# MERCURY®

# V6 175/200/225
# V8 200/225/250/300
# FourStroke
# Outboard


DIAGNOSTIC

MANUAL

FOURSTROKE

PRO XS

SEAPRO

VERADO

Racing

Starting serial number 2B529482

MERCURY

V6 175/200/225 V8 200/225/250/300 FourStroke Outboard

DIAGNOSTIC MANUAL

90-8M0146617
JULY 2018

# Notice to Users of This Manual

Throughout this publication, safety alerts labeled WARNING and CAUTION (accompanied by the International HAZARD Symbol ⚠) are used to alert the mechanic to special instructions concerning a particular service or operation that may be hazardous if performed incorrectly or carelessly. Observe these alerts carefully.

These safety alerts alone cannot eliminate the hazards that they signal. Strict compliance to these special instructions when performing the service, plus common sense operation, are major accident prevention measures.

| ⚠ WARNING |
|---|
| **Indicates a hazardous situation which, if not avoided, could result in death or serious injury.** |

| ⚠ CAUTION |
|---|
| **Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.** |

Additional alerts provide information that requires special attention:

| *NOTICE* |
|---|
| **Indicates a situation which, if not avoided, could result in engine or major component failure.** |

**IMPORTANT: Indicates information essential to the successful completion of the task.**

*NOTE: Indicates information that helps in the understanding of a particular step or action.*

This manual has been written and published by the Mercury Marine Service Department to aid our dealers' mechanics and company service personnel when servicing the products described herein. It is assumed that these personnel are familiar with marine product servicing procedures. Furthermore, it is assumed that they have been trained in the recommended service procedures of Mercury Marine power products, including the use of mechanics' common hand tools and the special Mercury Marine tools or recommended tools from other suppliers.

We could not possibly know of and advise the marine trade of all conceivable procedures and of the possible hazards and results of each method. Therefore, anyone who uses a service procedure or tool that is not recommended by the manufacturer must first completely satisfy himself that neither his nor the product's safety will be endangered.

All information, illustrations, and specifications contained in this manual are based on the latest product information available at the time of publication. As required, revisions to this manual will be sent to all dealers contracted by us to sell or service these products. We reserve the right to make changes to this manual without prior notification.

Refer to dealer service bulletins, operation and maintenance manuals, and installation manuals for other pertinent information concerning the products described in this manual.

# Precautions

While working on the product, keep in mind that the electrical and ignition systems are capable of violent and damaging short circuits or severe electrical shocks. When performing any work where electrical terminals could possibly be grounded or touched by the mechanic, the battery cables should be disconnected at the battery.

Any time the intake or exhaust openings are exposed during service they should be covered to protect against accidental entrance of foreign material into the cylinders, which could cause extensive internal damage when the engine is started.

During any maintenance procedure, replacement fasteners must have the same measurements and strength as those removed. Numbers on the heads of the metric bolts and on the surfaces of metric nuts indicate their strength. American bolts use radial lines for this purpose, while most American nuts do not have strength markings. Mismatched or incorrect fasteners can result in damage or malfunction, or possibly personal injury. Therefore, fasteners removed should be saved for reuse in the same locations whenever possible. Where the fasteners are not satisfactory for reuse, care should be taken to select a replacement that matches the original.

Personnel should not work on or under an engine that is suspended. Engines should be attached to workstands, or lowered to the ground as soon as possible.

# Replacement Parts

Use of parts other than the recommended service replacement parts will void the warranty on those parts that are damaged as a result.

**⚠ WARNING**

**Avoid fire or explosion hazard. Electrical, ignition, and fuel system components on Mercury Marine products comply with federal and international standards to minimize risk of fire or explosion. Do not use replacement electrical or fuel system components that do not comply with these standards. When servicing the electrical and fuel systems, properly install and tighten all components.**

## Cleanliness and Care of Product

A Mercury Marine power product is a combination of many machined, honed, polished, and lapped surfaces with tight tolerances. When any product component is serviced, care and cleanliness are important. Proper cleaning and protection of machined surfaces and friction areas is an implied part of the repair procedure. This is considered standard shop practice even if not specifically stated.

Whenever components are removed for service, they should be retained in order. At the time of installation, they should be installed in the same locations and with the same mating surfaces as when removed.

## Copyright and Trademark Information

# Manual Outline

# Important Information

## Section 1A - How to Use This Manual

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## Table of Contents



  

# Models Covered

This diagnostic manual provides service technicians with information relating to Mercury outboard engines that use the PCM 112 electronic control unit. At the time of this publication, that includes 175–300 hp FourStroke, Pro XS, SeaPro, and Verado models.

| Models Covered | Serial Number or Year |
|---|---|
| Mercury 175 V6, 175 V6 Pro XS, 200 V6, 200 V6 SeaPro, 225 V6 | 2018 and Newer |
| Mercury 200 V8 Pro XS, 225 V8 Pro XS, 225 V8 SeaPro, 250 V8, 250 V8 Pro XS, 250 V8 SeaPro, 250R V8, 300 V8, 300 V8 Pro XS, 300 V8 SeaPro, 300R V8 | 2018 and Newer |


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PCM label: The number in the lower left identifies the controller: PCM 112. The next two digits are the year it was introduced. The last three numbers are an internal cross-reference number.

# Manual Organization

## Section 1 - Important Information

The following comprise Section 1.

**Section 1A** - **How to Use This Manual.**

**Section 1B** - **System Theory** gives an overview of the speed/density theory and how it relates to open-loop and closed-loop control. This section also covers the oxygen sensor used on PCM 112 engines and how it gives precise control over fueling.

**Section 1C** - **Emissions** provides an overview of the emission control process.

**Section 1D** - **Glossary, Reference Charts, and Conversions**.

## Section 2 - PCM 112

The following comprise Section 2.

**Section 2A** - **PCM 112 Important Information and Pinouts** provides an overview of the PCM 112 and discusses recommended test equipment. The PCM 112 pinout diagrams list the function and wire color of each pin in the PCM 112 module.

**Section 2B** - **PCM 112 and Engine Control Overview** focuses on how faults are generated, and the steps involved when the engine starts and enters into closed-loop control.

## Section 3 - General Troubleshooting and CDS G3

The following comprise Section 3.

**Section 3A** - **General Troubleshooting** discusses the audio warning system, and general approaches for addressing MFD faults.

**Section 3B** - **Troubleshooting with the Computer Diagnostic System (CDS G3)** contains information on connecting the CDS G3 system to your PCM 112, as well as the different screens, information, and functions available to the technician.

**Section 3C** - **CDS G3—Live Data** covers the information available to the technician on CDS G3's live data screen—the data fields, a description of the data field, and typical data values—all useful information to provide a snapshot of what the engine is doing at this moment.

**Section 3D** - **CDS G3—PCM 112 Freeze Frame Data** provides an overview of the freeze frame data screen. The freeze frame data screen provides a snapshot of the engine at the time a fault occurred.

  

**Section 3E** - **CDS G3—Diagnostics Screen** provides an overview of the diagnostic tests available in CDS G3.

**Section 3F** - **CDS G3—Module Reflash** provides an overview of the diagnostic tests available in CDS G3.

## Section 4 - Fault Codes

The following comprise Section 4.

**Section 4A** - **Fault Codes** covers the possible faults the CDS G3 may report, along with an explanation and suggestions for eliminating the fault.

## Section 5 - Sensors, Actuators, Relays, and Accessories

The following comprise Section 5.

**Section 5A** - **Sensors** contains a sensor test, and removal and installation information for each sensor.

**Section 5B** - **Actuators and Relays** contains an overview of each actuator and relay, along with general troubleshooting.

**Section 5C** - **Accessories** contains circuit and general troubleshooting information for accessories.

## Section 6 - Electrical Systems

The following comprise Section 6.

**Section 6A** - **Ignition** focuses on ignition related specifications, tests, and wiring diagrams.

**Section 6B** - **Charging and Starting System** focuses on charging and starting system related specifications, tests, and wiring diagrams.

**Section 6C** - **Conventional Midsection (CMS) Power Trim** contains troubleshooting and testing information for the CMS power trim system.

**Section 6D** - **Advanced Midsection (AMS) Power Trim** contains troubleshooting and testing information for the AMS power trim system.

## Section 7 - Fuel System

The following comprise Section 7.

**Section 7A** - **Fuel System** contains specifications, system theory, parts overviews, and fuel flow diagrams.

**Section 7B** - **Troubleshooting and Diagnostics** contains general troubleshooting and diagnostic information for the fuel system.

## Section 8 - Color Diagrams

The following comprise Section 8.

**Section 8A** - **SmartCraft Circuit Diagrams** contains SmartCraft related, and clean power circuit diagrams.

**Section 8B** - **Engine Harness Diagrams** contains complete engine harness circuit diagrams.

# General Service Precautions When Working on EFI Systems

| ⚠ WARNING |
| --- |
| **Before working around electrical system components, disconnect the battery cables from the battery to prevent injury or damage to the electrical system due to an accidental short circuit.** |

| ⚠ CAUTION |
| --- |
| **Disconnecting or connecting the battery cables in the incorrect order can cause injury from electrical shock or can damage the electrical system. Always disconnect the negative (-) battery cable first and connect it last.** |

| ⚠ WARNING |
| --- |
| **Avoid serious injury or death from the loss of DTS electrical power. The DTS power harness must be securely fastened with cable ties to one of the battery cables near the battery. If not properly secured, the DTS power harness could be pulled off the battery, resulting in the loss of electrical power and a loss of throttle and shift control.** |

In addition to adhering to general safety practices, the following should be observed:

- Always disconnect the negative terminal first when removing a battery, and connect it last when installing a battery to prevent arcing.
- Never start the engine without the battery being solidly connected.

  

- Never disconnect the battery while the engine is running. This can cause a voltage spike in the charging system that can damage electronic components.
- Never separate the battery feed wire from the charging system while the engine is running.
- When charging the battery, disconnect it from the boat's electrical system. (This does not include low amperage battery tenders or onboard chargers.)
- Ensure that all cable harnesses are connected solidly and that battery connections are thoroughly clean.
- Never connect or disconnect the wiring harness at the PCM when the ignition is switched ON.
- Before attempting any electric welding (MIG, TIG, stick), disconnect the battery leads and the PCM connectors. Ensure that the ground clamp is as close to the work as possible.
- Steam cleaning or high pressure cleaning can cause many problems in the electrical system and should be avoided whenever possible. If you are steam cleaning engines, do not direct the steam cleaning nozzle at EFI system components, ignition system components or electrical connectors. If this happens, corrosion of the terminals or damage of components can take place.
- Use only the test equipment specified in the diagnostic charts, since other test equipment may either give incorrect results or damage good components.
- All voltage measurements using a voltmeter require a digital voltmeter with a rating of 10 megohms input impedance in order to prevent damaging the circuitry of the PCM.
- Use a kV meter or appropriate spark tester for checking physical spark. Failure to do so can damage ignition system components and endanger your safety.
- Do not allow spark plugs or wires to arc in the engine bay.
- Always relieve fuel system pressure prior to opening the fuel system. Safety glasses should be worn when working on the fuel system.

  

# Important Information

## Section 1B - System Theory

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# Overview

Mercury outboard engines that use the PCM 112 engine control module operate on a speed/density fuel injection strategy. In this strategy, the propulsion control module (PCM) monitors the engine's **speed** and the intake manifold's air **density**. Since the engine ideally maintains a standard, repeatable fuel pressure, the PCM can calculate how long to keep the fuel injectors open to achieve the desired air/fuel ratio.

This desired ratio is usually the **stoichiometric ratio**, that ratio of air to fuel that provides the most complete combustion possible with a minimum of hydrocarbon or nitrous oxides passed through the exhaust. For gasoline without ethanol it is typically 14.7:1. For gasoline with 10% ethanol, it is in the area of 14.1:1. Because of this variance, we use the term equivalency ratio or phi, which is the ratio of the air/fuel as reported by the O2 sensor, and the desired ratio targeted by the PCM.

The PCM 112 adjusts fueling and other engine parameters to achieve the desired equivalency ratio depending on load and RPM range.

# Speed/Density Theory

The engine is basically a mechanical air pump that pumps a specific amount of air at any specific RPM. The actual amount of air an engine pumps depends upon the density of the air in the intake manifold. This, in turn, depends upon RPM, throttle plate position, and barometric pressure.

If the air density in the intake manifold is known, the actual amount of air flowing through the engine (the air mass or mass air flow) could be calculated. This calculated air flow is a repeatable function, meaning that at a specific RPM and a specific manifold absolute pressure (MAP) reading, the air flow through the engine will always be the same.

The PCM uses a manifold absolute pressure sensor to measure the manifold pressure. It records this information as a measurement **above** absolute zero. This is similar to the way a barometer works and is unlike a conventional vacuum gauge, which measures the manifold pressure **below** the **current** atmospheric pressure. The use of the MAP sensor allows the system to compensate for variations in altitude and weather. A conventional vacuum gauge cannot provide this critical information.

As the PCM measures the engine speed with a crankshaft sensor and the air density with the MAP, it refers to a programmed lookup fueling table. This lookup table contains correct fuel injector information for every possible engine RPM, demand, and air density. It then sends signals to the ignition coils and fuel injectors to control combustion.

The PCM does not measure fuel pressure; it assumes that the fuel is supplied to the engine at a specified pressure. As long as the fuel in the fuel rails is maintained at the specified pressure for that engine, the PCM can order the fuel injectors to open for a specific length of time to inject the precise amount of fuel into the cylinder at the right time for optimal performance. If the pressure is out of specification, then the actual amount of fuel injected will be more or less than that calculated by the PCM.

# Stoichiometry, Equivalency Ratio, and Emissions Control

An air/fuel mixture that is neither rich nor lean will burn all of the fuel and all of the oxygen. This equilibrium point where the mixture is neither rich nor lean is called the **stoichiometric** point. (Stoichiometry is a section of chemistry that involves measuring the relative quantities of chemicals in chemical reactions.) An air-to-fuel ratio that is less than stoichiometric is considered rich, while an air-to-fuel ratio that is greater than stoichiometric is considered lean.

In practice, the actual stoichiometric ratio can change based upon factors such as fuel blend. For a 10% ethanol blend, the ratio may be 14.1:1, while for a pure gasoline fuel, the air-to-fuel ratio is 14.7:1.

The table below shows some stoichiometric values for different fuels.

| Fuel | Rich | Stoichiometric | Lean |
|---|---|---|---|
| Straight ethanol | 8.9:1 and lower | 9.0:1 | 9.1:1 and higher |
| Straight gasoline | 14.6:1 and lower | 14.7:1 | 14.8:1 and higher |
| E10 (gasoline w/10% ethanol) | 14.12:1 and lower | 14.13:1 | 14.14:1 and higher |

To allow for these differences, Mercury uses the **equivalency ratio**. This is defined as the ratio of the ideal air/fuel ratio to the actual air/fuel ratio: ideal/actual = equivalency ratio. An equivalency ratio of 1.00 means that the combustion is stoichiometric. A ratio of 1.03 means the blend is 3% rich. A blend of 0.97 means that it is 3% lean.

  

To determine the current equivalence ratio, an oxygen sensor measures the exhaust and compares its oxygen content to the ideal oxygen content. The equivalence ratio is also referred to by the Greek letter **phi** (pronounced fee).

| | | | |
|---|---|---|---|
| ☐ | O2ControlState | Closed Loop | Fuel system control state |
| ☐ | DesiredPhi | 1.1484 ratio | Equivalence ratio target |
| ☐ | UEGO1_phi | 1.14 ratio | Equivalence ratio port S1 |
| ☐ | UEGO1_Ri_Temp | 1435.95 °F | O2 sensor temperature port S1 |
| ☐ | UEGO1_HeaterDutyCycle | 23.13 % | O2 sensor heater duty cycle port S1 |
| ☐ | O2Control_ITerm_Port | 0.0186 mult | Fuel trim port |

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In this CDS G3 screen capture, the engine has entered closed-loop control. It is targeting a phi (equivalency ratio) of 1.1484. It is reading a phi of 1.14 and adjusting port fuel trim (02Control_Iterm_Port) by 1.86%.

At times, such as when the engine is first started, the PCM may target a higher phi (run richer than stoichiometric) to allow easy starting and better run quality when the engine is cold.

# Oxygen (O2) Sensor

The PCM uses a single oxygen sensor to measure the amount of hydrocarbons and oxides of nitrogen in the exhaust. If there are excess hydrocarbons (unburned fuel), the air/fuel ratio is too rich. If there are too many oxides of nitrogen, the mixture is to lean. The PCM can use these measurements to add or subtract fuel by changing the time the fuel injectors are open.

The PCM 112's O2 sensor is referred to as UEGO1 (universal exhaust gas oxygen), and S1 in CDS G3.

| | | | |
|---|---|---|---|
| ☐ | DesiredPhi | 1.1484 ratio | Equivalence ratio target |
| ☐ | UEGO1_phi | 1.16 ratio | Equivalence ratio port S1 |

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O2 sensor displays on a CDS G3 Live Data screen

| | | | |
|---|---|---|---|
| ☐ | UEGO1_Ri_Temp | 1435.37 °F | O2 sensor temperature port S1 |
| ☐ | UEGO1_HeaterDutyCycle | 23.31 % | O2 sensor heater duty cycle port S1 |

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The O2 sensor temperature and heater duty cycle

This sensor operates around 768–791 °C (1416–1456 °F). Maintaining the proper temperature is vital to precise measurement. The O2 sensor reaches temperature very quickly, usually within 10 seconds. The heater duty cycle can range from 0 to 100%, but typical values are 15–40% at idle. If a problem is suspected with the heater or sensor, the only diagnostic test is to replace it with a known good sensor and see if it reacts similarly.

Do not attempt to tap into or splice into the O2 sensor wires. It is more expedient and cost effective to replace the sensor if it has failed.

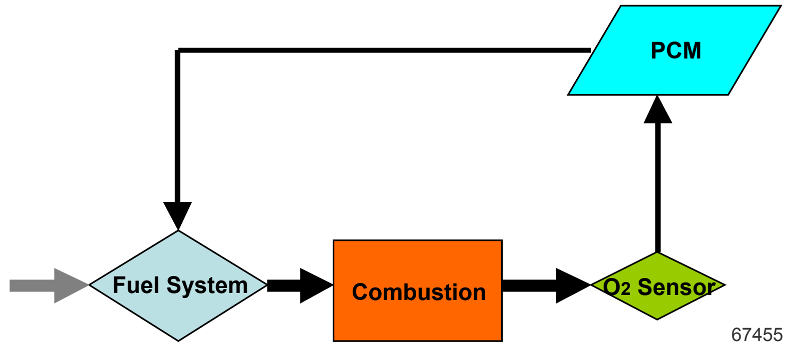
# Open-Loop and Closed-Loop Operation

When the PCM is monitoring the exhaust and adjusting the fuel, it is considered to be in **closed**-**loop** operation. An excess of hydrocarbons or oxides of nitrogen have important ramifications for air quality and are the subject of emissions control regulations.

The PCM 112 stays in closed-loop control throughout the power ranges, except for brief moments when the engine starts or transitions from power settings.

When the engine first starts, if there is a failure with the O2 sensor, or if for some reason, such as a failed fuel injector or spark plug, the information reported by the sensor would require the PCM to add or subtract an excessive amount of fuel, the PCM may revert to a default fuel table. It is then considered in **open-loop** operation and will continue to use the last known good values.




Closed-loop operation

## Closed-Loop Control Summary

| Step | Action |
|---|---|
| 1 | PCM calculates air/fuel ratio. |
| 2 | Fuel system delivers the required air/fuel ratio to the combustion chamber. |
| 3 | Combustion occurs (power stroke). |
| 4 | Exhaust gases enter the exhaust manifold (exhaust stroke). |
| 5 | The oxygen sensor sends a signal to the PCM, delivering oxygen information. |
| | The cycle returns to step 1. |

The speed/density system depends on the engine being unmodified from its original production state. If the engine is modified and its volumetric efficiency changes, the amount of air flow for a given RPM and air density will change, causing the fuel injector operation calculated by the PCM to be incorrect.

# Advanced Range Optimization

Advanced range optimization (ARO) is a software based feature which actively increases fuel economy under specific operating conditions. It becomes active when the engine is set within a defined RPM range, and certain load conditions are met. The status of ARO can only be monitored using CDS G3. In CDS G3, ARO is called **Lean Burn**. The main data point in CDS G3 is **LeanBurnCtrlState**. To learn more about ARO, and lean burn control states, an informative video can be found at: https://p.widencdn.net/dxaed0/Advanced-Range-Optimization.

# Propulsion Control Module (PCM)

The propulsion control module (PCM) system monitors sensor inputs and controls fuel delivery and spark timing. Its components are:

- PCM 112 assembly
- Wiring harness
- Input devices (sensors)
- Output devices (fuel injectors, ignition coils, etc.)

## Description

The PCM 112 is a 112-pin propulsion control module that manages engine conditions and closed-loop engine operation based on oxygen sensor feedback. The PCM 112 requires the use of a separate PCM power harness.

The PCM monitors the following engine sensor feedback to control fuel injector timing, pulse width, and ignition spark timing:

- Block water pressure sensor
- Camshaft position sensor
- Crankshaft position sensor
- Engine coolant temperature (ECT) sensor
- ESTOP or lanyard switch position
- Exhaust gas temperature (EGT) sensor

- Intake air temperature (IAT) sensor
- Manifold absolute pressure (MAP) sensor
- Oil level sensor
- Oil pressure sensor
- Oil temperature sensor
- Oxygen sensor (O2)
- Pitot pressure sensor
- Shift demand sensor
- Throttle demand sensor
- Trim position sensor
- Water-in-fuel (WIF) sensor

The PCM controls these components:

- Electronic throttle control (ETC)
- Fuel injectors
- Fuel pump master relay
- Ignition coils
- Main power relays (MPR)
- Start relay
- Trim up and down relays (on DTS engines)

In addition, the PCM communicates with the helm or other modules through CANs P and H, as well as X on DTS systems.

When system faults threaten engine damage, software installed on the PCM reduces power by limiting the RPM. Refer to **Engine Guardian System**.

You must have the CDS G3 system to communicate with the PCM and perform diagnostic tests.

# Engine Guardian System

The Engine Guardian System monitors critical engine functions and will reduce engine power accordingly in an attempt to keep the engine running within safe operating parameters.

**IMPORTANT: The Engine Guardian System cannot guarantee that powerhead damage will not occur when adverse operating conditions are encountered. The Engine Guardian System is designed to 1) warn the boat operator that the engine is operating under adverse conditions and 2) reduce power by limiting maximum RPM in an attempt to avoid or reduce the possibility of engine damage. The boat operator is ultimately responsible for proper engine operation.**

The Engine Guardian System may also affect engine speed. Guardian goes into effect if one or more of the engine system sensors indicates that reducing power is necessary to protect the engine.

The Engine Guardian System will reduce power in the event of:

- Engine coolant temperature overheating
- Low oil pressure
- Overspeed
- Battery voltage high/low
- All DTS critical faults

For example, if an open or short is found in any sensor, available power is reduced, the audio warning system will sound a critical fault alert and the SmartCraft gauges will display a warning.

# Important Terms

In discussing the PCM, there are a few terms to become familiar with:

- **Closed-loop control**: This is when the PCM is monitoring and adjusting the air/fuel ratio. When the engine is unable to enter closed-loop control, as when a sensor fails, the system reverts to **default fuel delivery**, a predetermined table of air/fuel values, and is then in **open-loop control**.
- **Error**: The difference between the desired equivalency ratio and the actual equivalency ratio. It is also referred to as **ITerm**.
- **Default fuel delivery**: The term used for the amount of fueling that occurs along a predefined power curve from idle to wide-open throttle. When the system is unable to enter closed-loop operation, it will revert to this table for values to be used in determining the appropriate air/fuel ratio in accordance with the **Speed/Density Theory**.

# Notes:

# Important Information

## Section 1C - Emissions

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# Exhaust Emission Standards

Through the U.S. Environmental Protection Agency (EPA), the federal government has established exhaust emissions standards for all new marine engines sold in the U.S.

## What Are Emissions?

Emissions are what come out of the exhaust system when the engine is running. They are formed during the chemical process of combustion from the elements that are present in the combustion chamber. Some emissions are harmless, while others can be harmful to people or the environment. The U.S. EPA regulates potentially harmful emissions.

Engines manufactured by Mercury Marine reduce the emissions of certain pollutants, and potentially harmful gases in the exhaust to conform with levels legislated by the U.S. EPA. Standards are set primarily with regard to three types of emissions: hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen (NOx).

## Hydrocarbons – HC

Gasoline is a hydrocarbon fuel. Two elements of hydrogen and carbon are combined with oxygen and burned during the combustion cycle. Some residual elements pass through the combustion chamber and exit the exhaust system as unburned gases known as hydrocarbons.

## Carbon Monoxide – CO

Carbon is one of the elements that make up the fuel burned in the engine along with oxygen during the combustion process. If the carbon in the gasoline could combine with enough oxygen (one carbon atom with two oxygen atoms), it would come out of the engine in the form of carbon dioxide ($CO_2$). $CO_2$ is a harmless gas. Carbon often combines with insufficient oxygen (one carbon atom with one oxygen atom), forming carbon monoxide (CO). Carbon monoxide is the product of incomplete combustion and is a dangerous, potentially lethal gas.

## Oxides of Nitrogen – NOx

NOx is a slightly different by-product of combustion. Nitrogen is one of the elements that makes up the air going into the engine. Under extremely high temperatures it combines with oxygen to form oxides of nitrogen (NOx). This happens in the engine's combustion chambers when temperatures are too high. NOx itself is not harmful, but when exposed to sunlight it combines with unburned hydrocarbons to create the visible air pollutant known as smog. Smog is a serious problem in California as well as many other heavily populated areas of the United States.

## Controlling Emissions

There are two principle methods of reducing emissions from a four-stroke marine engine. The first method is to control the air/fuel ratio that goes into the combustion chamber. The second is to control the time when this air/fuel mixture enters the combustion chamber. Timing is important, to prevent any unburned mixture from escaping through the exhaust.

## Stoichiometric Ratio (14.7:1) Air/Fuel Ratio

Engineers have discovered that pollutants and exhaust emissions can be reduced if a gasoline engine operates at an air/fuel ratio of 14.7:1. The technical term for this ratio is stoichiometry, or stoichiometric ratio. An air/fuel ratio of 14.7:1 provides the best control of all three elements in the exhaust under almost all conditions. The HC and CO content of the exhaust gas is influenced significantly by the air/fuel ratio. At an air/fuel ratio leaner than 14.7:1, HC and CO levels are low, but with a ratio richer than 14.7:1, they rise rapidly. It would seem that controlling HC and CO by themselves might not be such a difficult task; the air/fuel ratio only needs to be kept leaner than 14.7:1. However, there is also NOx to consider.

As the air/fuel ratio becomes leaner, combustion temperatures increase. Higher combustion temperatures raise the NOx content of the exhaust. Enrichment of the air/fuel ratio to decrease combustion temperatures and reduce NOx emissions will increase HC and CO emissions and adversely effect fuel economy. The solution to controlling NOx, HC, and CO - is to keep the air/fuel ratio as close to 14.7:1 as possible.

# Emissions Information

## Manufacturer's Responsibility

Beginning with 1998 model year engines, manufacturers of all marine propulsion engines must determine the exhaust emission levels for each engine horsepower family and certify these engines with the United States Environmental Protection Agency (EPA). A certification decal/emissions control information label, showing emission levels and engine specifications directly related to emissions, must be placed on each engine at the time of manufacture.

## Dealer Responsibility

When performing service on all 1998 and newer outboards that carry a certification, attention must be given to any adjustments that are made that affect emission levels.

Adjustments must be kept within published factory specifications.

Replacement or repair of any emission related component must be executed in a manner that maintains emission levels within the prescribed certification standards.

Dealers are not to modify the engine in any manner that would alter the horsepower or allow emission levels to exceed their predetermined factory specifications.

Exceptions include manufacturer's prescribed changes, such as that for altitude adjustments. Additional exceptions include factory authorized:

- Installation of performance style gear housings by Mercury Marine.
- Service replacement parts modified, changed, or superseded by Mercury Marine.

## Owner Responsibility

The owner/operator is required to have engine maintenance performed to maintain emission levels within prescribed certification standards.

The owner/operator is not to modify the engine in any manner that would alter the horsepower or allow emission levels to exceed their predetermined factory specifications.

Single engine exceptions may be allowed with permission from the EPA for racing and testing.

## EPA Emission Regulations

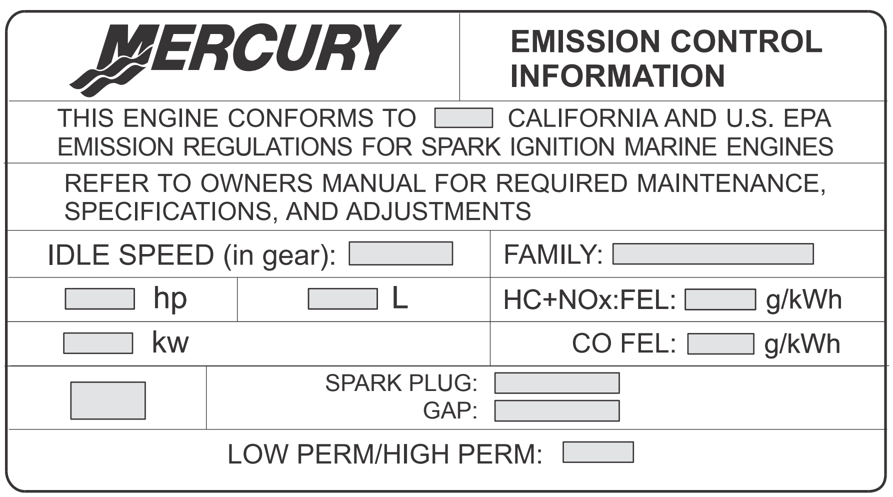
All 1998 and newer outboards manufactured by Mercury Marine are certified to the United States Environmental Protection Agency as conforming to the requirements of the regulations for the control of air pollution from new outboard motors. This certification is contingent on certain adjustments being set to factory standards. For this reason, the factory procedure for servicing the product must be strictly followed and, whenever practicable, returned to the original intent of the design.

