

Revisions to this document are noted
by a stripe in the left-hand margin

SIL 06-EP-19, Rev. A
May 10, 2021
Page 1 of 17

SUBJECT: Troubleshooting Hybrid Vehicles Equipped with High Voltage Accessories

MODELS AFFECTED: H 40/50 EP™ System

Introduction:

The primary function of the Energy Storage System (ESS) in the H 40/50 EP™ System is to store and provide DC electrical power to the Dual Power Inverter Module (DPIM). The DPIM converts the DC electrical power into AC electrical power for the three-phase AC electric motors in the Drive Unit.

In 2011, Allison Transmission announced the availability of an optional DC-to-DC converter that may be incorporated into the H 40/50 EP™ System (refer to [SIL 8-EP-11](#)). In 2013, and later in 2014, Increased Accessory Power (IAP1) and IAP2 were released (see [SIL 4-EP-13](#)), supporting a wider array of optional high-voltage (HV) accessory products. Currently, all optional DC-to-DC converters and HV accessory products that may be integrated in the H 40/50 EP™ System are manufactured by Vanner, Inc.

The incorporation of various Vanner HV accessories into the H 40/50 EP™ System adds additional demand to the ESS beyond powering the DPIM; it now also provides DC electrical power to the Vanner components and any OEM-installed equipment connected to Vanner's HV accessories.

It is important to note that this extension of the HV DC power from the ESS to non-Allison components can affect how the H 40/50 EP™ System operates and, depending on certain faults, effect which diagnostic trouble codes (DTCs) set and how to troubleshoot the H 40/50 EP™ System.

Recommended Practices and Contacts:

Depending on the complaint or what DTCs may be set, knowing whether the HV system is constrained to only the DPIM and Drive Unit or shared with other HV accessories can greatly reduce the time spent troubleshooting. Below are recommendations to help reduce time spent troubleshooting.

- Check to see if the vehicle is equipped with any HV accessories. If you are unsure, look for a splice in the HV DC cables between the ESS and DPIM that splits off to other components.
- If a DPIM or motor check sheet are to be completed, it is recommended to also check any Vanner equipment at the same time per Vanner's troubleshooting and testing documentation.
- Read, understand, and be familiar with Allison Transmission publications regarding HV accessories, including SILs, WATCH letters, and Tech Data.
- Keep up-to-date copies of Vanner publications on components you may encounter incorporated in the H 40/50 EP™ System.

ML / SL8483EN

Copyright © 2021 Allison Transmission, Inc. All Rights Reserved.

5452385

Please Note: Allison Transmission Service Information Letters are intended for use by professional, trained technicians, not for the "do-it-yourselfer." They are written to inform those technicians of conditions that may occur on some transmission models (or serial numbers ranges) or to provide information that could assist in the proper servicing of a specific Allison transmission. Properly trained technicians have the equipment, tools, safety instructions, and know-how to do a job properly and safely. If a condition is described, do not assume that the Service Information Letter applies to your transmission, or that your transmission has the condition described. Product evolution and information updates are inevitable. Please see your authorized Allison Transmission service dealer or distributor to understand if your particular transmission may benefit from the information contained within the Service Information Letter.

- Download and install the latest version of Vanner's Dashboard diagnostic software. Review any documentation included with the software.
- Perform basic component tests per Vanner publications when necessary during the troubleshooting process.

If during the troubleshooting process you discover an issue with a Vanner component or need assistance with testing Vanner components, please contact Vanner, Inc. Contact information is provided below.

Also provided below are two examples that highlight how the extension of HV DC power to non-Allison components can affect the H 40/50 EP™ System.

H 40/50 EP™ System Troubleshooting with HV Accessories:

Case 1: Vanner HBA (DC-to-DC Converter) Failure

A customer's 2013 bus will not start and the stop system light is set. Connecting with Allison DOC® Premium (H 40/50 EP™) shows active DTCs 73-90, 74-90, 73-91, and 74-91. All four DTCs are associated with HV isolation faults that stop the system and prevent the ESS from closing relays. The Electrical Disconnect Verification Procedure is performed and a DPIM and motor check sheet are completed. The DPIM check sheet does not reveal any isolation issues nor were any signs of moisture or liquid water observed in the DPIM lug boxes. The motor check sheet shows adequate isolation resistance in both the HV AC cables and the motor stator windings. Motor stator winding resistances are also within specification. More troubleshooting is required as no breakdown in HV isolation has been found.

Next, the HV DC cables are disconnected from the DPIM DC lug box and the Vanner HBA. The HV DC cables are checked with adequate isolation resistance measured between DC+ and DC- and from each conductor to vehicle chassis. Left to test are the ESS and the Vanner HBA. Following directions from Vanner's HBA Owner's Manual, the HBA is measured and resistance values are significantly lower than those specified. After replacing the HBA, the H 40/50 EP™ System is reassembled, cleared of any DTCs, started, road tested, and returned to service.

In this example it is important to note that the HBA, powered directly from the ESS via HV DC cables specifically installed for this application, is sharing the same DC bus that the DPIM uses. The low isolation resistance in the HBA was detected by the TCM which then set DTCs disabling the H 40/50 EP™ System.

Case 2: Air Compressor Motor Failure

A customer's 2018 bus is out of service for complaints of active DTCs and possible open ESS fuses. Connecting with Allison DOC® Premium (H 40/50 EP™) and reviewing ESS data indicates all three ESS fuses are open and multiple DTCs are logged, including 77-30 Battery Pre-Charge, 76-51 Battery Subpack SOC Deviation High, and 79-41 Battery Subpack Under Voltage. The Electrical Disconnect Verification Procedure is performed and a DPIM check sheet is completed. The DPIM check sheet indicates an issue internal to the DPIM as the first row of resistance measurements are returning "OL" on the meter. The main cover is removed from the DPIM to reveal a burned resistor on the HVIL card and arcing damage on the DC busbar. The burnt resistor on the HVIL card is an indicator of a short in an AC electrical component, typically a shorted AC motor stator winding in the Drive Unit. The motor check sheet is completed but does not indicate an issue with either Drive Unit motor or the HV AC cables. An on-site Vanner representative discovers an open channel 2 fuse in the Vanner High Voltage Distribution Module (HVDM). More troubleshooting is needed as there is no clear reason why the HVIL card resistor burned, damaging the DC busbar, and there is an open channel 2 fuse in the HVDM.

