SOP – HydroGreen – CAN Troubleshooting

Overview

The CAN Bus is the main communication channel by which the HydroGreen Controller Application controls the distributed IO ECUs. CAN failures can take many forms and result in various symptoms, but some failure modes are significantly more common than others, and not all abnormal table behavior is the result of CAN failures.

• Ensure Terminator Functionality

Much of the troubleshooting procedures described in this document rely on the functionality of the CAN terminators present on the Bus. For this reason, it is imperative to ensure terminator functionality before engaging in further troubleshooting procedures.

Initial Visual Inspection

Prior to any further testing, both terminators should be inspected for visible water ingress and corrosion. Ensure terminators are stored upright such that the terminator is not hanging down such that water would run down the wire into the connector.

If obvious corrosion or water ingress are found, the terminator should have water removed or should be replaced in the case of corrosion. Check if functionality has been restored prior to further troubleshooting.

Direct Measurement

The CAN terminator is an exceedingly simple device. It merely functions as a 120 Ohm resistor between CAN high and low. If a technician with a digital multimeter is on site, they can simply remove the terminator and probe for resistance between the CAN high and low pins (2 and 4). If ~120 Ohms are measured, then the terminator can be assumed functional.

Use on Functional Table

If multiple tables are on location, both terminators can be transferred from the afflicted table to the known-good table. If failures move with the terminators to the known-good table, then the terminators must be replaced. If functionality remains on the known-good table, then the terminators can be assumed functional.

Pre-emptive Replacement

If no method to confirm terminator functionality is available, but replacement terminators are on-hand. These terminators should be placed on the table. If issues persist, we shall proceed assuming the new terminators are functional (as a single failure somewhere in the bus is more likely than two independent sets of terminators failing).

• Isolate Wiring Branches

The table consists of three main wiring branches: the front, middle, and rear node groups. Assuming the issue is located on one of these branches, we can determine which branch has failed by removing each branch from the bus in turn. When the failed branch is removed from the bus, CAN functionality will be restored. From there we can more thoroughly inspect the failed branch to determine the exact point of failure.

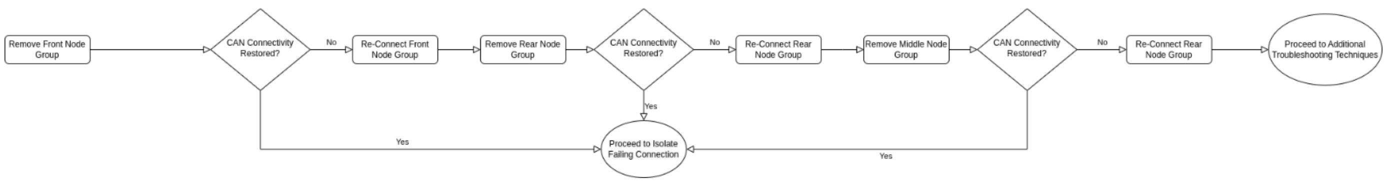
The nodes/harnesses are embedded into the CAN bus and daisy chain their connections. Within this section I will refer to the Advantech as the source of the CAN bus, the 4P/S connector on a node harness that leads toward the screen as the “input” or “upstream” connection, and the 4P/S connector on a node harness that leads away from the Advantech and toward another node/terminator as the “output” or “downstream”. This is not a literal description of how CAN protocol or the bus works. The bus is simply a single continuous pair of wires containing terminators at both ends – no individual point is special or privileged. However, this vocabulary is useful in orienting/describing connectors on the table.

Removing branches

Branches at the front or rear of the table can be easily removed from the bus by disconnecting the DT4P/S junction at the top of the table (just before the CAN/PWR 4 wire line connects into the top node) and placing the terminator in this location. The CAN connections are daisy chained from the top node to the lower nodes, so disconnecting the connection into the top node also removes all downstream nodes. The terminator must be placed at this open location to complete the bus.

The middle branch can be removed from the table either by bypassing it (achieved by disconnecting both CAN connections running to the middle node and running the input line directly to the output line) or by moving the rear terminator to the upstream connector (which will remove the middle and rear nodes from the bus).