The responsibilities listed above are general and in no way a complete listing of the rules and regulations pertaining to the EPA laws on exhaust emissions for marine products. For more detailed information on this subject, you may contact the following location:

**EPA INTERNET WEB SITE**: EPA.gov

# Manufacturer's Certification Label

The certification label must be placed on each engine at the time of manufacture and must be replaced in the same location if damaged or removed. Shown below is a typical certification label and is not representative of any one model. Label shown below is not to scale.

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Emissions information provided on label:

- Year (California and U.S. EPA emission regulations)
- Idle speed
- Engine horsepower
- Piston displacement
- Engine power in kilowatts
- Date of manufacture
- US EPA engine family name
- HC+NOx family emissions level

- CO family emissions level
- Recommended spark plug and gap
- Percent of fuel line permeation

# Service Replacement EPA Decal

IMPORTANT: **By federal law, it is required that all 1998 and newer Mercury Marine outboards have a visible and legible emission certification decal. If this decal is missing or damaged, contact Mercury Marine Service for a replacement.**

## Removal

Remove all remaining pieces of the damaged or illegible decal. Do not install the new decal over a damaged old decal. Use a suitable solvent to remove any traces of the old decal adhesive from the display location.

*NOTE: If the original decal surface is in good condition, it is acceptable to clean the surface and apply the new decal over the original.*

## Installation

Apply the decal on a clean surface in the original factory location.

# Important Information



## Section 1D - Glossary, Reference Charts, and Conversions

## Table of Contents



# Glossary

| | |
|---|---|
| Adaptive Speed Control | Adaptive speed control is a feature that will strive to maintain engine speed during turns or when trimming. |
| Ah | Amp hour. Battery rating method used in some international locations. |
| CAN | Controller area network. A communications protocol developed for the automotive industry and adapted for use in the marine and other industries. |
| CAN bus | The controller area network circuits anywhere in the system (engine harness, data harness, command module harness, junction box, etc.). |
| CAN H | CAN circuit used in joystick piloting applications to communicate between the multiple CAN X circuits. |
| CAN P | CAN circuit used to communicate engine data and propulsion information between the PCM, command module, and helm (blue and white wires). Previously referred to as CAN 1. |
| CAN V | CAN circuit used to communicate vessel data between various vessel accessories and the helm (orange and green wires). |
| CAN X | CAN circuit used to communicate throttle and shift data between the PCM, command module, and helm (yellow and brown wires). Previously referred to as CAN 2. |
| CCA | Cold cranking amps, a rating method for batteries tested at –17.7 °C (0 °F). |
| CDS G3 | Mercury's latest computer diagnostic system. |
| Clean Power | Powers up the DTS/SmartCraft system. Two-wire harness that connects directly to the engine cranking battery. Also referred to as DTS power. Optional connection into a junction box when batteries are at the helm. |
| Closed-loop fuel control | When the PCM is working to adjust the air/fuel ratio to achieve an equivalency ratio of 1. |
| Command module | Small computer that manages communication between the ERC and the PCM. |
| Cruise control | Sets and controls the speed of the engine for cruising (Smart Tow tachometer only). |
| Data harness | The 14-pin harness that connects the engine to the command module harness and/or connects the command module harnesses between stations/helms. |
| Default fuel delivery | A predetermined table of air/fuel values. If the engine leaves closed-loop control it uses these tables to fuel the engine. |
| DTM | Digital Throttle, Mechanical Shift |
| DTS | Digital Throttle and Shift |
| DTS power harness | Powers up the DTS/SmartCraft system. Two-wire harness that connects directly to the engine cranking battery. Also referred to as clean power. Optional connection into a junction box when batteries are at the helm. |
| Dual | Used to describe an application of two: two engines or two controls installed on a boat. |
| Dual helm | Two control/operating stations installed on a boat. |
| eBOM | Electronic bill of material. Used to identify engine and boat configuration in CDS G3. |
| ECM | Engine control module, controls engine functions. Also referred to as PCM. |
| ECT | Engine coolant temperature |
| Engine Guardian System | Monitors the critical sensors on the engine for any early indications of problems. The system will respond to a problem by reducing engine speed and alert the operator to a potentially damaging situation. |
| Equivalence ratio | The ratio of the actual air/fuel ratio to the ideal ratio (refer to stoichiometry). A ratio of 1 means that all of the oxygen is being used in the combustion process. A value greater than 1.00 means the engine is running rich. A value below 1.00 means it is running lean. Also referred to as 'phi.' |
| ERC | Electronic remote control, sends throttle and shift inputs electronically to the engine via the command module and PCM. |
| Error | The difference between where the system is and where we want the system to be. Also referred to as ITerm. |
| ESC | Electronic shift control, sometimes referred to as the shift actuator. Uses a small electric motor to move a shaft that places the gearcase or transmission in forward, neutral, or reverse gear, based upon requests from the ERC (via the command module and PCM). |
| ETC | Electronic throttle control, sometimes referred to as throttle body. Uses a small electric motor to move the position of the throttle plate, based upon requests from the ERC (via the command module and PCM). |

| | |
|---|---|
| Fuel trim | Measured by ITerm values, it is the amount of fuel above or below the expected value that the engine is adding to achieve stoichiometry or an equivalency ratio of 1. |
| FWD | Forward gear position. |
| G3 | Mercury's latest computer diagnostic system. Also known as CDS G3. |
| IAT | Intake air temperature sensor, alternately known as a manifold air temperature (MAT) sensor. |
| ITerm | An engineering term describing the percentage of fuel being added or subtracted from the base fueling number. An ITerm of 0.02 is adding 2% fuel. If the value exceeds a certain number for that engine (20%) for two key cycles, an ITerm fault will be triggered. |
| J-box | Junction box, available in 4-, 6-, and 8-way configurations. |
| Lean | Air/fuel ratio greater than stoichiometric (less than 1.000 equivalency ratio). |
| Main station | On boats with dual operating stations/helms, the station that normally has key switches is considered the main station, sometimes called the primary station, or helm 1. |
| MAT | Manifold air temperature sensor, alternately known as an intake air temperature (IAT) sensor. |
| MCA | Marine cranking amps, a rating method for batteries tested at 0 °C (32 °F). |
| Misfire | An unexpected change of speed in subsequent power strokes of the engine. |
| Phi | A Greek letter (pronounced 'fee') used to refer to the equivalence ratio. |
| Port | Refers to the left side of the vessel as seen when facing forward. |
| Pot | Potentiometer used in ERC, ESC, and ETC. |
| Primary station | On boats with dual operating stations/helms, the station which normally has key switches is considered the primary station, sometimes called the main station or helm 1. |
| Quad | Used to describe an application of four: four engines or four controls installed on the boat. |
| REV | Reverse gear position. |
| Rich | Air/fuel ratio less than stoichiometric (greater than 1.000 equivalency ratio). |
| Secondary station | On boats with dual operating stations/helms, the station which normally has only stop/start buttons and no key switches is considered the secondary station, sometimes called the auxiliary station or helm 2. |
| Starboard | Refers to the right side of the vessel as seen when facing forward. |
| Stoichiometry | A branch of chemistry that deals with the relations among quantities in a chemical reaction. As it applies to gasoline engines, it is the ratio of air to gas in the fuel mixture that produces an exhaust gas that uses all of the oxygen in the process. The ratio is dependent upon the quality of the fuel. Gasoline with no ethanol typically has a stoichiometric ratio of 14.7:1. Gasoline with 10% ethanol may have a stoichiometric ratio of 14.1:1. Comparing the actual air/fuel ratio to the stoichiometric ratio, produces an equivalency ratio.<br>Oxygen sensors measure the amount of oxygen in the exhaust gas and feed this information back to the PCM 112 to determine the equivalency ratio. If the equivalency ratio is equal to 1.000 the combustion is stoichiometric. If it is above or below 1.000, the system will add or subtract fuel to achieve 1.000. |
| Terminator resistor | The DTS terminator resistor is used as a CAN line signal conditioner. The resistor places a known load on the CAN line to ensure proper communication between the command module and the PCM.<br>In a typical single station application, there is one terminator resistor at the engine end of the CAN line and one at the furthest end of the CAN line near the helm. |
| Triple | Used to describe an application of three: three engines or three controls installed on the boat. |
| Troll control | Sets and controls the idle speed of the engine for trolling without using the throttle (System Tachometer and Speedometer). |
| UEGO | Universal exhaust gas oxygen sensor. |
| Warning system | During an event that may damage the engine, the system sounds the warning horn and SmartCraft gauges display the warning message. |
| Weather cap | Provides protection on unused connections. |

# Abbreviations

| Abbreviation | Definition | Abbreviation | Definition |
|---|---|---|---|
| AD | Analog to Digital | INJ | Injector |
| ADC | Analog to Digital Counts | kPa | Kilopascal |
| Adv | Advance | KS | Knock Sensor |
| Amp | Ampere | kV | Kilovolt |
| ASC | Advanced Sound Control | mA | Milliamperes |
| BARO | Barometric Pressure | MAF | Mass Air Flow |
| B+ | Battery Positive | MAP | Manifold Absolute Pressure |
| Cal | Calibration | MAT | Manifold Air Temperature |
| CAM | Camshaft | MIL | Malfunction Indicator Lamp |
| CAN | Controller Area Network | MPI | Multiport Fuel Injection |
| CDS | Computer Diagnostic System | MPR | Main Power Relay |
| CKT | Circuit | MY | Model Year |
| CMP | Camshaft Position (Sensor) | O2 | Oxygen |
| CPS | Crankshaft Position Sensor | PCM | Propulsion Control Module |
| Crank | Crankshaft | PCV | Positive Crankcase Ventilation |
| Diag | Diagnostic | PWM | Pulse Width Modulation |
| DMM | Digital Multimeter | REF HI | Reference High |
| DMT | Digital Multimeter/Tachometer | REF LO | Reference Low |
| DTS | Digital Throttle and Shift | RPM | Revolutions per Minute |
| DVOM | Digital Volt - Ohmmeter | Rx | Receiver |
| ECM | Engine Control Module | SOH | State of Health |
| ECT | Engine Coolant Temperature | SS | Steady State |
| EFI | Electronic Fuel Injection | Stbd | Starboard |
| EGT | Exhaust Gas Temperature | TACH | Tachometer |
| EMCT | Exhaust Manifold Coolant Temperature | Tbl | Table |
| ERC | Electronic Remote Control | TDC | Top Dead Center |
| ESC | Electronic Shift Control | TPS | Throttle Position Sensor |
| EST | Electronic Spark Timing | UEGO | Universal Exhaust Gas Oxygen |
| ETC | Electronic Throttle Control | uX | Micro Chi (DTS command module) |
| GND | Ground | V | Volt |
| IAC | Idle Air Control | WOT | Wide-Open Throttle |
| IAT | Intake Air Temperature | XDRP | Sensor Power (transducer power) |
| In. Hg | Inches of Mercury | | |

# General Reference Charts

## Manifold Vacuum and Pressure

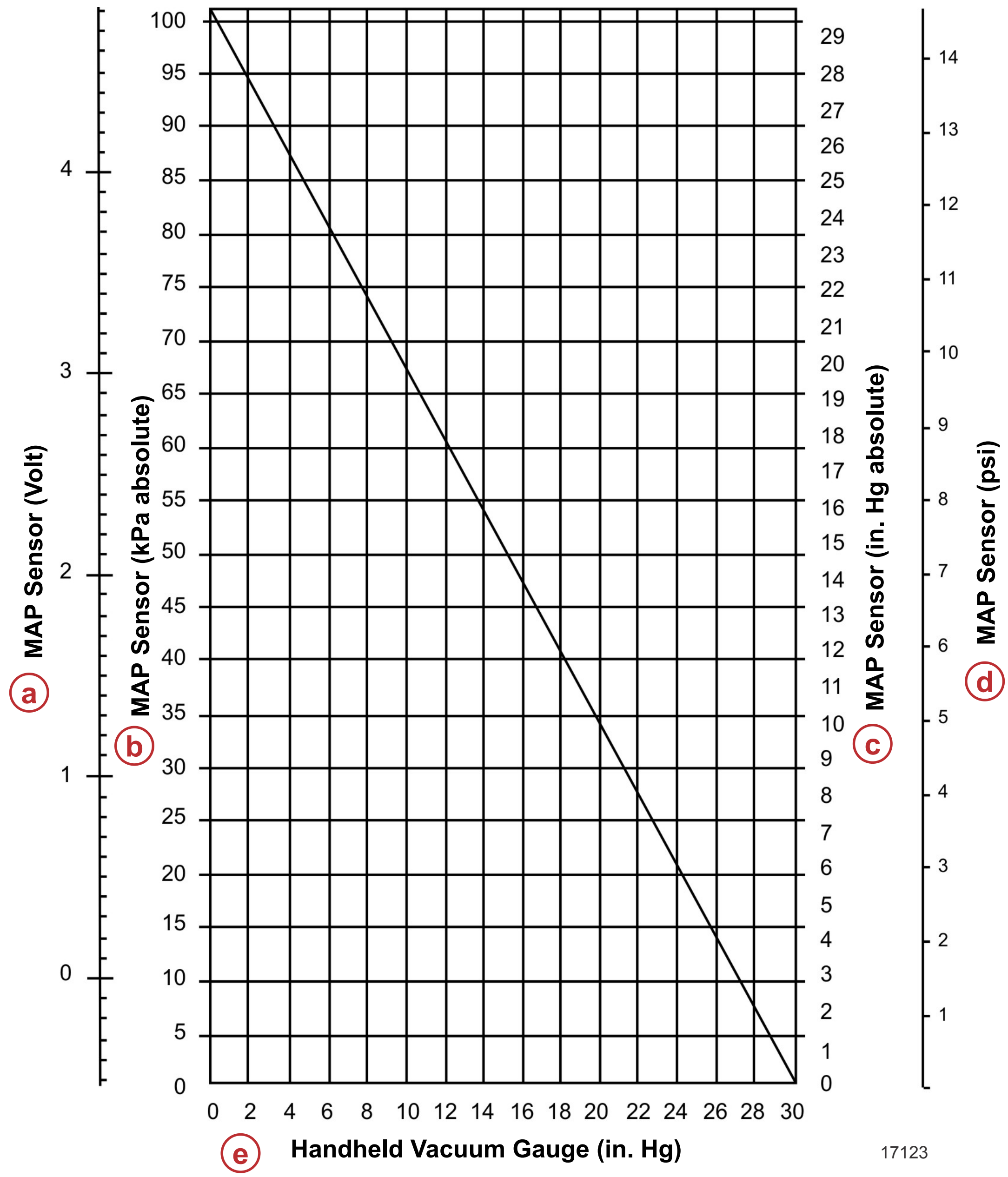
| Manifold Vacuum | Absolute Pressure | | Manifold Vacuum | Absolute Pressure | |
|---|---|---|---|---|---|
| psi | psi | kPa | psi | psi | kPa |
| 0 | 14.7 | 101.3 | 7-1/2 | 7.2 | 49.6 |
| 1/4 | 14.45 | 99.6 | 7-3/4 | 6.95 | 47.9 |
| 1/2 | 14.2 | 97.9 | 8 | 6.7 | 46.2 |
| 3/4 | 13.95 | 96.2 | 8-1/4 | 6.45 | 44.5 |
| 1 | 13.7 | 94.4 | 8-1/2 | 6.2 | 42.7 |
| 1-1/4 | 13.45 | 92.7 | 8-3/4 | 5.95 | 41.0 |
| 1-1/2 | 13.2 | 91.0 | 9 | 5.7 | 39.3 |
| 1-3/4 | 12.95 | 89.3 | 9-1/4 | 5.45 | 37.6 |
| 2 | 12.7 | 87.5 | 9-1/2 | 5.2 | 35.8 |
| 2-1/4 | 12.45 | 85.8 | 9-3/4 | 4.95 | 34.1 |
| 2-1/2 | 12.2 | 84.1 | 10 | 4.7 | 32.4 |
| 2-3/4 | 11.95 | 82.4 | 10-1/4 | 4.45 | 30.7 |
| 3 | 11.7 | 80.6 | 10-1/2 | 4.2 | 29.0 |
| 3-1/4 | 11.45 | 78.9 | 10-3/4 | 3.95 | 27.2 |
| 3-1/2 | 11.2 | 77.2 | 11 | 3.7 | 25.5 |
| 3-3/4 | 10.95 | 75.5 | 11-1/4 | 3.45 | 23.8 |
| 4 | 10.7 | 73.8 | 11-1/2 | 3.2 | 22.1 |
| 4-1/4 | 10.45 | 72.0 | 11-3/4 | 2.95 | 20.3 |
| 4-1/2 | 10.2 | 70.3 | 12 | 2.7 | 18.6 |
| 4-3/4 | 9.95 | 68.6 | 12-1/4 | 2.45 | 16.9 |
| 5 | 9.7 | 66.9 | 12-1/2 | 2.2 | 15.2 |
| 5-1/4 | 9.45 | 65.1 | 12-3/4 | 1.95 | 13.4 |
| 5-1/2 | 9.2 | 63.4 | 13 | 1.7 | 11.7 |
| 5-3/4 | 8.95 | 61.7 | 13-1/4 | 1.45 | 10.0 |
| 6 | 8.7 | 60.0 | 13-1/2 | 1.2 | 8.3 |
| 6-1/4 | 8.45 | 58.2 | 13-3/4 | 0.95 | 6.5 |
| 6-1/2 | 8.2 | 56.5 | 14 | 0.7 | 4.8 |
| 6-3/4 | 7.95 | 54.8 | 14-1/4 | 0.45 | 3.1 |
| 7 | 7.7 | 53.1 | 14-1/2 | 0.2 | 1.4 |
| 7-1/4 | 7.45 | 51.4 | | | |

## Altitude and Barometric Pressure

| Altitude Above Seal Level | | | Temperature | | Barometric Pressure | | Atmospheric Pressure | | |
|---|---|---|---|---|---|---|---|---|---|
| **Feet** | **Miles** | **Meters** | **°F** | **°C** | **In. Hg** | **mm Hg** | **PSI** | **Kg/sq cm** | **kPa** |
| 0 | – | 0 | 59 | 15 | 29.92 | 760 | 14.696 | 1.0333 | 101.33 |
| 500 | – | 153 | 57 | 14 | 29.38 | 746.3 | 14.43 | 1.015 | 99.49 |
| 1000 | – | 305 | 55 | 13 | 28.86 | 733 | 14.16 | 0.996 | 97.63 |
| 1500 | – | 458 | 54 | 12 | 28.33 | 719.6 | 13.91 | 0.978 | 95.91 |
| 2000 | – | 610 | 52 | 11 | 27.82 | 706.6 | 13.66 | 0.96 | 94.19 |
| 2500 | – | 763 | 50 | 10 | 27.32 | 693.9 | 13.41 | 0.943 | 92.46 |
| 3000 | – | 915 | 48 | 9 | 26.82 | 681.2 | 13.17 | 0.926 | 90.81 |
| 3500 | – | 1068 | 47 | 8 | 26.33 | 668.8 | 12.93 | 0.909 | 89.15 |
| 4000 | – | 1220 | 45 | 7 | 25.84 | 656.3 | 12.69 | 0.892 | 87.49 |
| 4500 | – | 1373 | 43 | 6 | 25.37 | 644.4 | 12.46 | 0.876 | 85.91 |
| 5000 | 0.95 | 1526 | 41 | 5 | 24.9 | 632.5 | 12.23 | 0.86 | 84.33 |
| 6000 | 1.1 | 1831 | 38 | 3 | 23.99 | 609.3 | 11.78 | 0.828 | 81.22 |
| 7000 | 1.3 | 2136 | 34 | 1 | 23.1 | 586.7 | 11.34 | 0.797 | 78.19 |
| 8000 | 1.5 | 2441 | 31 | –1 | 22.23 | 564.6 | 10.91 | 0.767 | 75.22 |
| 9000 | 1.7 | 2746 | 27 | –3 | 21.39 | 543.3 | 10.5 | 0.738 | 72.4 |
| 10,000 | 1.9 | 3050 | 23 | –5 | 20.58 | 522.7 | 10.1 | 0.71 | 69.64 |
| 15,000 | 2.8 | 4577 | 6 | –14 | 16.89 | 429 | 8.29 | 0.583 | 57.16 |
| 20,000 | 3.8 | 6102 | –12 | –24 | 13.76 | 349.5 | 6.76 | 0.475 | 46.61 |
| 25,000 | 4.7 | 7628 | –30 | –34 | 11.12 | 282.4 | 5.46 | 0.384 | 37.65 |
| 30,000 | 5.7 | 9153 | –48 | –44 | 8.903 | 226.1 | 4.37 | 0.307 | 30.13 |
| 35,000 | 6.6 | 10,679 | –66 | –54 | 7.06 | 179.3 | 3.47 | 0.244 | 23.93 |
| 40,000 | 7.6 | 12,204 | –70 | –57 | 5.558 | 141.2 | 2.73 | 0.192 | 18.82 |
| 45,000 | 8.5 | 13,730 | –70 | –57 | 4.375 | 111.1 | 2.15 | 0.151 | 14.82 |
| 50,000 | 9.5 | 15,255 | –70 | –57 | 3.444 | 87.5 | 1.69 | 0.119 | 11.65 |
| 55,000 | 10.4 | 16,781 | –70 | –57 | 2.712 | 68.9 | 1.33 | 0.0935 | 9.17 |
| 60,000 | 11.4 | 18,306 | –70 | –57 | 2.135 | 54.2 | 1.05 | 0.0738 | 7.24 |
| 70,000 | 13.3 | 21,357 | –67 | –55 | 1.325 | 33.7 | 0.651 | 0.651 | 4.49 |
| 80,000 | 15.2 | 24,408 | –62 | –52 | 0.8273 | 21 | 0.406 | 0.406 | 2.8 |
| 90,000 | 17.1 | 27,459 | –57 | –59 | 0.52 | 13.2 | 0.255 | 0.255 | 1.76 |
| 100,000 | 18.9 | 30,510 | –51 | –46 | 0.329 | 8.36 | 0.162 | 0.162 | 1.12 |

## Vacuum Gauge versus MAP Sensor




This graph is correct at sea level only

- a - MAP sensor (volt)
- b - MAP sensor (kPa absolute)
- c - MAP sensor (in. Hg absolute)
- d - MAP sensor (psi)
- e - Handheld vacuum gauge (in. Hg)

## Centigrade to Fahrenheit Conversion

| Centigrade | Fahrenheit | Centigrade | Fahrenheit |
|---|---|---|---|
| –55 | –67 | 85 | 185 |
| –50 | –58 | 90 | 194 |
| –45 | –49 | 95 | 203 |
| –40 | –40 | 100 | 212 |
| –35 | –31 | 105 | 221 |
| –30 | –22 | 110 | 230 |
| –25 | –13 | 115 | 239 |
| –20 | –4 | 120 | 248 |
| –15 | 5 | 125 | 257 |
| –10 | 14 | 130 | 266 |
| –5 | 23 | 135 | 275 |
| 0 | 32 | 140 | 284 |
| 5 | 41 | 145 | 293 |
| 10 | 50 | 150 | 302 |
| 15 | 59 | 155 | 311 |
| 20 | 68 | 160 | 320 |
| 25 | 77 | 165 | 329 |
| 30 | 86 | 170 | 338 |
| 35 | 95 | 175 | 347 |
| 40 | 104 | 180 | 356 |
| 45 | 113 | 185 | 365 |
| 50 | 122 | 190 | 374 |
| 55 | 131 | 195 | 383 |
| 60 | 140 | 200 | 392 |
| 65 | 149 | 205 | 401 |
| 70 | 158 | 210 | 410 |
| 75 | 167 | 215 | 419 |
| 80 | 176 | 220 | 428 |

# PCM 112

## Section 2A - PCM 112 Important Information and Pinouts

2
A

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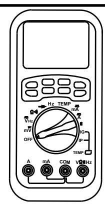
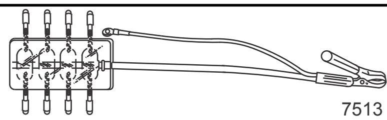
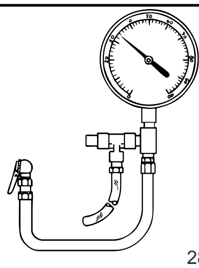
## Special Tools

| CDS G3 Interface Kit | 8M0138392 |
|---|---|
|  66165 | CDS G3 License Key, Interface, Adapter, and Harness |

| DMT 2004 Digital Multimeter | 91-892647A01 |
|---|---|
|  4516 | Measures RPM on spark ignition (SI) engines, ohms, amperes, AC and DC voltages; records maximums and minimums simultaneously, and accurately reads in high RFI environments. |

| Spark Gap Tester | 91-850439T 1 |
|---|---|
|  7513 | Provides a visual indication of spark/coil efficiency. |

| Fuel Pressure Gauge Kit | 91-881833A03 |
|---|---|
|  2807 | Tests the fuel pump pressure; can be used to relieve fuel pressure. |

| Terminal Test Probe Kit | Bosch P/N MM- 46523 |
|---|---|
|  7915 | Test probes adapt test meter leads to harness connections without damaging harness terminals. May be used with Computer Diagnostic System (CDS). |

# Important Information

## Propulsion Control Module (PCM) Overview

IMPORTANT: Refer also to **Section 2B** - **PCM 112** and Engine Control Overview.

The propulsion control module requires 9.5 VDC minimum to operate. If the PCM should fail, the engine will stop running.

The inputs to the PCM can be monitored and tested by using the computer diagnostic system (CDS G3).

| CDS G3 Interface Kit | 8M0138392 |
|---|---|

The PCM controls the following functions and components:

- Electronic shift control
- Electronic throttle control
- Main power relay

- Fuel injectors
- Ignition coils
- Power steering
- Trim up
- Trim down
- Start relay
- Fuel pump
- Diagnostics
- Engine Guardian
- Tachometer link (analog tachometer output)
- Advanced sound control (V8 Verado engines only)
- CAN communications with helm controller
- Moving propeller (MP) alert (optional)

The PCM operates in four modes: power off, stall, crank, and run. The PCM also provides for a smooth throttle response between varying throttle positions and engine loads. A warm-up mode is integrated with the run mode and disengaged after the engine accumulates a given amount of power.

Power off mode - With the key switch OFF, the PCM function does not exist; however, trim will remain available for 15 minutes after key off on DTS engines. On mechanical engines, pushing the trim up or down button will turn on the PCM and allow the engine to trim. 12 VDC power is available from the battery at the starter battery terminal, fuses, positive cable terminal, and at the alternator.

Stall mode - With the key switch in the RUN position, the PCM is energized. The PCM powers the main power relay, the sensors, and the fuel pump relay (for five seconds at key-up). The PCM records barometric pressure from the manifold absolute pressure (MAP) sensor, intake air temperature from the intake air temperature (IAT) sensor, and coolant temperature from the coolant temperature sensors. The PCM uses this information to establish a warm-up strategy that controls fuel delivery and engine speed during warm-up and idle.

Crank mode - When the key switch is turned to the START position, the start relay and the starter solenoid are energized and battery power turns the starter motor. With the engine rotating, a pulse is generated at the crankshaft sensor, which provides the PCM with engine speed information. The PCM then supplies power to the fuel pump and ignition coils through the main power relay and the fuel pump relay.

Run mode - At approximately 500 RPM, the PCM transitions to the run mode.

- The warm-up strategy continues to adjust engine speed with the fuel injector pulse width and engine spark advance until the engine accumulates a given amount of power.
- The camshaft position sensor provides cylinder compression phasing information to the PCM for sequential fuel injection.
- The intake air temperature (IAT), throttle position, and manifold absolute pressure (MAP) are monitored to determine proper spark timing and the fuel needs necessary to develop the amount of power asked for by the operator.

## Important PCM Notes

- PCMs have a low failure rate. Often the problem may be a corroded connection, and simply removing and reinserting the connector was enough to clean the pins and restore the connections. In general, assume the PCM 112 is working correctly unless you have reason to believe otherwise.
- If possible, familiarize yourself with the data values displayed by the engine when it is running well. This will make it easier to spot out-of-range values later on.

## Test Equipment

In diagnosing Mercury PCM 112 engines, the following test equipment will prove to be invaluable:

- The **Mercury CDS G3 System.** CDS G3 is designed to work specifically with Mercury engines. It includes live data monitoring, active tests, and calibrations for many Mercury engines. Often, a calibration update can resolve an issue.

| | |
|---|---|
| CDS G3 Interface Kit | 8M0138392 |

- A **digital multimeter**. An analog multimeter will not provide the accuracy required to test the equipment involved.

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

- **Spark gap tester**. Two of these, one for each bank, allows you to see if a spark is being produced.

| | |
|---|---|
| Spark Gap Tester | 91-850439T 1 |

- **Fuel pressure gauge**. The PCM 112 does not monitor fuel pressure. It assumes that the correct pressure is available in the fuel rails. Always use a gauge to verify that the pressure is correct before beginning more complicated diagnostics of the fuel system.

| | |
|---|---|
| Fuel Pressure Gauge Kit | 91-881833A03 |

- **Test probe kit**. Do not use standard test probes to check the connectors; they could spread the pins apart and lead to intermittent connections. Use the appropriate sized test probe leads included in the terminal test probe kit, or a suitable alternative.

| | |
|---|---|
| Terminal Test Probe Kit | Bosch P/N MM- 46523 |

- **Known good fuel**. A small tank of known good fuel can eliminate stagnant fuel as a source of the problem. If the engine seems starved of fuel, but has good fuel pressure, ensure that the fuel is good.