Next, Vanner personnel check the Vanner Exportable Power Inverter (VEPI) connected to channel 2 of the HVDM suspecting a fault in the VEPI may have caused the issue. No issues with the VEPI were found. Vanner personnel proceed to inspect the OEM-installed electric accessories powered by the VEPI. A short in the three-phase AC electric motor driving the vehicle's onboard air compressor is identified and the AC circuit

breakers are found to be open. The air compressor motor is replaced and fuses in the ESS and HVDM are replaced. The DPIM is repaired and a DPIM check sheet completed with no issues found. The H 40/50 EP™ System is reassembled, cleared of any DTCs, started, test driven, and returned to the customer for service.

In this example it is important to note that the three-phase AC electric motor for the onboard air compressor is attached to the VEPI, an inverter powered by channel 2 of the HVDM, sharing the same DC bus that the DPIM uses. The short in the OEM-installed electric AC motor caused fuses in multiple components to open and damaged components internal to the DPIM.

Provided below is technical information authored and maintained by Vanner, Inc. The copies below are accurate as of March 4th, 2019. Please contact Vanner, Inc. for the latest copies or visit their publications website at <http://www.vanner.com/products/product-manuals/>.

Vanner, Inc.

4282 Reynolds Drive
Hilliard, OH 43026
TOLL FREE: 1-800-AC-POWER (227-6937)
<http://www.vanner.com/>

Service and Repair Department

4282 Reynolds Drive
Hilliard, OH 43026
TOLL FREE: 1-800-227-6937 x3512
614-771-3512
service@vanner.com
www.vanner.com/contact-vanner/

For technical support please contact: Mike Thomas, Jeff Carey, Mike O'Sullivan, or Craig Bushman.

To return a field unit for service or a replacement unit if required contact: James Finley, Craig Bushman, or Jeff Carey.

Mike Thomas

Customer Technical Support
M: 856-287-8588
miket@vanner.com

Jeff Carey

Customer Technical Support
O: 614-771-3503
M: 614-329-1589
jeffc@vanner.com

James Finley

Service Manager
O: 614-771-3512
jamesf@vanner.com

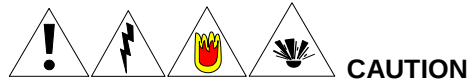
Craig Bushman

Service Technician
O: 614-771-3520
craigb@vanner.com

Mike O'Sullivan

System Integration Manager
M: 614-329-1495
mikeo@vanner.com

Testing and Troubleshooting



Servicing of electrical systems should only be performed by trained and qualified technical personnel.

Equipment Required

Required: A laptop provisioned with Vanner's Dashboard software, supporting hardware and interface cables.

Note: There are kits available for purchase that include Vanner's Dashboard software, a USB to CAN adapter module and a harness to connect to the vehicle's CAN network. Please contact Vanner's inside sales department for the appropriate kit part number for your application.

Optional: Volt Meter having 0.01 volt resolution. (Fluke Model 87 Multimeter recommended).
Clamp-on current meter (Fluke Model 36 Clamp-on Meter recommended).

Test Procedure for HBA

The HBA is working properly if:

1. The 24 volt DC loads are being operated continuously and are within the rated capacity of the HBA and;
2. The power drawn from the hybrid drive train system is within its rated capacity.

HBA Test Procedure:

1. Field-test the HBA while fully connected to the vehicles high and low voltage batteries.
 - The 24V battery must measure between 16 and 32 volts. If the 24V battery is below 16 volts, apply a 24 volt battery charger to the batteries.
 - The high voltage battery must measure between 500 and 780 volts for the HBA to start properly.
2. Start the vehicle normally while monitoring the HBA status with a laptop provisioned with Vanner's Dashboard software. The laptop must be connected to the vehicle CAN Bus utilizing a USB to CAN adapter and harness.
 - The HBA will turn on automatically upon receiving the engine RPM signal or CAN On/Off command via CAN bus and a +24V enable signal.
 - Upon normal system startup, the output voltage will increase to 28.5 volts and the output current will increase indicating charging of the 24V batteries and providing power for the 24V auxiliary loads.
3. The Vanner Dashboard software monitors the following data which can be observed on the laptop;

