SECTION 16-601.10
V-BEA (VOLVO BUS ELECTRONIC ARCHITECTURE)

KEY NOMENCLATURE

V-BEA
Volvo - Bus Electronic Architecture.

CAN
Controller Area Network. The primary communication standard within the automotive industry. Communication speed - V-BEA 250 kbit/s.

XML
eXtended Mark-up Language. A computer language used to keep track of data, texts etc. Could be considered as a superset of HTML.

ISAGRAF
ISaGRAF is a control software environment that enables the creation of local or distributed control systems. A PLC (Programmable Logic Controller) language, comprised of a graphical programming editor and simulation tool.

GENERAL DESCRIPTION AND OPERATION

See Figures 1 and 2A and 2B.

V-BEA is a system within which the associated control units communicate with each other through data links in a network, CAN (Controller Area Network). The control units in the V-BEA system are located as close as possible to the components they control, in order to reduce cable length and thereby minimize the source of errors. There are two types of communication link in V-BEA — J1939 (engine, transmission, ABS) and J1587/J1708 (engine).

- The V-BEA system has been designed and built to simplify the connection between electrical devices.
- Optimized electrical architecture with integration of new functions.
- Good modularity, step by step increase from low to high level body functionality.
- Increased reliability of the electrical distribution.
- Reduction of numbers of wires, splices and connections from the harnesses, resulting in the reduction of possible fault locations.
- Reduction of fuses and relays.

COMPONENTS

See Figures 1, 2A and 2B.

The following components are part of the V-BEA system. See the COACH WIRING DIAGRAM for additional information.

CECM, CENTRAL ELECTRONIC CONTROL MODULE

The Central Electronic Control Module is the top-level device. It is the command post for all activity throughout the operating system. See Figure 1.

The Volvo CECM is used as a gateway between SAE J1939 and the rest of the network and also maintains a backup of the application software.

The CECM is also used as a normal control unit with several inputs and output.

CECM-B acts as a port between the data links J1708, J1939 and B-bus. CECM-B also acts as a reserve memory for the body modules in the body system and communicates with them via the CAN-B link. If the vehicle is equipped with an AIC then it is connected to CECM-B via the B-bus.

If a CECM-B is changed, it will be updated automatically by the Master ID.

Figure 1 - V-BEA System Components
Figure 2A - V-BEA Component Locations - Nova LFS (Typical)

Figure 2B - V-BEA Component Locations - Nova LFS Artic (Typical)
GENERAL INFORMATION

- One CECM can handle up to 28 I/O modules at the same time.
- When an I/O module is replaced or loses its software, that module is automatically updated by the CECM with the correct software package. This is performed at system start up.
- All diagnosis information is stored in the CECM until the power is disconnected.
- Smart power switches are fitted to all outputs allowing short circuit and open circuit detection.
- EMC certificate 95/54/EC.

HARDWARE INFORMATION

- 19 LDI/HDI
- 19 LDO/HDO
- Smart power switches
- 3 CAN interfaces
- 1 SAE J1708/1587 interface
- 16 bits CPU, Motorola 68376
- Application SW download on Flash
- 1 MB Flash
- 128 kB RAM

BODY MODULES (BM)

Body modules are so-called I/O modules. The location of the body modules can differ depending on the functions they control.

There are two types of I/O module in the system, I/O-A and I/O-B. The difference between the two is that I/O-B is used for components that require a stronger current, such as headlamps, for example. Each module has a unique identity. To determine the identity, there are six identifying pins on the module designated J1-24 to J1-29.

These pins can be strapped in various ways to provide a particular body module with its network identity.

If a body module becomes defective, it can be replaced with a corresponding unloaded body module. CECM identifies the module by its network identity and downloads the correct software to the module.

I/O-A

I/O-A has three connectors, J1, J2 and J3.

The total current load on the outputs must not exceed 4A and the load on an individual output must not exceed 1A.

The Volvo I/O A modules act as distributed electrical interface circuitry for the CECM in the CAN network.

This module is primarily used for input signals from sensors and switches, but also has output capabilities for limited current applications.

- Interface for low effect components
- Plug and play

I/O-B

I/O-B or BM-B (Body Module B) is used for more current-intensive components. I/O-B has three connectors, J1, J2 and J3.

The total current load on the outputs must not exceed 30A and the load on an individual output must not exceed 16A.

The I/O B modules act as distributed electrical interface circuitry for the CECM in the CAN network.

This module is primarily used for driving high-current output signals, but also has input capability.

Can supply bulbs, DC motors and buzzers, for example.

