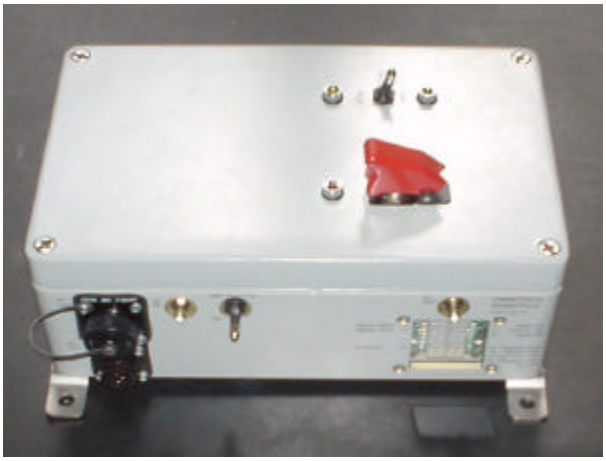
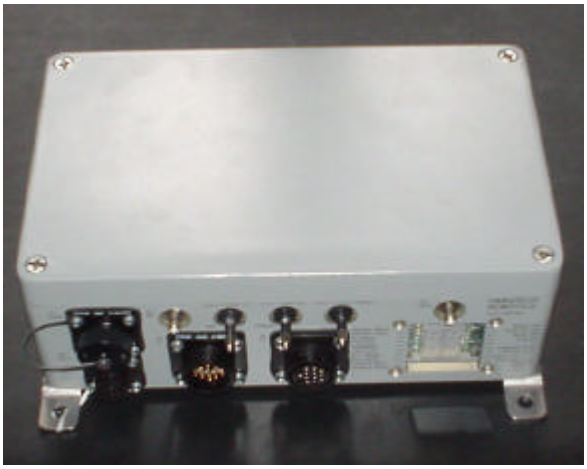
DARPA Grand Challenge Safety Radio (DGCSR) User Manual

Revision 1.1

November 4, 2003





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1.0 Important Notices

1) The DGCSR STX and DGCSR RX contain expensive and sensitive electronics and must never be dropped. They should be installed on their vibration isolation mounts in the vehicle as soon as possible to avoid inadvertent damage from dropping.

2) The DGCSR STX and DGCSR RX contain expensive and sensitive electronics and must never be exposed to electro-static discharge (ESD) on the exposed connector pins. All personnel who handle the devices should keep the connector caps installed over the exposed connector pins to minimize the chance of an ESD event. To minimize the probability of an ESD occurrence and potential damage, the connector caps should only be removed in a controlled ESD safe environment once proper ESD precautions have been implemented. Typical ESD prevention measures include the use of an earth ground contact strap or mat in contact with the body of the installer and the ESD sensitive components. Handling the DGC SR components in environments that generate ESD should be avoided, like areas with carpet or anywhere that ESD sparks or shocks to metal objects occur.

3) The DGCSR STX and RX use RF transceivers in the 902-928 MHz ISM band, at power levels up to 1 watt. Users should maintain at least a 23 cm distance separation between the attached RF antenna and any part of their body to limit their exposure to RF radiation per FCC guidelines.

4) The DGCSR uses pull-to-actuate toggle switches. For safety reasons, these switches are intended to avoid inadvertent actuation by requiring the user to pull the toggle switch lever out away from the switch base prior to trying to move the switch to a different position. Failure to pull the toggle lever out prior to actuation may cause the switch to break, and necessitate replacement.

5) The DGCSR system is primarily designed to provide a remote controlled safety radio RUN/PAUSE and ENABLE/DISABLE function for the DGC competition vehicles during the DGC event. It relies on each DGC competition team to install it as a part of an overall safety program, and maintain it in an operational state. DGCSR operators should normally command a “PAUSE” prior to commanding a “DISABLE” to allow the competition vehicle control system to stop in an orderly way using the power brakes and power steering and other power assisted devices of their vehicle. This is because one of the DGCSR systems intended functions is to DISABLE the power-plant of a rogue vehicle to avoid a run-away condition in case of catastrophic control system failures. However, disabling the engine of some automotive vehicles reduces or eliminates power assisted control devices like steering and brakes. It is the responsibility of each DGC team

to analyze and design a safe, conservative, and effective means of using the RUN/PAUSE and ENABLE/DISABLE to assure safe and reliable operations occur as required.

6) This manual and the DGCSR system specifications are subject to changes, updates, modifications, or clarifications, as determined by Omnitech Robotics International LLC. Users should periodically check for the latest revisions of all manuals and product information posted at www.omnitech.com, under the DGCSR heading and links.

7) All DGCSR components were designed with Electromagnetic Compatibility and Interference in mind. Special design precautions have been taken to minimize the noise generated from the DGCSR components and the sensitivity of these component to noise from other sources like the user's DGC competition vehicle ignition or control system. Users should exercise good design practice to minimize the amount of noise (electrical, RF, magnetic) their system produces to assure the best DGCSR radio link range and performance. It is specifically suggested that high noise sources like PWM motor amplifiers, DC/DC converters, and all switching power supplies use LC filters, ferrite EMI suppressors, and proper power ground and chassis ground design practices to limit the noise generated by these components.

8) The DGC SR system should always be tested for proper operation prior to use as a safety interlock for the DGC competition vehicle.

9) Please note that upon returning a vehicle to an ENABLED state from a PAUSED or DISABLED state, the vehicle may resume it's progress immediately and may move immediately in any direction. It is imperative that users ensure that the area around the vehicle is clear and safe before returning the vehicle to an ENABLED state.

2.0 Assignment of Liability

By using the DGCSR components provided, each DGC competition team thereby agrees to accept full responsibility and all legal liability for their DGC competition vehicle and its operation and consequences, and to indemnify and hold harmless Omnitech Robotics International LLC from all responsibility and legal liability and recourse.

Omnitech Robotics International LLC does not take any responsibility for the safe operation of any DGC competition vehicle or any related equipment or conduct at any time. It is entirely up to each team to implement a comprehensive and conservative safety program to assure safe operation and testing of their competition vehicles at all times.

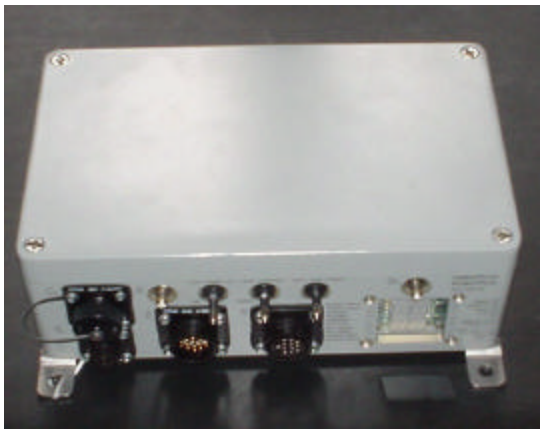
The DGCSR components provided have been tested for proper functionality and reliable operations when installed, used, and maintained properly. However since most critical aspects of the DGCSR system are under the control of the competition teams, each team is exclusively responsible for the overall safety of their entry at all times.

If any team does not agree to accept total and complete responsibility and legal liability for their DGC competition vehicle at all times, and to unconditionally hold Omnitech Robotics International LLC harmless against any incidents that might occur, then the DGCSR systems are not authorized for use and should be returned immediately.

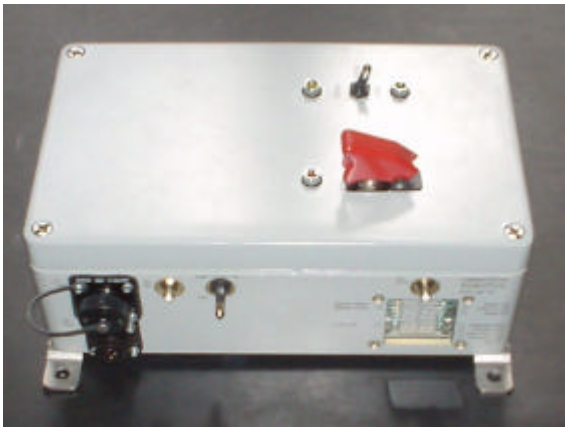
3.0 Package Contents

Upon receiving the DGCSR materials, you should carefully unpack the contents of all boxes and verify the receipt of all contents using the following checklist:

- 1 each of a DGCSR RX
- 1 each of a DGCSR STX
- 2 each of a CA19 - GPS antenna with 5 meter long cable and SMA connector
- 2 each of a CA18 - (ASC0102SN) 10' RF antenna cable, (EB8965C) 5 dB gain antenna, (MBC800) antenna base and mounting bracket
- 2 each of a CA20 - Power Cable
- 1 each of a CA21 - Safety Interlock Cable
- 1 each of a bag of 8 Vibration Isolation Mounts
- DGCSR User Manual (this document)



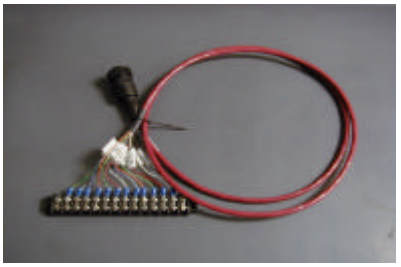
DGCSR RX



DGCSR STX

CA19 - GPS

CA20 - Power Cable



CA21 - Safety Interlock Cable

CA18 - 10' RF cable, antenna, and mount

Figure 1: The DGCSR Components

4.0 Introduction

The DGCSR system provides a remotely controlled “Safety Interlock” for the DGC competition vehicles to allow for a safety operator to remotely 'PAUSE / RUN' and 'ENABLE / DISABLE' one or more competition vehicles during the course of the DGC event. The systems are being provided to DARPA Grand Challenge (DGC) teams in advance of the DGC event to allow each team to install these components in their competition vehicles. They will be used during the DGC event, and may also be used by the competition teams during their development and testing.

The DGCSR system is only part of an overall safety program that all teams must implement, and is not a single catch all safety system. ***All competition teams are fully responsible for all operations of their competition vehicles, and for monitoring and assuring the DGCSR components provided are fully functional at all times.***

The DGCSR consists of two major components, first the “DGCSR RX” or Safety Receiver, and secondly the “DGCSR TX” or Safety Transmitter. These components are shown in Figure 1. The DGCSR RX is intended to be integrated with the DGC competition vehicle. The DGCSR TX is intended to be operated by a human safety monitor/supervisor from a remotely positioned chase vehicle or stationary position. The main function of the DGCSR system is to provide a “Safety Interlock” for the competition vehicles to allow for a safety operator to 'PAUSE' or 'DISABLE' one or more competition vehicles during the course of the DGC event. This is done by flipping toggle switches on the DGCSR TX. In addition, if the radio link between the DGCSR TX and RX is lost for any reason, the PAUSE and DISABLE outputs will automatically assert after a programmable delay time.