High Input Voltage

High Input Current

Low Output Voltage

Low Output Current

Engine RPM

Heartbeat

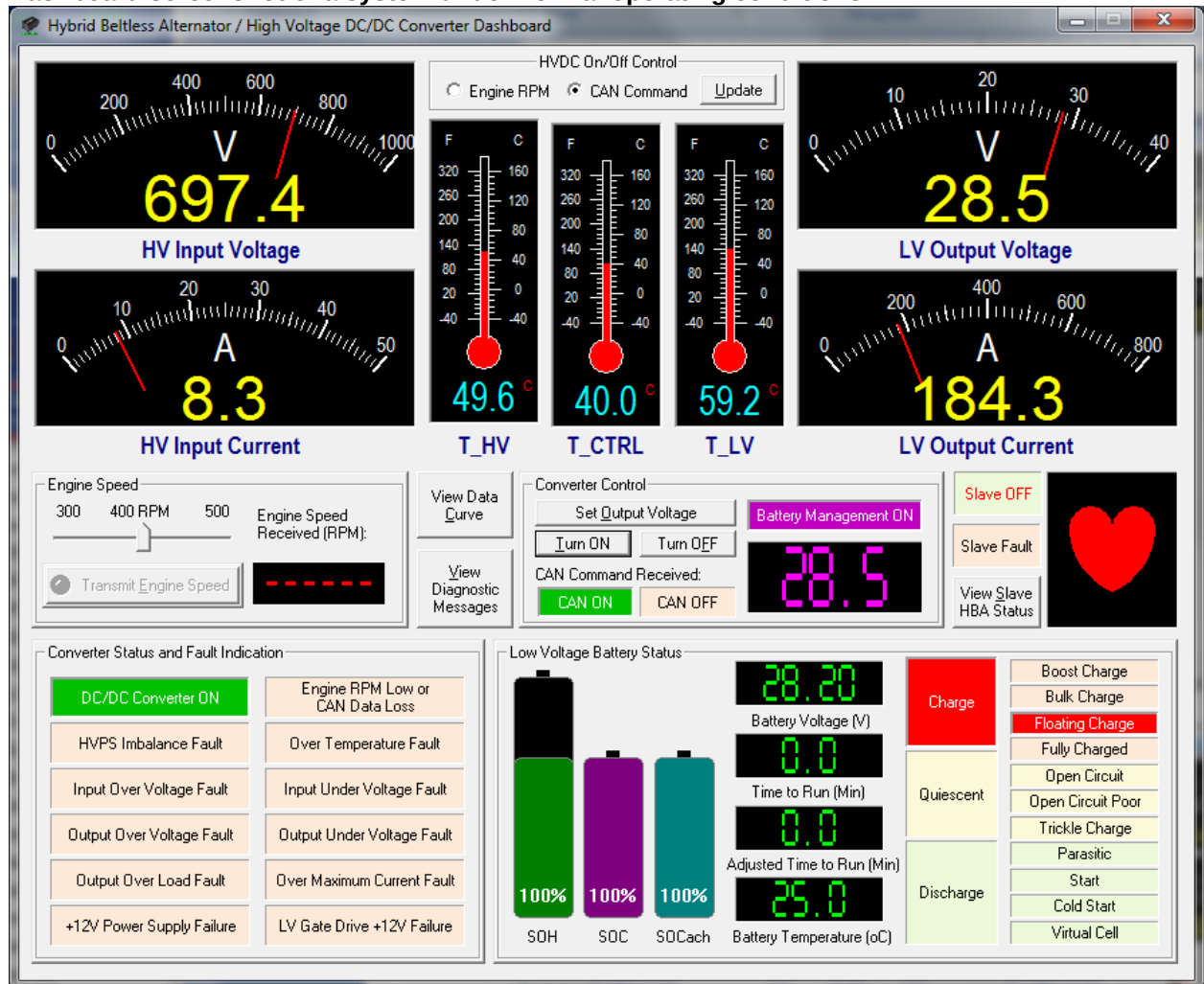
Power Stage Temps.

Control Board Temp

CAN On/Off Command Message Status

Converter Status and Faults

Dashboard screenshot of a system under normal operating conditions



4. If the Vanner Dashboard software isn't utilized or available, proper start up can be validated by measuring the 24V output terminals with a Volt Meter. Upon start up, the voltage will increase from the 24V battery nominal value up to ≈ 28.5 volts. **Note:** The measurement is dependent on the voltage drop in the cables/bolted connections between the HBA output terminals and the 24V battery terminals.
5. A clamp on style current meter can also be used to validate the output current of the HBA.
6. **Important:** The high voltage terminals are inaccessible for measurement. A high voltage interlock circuit is implemented for safety purposes to prevent an accidental and potentially lethal shock to personnel. The high voltage input to the HBA can only be read via the Dashboard software.

Trouble Shooting an HBA No-Start Situation

In the event the Vanner HBA does not start, the following need to be reviewed/validated;

1. Is the high voltage battery within the acceptable input range? 550 - 780VDC
2. Is the 24V battery within the acceptable range? 20 – 32VDC
3. Is 24V battery voltage present at the output terminals of the HBA upon closing the battery disconnect switch?
4. If not, verify the fuse between the 24V battery and the HBA is installed and hasn't cleared.
5. Upon startup of the engine, does the 24V battery remain within the acceptable range? If the health of the 24V batteries is questionable, the voltage may collapse below 20 volts before the HBA starts. There is an approximate 2 - 3 second delay from the time the engine starts to the start of the HBA.
6. Is the +24V enable signal present at the I/O connector?
7. If the +24V enable signal is present, is the wire in the proper location of the mating I/O connector?
8. For vehicles with pre MY2013 engines: Is the engine rpm data being transmitted properly via the CAN Bus? PGN 61444 (0xF004)
9. If so, is the engine rpm greater than 400 rpm?
10. For vehicles with MY2013 engines or newer, is the "Converter Control" command message being received? PGN 65498 (0xFFDA)
11. If the answers to 5 and 6 are yes, are the CAN signal wires (HI,LO and Shield) in the proper locations of the mating connector?

HBA Status and Fault Indication Definitions

The HBA monitors several status and fault conditions. If any faults occur, they are reported via CAN bus and can be observed with the Dashboard software. The HBA status and fault indications in the lower left corner of the screenshot on page 16, are defined as follows;

DC/DC Converter ON: Green indication that HBA has turned on successfully

DC/DC Converter OFF: Red indication that HBA is off. If the reason is due to a fault, that condition will be indicated by a red icon.

Engine RPM/ Low or CAN Data Loss: The HBA will perform a soft shutdown if the engine speed drops below 350 RPM for four seconds or there is a loss of CAN communication. The HBA will restart automatically when the engine speed exceeds 400 RPM for 0.1 seconds or CAN communication is restored.