- Plug and play
GENERAL INFORMATION

- 2 outputs able to deliver 16 A / 20 A peak
- 8 outputs able to deliver 10 A / 20 A peak
- 4 digital inputs
- 2 inputs for analog sensors
- 1 reference voltage supply 5V for potentiometers or sensors able to deliver 20 mA
- Smart power switches are fitted to all outputs allowing short circuit and open circuit detection

HARDWARE INFORMATION

- 4 LDI/HDI
- 10 LDO/HDO/PWM
- Smart power switches
- 1 CAN interface
- 8 bit CPU, Fujitsu MB90F598A
- 6 KB RAM
- 128 KB Flash
- 256 B EEPROM

MASTER ID

HARDWARE SPECIFICATION:

The Volvo Master ID is a control unit with no I/O-capability. It contains an internal web browser where general system information, schematic drawings and diagnosis information is stored (documentation stored in xml-format). This information can be extracted using only a laptop, an RS232 connection and a standard web browser.

The Master ID also maintains a back up of the application software. It acts as an interface between the electrical system and the developer and/or service personnel. It has no inputs or outputs.

The Master ID is located in the front electrical distribution unit. This component is used as a memory reserve for CECM-B, as well as an RS232 interface between the CAN link and a diagnosis PC. The Master ID contains information on the functions in the body and their diagnosis possibilities.

GENERAL INFORMATION

The Master ID is used as an interface between the electrical system and the system developer or service personnel. From the Master ID home page it is possible to:

- Download software (the one download point)
- View detailed diagnosis information down to the module pin level
- Examine system behavior in real time by examining the actual code together with textual descriptions
- View overall system information
- View electrical drawings over the system
- Change parameters and choose language

HARDWARE INFORMATION

- 32 bit CPU
- 512 KB RAM
- 4 MB Flash
- 1 RS232 serial interface
- 2 CAN interfaces

DATA LINKS IN V-BEA

See Table 1.

The J1939 link is used to send information that requires a fast refresh rate. For example, communication between the powertrain and chassis control units.

The J1587/J1708 link is connected to the same control units as the J1939 link, as well as to BIC (instrument control unit). This link is used mainly for communication diagnosis, but also as a reserve link for the J1939 link.

The CAN links are used for the chassis and body networks.

- ISO 11 898 is a dedicated CAN link used for the D-bus.
- J1587 for diagnostic information (9600 bps, not CAN).
- J1939 for messages from drive line (250 kbps).
- B-Bus for messages in body (250 kbps).
- Two termination resistors at 120 Ω, one at each end of the CAN-bus and two more for J1939.
<table>
<thead>
<tr>
<th>LINK</th>
<th>REPORT</th>
<th>COLOUR</th>
<th>TRANSMISSION SPEED</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-bus</td>
<td>J1939</td>
<td>yellow/green</td>
<td>250,000 bps</td>
<td>Communication between powertrain and chassis control units and CECM-B</td>
</tr>
<tr>
<td>A-bus</td>
<td>J1587/J1708</td>
<td>black/white</td>
<td>9,600 bps</td>
<td>Diagnostic info from powertrain and chassis control units. Reserve for J1939 link</td>
</tr>
<tr>
<td>B-bus</td>
<td>CAN</td>
<td>green/yellow</td>
<td>250,000 bps</td>
<td>Links CECM-B with the body modules (BM) and Master-ID (MID 210) D-bus</td>
</tr>
</tbody>
</table>

**Table 1 - Data Links in V-BEA**

**TELL-TALE LIGHTS ON THE DASHBOARD**

ALL TELL-TALE LIGHTS ARE DIGITALLY CONTROLLED.
The tell-tale panels may only be replaced as individual assemblies.

**ADDRESS STRAPPING**

See Table 2.

Each control unit has a unique network ECU-address.

6 pins in one of the connectors are used for address strapping.

The address is strapped by connecting a combination of pins.

This system for addressing enables the plug and play functionality.

<table>
<thead>
<tr>
<th>BUS ADDRESSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECU #</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>36 = CECM-B</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>37</td>
</tr>
<tr>
<td>38</td>
</tr>
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<tr>
<td>51</td>
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<tr>
<td>52</td>
</tr>
</tbody>
</table>

**Table 2 - Address Strapping**
V-BEA REPROGRAMMING

**NOTE:**
Throughout the entire download procedure, the BATTERY MASTER SWITCH must be in the NORMAL or ON position, depending on the model.

1. Place the MASTER CONTROL SWITCH in the RUN position.
2. Open the access door to the console located over the driver's window to access the overhead left panel.

3. Connect your laptop to the MASTER ID connector with the standard RS232 serial cable provided. Connect first to the MASTER ID connector, located in the upper left console, then to the laptop. See Figure 3.