During the DGC event, more than one safety operator will be supervising each vehicle, and more than one DGCSR Transmitter will be used. Teams are being supplied with only a single DGCSR TX, but during the competition officials will also use another component called a DGCSR Master Transmitter capable of sending a PAUSE or DISABLE to all teams DGCSR RX units individually or as a whole.

The DGCSR is designed to allow more than 100 safety radio components (Receivers, Transmitters, or Master Transmitters) to operate in one area at one time. The operating range of the DGCSR system has been tested in specific parts of the DGC competition route, with line-of-sight range in excess of 11 miles. Non-line-of-sight range has also been tested in specific critical areas of the route with range in excess of 1 mile.

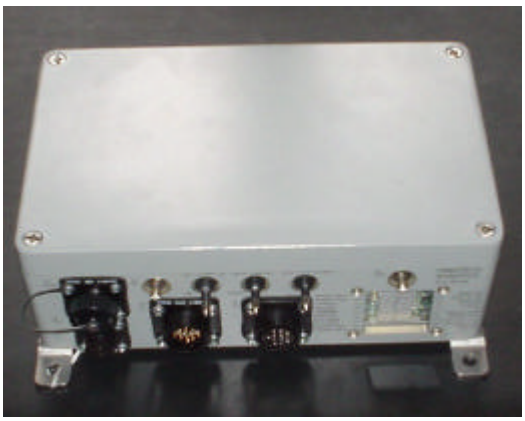
The 'PAUSE' capability is intended to allow safety operator personnel to pause the competition vehicles during the course of the race, with the understanding that the pause will be subsequently removed and a RUN status resumed. It is emphasized that a PAUSE mode will occur on numerous occasions during the race, and the competition vehicles should be able to perform a quick but controlled stop upon the assertion of this command (PAUSE mode), and to perform a controlled restart upon the removal of this command (RUN mode). It is anticipated that each DGC vehicles' control computer(s) will be responsible for monitoring and responding to this command, and that the vehicles should come to a complete stop within about 3 seconds after this signal is asserted at the DGCSR RX (from a typical operating speed of about 25 m.p.h.). While the PAUSE is asserted, the vehicle brakes should be held on even after the vehicle is stopped, so that if the vehicle is stopped on a slope it will not roll. The PAUSE signal interface is provided in two formats: first as signal level (100 mA max) optically coupled digital output; and second as a power level (3A) relay type output.

The 'DISABLE' capability is intended to allow safety operator personnel to DISABLE the competition vehicle(s) during the course of the DGC event, with the understanding that a DISABLE is intended to be permanent and not reversible. Thus it will be used to assure the vehicle stops and stays stopped and disabled for the rest of the DGC event. It is MANDATORY that all competition vehicles use the DISABLE interface to implement an immediate STOP of the vehicle using whatever means necessary for that specific vehicle. Further, the DISABLE signal must use a hardware circuit to assure the competition vehicles main power source (motor or engine) can not continue to operate. In the case of a software failure, this hardware circuit is intended to assure the vehicle does not continue to operate with the engine (motor) on. Asserting the DISABLE should also result in the main service brakes being applied and held on. While it is acceptable to use software in the loop to help implement a DISABLE, a hardware disable of the main power source is also necessary, AND IT MUST TAKE EFFECT WITHIN 1 SECOND. Also, this hardware only engine disable circuit must function to disable in the power off state (fail safe). This will be an inspection criteria of the pre-qualifying inspection and test process. The DISABLE signal interface is provided in two formats: first as a signal level (100 mA max) optically coupled digital output; and second as a power level (3A) relay type output.

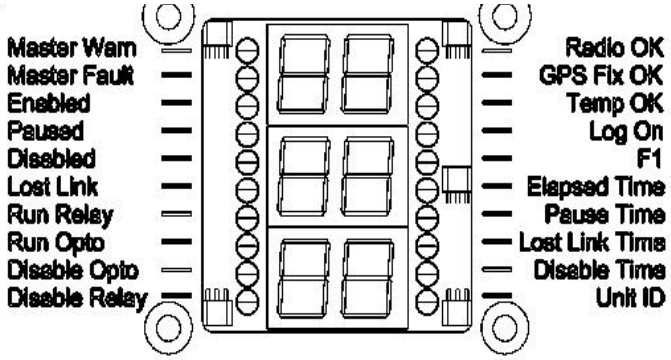
4.1 Overview of the DGCSR Components

4.1.1 DGCSR RX - Safety Receiver

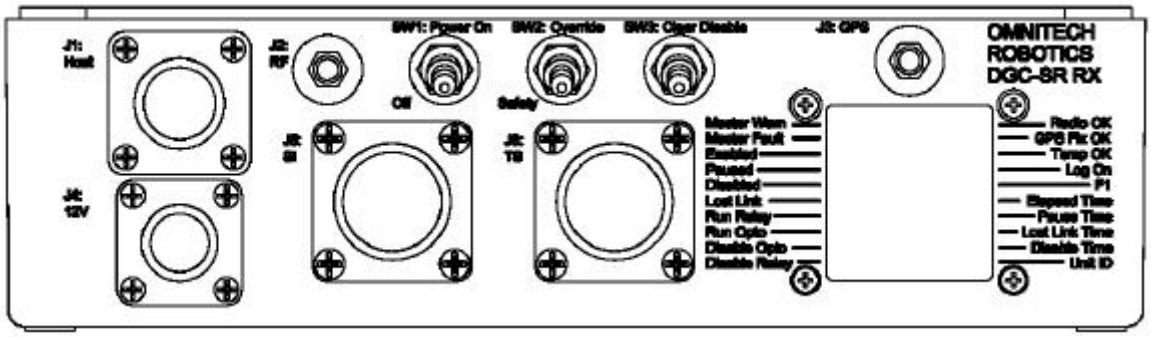
The DGCSR RX is shown in Figure 2. Subsequent sections detail the connector, switch, display, and interface details for this component.



DGCSR RX Photograph



DGCSR RX Status Display Detail



DGCSR RX Connector Detail

Figure 2: The DGCSR RX Side Panel Detail

4.1.1.1 Connector Summary:

- J1: Host - This is a special purpose RS-232 port for use by trained maintenance personnel. DGC Competition teams are not required to use this connector or functionality.
- J2: RF - This is a Radio Frequency (RF) input/output connector using an SMA connector type. It carries a 902-928 MHz RF signal from the DGCSR transceiver, at up to 1 watt of power. It is intended to cable to the supplied RF antenna using the supplied coaxial cable. Users should take care to always have an antenna attached to J2

prior to applying power to the DGCSR TX or RX. Users should also maintain at least a 23 cm distance between the attached antenna and any part of their body to limit their exposure to RF radiation.

- J3: GPS - This is a GPS antenna input. It uses a normal thread SMA connector, and is intended to connect to the supplied 3.3 volt active GPS antenna with preamplifier and filter.
- J4: 12V - This is the power input connector. It is intended to connect to the supplied power input cable with terminal block connections. Nominal power input is 12 volts, 0.4A. This power input can range from a minimum of 10 volts to a maximum of 20 volts.
- J5: SI - This is the Safety Interlock interface connector. It is intended to connect to the provided Safety Interlock cable with terminal block connectors for user signal terminations. Users should review the detailed SI interface specification for more details on this set of signals.
- J6: TS - This is the Tracking System interface connector. It is intended to connect to the separate Tracking System box using a cable provided with that system.

4.1.1.2 Switch Summary:

- SW1: Power On (up position) or Power Off (down position) - This is a pull-to-actuate toggle switch. It is used to turn power “on” or “off” for the DGCSR RX power.
- SW2: Override (up position) or Safety (down position). This is a pull-to-actuate toggle switch. It is used to override the safety radio function altogether. In some cases a DGC team may want to drive their vehicle normally some of the time, without the need to use the DGCSR. In that case, they can place the toggle switch in the up position, selecting the “Safety Override” option, and the vehicle pause and disable outputs are forced to their operating state. This may be useful when it is necessary to operate the vehicle in a manned mode to move it in or out of a building for instance. Alternatively, if this switch is in the down position selecting the “Safety” option, then the DGCSR will operate as defined in this manual and a continual safety radio enable is necessary.
- SW3: Clear Disable - This is a momentary acting pull-to-actuate toggle switch. It is used to clear the ‘DISABLE’ state first at power up, and subsequently after any DISABLE of the system.

4.1.1.3 Status Display LED Function Summary:

- “Master Warn” -- Indicates a Master Warning Status.
- “Master Fault” -- Indicates a Master Fault Status
- “Enabled” -- Indicates that the receiver is in the Enabled State
- “Paused” -- Indicates that the receiver is in the Paused state
- “Disabled” -- Indicates that the receiver is in the Disabled state
- “Lost Link” -- Indicates that the communications link to the single transmitter has been lost.
- “Run Relay” -- Indicates the state of the RUN Output at the Safety Interlock RELAY output pins. A green LED light indicates the RUN mode is asserted. Lack of a green LED indicates a PAUSE or DISABLE mode is asserted or the user power supply on J6: TS is not present.
- “Run Opto” -- Indicates the state of the RUN Output at the Safety Interlock OPTO output pins. A green LED light indicates the RUN mode is asserted. Lack of a green LED indicates a PAUSE or DISABLE mode is asserted or the user power supply on J6: TS is not present.
- “Disable Opto” -- Indicates the state of the DISABLE Output at the Safety Interlock RELAY output pins. A green LED light indicates the ENABLE mode is asserted. Lack of a green LED indicates a DISABLE mode is asserted or the user power supply on J6: TS is not present.

- "Disable Relay" -- Indicates the state of the DISABLE Output at the Safety Interlock RELAY output pins. A green LED light indicates the ENABLE mode is asserted. Lack of a green LED indicates a DISABLE mode is asserted or the user power supply on J6: TS is not present.
- "Radio OK" -- A green LED Indicates that the DGCSR transceiver radio has power and is operating normally.
- "GPS Fix OK" -- Indicates that the GPS has found a position solution (This may take up to 1 1/2 minutes to come on the first time. Subsequently the time to get the GPS Fix OK signal is reduced).
- "Temp OK" -- Indicates that the internal temperature is within acceptable ranges. (< 70C)
- "Log ON" -- Indicates that the data logging feature has been activated.
- "F1" -- Function 1, Reserved for special use.
- "Elapsed Time" -- This LED Indicates that the six seven-segment displays are showing hours [top 2 seven segment displays], minutes [middle 2 seven segment displays] and seconds [bottom 2 seven segment displays] of total "on-time" since the receiver was turned on.
- "Paused Time" -- This LED Indicates that the six seven-segment displays are showing hours, minutes and seconds of total time (cumulative) in the Paused state. This value is logged to non-volatile memory also for use in making adjustments to time or judging of the DGC event.
- "Lost Link Time" -- This LED Indicates that the six seven-segment displays are showing hours, minutes and seconds of total time that the receiver has not had a link with a transmitter. This value is logged to non-volatile memory also for use in making adjustments to time or judging of the DGC event.
- "Disable Time" -- This LED Indicates that the six seven-segment displays are showing hours, minutes and seconds of total (cumulative) time in the Disabled state. This value is logged to non-volatile memory also for use in making adjustments to time or judging of the DGC event.
- "Unit ID" -- Indicates that the bottom 2 seven-segment displays are showing the unit ID.