HVPS (High Voltage Power Stage) Imbalance Fault: Internal circuitry detects if the voltage differential between the center point to negative and center point to positive is excessive, > 200V. If an imbalance fault is detected, the HBA will "permanently" shut down. The unit will not restart automatically if the imbalance condition clears, the ignition must be cycled off and on. See note below.

Note: An imbalance fault can be caused by leakage current or a defective detection circuit within the HBA. However, the HBA will also detect external leakage paths. The external leakage path could be caused by water ingress in a high voltage cable assembly or junction box. It could also be caused by damaged shielding on a high voltage cable assembly. If the high voltage imbalance fault does not clear after cycling the ignition, Vanner recommends inspecting the high voltage cable assemblies for leakage paths.

Over Temperature Fault: The HBA will perform a soft shutdown if any of the following conditions exist: the temperature on the low voltage power stage reaches 82°C, or the temperature on the high voltage power stage reaches 98°C, or temperature on the control board reaches 98°C. The HBA will restart automatically if all of the following conditions exist: the temperature on the low voltage power stage drops below 78°C, and the temperature on the high voltage power stage drops below 92°C, and the temperature on the control board drops below 92°C.

HBA Status and Fault Indications Cont'd

Input Overvoltage Fault: The HBA will perform a soft shutdown if the input voltage is above 800V and below 850V. It will restart automatically once the input voltage drops below 750V. If the input voltage exceeds 850V, the converter will “permanently” shut down. The unit will not restart automatically if the input voltage drops below 750V, the ignition switch must be cycled off and on.

Input Under Voltage Fault: The HBA will perform a soft shut down if the input voltage drops below 500V. Once the input voltage is equal to or greater than 550V, the converter will restart automatically.

Output Overvoltage Fault: The HBA will perform a soft shutdown if the low voltage battery exceeds 32V. The HBA will restart automatically if the voltage returns to the normal operating range of 16 - 32V.

Output Under Voltage Fault: If the low voltage battery drops below 15V, the HBA will perform a soft shutdown. The converter will restart automatically if the voltage returns to the normal operating range of 16 – 32V.

Output Overload Fault: The HBA is current limited to 250A or 300A. If the load is above 250A or 300A, the unit will begin current limiting and gradually reduce the output voltage. Once the HBA output voltage decreases to a value less than or equal to the battery voltage, the batteries will begin to assist in supporting the load. If the load continues to increase and the output voltage drops to 20V, the output current will begin to fold back. If the output or battery voltage is reduced to 16V, the HBA will turn off. The HBA will restart automatically if the loads are reduced and the battery voltage returns to the normal operating range of 16 - 32V.

Over Maximum Current Fault: The HBA will perform a soft shutdown if the current flowing through an internal power stage current transformer exceeds 90A. The HBA will restart automatically if the current returns to a value below 90A.

+12V Power Supply Failure Fault: The HBA will perform a permanent shutdown in the event of a +12V power supply failure. The unit should be replaced and the failed unit returned to Vanner for evaluation.

LV Gate Drive +12V Failure: The HBA will perform a permanent shutdown in the event of a LV Gate Drive +12V power supply failure. The unit should be replaced and the failed unit returned to Vanner for evaluation.

Purpose: Testing the HBA when looking for the cause of an Allison Isolation Fault DTC.

Procedure: How to measure the isolation resistance of an HBA using a Megohmmeter.

Meters: Vanner recommends using an Amprobe AMB-45, Fluke 1507, or Fluke 1587 for this procedure.

WARNING! The Vanner HBA uses potentially lethal voltages for operation. **DO NOT** attempt to replace the HBA unless you have been trained to work with the Allison H 40/50 EP system.

1. Before beginning, reference Allison Transmission's "Electrical Disconnect Verification Procedure" for the H 40/50 EP product family. It contains important steps that are not covered in these instructions.
2. High Voltage Personal Protective Equipment (PPE) must be worn for this procedure.
3. Assure that the vehicle ignition switch is in the OFF position.
4. Assure that the vehicle master battery disconnect switch is in the OFF position. Use lockout devices to assure the switch cannot be moved to the ON position until the test procedure is complete.
5. Disconnect the high voltage positive and negative cables from the HBA input studs.
6. Insulate the ring terminals.
7. Do not disconnect the 24V positive and negative cables, 14 pin Deutsch connector, and chassis GND from the HBA. **Note:** If bench testing, connect HBA 24v negative to HBA chassis.
8. Set Megohmmeter to the 250V scale.
9. **Step 1:** Connect Megohmmeter negative lead to the HBA chassis. Connect Megohmmeter positive lead to the HBA high voltage negative stud. Press test button and record resistance.
10. **Step 2:** Leave Megohmmeter negative lead connected to the HBA chassis. Connect Megohmmeter positive lead to the HBA high voltage positive stud. Press test button and record resistance.
11. **Step 3:** Relocate Megohmmeter negative lead from the HBA chassis to the HBA high voltage negative stud. Leave the Megohmmeter positive lead connected to the HBA high voltage positive stud. Press the test button and record resistance if using an AMB-45 and record voltage if using a Fluke 1507 or Fluke 1587.
12. See table below for proper readings.
13. If any readings are out of range, the HBA may be defective and should be returned to Vanner for repair.

HBA Serial Number	Positive to Chassis	Negative to Chassis	Positive to Negative	Actual Measurements
Prior to 13246-250093	810kΩ +/- 10%			Positive to Chassis: Negative to Chassis:
After 13246-250093	2.8MΩ +/- 10%			Positive to Chassis: Negative to Chassis:
All "DUAL" Model Numbers	2.8MΩ +/- 10%			Positive to Chassis: Negative to Chassis:
All Model Numbers	AMB-45		0.012MΩ – 0.018MΩ	Positive to Negative:
	Fluke 1507 or 1587		23 – 27 VDC	Positive to Negative:

Dual HBA's - General Description

Paralleling Two HBA's

Two versions of HBA's, **HBA400-28-CAN-DUAL** and **HBA500-28-CAN-DUAL**, have been developed to load share when the outputs are connected in parallel. Two HBA400-28-CAN-DUAL HBA's connected in parallel provide 500A of 28V charging current and two HBA500-28-CAN-DUAL HBA's connected in parallel provide 600A of 28V charging current.