It is also possible to connect the laptop directly to the MASTER ID module, located in the main electrical panel directly above the operator's seat. In this case, use a specially designed shielded twisted pair (STP) transfer cable. **DO NOT USE A STANDARD RS232 CABLE.** One end of the transfer cable is connected to the laptop (towards PC), and the other end is connected directly to the MASTER ID (towards Master ID). Do not invert the cable.
4. For a first-time connection to the vehicle’s system, the laptop must be configured for a dial-up connection. To perform the dial-up modem configuration for a laptop running Windows XP or Windows 2000 operating systems, follow the procedure in the document entitled, NOVA3616ENG.PDF, a copy of which was supplied at the time of delivery of the vehicle. If you do not have this document, and for all other computer operating systems, please contact your Nova Bus representative.

5. Once the laptop has been configured for a dial-up connection, connect to the MASTER ID software by clicking on the desktop icon, installed during the configuration procedure. See Figure 4.

6. This will display the CONNECT TO MASTER ID window. Click on the DIAL button. See Figure 5.

7. Access the VOLVO BUS-ON BOARD WEB SERVER. The access method will vary depending on whether it is a simple PROGRAM UPDATE using a BA_LXXX file, or a COMPLETE REPROGRAMMING using an FB_LXXX file:

**PROGRAM UPDATE**

a. If this is a first-time connection to the server as part of a PROGRAM UPDATE, click on the START button in the lower left corner of the screen. In the pop-up menu, click on the RUN command. See Figure 6.

In the window that appears, enter IP address http://192.168.86.1/ in the command field, and then click on OK, See Figure 7.
It is recommended to create a shortcut on the computer desktop and to rename it to facilitate future connections to the system. See Figure 8 for an example.

b. If a shortcut has already been created during a previous connection, as part of a PROGRAM UPDATE, use it to access the VOLVO BUS ON-BOARD SERVER. See Figure 8.

**CAUTION:**

It is important to use the shortcut created for program updates with a BA type file. If a shortcut, created for another type of reprogramming, is used (e.g., an FB type file), the wrong page will open and the reprogramming will not be executed.

c. The home page of the VOLVO BUS ON-BOARD SERVER appears, confirming that the MASTER ID is connected. In the left-hand panel of the screen there is a menu that contains the command PROGRAMMING. Click on the command PROGRAMMING. See Figure 9.

d. A sub-command DOWNLOAD appears. Click on the sub-command DOWNLOAD.

e. A new window will appear with the menu option DOWNLOAD SOFTWARE PACKAGE. Proceed to the next step.
**COMPLETE REPROGRAMMING**

a. If this is a first-time connection to the server, as part of a COMPLETE REPROGRAMMING, click on the START button in the lower left corner of the screen. In the pop-up menu, click on the RUN command. See Figure 6.

   In the window that appears, enter IP address `http://192.168.86.1/start_bl.html` in the command field, and then click on **OK**, See Figure 10.

b. If a shortcut has already been created during a previous connection, as part of a COMPLETE REPROGRAMMING, use it to access the VOLVO BUS ON-BOARD SERVER. See Figure 11.

   **CAUTION:**
   It is important to use the shortcut created for complete reprogramming with an FB type file. If a shortcut created for another type of reprogramming is used (e.g. a BA type file), the wrong page will open and the reprogramming will not be executed.

c. A window appears with the menu option **DOWNLOAD SOFTWARE PACKAGE**, confirming that the MASTER ID is connected. Proceed to the next step.

![Run window](image)

*Figure 10 - IP Address (Complete Reprogramming)*

It is recommended to create a shortcut on the computer desktop and to rename it to facilitate future connections to the system. See Figure 11 for an example.

![V-BEA_FB](image)

*Figure 11 - V-BEA Icon (Complete Reprogramming)*
8. Click on the option **DOWNLOAD SOFTWARE PACKAGE**. See Figure 12.

9. A pop-up window will appear requesting a **USER NAME** and **PASSWORD**. See Figure 13. Use the following:

- User Name: user1
- Password: fqYos

It is recommended to check the box **REMEMBER MY PASSWORD**, in order to alleviate having to enter this information on subsequent connections.

10. Click on **OK**.
11. A new window will open requesting the location of the downloaded software package. See Figure 14.
12. Click on BROWSE and navigate to the location on your laptop where the software package is stored. (If the file is attached to an e-mail message, it is recommended to save this file to your desktop, or create a folder to store all downloaded packages for easier access). See Figure 14.
13. Select the following file:
   a. If executing a PROGRAMMING UPDATE, select BA_LXXX. See Figure 15.
   c. If executing a COMPLETE REPROGRAMMING, for example after replacing the MASTER ID, select FB_LXXX. See Figure 15.
14. Click on OPEN. See Figure 15.
15. Then, click on **DOWNLOAD**. A progress bar will appear at the bottom of the page. The download may take several minutes, depending on the size of the file and the speed of the laptop.