## Software and Adaptive Speed Control

Adaptive Speed Control is a feature included with the PCM 112. With Adaptive Speed Control, the PCM will strive to maintain engine speed during turns or during trim events. This is part of the PCM's programming, and adds no working parts.

The following **Live Data** fields on CDS G3 apply to Adaptive Speed Control:

- **Demand** refers to the demand requested by the software.
- **DemandLinear** refers to the demand by the operator at the remote control. Therefore, the operator may have the throttle (DemandLinear) at 60%, but because the boat is in a turn, Adaptive Speed Control (**Demand**) may be 70% to maintain engine speed.
- **DemandLinear_with_Guardian** reports the DemandLinear value less any Guardian limits. If the engine is operating without any Guardian limits, both DemandLinear and DemandLinear_with_Guardian will be equal to each other. If the engine is in Guardian, DemandLinear_with_Guardian will be less than DemandLinear, meaning the operator is asking for more than the PCM will allow to protect the engine.

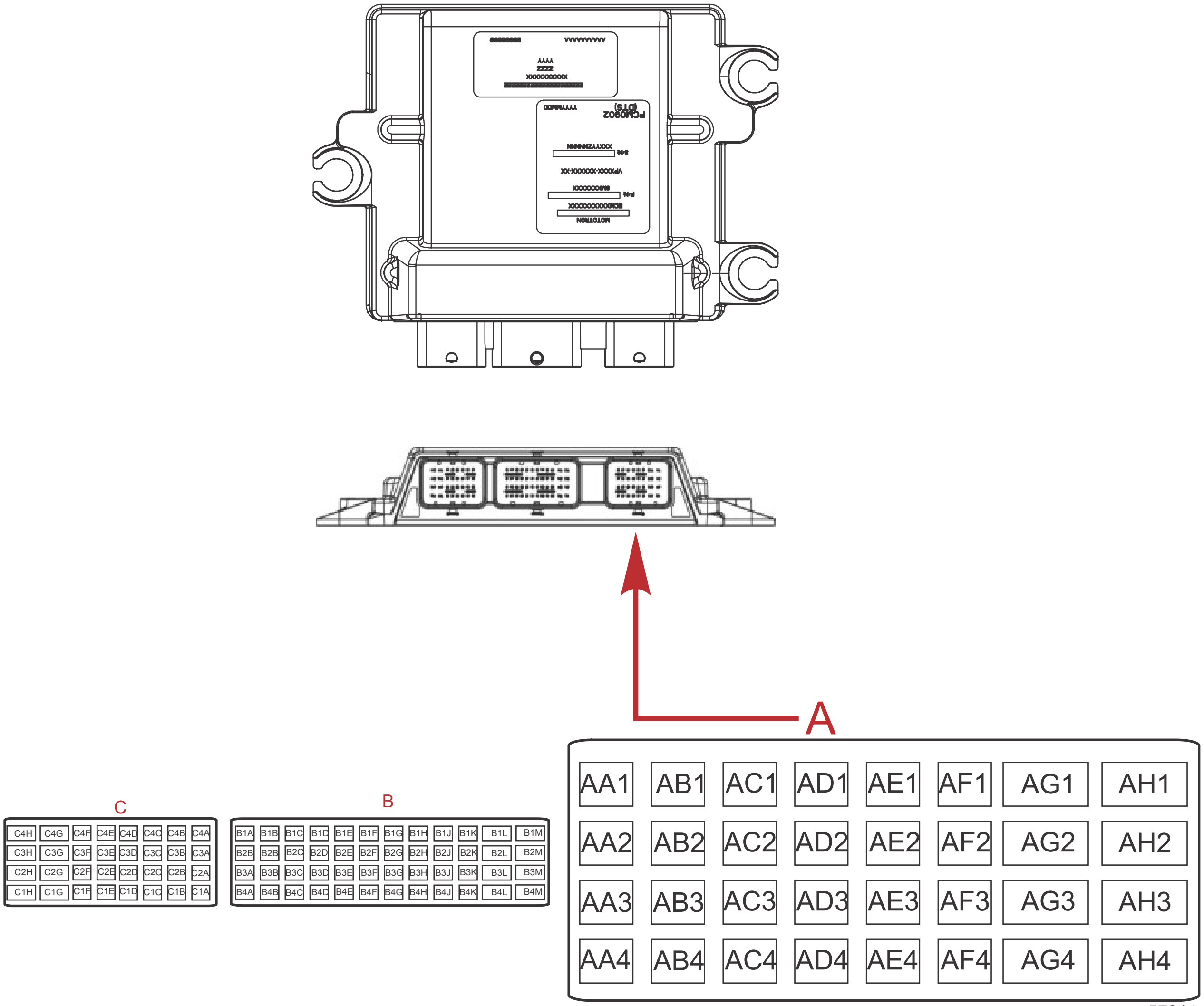
## Load Balancing

Load balancing is the strategy developed to ensure torque balance and idle stability. The system adds or subtracts ignition timing to allow an independent cylinder to carry more or less of the total load. Spark is added to weak cylinders, and subtracted from strong cylinders to achieve a balanced load.

# PCM 112 Pinouts

## Connector A



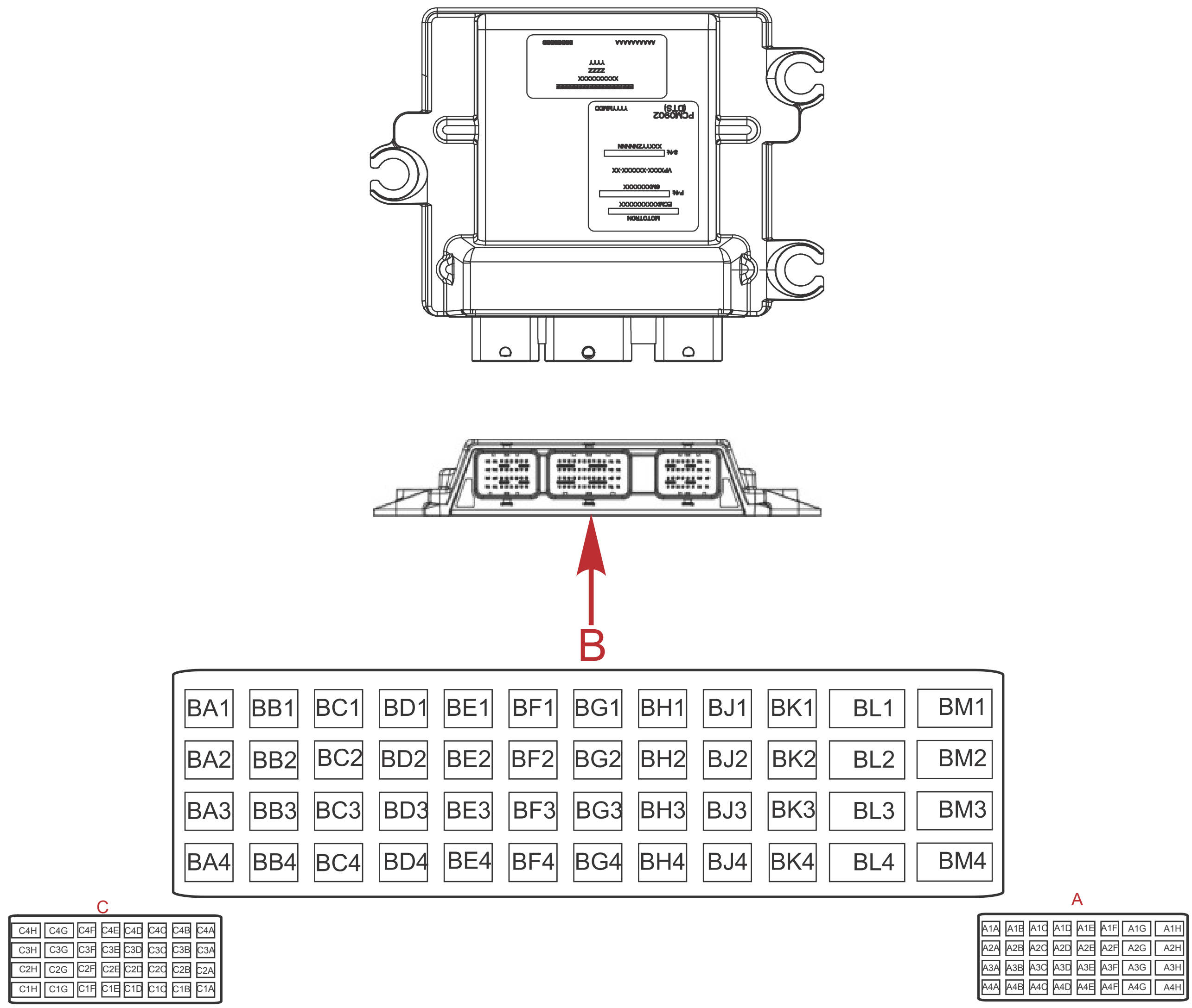

57214

| Pin | Function | Wire Color | Application Notes | Description |
|---|---|---|---|---|
| AA1 | Tachometer output signal | Gray | – | Provides a signal to drive a conventional analog tachometer. |
| AB1 | Fuel injector driver—cylinder number 8 | Pink/light green | Not used on V6 | The PCM grounds this pin to turn on the injector and spray fuel into the intake of cylinder number 8. |
| AC1 | Fuel injector driver—cylinder number 7 | Pink/white | Not used on V6 | The PCM grounds this pin to turn on the injector and spray fuel into the intake of cylinder number 7. |
| AD1 | Fuel injector driver—cylinder number 2 | Pink/red | – | The PCM grounds this pin to turn on the injector and spray fuel into the intake of cylinder number 2. |
| AE1 | Fuel injector driver—cylinder number 5 | Pink/blue | – | The PCM grounds this pin to turn on the injector and spray fuel into the intake of cylinder number 5. |
| AF1 | Fuel injector driver—cylinder number 4 | Pink/yellow | – | The PCM grounds this pin to turn on the injector and spray fuel into the intake of cylinder number 4. |
| AG1 | MP Alert | Blue/red | – | |
| AH1 | Ignition coil driver—number 4 | Green/yellow | Fires cylinders 2 and 3 on V8; not used on V6. | Directly drives the ignition coil by grounding the circuit internally. |

| Pin | Function | Wire Color | Application Notes | Description |
|---|---|---|---|---|
| AA2 | Main power relay (MPR) control | Yellow/purple | – | The PCM grounds this pin to activate the MPR. The output from the MPR goes to several circuits, each protected with a fuse. |
| AB2 | Not used | – | – | – |
| AC2 | Not used | – | – | – |
| AD2 | Not used | – | – | – |
| AE2 | Start relay control | Black/blue | – | The PCM grounds this pin to activate the start relay, which turns on the starter motor. If no RPM is detected, the PCM will quickly turn the starter off. |
| AF2 | Fuel injector driver—cylinder number 6 | Pink/purple | – | The PCM grounds this pin to turn on the injector and spray fuel into the intake of cylinder number 6. |
| AG2 | Alternator | Orange | – | – |
| AH2 | Ignition coil driver—number 3 | Green/purple | Fires cylinders 4 and 7 on V8. Fires cylinders 2 and 5 on V6. | Directly drives the ignition coil by grounding the circuit internally. |
| AA3 | Trim up relay control | Light blue/ white | | The PCM grounds this pin to activate the trim up relay. The DTS command module sends an electronic trim up command to the PCM on CAN X. |
| AB3 | Not used | – | – | – |
| AC3 | Not used | – | – | – |
| AD3 | Safety lanyard circuit (ESTOP) | Black/yellow | – | The ESTOP switch is normally open. When activated, it closes to ground. Activating the lanyard switch disables the ignition coil drivers and the fuel pump. |
| AE3 | Serial communications + | Blue/white | – | Communication circuit—SmartCraft depth finder. |
| AF3 | Fuel injector driver—cylinder number 1 | Pink/brown | – | The PCM grounds this pin to turn on the injector and spray fuel into the intake of cylinder number 1. |
| AG3 | PCM ground 3 | Black/white | – | One of three (AG3, CG1, CG2) PCM ground pins. These circuits end at the battery negative terminal. |
| AH3 | Ignition coil driver—number 2 | Green/red | Fires cylinders 5 and 8 on V8. Fires cylinders 3 and 6 on V6. | Directly drives the ignition coil by grounding the circuit internally. |
| AA4 | Warning horn driver | Tan/light blue | Not used on DTS engines. | The PCM grounds this pin to sound the warning horn. |
| AB4 | Fuel pump relay (FPR) control | Yellow/black | – | The PCM grounds this pin to activate the fuel pump relay. |
| AC4 | Crankshaft position sensor + | Red | – | – |
| AD4 | Crankshaft position sensor – | White | – | – |
| AE4 | Serial communications – | White/blue | – | Communication circuit—SmartCraft depth finder. |
| AF4 | Fuel injector driver—cylinder number 3 | Pink/orange | – | The PCM grounds this pin to turn on the injector and spray fuel into the intake of cylinder number 3. |
| AG4 | Power steering | White/blue | – | – |
| AH4 | Ignition coil driver—number 1 | Green/brown | Fires cylinders 1 and 6 on V8. Fires cylinders 1 and 4 on V6. | Directly drives the ignition coil by grounding the circuit internally. |

## Connector B

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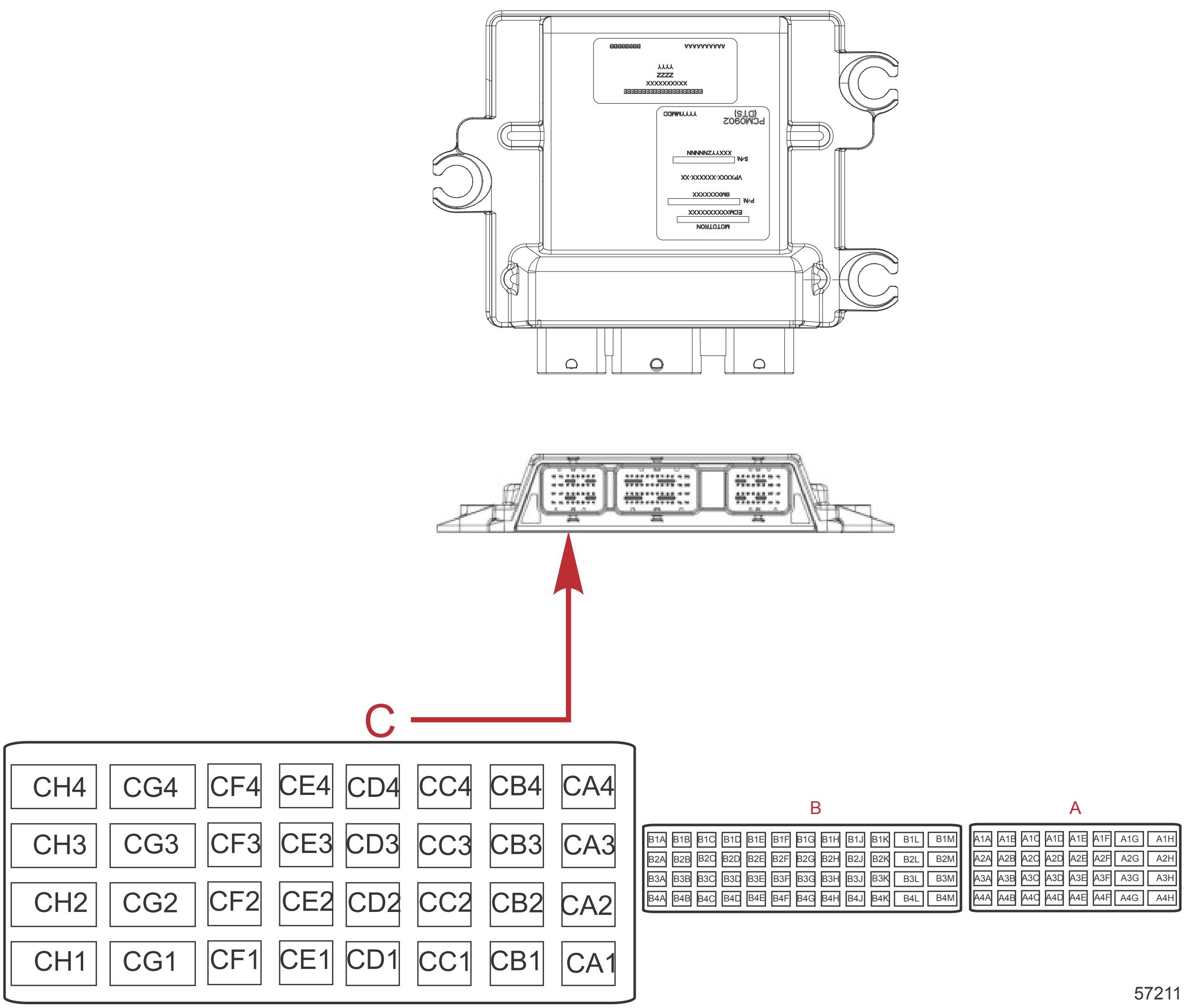
| Pin | Function | Wire Color | Application Notes | Description |
|---|---|---|---|---|
| BA1 | Not used | – | – | – |
| BB1 | UEGO (S1) O2 sensor | White/gray | – | Connects to pin 1 of the O2 connector. |
| BC1 | Shift position sensor 2 | Pink | – | – |
| BD1 | Oil level sensor | Tan/black | – | – |
| BE1 | Exhaust gas temperature (EGT) sensor signal | Brown/white | – | 2-wire thermistor. Resistance increases as temperature decreases. |
| BF1 | Not used | – | – | – |
| BG1 | CAN P (propulsion data)—low | Blue | – | CAN P bus carries dashboard gauge data and backup digital throttle and shift commands. These circuits require both high and low sides to operate. This is the low (negative) side. |
| BH1 | CAN X (DTS commands)—low | Brown | – | CAN X bus carries primary digital throttle and shift commands. These circuits require both high and low sides to operate. This is the low (negative) side. |
| BJ1 | Throttle demand sensor position 1 | Gray/green | Not used on DTS engines | – |

| Pin | Function | Wire Color | Application Notes | Description |
|---|---|---|---|---|
| BK1 | Shift position sensor | Green | | Connects to the electronic shift control connector, which contains a 3-wire position sensor and 2-wire shift actuator circuit. |
| BL1 | UEGO (S1) O2 sensor heater | Orange/white | – | O2 sensors must maintain a minimum temperature to function. The heater speeds sensor warmup and maintains minimum temperature during idle and low speed operation. |
| BM1 | Not used | – | – | – |
| BA2 | Not used | – | – | – |
| BB2 | UEGO (S1) O2 sensor | Tan/green | – | Connects to pin 5 of the O2 sensor connector. Check for continuity in the harness before replacing the sensor. To test the sensor itself, replace it with a known good sensor. |
| BC2 | Trim position sensor signal—hall effect | Yellow | – | – |
| BD2 | Seawater temperature sensor signal | Tan/orange | – | 2-wire thermistor. Resistance increases as temperature decreases. |
| BE2 | Starboard exhaust coolant temperature sensor signal | Brown/black | – | 2-wire thermistor. Resistance increases as temperature decreases. |
| BF2 | Not used | – | – | – |
| BG2 | CAN P (propulsion data)—high | White | – | CAN P bus carries dashboard gauge data and backup digital throttle and shift commands. These circuits require both high and low sides to operate. This is the high (positive) side. |
| BH2 | CAN X (DTS commands)—high | Yellow | – | CAN X bus carries primary digital throttle and shift commands. These circuits require both high and low sides to operate. This is the high (positive) side. |
| BJ2 | Throttle position sensor (TPS) 1 signal | Light blue/black | – | 3-wire position sensor. Reads low voltage when throttle is closed, high voltage when throttle is open. Signal is proportional to throttle plate movement. |
| BK2 | Shift request 2 | Blue/black | Not used on DTS engines | – |
| BL2 | Intake air temperature (IAT) | Tan | – | – |
| BM2 | Not used | – | – | – |
| BA3 | Not used | – | – | – |
| BB3 | UEGO (S1) O2 sensor | White/purple | – | Connects to pin 2 of the O2 sensor connector. |
| BC3 | UEGO (S1) O2 sensor | Light green/ orange | – | Connects to pin 6 of the O2 sensor connector. |
| BD3 | Not used | – | – | – |
| BE3 | Advanced sound control diagnostics | Green | Not used on V6 | – |
| BF3 | Not used | – | – | – |
| BG3 | Not used | – | – | – |
| BH3 | Not used | – | – | – |
| BJ3 | Not used | – | – | – |
| BK3 | Shift request 1 | Blue/pink | Not used on DTS engines | – |
| BL3 | Oil pressure analog gauge driver | Blue/yellow | – | – |
| BM3 | Not used | – | – | – |
| BA4 | Not used | – | – | – |
| BB4 | Not used | – | – | – |
| BC4 | Not used | – | – | – |

| Pin | Function | Wire Color | Application Notes | Description |
|---|---|---|---|---|
| BD4 | Water-in-fuel sensor | Tan/purple | – | – |
| BE4 | Paddle wheel sensor signal | Gray/blue | – | Paddle wheel provides boat speed data to SmartCraft gauges. If a pitot sensor is also installed, the paddle provides slow speed data, while the pitot provides high speed data. |
| BF4 | Not used | – | – | – |
| BG4 | Not used | – | – | – |
| BH4 | Throttle demand sensor position 2 | Gray/white | Not used on DTS engines | – |
| BJ4 | Throttle position sensor 2 (TPS 2) signal | White/yellow | – | 3-wire position sensor. Measured circuit voltage is opposite of TPS 1. Voltage is high when throttle is closed and low when throttle is open. The service tool indicates voltage changes in the same direction as TPS 1. This is not accurate when physically measuring signals with multimeter. |
| BK4 | Camshaft position sensor | Red/white | – | Hall effect sensor |
| BL4 | Not used | – | – | – |
| BM4 | Trim down relay control | Green/white | – | The PCM grounds this pin to activate the trim down relay. |

## Connector C



| Pin | Function | Wire Color | Application Notes | Description |
|---|---|---|---|---|
| CA1 | Oil pressure signal | Light blue | – | – |
| CB1 | Oil temperature | Tan/light blue | – | – |
| CC1 | 12 V wake circuit (+) | Purple | – | 12 V battery positive when key is on. When the key switch is turned off, software shuts down the PCM after a delay. |
| CD1 | Coolant temperature analog | Brown | – | – |
| CE1 | Sensor ground A | Black/orange | – | Dedicated signal return path (ground) for sensors powered by sensor power A. |
| CF1 | Sensor power A | Purple/yellow | – | Dedicated 5 V positive power supply for engine sensors. Maintains 5 V regardless of battery voltage fluctuations. |
| CG1 | PCM ground 1 | Black/white | – | One of three (AG3, CG1, CG2) PCM ground pins. These circuits end at the battery negative terminal. |
| CH1 | Throttle actuator B low | Blue/red | – | – |
| CA2 | Start/stop signal | Yellow/red | Not used on DTS engines | Connects to 14-pin connector. |
| CB2 | Fuel level 2 sensor signal | Brown | – | Circuit is designed to read low resistance sensors, typically between 0 and 200 ohms. Uses standard fuel tank sending units. |
| CC2 | Trim up | Light blue/ white | – | When the trim up switch is activated, the PCM is sent a wake signal, much like the key switch does, and allows the software to trim the engine up. |
| CD2 | Manifold absolute pressure (MAP) sensor signal | Yellow | – | PCM uses the MAP signal and RPM to determine the density of the air flowing through the engine. When running, the signal should be constantly changing. No movement = clogged sensor. |
| CE2 | Sensor ground B | Black/pink | Not used on DTS engines | Dedicated signal return path (ground) for sensors powered by sensor power B (XDRP_B). |
| CF2 | Sensor power B | Purple/green | Not used on DTS engines | Dedicated 5 V positive power supply. |
| CG2 | PCM ground 2 | Black/white | – | One of three (AG3, CG1, CG2) PCM ground pins. These circuits end at the battery negative terminal. |
| CH2 | Throttle actuator A high | Black/red | – | – |
| CA3 | Trim position analog | Orange/green | – | – |
| CB3 | Pitot pressure sensor signal | White/orange | – | Pitot sensor data provides boat speed data to SmartCraft gauges. If a paddle wheel sensor is also installed, the paddle provides slow speed data, while the pitot provides high speed data. |
| CC3 | Trim down | Green/white | – | When the trim switch is activated, the PCM is sent a wake signal, much like the key switch does, and allows the software to trim the engine down. |
| CD3 | Not used | – | – | – |
| CE3 | Sensor ground C | Black/green | – | Dedicated signal return path (ground) for sensors powered by sensor power C (XDRP_C). |
| CF3 | Advanced sound control | White/black | Not used on V6 | – |
| CG3 | Driver 1 power | Red/blue | – | Battery positive into the PCM from the main power relay (MPR) pin 30. The PCM controls the MPR through pin AA2. This power is used for high current actuators. |
| CH3 | Shift actuator B (negative) | Black | – | – |
| CA4 | Continuous battery | Red/black | – | Continuous battery power for the PCM. Connects directly to the engine battery and is protected with a 5 A fuse. Do not connect to a battery switch. |
| CB4 | Block water pressure | White/green | – | – |

| Pin | Function | Wire Color | Application Notes | Description |
|---|---|---|---|---|
| CC4 | Fuel level 1 sensor signal | Pink/black | – | Circuit is designed to read low resistance sensors, typically between 0 and 200 ohms. Uses standard fuel tank sending units. |
| CD4 | Not used | – | – | – |
| CE4 | Sensor power C | Purple/black | – | Dedicated 5 V positive power supply for transom and hull sensors. Maintains 5 V regardless of battery voltage fluctuations. |
| CF4 | Not used | – | – | – |
| CG4 | Driver power 2 | Red/blue | – | 12 V power supply from the battery, through the main power relay (MPR) and through the PCM 112. The PCM controls the MPR through pin AA2. This power is used for high current actuators. |
| CH4 | Shift actuator A (+) | Red/purple | – | – |

# Notes:

# PCM 112

## Section 2B - PCM 112 and Engine Control Overview



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# PCM 112 Operation, Faults, and Data Fields

## PCM Operation, Faults, and Data Fields

When the engine is started, the PCM begins checking the various engine sensors and actuators for proper operation. During this time, the system is said to be in **closed-loop control**. If for some reason, the PCM cannot enter closed-loop control, it will remain in **open-loop control** and revert to **default look-up tables** to control the engine.

In response to changing inputs, it sends control information to the various systems, such as to control the pulse width of the fuel injectors in response to a throttle change by the operator.

## Faults

A fault indicates that the PCM has either sensed that the circuit in question has recorded a sensor value outside of its acceptable window, meaning that the sensor circuit has failed, or that a sensor value has gone outside its normal range, as when the engine is running too hot.

Mercury fault codes are explained in **Section 4A**.

Not every engine issue triggers a fault; however, the **Live Data** feature in CDS G3 can provide important clues to the engine's operation.

**Live Data** is available after the CDS G3 system has been correctly connected to the engine, the correct electronic bill of materials (eBOM) has been selected, the key switch is in the run position, and the engine module has been selected under the **Module Data** screen in CDS G3.

CDS G3's **Live Data Screen** provides real-time feedback from the engine, identifying the values reported from the various sensors, how the emissions control system is working, how much spark and fuel is being added or subtracted, and many other data items. Live data takes time and experience to interpret. With experience, you will be able to determine which values are out of range or inconsistent with other data. For an explanation of the data included in the live data stream, refer to **Section 3C** - **CDS G3—Live Data**.

# System Diagnostics Overview

## Comprehensive Component Diagnostics

Upon engine start-up, the PCM will conduct a comprehensive component diagnostics routine. This includes **open- and short-circuit checks** of circuits and sensors, as well as **rationality checks** to ensure that the sensors are returning expected values.

While a short or open circuit will show a value that is at the extreme of its range and is fairly easy to detect, a **rationality check** checks the value of the sensor against an expected value. For example, the barometric pressure reading shows 61.2 kPa, which equates to approximately 14,000 feet. This would be the altitude of Pikes Peak, in the US. Since there are no lakes that high where engines will be run, it will not pass the rationality check for barometer.

The system must be able to identify components that are not functioning properly. These components include:

- Manifold absolute pressure (MAP) sensor
- Camshaft position sensor
- Crankshaft position sensor (CPS)
- Throttle position sensor (TPS)
- O2 sensor
- Injectors
- Ignition coils
- Temperature sensors
- Pressure sensors

If the diagnostic routine finds an issue with a device or circuit, it will return a fault code that can be viewed on CDS G3. It may indicate a faulty component or device, or that a value is out of range. Refer to **Section 4A** - **Fault Codes**. It may then revert to open-loop operation, and depending on the severity, may enact Engine Guardian to limit engine speed.

## Closed-Loop Control Status

The term **O2ControlState** on the **Engine** data tab in CDS G3 displays the current status of closed-loop control. The statuses that can appear in this field are:

- **Open-loop** means the engine has not yet met the requirements to go into the closed-loop mode, the engine is undergoing a change in demand or gear, or it is running a diagnostic routine.
- **Closed-loop** means that the engine is in the closed-loop fuel control mode and responding to inputs from the O2 sensor to adjust fueling.

