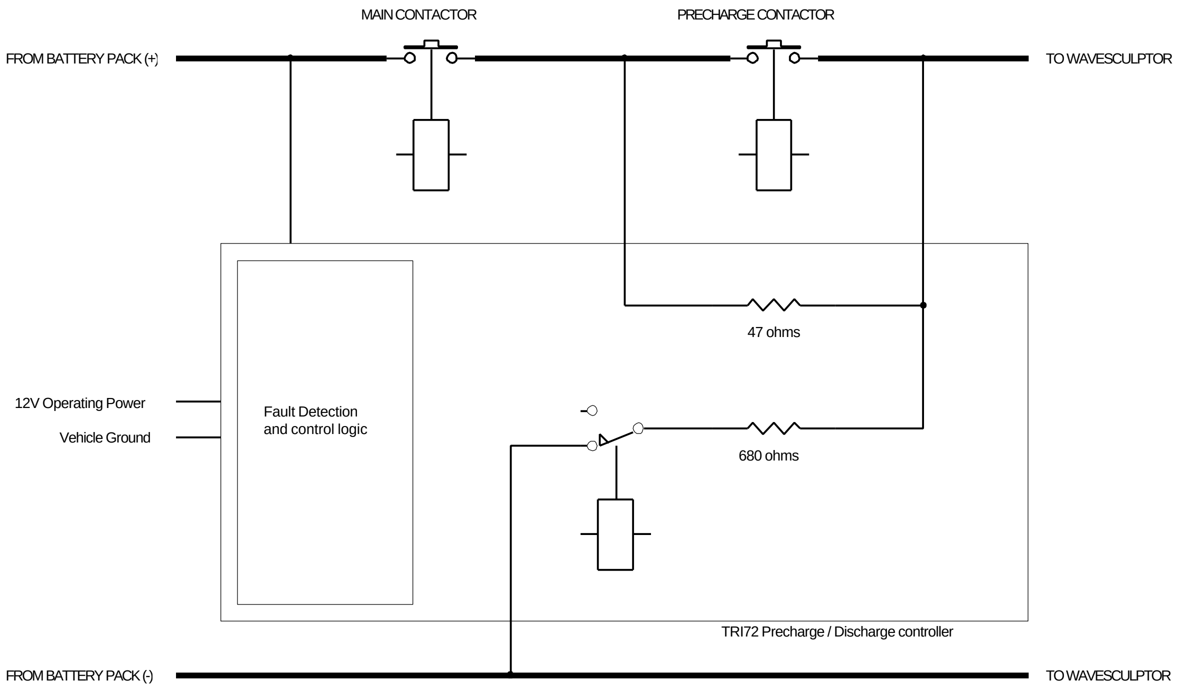
The controller operates as follows (for a type 1 circuit):

1. 12V operating power is applied to the precharge circuit from a auxiliary battery in your vehicle. This power should be routed through both a key (ignition) switch and a red dome (mushroom) type emergency shutdown switch.
2. Subject to a valid resistor temperature:
    a. The main contactor is energised, connecting the WaveSculptor to the batteries through the 47 ohm resistor
    b. The internal relay is energised, disconnecting the 680 ohm resistor
3. If the WaveSculptor connection has a short circuit fault
    a. The WaveSculptor voltage will not rise
    b. The 47 ohm resistor will heat
    c. The main contactor and internal relay will be de-energised until the resistor cools
4. Once the Battery voltage and the WaveSculptor voltage are within 10% of each other, the precharge contactor is energised, connecting the WaveSculptor and the batteries directly.
5. On removal of the 12V operating power, both contactors and the internal relay will de-energise, with the result of:
    a. The batteries are disconnected from the WaveSculptor
    b. The 680 ohm resistor discharges the DC bus capacitors

5.2.2 Precharge type 1

This configuration is both the safest and highest cost option. It provides a circuit such that a failure of any single component will not result in a low-impedance uninterruptible connection between the batteries and the WaveSculptor. It does, however, use two relatively expensive DC contactors.