When connected in parallel, one unit is designated as the "Primary" (Master) unit and the other as "Secondary" (Slave) by installing external jumpers in the circular I/O connector. To designate a unit as the Primary, install a jumper between pins "M" and "N". To designate a unit as the Secondary, install a jumper between pins "A" and "N". (See wiring diagram on next page.)

The two units communicate with each other via the vehicle CAN network with the Primary unit providing voltage and control loop logic information for the Secondary unit. Any imbalances introduced to the system, i.e. rapid load changes, are automatically compensated for to ensure equal load sharing.

System Response to Vann-Bus Dynamic Voltage Regulation

If the 28V batteries are in a discharged state, the output voltage of the Primary unit will increase to a value prescribed by the battery monitoring software. Since its reference voltage will be higher than the Secondary unit, it will provide the majority of the load. The Primary unit will request a higher output voltage from the Secondary unit causing its output voltage to increase at a rate of 10mV/s. Once the voltage differential between the two units is approximately $\leq 0.5V$, the Secondary unit will begin to provide more current. Once the voltage differential is approximately $\leq 0.1V$, the units will load share evenly.

After the batteries reach a quiescent state, the output voltage of the Primary unit will reduce to a value prescribed by the battery monitoring software. Since the reference voltage of the Secondary will be higher, it will provide the majority of the current. The output voltage of the Secondary unit will begin to reduce at a rate of 10mV/s. Once the voltage differential is approximately $\leq 0.1V$, the units will load share evenly.

Note: The maximum and minimum output voltages of the HBA's can be set via Vanner's Dashboard Interface Software.

System Response to a Failed Converter, Fault Condition or Loss of +24V Enable Signal

If either unit shuts down due to a failure, fault condition or loss of +24V enable signal, the operational unit will remain on and provide current up to 250A or 300A. If the load is above 250A or 300A, the operational unit will begin current limiting and gradually reduce the output voltage. Once the HBA output voltage decreases to a value less than or equal to the battery voltage, the batteries will begin to assist in supporting the load. If the load continues to increase and the output voltage drops to 20V, the current will begin to fold back. If the output voltage is reduced to 16V, the HBA will turn off.

If certain fault conditions clear or the +24V enable signal is restored, the HBA will restart automatically.

Note: Some fault conditions, once cleared, require cycling the ignition/+24V enable signal before the HBA will restart.

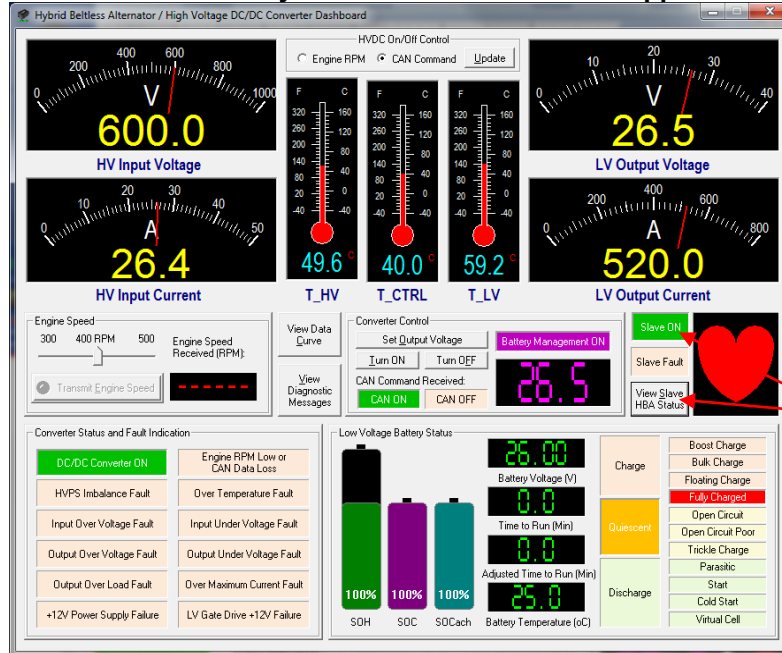
System Response to Loss of CAN Communication

If either unit loses CAN communication both will continue to run, however, their voltage and current loop controls will function independently of each other. Once CAN communication is restored, voltage and control loop controls will be maintained by the Primary unit.

Paralleling Two HBA's Cont'd

The Vanner Dashboard software permits viewing the operational status of both HBA's in a dual application. See screenshots below and display definitions.

Screenshot of Primary HBA Dashboard in a dual application with battery management "ON"

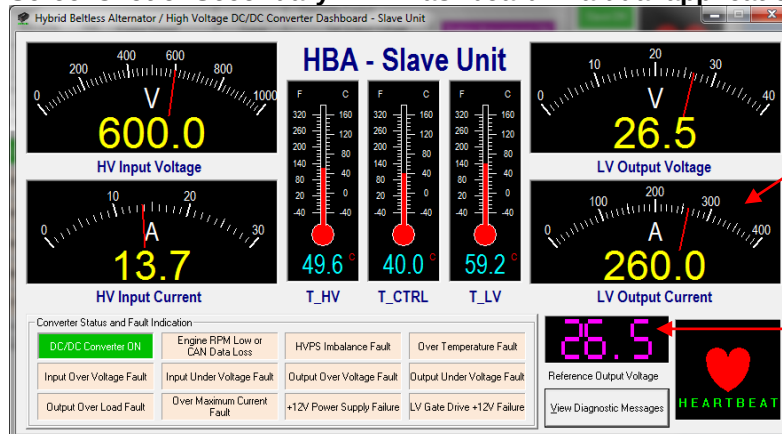


Note that the output voltage is reduced since the 24V batteries are in a "Quiescent" state.