  

***NOTE:*** *While monitoring in CDS G3, in some situations the display may show closed-loop, when the engine is actually in open-loop. An engine is truly operating in closed-loop when the UEGO1phi Live Data item is a value other than 0.98.*

The PCM will then compare the targeted equivalency ratio (phi) to the actual ratio for the engine, and adjust fuel accordingly. The amount being changed is shown in the O2Control_ITermPort/Port. This value is a multiplier. An ITerm of 0.02 is adding 2% fuel.

| | | |
|---|---|---|
| O2ControlState | Closed Loop | Fuel system control state |
| DesiredPhi | 1.1484 ratio | Equivalence ratio target |
| UEGO1_phi | 1.14 ratio | Equivalence ratio port S1 |
| UEGO1_Ri_Temp | 1435.95 °F | O2 sensor temperature port S1 |
| UEGO1_HeaterDutyCycle | 23.13 % | O2 sensor heater duty cycle port S1 |
| O2Control_ITerm_Port | 0.0186 mult | Fuel trim port |

67641

**In this CDS G3 screen capture, the engine has entered closed-loop control. It is targeting a phi (equivalency ratio) of 1.1484. It is reading a phi of 1.14 and adjusting port fuel trim (02Control_Iterm_Port) by 1.86%.**

| | Data 1 | Data 2 | Data 3 | Data 4 | Data 5 | Data 6 | Data 7 | Data 8 | |
|---|---|---|---|---|---|---|---|---|---|
| InjMPW | 2.404 | 2.404 | 2.404 | 2.404 | 2.404 | 2.404 | 2.404 | 2.403 | Fuel injector pulse width |

67648

**The fuel injector pulse width times reflect that all cylinders are adjusted equally, rather than across banks of cylinders. Note that eight cylinders are shown even for a six-cylinder engine; only the first six are relevant.**

# O2 Control State Diagnostic Aids

There are a number of items that could cause the fuel system monitoring diagnostic to fail. Check the following conditions if a fuel system monitoring fault has occurred.

- Check fuel pressure in the rails.
- Check the power and ground connections.
- Check the fuel quality. Use a tank of known good fuel.
- Check the O2 sensor.
- Check the fuel injectors and connectors.
- Check the spark plug leads and coils.
- Check for leaks in the intake system.
- Check for exhaust leaks.
- Check the MAP sensor.

## Recommended Course of Action

| Step | Action | Yes | No |
|---|---|---|---|
| 1 | Connect CDS G3, select the correct eBOM and module, and download all available updates. Record **Freeze Frame** data using the **Print Screen** function or **Record Data**. Are these steps complete? | Go to step 2. | An update to software may have addressed a known issue. Make sure you are using the most current software for CDS G3 and the PCM. |
| 2 | O2 sensor faults may be triggered by primary faults, such as a failed sensor or actuator, battery or sensor power high or low, or range high or low limits (low oil pressure, high engine coolant temperature, etc.).<br>Check for and resolve any primary faults. Did you find and resolve any primary faults? | Go to step 8. | Go to the next step. |

  

| Step | Action | Yes | No |
|---|---|---|---|
| 3 | Check for O2 sensor heater, O2 sensor range high or low, and O2 sensor open-circuit faults. To check these, the key should be turned to the on position, but the engine should not be running. Do any of these faults exist? | Check for continuity in the harness, and for solid connections. Check for open fuses in the heater circuit. The quickest and easiest way to diagnose an O2 sensor is to replace it with a known good sensor, clear the faults, and determine if the fault returns under the same conditions. Go to step 8. | Go to the next step. |
| 4 | Check the fuel pressure in the fuel rails and ensure that it meets specifications. No fault will be triggered if this value is out of specification. Is the fuel pressure outside of specification? | Refer to the engine service manual, repair the fuel system as necessary, and go to step 8. | Go to the next step. |
| 5 | Check the fuel quality by using a tank of known good fuel. Does this clear the problem? | Drain the contaminated fuel from the engine and tank, and replace it with good fuel. Go to step 8. | Go to the next step. |
| 6 | Check the spark plugs, leads, and coils for proper spark. Note that the 3.4L and 4.6L engines use waste spark ignition, and a problem with a coil may affect two cylinders. Has an issue been detected with these components? | Refer to the engine service manual, repair or replace components as necessary, and go to step 8. | Go to the next step. |
| 7 | Check the fuel injectors for proper operation. Have you identified an issue with an injector? | Refer to the engine service manual, repair or replace components as necessary, and go to step 8. | Go to the next step. |
| 8 | Clear all faults, and after **Freeze Frame** data is recorded, clear the Freeze Frame buffer. Water test the boat. Does the fault reoccur? | Contact Mercury Product Support. | Put the engine back into service. |

  

# General Troubleshooting and CDS G3

## Section 3A - General Troubleshooting

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3
A

# Audio Warning System

**IMPORTANT: The audio warning system alerts the operator that a problem has occurred. It does not protect the engine from damage.**

Most faults cause the warning horn circuit to activate. How the warning horn activates depends upon the severity of the problem.

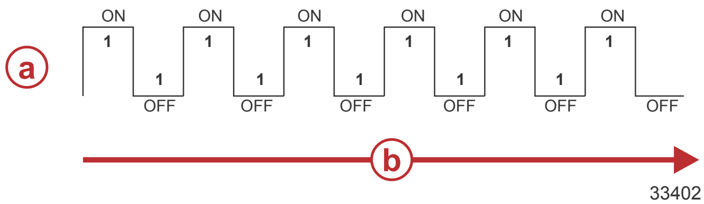
There are two warning horn states:

- Caution
- Critical

There is also an alarm that sounds if the helm has not been properly configured using the G3 service tool.

## Caution

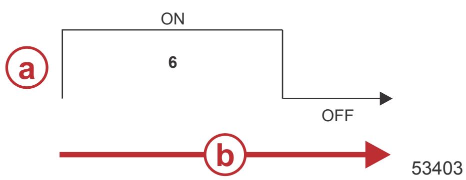
If a caution state is detected, the audio warning system will sound for six one-second intervals.




a - Horn (on or off)
b - Time (in seconds)

## Critical

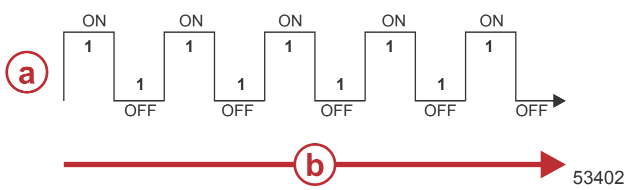
If a critical state is detected, the audio warning system sounds for six seconds and then turns off.




a - Horn (on or off)
b - Time (in seconds)

## Nonconfigured Alarm

If the helm has not been properly configured using the G3 service tool, the audio warning system will sound for five one-second intervals.




a - Horn (on or off)
b - Time (in seconds)

## Testing the Audio Warning System

1. Turn the key switch to the on position without cranking the engine.
2. Listen for the audio alarm. The alarm will sound if the system is functioning correctly.

   **IMPORTANT: Horn strategy is dependent upon software and calibration levels.**

# Troubleshooting MFD Faults

The table across the following pages does three things:

1. It lists all of the faults visible to the boat operator on a Mercury-approved multifunction display (MFD). The information in the first, third, and fourth columns (**Short Text**, **Action**, and **Long Text**, respectively) correspond directly to what the operator sees on the screen. The second column describes the type of warning horn (refer to **Audio Warning System**, preceding) that accompanies each MFD fault.

   *NOTE: Text shown in the first, third, and fourth columns is verbatim from the MFD.*

   *NOTE: The Mercury universal fault code (UFC) is also visible to the boat operator on the MFD or on certain SmartCraft gauges. The UFC contains two parts: 1) a three or four digit fault code and 2) a one or two digit failure code. These two codes are listed in the following table in the two columns under the **UFC** heading. For a list of faults sorted by UFC, refer to **Section 4A - Fault Codes**.*

2. It provides a **Quick Fault Resolution** for the technician. This information is not directly available to the operator. We have provided the information here to allow you, the dealer, to step a boat owner through fault resolution, should they encounter a fault on their MFD. In most cases, if the resolution does not work, the escalation is for the operator to bring the boat into your service center.
3. It correlates the MFD fault to the Mercury universal fault codes (UFC) and CDS G3 Freeze Frame names for propulsion control module (PCM) faults. In some cases, there is a one-to-one correspondence between the MFD fault and a PCM fault, although this is not always true. Knowing this correlation will help you to get started in the troubleshooting process, should the quick fault resolution prove unsuccessful. Refer to **Section 4A** - **Fault Codes** for fault description and resolution.

*NOTE: Within the* ***Quick Fault Resolution*** *column, the table uses the following shorthand:*

- *Clean power issue = There is a possible issue with the clean power supply. Check all fuses and battery connections.*
- *No QFR = There is no quick fault resolution available to the operator. The fault must be diagnosed by a qualified technician.*

| Short Text | Horn | Action | Long Text | Quick Fault Resolution | UFC | | PCM Fault Name |
|---|---|---|---|---|---|---|---|
| Active Exhaust | Caution | Service engine soon. | Active exhaust valve is not working properly. | Check active exhaust actuator | 3002 | 16 | AEV_OutputFault |
| Communication Error | Caution | Service engine soon. | There is a communication problem with the SmartCraft control system. | Check wire connections and terminator resistors | 4005 | 6 | RxDoc2_SOH |
| | | | | | 4011 | 23 | AuthTimeout |
| | | | There is a communication problem with the SmartCraft control system. Cruise control may not work properly. | Check wire connections and terminator resistors | 4010 | 6 | RxDoc11_SOH |
| Critical - Communication Error | Critical | Return to port immediately - Service engine before next use. | There is a communication problem with the SmartCraft control system. | Check wire connections and terminator resistors | 4001 | 6 | Demand_XCheck_Diff |
| | | | | | 4002 | 6 | Shift_XCheck_Diff |
| | | | | | 4003 | 6 | MicroChi_PWM_ADC |
| | | | | | 4004 | 6 | RxDoc1_SOH |
| | | | | | 4006 | 6 | RxDoc3_SOH |
| | | | | | 4007 | 6 | RxDoc7_SOH |
| | | | | | 4008 | 6 | RxDoc9_SOH |
| | | | | | 4009 | 6 | RxDoc10_SOH |
| | | | | | 4012 | 6 | Dual_CAN_SOH_Faults |
| | | | | | 4013 | 23 | Watchdog_Active |
| | | | | | 4014 | 6 | Crosscheck_Failed |
| | | | | | 4016 | 6 | SPI_CrosscheckData_SOH |
| Critical - Engine Sensor | Critical | Return to port immediately - Service engine before next use. | Engine crankshaft or camshaft encoder is not working properly. | Inspect wire connectors, check G3 for RPM signal | 1052 | 6 | EncoderFaultCrankCamTrigger |
| Critical - Engine Sensor | Critical | Return to port immediately - Service engine before next use. | Engine Shift Demand Sensor is not working properly. | Check shift cable adjustment and shift demand sensor wire connection | 1078 | 6 | Dual_ShiftDemandSen_Fault |
| | | | | | 1077 | 6 | ShiftDemandSensor_Diff |
| Critical - Engine Sensor | Critical | Return to port immediately - Service engine before next use. | Engine Throttle Demand Sensor is not working properly. | Check throttle cable adjustment and throttle demand sensor wire connection | 1073 | 6 | DemandSensor_Diff |
| | | | | | 1074 | 6 | Dual_DemandSen_Fault |
| Critical - Engine Sensor | Critical | Return to port immediately - Service engine before next use. | Shift actuator is not working properly. | Use G3 to check shift actuator | 1021 | 24 | ShiftPos_RangeHigh |
| | | | | | 1021 | 25 | ShiftPos_RangeLow |
| | | | | | 1023 | 24 | ShiftPos2_RangeHigh |
| | | | | | 1023 | 25 | ShiftPos2_RangeLow |
| | | | Shift position sensor is not working properly. | Use G3 to check actual and demanded gear position | 1024 | 6 | ShiftPositionSensor_Diff |
| | | | | | 1025 | 6 | Dual_ShiftPosSen_Fault |

| Short Text | Horn | Action | Long Text | Quick Fault Resolution | UFC | | PCM Fault Name |
|---|---|---|---|---|---|---|---|
| Critical - Engine Sensor | Critical | Return to port immediately - Service engine before next use. | Throttle Position sensors do not agree. | Check ETC | 311 | 6 | Dual_TPS_Faults |
| | | | | | 331 | 6 | ETC_TPSDisagree |
| Critical - Fuel Pump | Critical | Return to port immediately - Service engine before next use. | Fuel pump is not working properly. | Check fuel pump wire connections, check for fuel inlet restriction | 3061 | 16 | FULP_OutputFault |
| Critical - High Voltage | Critical | Return to port immediately - Service engine before next use. | Battery voltage is above normal limit. | Check alternator | 621 | 4 | SysVolt_RangeHigh |
| Critical - Low Voltage | Critical | Return to port immediately - Turn off unnecessary loads and check battery connections- Service engine before next use. | Battery voltage is below normal limit. | Check battery cable connections, inspect alternator or alternator fusible link | 621 | 5 | SysVolt_RangeLow |
| | | | | | 4602 | 23 | SysVolt_FaultBlocker |
| Critical - Oil Pressure | Critical | Stop engine and check oil level. If condition persists return to port immediately. Service engine before next use. | Engine oil pressure is low. | Check oil level, check oil pressure with a mechanical gauge, check oil pressure sensor | 431 | 21 | OilPress_Low |
| Critical - Overtemp | Critical | Stop engine and check for plugged water inlet. If condition persists return to port immediately. Service engine before next use. | Engine is overheating. | Check water inlets, check water pump, check thermostat, backflush system | 521 | 20 | StbdECT_Overtemp |
| | | | Engine exhaust manifold is overheating. | Check exhaust sprayers | 2124 | 20 | EGT_Overtemp |
| Critical - Security | None | Do NOT key off engine. Return to port immediately - Service engine before next use. | Security device is not available. | Check wire connections | 4501 | 23 | Security_Device_Missing |
| Critical - Shift Actuator | Critical | Return to port immediately - Service engine before next use. | Shift actuator is not working properly. | Check wire connections and check ESA with G3 | 3031 | 6 | ESC_DesiredActualDiff |
| | | | | | 3032 | 6 | ESCLossOfControl |
| | | | | | 3037 | 6 | ESC_TimeOut |
| | | | | | 3049 | 16 | SHFT_OutputFault |
| Critical - Start System | Critical | Return to port immediately - Service engine before next use. | The starting system is not working properly. Engine may not start. | Check wire connections, check start circuit fuse, check starter | 3171 | 16 | STRT_OutputFault |
| Critical - Throttle Control | Critical | Return to port immediately - Service engine before next use. | Electronic throttle controller is not working properly. | Check wire connections, check ETC for anything restricting throttle blade | 3012 | 6 | ETC_Loss_Of_Control |
| | | | | | 3013 | 6 | ETC_OutputFault |
| | | | | | 3014 | 6 | ETC_Sticking |

| Short Text | Horn | Action | Long Text | Quick Fault Resolution | UFC | | PCM Fault Name |
|---|---|---|---|---|---|---|---|
| Critical - Voltage | Critical | Return to port immediately - Service engine before next use. | Sensor power supply voltage is high. | Inspect wire harness, inspect sensors | 601 | 4 | XDRPa_RangeHigh |
| | | | | | 602 | 4 | XDRPb_RangeHigh |
| | | | Sensor power supply voltage is low. | Inspect wire harness, inspect sensors | 601 | 5 | XDRPa_RangeLow |
| | | | | | 602 | 5 | XDRPb_RangeLow |
| Emergency Stop | Caution | Check lanyard - Key engine off and restart. If condition persists - service engine soon. | Emergency stop has been activated. | Check lanyard circuit | 1109 | 23 | ESTOP_Active |
| Engine Overspeed | None | If condition persists trim angle may be too high. Stop engine and check propeller for damage or improper size. | Engine Guardian is active due to excessive engine speed. Power will be limited to prevent engine damage. | Check propeller | 2091 | 23 | Guardian_Overspeed |
| | | Reduce engine speed. | Engine speed is above specified limits with engine in neutral. | Put engine in gear | 2092 | 23 | Neutral_Overspeed |
| Engine Power Limited | Caution | Reduce engine speed. | Engine Guardian is active due to battery voltage. Power will be limited to prevent engine damage. | Check battery connections and fusible link | 2111 | 23 | Guardian_Voltage |
| | | | Engine Guardian is active due to excessively high or low oil temp. Power will be limited to prevent engine damage. | Check engine oil level | 2021 | 6 | Guardian_OilTemp |
| | | | | | 2021 | 23 | Guardian_Oil_Temp_Derate |
| | | | Engine Guardian is active due to exhaust overtemp. Power will be limited to prevent engine damage. | Check exhaust sprayers | 2032 | 23 | Guardian_EGTTemp |
| Engine Power Limited | Caution | Reduce engine speed. If condition persists stop engine and check for plugged water inlet. | Engine Guardian is active due to engine overtemp. Power will be limited to prevent engine damage. | Check exhaust sprayers | 2081 | 23 | Guardian_Overheat |
| | | | Engine Guardian is active due to low engine water pressure. Power will be limited to prevent engine damage. | Check water pickups, check sensor hose for debris | 2061 | 23 | Guardian_WaterPressure |
| Engine Power Limited | Caution | Reduce engine speed. If condition persists stop engine and check oil level. | Engine Guardian is active due to low oil pressure. Power will be limited to prevent engine damage. | Check oil level | 2051 | 23 | Guardian_OilPressure |
| Engine Power Limited | None | Reduce engine speed. | Engine Guardian is active due to a helm fault. Power will be limited to prevent engine damage. | Check wire connectors and terminator resistors | 2101 | 23 | Guardian_uXPowerLimit |
| | | | Engine Guardian is active. Power will be limited to prevent engine damage. | Key engine off and back on | 2011 | 23 | Guardian_Active |
| Engine Sensor | Caution | Check oil level on dipstick. Service engine soon. | Engine oil level sensor is not working properly. | Check oil level, check wire connections | 711 | 24 | OilLevel_RangeHigh |
| | | | | | 711 | 6 | OilLevel_Sensor_Faulted |
| | | | Engine oil may be contaminated. | | 711 | 12 | OilLevel_Sensor_Invalid |

| Short Text | Horn | Action | Long Text | Quick Fault Resolution | UFC | | PCM Fault Name |
|---|---|---|---|---|---|---|---|
| Engine Sensor | Caution | Service engine soon. | Coolant temperature sensor is not working properly. | Check wiring | 521 | 24 | StbdECT_RangeHigh |
| | | | | | 521 | 25 | StbdECT_RangeLow |
| Engine Sensor | Caution | Service engine soon. | Engine air temperature sensor is not working properly. | Check wiring | 511 | 24 | IAT_RangeHigh |
| | | | | | 511 | 25 | IAT_RangeLow |
| Engine Sensor | Caution | Service engine soon. | Engine camshaft encoder is not working properly. | Check wiring | 1051 | 23 | Camshaft_Encoder_Fault |
| Engine Sensor | Caution | Service engine soon. | Engine oil pressure sensor is not working properly. | Check wiring | 431 | 24 | OilPress_RangeHigh |
| | | | | | 431 | 25 | OilPress_RangeLow |
| Engine Sensor | Caution | Service engine soon. | Engine oil temperature sensor is not working properly. | Check wiring | 531 | 24 | OilTemp_RangeHigh |
| | | | | | 531 | 25 | OilTemp_RangeLow |
| Engine Sensor | Caution | Service engine soon. | Engine shift demand sensor is not working properly. | Check wiring | 1063 | 24 | ShiftDmdSensor1_RangeHigh |
| | | | | | 1063 | 25 | ShiftDmdSensor1_RangeLow |
| | | | | | 1064 | 24 | ShiftDmdSensor2_RangeHigh |
| | | | | | 1064 | 25 | ShiftDmdSensor2_RangeLow |
| Engine Sensor | Caution | Service engine soon. | Engine throttle demand sensor is not working properly. | Check wiring | 1061 | 24 | DemandSensor1_RangeHigh |
| | | | | | 1061 | 25 | DemandSensor1_RangeLow |
| | | | | | 1062 | 24 | DemandSensor2_RangeHigh |
| | | | | | 1062 | 25 | DemandSensor2_RangeLow |
| | | | | | 1071 | 6 | DmdSense1_NoAdapt |
| | | | | | 1072 | 6 | DmdSense2_NoAdapt |
| Engine Sensor | Caution | Service engine soon. | Exhaust gas temperature sensor is not working properly. | Check wiring | 572 | 24 | EGT_RangeHigh |
| | | | | | 572 | 25 | EGT_RangeLow |
| Engine Sensor | Caution | Service engine soon. | Manifold absolute pressure sensor and throttle position sensor do not agree. | Check wiring | 404 | 6 | MAPR_TPS1Rationality |
| | | | | | 405 | 6 | MAPR_TPS2Rationality |
| Engine Sensor | Caution | Service engine soon. | Manifold absolute pressure sensor is not working properly. | Check wiring | 401 | 24 | MAP_Time_RangeHigh |
| | | | | | 401 | 25 | MAP_Time_RangeLow |
| Engine Sensor | Caution | Service engine soon. | Throttle position sensor is not working properly. | Check wiring | 301 | 24 | TPS1_RangeHigh |
| | | | | | 301 | 25 | TPS1_RangeLow |
| | | | | | 302 | 24 | TPS2_RangeHigh |
| | | | | | 302 | 25 | TPS2_RangeLow |
| | | | | | 341 | 6 | TPS1_ETC_NoAdapt |
| | | | | | 342 | 6 | TPS2_ETC_NoAdapt |
| Engine Sensor | Caution | Service engine soon. | Trim position is not working properly. Trim limiting may not be enforced. Boat damage could occur. | Check wiring | 1012 | 24 | TrimPos_RangeHigh |
| | | | | | 1012 | 25 | TrimPos_RangeLow |

| Short Text | Horn | Action | Long Text | Quick Fault Resolution | UFC | | PCM Fault Name |
|---|---|---|---|---|---|---|---|
| Engine Sensor | Caution | Service engine soon. | Water pressure sensor is not working properly. | Check wiring | 421 | 24 | SeaPumpPress_RangeHigh |
| | | | | | 421 | 25 | SeaPumpPress_RangeLow |
| Engine Sensor | None | Check oil level before continuing engine operation. | Oil level could not be determined. | Check wiring | 711 | 19 | OilLevelInvalid |
| Engine Sensor | None | Service engine soon. | Exhaust oxygen sensor is not working properly. | Check wiring | 821 | 1 | UEGO1_Sensor_Open |
| | | | | | 821 | 27 | UEGO1_Sensor_Short |
| | | | | | 822 | 5 | UEGO1_HtrLwrLimit |
| | | | | | 822 | 16 | UEGO1_HtrOpnShrt |
| | | | | | 822 | 4 | UEGO1_HtrUprLimit |
| Engine Sensor | None | Service engine soon. | Manifold absolute pressure sensor is not working properly. | Check wiring | 402 | 24 | MAP_Angle_RangeHigh |
| | | | | | 402 | 25 | MAP_Angle_RangeLow |
| | | | | | 407 | 17 | BaroRange |
| Fuel Injector | Caution | Service engine soon. | Fuel injector is not working properly. | Check wiring | 201 | 16 | INJ1_OutputFault |
| | | | | | 202 | 16 | INJ2_OutputFault |
| | | | | | 203 | 16 | INJ3_OutputFault |
| | | | | | 204 | 16 | INJ4_OutputFault |
| | | | | | 205 | 16 | INJ5_OutputFault |
| | | | | | 206 | 16 | INJ6_OutputFault |
| | | | | | 207 | 16 | INJ7_OutputFault |
| | | | | | 208 | 16 | INJ8_OutputFault |
| Fuel System | None | Service engine soon. | Fuel system is not working properly. | Check wiring, check for fuel restriction | 902 | 4 | O2Control_ITermHighPort |
| | | | | | 902 | 5 | O2Control_ITermLowPort |
| Ignition | Caution | Service engine soon. | Ignition coil is not working properly. | Check wiring | 101 | 16 | EST1_OutputFault |
| | | | | | 102 | 16 | EST2_OutputFault |
| | | | | | 103 | 16 | EST3_OutputFault |
| | | | | | 104 | 16 | EST4_OutputFault |
| Oil Level | Critical | Check oil level before continuing engine operation. | Engine oil level is low. | Fill sump | 713 | 21 | OilLevel_Critically_Low |
| Reverse Gear Unavailable | Critical | Return to port immediately - Service engine before next use. | Reverse gear is not available. Moving control lever into reverse will result in a forward gear shift. Engine power is limited. | Check shift demand sensor, check ESC wiring | 3039 | 23 | Loss_of_Shift_Command |
| Security | None | Insert correct key fob. | Failed to pass security check. | Check wiring | 4502 | 23 | Security_Locked |
| | | Insert other key fob, wait 10 sec, then key off all engines. | Security device is in setup mode. | Check wiring | 4503 | 23 | Security_Setup |
| Shift Actuator | Caution | Service engine soon. | Shift actuator is not working properly. | Check wiring, check with G3 | 3033 | 6 | ESC_NoAdapt_Reverse |
| | | | | | 3034 | 6 | ESC_NoAdapt_Forward |

| Short Text | Horn | Action | Long Text | Quick Fault Resolution | UFC | | PCM Fault Name |
|---|---|---|---|---|---|---|---|
| Trim | Caution | Service engine soon. | The trim down relay is not working properly. | Swap relays, check wiring | 3182 | 16 | TRMD_OutputFault |
| | | | The trim up relay is not working properly. | | 3181 | 16 | TRMU_OutputFault |
| Voltage | Caution | Service engine soon. | Sensor power supply voltage is high. | Check wiring for shorts or opens | 603 | 4 | XDRPc_RangeHigh |
| | | | Sensor power supply voltage is low. | | 603 | 5 | XDRPc_RangeLow |
| Warning Horn | None | Service engine soon. | Warning horn in boat is not working properly. | Check wiring connections | 3152 | 16 | HORN_OutputFault |
| Water in Fuel | Caution | Service engine soon - Refer to Owner's Manual for service procedure. | There is water in the fuel system. Continued operation may cause engine damage. | Drain filter | 1108 | 25 | WaterInFuel_RangeLow |

# Notes:

# General Troubleshooting and CDS G3

## Section 3B - Troubleshooting with the Computer Diagnostic System (CDS G3)

3
B

## Table of Contents



## Special Tools

| CDS G3 Interface Kit | 8M0138392 |
|---|---|
|  66165 | CDS G3 License Key, Interface, Adapter, and Harness |

# Troubleshooting with the Computer Diagnostic System (CDS G3)

The PCM is designed such that if a sensor fails, the PCM will prevent the engine from going into an overly rich condition. This means that disconnecting a sensor for troubleshooting purposes may have no noticeable effect, presenting the technician with a difficult diagnostic challenge. To meet this challenge, Mercury Marine has developed the CDS G3 diagnostic tool.

## About CDS G3

CDS G3 is a standalone program that provides diagnostic support for select Mercury engines and engine control systems. CDS G3 also supports all configuration functions necessary for preparing these systems for delivery. CDS G3 provides a clean, easy-to-navigate interface.

While the engine is operating, the PCM records various data, including the state of engine sensors. The recorded information can be reviewed with CDS G3, to help diagnose intermittent engine problems. Refer to the documentation included within the CDS G3 program, for additional details.

## Installing CDS G3

This manual assumes that you have successfully installed CDS G3 on your computer and have updated it to the most current version. For installation instructions, refer to the user manual loaded onto the computer diagnostic system computer (in the Windows® **Start** menu > All Programs > Mercury Marine > User Manual).

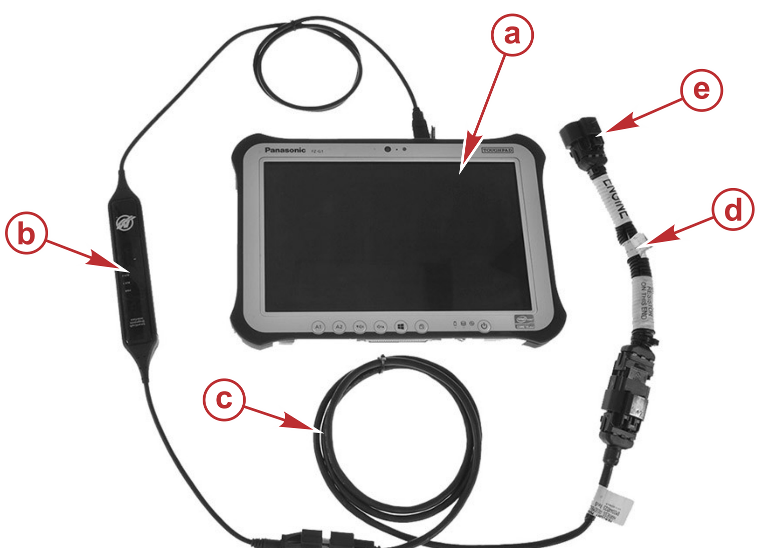
| CDS G3 Interface Kit | 8M0138392 |
|---|---|

# Connecting and Starting CDS G3

## Connection to the Engine

1. Insert the CDS G3 SmartCraft diagnostic interface USB connector into a USB port on your tablet/computer.
2. Connect the SmartCraft diagnostic interface 9-pin connector to the CAN P/CAN H adapter harness 9-pin connector.
3. Connect the CAN P/CAN H adapter harness to the CDS G3 engine harness adapter.
4. Remove the CAN P/CAN H termination resistor from the engine harness.
5. Connect the CDS G3 engine harness adapter to the CAN P/CAN H engine harness connector.

   **IMPORTANT: The CDS G3 engine harness adapter (84-8M0046081) provides the proper resistance for communication on CAN P and CAN H.**




67520

- a - Tablet/computer
- b - CDS G3 SmartCraft diagnostic interface
- c - CAN P/CAN H adapter harness
- d - CDS G3 engine harness adapter
- e - Connect to the engine CAN P/CAN H connector

## Connection to the Junction Box or Diagnostic Port

1. Insert the CDS G3 SmartCraft diagnostic interface USB connector into a powered USB port.
2. Connect the SmartCraft diagnostic interface 9-pin connector to the CAN P/CAN H adapter harness 9-pin connector.
3. Connect the CAN P/CAN H adapter harness to the junction box or diagnostic port.