4.1.1.4 Interface Cables

Figure 3 illustrates the overall cable connections diagram for the DGCSR RX.

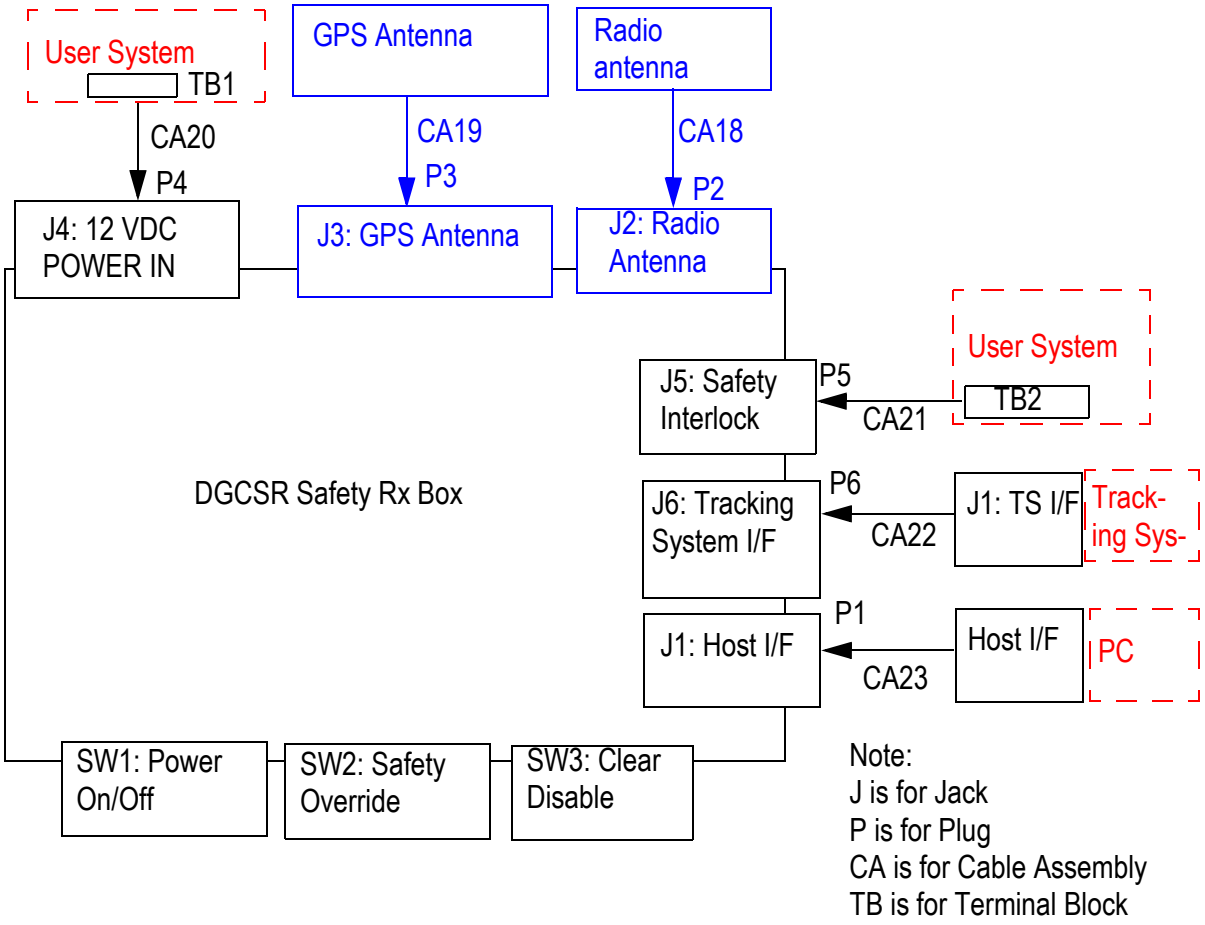
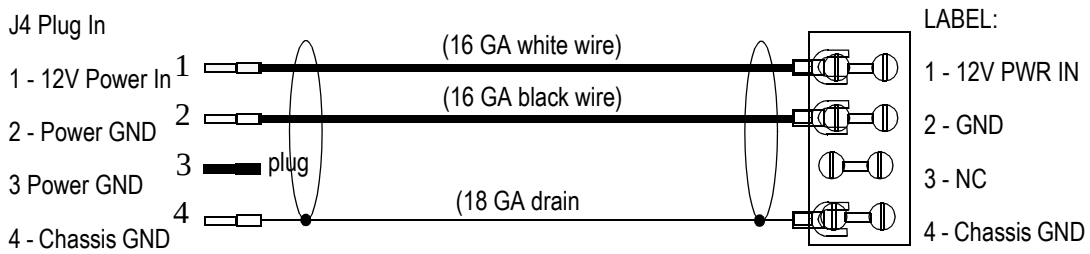


Figure 3: The DGCSR RX Cable Connections Overview

The two cables that require integration with the user system are CA20 and CA21. These are detailed in Figure 4 and Figure 5 respectively.

Figure 6 illustrates the suggested user connections to the Safety interlock (SI) cable terminal block TB2.



Notes:

1) Pin 1 is nominally 12 V power in with respect to pin 2 GND. Acceptable range is 10 V to 20V. Typical Current draw for the DGCSR TX or RX without DGCTS is 0.4A. Input is internally fused at 5A.

2) Pin 4 is chassis GND. It should be connected to the vehicles chassis ground, or control electronic main chassis ground star point.

Figure 4: CA20 Detail

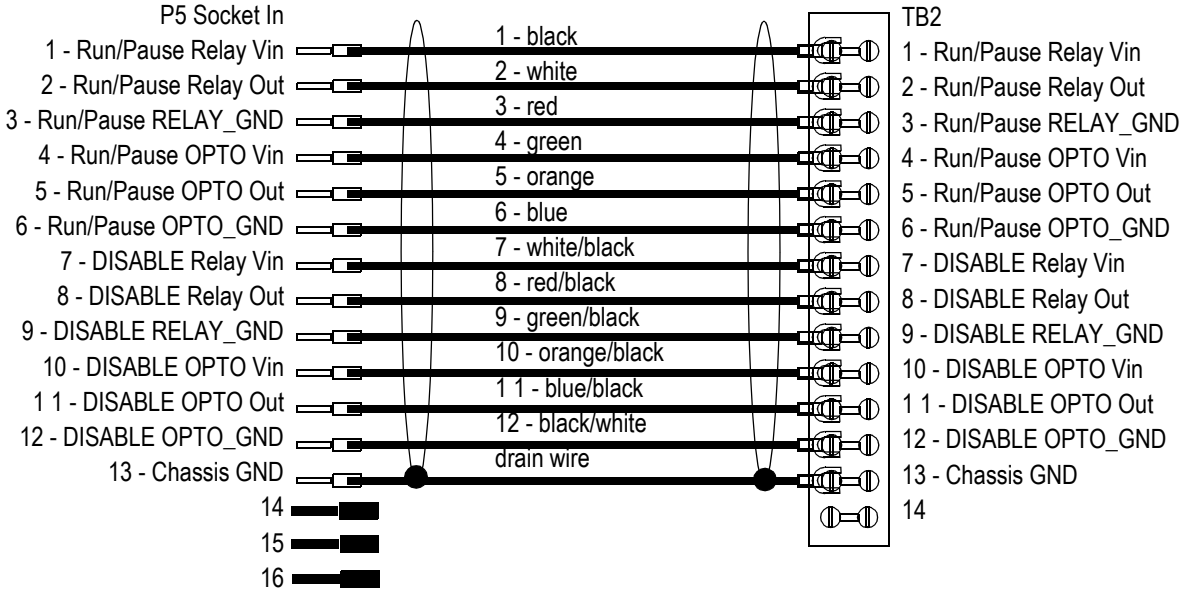


Figure 5: CA21 Detail

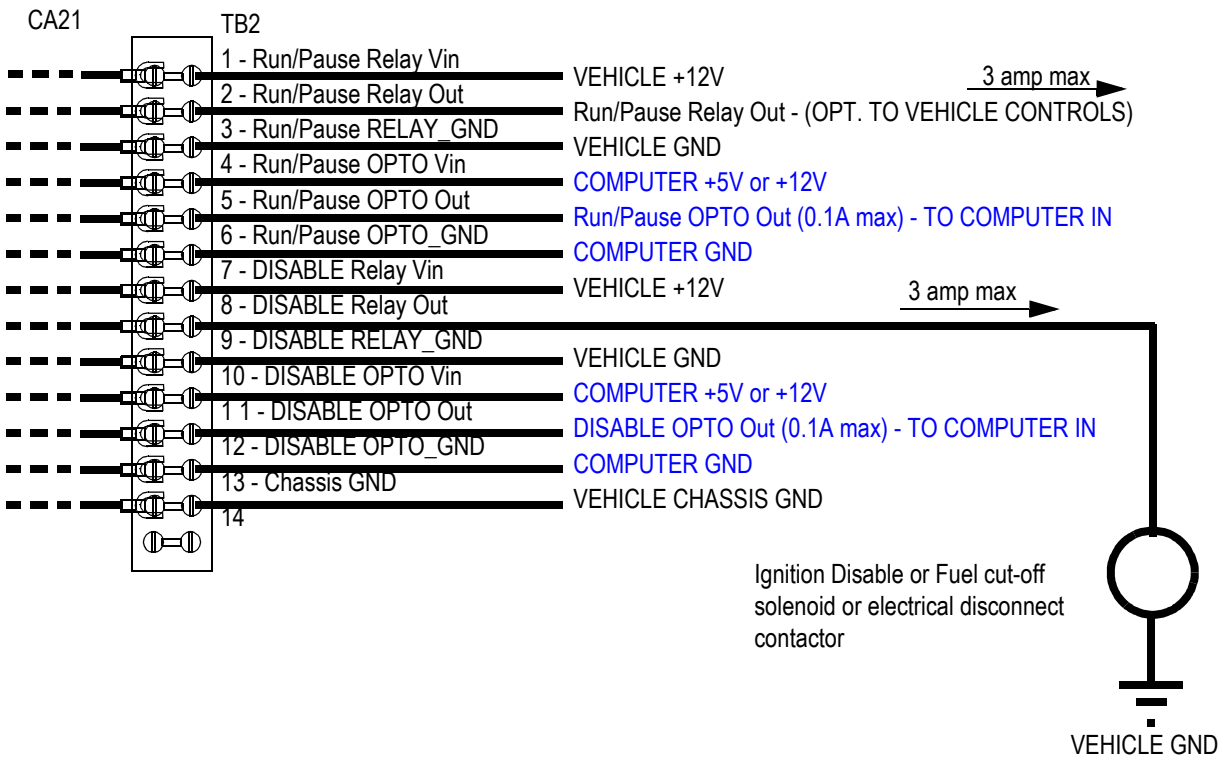
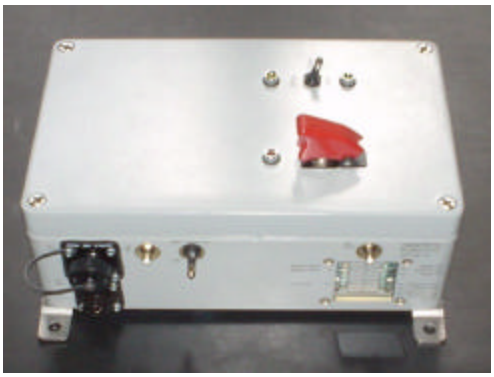