The LV Output Current displayed here is the sum of the "Primary" and "Secondary" HBA's.

"Secondary" unit status. Select the "View Slave HBA Status" icon to open the secondary unit dashboard.

Screenshot of Secondary HBA Dashboard in a dual application



Low voltage output current of "Secondary" HBA. Note that it is 1/2 of total current indicating equal load sharing.

The voltage displayed here is the value the "Primary" unit is requesting from the "Secondary" unit.

Test Procedure for HVDM

HVDM Test Procedure:

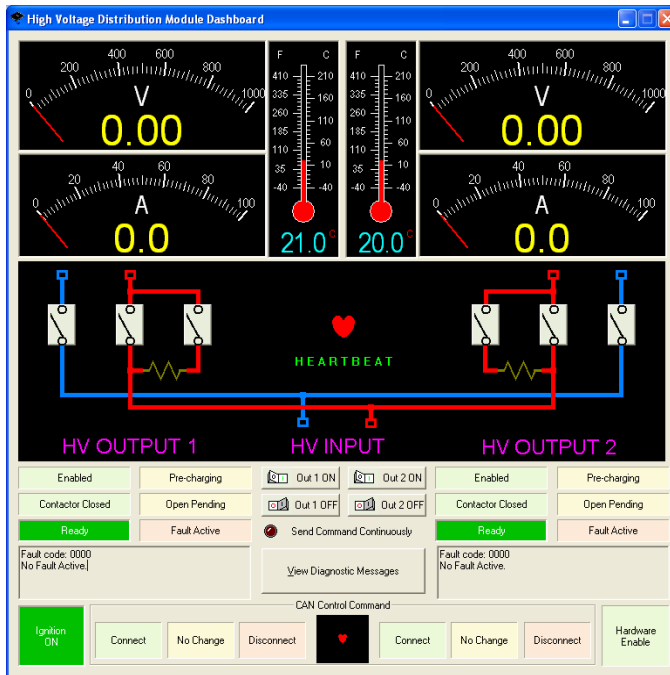
Note: Although not required, using Vanner's Dashboard Interface software for monitoring the status of the HVDM is highly recommended. The Dashboard software provides a graphical representation of the states of the Channel 1 and 2 contactors as well as the high voltage and current of each channel.

1. Field-test the HVDM while fully connected to the vehicles high voltage batteries and the Channel 1 and Channel 2 loads.
2. Ensure the chassis cover is installed and all fasteners are in place. The HVDM is provisioned with an HVIL switch, therefore if the cover is not installed properly, the ESS contactors will not close.
3. The low voltage battery must measure between 18 and 32 volts. If the low voltage battery is below 18 volts, apply a 24 volt battery charger to the batteries.
4. The high voltage battery must measure between 400 and 800 volts for the HVDM to start properly.
5. Monitor the HVDM status via laptop provisioned with the Dashboard software.
6. The HVDM will enter the "Standby" mode when the low voltage battery master disconnect switch is closed.
7. Start the vehicle normally.
8. Provided the operational conditions outlined above are met, the HVDM will enter a "Ready" state upon receiving an ignition signal and await a hardware "Enable" command, active low, from the TCM.
9. After receiving the "Enable" command from the TCM, the pre-charge sequence will begin once the HVDM receives a "Connect" CAN message from the HCM.
10. Upon successfully pre-charging the loads on Channel 1 and/or Channel 2, the respective contactor(s) will close.
11. The contactor status is graphically displayed on the Dashboard but closure can also be verified by observing the voltage and current values. **Note:** The current and voltage values are measured on the secondary side of the contactors.
12. If the Dashboard software isn't being utilized, contact closure can be verified by observing the operational status of the loads connected to Channel 1 and/or Channel 2.
13. Upon successful contact closure, the HVDM enters an "Open Pending" state. The contactors are opened via the CAN "Disconnect" message or removal of the hardware enable signal.

Note: The high voltage terminals are inaccessible for measurement with a meter. A high voltage interlock circuit is implemented for safety purposes to prevent an accidental and potentially lethal shock to service personnel. The high voltage input and Channel 1 and Channel 2 outputs can only be read via the Dashboard software.

HVDM Dashboard Screenshots

Figure 1: HVDM in "Ready" state after receiving ignition signal



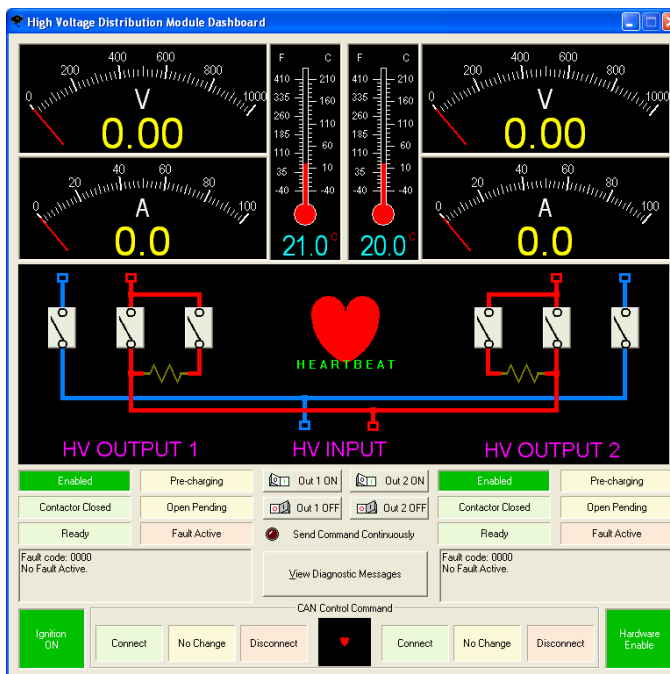
Channel 1 and Channel 2 voltages, currents and bus bar temperatures displayed in this section