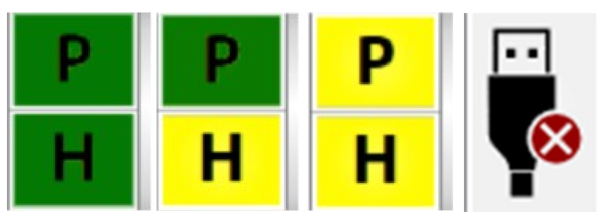
   **IMPORTANT: Ensure that the correct termination resistors are installed on the CAN P and CAN H buses. The CAN P and CAN H buses must be properly terminated for the tool to communicate. Improper termination will result in communication errors or complete loss of communication.**


67521

- **a -** Tablet/computer
- **b -** CDS G3 SmartCraft diagnostic interface
- **c -** CAN P/CAN H adapter harness
- **d -** Connect to junction box or diagnostic port

## Starting CDS G3

With the CDS G3 computer correctly connected to the vessel's CAN P bus and the CDS G3 program running, turn the key to the on position. The CAN P indicator should turn green, indicating that CAN traffic exists between the PCM and the computer.

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CAN traffic indicators

The CAN indicators will let you know the communication status on CAN P and CAN H.

**Green**—The computer is communicating on the CAN bus.

**Yellow**—The computer is communicating with the cable but no data is being received on the CAN bus.

**Red X**—The computer is not connected to the SmartCraft diagnostic interface cable.

## If CDS G3 Does Not Communicate with the System

**Is the CDS G3 CAN P traffic indicator icon red or yellow?** If it is red, the SmartCraft diagnostic interface is not connected, not recognized by Windows®, or not configured correctly in the CDS G3 options menu. This is not a CAN issue, but rather a computer issue.

Improper installation of CDS G3 driver software can result in disabling a USB port from communicating with the CDS G3 diagnostic cable. Try moving the CDS G3 diagnostic interface cable from the current USB port to an alternative port to see if this resolves the red CAN P/CAN H.

If the indicator is yellow, the SmartCraft diagnostic interface is connected and communicating with the CDS G3 program through the USB port, but it is not communicating with the CAN bus. Ensure that the key switch is in the on position and that the proper termination resistance is being used.

**Is the SmartCraft diagnostic interface's PWR LED illuminated continuously?** This indicates the cable is recognized by the computer and is communicating with the computer.

**With the key switch in the on position, is the BUS 1 LED illuminated on the SmartCraft diagnostic interface**? If it is off, the cable is not communicating on the CAN P bus. Verify proper CAN P bus termination and operation.

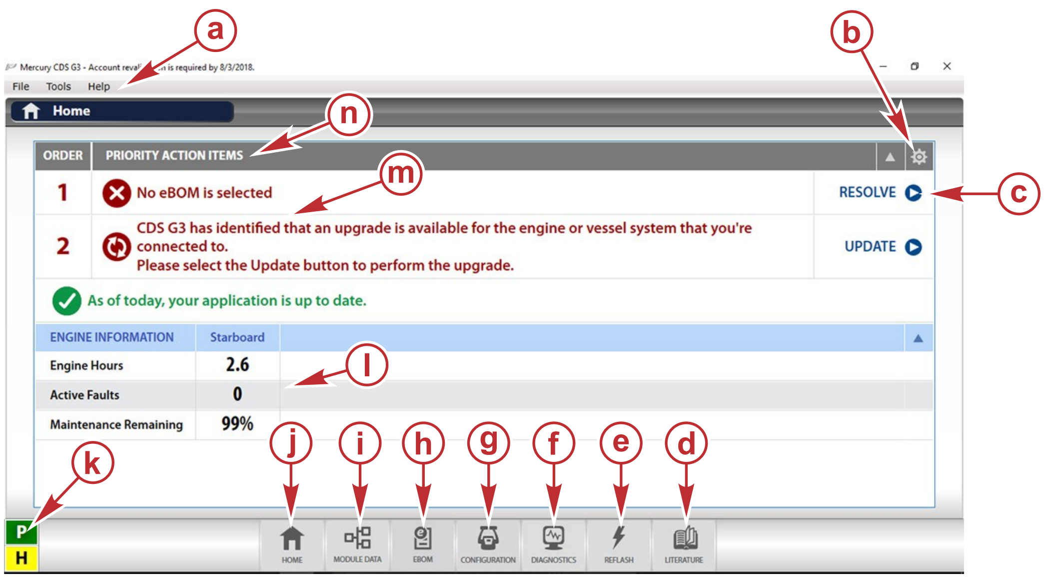
If CDS G3 does not communicate with the system:

1. Ensure that the key is in the on position, and that the boat's gauges light up. If there is no gauge activity, no warning horn self test, and no other indication that the boat is powering up, troubleshoot accordingly.
2. Ensure that the SmartCraft diagnostic interface is properly connected. Check the:
   - USB port on the computer
   - 10-pin CAN connector at the engine or helm
   - Terminator adapter cable, if used
3. Unplug the diagnostic interface at both ends, wait a few minutes, and plug it in again.
4. Try rebooting your computer after all the connections have been made.
5. If none of these resolve the issue, contact Mercury Product Support.

# CDS G3 Operation and Screen Descriptions

## Home Screen

### Priority Action Items

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Home screen

- a - Tool bar, including **File**, **Tools** (options, updates, registration), and **Help**
- b - **Gear** icon (rescan and check updates)
- c - **Resolve** and **Update** buttons for addressing priority action items
- d - **Literature** button
- e - **Reflash** button
- f - **Diagnostics** button
- g - **Configuration** button
- h - **eBOM** button
- i - **Module Data** button
- j - **Home** button
- k - CAN communication indicators
- l - **Module** information
- m - Examples of priority action items
- n - **Priority Action Items**—issues that need to be resolved

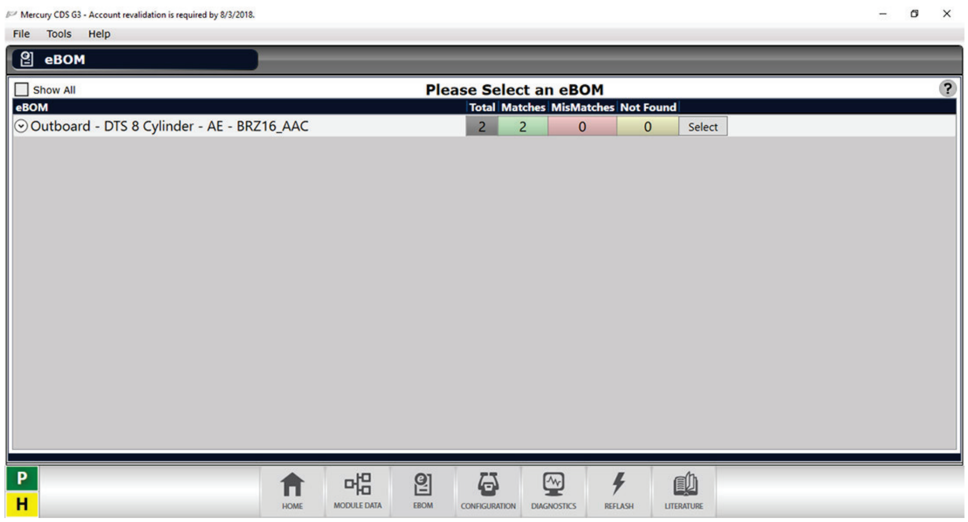
After CDS G3 is connected to the PCM, and the program is started, the **Home** screen will appear and list any priority action items that need to be resolved before proceeding.

In the preceding image, CDS G3 is indicating communication on CAN P. It also shows than an electronic bill of materials (eBOM) has yet to be selected and that an update is available. To select an eBOM, click the **Resolve** button and follow the instructions. Click the **Update** button and refer to **Section 3F** - **CDS G3—Module Reflash** to perform the upgrade.

## Selecting an eBOM

Typically, as in the preceding image, selecting an (eBOM) is the first issue that needs to be addressed before the active faults or live data can be examined. Either select the **Resolve** option from the home screen or select the eBOM icon from the bottom of the screen to bring up the eBOM screen.

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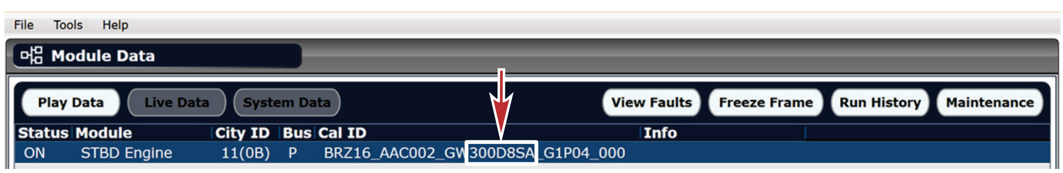
eBOM screen

The eBOM screen will present a selection that matches what CDS G3 sees on the CAN line. More than one possible match may be displayed. Select the correct one for your application. After the eBOM is selected, make sure that the PCM is running the most recent calibration. Refer to **Reflash Screen** for information on finding the most recent calibration.




67524

This section of the CAL ID contains the engine code

The following table explains the meaning of the engine code in the preceding image:

| Power level in HP | + | Control | + | Cylinder Configuration | + | Model | | + | Midsection |
|---|---|---|---|---|---|---|---|---|---|
| 200 | | D = DTS | | V6 | | F = Foundation (mechanical) | C = CMS SeaPro | | C = CMS |
| 225 | | M = Mechanical | | V8 | | P = Performance | X = Verado SeaPro | | A = AMS |
| 250 | | | | | | S = Verado | R = Racing | | |
| 300 | | | | | | | | | |

Thus, the **300D8SA** pictured above is the engine code for a 300 HP DTS V8 Verado engine with an Advanced Midsection.

## Print Screen/Print Report

Selecting the **Print Screen** option from either the **File** menu or by pushing **CTRL+F12** will take a screen capture of whatever is being displayed at the time and save it in an Adobe® pdf file in the location specified under the **Options** tab. Refer to the **CDS G3 User Manual**, which was installed on the computer along with the program.

**Print Full Report**, accessible through the **File** menu or by pressing **F12**, will print a full report, which includes freeze frame data, faults, and run history, along with the ability to include dealership information and your customer’s information.

## Reflash Screen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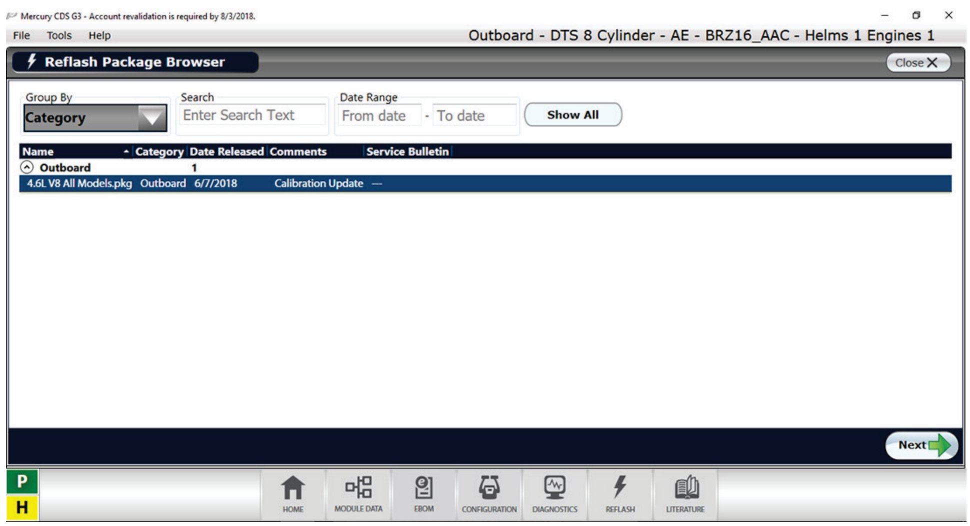
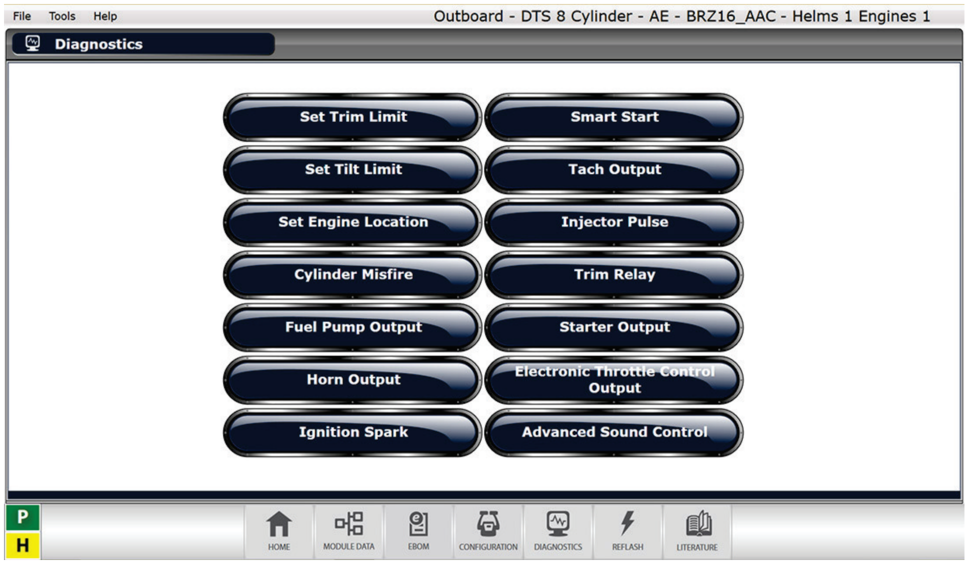



67527

**Reflash Package Browser—**When CDS G3 is connected to the engine, the available reflash package will appear on the filtered display under the outboard category. If **Show All** is selected, all available reflash packages are displayed. The page file consists of specific modules that are allowed to be upgraded. The page also gives the user a wide variety of methods to sort and search the list of package files (for example; date, category, service bulletin, etc.). Click the **Show Filtered** button and the diagnostic tool will automatically filter the correct reflash package. Refer to **Section 3F - CDS G3—Module Reflash** for more information.

## Diagnostics Screen

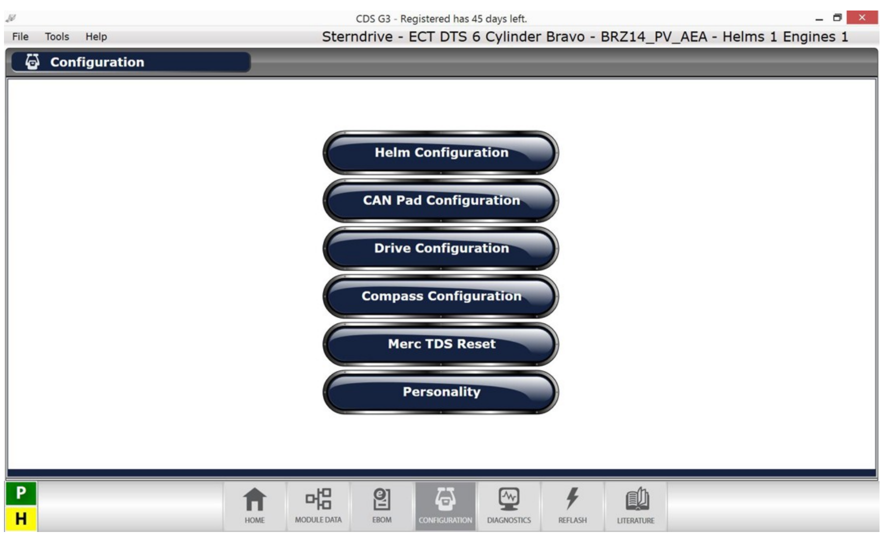



67528

Diagnostics screen

The **Diagnostics** screen provides a variety of set-up screens and diagnostic tests. Depending on your application, not all of the tests may be available. Refer to **Section 3E** - **CDS G3—Diagnostics Screen** for more information.

## Configuration Screen




53168

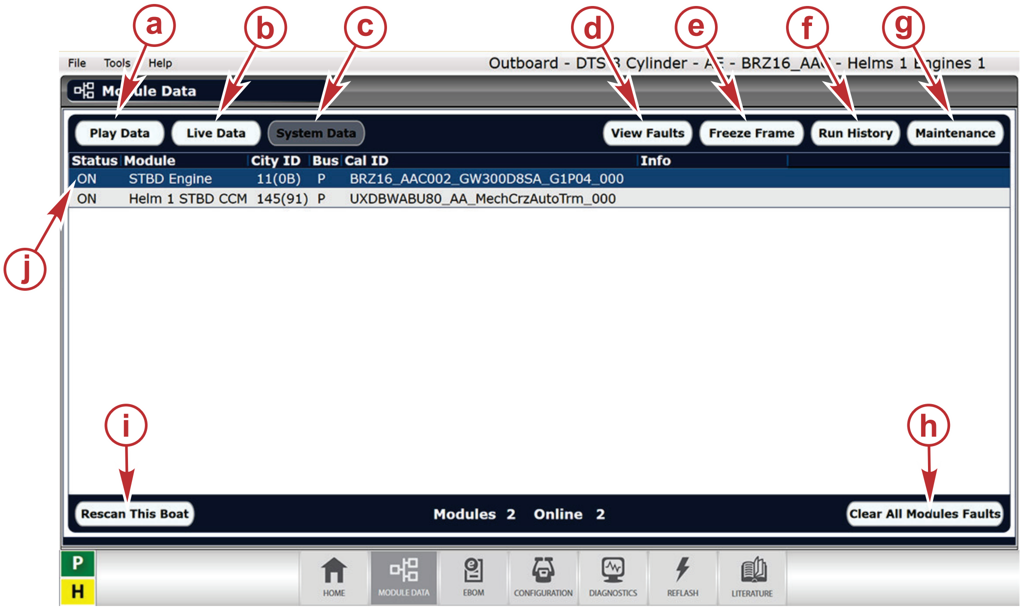
Configuration screen

The **Configuration** screen provides options for configuring the helm, CAN pads, and electronic compass, as well as resetting the theft deterrent system, or importing a vessel personality. Each option walks the operator through the necessary procedures, and is not covered in this manual.

## Module Data Screen

After the eBOM is selected, selecting the **Module Data** screen will bring up a selection of modules connected to the boat. This includes the PCM 112 and any other modules, such as the command control module (CCM). After the engine PCM is selected, other screens can be accessed as shown in the following image.



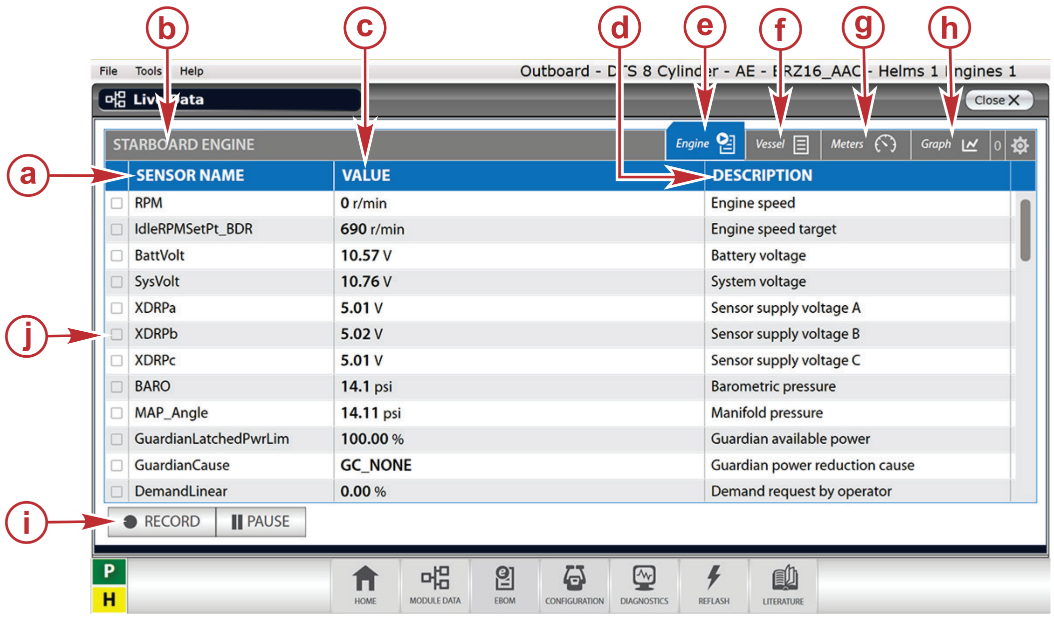

67529

- a - **Play Data** button—Plays back recorded data, in the Live Data screen, or on the Graph or Meters tab.
- b - **Live Data** button—Displays data as it is being received. Refer to **Section 3C** - **CDS G3—Live Data**.
- c - **System Data** button—Used on multiple engine applications.
- d - **View Faults** button—Lists the active faults. Refer to **Section 4A** - **Fault Codes**.
- e - **Freeze Frame** button—Displays a snapshot of engine data at the moment of the last time each fault occurred. Refer to **Section 3D** - **CDS G3—PCM 112 Freeze Frame Data**.
- f - **Run History** button—Provides access to a run time history map. Each time value is assigned to an RPM band. The data on this screen cannot be cleared or reset with the CDS G3 tool.
- g - **Maintenance** button—Displays the current maintenance value, and provides access to resetting the maintenance percentage to 100%.
- h - **Clear All Modules Faults** button—Clears existing faults. Used to clear the buffer. Faults that are still active will reappear after a few moments.
- i - **Rescan This Boat** button—Refreshes the list of modules on the boat.
- j - **Status**—Displays the status of each listed module.

## Live Data Screen

The **Live Data** screen includes **Engine**, **Vessel**, **Meters**, and **Graph** tabs. These tabs give access to current engine data as reported by the sensors at the moment. The meaning of the data items is explained in **Section 3C** - **CDS G3—Live Data**. The information can be recorded for playback by pressing the record button in the lower left corner of the screen.




67530

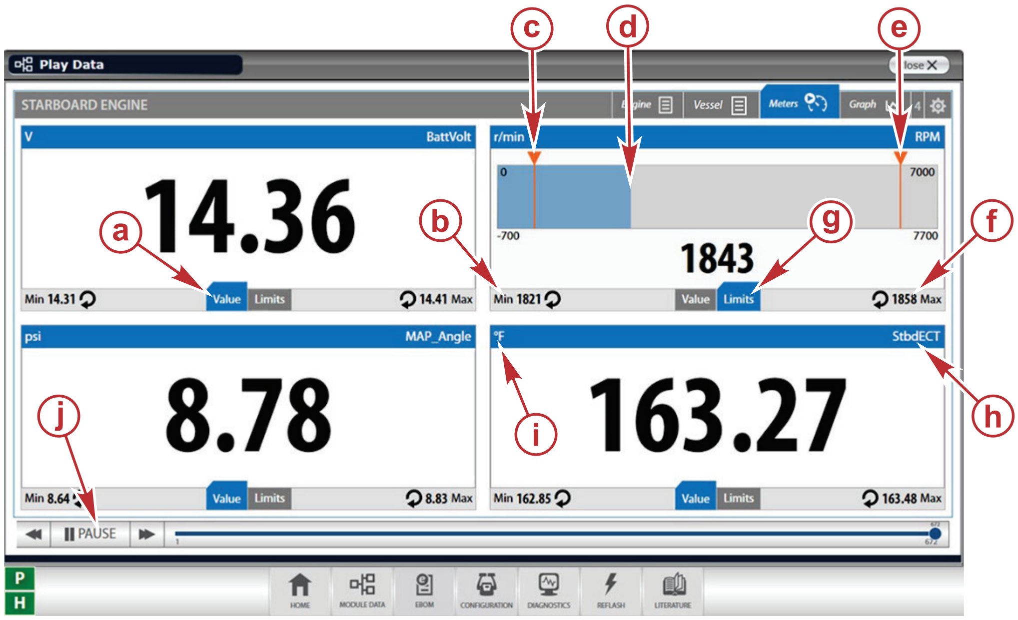
Typical Live Data screen

a - Sensor name
b - Module being referenced, the starboard engine in this example
c - Data value
d - Plain-text description
e - Engine tab
f - Vessel tab
g - Meters tab
h - Graph tab
i - Record and Pause buttons
j - Check boxes to select data on graph and meters tab

## Meters Tab

The **Meters** tab displays an enlarged view of selected live data values. While in the **Live Data** screen, select the check box next to the data item you want to display, as many as eight at a time. Next click the **Meters** tab and the following screen will be displayed. The minimum and maximum values are displayed for each data item and can be reset at any time. There is also an upper and lower limit that can be slid anywhere along the data bar. If the data moves outside the range, the bar will turn red. You may also use the **Meters** tab while playing back a previously recorded run file.




67532

- a - Value tab
- b - Minimum value and reset icon
- c - Lower limit set bar
- d - Data bar
- e - Upper limit set bar
- f - Maximum value and reset icon
- g - Limits tab
- h - Data item being measured
- i - Unit of measure
- j - Play/pause button (record and pause buttons when displaying live data)

## Graph Tab

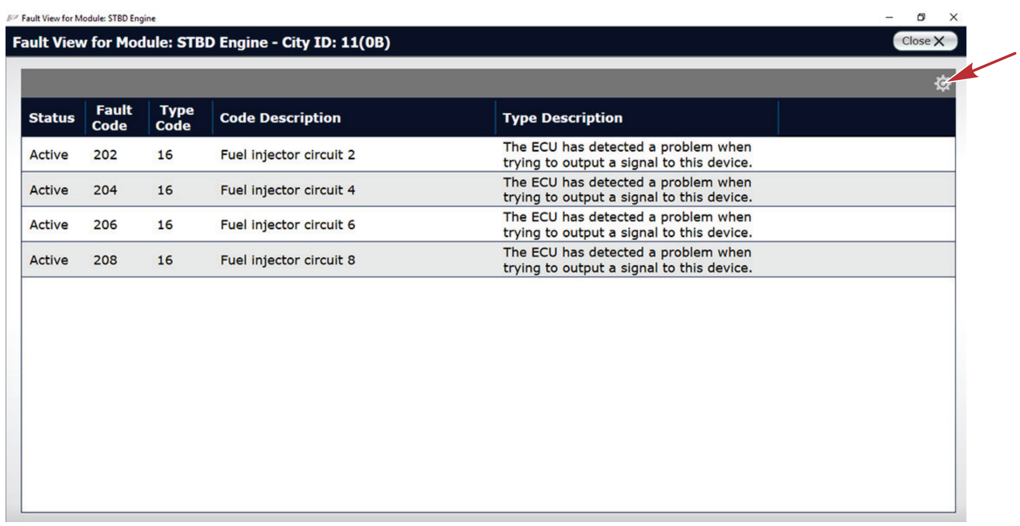
The **Graph** tab displays a graph showing how the selected data changes over time. While in the **Live Data** screen, select the check box next to the data item you want to display, as many as eight at a time. Next, click the **Graph** tab and the following screen will be displayed. Clicking the expand button on any graph will enlarge it to fit the entire screen. You may also use the **Graph** tab while playing back a previously recorded run file.


67533

Graph screen
- a - Playback head, plays from right to left
- b - Expand button, expands graph to fill the whole screen
- c - Frame location of playback head
- d - Playback slider
- e - Play/pause button

## Fault Screen

The **Fault** screen lists the active faults for the selected module. The faults for PCM 112 are listed in **Section 4A** - **Fault Codes**.



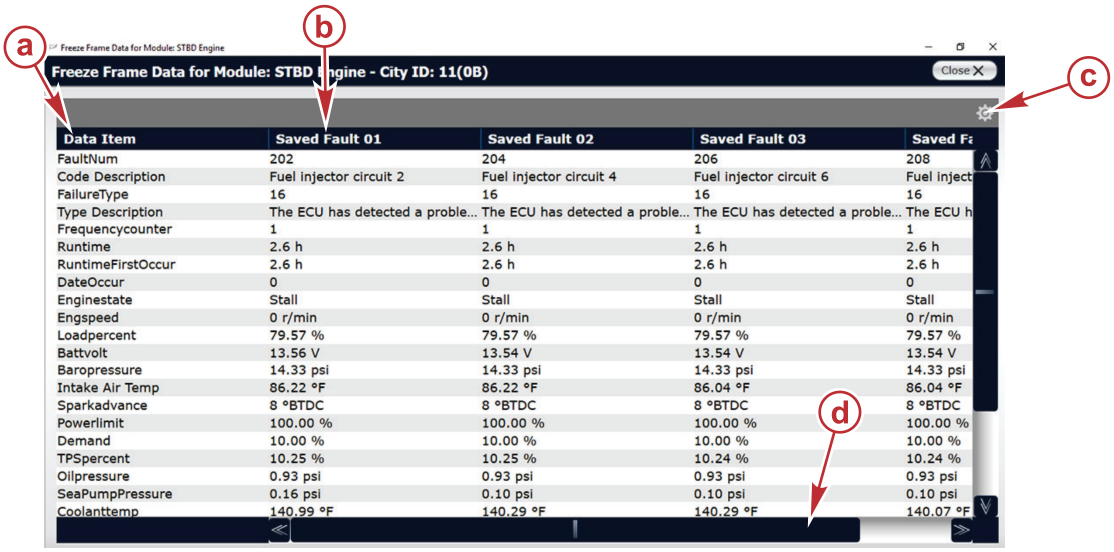

67655

Fault screen. To clear the faults, select the gear icon in the upper right corner.