Initial troubleshooting can then be performed via the following steps:



• Isolate Failing Connection

At this point, we have determined which branch of the bus is failing. Now we must isolate the specific connection that has failed. Typically, the failure is due to water ingress/corrosion. In these cases, a simple visual inspection will reveal the failure point. Before proceeding, inspect each connector for obvious signs of corrosion, and replace as necessary. Other failure modes include sheering of the wire at the crimp location within the connector or an improperly seated pin/socket within the connector.

If the failure point cannot be determined from a visual inspection, a similar procedure to determining the failed branch can be employed. Simply move the terminator once again to the position to remove this branch, then successively drop the terminator one position on the branch (incorporating one node at a time into the bus.) For example, if the front branch were the failure point, we would first move the terminator to the position just below the topmost front node (to the connection point that typically forwards the bus on to the next node.) Iterate this process until the bus fails, and the failure must be in most recently incorporated connections.

It is important to note that with each move of the terminator, we bring 2 connections into the bus (the 4P connector facing upstream of the node we added in, and the 4S connector running down into the terminator.) Once The failure has been isolated to one of these two connectors, disassemble the connectors to look for damage/loose connections.

IMPORTANT: These connections contain 24V from the Low Current power supply which is NOT disconnected by the E-stop switch. Either switch off the low current power supply or disconnect both ECU PWR and the 4P/S bus upstream of this node and ensure power is not present with a multimeter prior to disassembling any connectors.

Once the failed connector has been determined, simply replace it with a 4P/S splice kit/pigtail.

• Additional Troubleshooting Techniques

If the CAN failure cannot be isolated to a branch, we have a few other options for deducing what is causing the issues. Many of the following troubleshooting techniques will involve inspecting/manipulating the DB9 connector at the HMI (which will require the case to be opened.) At this point, it is helpful to review the minimum requirements for the HMI to send CAN messages.

1. The Advantech is receiving CAN High, CAN Low, and GND to in the appropriate terminals of the DB9 Connector (and this connector is seated properly in the ISO CAN A Port.)
2. The CAN High and Low connections are terminated on both ends by CAN terminators of ~120 Ohm resistance.

Before we dive into more robust troubleshooting techniques, let us get a couple sanity checks out of the way.

Ensure CAN DB9 Connector is Pinned and Seated Properly

Open the HMI case and ensure the DB9 connector is present, wired, and plugged in to the correct port (ISO CAN A). Disconnect and open the DB9 connector and inspect the wiring. It should be wired connected to a DT4P/S junction coming in from the bottom of the screen and connected as follows.

DB9 Terminal	Purpose	DT4P/S Terminal
2	CAN Low	4
3	GND	3
7	CAN High	2

After inspecting the wiring in the DB9 Connector, re-connect it to the HMI and check if CAN functionality has been restored. Occasionally, simply re-seating the DB9 connector will resolve issues.

Probe for Continuity to CAN Terminators via Resistance Measurement

If both CAN terminators are on the bus, CAN High and Low will have ~60 Ohms of resistance between them (due to the 2 individual 120 Ohm resistors in parallel from the terminators). To probe for resistance on the CAN lines, we must first shut down the Low Current power supply (this prevents the nodes or HMI from putting any signals on the lines which will corrupt our resistance measurements).

Probe for resistance between terminals 2 and 7 on the DB9 connector in the HMI case (with the connector unplugged from the Advantech). If an open circuit is measured, then both connections to the terminators are severed. If ~120 Ohms is measured, then only one connection is severed. Remove a terminator and re-measure to determine which connection is broken.

From here, we can follow a similar procedure to the one outlined above (moving terminators toward/away from the screen to manipulate what connections are on the bus and measuring continuity.) However, by directly measuring resistance, we can move the terminators to locations that would normally remove the GND connection (rendering CAN inoperable) such as immediately adjacent to the screen or just after the screen mounting bar.

Ensure GND Connection is Present and Continuous

The GND connection on Pin 3 of the DB9 terminal originates from the LC power supply. This line runs to a node harness in which it is spliced to the black wire in position 3 of the DT4P/S connectors. However, the HMI is also powered from the LC Power supply from a separate wire run, so it should share a V- connection with the CAN/PWR 4 wire line. We can test if the GND pin of the DB9 connector is making it back to the LC Power supply by probing for continuity between this pin and the V- terminal powering the HMI. Again, the LC power supply should be powered off prior to prevent it from interfering with our measurement. Note: at least 1 node MUST be included in the bus (e.g., not isolated due to CAN terminator position) for the harness splice completing this circuit to be present.