16. Once the download is complete, a new window will open. Make sure the reprogramming was successful by verifying if the **CODE 100: DOWNLOAD OK** is displayed in the window. See Figure 16. If so, click on the **RESTART SYSTEM SOFTWARE**. See Figure 16. If not, click once more on **DOWNLOAD SOFTWARE PACKAGE** and repeat the procedure.

17. A window will appear confirming that the system is programming the **CECM-B** application. This stage will download the update directly to the **CECM**. A progress indicator confirms the download process. See Figure 17.
18. Once completed, the main VOLVO BUS-ON-BOARD WEB SERVER page appears. Click on the line VEHICLE INFORMATION and a sub-menu will appear with several choices. See Figure 18.

19. Click on BODY ECU INFO from the sub-menu. This allows viewing the status of the modules. Initially, the BODY ECU INFO window that appears will show the number 1 in the STATE column against the line corresponding to CECM, under the column ECU TYPE. All other lines will indicate 0. See Figure 19.

20. Place the MASTER CONTROL SWITCH in the OFF position.

21. Flip down, once only, the MIRROR DEFROSTER SWITCH found on the DCP, to the DEACTIVATED position. See Figure 20. If NO MIRROR DEFROSTER SWITCH is installed, refer to the Operator’s manual for the alternative designated switch.

**NOTE:**

The downloading process will take several minutes, and during the process, error messages will appear against each module line. This is normal. **DO NOT STOP OR CANCEL THIS PROCESS.**
22. Eventually each module line will change from 0 to 1 under the STATE column. If the process terminates with some zeros still evident against each module line, then flip the MIRROR DEFROSTER SWITCH, or designated switch, once again, to reactivate this process.

23. When the STATE column displays all 1s, the process is complete and you may exit the Volvo web server by clicking on the RED X in the upper right-hand side of the screen.

24. Deactivate the MASTER ID connection by double-clicking on the MASTER ID STATUS ICON on the tool bar located in the lower right corner of the screen. In the window that appears, click on the DISCONNECT button. See Figure 21.

**CAUTION:**

It is important to deactivate the MASTER ID connection (software link) before disconnecting the transfer cable.

25. Close the access door to the console located over the driver’s window or close the main electrical panel over the driver’s seat.

26. Start the vehicle and perform a running test prior to returning the vehicle to service.

**REPLACING THE MODULES**

The IO-A, IO-B and CECM modules can be replaced and re-programmed without connecting a PC to the vehicle. This procedure must be followed precisely for successful programming of the new-module.

**REPLACING AN IO-A OR IO-B**

1. Place the MASTER CONTROL SWITCH in the OFF position. The MAIN BATTERY SWITCH must remain ON.

2. Remove and replace the defective IO-A or IO-B module.

3. Place the MAINTENANCE switch, located in the overhead left panel, in the ON position. The Network Fail LED on the instrument panel will illuminate.
4. Deactivate the supply breaker for the CECM module. The location of this breaker varies depending on the vehicle. See the vehicle’s **COACH WIRING DIAGRAM** for more information.

5. Reactivate the CECM’s breaker without activating the **MASTER CONTROL SWITCH**. This triggers the automatic reprogramming of the V-BEA system. The hazard lights flash momentarily confirming the signal. The vehicle is now completely shut down.

6. Wait a few minutes to provide the CECM enough time to program the new module.

7. When the reprogramming has finished, the Network Fail LED extinguishes. To ensure reprogramming has been completed, check to see whether a fault is displayed in the **V-BEA MUX STATE / V-BEA MODULE FAULT** menu of the Actia speedometer display.

8. If a module has not been reprogrammed, a fault corresponding to the module number will be displayed. (ex.: 41).

### REPLACING THE CECM

1. Place the **MASTER CONTROL SWITCH** in the **OFF** position. The main battery switch must remain **ON**.

2. Deactivate the circuit breaker for the CECM module located in the +BCA compartment, or in the main +RF0 compartment. The module is connected directly to the batteries.

3. Remove and replace the defective CECM.

4. Reactivate the CECM’s breaker without activating the master control switch.

5. This will trigger automatic re-programming of the **MASTER ID** toward the CECM.

6. Wait for the completion of the transfer (about 4 minutes) and flip down, once only, the **MIRROR DEFROSTER SWITCH** found on the DCP, to the **DEACTIVATED** position. This procedure activates the sleep mode and automatically transfers the new CECM program to the other modules. It may be necessary to flip the switch more than once before the process is complete.