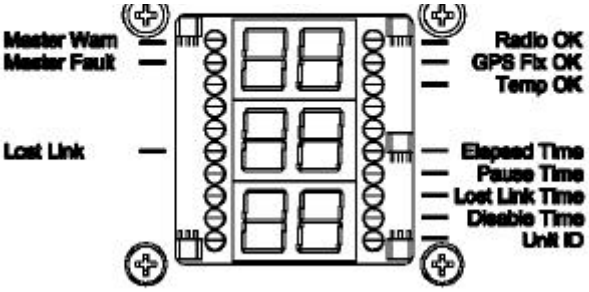
Figure 6: Suggested User Connections to Safety Interlock (SI) Signals on Terminal Block TB2

4.1.2 DGCSR STX - Safety Transmitter

The DGCSR STX is shown in Figure 7. Subsequent sections detail the connector, switch, display, and interface details for this component.

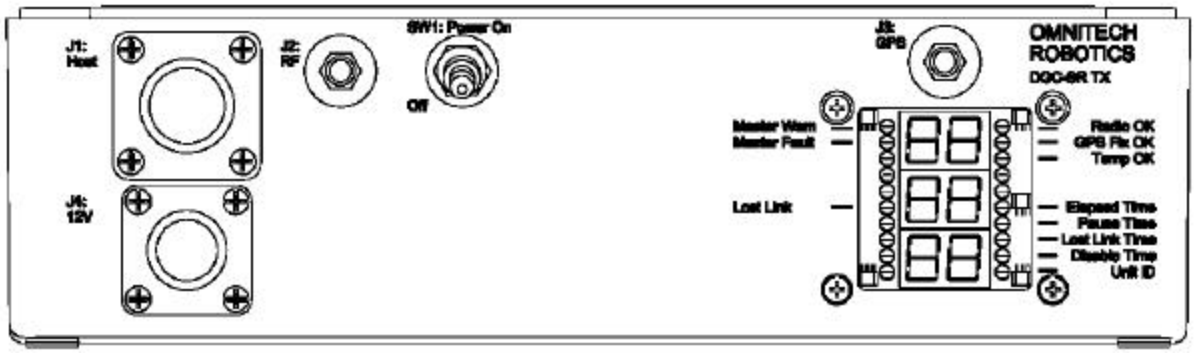


DGCSR STX



DGCSR STX Status Display Detail

DGCSR STX Top Panel, Switch and Mode LED Detail



DGCSR STX Connector Detail

Figure 7: The DGCSR STX Side Panel Detail

4.1.2.1 Connector Summary:

- J1: Host - This is a special purpose RS-232 port for use by trained maintenance personnel. DGC Competition teams are not required to use this connector or functionality.
- J2: RF - This is a Radio Frequency (RF) input/output connector using an SMA connector type. It carries a 902-928 MHz RF signal from the DGCSR transceiver, at up to 1 watt of power. It is intended to cable to the supplied RF antenna using the supplied coaxial cable. Users should take care to always have an antenna attached to J2 prior to applying power to the DGCSR TX or RX. Users should also maintain at least a 23 cm distance between the attached antenna and any part of their body to limit their exposure to RF radiation.
- J3: GPS - This is a GPS antenna input. It uses a normal thread SMA connector, and is intended to connect to the supplied 3.3 volt active GPS antenna with preamplifier and filter.
- J4: 12V - This is the power input connector. It is intended to connect to the supplied power input cable with terminal block connections. Nominal power input is 12 volts, 0.4A. This power input can range from a minimum of 10 volts to a maximum of 20 volts.

4.1.2.2 Switch Summary:

- SW1: Power On (up position) or Power Off (down position) - This is a pull-to-actuate toggle switch. It is used to turn power “on” or “off” for the DGCSR STX power.
- SW2: Run/Passive/Pause: This is a three position, sustaining, pull-to-actuate toggle switch. It is used to command the desired mode for the vehicle, usually either “RUN” or “PAUSE”, or in a special cases during the DGC event only while using Master Transmitters, also a “PASSIVE” mode.
- SW3: Enable / Disable: This is a two position, sustaining, toggle switch with cover. It is used to command the “ENABLE” or “DISABLE” for the vehicle. ENABLE is the normal mode for operation of the DGC competition vehicle, and DISABLE is required to stop the engine or prime mover immediately. Usually a DISABLE is only done after a PAUSE has been initiated, to allow the PAUSE to initiate a controlled stop of the vehicle prior to disabling the vehicles prime mover (engine or battery power) and associated power assisted devices (steering and brakes). Once a DISABLE has been initiated, it will be latched, and the system will maintain this mode until the “Clear Disable” toggle switch is asserted (located on the side panel of the DGCSR RX).

4.1.2.3 Status Display LED Function Summary:

- “Master Warn” -- Indicates a Master Warning Status.
- “Master Fault” -- Indicates a Master Fault Status
- “Lost Link” -- Indicates that the communications link to the single transmitter has been lost.
- “Radio OK” -- A green LED Indicates that the DGCSR transceiver radio has power and is operating normally.
- “GPS Fix OK” -- Indicates that the GPS has found a position solution. (This may take up to 1 1/2 minutes to come on the first time. Subsequently the time to get the GPS Fix OK signal is reduced.
- “Temp OK” -- Indicates that the internal temperature is within acceptable ranges. (< 70C)
- “Elapsed Time” -- This LED Indicates that the six seven-segment displays are showing hours [top 2 seven segment displays], minutes [middle 2 seven segment displays] and seconds [bottom 2 seven segment displays] of total “on-time” since the unit was turned on.
- “Paused Time” -- This LED Indicates that the six seven-segment displays are showing hours, minutes and seconds of total time (cumulative) in the Paused state (from RX). This value is logged to non-volatile memory also for use in making adjustments to time or judging of the DGC event.

- "Lost Link Time" -- This LED Indicates that the six seven-segment displays are showing hours, minutes and seconds of total time that the receiver has not had a link with a transmitter (from RX). This value is logged to non-volatile memory also for use in making adjustments to time or judging of the DGC event.
- "Disable Time" -- This LED Indicates that the six seven-segment displays are showing hours, minutes and seconds of total (cumulative) time in the Disabled state (from RX). This value is logged to non-volatile memory also for use in making adjustments to time or judging of the DGC event.
- "Unit ID" -- Indicates that the bottom 2 seven-segment displays are showing the unit ID.

4.1.2.4 Top Panel Mode LED Summary

RUN Status LED - Lit Green if Radio Link is working, System Mode is ENABLED and Operating Mode is RUN

PAUSE Status LED - Lit Yellow if Radio Link is working and PAUSE is asserted. e.g. System mode is ENABLED and Operating Mode is PAUSED, or if System Mode is DISABLED

DISABLE Status LED - Lit RED if Radio Link is working and System Mode is DISABLED

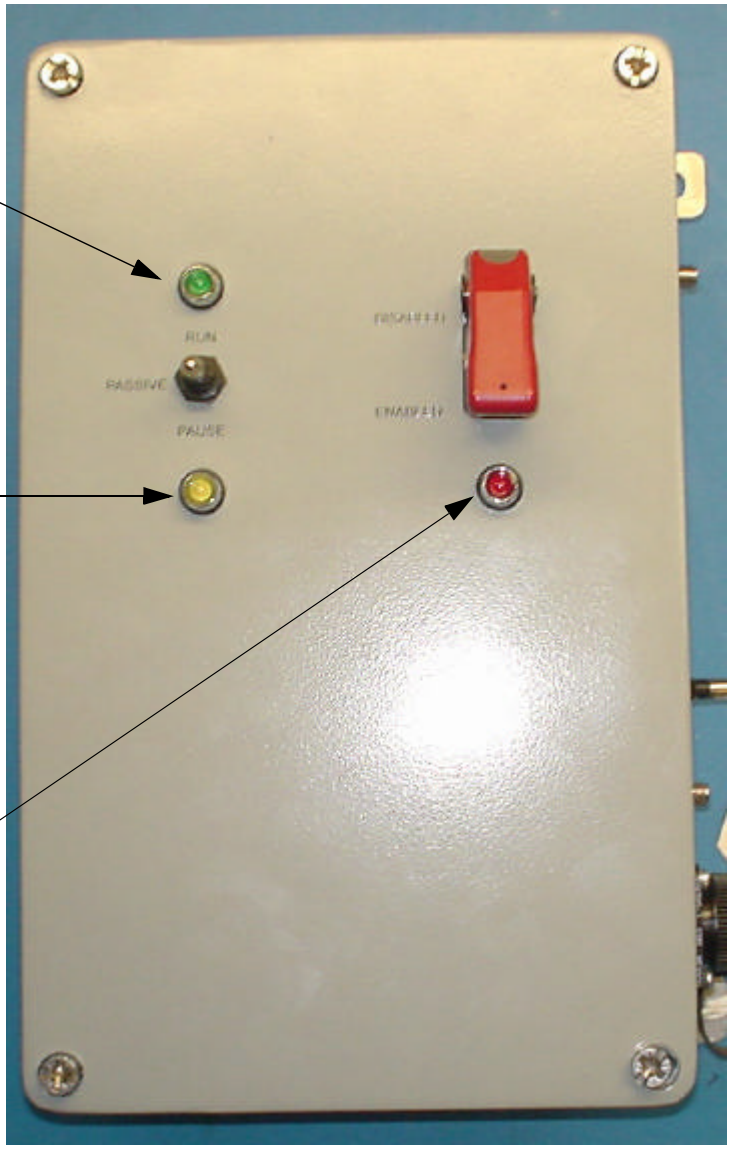


Figure 8: The DGCSR STX Top Panel Detail

4.1.2.5 Interface Cables

Figure 9 illustrates the overall cable connections diagram for the DGCSR STX.