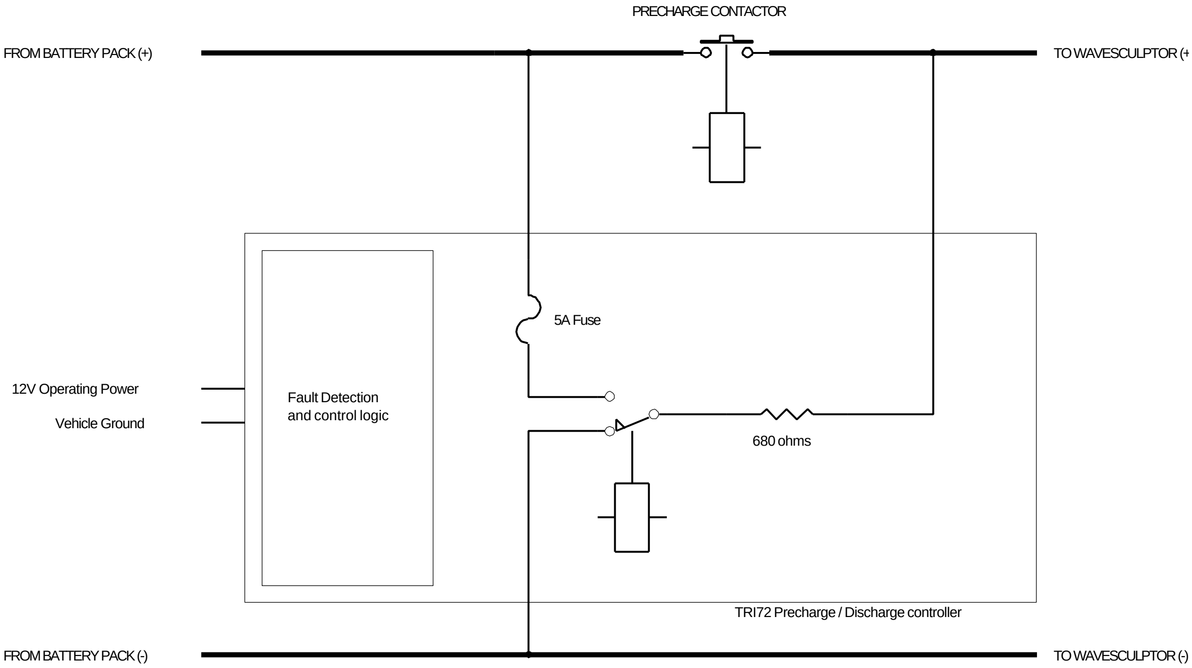
It provides a rapid precharge time of 1.5 seconds, and a discharge time of 25 seconds. The following diagram shows the high-power connections to the precharge controller.