7. Place the **MAINTENANCE** switch, located in the overhead left panel, in the **ON** position. The Network Fail LED on the instrument panel will illuminate.

8. Deactivate the supply breaker for the CECM module. The location varies depending on the vehicle. See the vehicle’s **COACH WIRING DIAGRAM** for more information.

9. Reactivate the CECM’s breaker without activating the **MASTER CONTROL SWITCH**. This triggers the automatic reprogramming of the V-BEA system. The hazard lights flash momentarily confirming the signal. The vehicle is now completely shut down.

10. Wait a few minutes to provide the CECM enough time to program the new module.

11. Once programming is finished, perform a check. This means cycling through the driver/cabin switches. The goal is to ensure the transfer has been properly completed.

12. Also, check the Actia display menu for fault messages to ensure that the module has been reprogrammed.

### DIAGNOSIS AND TROUBLESHOOTING

#### DIAGNOSIS AND TROUBLESHOOTING STEPS

The advantage of this multiplex system is that it creates several possibilities for diagnosis. When a failure occurs, the system indicates the exact place of the failure. The system can even foresee the failures that may occur, while supervising features of the key components.

The only manner to diagnose and troubleshoot the V-BEA system is by using electronic testing software, either linked directly through the Actia IP (initial start-up), AIC (optional) or with a laptop computer. There is no way to visually identify faults or failures.

**CAUTION:**

Before executing troubleshooting, always refer to the **COACH wiring diagram**.

**WARNING:**

Follow all general safety guidelines. Always use safety equipment properly whenever performing trials/tests or work on the V-BEA system.

### ACTIA IP

- Instrument panel test including tell tale, buzzer and gauges
- J1939 error codes for engine, transmission and ABS
- V-BEA self test for:
  - Lighting sequence: in this mode, driver walks around the bus and exterior lights illuminate sequentially, driver can detect a burnt bulb, for example.
  - Input test: in this mode, electrical technician can change the state of any condition (i.e. open a door, flip a switch) and the **NEXT STOP** buzzer will sound.
  - Brake wear (optional): in this mode, the percentage of brake wear is indicated per wheel in real time.
LAPTOP COMPUTER

Use any properly configured laptop to connect to the internal web server. For the configuration procedure, see the V-BEA REPROGRAMMING header of this section.

This server will display browser-based diagnosis information.
- Input/Output state
- Line color changes, depending on state
- Diagnosis in HTML, Internet Explorer displays the diagnosis screen (no internet connection is required, the CECM acts as a web server)
- No software to install for diagnosis

**WARNING:**
Only authorized personnel having received proper training should perform diagnosis. Misuse may compromise the integrity of the electrical system and render the vehicle non-functional. Special care and authorization are required to perform these procedures.

SOFTWARE AND PROGRAMMING TEST

The following preparations are necessary before diagnosis and troubleshooting can begin:
- Connect a suitable laptop to the transmission control via the cable (RS232) provided for this purpose. See Figure 4. For more information, see the V-BEA REPROGRAMMING header of this section.
- Start the diagnosis program.
- Start communication.
- Read fault memory.
- Test faulty components individually. This is to determine whether the fault still exists.

FAILURE MODE INDICATOR (FMI)

This function makes it possible to the user to see a complete description of failures and the number of times it was recorded.

The registers of errors should be read as follows:
- The information read gives a FMI type error and the control unit which sends this signal.
- When receiving the information, the device shows the "address and sub-address of the module", the typical circuit of the function, the name of the component receiving this signal and its function description.
- It is possible to see the function part number and the number of times that the error was recorded.

NOTE:
For a list of fault codes, see Table 3 at the end of this section.

POWER SHEDDING SYSTEM

OPERATION

LFS vehicles are equipped with a power control system allowing activation and deactivation of the electric power from different areas of the vehicle. This system replaces both the manual battery disconnecting switch and the circuit breaker that were in place on the earlier models.

This system has several advantages compared to the earlier systems, in that;
- It allows the power supply to stop automatically after a predetermined delay of inactivity, which prevents discharging the batteries.
- It also makes it possible to re-engage the power supply without having to reach the main circuit breaker, directly from the driver’s compartment.

**WARNING:**
Before diagnosing a shedding problem, it is recommended to disconnect the shedding coil and the resetting coil of the main circuit breaker. See the COACH WIRING DIAGRAM.