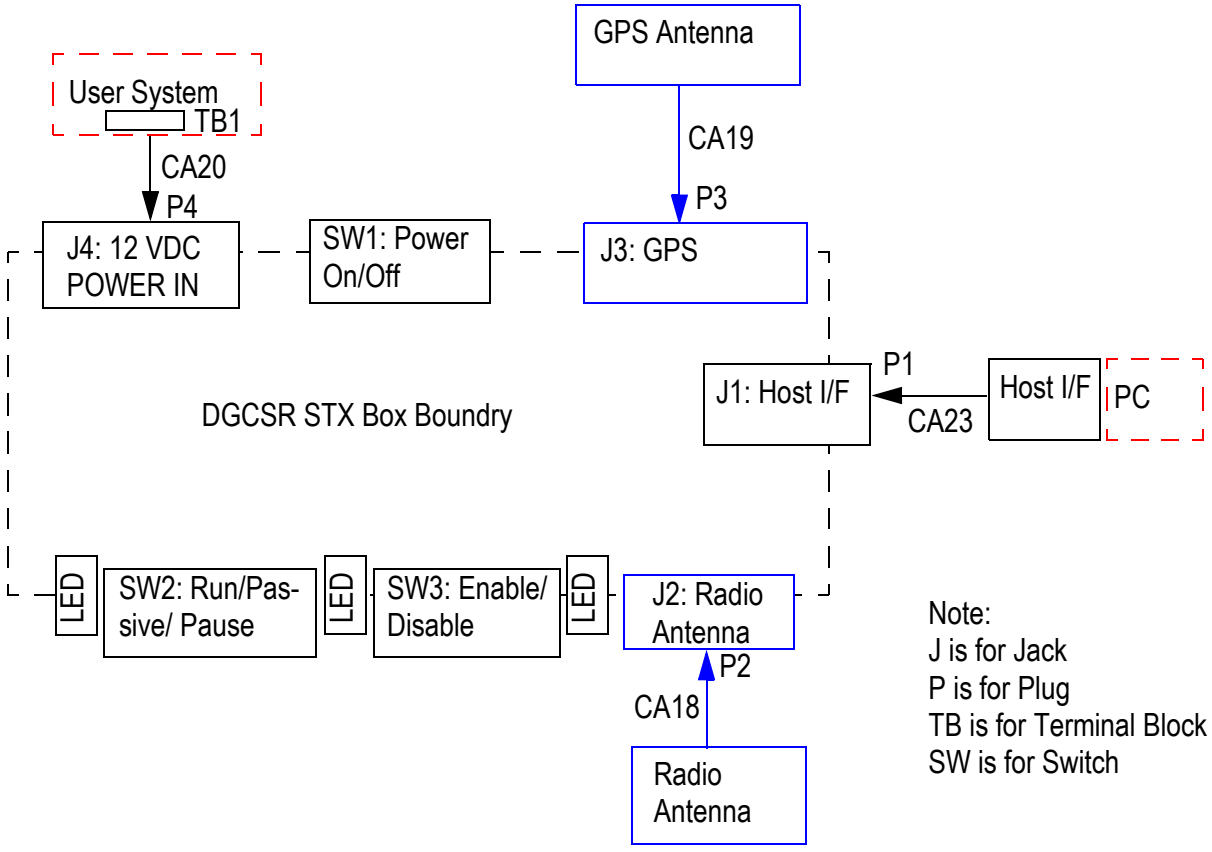
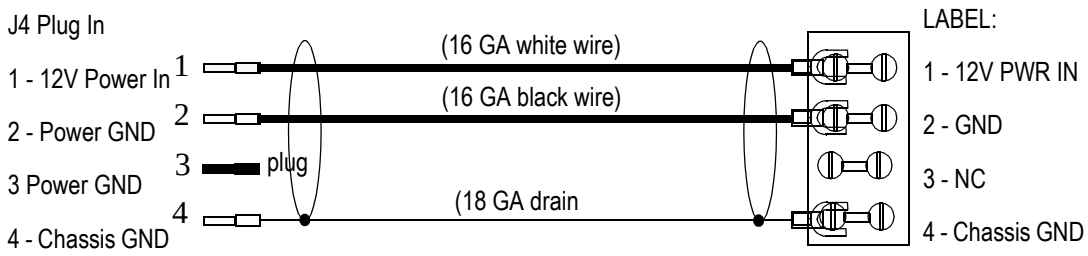


Figure 9: The DGCSR STX Cable Connections Overview

The only cable that requires user integration with their system is CA20. This is detailed in Figure 10.



Notes:

1) Pin 1 is nominally 12 V power in with respect to pin 2 GND. Acceptable range is 10 V to 20V. Typical Current draw for the DGCSR TX or RX without DGCTS is 0.4A. Input is internally fused at 5A.

2) Pin 4 is chassis GND. It should be connected to the vehicles chassis ground, or control electronic main chassis ground star point.

3) For mobile chase vehicle operations, the 12V and GND power connections can be adapted to a car cigarette lighter adapter plug, like Digikey part # APP-001-ND

Figure 10: CA20 Detail

4.2 DGCSR Design Features

- Networked Time Division Multiple Access (TDMA) radios for all units to allow close range and long range operations of over 100 units
- License-free, Instrumentation, Scientific and Medical (ISM) band (902 - 928 MHz) Spread Spectrum Radios are multi-path interference resistant. Radio link interference problems are minimized using TDMA protocol, spread spectrum RF techniques, and custom frequency hopping patterns.
- All Communications occur in a TDMA cycle epoch with 1 Hz period. Latency time from the assertion of a PAUSE or DISABLE toggle switch on the DGCSR TX to the relay or opto-coupler assertion on the DGCSR RX is typically between 1 to 2 seconds
- Programmable time-out for the PAUSE to assert after a loss of RF data link, 1 to 60 seconds
- Programmable time-out for the DISABLE to assert following a PAUSE time-out, 1 to 60 seconds
- GPS based time reference, accurate to 1 microseconds with a hold-up circuit in case of temporary GPS drop-outs (typically sufficient for more than 10 minutes of GPS loss without loss of radio functionality)
- Integrated GPS based vehicle tracking capable
- Integrated data logging with 1000 hours of data logging of critical Built In test (BIT) data and vehicle tracking log
- Power-up and background Built in Test (BIT) of power supply voltages, enclosure ambient and internal power supply temperatures, and other operational performance parameters
- Interface to the DGC TS tracking system and satellite transceiver communications relay system
- Normal Operating Temperature range 0 to 60 C. [Units tested to 70C, and safety critical circuits built with 85 C temperature range specified components]
- Designed and tested for high shock and vibration environments
- Power and Interface connections designed for automotive voltage range: 12V nominal, minimum 10V, maximum 20V.

5.0 System Integration Precautions and Warnings

- The DGC SR system should always be tested for proper operation prior to use as a safety interlock for the DGC competition vehicle.
- It is recommended that users implement a control system for the competition vehicle that does not allow the engine to start when the vehicle is in gear. Many commercial automotive systems have this feature already. This increases safety when using the DGCSR by assuring that when the engine is first started the vehicle will not move right away. This is important in case users are near the vehicle to operate as is often the case.
- The radio frequency (RF) Antenna emits RF radiation in the 902-928 MHz frequency range, at power levels up to 1 watt. The FCC authorizes these radios to operate at this power level license free, however all personnel should maintain a minimum separation from all parts of their body to the radio antennas of at least 23 cm at all times to reduce their exposure to RF radiation
- If a particular competition vehicle uses power steering, power brakes, or other power assist devices to maintain control of their vehicle, then consideration must be given to assure the compatibility of the DGC SR system. Specifically, the PAUSE signal does not necessarily stop the prime mover (motor or engine) of the competition vehicle, but the DISABLE command does. It is intended that the PAUSE is used to initiate an immediate controlled stop using all such power assist equipment, and the DISABLE will engage after the vehicle has come to a controlled stop to turn off the engine and assure a faulty vehicle does not drive off indefinitely with power.
- The DGC competition vehicle control system should be designed to stop the vehicle and apply the brakes quickly when a PAUSE is asserted. It should also stop the vehicle and apply the brakes and stop the engine when a DISABLE is asserted. The engine should stop quickly (within one second) of a DISABLE command assertion. The brakes should apply quickly (within one second) in either case to initiate a controlled stop as fast as possible. The brakes actuator should also be designed to allow the brakes to be applied full force with a 100% duty cycle (continuously for 1 hour) and with sufficient holding force to hold the vehicle while on a 45 degree slope (100% grade). Meeting these requirements will require careful design and implementation. These aspects of the DGCSR systems integration are critical to the safe and reliable operation of the DGCSR system, and are under the control and responsibility of each competition team.

6.0 DGCSR System Operation

The basic operating procedure for the DGCSR system is outlined here as initial guidance and for training purposes. It is expected that normal operation of the DGCSR system will become routine after a few hours of successful operation. However, care must be taken to assure that all personnel are properly trained in the use of the DGCSR system, and prepared to act quickly and reliably as necessary to implement an effective safety radio shut-down procedure at any time. ***To enhance the reliability of operators using the DGCSR, and to assure the DGCSR system is operating normally, it is important to test the DGCSR system each time it is used prior to allowing the DGC competition vehicle to drive unmanned.***

6.1 Confirm Antennas are Installed

The DGCSR should always have the RF antenna installed prior to powering up the DGCSR TX or RX. An occasional brief failure to do this will not damage the DGCSR radios, however it is not advised. Operators should always keep at least a 23 cm separation between the antenna and their body parts to maintain compliance with FCC limits on recommended RF radiation exposure from this antenna.

The DGCSR requires the GPS antenna to be installed and an initial GPS location fix to be acquired prior to operation of the DGCSR. This is because the GPS provides a precise time reference that is an integral part of the DGCSR TDMA radio network design. For this reason, the GPS antenna needs to be installed as an initial check.

6.2 Set Safety Override Switch

The safety override toggle switch on the DGCSR RX has two settings: up for OVERRIDE and down for SAFETY. If the user wants to use the DGCSR system this switch must be in the down position, selecting SAFETY. If the user wants to operate the DGC competition vehicle without the DGCSR (including to simply start the vehicle engine with the safety interlock in place) the switch should be in the up or OVERRIDE position. Because this switch can potentially be placed in the wrong position inadvertently, it is important to always test the DGCSR for proper operation prior to use.