5.2.3 Precharge type 2

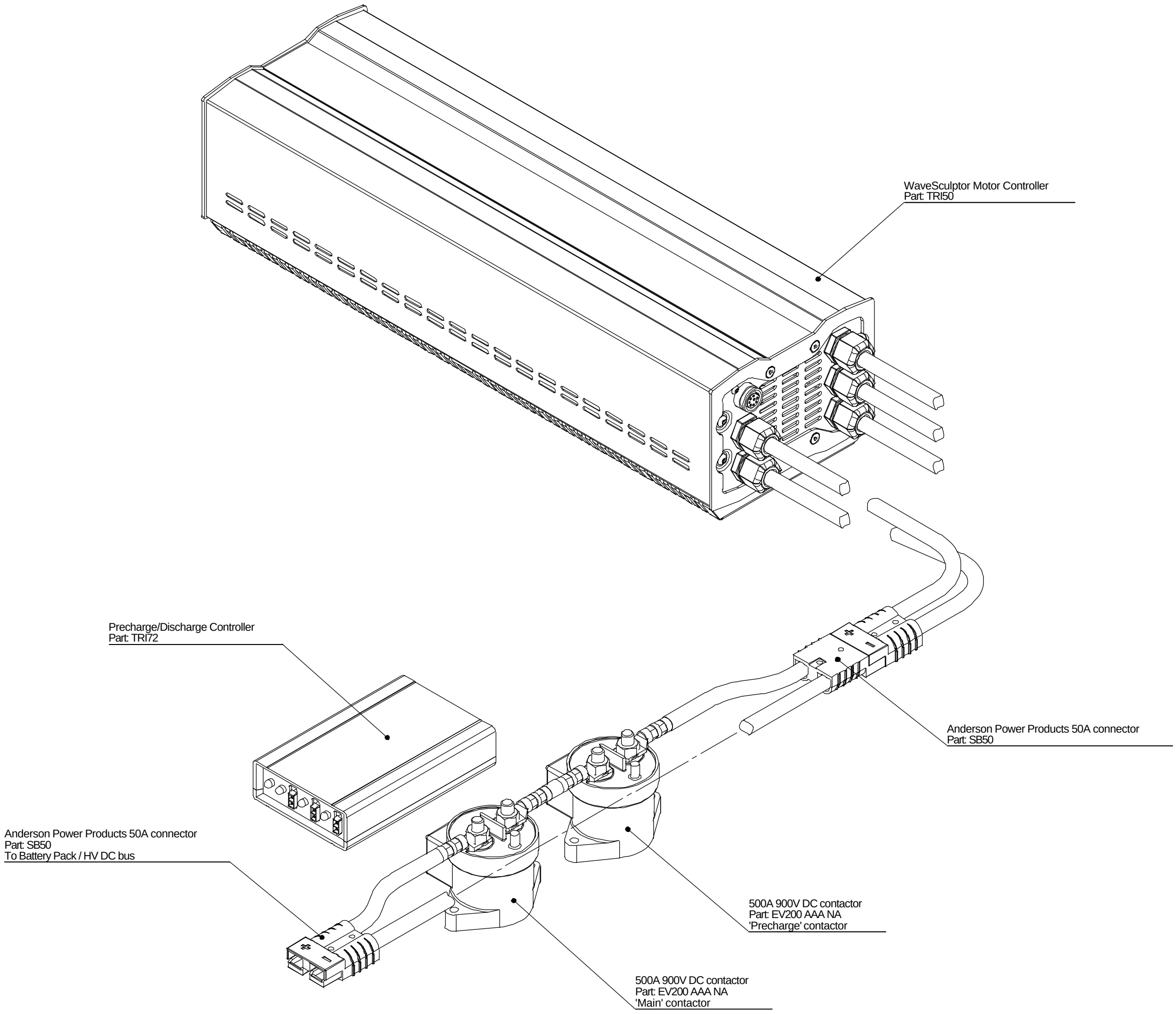
This configuration provides a lower-cost option to precharging and discharging the WaveSculptor.

It provides a precharge and discharge time of 25 seconds. The following diagram shows the high-power connections to the precharge controller.



5.2.4 Precharge layout

Tritium recommends that the precharge circuit be implemented with connectors (not bolt terminals) at both ends of the circuit, for safe connection and disconnection of the circuit if required. Please refer to the following diagram for a suggested layout.



6 ISOLATION

The WaveSculptor has an isolation barrier rated to 400V continuously between the CAN bus, the DC bus, and the Motor position connection. This helps minimise damage in the event of a fault, and also allows safe connection of the high voltage battery pack.

Tritium recommends that the CAN bus be operated at the system ground potential, with CAN Ground connected to the vehicle chassis at some point in your system.

The battery ground, high-voltage DC connections, and motor phases should be isolated from the vehicle chassis. This is so that a single fault anywhere in the high voltage system will not result in a high voltage potential being present between any wiring and the chassis of the vehicle.

Please refer to any relevant regulations governing this type of connection.

7 REVISION HISTORY

Version	Date	Description
1	22 August, 2006	Document creation – internal use only (DAF)
2	31 October, 2006	Internal use only (DAF)
3	3 December, 2006	First public release (JMK)
4	31 March, 2007	Modified motor phase & DC bus cable size Modified motor phase connector to PP75