## Freeze Frame Screen

The **Freeze Frame** screen displays previously recorded faults, even when they are no longer active. It also saves a snapshot of numerous data items in the instant that the fault occurred. Faults are listed in the order that they occurred, starting with the most recent. This history may be cleared by clicking the gear icon in the upper right corner of the display and selecting "Clear History."




| Data Item | Saved Fault 01 | Saved Fault 02 | Saved Fault 03 | Saved Fa |
|---|---|---|---|---|
| FaultNum | 202 | 204 | 206 | 208 |
| Code Description | Fuel injector circuit 2 | Fuel injector circuit 4 | Fuel injector circuit 6 | Fuel inject |
| FailureType | 16 | 16 | 16 | 16 |
| Type Description | The ECU has detected a proble... | The ECU has detected a proble... | The ECU has detected a proble... | The ECU h |
| Frequencycounter | 1 | 1 | 1 | 1 |
| Runtime | 2.6 h | 2.6 h | 2.6 h | 2.6 h |
| RuntimeFirstOccur | 2.6 h | 2.6 h | 2.6 h | 2.6 h |
| DateOccur | 0 | 0 | 0 | 0 |
| Enginestate | Stall | Stall | Stall | Stall |
| Engspeed | 0 r/min | 0 r/min | 0 r/min | 0 r/min |
| Loadpercent | 79.57 % | 79.57 % | 79.57 % | 79.57 % |
| Battvolt | 13.56 V | 13.54 V | 13.54 V | 13.54 V |
| Baropressure | 14.33 psi | 14.33 psi | 14.33 psi | 14.33 psi |
| Intake Air Temp | 86.22 °F | 86.22 °F | 86.04 °F | 86.04 °F |
| Sparkadvance | 8 °BTDC | 8 °BTDC | 8 °BTDC | 8 °BTDC |
| Powerlimit | 100.00 % | 100.00 % | 100.00 % | 100.00 % |
| Demand | 10.00 % | 10.00 % | 10.00 % | 10.00 % |
| TPSpercent | 10.25 % | 10.25 % | 10.24 % | 10.24 % |
| Oilpressure | 0.93 psi | 0.93 psi | 0.93 psi | 0.93 psi |
| SeaPumpPressure | 0.16 psi | 0.10 psi | 0.10 psi | 0.10 psi |
| Coolanttemp | 140.99 °F | 140.29 °F | 140.29 °F | 140.07 °F |

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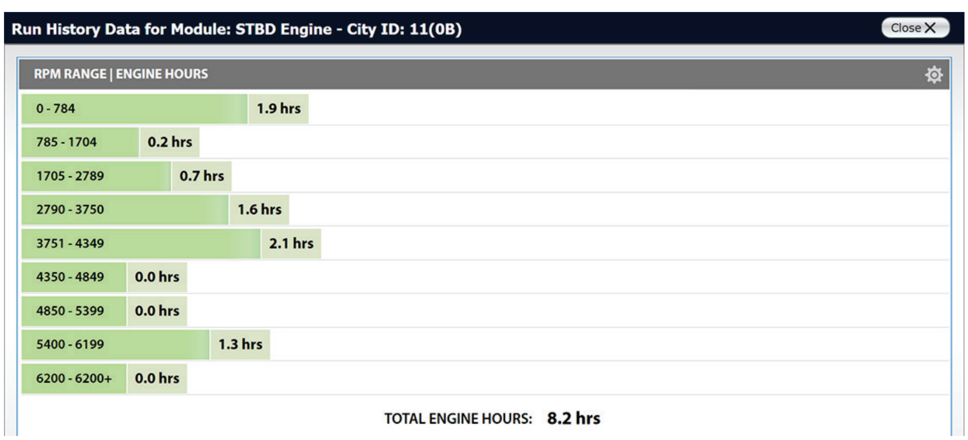
- **a -** Data item recorded
- **b -** Most recent occurred fault
- **c -** Gear icon, click for clear history option
- **d -** Scroll bar to view all recorded faults

## Run History Screen

The **Run History** screen displays a list of RPM ranges and the corresponding run time of the engine inside each of those ranges. It also displays the total engine run time at the bottom of the screen. The data on this screen cannot be cleared or reset with the CDS G3 tool.



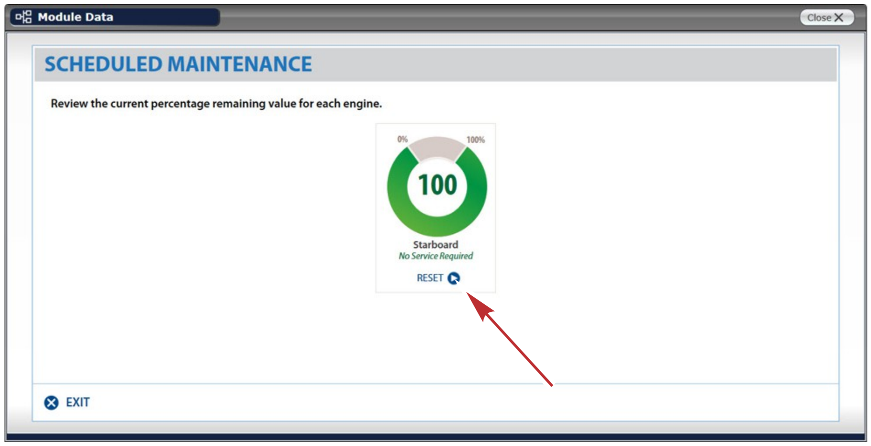

67534

Run History screen

### Maintenance Screen

The **Maintenance** screen displays the percentage of engine run time remaining before the next service is due. Clicking the reset icon will return it to 100%. All PCM 112 engines are compatible with this maintenance indicator.




60029

Maintenance screen

# CDS G3 and Diagnostic Fault Resolution

## How to Begin

Diagnostics is as much an art as it is a science. Diagnostic approaches vary, but a methodical approach that combines your experience and resources will likely serve you well. Here is one possible approach.

CDS G3 is a powerful tool. Take some time to become acquainted with its operation, features, and capabilities. It will not diagnose all problems, but will provide clues as to what is happening with a Mercury engine.

1. Talk to the customer to get as much information as possible about the complaint. There's a reason the boat was brought in. Did a fault message appear or an alarm sound? When did the problem first start? At what speeds or power ranges does it occur? Were there any recent changes made to the boat, its electrical system, or its use? (A new propeller or sound system can impact the operation of a boat.) Was fuel recently added? (Stale fuel or fuel with alcohol separation can cause problems that are difficult to pick up with a diagnostic tool.)
2. If possible, verify the symptom while the customer is present.
3. Take note of any faults that were reported by the customer.
4. Perform a brief visual inspection. Refer to **Visual/Physical Check**.
5. Connect the CDS G3 tool, choose the right eBOM, and download all updates.
6. Scan the PCM and other modules for faults.
7. If no active faults are present and none are shown in **Freeze Frame**, CDS G3 still has various diagnostic tests available, and examining **Live Data** can provide important clues. Refer to the **Live Data** screen while the engine is running to ensure that sensors and actuators are behaving as expected. Refer to the **Diagnostics** screen for available interactive tests.
8. It is important to note that CDS G3:
    a. Does not indicate low fuel pressure. (Refer to **Section 1B** for an explanation of system theory.) The PCM assumes that the pressure in the fuel rail is held at the specified pressure. If CDS G3 indicates a lean running engine, and the fuel injectors appear to be working, verify that the pressure in the fuel rail is within specifications.
    b. Does not detect poor fuel. As blended fuel ages, the alcohol and gasoline may separate and allow water to be introduced. The PCM will try to compensate for poor fuel by keeping the fuel injectors open longer. If it tries to add too much fuel, it will trigger a fault. Even if it does not trigger a fault, bad fuel can result in a poor-running engine. A small tank of known good fuel can be an important diagnostic tool.
    c. Cannot determine the mechanical health of the engine. Always confirm the health of the cylinders by performing a leakdown test after confirming that all cylinders are receiving fuel and spark. Refer to the appropriate engine service manual.
9. If faults are present:
    - Fix any active faults first. Start where the air enters the engine and work toward the exhaust. Addressing faults in this order can save time, since a problem early in the process can lead to faults further in the process.
    - Fix inactive faults second.

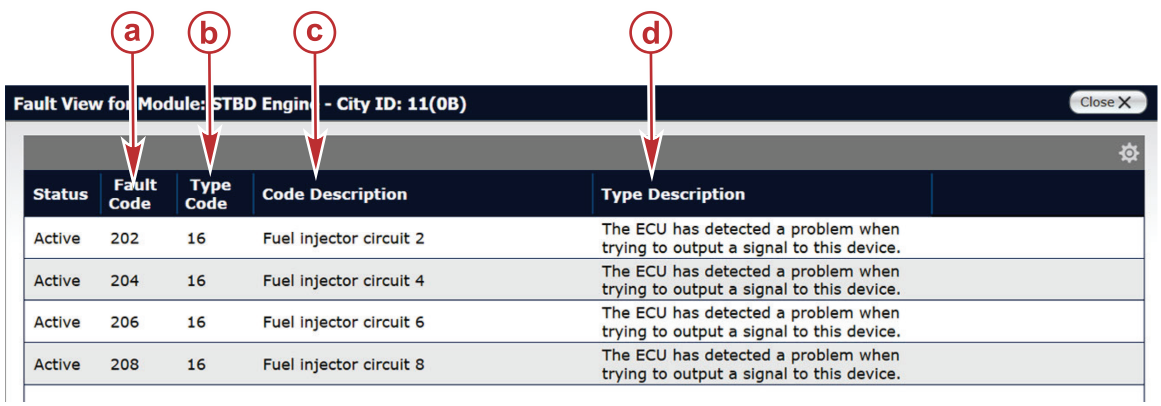
  

- Examine the **Freeze Frame** buffers, which do not relate to active or inactive faults. Be careful about faults that happened a long time ago and only happened once or twice.
- Use the freeze frame information to determine the state of the engine when the fault occurred. Refer to **Section 3D** - **CDS G3—PCM 112 Freeze Frame Data**.
- If there are multiple faults:
  - Look for shared circuits and relationships between the components. If failed sensors share the same power or ground connection, examine the harness for opens or shorts.
  - O2 sensor faults may be the result of other faults upstream. For instance, a failed fuel injector can lead to an O2 sensor out-of-range fault. Fix the other faults first, test the boat, and see if those repairs addressed the O2 sensor faults.
- Continue diagnosis on each fault until you can clear them, and they don't come back after a test run on the water.

10. **If there are no faults and there are no symptoms, then you are finished.** Do not get caught chasing a problem that does not exist. Return the boat to service.

## Fault Codes

This engine uses universal fault codes. Refer to **Section 4A** - **Fault Codes** for a complete list of those used on the PCM 112. These codes will help ensure uniformity in fault reporting in this and future control modules. It will also help ensure that boat operators will receive consistent information and instructions, such as **Service Engine Soon**, **Reduce Engine Speed**, and others in response to specific faults.

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Active fault list example (actual screen appearance may vary)

a - Fault code (the affected component)
b - Fault type code (how it was affected)
c - Code description
d - Fault type code description

In the last line of this example, fault code **208**, **Fuel injector circuit 8**, had a fault type code **16**, meaning that the PCM 112 is unable to output a signal to the device. This could indicate a faulty fuel injector. In this case, the same fault is affecting multiple injectors, which likely indicates a more widespread fault, such as an unplugged harness, issues with a power supply, or some other systemic issue.

A complete list of fault types and codes is in **Section 4A**.

## Addressing Faults

A fault indicates that the PCM has detected that the circuit in question has recorded a sensor value outside of its acceptable window, or that a sensor value has gone outside its normal range. Faults rarely indicate a defective PCM. Assume that the PCM is working correctly until complete and thorough troubleshooting procedures prove otherwise.

1. Connect the CDS G3 diagnostic tool and check for faults.
   a. A circuit with an open or short would give a fault that is an **Input High** or **Input Low**. This means that the sensor itself has failed with an open or short circuit, or one of the leads between the sensor and the PCM is open or shorted. An **Input High** fault means that the PCM is seeing a 5-volt signal. An **Input Low** fault means that the PCM is seeing no voltage.
   b. A sensor showing a reading outside of its normal range, but not shorted or open, has a **Range High** or **Range Low** fault. This means the circuit is operating correctly, but the engine is outside of its operating range, such as engine coolant overheating.

2. If the fault is an **Input High** or **Input Low**, refer to the wiring diagram and check each of the leads between the suspect sensor and the PCM for open and short circuits. Refer to **Section 5A** - **Sensors** for information on testing sensors and circuits. The short circuit does not have to be to ground, it could be to any other wire in the harness.
   a. If the leads test good, then the sensor should be replaced. If more than one sensor is affected, look for patterns.

      *NOTE: When troubleshooting active faults (faults displayed under the* ***View Faults*** *screen), the circuit in question is experiencing a failure right now. Look for an open circuit or short circuit in the two or three wires involved with the sensor in question; the sensor itself has actually failed or the connections at the PCM have failed.*
   b. If the input is high or low for more than one sensor, check the wiring harness for opens or shorts, and eliminate sensors one at a time by unplugging them to see if the fault clears.

      *NOTE: When troubleshooting intermittent faults (faults displayed under the* ***Freeze Frame*** *screens or faults that are not active in the* ***View Faults*** *screen), the circuit in question is not experiencing a failure at this time. Look for an intermittent connection or an intermittent short circuit that is not present right now. You must still check circuits for opens and shorts, but you must wiggle wires and connectors during all tests in attempt to locate the poor connection. Carefully look for subtle problems, such as corroded connections and internal wiring harness splices, and for connectors with a loose fit between the male and female pins. Ensure that the engine ground connections are clean and secure.*

      *NOTE: Use the CDS G3* ***Live Data*** *screen to find intermittent problems. While observing the data from the suspect circuit, wiggle the wires and connectors (of the suspect circuit) while the key is on or while the engine is running. When you locate the bad connection or broken or shorted lead, the data reading will fluctuate on the diagnostic tool. Keep in mind that the refresh rate of the diagnostic tool is relatively slow (every 50 milliseconds or so).*
3. If the fault is an abnormal operating condition, repair the system as needed. For example, if the sea-pump pressure is low, check the water pickups for obstructions, and then replace the water pump impeller (and other parts as needed). Abnormal operating condition faults can be active or intermittent.

## Diagnosing Intermittent Problems

IMPORTANT: Intermittent problems may or may not cause a fault to be stored.

Most intermittent problems are caused by faulty electrical connections or wiring. Perform a careful visual check for the following conditions:

- Poor mating of the connector halves or a terminal not fully seated in the connector body.
- Poor terminal-to-wire connection (crimping). Remove the terminal from the connector body to check.

All connector terminals in the problem circuit should be carefully checked for proper contact tension.

An intermittent problem may be caused by the following:

- Ignition coil shorted to ground and arcing at ignition wires or plugs.
- Poor PCM grounds, or loose or corroded engine harness ground connections.
- Electrical system interference caused by a sharp electrical surge. Normally, the problem will occur when the faulty component is operated.
- Improper installation of electrical options such as lights, stereo systems, ship-to-shore radios, or sonar.

### Digital Multimeter or Diagnostic Tool Use

The vessel may be driven with a digital multimeter connected to a suspected circuit. An abnormal voltage when the malfunction occurs is a good indication that there is a fault in the circuit being monitored.

A diagnostic tool, such as CDS G3, can be used to help detect intermittent conditions. The diagnostic tool allows manipulation of wiring harnesses or components with the engine not operating, while observing the diagnostic tool readout. The diagnostic tool can also be plugged in and observed while operating the vessel.

If the problem seems to be related to certain parameters that can be checked on the diagnostic tool, they should be checked while operating the vessel. If there does not seem to be any correlation between the problem and a specific circuit, use the diagnostic tool data to see if there is any change in the readings that might indicate intermittent operation.

The diagnostic tool is also an easy way to compare the operating parameters of a poorly operating engine with those of a known good one. For example, a sensor may shift in value but not set a fault. Comparing the sensor's readings with those of the typical diagnostic tool data readings may uncover the problem.

The diagnostic tool has the ability to save time in diagnosis and prevent the replacement of good parts. The key to using the diagnostic tool successfully lies in the technician's ability to understand the system being diagnosed and the diagnostic tool operation and limitations. The technician should read the tool manufacturer's operating manual to become familiar with the tool's operation.

## Visual/Physical Check

1. Ensure that the safety lanyard is correctly installed and that the customer understands the correct starting procedure.
2. Verify that the battery is fully charged and is of sufficient capacity for the engine being tested. If necessary, substitute a known good battery.

3. Check the fuses.
4. Check the battery cable connections. Ensure that they are clean and tight. If wing nuts are being used, discard them and replace them with corrosion-resistant hex nuts. A corrosion-resistant terminal cable washer nut should be installed between the battery terminal and the cable end (stack up order must be: battery terminal, washer, cable, nut).
5. Ensure that the cable connections are tight at the hot stud on the engine. Also ensure that the ground stud is not loose in the engine block and that the nut is tight.
6. Check that all grounds are clean and tight.
7. If there is any doubt about the mechanical condition of the engine, perform a compression test and a cylinder leak-down test.

| ⚠ WARNING |
| --- |
| **Performing tests with the engine running may cause the propeller to rotate and result in serious injury or death. Use caution when performing a test that requires the engine running, and remove the propeller to avoid injury.** |

8. Unplug and inspect the main harness connector between the engine and boat harnesses. If there is any doubt about the boat harness, substitute a shop harness and key switch assembly and run the boat. If the problem disappears, the problem is in the boat harness, not the engine harness. A transom mount key switch harness can be purchased for this purpose.
9. Check for adequate fuel pressure at the fuel rail.
   a. If there is no fuel pressure, check that the fuel pumps are operating. The pumps must run for at least three seconds each time the key is turned to the on position. If the fuel pumps and the warning horn are not operating as the key is turned on, ensure that the PCM is powering up (check the fuses and the wake-up power), and that clean power is available.
   b. Fuel pressure varies with engine vacuum. Fuel pressure will be high during cranking, low at idle, and increase proportionally as the throttle is opened to the wide-open position. Disconnect the reference hose to find the regulator’s rated pressure. Then reconnect the reference hose to ensure that the pressure drops at idle.

   | Rated Fuel Pressure at Idle |
   | --- |
   | 390–340 kPa (42.1–43.9 psi) |

   Pressure usually drops about 41–45 kPa (4–6 psi) at idle (from the regulator’s rated specification).
   c. If the fuel pressure drops at higher speed and higher engine loads, check the boat’s fuel system (the supply system) for restrictions with an accurate vacuum gauge and clear hose at the water-separating fuel filter inlet. As the engine is run from idle to wide-open throttle and back to idle, the clear hose must not show the presence of any air bubbles and the vacuum gauge must not read higher than 6.7 kPa (1 psi) (2.0 in. Hg).
   d. If the supply system is working correctly, but the fuel pressure is low at high speeds and loads, replace the water-separating fuel filter and retest. If pressure is still low, the fuel pump is most likely defective.
10. Check the two vacuum lines for splits, kinks, and proper connections.
11. Check for any other air leaks in the induction system, such as at the throttle body and intake manifold gaskets.
12. Unplug and inspect the PCM connectors. Ensure that there are no bent PCM pins and that all of the correct pins are present. Refer to **Section 2B** for the pins used and not used on PCM 112 engines. Look for signs of tampering, corrosion, damage to the pin locking mechanisms, melted insulation, any other evidence of shorts, or other damage.
13. Unplug and inspect as many of the sensors and actuators as you can reasonably access. Look for signs of tampering, corrosion, damage to the pin locking mechanisms, melted insulation, any other evidence of shorts, or other damage. Based on the results of this inspection, further inspection of the harness may be necessary. Remember that there are many internal splices in the harness that may be damaged or defective. If there is damage at the external connections, you will have to inspect several of the internal splices to verify that the damage is not also present at these locations.

# General Troubleshooting and CDS G3

## Section 3C - CDS G3—Live Data

## Table of Contents



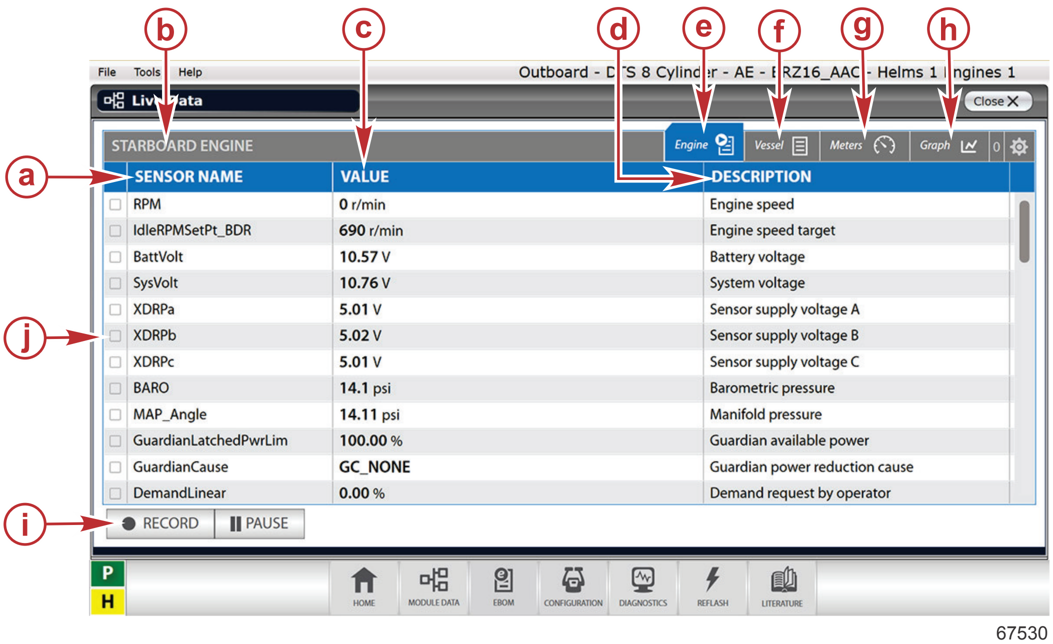


# Live Data Screen

The **Live Data** screen, which is available after the eBOM and engine module data screen have been selected, displays real-time engine information. The three columns display the sensor name (data items), their values, and a plain-text description of each item. Note that the columns can be arranged in different order depending upon the operator's preference.

Preferred units for temperature, speed, flow rate, volume, and pressure may be selected from the tools/options/units tab on the home screen.




Typical Live Data screen

- a - Sensor name
- b - Module being referenced, the starboard engine in this example
- c - Data value
- d - Plain-text description
- e - Engine tab
- f - Vessel tab
- g - Meters tab
- h - Graph tab
- i - Record and Pause buttons
- j - Check boxes to select data on graph and meters tab

The following table explains the line entries on the **Live Data** screen. Note that some entries appear on the **Engine** (Eng.) tab, and some on the **Vessel** (Ves.) tab. The information in the **Name**, **Description**, and **Value** columns correspond directly to what is displayed in CDS G3.

| Shown on: Eng. tab | Ves. tab | Name | Description | Value | Units (*=user selected) | Explanation |
|---|---|---|---|---|---|---|
| X | | ActiveFaultMarqueeDisp | – | (None) or fault data | – | Any active faults are displayed here. |
| X | | ActualGear | Gear position actual | Neutral/forward/reverse | – | The actual gear position based on the shift position sensor on the engine. |
| X | | AEV_DutyCycle | Commanded position of Active Exhaust system | 90 or 10 | Percent | Active Exhaust (Advanced Sound Control) feature; 90% indicates stealth mode—low noise, 10% indicates sport mode—higher noise. |
| | X | AG_Coolant_Volts | Analog gauge coolant temperature output | Variable | Volts | Sends a voltage relative to coolant temperature to an analog gauge, if a gauge is present. |
| | X | AG_OilPress_Volts | Analog gauge oil pressure output | Variable | Volts | Sends a voltage relative to oil pressure to an analog gauge, if a gauge is present. |
| | X | AG_Trim_Volts | Analog gauge trim position output | Variable | Volts | Sends a voltage relative to trim position to an analog gauge, if a gauge is present. |
| | X | AirMarDepth | Sea depth | Variable | m | Displays the depth of the water you are operating in (in meters), if connected to an optional depth sensor. |
| | X | AirMarSeaTemp | Sea temperature | Variable | ºC (ºF)* | The temperature of the water you are operating in, if the optional lake and sea temperature sensor is being used. If a lake and sea temperature sensor is not being used, the field will show a default value of –50 ºC or –58 °F. |
| X | | Arb_TPS | Throttle position | 0–100 | Percent | The percent the throttle blade is open from the closed position. |
| X | | BARO | Barometric pressure | Variable | kPa (psi, in. Hg)* | The barometric pressure reading when the key is turned on. |
| X | | BattVolt | Battery voltage | 12.0–14.5 V | Volts | The DC voltage as measured by the PCM on the input side of the system. Typical values range from 12.0–14.5 V. |
| X | | CTRL_Gear | Gear position target | Forward/reverse/neutral | – | The gear position commanded by the remote control. |
| X | | Demand | Demand request by control software | 0–100 | Percent | After demand is measured at the ERC, it may be adjusted by the control software to account for functions such as **Autosync**, **Dock Mode**, **Cruise**, **Smart Tow**, or **Troll**. |
| X | | DemandLinear | Demand request by operator | 0–100 | Percent | A measurement of the throttle demand requested at the ERC or throttle demand sensor. |
| X | | DemandLinear_with_Guardian | Demand request by Guardian | 0–100 | Percent | After registering the demand from the ERC (DemandLinear), and accounting for additional functions (Demand), any further restrictions, such as Guardian, or Adaptive Speed Control, are factored into this number. |
| X | | DemandSensor1 | Mechanical demand sensor A | 0–100 | Percent | This is a dual Hall-effect sensor used only on mechanical engines. It is mounted on the throttle and shift bracket. The magnet is mounted on the throttle lever. |

| Shown on: Eng. tab | Shown on: Ves. tab | Name | Description | Value | Units (*=user selected) | Explanation |
|---|---|---|---|---|---|---|
| X | | DemandSensor2 | Mechanical demand sensor B | 0–100 | Percent | This is a dual Hall-effect sensor used only on mechanical engines. It is mounted on the throttle and shift bracket. The magnet is mounted on the throttle lever. |
| X | | DesiredPhi | Equivalence ratio target | 0.85–1.40 | Ratio | The ratio of the ideal air/fuel ratio to the actual air/fuel ratio. This can vary with engine demand, from 0.85 to 1.40. **1.0** = stoichiometric, **<1** = lean, **>1** = rich. |
| X | | ECT | Engine coolant temperature | Variable | ºC (ºF)* | The engine block water temperature. |
| X | | EGT | Exhaust gas temperature | Variable | ºC (ºF)* | Exhaust gas temperature after water sprayer. |
| X | | EngineSerialNumber | Engine serial number | – | – | This will display the engine serial number, as programmed into the PCM at the time the engine is manufactured. |
| X | | ESCDutyCycleProbe | Duty cycle of the electronic shift actuator | Positive value = forward shift<br>0 = neutral/ stationary<br>Negative value = reverse shift | Status | This indicates the position the shift actuator is reporting.<br>***NOTE:*** *When the forward shift is complete, the value will likely return to zero. However, the actuator will maintain a negative value in reverse to ensure that the clutch stays engaged.* |
| X | | ESTOP | Emergency stop | 0 or 1 | Status | The status of the emergency stop switch: **1** for E-stop active or **0** for E-stop not active. |
| | X | FuelLevel1 | Fuel level 1 | 0–100 | Percent | The tank level reading from Tank 1 on the 6-pin SmartCraft boat harness. |
| | X | FuelLevel2 | Fuel level 2 | 0–100 | Percent | The tank level reading from Tank 2 on the 6-pin SmartCraft boat harness. |
| X | | FuelRate_J1939 | Fuel flow rate | Engine dependent | L/h (gph)* | The calculated volume of fuel being delivered to the cylinders by the fuel injectors. |
| X | | GuardianCause | Guardian power reduction cause | Variable | Text | When the engine goes into Guardian mode, the value in this field shows the cause. |
| X | | GuardianLatchedPwrLim | Guardian available power | 0–100 | Percent | This is the current percentage of power allowed by the PCM. |
| X | | IAT | Intake air temperature | Engine dependent | ºC (ºF)* | The temperature of the air in the induction system. |
| X | | IdleRPMSetPt_BDR | Engine speed target | Engine dependent | RPM | The idle speed (RPM) that the PCM wants, based on a programmed value in the calibration. |
| X | | InjMPW | Fuel injector pulse width | Engine dependent | ms | Injector pulse width displayed for each cylinder, in numerical order, showing the time that the injector is open at that time. These numbers fluctuate rapidly as the engine runs in the various RPM ranges.<br>These numbers refresh constantly and provide good clues for what's going on with the fuel delivery for each cylinder. This number is what the PCM is commanding based on the current calculations being performed within the program. It does not know if the fuel is actually making it to the cylinder. |

| Shown on: Eng. tab | Shown on: Ves. tab | Name | Description | Value | Units (*=user selected) | Explanation |
|---|---|---|---|---|---|---|
| X | | J1939_Cal_ID | Calibration part number | Variable but having the form: 8M2020739 | – | The PCM calibration ID or identifier. |
| X | | LeanBurnCtrlState | – | Normal operation/ Enable delay/ Enable ramping/ LeanBurn/ Disable ramping | Status | This identifies the current status of Lean Burn (advanced range optimization) function. |
| X | | LeanBurnEnablementVector | Indicates whether all conditions are met to allow lean burn | 0 or 1 | Status | All parameters must be **1** to enter Lean Burn. Any parameter displaying **0** is preventing the engine from entering Lean Burn. |
| X | | MAP_Angle | Manifold absolute pressure (MAP) | Refer to your service manual | kPa (psi, in. Hg)* | The current pressure in the engine's induction system. |
| X | | NECCTIsSteadyState | Warmup state | 0 or 1 | Status | The engine warmup state. **1** means the temperature is in operating range. **0** means the engine temperature has not reached operating range.<br>***NOTE:*** *Normalized effective combustion chamber temperature (NECCT) is the expected operating temperature of the combustion chamber.* |
| X | | O2Control_ITerm_Port | Fuel trim port | Engine dependent | Percent in decimal form (0.20 = 20%) | This is the multiplier by which the PCM is adjusting fuel to achieve the desired phi. If this number exceeds ±20%, it will trigger an ITerm fault.<br>The numbers in this field can appear as in the following examples:<br>• 0.25, which is 25%. It means the adjustment is rich and the system is adding fuel.<br>• –0.25, which is negative 25%. It means the adjustment is lean and the system is subtracting fuel from the base fueling curve. |
| X | | O2ControlState | Fuel system control state | Open-loop/ Closed-loop | – | • **Open-loop** means the engine has not yet met the requirements to go into the closed-loop mode, the engine is undergoing a change in demand or gear, or it is running a diagnostic routine.<br>• **Closed-loop** means that the engine is in the closed-loop fuel control mode and responding to inputs from the O2 sensor to adjust fueling.<br>***NOTE:*** *While monitoring in CDS G3, in some situations the display may show closed-loop, when the engine is actually in open-loop. An engine is truly operating in closed-loop when the UEGO1-phi Live Data item is a value other than 0.98.* |