Graphical representations of Channel 1 and Channel 2 contactor states in this section

HVDM and contactor status information displayed in this section

Ignition, enable and CAN Control Command information displayed in this section

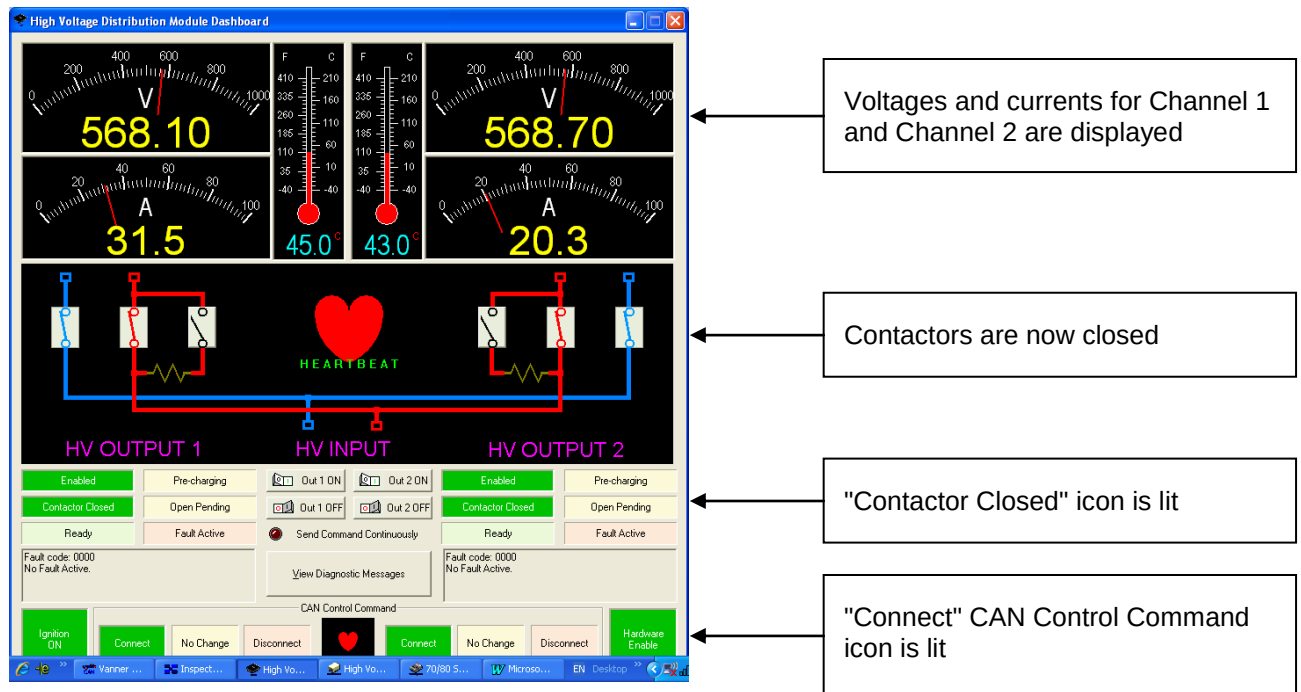
Figure 2: Hardware "Enable" signal from TCM activated. Note contactors are still open.



Note status change to "Enabled"

Note "Hardware Enable" icon is lit

Figure 3: Contactors closed after receiving CAN message from HCM



Trouble Shooting an HVDM No-Start Situation

In the event Channel 1 and/or Channel 2 contactors do not close, the following need to be reviewed/validated;

1. Is the capacitive load $\leq 6,800\mu\text{F}$?
2. Is there a short circuit on the output of either channel?
3. Is the high voltage battery within the acceptable input range of 400 - 800VDC?
4. Is the low voltage battery within the acceptable range of 18 – 32VDC?
5. Are the high voltage terminations tightened to the proper torque value?
6. Are the high voltage fuses in place and installation hardware tightened to the proper torque value?
7. Is either high voltage fuse blown?
8. Is the HVIL switch in place and the plunger free to travel?
9. Is the enclosure cover in place and all hardware installed?
10. Is the external HVIL connector fully seated?
11. Is the rectangular I/O connector fully seated?
12. Are the +24V, Ignition, CAN and enable signal wires terminated in the proper locations of the rectangular I/O connector?
13. Is the +24V ignition signal present upon vehicle startup?
14. Is the enable signal, active low, working properly?

Trouble Shooting an HVDM Abnormal Contactor Open Situation

The following conditions will cause a contactor to open:

1. The 24V wakeup signal is lost/off.
2. The hardware enable signal is lost or turned off.
3. The input voltage exceeds 860V.
4. The channel current exceeds 160A.
5. The temperature at the input/output terminals exceeds 95°C.

Note: For additional troubleshooting assistance, reference the "Distribution Module Abnormal Conditions" section for conditions that will flag faults and affect contact closure.

Distribution Module Abnormal Conditions

The following outlines conditions that will flag faults and the resultant impact on contactor closure/opening. All conditions apply to both Channels 1 and 2. Reference Vanner's "High Voltage Distribution Module DM1 Messages CAN Communication Specification" for more details about DM1 messaging.

Over Capacitance

- If pre-charge fails within 1 second due to a load capacitance $\geq 6,800\mu\text{F}$, a fault will be flagged during the current key cycle. The fault will clear upon cycling the 24V off/on.

Short Circuit

- If pre-charge fails within 100 milliseconds, a fault will be flagged during the current key cycle. The fault will clear upon cycling the 24V off/on.