6.3 Power-Up

Powering up the DGCSR TX and RX can occur in either order. To power the units, the Power On / Off toggle switch (SW1) should be placed in the up (ON) position. Visual confirmation of the power-up sequence of the units is possible by observing the Status Display window and watching the LED light test where all DGCSR controlled LEDs are turned on briefly at power-up.

6.4 Monitor Status Displays

The initial power-up progress can be monitored by observing the status display LEDs. Normal operation will be indicated by the presence of the Elapsed Time LED coming on, and the time displays beginning to increment (there are six 7-segment displays that show hours (top 2 characters), minutes (middle 2 characters) and seconds (bottom 2 characters)).

If the display shows an EE and number code, this is an error code display indicating an abnormal situation. The error code number should be recorded for later reference. If this occurs, users should verify proper installation and use of the system, then call Omnitech Robotics for consultation if necessary.

Once the elapsed time counter begins to increment, the user can observe the “GPS FIX OK” LED in the upper right corner of the status display window. This LED will turn green once the GPS has obtained a correct GPS position location fix, and therefore has an accurate time reference. Until this LED lights up, the DGCSR system will not function.

Once both the DGCSR STX and RX are powered up and each unit’s “GPS FIX OK” LED is lit, the “RADIO OK” LED should be lit green and the “LOST LINK” LED should be off. The system is now ready to operate.

6.5 Preset the DGCSR TX Mode Switches

It is necessary to preset the DGCSR TX mode select switches to the state desired for initial operation. Usually this will be system mode ENABLED and operational mode PAUSED. This allows the vehicle engine to start, but signals the user’s control computer to maintain a Paused (stopped) status. This is important so the vehicle does not start to move immediately after the next step, before the operator can get away from the competition vehicle.

6.6 Clear the Initial System DISABLE Mode

When the DGCSR system first powers up, with the Safety Override in the SAFETY position (not Override) the system will default to the DISABLED system mode. This is intended to assure that the vehicle engine will be off to begin with, to allow a careful and controlled transition to the DGCSR system Safety Interlock operations and subsequently to the unmanned operations using each team's control system.

After the DGCSR is ready, and the competition vehicle's control system is ready, users should clear the system disable by asserting the CLEAR DISABLE toggle switch on the DGCSR RX. This switch should be asserted and held in the CLEAR DISABLE position for about a second.

The system will then enter the ENABLED system mode. Confirmation that the DGCSR is in this mode and is ready for operation is possible by observing the mode status LEDs on the front panel of the DGCSR TX.

6.7 Test the DGCSR Operation Prior to Use

At this point, the DGCSR is fully operational, and the RX outputs (Run/Pause and Enable/Disable) should follow the command from the TX toggle switches. Prior to use, proper operation should be confirmed however.

First, assert a PAUSE using the TX toggle switch, and verify the RX Status Display LEDs show the PAUSED LED goes on (Red LED on). The user powered RUN OPTO LED and RUN RELAY LED should go off. Return the operational Mode switch to the RUN position and verify the RX Status Display LEDs show the PAUSED LED goes off (Red LED off) and RUN OPTO LED and RUN RELAY LED should go on. Users may also use these signals to implement their own unique indication prompting / enunciation of these modes and states using their own electrical or computer means.

Second, assert a DISABLE using the covered TX toggle switch, and verify the RX Status Display LEDs show the ENABLED LED goes off (Green LED off). The user powered DISABLED OPTO LED and DISABLE RELAY LED will go on. Now assert an ENABLE using the covered TX toggle switch, however note the LEDs will not change right away. It is necessary to go the DGCSR RX and lift (assert) the Clear Disable toggle switch first. Then you can verify the RX Status Display LEDs show the ENABLED LED goes on (Green LED on). Also note the user powered DISABLED OPTO LED and DISABLE RELAY LED will go off. Users may

also use these signals to implement their own unique indication prompting / enunciation of these modes and states using their own electrical or computer means.

Next it is recommended that the time-out function be tested. Move the DGCSR TX operating mode toggle switch to the PASSIVE position. This causes the DGCSR TX to stop sending RF messages to the DGCSR RX. After a period of time called the "Pause time-out" period, the DGCSR should assert the PAUSE operational mode, then after an additional second period of time called the "Disable time-out" period, the DISABLE system mode should assert. The actual "Pause time-out" period and "Disable time-out" period are programmable, and will be set by DGC officials. Users should confirm their units time-out periods as received and confirm they are consistent over time within one second. (longer is possible if communications links are unreliable or noisy). Again clear the DISABLED system mode and enter the ENABLED system mode to allow continued testing.

Next, it is recommended that the actual engine kill function be tested. To do this, make sure the system is in neutral gear, PAUSE mode, and ENABLED. (Be careful not to allow the engine to start when the vehicle is in gear and a user is around the vehicle.) Start the engine then assert the DISABLE toggle switch. Verify the engine or prime mover stops within one second. Turn off the engine start signal if necessary in the user control system, then press the Clear Disable toggle Switch on the DGCSR RX.

6.8 Run / Pause Operation

Once the DGCSR system is operational, and tested for functionality it can be used by a safety operator to aid in testing the DGC competition vehicles. While testing, if an unsafe condition is arising, the operator should assert the PAUSE command with sufficient advance notice and planning to assure the vehicle will stop prior to a problematic event or accident. If the situation warrants it, the PAUSE can be removed and a normal RUN mode entered again. Alternatively, if the situation warrants it, or if the PAUSE fails to stop the vehicle, the DISABLE should be asserted to stop the engine (prime mover) on the vehicle.

6.9 Emergency DISABLE Operation

While testing, if an unsafe condition is arising, the operator should assert the PAUSE command with sufficient advance notice and planning to assure the vehicle will stop prior to a problematic event or accident. In an emergency if the situation warrants it, or if the PAUSE fails to stop the vehicle, the DISABLE should be asserted to stop the engine (prime mover) on the vehicle. This should prevent a run-away vehicle condition.

Operational Notes:

- the system will only work is GPS lock can be acquired (i.e. not indoors)

7.0 Error Codes

The DGCSR STX and RX will display error codes on the Status Display if an error condition is detected. To aid in diagnosing system faults, the following error codes are provided.

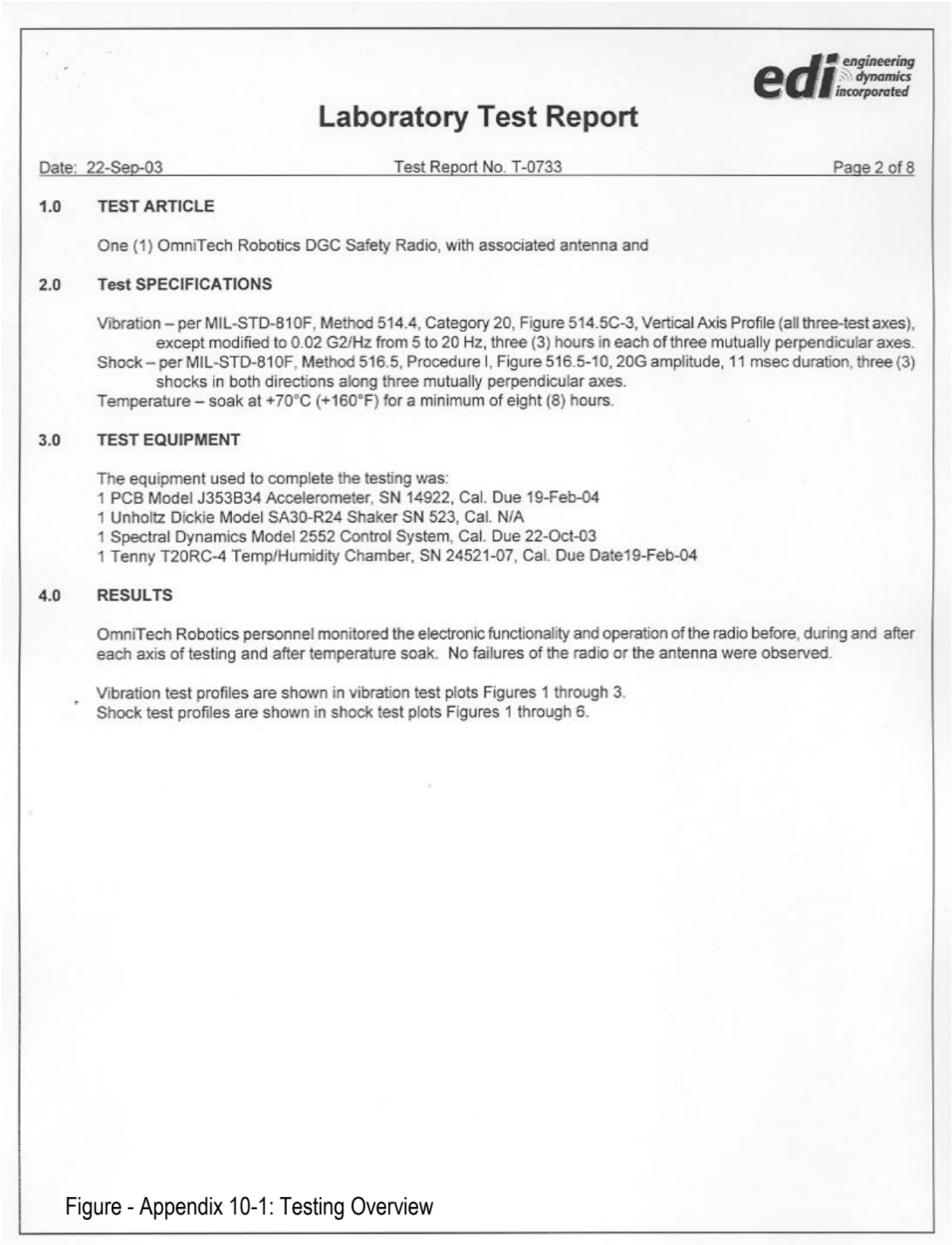
Table 1: Error Codes

Error Code	Error Condition	Likely Error Source	Recommended Procedure
01	No Com-pactFlash Found	Compact Flash Not Installed or error	Note recent operational and storage conditions. Contact ORI.
50	GPS Not Respond-ing	The GPS uses a "battery backup" to maintain nonvolatile memory and real-time clock settings. This "battery backup" is actually designed using an 0.47 F ultra capacitor that requires charging occasionally if it is fully dis-charged. Until it has sufficient charge, this error may occur at power-up.	Keep the power on for several minutes, then cycle the power off and on again. The error should go away.
51	Trans-ceiver Not Respond-ing	Radio Failure	Note recent operational and storage conditions. Contact ORI.
53	Remote BIT Error	Built In Test error	Note recent operational and storage conditions. Contact ORI.
67	+5 V error	Internal 5V power supply failure or fuse blown	Note recent operational and storage conditions. Contact ORI.
68	+5VA Error	Internal 5V Analog power sup-ply failure or fuse blown	Note recent operational and storage conditions. Contact ORI.
69	+12 V Error	Internal 12V power supply fail-ure or fuse blown	Note recent operational and storage conditions. Contact ORI.