| Shown on: Eng. tab | Shown on: Ves. tab | Name | Description | Value | Units (*=user selected) | Explanation |
|---|---|---|---|---|---|---|
| X | | OilPressure | Oil pressure | Engine dependent | kPa (psi, in. Hg)* | Oil pressure in the block. This data item changes with engine speed and is limited on the top end by a check valve in the engine block. |
| X | | OilTemp | Oil temperature | Engine dependent | °C (°F)* | Engine oil temperature. |
| | X | PaddleWheelFilt | Paddle wheel sensor | Engine dependent | Hz | A signal generated by an optional paddle wheel displayed in hertz (cycles per second) and interpreted by the SmartCraft software to display speed through the water. If a paddle wheel sensor is not being used, you will see a default value of 0 Hertz. |
| | X | PitotPres_ADC | Pitot pressure sensor | 10–1013 | Counts | The amount of pressure supplied in the pitot system, if the optional pitot pressure water pickup is installed. The pitot system is used to drive a speedometer. The data is displayed in counts, with a usable range from 10–1013.<br>The number of counts is interpreted by the SmartCraft software to equate to mph or km/h for display on the gauge. A count of 10 represents 0 km/h (0 mph), while 1013 represents the top speed detectable by the pitot sensor. |
| X | | RPM | Engine speed | Engine dependent | RPM | Engine speed in revolutions per minute or RPM. |
| X | | SeaPumpPress | Sea pump pressure | Engine dependent | kPa (psi, in. Hg)* | The water pressure in the engine block. This item will fluctuate from idle through wide-open throttle. It can be affected by the condition of cooling circuits and the water pump. |
| X | | SerialNumber | Module serial number | – | – | Every PCM has a unique serial number, a combination of letters and numbers that also identifies the controller type and vintage. |
| X | | ShiftDmdSensor1 | Shift demand sensor | –100–100 | Percent | This is a dual Hall-effect sensor used only on mechanical engines. It is mounted on the throttle and shift bracket. The magnet is mounted on the shift lever. 0% indicates neutral, a positive value indicates forward, a negative value indicates reverse. |
| X | | ShiftDmdSensor2 | Shift demand sensor | –100–100 | Percent | This is the secondary dual Hall-effect sensor used only on mechanical engines. It is mounted on the throttle and shift bracket. The magnet is mounted on the shift lever. 0% indicates neutral, a positive value indicates forward, a negative value indicates reverse. |
| X | | ShiftPos_ADC | Shift position sensor | 10–1013 | Counts | The shift position sensor has a total range from 0–1024 counts, with a usable range from 10–1013. These counts are used to calculate the actual position of the shift actuator. |
| X | | ShiftPos2_ADC | Shift position sensor | 10–1013 | Counts | The secondary shift position sensor has a total range from 0 to 1024 counts, with a usable range from 10–1013. This sensor provides redundancy, and allows the PCM to compare its values to the primary sensor. |

| Shown on: Eng. tab | Shown on: Ves. tab | Name | Description | Value | Units (*=user selected) | Explanation |
|---|---|---|---|---|---|---|
| X | | SparkAdv | Spark advance | Engine dependent | Degrees | Indicates degrees of spark advance for each cylinder.<br>*NOTE: Slight variation in these numbers is normal; this indicates that load balancing is functioning properly.* |
| X | | SSEngOpr | Engine speed and load steady state | 0 or 1 | Status | This is 0 if the engine speed is varying by more than 100 RPM, and 1 if engine speed is varying less than 100 RPM. |
| X | | SysVolt | System voltage | Typical: 12.0–14.5 | Volts | The DC voltage measured by the PCM on the output side of the system, as it is being supplied to components on the engine. Typical values range from 12.0–14.5 V. |
| X | | TPS1_ADC | Throttle position sensor A | 10–1013 | Counts | The throttle position sensor has a total range from 0–1024 counts, with a usable range from 10–1013. These counts are used to calculate the actual throttle position. |
| X | | TPS2_ADC | Throttle position sensor B | 10–1013 | Counts | The secondary throttle position sensor has a total range from 0–1024 counts, with a usable range from 10–1013. This sensor provides redundancy, and allows the PCM to compare its values to the primary sensor. |
| X | | TrailerMode | Trailer mode | True or False | – | This displays **True**, if the engine is in the trailer range. It is used to limit maximum engine angle. |
| X | | TrimPos_ADC | Trim position sensor | 0–1024 | Counts | The number of counts associated with the trim position sensor. The sensor has a total range from 0–1024 counts, with a usable range from 50–950. The result of the actual position contributes to the trim position percent value. |
| X | | TrimPospercent | Trim position | 0–100 | Percent | Trim position as a percentage. The fully trimmed-in position is shown as 0%. Trailer position is shown as 100%. |
| X | | UD_ShiftIntoFwdCnts | Shifts into forward | Continuous | Counts | Indicates the number of forward shift occurrences. |
| X | | UD_ShiftIntoRevCnts | Shifts into reverse | Continuous | Counts | Indicates the number of reverse shift occurrences. |
| X | | UEGO1_HeaterDutyCycle | O2 sensor heater duty cycle, port S1 | 0–100 | Percent | This value shows what percentage of time the O2 heater is on in order to maintain the required temperature. (Refer to UEGO1_Ri_Temp.) |
| X | | UEGO1_phi | Equivalence ratio, port S1 | ±1.00 | Ratio | The equivalence ratio, or phi, is the ratio of the actual fuel/air ratio to the targeted ratio. If this number is above 1.00, the engine is running rich. If it is below 1.00, it is running lean. |
| X | | UEGO1_Ri_Temp | O2 sensor temperature, port S1 | 768–791 (1416–1456) | ºC (ºF)* | UEGO sensors operate at 768–791 °C (1416–1456 °F). The UEGO1_HeaterDutyCycle should vary accordingly to maintain this temperature. |
| X | | XDRPa | Sensor supply voltage A | 5.00 | Volts | The 5 V reference voltage that is supplied to engine sensors. The normal value is 5 V, plus or minus a few hundredths of a volt. |

| Shown on: | | Name | Description | Value | Units (*=user selected) | Explanation |
|---|---|---|---|---|---|---|
| Eng. tab | Ves. tab | | | | | |
| X | | XDRPb | Sensor supply voltage B | 5.00 | Volts | The 5 V reference voltage that is supplied to the shift demand sensor and throttle demand sensor (mechanical engines only). The normal value is 5 V, plus or minus a few hundredths of a volt. |
| X | | XDRPc | Sensor supply voltage C | 5.00 | Volts | The 5 V reference voltage that is supplied to the MAP sensor, optional oil level sensor, and SmartCraft sensors. The normal value is 5 V, plus or minus a few hundredths of a volt. |

# General Troubleshooting and CDS G3

## Section 3D - CDS G3—PCM 112 Freeze Frame Data

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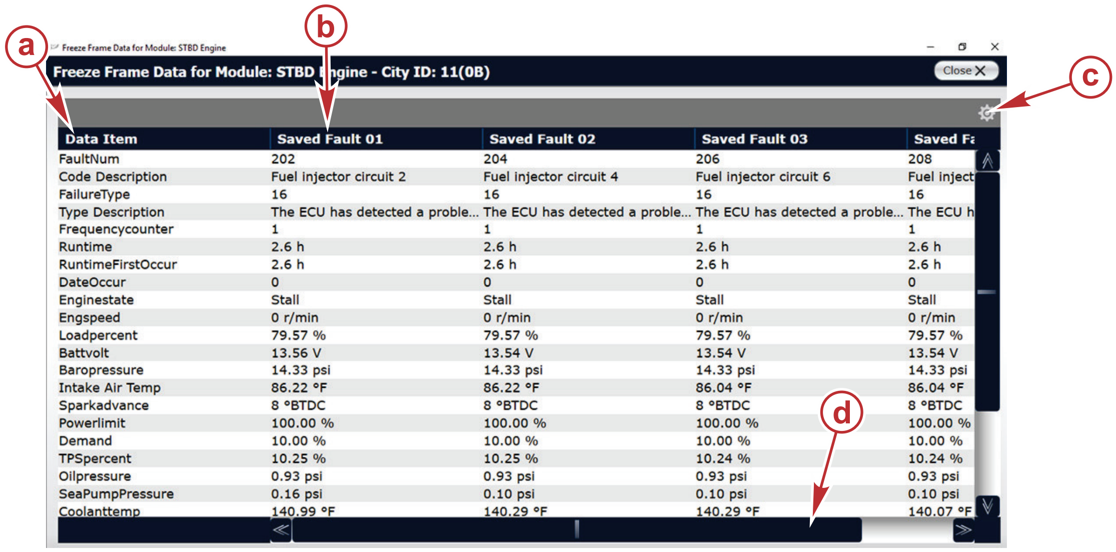
# Freeze Frame Screen

The **Freeze Frame** screen (refer to **Section 3B** - **Connecting and Starting CDS G3** for details on bringing up this screen) captures a snapshot of 25 data items at the time a fault occurs. These items include the fault number, battery voltage, and others. A complete list with their explanations follows.

Up to 10 different faults can be saved on this screen. If the same fault occurs multiple times, the frequency counter will show how often it has occurred since the faults were reset, and the data for the most recent fault will be displayed. To clear the fault list, click on the gear icon in the upper right corner, and select the appropriate action item.

The data items are listed in the order in which they appear.

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**a -** Data item recorded
**b -** Most recent occurred fault
**c -** Gear icon, click for clear history option
**d -** Scroll bar to view all recorded faults

| Data Item | Possible Values/Types | Explanation |
|---|---|---|
| FaultNum | Refer to **Section 4A** - **Fault Codes** | – |
| Code Description | Describes the component or affected system | – |
| FailureType | Refer to **Section 4A** - **Fault Codes** | – |
| Type Description | Describes how the component or system failed | – |
| Frequencycounter | Numeric | Counts how many times the fault has occurred. The rest of the values only display information for the most recent of the occurrences. |
| Runtime | Hours | Total amount of time that the engine has run in hours in which the fault was last set. |
| RuntimeFirstOccur | Hours | Total amount of time that the engine has run in hours in which the fault was first set. |
| DateOccur | Calendar date | Calendar date that the fault was set. (Only available when a GPS signal is present on the SmartCraft network) |
| Enginestate | Stall - Engine stalled, key on<br>Crank - Engine is cranking<br>Run - Engine is running | The engine function at the time the fault occurred. |
| Engspeed | RPM | Engine speed in RPM at the time the fault occurred. |

  

| Data Item | Possible Values/Types | Explanation |
|---|---|---|
| Loadpercent | 0–100% | Shows how much of the total possible engine power is being produced as a percentage. On a normally aspirated engine, the engine load and manifold pressure data follow each other in a parallel fashion. |
| Battvolt | Battery voltage | Battery voltage at the time the fault occurred. |
| Baropressure | PSI | Barometric pressure reading during the key cycle that the fault occurred in. |
| Intake Air Temp | Degrees Fahrenheit | Temperature of the air entering the intake plenum at the time the fault occurred. |
| Sparkadvance | Degrees of spark timing | The total spark advance in degrees added to the base spark advance table at the time the fault was set in Freeze Frame. |
| Powerlimit | 0–100% | Available engine output power as a percentage at the time the fault was set in freeze frame. |
| Demand | 0–100% | Information that the PCM has received from the command control module (CCM) (on DTS engines), or the throttle demand sensor (on mechanical engines). Measurement of the amount of power requested by the operator or control software. |
| TPSpercent | 0–100% | Throttle position sensor measured in percentage of the amount the throttle blade was open at the time the fault was set in freeze frame. |
| Oilpressure | PSI, engine dependent | Oil pressure measured in PSI at the time the fault was set in freeze frame. |
| SeaPumpPressure | PSI, engine dependent | Sea pump pressure measured in PSI at the time the fault was set in freeze frame. |
| Oiltemp | Degrees Fahrenheit, engine dependent | The engine oil temperature measured in Fahrenheit at the time the fault was set in freeze frame. |
| Coolanttemp | Degrees Fahrenheit, engine dependent | The coolant temperature measured in Fahrenheit at the time the fault was set in freeze frame. |
| Gearposition | Reverse | The reported gear position at the time of the fault. |
| | Forward | |
| | Neutral | |
| Trimposition | 0–1024 ADC | Measured in AD counts, this is the position of the outboard between 0 (0%) and 1024 (100%) at the time of the fault. |
| MapAngle | kPa, engine dependent | The manifold absolute pressure measured in kPa. The **angle** refers to the angle of the crankshaft where the vacuum is optimally measured. This is the parameter at the time the fault was set in freeze frame. |
| O2CtrlState | Open-loop | The state of fuel system monitoring. |
| | Closed-loop | |
| Oillevelpercent | 0–1024 ADC | Measured in AD counts, this is the engine oil level between 0 (0%) and 1024 (100%) at the time of the fault. (Not all engines are equipped with an oil level sensor.) |

  

# Notes:

# General Troubleshooting and CDS G3

## Section 3E - CDS G3—Diagnostics Screen

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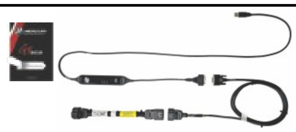
## Special Tools

| CDS G3 Interface Kit | 8M0138392 |
|---|---|
|  66165 | CDS G3 license key, interface, adapter, and harness. |

## Diagnostic Screen

**IMPORTANT: Follow the instructions on each CDS G3 screen and observe all safety warnings.**

A variety of diagnostic tests can be accessed from CDS G3 by opening the diagnostic screens from the Diagnostics tab. The diagnostic menu is established by the engine's control module and the eBOM that is selected. The menu items may differ depending on the engine that CDS G3 is connected to. The following sample screens are representative of typical diagnostic menus.

| CDS G3 Interface Kit | 8M0138392 |
|---|---|

Download the **CDS G3 User's Manual** from service.mercurymarine.com for other CDS G3 diagnostic information.

The CDS G3 diagnostic interface tool is an essential platform for engine diagnostics. Use the **Module Data Screen** to view engine data and faults, then inspect and test the suspect component or circuit. Refer to **Section 4A** - **Fault Codes** of this manual for detailed fault code descriptions. Use the **Diagnostics** tab to access other diagnostic functions including: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| Name | Description | Additional Comments |
|---|---|---|
| Set Trim Limit | Adjusts the maximum trim angle allowed at engine speeds higher than 4200 RPM. | Only necessary to adjust if poor boat handling occurs prior to the factory trim limit setting. |
| Set Tilt Limit | Adjusts the maximum height that the engine is allowed to tilt up. | Only necessary if interference occurs between the engine cowl and the boat prior to the full tilt position. |
| Set Engine Location | Assigns the location of non-DTS engines on multiple engine boats. | DTS engine location will be correctly assigned during the City ID/Lever Adapt procedures. |
| Cylinder Misfire | Shuts off the fuel injector for the chosen cylinder to observe if an RPM drop occurs or not. | RPM drop will be more visible while under load. |
| Fuel Pump Output | Activates the fuel pump relay for diagnostic purposes. | |
| Horn Output | Activates the warning horn to confirm its functionality. | |

  

| Name | Description | Additional Comments |
|---|---|---|
| Ignition Spark | Activates the chosen ignition coil to allow for testing with a spark gap tester. | Since these engine utilize waste-spark, both leads on the shared coil must be grounded and will fire simultaneously. |
| Smart Start | Activates a start sequence, engine will crank and start if able. | |
| Tach Output | Sends a 3000 RPM signal on the gray analog tachometer lead to test operation of a tachometer. | |
| Injector Pulse | Activates the chosen fuel injector to diagnose functionality. | Disconnect the fuel pump and relieve fuel pressure to prevent flooding cylinders during the test. |
| Trim Relay | Activates the trim up or down relays to diagnose their functionality. | |
| Starter Output | Activates the start relay to crank the engine, without applying fuel or spark. | |
| Electronic Throttle Control Output | Allows the ETC to be manually activated to observe its operation with the engine off. | |
| Advanced Sound Control | Activates the Advanced Sound Control valve open or closed. | With the engine running, a change in the exhaust noise should be very apparent. |

  

# Notes:

  

# General Troubleshooting and CDS G3

## Section 3F - CDS G3—Module Reflash

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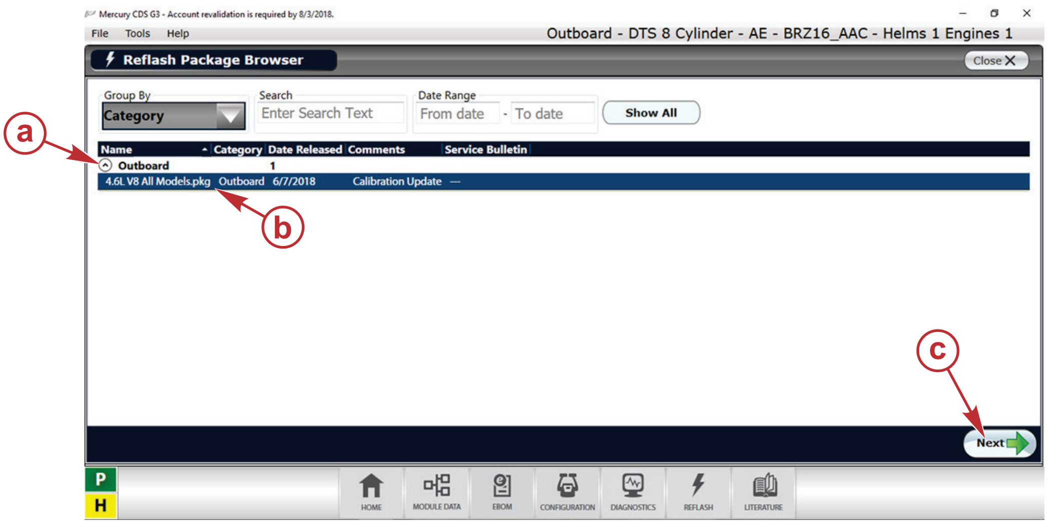
# Reflash Procedure

Mercury Marine will occasionally make changes or enhancements to its engine calibrations. The CDS G3 tool has the ability to reflash PCMs and other vessel control modules when necessary. Always make sure to keep the CDS G3 tool updated, as this will ensure that you have the latest available calibration files from Mercury.

CDS G3 will identify when an updated calibration is available for the engine it's connected to and will place a priority action item on the home screen. Select Update or select the Reflash button at the bottom of the screen.

1. The Reflash Package Browser screen will filter the available calibration for the connected engine. CDS G3 will look at the current calibration and will only allow the correct update to be made. Click the drop-down arrow, select the calibration update, and then click next at the bottom of the screen.

   **IMPORTANT: If other vessel control module updates are available such as JPO, always refer to the service bulletin referenced on the reflash package browser prior to reflashing those modules. Updating vessel control module calibrations without performing the service bulletin in its entirety may result in an inoperable vessel.**

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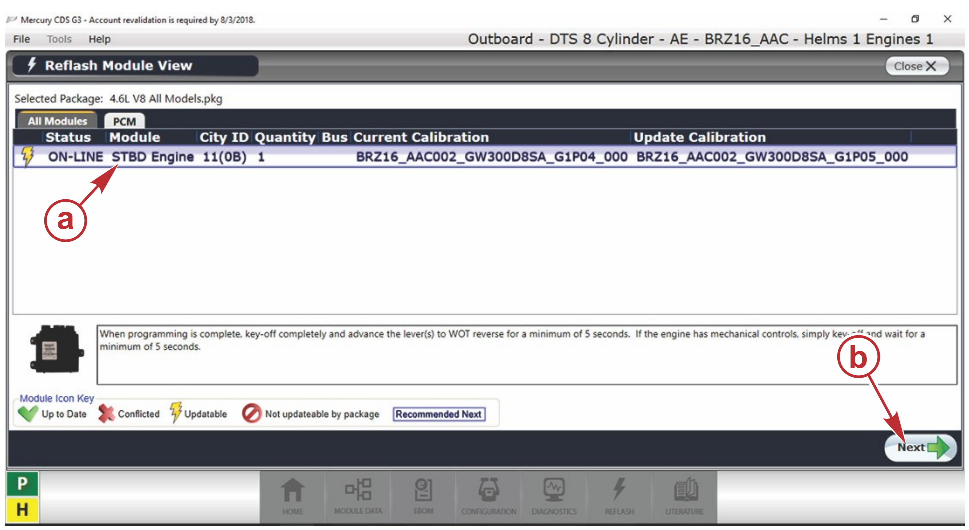
- **a -** Drop-down arrow
- **b -** Updated PCM calibration
- **c -** Next button

2. On the Reflash Prerequisites screen, ensure all parameters pass the check and then click Next.
3. Ensure the engine PCM is selected on the Reflash Module View screen, then click next at the bottom of the screen.

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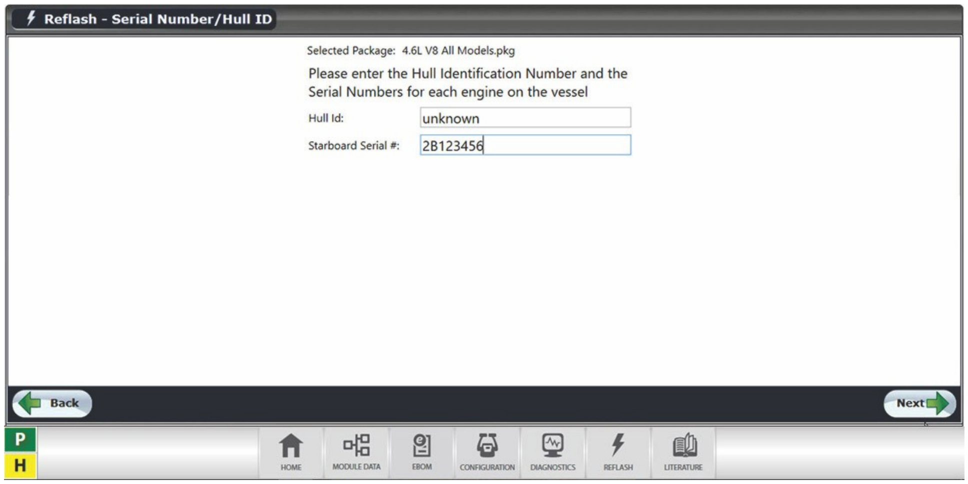
- **a -** Engine PCM selection
- **b -** Next button

4. Enter the hull ID and engine serial number on the next screen before clicking the Next button.

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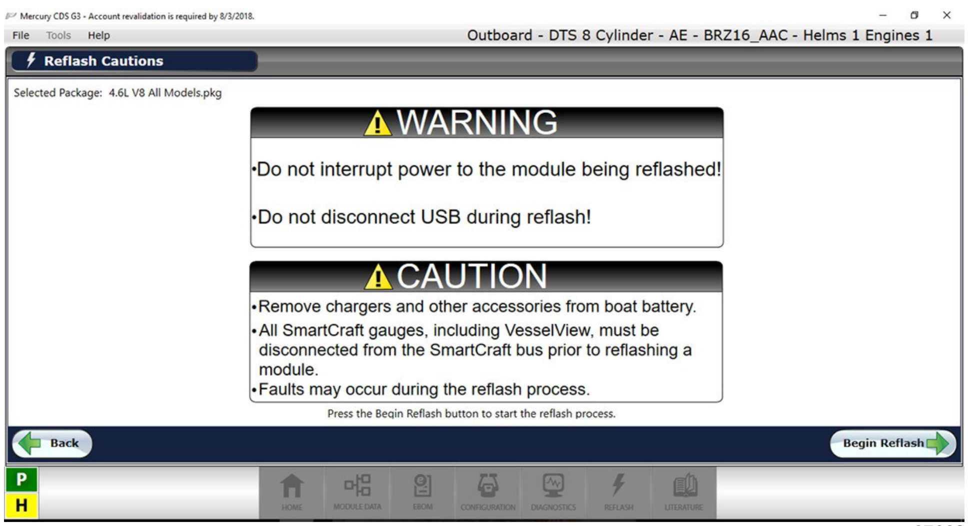
5. Read and follow the warning messages on the following screen before clicking Begin Reflash.

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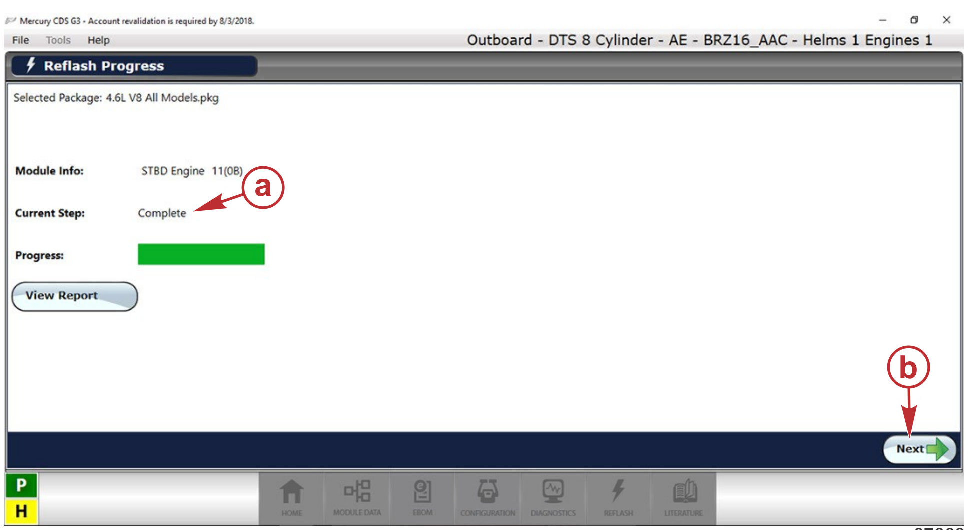
6. Once the reflash has completed, click the Next button at the bottom of the screen.

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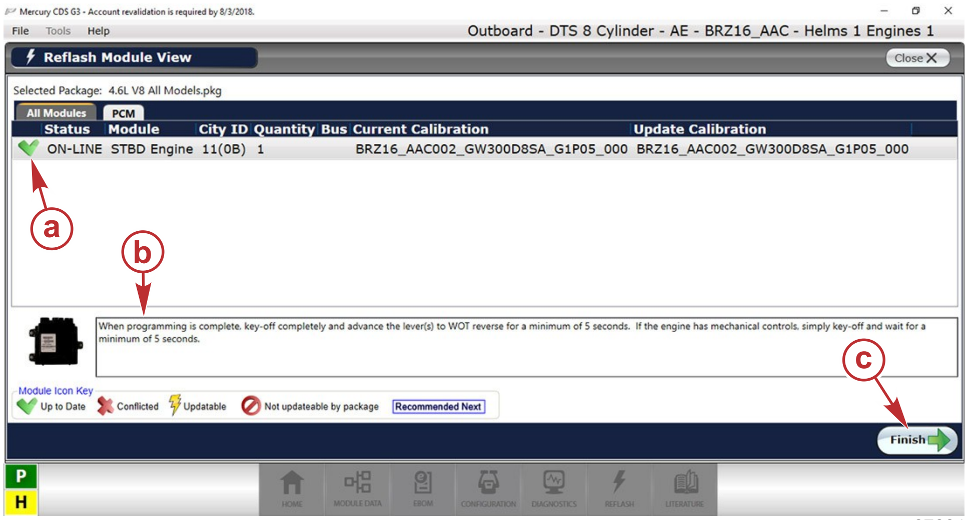
a - Complete status
b - Next button

7. The Reflash Module View screen should show a green checkmark icon. Follow the instructions to key-off and move the control lever to reverse wide-open throttle (RWOT) for at least five seconds. After turning the key back on, click the finish button.