NORMAL STARTING

Under normal conditions, with the MASTER POWER SWITCH in the NORMAL position, starting the electric power supply of the vehicle is performed simply by turning the MASTER CONTROL SWITCH to the RUN, RUN/LIGHTS or the ACCESSORIES position. The circuit breaker will automatically engage and the 24-volt circuit will be supplied with power.
To cut off the power supply, simply place the master control switch in the OFF position, or the master power switch can be placed in the DISABLE position. The circuit breaker will disengage automatically after the delay.

The system may also be re-engaged, with the master power switch in the NORMAL position, using either the emergency light switch (HAZARD SW), or the 9-1-1 emergency switch, located near the driver, or the power assistance emergency release command (DOOR MASTER SWITCH). As long as one of these applications is functional, the automatic inactivity shutdown will remain inactive.

VEHICLE MAINTENANCE

During vehicle maintenance, it may be necessary to deactivate the electric circuits of the vehicle. To deactivate them, manually switch off the battery master switch, located in the battery compartment, or in the engine compartment, depending on the model. This interruption has complete precedence over all other commands. It is impossible, for safety reasons, to restart the power supply without manually placing the switch in the ON position.

The temporary positioning of the switch in the NORMAL position engages the power supply. However, it will stop automatically after a delay if the control logic is applied.

CAUTION:

Some circuits, such as the optional fire detector, the voltage equalizer or converter, the ID 36 module, the radio, the 9-1-1 emergency switch and the horn will remain supplied at all times, if necessary.

V-BEA MAINTENANCE

RECOMMENDATIONS

- The use of tell-tales, LEDs or analog voltmeters to diagnose the communication networks is prohibited.
- When making repairs to the structure, respect the origin, routing and integrity of the harnesses, to maintain a virus-free environment.
- Multiplexing allows an interface with computers (computer networks), therefore, it is necessary to respect some rules before disconnecting a computer or a battery, since the communications will be interrupted (possible communication failure).
- All operations must be carried out according to manufacturer recommendations, concerning removal, installation, training, rebooting, etc.

CAUTION:

Follow all the general safety precautions. While testing or working on the V-BEA system, always use security equipment properly.

WELDING PRECAUTIONS:

As a precaution before any welding, the V-BEA modules should be completely disconnected.

In addition, the LFS-HEV operates with a high-voltage system that could cause serious injury or death if handled improperly. Take care when handling the color-coded (orange) cables. These contain the wiring for the high-voltage system. The high-voltage system is dedicated entirely to the Allison Electric Drive E⁹-40 System. The 24-volt electric circuit handles functions, such as vehicle wake-up, vehicle accessories, etc.

See special instructions in section 10-108: Allison Electric Drive E⁹-40 System for welding requirements on the vehicle. As a minimum precaution, before any welding, the V-BEA modules should be completely disconnected.
**MODULE PROTECTION**

- If maintenance is performed on the vehicle that generates contaminants, such as metal filings, sawdust, etc., protect the modules and connectors that might be exposed, to avoid contaminating such components.
- Never pick at the wires. A broken sheath is a weak point in service.

**WIRING**

- Use the proper tools to remove each terminal from the connectors. If you damage the connectors, this could cause electric problems that may only surface at a later time.
- Pay particular attention to the secondary ridge on the green connectors of the modules. It is easy to break.
- Ensure that terminals are crimped properly on the wires, in order not to expose the copper. See Figure 22.
- If you break a terminal while repairing or disassembling a component, repeat the previous steps, if necessary, to ensure that a good connection is achieved.
- Do not exert pressure on the contacts. The end of the wire between the attachment and the connector must not pull on the contacts. Also, the end of this wire must not be stretched.
- Be careful not to cut the electrical wiring too close. Since the wire is very thin, with constant vibration, the wire could wear out.
- For the CAN wiring, it is very important to maintain the number of twists per inch in the wire, as prescribed by the SAE J1939 standard; either 28 to 38 mm between every twist and not more than 50 mm without any twist up to the connector splicing point. Therefore, it is unadvised to repair CAN wiring.
- If the CAN wiring requires repair in an electric panel, it is preferable to replace the complete bundle. The CAN bundles are separated at the main wiring panel to facilitate this.

**USE OF NYOGEL ON CONNECTORS**

- Do not use Nyogel grease on the Multiplex module connectors.

**DISCONNECTING MODULES**

See Figures 23 and 24.

- The connecting and disconnecting of modules must be performed with caution.
- For disconnecting, push on the part provided for this purpose.
- For the large connectors, it is necessary to push the tongue downwards to release the connector.

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*Figure 22 - Improper Crimping*
EXTRACTION TOOLS

If you must remove a terminal from its connector, use the appropriate extraction tool and the preferred extraction method as follows:

JAE

See Figures 25 and 26.