Table 1: Error Codes

Error Code	Error Condition	Likely Error Source	Recommended Procedure
70	+3.3 V Error	Internal 12V power supply failure or fuse blown	Note recent operational and storage conditions. Contact ORI.
71	J15 temp sensor Error	J15 temp sensor not used. Provisional Over-temp Sensor.	Note recent operational and storage conditions. Contact ORI.
72	J16 temp sensor Error	J16 temp sensor not used. Provisional Over-temp Sensor.	Note recent operational and storage conditions. Contact ORI.
73	Main Board (ambient) temp sensor Error	Main board (ambient) temp greater than 70 C	Note recent operational and storage conditions. Contact ORI.
74	Power Board Temp Sensor Error	Power Supply board temperature greater than 70 C	Note recent operational and storage conditions. Contact ORI.

8.0 Appendix A - Shock/Vibration Testing Reference



edi engineering dynamics incorporated

Laboratory Test Report

Date: 22-Sep-03 Test Report No. T-0733 Page 2 of 8

1.0 TEST ARTICLE

One (1) OmniTech Robotics DGC Safety Radio, with associated antenna and

2.0 Test SPECIFICATIONS

Vibration – per MIL-STD-810F, Method 514.4, Category 20, Figure 514.5C-3, Vertical Axis Profile (all three-test axes), except modified to 0.02 G2/Hz from 5 to 20 Hz, three (3) hours in each of three mutually perpendicular axes.
Shock – per MIL-STD-810F, Method 516.5, Procedure I, Figure 516.5-10, 20G amplitude, 11 msec duration, three (3) shocks in both directions along three mutually perpendicular axes.
Temperature – soak at +70°C (+160°F) for a minimum of eight (8) hours.

3.0 TEST EQUIPMENT

The equipment used to complete the testing was:
1 PCB Model J353B34 Accelerometer, SN 14922, Cal. Due 19-Feb-04
1 Unholtz Dickie Model SA30-R24 Shaker SN 523, Cal. N/A
1 Spectral Dynamics Model 2552 Control System, Cal. Due 22-Oct-03
1 Tenny T20RC-4 Temp/Humidity Chamber, SN 24521-07, Cal. Due Date19-Feb-04

4.0 RESULTS

OmniTech Robotics personnel monitored the electronic functionality and operation of the radio before, during and after each axis of testing and after temperature soak. No failures of the radio or the antenna were observed.

Vibration test profiles are shown in vibration test plots Figures 1 through 3.
Shock test profiles are shown in shock test plots Figures 1 through 6.