Welded Contactor

- The HVDM is provisioned with welded contactor detection circuitry. If the HVDM detects one or more welded contactors on the respective channel, the channel is disconnected for the current key cycle.

Pre-Charge Lockout

- If pre-charging load(s) is unsuccessful after 2 attempts, the channel will be disconnected from the high voltage bus during the current key-cycle.

Non-Operational Relay

- If the HVDM detects a non-operational relay, a fault will be flagged during the current key cycle. The fault will clear upon cycling the 24V off/on.

High Voltage Out of Range (340 - 860VDC)

- If the HVDM detects the high voltage is out of range, a fault is flagged.
- High: If channel is not connected, it will not connect upon receiving turn-on command; If channel is already connected, it will remain connected. The fault will clear when the input voltage drops below 850V.
- Low: If channel is not connected, it will not connect upon receiving turn-on command; If channel is already connected, it will remain connected. The fault will clear when the input voltage rises above 350V.

+24VDC Out of Range (18 - 32VDC)

- If the HVDM detects the low input control voltage is out of range, a fault is flagged.
- High: If channel is not connected, it will connect upon receiving turn-on command; If channel is already connected, it will remain connected. The fault will clear when the input voltage drops below 30.5V.
- Low: If channel is not connected, it will connect upon receiving turn-on command; If channel is already connected, it will remain connected. The fault will clear when the input voltage rises above 19.5V.

Over Current ($\geq 160\text{A}$)

- If an over current condition exists, a fault is flagged and the contactors opened during the current key cycle. The fault will clear upon cycling the 24V off/on.

Distribution Module Abnormal Conditions Cont'd**Temperature Out of Range (Loose Connection Detection)**

- The HVDM is provisioned with temperature sensors on the HV Input bus bars as well as Channel 1 and Channel 2 output bus bars for the purpose of detecting loose mechanical connections. If the HVDM detects an over-temperature condition (+95°C), a fault is flagged and both channels are disconnected for the current key cycle.

Current Sensor Data Erratic

- The HVDM is provisioned with automotive style sensors for measuring current on both output channels. If the signal voltage from a sensor to the control board falls outside of the 2.5V - 5V range, a fault will be flagged. If channel is not connected, it will connect upon receiving turn-on command; If channel is already connected, it will remain connected. The fault will clear when the signal voltage falls within the 2.5V - 5V range.

Loss of CAN Command

- If the HVDM loses the CAN turn on command from the HCM (Hybrid Control Module), a fault is flagged. If channel is not connected, it will connect upon receiving turn-on command; If channel is already connected, it will remain connected. The fault will clear when new CAN command is received continuously.

AC HVIL

- The Allison software watches the IAP2 HVIL AC status on CAN but takes no response to an open condition. The VEPI disables on its own.
- If the issue clears, the VEPI stays disabled until reset (JD logic).
- The hybrid system will respond when HVIL is healthy again by re-enabling/resetting the inverter after a short time. Note: The enable signal (digital input) is not removed upon sensing an HVIL open.
- The hybrid system logs VEPI AC HVIL faults.
- The max is 5ms from time of disconnect to the drive turning off.
- The hybrid system will only re-enable the inverter for a set number of cycles after a critical VEPI fault occurs within a given time window (i.e. loose cover on compressor or other AC HVIL switch issue). The TCM doesn't always know the reason that the VEPI disables due to latencies with the DM1 message. In the event that an intermittent signal trips/resets the VEPI repeatedly, the TCM will not continuously request to re-enable.

DC HVIL

- If the H40/50 EP receives indication that the DC side HVIL is broken, the controls will disconnect channel 2 of the HVDM (as long as we receive the CAN signal).
- The max is 5ms from time of disconnect to the drive turning off.
- The hybrid system logs a VEPI DC HVIL fault.

AC or DC HVIL Summary

- The inverter (VEPI) takes independent action to disable with a loss of HVIL on either side (DC or AC).
- The difference between an AC and DC HVIL break is that for a DC side break, the hybrid system disconnects Channel 2 immediately.
- For an AC side break, the inverter (VEPI) shuts down but HVDC remains connected via Channel 2. The hybrid system will disconnect Channel 2 if the retry/re-enable limit of 3 is exceeded.

VEPI Isolation Detection

- There are two isolation fault detection systems in the H40/50 EP hybrid. One is located in the ESS and the other in the DPIM. The ESS only runs during initialization while the DPIM runs continuously.
- A phase to chassis fault is difficult for the H40/H50 EP system to detect, therefore the system is reliant on the AC circuit breakers and/or VEPI to limit current flow.
- A phase to phase fault will trigger an over current fault in the inverter or a desat fault (gate driver fault) depending on the impedance of the short. The over current is a little slower than the desat, but trips at 600A. The desat is very fast but requires about 1500A to trigger the fault.
- The VEPI reacts quicker than typical circuit breakers in a phase-phase short scenario.

VEPI: @600A $\approx 10\mu\text{s}$ (Over current fault)
@1,500A $\approx 2\mu\text{s}$ (Desat fault)

30A Breaker: @600A $\approx 300\text{ms}$, @1,500A $\approx 15\text{ms}$
60A Breaker: @600A $\approx 1.5\text{s}$, @1,500A $\approx 15\text{ms}$

- The VEPI does not have specific faults for a phase to ground short. However, a hard fault to ground while operating can trigger an over-current or desat fault but is not a guaranteed reaction.
- The inverter will shut off, e.g. no more switching, when an over-current or desat fault is detected.

VEPI Current Limit

- The current limit where the inverter starts to cut back frequency/voltage for IAPII is 300Arms (max continuous output of the PD300). The instantaneous overcurrent threshold of the inverter is $\sim 600\text{A}$ peak, a fault will trigger in that case.