**NOTE:**
A double locking device prevents the contacts from becoming dislodged.

The JAE extraction tool:
Contact extraction tool: ET-AG5
Lock clearing tool: RT-AG5 • EX5
AMP
See Figures 27 and 28.

NOTE:
A double locking device prevents the contacts from accidentally opening.

The AMP tool is:
Contact extraction tool: 725864-1

YAZAKI
See Figures 29 to 30.

NOTE:
A simple locking device prevents the contacts from becoming dislodged.

The Yazaki tool is:
Contact extraction tool: G0406 (Type PA).
<table>
<thead>
<tr>
<th>FMI = 0 — DATA VALID BUT ABOVE NORMAL OPERATIONAL RANGE - MOST SEVERE LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>The signal communicating information is within a defined acceptable and valid range, but the real world condition is above what would be considered normal as determined by the predefined most severe level limits for that particular measure of the real world condition (Region E of the signal range definition). Broadcast of data values is continued as normal.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FMI = 1 — DATA VALID BUT BELOW NORMAL OPERATIONAL RANGE - MOST SEVERE LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>The signal communicating information is within a defined acceptable and valid range, but the real world condition is below what would be considered normal as determined by the predefined least severe level limits for that particular measure of the real world condition (Region D of signal range definition). Broadcast of data values is continued as normal.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FMI = 2 — DATA ERRATIC, INTERMITTENT OR INCORRECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erratic or intermittent data includes all measurements that change at a rate that is not considered possible in the real world condition and must be caused by improper operation of the measuring device or its connection to the module. Broadcast of data value is substituted with the ERROR INDICATOR value. Incorrect data includes any data not received and any data that is exclusive of the situations covered by FMI 3, 4, 5 and 6. Data may also be considered incorrect if it is inconsistent with other information collected or known about the system.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FMI = 3 — VOLTAGE ABOVE NORMAL, OR SHORTED TO HIGH SOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. A voltage signal, data or otherwise, is above the predefined limits that bound the range (Region G of the signal range definition). Broadcast of data value is substituted with the ERROR INDICATOR value.</td>
</tr>
<tr>
<td>b. Any signal external to an electronic control module whose voltage remains at a high level when the ECM commands it to low. Broadcast of data value is substituted with the ERROR INDICATOR value.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FMI = 4 — VOLTAGE BELOW NORMAL, OR SHORTED TO LOW SOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. A voltage signal, data or otherwise, is below the predefined limits that bound the range (Region F of the signal range definition). Broadcast of data value is substituted with the ERROR INDICATOR value.</td>
</tr>
<tr>
<td>b. Any signal external to an electronic control module whose voltage remains at a low level when the ECM commands it to high. Broadcast of data value is substituted with the &quot;error indicator&quot; value.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FMI = 5 — CURRENT BELOW NORMAL OR OPEN CIRCUIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. A current signal, data or otherwise, is below the predefined limits that bound the range (Region G of the signal range definition). Broadcast of data value is substituted with the ERROR INDICATOR value.</td>
</tr>
<tr>
<td>b. Any signal external to an electronic control module whose current remains off when the ECM commands it on. Broadcast of data value is substituted with the ERROR INDICATOR value.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FMI = 6 — CURRENT ABOVE NORMAL OR GROUNDED CIRCUIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. A current signal, data or otherwise, is above the predefined limits that bound the range (Region G of the signal range definition). Broadcast of data value is substituted with the ERROR INDICATOR value.</td>
</tr>
<tr>
<td>b. Any signal external to an electronic control module whose current remains on when the ECM commands it off. Broadcast of data value is substituted with the ERROR INDICATOR value.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FMI = 7 — MECHANICAL SYSTEM NOT RESPONDING OR OUT OF ADJUSTMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any fault that is detected as the result of an improper mechanical adjustment or an improper response or action of a mechanical system that, with a reasonable confidence level, is not caused by an electronic or electrical system failure. This type of fault may or may not be directly associated with the value of general broadcast information.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FMI = 8 — ABNORMAL FREQUENCY OR PULSE WIDTH OR PERIOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>To be considered in cases of FMI 4 and 5. Any frequency or PWM signal that is outside the predefined limits which bound the signal range for frequency or duty cycle (outside Region B or the signal definition). Also if the signal is an ECM output, any signal whose frequency or duty cycle is not consistent with the signal which is emitted. Broadcast of data value is substituted with the &quot;error indicator&quot; value.</td>
</tr>
</tbody>
</table>