Figure - Appendix 10-1: Testing Overview

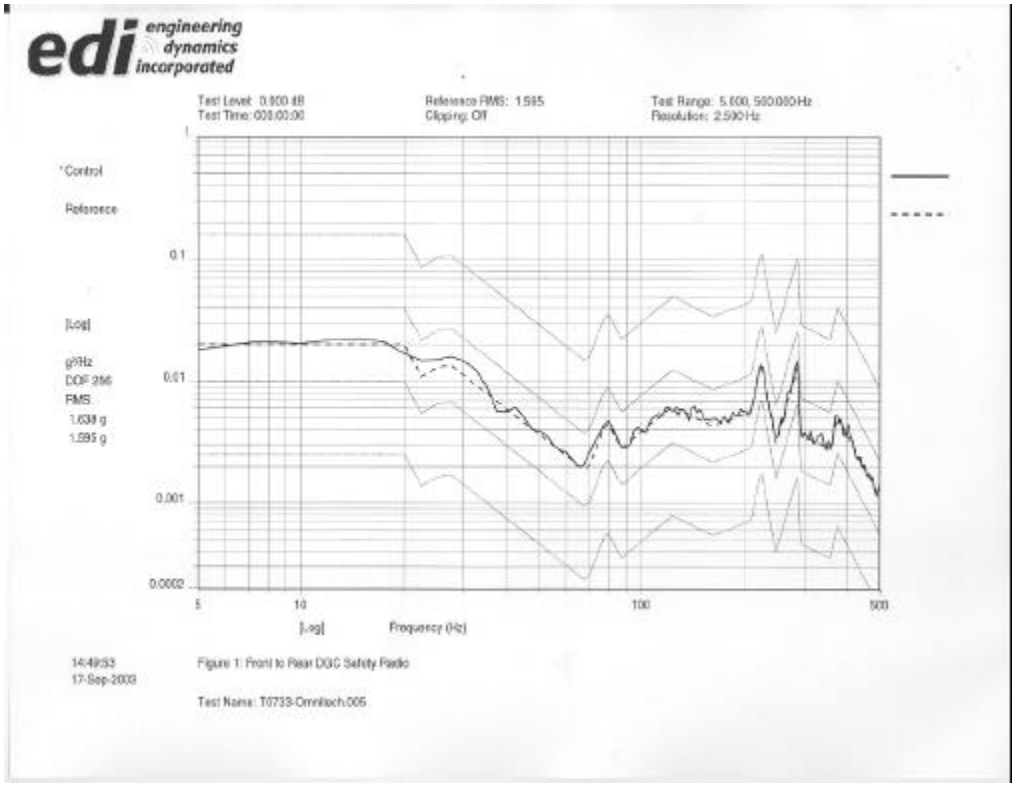


Figure - Appendix 10-2: Typical Vibration Profile

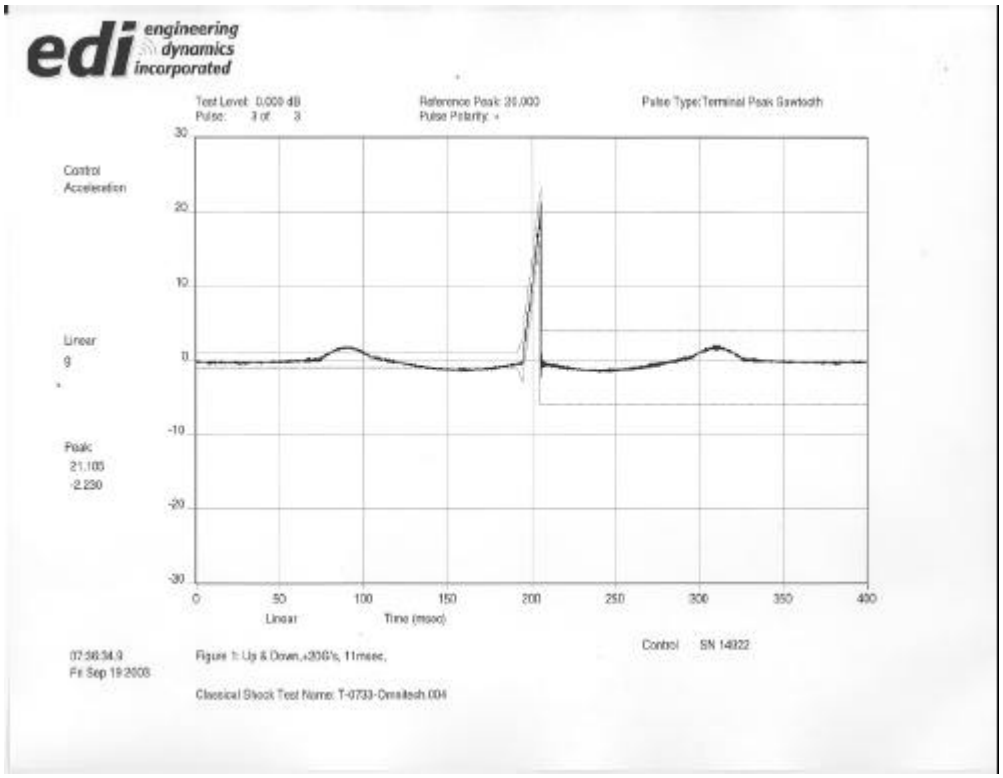
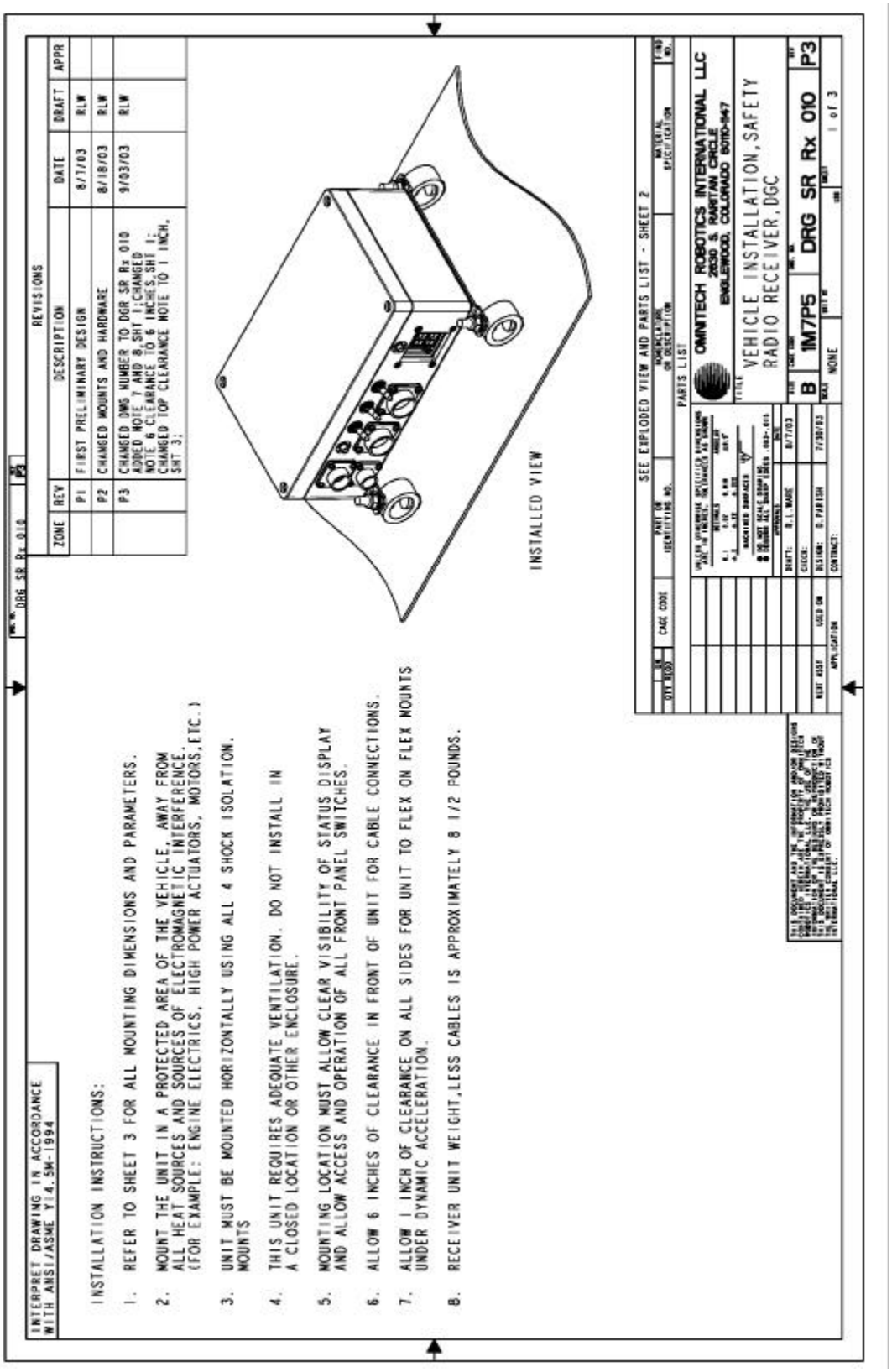
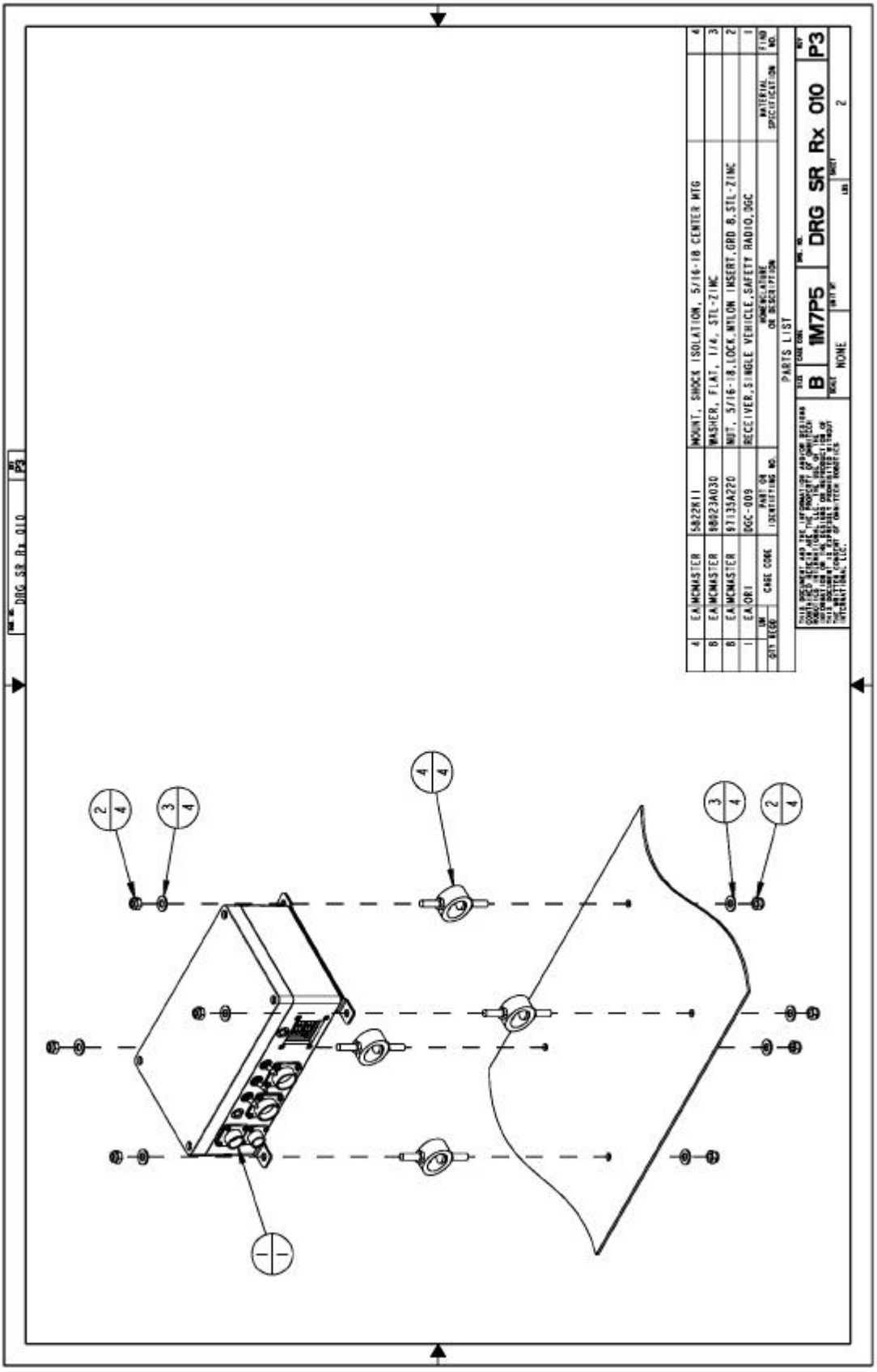
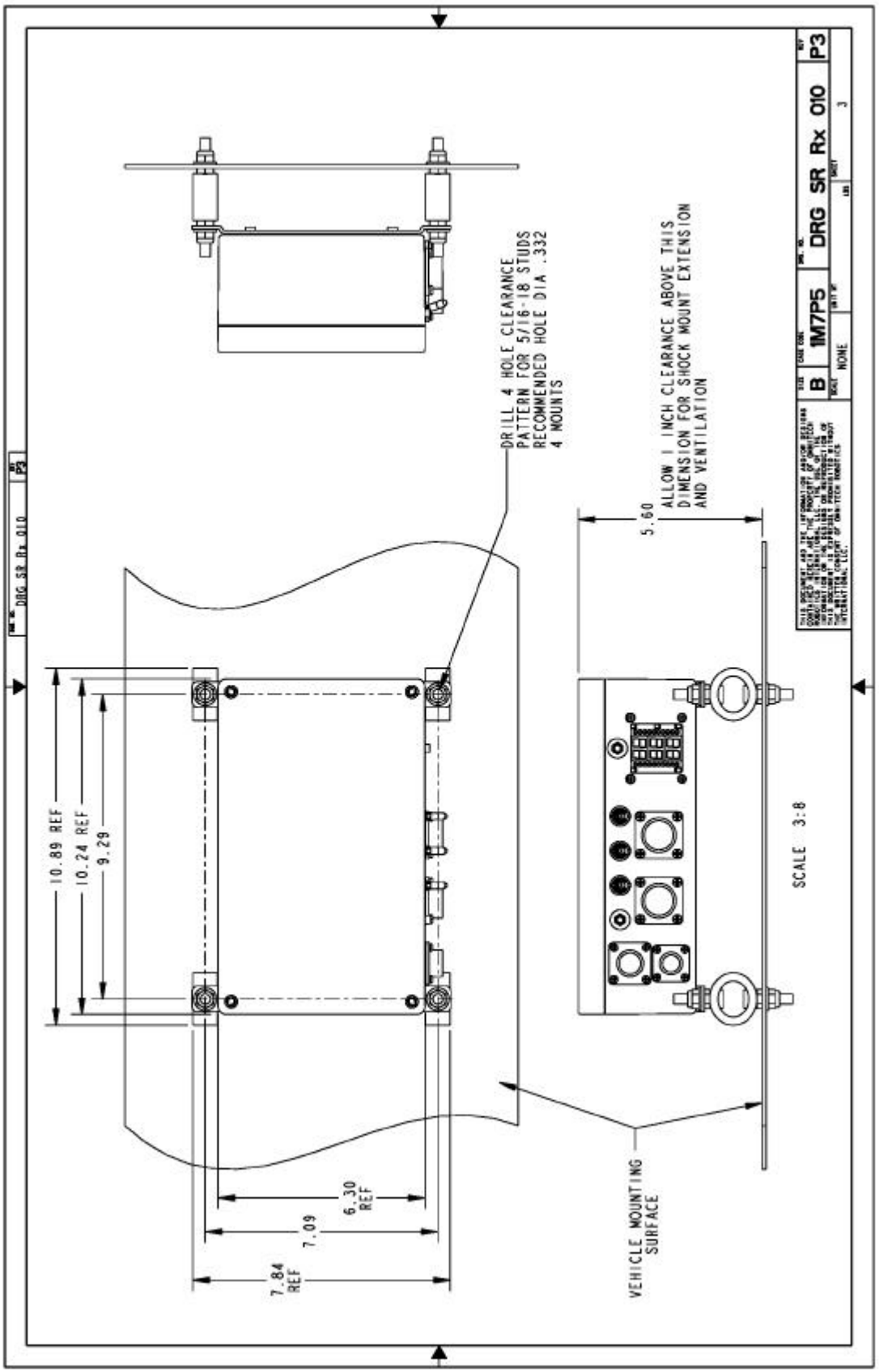


Figure - Appendix 10-3: Typical Shock Profile

9.0 Mounting Instructions




DRG SR Rx 010 P3
4 EA MCMASTER 5822K11 MOUNT, SHOCK ISOLATION, 5/16-18 CENTER MTG
3 8 EA MCMASTER 98023A030 WASHER, FLAT, 1/4, STL-ZINC
2 8 EA MCMASTER 91735A220 NUT, 5/16-18,LOCK,NYLON INSERT,GRD 8,STL-ZINC
1 1 EA ORI DGC-009 RECEIVER,SINGLE VEHICLE,SAFETY RADIO,DGC
QTY REQD DWG CAGE CODE PART OR IDENTIFYING NO. NOMENCLATURE OR DESCRIPTION MATERIAL SPECIFICATION FIND NO.
PARTS LIST
SIZE B CAGE CODE 1M7P5 DWG NO. DRG SR Rx 010 REV P3
SCALE NONE UNIT OF LBS SHEET 2


DRILL 4 HOLE CLEARANCE
PATTERN FOR 5/16-18 STUDS
RECOMMENDED HOLE DIA .332
4 MOUNTS
ALLOW 1 INCH CLEARANCE ABOVE THIS
DIMENSION FOR SHOCK MOUNT EXTENSION
AND VENTILATION
5.60
10.89 REF
10.24 REF
9.29
6.30
REF
7.09
7.84
REF
VEHICLE MOUNTING
SURFACE
SCALE 3:8
DRG SR Rx 010
P3
B
1M7P5
NONE

10.0 Technical Support

After reading this users manual, if you have additional questions please check our web-site for updates to this manual or other information. If you still have questions or comments, you can contact us using the following contact information:

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2630 South Raritan Circle

Englewood, Co 80110

Phone: 303 922 7773

Fax: 303 922 7775

web site: www.omnitech.com

email: info@omnitech.com