---

Table 3 - FMI and Description
<table>
<thead>
<tr>
<th>FMI</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>ABNORMAL UPDATE RATE</td>
</tr>
<tr>
<td></td>
<td>Any failure that is detected when receipt of data via the data link or</td>
</tr>
<tr>
<td></td>
<td>as input from a smart actuator or smart sensor is not at the update rate</td>
</tr>
<tr>
<td></td>
<td>expected or required by the ECM (outside Region C of the signal range</td>
</tr>
<tr>
<td></td>
<td>definition). Also any error that causes the ECM not to send information at</td>
</tr>
<tr>
<td></td>
<td>the rate required by the system.</td>
</tr>
<tr>
<td></td>
<td>This type of fault may or may not be directly associated with the value of</td>
</tr>
<tr>
<td></td>
<td>general broadcast information.</td>
</tr>
<tr>
<td>10</td>
<td>ABNORMAL RATE OF CHANGE</td>
</tr>
<tr>
<td></td>
<td>Any data, exclusive of the abnormalities covered by FMI 2, that is</td>
</tr>
<tr>
<td></td>
<td>considered valid but whose data is changing at a rate that is outside the</td>
</tr>
<tr>
<td></td>
<td>predefined limits that bound the rate of change for a properly functioning</td>
</tr>
<tr>
<td></td>
<td>system (outside Region C of the signal range definition). Broadcast of data</td>
</tr>
<tr>
<td></td>
<td>values is continued as normal.</td>
</tr>
<tr>
<td>11</td>
<td>ROOT CAUSE NOT KNOWN</td>
</tr>
<tr>
<td></td>
<td>It has been detected that a failure has occurred in a particular subsystem</td>
</tr>
<tr>
<td></td>
<td>but the exact nature of the fault is not known. Broadcast of data value is</td>
</tr>
<tr>
<td></td>
<td>substituted with the &quot;error indicator&quot; value.</td>
</tr>
<tr>
<td>12</td>
<td>BAD INTELLIGENT DEVICE OR COMPONENT</td>
</tr>
<tr>
<td></td>
<td>Inconsistency of data indicates that a device with some internal</td>
</tr>
<tr>
<td></td>
<td>intelligence, such as a controller, module, smart sensor or smart actuator,</td>
</tr>
<tr>
<td></td>
<td>is not properly functioning. This data may be internal to a module or</td>
</tr>
<tr>
<td></td>
<td>external from a data link message or from various system responses.</td>
</tr>
<tr>
<td></td>
<td>Broadcast of data value is substituted with the &quot;error indicator&quot; value.</td>
</tr>
<tr>
<td></td>
<td>This error is to include all internal controller trouble codes that can</td>
</tr>
<tr>
<td></td>
<td>not be caused by connections or systems external to the controller.</td>
</tr>
<tr>
<td>13</td>
<td>OUT OF CALIBRATION</td>
</tr>
<tr>
<td></td>
<td>A failure that can be identified to be the result of not being properly</td>
</tr>
<tr>
<td></td>
<td>calibrated. This may be the case for a subsystem which can identify that</td>
</tr>
<tr>
<td></td>
<td>the calibration attempting to be used by the controller is out of date. Or</td>
</tr>
<tr>
<td></td>
<td>it may be the case that the mechanical subsystem is determined to be out of</td>
</tr>
<tr>
<td></td>
<td>calibration. This failure mode does not relate to the signal range</td>
</tr>
<tr>
<td></td>
<td>definition as do many of the FMIs.</td>
</tr>
<tr>
<td>14</td>
<td>SPECIAL INSTRUCTIONS</td>
</tr>
<tr>
<td></td>
<td>SPNs 611 through 615 are defined as SYSTEM DIAGNOSTIC CODES and are used</td>
</tr>
<tr>
<td></td>
<td>to identify failures that cannot be tied to a specific field replaceable</td>
</tr>
<tr>
<td></td>
<td>component. Due to the fact that SPNs 611-615 are manufacturer defined and</td>
</tr>
<tr>
<td></td>
<td>are not component specific, FMIs 0-13 and 15-31 have little meaning.</td>
</tr>
<tr>
<td></td>
<td>Therefore, FMI 14, SPECIAL INSTRUCTIONS, is usually used. The goal is to</td>
</tr>
<tr>
<td></td>
<td>refer the service personnel to the manufacturer’s troubleshooting manual</td>
</tr>
<tr>
<td></td>
<td>for more information on the particular diagnostic code. This failure mode</td>
</tr>
<tr>
<td></td>
<td>does not relate to the signal range definition as do many of the FMIs.</td>
</tr>
<tr>
<td></td>
<td>This type of fault may or may not be directly associated with the value of</td>
</tr>
<tr>
<td></td>
<td>general broadcast information.</td>
</tr>
</tbody>
</table>

Table 3 - FMI and Description (cont'd)