67664

a - Green check mark

b - Key-off RWOT reminder

c - Finish button

# Fault Codes

## Section 4A - Fault Codes

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# Mercury UFC List

The following table lists every fault currently (as of this writing) enabled on Mercury V6 and V8 4-stroke outboard engines. Not all faults will apply to every model. The faults are presented in the order of their Mercury universal fault code (UFC). The columns contain the following information:

- Fault (first half of the UFC)
  - Code (3 or 4 digits)
  - Description (as presented in CDS G3)
- Failure (second half of the UFC)
  - Code (1 or 2 digits)
  - Description (as presented in CDS G3)
- PCM Fault Name - The full fault name, as displayed in CDS G3. The fault descriptions and resolutions in this section are listed alphabetically by this name.

| Fault | | Failure | | PCM Fault Name |
|---|---|---|---|---|
| Code | Description | Code | Description | |
| 0 | Fault system | 0 | The system has no active faults. | (None) |
| 101 | Ignition circuit 1 | 16 | The ECU has detected a problem when trying to output a signal to this device. | EST1_OutputFault |
| 102 | Ignition circuit 2 | 16 | The ECU has detected a problem when trying to output a signal to this device. | EST2_OutputFault |
| 103 | Ignition circuit 3 | 16 | The ECU has detected a problem when trying to output a signal to this device. | EST3_OutputFault |
| 104 | Ignition circuit 4 | 16 | The ECU has detected a problem when trying to output a signal to this device. | EST4_OutputFault |
| 201 | Fuel injector circuit 1 | 16 | The ECU has detected a problem when trying to output a signal to this device. | INJ1_OutputFault |
| 202 | Fuel injector circuit 2 | 16 | The ECU has detected a problem when trying to output a signal to this device. | INJ2_OutputFault |
| 203 | Fuel injector circuit 3 | 16 | The ECU has detected a problem when trying to output a signal to this device. | INJ3_OutputFault |
| 204 | Fuel injector circuit 4 | 16 | The ECU has detected a problem when trying to output a signal to this device. | INJ4_OutputFault |
| 205 | Fuel injector circuit 5 | 16 | The ECU has detected a problem when trying to output a signal to this device. | INJ5_OutputFault |
| 206 | Fuel injector circuit 6 | 16 | The ECU has detected a problem when trying to output a signal to this device. | INJ6_OutputFault |
| 207 | Fuel injector circuit 7 | 16 | The ECU has detected a problem when trying to output a signal to this device. | INJ7_OutputFault |
| 208 | Fuel injector circuit 8 | 16 | The ECU has detected a problem when trying to output a signal to this device. | INJ8_OutputFault |
| 301 | Throttle position sensor A | 24 | The input circuit for the sensor is above the valid limit. | TPS1_RangeHigh |
| | | 25 | The input circuit for the sensor is below the valid limit. | TPS1_RangeLow |
| 302 | Throttle position sensor B | 24 | The input circuit for the sensor is above the valid limit. | TPS2_RangeHigh |
| | | 25 | The input circuit for the sensor is below the valid limit. | TPS2_RangeLow |
| 311 | Throttle position sensors A and B | 6 | The device, calculation or process detected a fault. | Dual_TPS_Faults |
| 331 | Throttle position sensors A and B difference | 6 | The device, calculation or process detected a fault. | ETC_TPSDisagree |
| 341 | Throttle position sensor adapt A | 6 | The device, calculation or process detected a fault. | TPS1_ETC_NoAdapt |

| Fault | | Failure | | PCM Fault Name |
|---|---|---|---|---|
| Code | Description | Code | Description | |
| 342 | Throttle position sensor adapt B | 6 | The device, calculation or process detected a fault. | TPS2_ETC_NoAdapt |
| 401 | Manifold pressure sensor using time sampling | 24 | The input circuit for the sensor is above the valid limit. | MAP_Time_RangeHigh |
| | | 25 | The input circuit for the sensor is below the valid limit. | MAP_Time_RangeLow |
| 402 | Manifold pressure sensor using angle sampling | 24 | The input circuit for the sensor is above the valid limit. | MAP_Angle_RangeHigh |
| | | 25 | The input circuit for the sensor is below the valid limit. | MAP_Angle_RangeLow |
| 404 | Manifold pressure sensor and throttle position sensor A rationality | 6 | The device, calculation or process detected a fault. | MAPR_TPS1Rationality |
| 405 | Manifold pressure sensor and throttle position sensor B rationality | 6 | The device, calculation or process detected a fault. | MAPR_TPS2Rationality |
| 407 | Manifold pressure sensor barometer reading | 17 | The signal or result is outside the expected range. | BaroRange |
| 431 | Oil pressure | 21 | Relative to a specified threshold, the value is too low. | OilPress_Low |
| | | 24 | The input circuit for the sensor is above the valid limit. | OilPress_RangeHigh |
| | | 25 | The input circuit for the sensor is below the valid limit. | OilPress_RangeLow |
| 511 | Intake air temperature | 24 | The input circuit for the sensor is above the valid limit. | IAT_RangeHigh |
| | | 25 | The input circuit for the sensor is below the valid limit. | IAT_RangeLow |
| 521 | Engine coolant temperature starboard | 20 | A temperature sensor value is higher than normal. | StbdECT_Overtemp |
| | | 24 | The input circuit for the sensor is above the valid limit. | StbdECT_RangeHigh |
| | | 25 | The input circuit for the sensor is below the valid limit. | StbdECT_RangeLow |
| 531 | Oil temperature | 24 | The input circuit for the sensor is above the valid limit. | OilTemp_RangeHigh |
| | | 25 | The input circuit for the sensor is below the valid limit. | OilTemp_RangeLow |
| 572 | Bank 1 exhaust gas temperature sensor | 24 | The input circuit for the sensor is above the valid limit. | EGT_RangeHigh |
| | | 25 | The input circuit for the sensor is below the valid limit. | EGT_RangeLow |
| 601 | Sensor supply voltage A | 4 | The signal received is valid but is higher than the expected range. | XDRPa_RangeHigh |
| | | 5 | The signal received is valid but is lower than the expected range. | XDRPa_RangeLow |
| 602 | Sensor supply voltage B | 4 | The signal received is valid but is higher than the expected range. | XDRPb_RangeHigh |
| | | 5 | The signal received is valid but is lower than the expected range. | XDRPb_RangeLow |
| 603 | Sensor supply voltage C | 4 | The signal received is valid but is higher than the expected range. | XDRPc_RangeHigh |
| | | 5 | The signal received is valid but is lower than the expected range. | XDRPc_RangeLow |

| Fault | | Failure | | PCM Fault Name |
|---|---|---|---|---|
| Code | Description | Code | Description | |
| 621 | System voltage | 4 | The signal received is valid but is higher than the expected range. | SysVolt_RangeHigh |
| | | 5 | The signal received is valid but is lower than the expected range. | SysVolt_RangeLow |
| 711 | Oil level sensor | 6 | The device, calculation or process detected a fault. | OilLevel_Sensor_Faulted |
| | | 12 | The device is disabled due to conditions present. | OilLevel_Sensor_Invalid |
| | | 19 | Conditions are such that the test cannot be performed. | OilLevelInvalid |
| | | 24 | The input circuit for the sensor is above the valid limit. | OilLevel_RangeHigh |
| 713 | Crankcase oil level | 21 | Relative to a specified threshold, the value is too low. | OilLevel_Critically_Low |
| 821 | O2 sensor Port S1 | 1 | The output signal from the ECU to the device is open circuit or has too much resistance. | UEGO1_Sensor_Open |
| | | 27 | The input signal to the ECU from the device is short circuit or has too little resistance. | UEGO1_Sensor_Short |
| 822 | O2 sensor heater Port S1 | 4 | The signal received is valid but is higher than the expected range. | UEGO1_HtrUprLimit |
| | | 5 | The signal received is valid but is lower than the expected range. | UEGO1_HtrLwrLimit |
| | | 16 | The ECU has detected a problem when trying to output a signal to this device. | UEGO1_HtrOpnShrt |
| 902 | Short term fuel trim Port | 4 | The signal received is valid but is higher than the expected range. | O2Control_ITermHighPort |
| | | 5 | The signal received is valid but is lower than the expected range. | O2Control_ITermLowPort |
| 1012 | Engine or drive trim position | 24 | The input circuit for the sensor is above the valid limit. | TrimPos_RangeHigh |
| | | 25 | The input circuit for the sensor is below the valid limit. | TrimPos_RangeLow |
| 1021 | Shift position A from shift actuator | 24 | The input circuit for the sensor is above the valid limit. | ShiftPos_RangeHigh |
| | | 25 | The input circuit for the sensor is below the valid limit. | ShiftPos_RangeLow |
| 1023 | Shift position B from shift actuator | 24 | The input circuit for the sensor is above the valid limit. | ShiftPos2_RangeHigh |
| | | 25 | The input circuit for the sensor is below the valid limit. | ShiftPos2_RangeLow |
| 1024 | Shift position from shift actuator A and B difference | 6 | The device, calculation or process detected a fault. | ShiftPositionSensor_Diff |
| 1025 | Shift position A and B from shift actuator | 6 | The device, calculation or process detected a fault. | Dual_ShiftPosSen_Fault |
| 1051 | Camshaft synchronization | 23 | A particular state or condition exists. | Camshaft_Encoder_Fault |
| 1052 | Crankshaft or camshaft trigger | 6 | The device, calculation or process detected a fault. | EncoderFaultCrankCamTrigger |
| 1061 | Mechanical demand sensor A | 24 | The input circuit for the sensor is above the valid limit. | DemandSensor1_RangeHigh |
| | | 25 | The input circuit for the sensor is below the valid limit. | DemandSensor1_RangeLow |
| 1062 | Mechanical demand sensor B | 24 | The input circuit for the sensor is above the valid limit. | DemandSensor2_RangeHigh |
| | | 25 | The input circuit for the sensor is below the valid limit. | DemandSensor2_RangeLow |

  

| Fault | | Failure | | PCM Fault Name |
|---|---|---|---|---|
| Code | Description | Code | Description | |
| 1063 | Mechanical shift demand sensor A | 24 | The input circuit for the sensor is above the valid limit. | ShiftDmdSensor1_RangeHigh |
| | | 25 | The input circuit for the sensor is below the valid limit. | ShiftDmdSensor1_RangeLow |
| 1064 | Mechanical shift demand sensor A | 24 | The input circuit for the sensor is above the valid limit. | ShiftDmdSensor2_RangeHigh |
| | | 25 | The input circuit for the sensor is below the valid limit. | ShiftDmdSensor2_RangeLow |
| 1071 | Mechanical demand sensor adapt A | 6 | The device, calculation or process detected a fault. | DmdSense1_NoAdapt |
| 1072 | Mechanical demand sensor adapt B | 6 | The device, calculation or process detected a fault. | DmdSense2_NoAdapt |
| 1073 | Mechanical demand sensors A and B difference | 6 | The device, calculation or process detected a fault. | DemandSensor_Diff |
| 1074 | Mechanical demand sensors A and B | 6 | The device, calculation or process detected a fault. | Dual_DemandSen_Fault |
| 1077 | Mechanical shift demand sensors A and B difference | 6 | The device, calculation or process detected a fault. | ShiftDemandSensor_Diff |
| 1078 | Mechanical shift demand sensors A and B | 6 | The device, calculation or process detected a fault. | Dual_ShiftDemandSen_Fault |
| 1108 | Water in fuel | 25 | The input circuit for the sensor is below the valid limit. | WaterInFuel_RangeLow |
| 1109 | Emergency stop | 23 | A particular state or condition exists. | ESTOP_Active |
| 2011 | Guardian | 23 | A particular state or condition exists. | Guardian_Active |
| 2021 | Guardian due to oil temperature | 23 | A particular state or condition exists. | Guardian_Oil_Temp_Derate |
| 2032 | Guardian due to exhaust system temperature | 23 | A particular state or condition exists. | Guardian_EGTTemp |
| 2051 | Guardian due to oil pressure | 23 | A particular state or condition exists. | Guardian_OilPressure |
| 2081 | Guardian due to overheat | 23 | A particular state or condition exists. | Guardian_Overheat |
| 2091 | Guardian due to overspeed | 23 | A particular state or condition exists. | Guardian_Overspeed |
| 2092 | Neutral overspeed | 23 | A particular state or condition exists. | Neutral_Overspeed |
| 2101 | Guardian due to power limit from helm module | 23 | A particular state or condition exists. | Guardian_uXPowerLimit |
| 2111 | Guardian due to voltage | 23 | A particular state or condition exists. | Guardian_Voltage |
| 2124 | Exhaust gas temperature S2 | 20 | A temperature sensor value is higher than normal. | EGT_Overtemp |
| 3002 | Active exhaust valve | 16 | The ECU has detected a problem when trying to output a signal to this device. | AEV_OutputFault |
| 3012 | Electronic throttle control loss of control | 6 | The device, calculation or process detected a fault. | ETC_Loss_Of_Control |
| 3013 | Electronic throttle control output | 6 | The device, calculation or process detected a fault. | ETC_OutputFault |
| 3014 | Electronic throttle control sticking | 6 | The device, calculation or process detected a fault. | ETC_Sticking |
| 3031 | Electronic shift control commanded to actual position difference | 6 | The device, calculation or process detected a fault. | ESC_DesiredActualDiff |
| 3032 | Electronic shift control loss of control | 6 | The device, calculation or process detected a fault. | ESCLossOfControl |
| 3033 | Electronic shift control reverse adapt | 6 | The device, calculation or process detected a fault. | ESC_NoAdapt_Reverse |

| Fault | | Failure | | PCM Fault Name |
|---|---|---|---|---|
| Code | Description | Code | Description | |
| 3034 | Electronic shift control forward adapt | 6 | The device, calculation or process detected a fault. | ESC_NoAdapt_Forward |
| 3037 | Electronic shift control timeout | 6 | The device, calculation or process detected a fault. | ESC_TimeOut |
| 3039 | Reverse gear unavailable | 23 | A particular state or condition exists. | Loss_of_Shift_Command |
| 3049 | Hydraulic shift | 16 | The ECU has detected a problem when trying to output a signal to this device. | SHFT_OutputFault |
| 3061 | Fuel pump | 16 | The ECU has detected a problem when trying to output a signal to this device. | FULP_OutputFault |
| 3152 | Warning horn | 16 | The ECU has detected a problem when trying to output a signal to this device. | HORN_OutputFault |
| 3171 | Starter | 16 | The ECU has detected a problem when trying to output a signal to this device. | STRT_OutputFault |
| 3181 | Trim up | 16 | The ECU has detected a problem when trying to output a signal to this device. | TRMU_OutputFault |
| 3182 | Trim down | 16 | The ECU has detected a problem when trying to output a signal to this device. | TRMD_OutputFault |
| 4001 | Demand crosscheck | 6 | The device, calculation or process detected a fault. | Demand_XCheck_Diff |
| 4002 | Shift crosscheck | 6 | The device, calculation or process detected a fault. | Shift_XCheck_Diff |
| 4003 | Helm module crosscheck | 6 | The device, calculation or process detected a fault. | MicroChi_PWM_ADC |
| 4004 | CAN X Doc 01 state of health | 6 | The device, calculation or process detected a fault. | RxDoc1_SOH |
| 4005 | CAN P Doc 02 state of health | 6 | The device, calculation or process detected a fault. | RxDoc2_SOH |
| 4006 | CAN P Doc 03 state of health | 6 | The device, calculation or process detected a fault. | RxDoc3_SOH |
| 4007 | CAN X Doc 07 state of health | 6 | The device, calculation or process detected a fault. | RxDoc7_SOH |
| 4008 | CAN X Doc 09 state of health | 6 | The device, calculation or process detected a fault. | RxDoc9_SOH |
| 4009 | CAN X Doc 10 state of health | 6 | The device, calculation or process detected a fault. | RxDoc10_SOH |
| 4010 | CAN X Doc 11 state of health | 6 | The device, calculation or process detected a fault. | RxDoc11_SOH |
| 4011 | CAN bus authentication timeout | 23 | A particular state or condition exists. | AuthTimeout |
| 4012 | CAN P and CAN X state of health | 6 | The device, calculation or process detected a fault. | Dual_CAN_SOH_Faults |
| 4013 | Watchdog | 23 | A particular state or condition exists. | Watchdog_Active |
| 4014 | Watchdog module crosscheck | 6 | The device, calculation or process detected a fault. | Crosscheck_Failed |
| 4016 | Watchdog crosscheck state of health | 6 | The device, calculation or process detected a fault. | SPI_CrosscheckData_SOH |
| 4501 | Security device missing | 23 | A particular state or condition exists. | Security_Device_Missing |
| 4502 | Security locked | 23 | A particular state or condition exists. | Security_Locked |
| 4503 | Security setup | 23 | A particular state or condition exists. | Security_Setup |
| 4602 | Fault blocker system voltage | 23 | A particular state or condition exists. | SysVolt_FaultBlocker |

# CDS G3 Freeze Frame Faults

The following pages list all of the faults that could be displayed in the CDS G3 Freeze Frame window for Mercury V6/V8 4-stroke outboards. The faults are sequenced alphabetically. Where applicable, the following details are provided for each fault:

- **Fault Type** - Fault codes may be classified as sticky or nonsticky:

| Type of fault | Method to clear |
|---|---|
| Nonsticky | Clears immediately after the fault is resolved |
| Sticky | Requires a key cycle (off and on) after the fault is resolved to clear |

- **Horn** - A fault can sound the warning horn. The types of warning are critical, caution, or none. Refer to **Section 3A - Audio Warning System** for details.
- **Guardian** - The Guardian Protection System monitors critical engine functions and will reduce engine power accordingly in an attempt to keep the engine running within safe operating parameters. This is expressed as a percentage of full power on the following pages.

  IMPORTANT: **The Guardian Protection System cannot guarantee that powerhead damage will not occur when adverse operating conditions are encountered. The Guardian Protection System is designed to 1) warn the boat operator that the engine is operating under adverse conditions and 2) reduce power by limiting maximum RPM in an attempt to avoid or reduce the possibility of engine damage. The boat operator is ultimately responsible for proper engine operation.**
- **UFC** - The universal fault code (UFC) is displayed on VesselView and in some SmartCraft gauges. For a list of faults sorted by UFC, refer to **Mercury UFC List**.
- **Transmission to Helm** - This column identifies whether the fault is transmitted to the helm. Faults transmitted to the helm will be visible on the VesselView or system gauges, if equipped.
- **Freeze Frame Priority** - This column identifies the priority of the Freeze Frame fault on a scale of zero to five; "5" indicates the highest importance, "0" indicates lowest importance.
- **Explanation** - An explanation is provided for what a given fault means.
- **Possible Causes** - The most likely causes for a given fault are presented in list format.
- **Summary of Fault Correction Possibilities**

# A ..........

## AEV_OutputFault

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 3002-16 | Yes | 2 |

### Explanation

The advanced sound control actuator is not working properly.

### Possible Causes

- Wiring problem
- Defective AEV actuator

### Summary of Fault Correction Possibilities

- Inspect the wiring.
- Replace the AEV actuator.

## AuthTimeout

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 4011-23 | Yes | 2 |

### Explanation

There is a communication problem with the SmartCraft control system.

### Possible Causes

- Wiring problem

- Terminator resistor failed

### Summary of Fault Correction Possibilities

- Check the resistance of CAN P and CAN V. The resistance should be 60 ohms. Correct the wiring problem if present.

# B ..........

## BaroRange

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | None | 100% | 407-17 | No | 2 |

### Explanation

The manifold absolute pressure (MAP) sensor does not appear to be working properly.

### Possible Causes

- Restricted MAP sensor hose
- Wiring problem
- Defective MAP sensor

### Summary of Fault Correction Possibilities

- Inspect the MAP sensor hose for restrictions.
- Inspect the MAP sensor wiring.
- Replace the MAP sensor.

# C ..........

## Camshaft_Encoder_Fault

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Caution | 100% | 1051-23 | Yes | 2 |

### Explanation

The camshaft position sensor does not appear to be working properly.

### Possible Causes

- Wiring problem
- Mechanical timing problem
- Metallic debris on sensor magnet
- Sensor target damage
- Defective sensor

### Summary of Fault Correction Possibilities

- Check the wiring.
- Check the mechanical timing.
- Check the sensor for metallic debris.
- Check the sensor target for damage.
- Replace the sensor.

## Crosscheck_Failed

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Critical | 5% | 4014-6 | Yes | 2 |

### Explanation

There is a communication problem with the SmartCraft control system.

### Possible Causes

- Open or short on CAN P (blue and white wires; should measure 58–60 ohms across bottom PCM engine harness pins A11 and A21 and across command module harness pins 8 and 9) or CAN X (brown and yellow wires; should measure 58–60 ohms across bottom PCM engine harness pins A31 and A32 and across command module harness pins 6 and 7).
- Incorrect number of resistors used
- Faulty terminator resistor

### Summary of Fault Correction Possibilities

- Correct the wiring issue.
- Install the correct count of resistors.
- Replace the faulty resistor.

# D ..........

## DemandSensor1_RangeHigh

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Caution | 100% | 1061-24 | Yes | 2 |

### Explanation

The primary encoder in the throttle demand sensor does not appear to be working properly; the PCM received a signal that is above the valid limit.

### Possible Causes

- Wiring problem
- Defective sensor

### Summary of Fault Correction Possibilities

- Check the wiring.
- Replace the sensor.

## DemandSensor1_RangeLow

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Caution | 100% | 1061-25 | Yes | 2 |

### Explanation

The primary encoder in the throttle demand sensor does not appear to be working properly; the PCM received a signal that is below the valid limit.

### Possible Causes

- Wiring problem
- Defective sensor

### Summary of Fault Correction Possibilities

- Check the wiring.
- Replace the sensor.

## DemandSensor2_RangeHigh

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Caution | 100% | 1062-24 | Yes | 2 |

### Explanation

The secondary encoder in the throttle demand sensor does not appear to be working properly; the PCM received a signal that is above the valid limit.

### Possible Causes

- Wiring problem
- Defective sensor

### Summary of Fault Correction Possibilities

- Check the wiring.
- Replace the sensor.

## DemandSensor2_RangeLow

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Caution | 100% | 1062-25 | Yes | 2 |

### Explanation

The secondary encoder in the throttle demand sensor does not appear to be working properly; the PCM received a signal that is below the valid limit.

### Possible Causes

- Wiring problem
- Defective sensor

### Summary of Fault Correction Possibilities

- Check the wiring.
- Replace the sensor.

## DemandSensor_Diff

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Critical | 5% | 1073-6 | Yes | 4 |

### Explanation

The throttle demand sensor does not appear to be working properly. The difference between the primary and secondary encoder signals exceeded the valid limit.

### Possible Causes

- Wiring problem
- Defective sensor

### Summary of Fault Correction Possibilities

- Check the wiring.
- Replace the sensor.

## Demand_XCheck_Diff

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Critical | 5% | 4001-6 | Yes | 4 |

### Explanation

This fault indicates that a command module is not equal to the PCM in the cross-check of demand value.

### Possible Causes

- Incorrect positions used when configuring levers

  

- Faulty command module or PCM

### Summary of Fault Correction Possibilities

- Reconfigure the vessel.
- Replace the modules.

## DmdSense1_NoAdapt

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 1071-6 | Yes | 2 |

### Explanation

The primary encoder in the throttle demand sensor does not appear to be working properly.

### Possible Causes

- Wiring problem
- Throttle cable out of adjustment
- Defective sensor

### Summary of Fault Correction Possibilities

- Check the wiring.
- Check the throttle cable adjustment.
- Replace the sensor.

## DmdSense2_NoAdapt

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 1072-6 | Yes | 2 |

### Explanation

The secondary encoder in the throttle demand sensor does not appear to be working properly.

### Possible Causes

- Wiring problem
- Throttle cable out of adjustment
- Defective sensor

### Summary of Fault Correction Possibilities

- Check the wiring.
- Check the throttle cable adjustment.
- Replace the sensor.

## Dual_CAN_SOH_Faults

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Critical | 5% | 4012-6 | Yes | 4 |

### Explanation

This fault indicates that communication between the helm and the PCM has been lost. There is a discrepancy between CAN circuits.

*NOTE: The engine is locked in whichever gear it was in when the fault occurred.*

### Possible Causes

- Open or short on CAN P (blue and white wires; should measure 58–60 ohms across bottom PCM engine harness pins A11 and A21 and across command module harness pins 8 and 9) or CAN X (brown and yellow wires; should measure 58–60 ohms across bottom PCM engine harness pins A31 and A32 and across command module harness pins 6 and 7).

  

- Faulty terminator resistor

### Summary of Fault Correction Possibilities

- Correct the wiring problem.
- Install the correct count of resistors.
- Replace the faulty resistor.

## Dual_DemandSen_Fault

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Critical | 5% | 1074-6 | Yes | 4 |

### Explanation

The throttle demand sensor does not appear to be working properly.

### Possible Causes

- Wiring problem
- Defective sensor

### Summary of Fault Correction Possibilities

- Repair the wiring.
- Replace the sensor.

## Dual_ShiftDemandSen_Fault

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Critical | 5% | 1078-6 | Yes | 4 |

### Explanation

The shift demand sensor does not appear to be working properly.

### Possible Causes

- Wiring problem
- Defective sensor

### Summary of Fault Correction Possibilities

- Repair the wiring.
- Replace the sensor.

## Dual_ShiftPosSen_Fault

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Critical | 100% | 1025-6 | Yes | 4 |

### Explanation

The shift position sensors do not appear to be working properly.

### Possible Causes

- Shift actuator wiring problem
- Failed shift actuator

### Summary of Fault Correction Possibilities

- Inspect the wiring to the shift actuator.
- Replace the shift actuator.

## Dual_TPS_Faults

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Critical | 7% | 311-6 | Yes | 4 |

### Explanation

The throttle position sensors (TPS) do not agree.

### Possible Causes

- ETC wiring problem
- Failed throttle body assembly

### Summary of Fault Correction Possibilities

- Inspect the wiring to the ETC.
- Replace the throttle body assembly.

# E ..........

## EGT_Overtemp

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Critical | 10% | 2124-20 | Yes | 4 |

### Explanation

The value from the exhaust gas temperature (EGT) sensor is higher than normal, indicating that the exhaust manifold is overheating.

### Possible Causes

- Restricted water flow
- Plugged exhaust sprayer
- Wiring problem
- Defective sensor

### Summary of Fault Correction Possibilities

- Restore the water flow.
- Remove debris from the sprayer.
- Inspect the wiring.
- Check the sensor, replace if required.

## EGT_RangeHigh

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 572-24 | Yes | 2 |

### Explanation

The exhaust gas temperature (EGT) sensor does not appear to be working properly; the PCM received a signal that is above the valid limit.

### Possible Causes

- Wiring problem
- Defective sensor

### Summary of Fault Correction Possibilities

- Inspect the wiring to the sensor.
- Check the sensor.
- Check the exhaust sprayer outlets for obstructions.

  

## EGT_RangeLow

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 572-25 | Yes | 2 |

### Explanation

The exhaust gas temperature (EGT) sensor does not appear to be working properly; the PCM received a signal that is below the valid limit.

### Possible Causes

- Wiring problem
- Defective sensor

### Summary of Fault Correction Possibilities

- Inspect the wiring.
- Check the sensor, replace if required.

## ESCLossOfControl

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Critical | 5% | 3032-6 | Yes | 4 |

### Explanation

The shift actuator does not appear to be working properly.

### Possible Causes

- Wiring problem
- Worn linkage between shift shaft and shift actuator
- Worn gearcase components
- Faulty shift actuator

### Summary of Fault Correction Possibilities

- Correct the wiring problem.
- Replace the worn shift linkage components.
- Replace the worn gearcase components.
- Replace the shift actuator.

## ESC_DesiredActualDiff

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Critical | 5% | 3031-6 | Yes | 4 |

### Explanation

The shift position reading at the helm ERC does not match the shift actuator position of the engine.

### Possible Causes

- Wiring problem
- Worn linkage between shift shaft and shift actuator
- Worn gearcase components
- Faulty shift actuator

### Summary of Fault Correction Possibilities

- Correct the wiring problem.
- Replace the worn shift linkage components.

  

- Replace the worn gearcase components.
- Replace the shift actuator.

## ESC_NoAdapt_Forward

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 3034-6 | Yes | 2 |

### Explanation

The shift actuator does not appear to be working properly.

### Possible Causes

- Wiring problem
- Worn linkage between shift shaft and shift actuator
- Worn gearcase components
- Faulty shift actuator

### Summary of Fault Correction Possibilities

- Correct the wiring problem.
- Replace the worn shift linkage components.
- Replace the worn gearcase components.
- Replace the shift actuator.

## ESC_NoAdapt_Reverse

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 3033-6 | Yes | 2 |

### Explanation

The shift actuator does not appear to be working properly.

### Possible Causes

- Wiring problem
- Worn linkage between shift shaft and shift actuator
- Worn gearcase components
- Faulty shift actuator

### Summary of Fault Correction Possibilities

- Correct the wiring problem.
- Replace the worn shift linkage components.
- Replace the worn gearcase components.
- Replace the shift actuator.

## ESC_TimeOut

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Critical | 100% | 3037-6 | Yes | 2 |

### Explanation

This fault indicates that the shift actuator has not physically moved with respect to the control lever (demand) position. This can also denote the PCM is constantly trying to adjust the ESC because it is falling out of the adapted position. If the ESC tries to continuously adjust, the PCM will time out the circuit. This fault is most prevalent under high torque use.

### Possible Causes

- Wiring problem

  

- Worn linkage between shift shaft and shift actuator
- Worn gearcase components
- Faulty shift actuator

### Summary of Fault Correction Possibilities

- Correct the wiring problem.
- Replace the worn shift linkage components.
- Replace the worn gearcase components.
- Replace the shift actuator.

## EST1_OutputFault

## EST2_OutputFault

## EST3_OutputFault

## EST4_OutputFault

The following information applies to **EST1_OutputFault**, **EST2_OutputFault**, **EST3_OutputFault**, and **EST4_OutputFault**.

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 101-16, 102-16, 103-16, 104-16 | Yes | 2 |

### Explanation

The respective ignition coil (1, 2, 3, or 4) does not appear to be working properly; the PCM detected a problem when trying to send a signal to this coil.

### Possible Causes

- Air in the fuel system
- Fouled spark plug
- Failed spark plug wire
- Failed ignition coil
- Damaged wiring to ignition coil

### Summary of Fault Correction Possibilities

- Purge the fuel system of air.
- Replace the spark plugs.
- Inspect the spark plug wires.
- Replace the ignition coil.
- Repair the wiring to the ignition coil.

## ESTOP_Active

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 1109-23 | Yes | 1 |

### Explanation

This fault indicates that an E-stop has been activated. The engine will power up, but the PCM will disregard a start command.

### Possible Causes

- Lanyard has been activated or the circuit is shorted
- DTS (if equipped) calibration has not been correctly completed
- Failed command module

### Summary of Fault Correction Possibilities

- Deactivate the lanyard or troubleshoot the circuit (locate and correct the short).

  

- Calibrate the DTS system (if equipped).
- Replace the command module.

## ETC_Loss_Of_Control

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Critical | 7% | 3012-6 | Yes | 4 |

### Explanation

The throttle position sensor (TPS) signals indicate that the actual throttle plate position does not match where the PCM thinks it should be.

### Possible Causes

- If this fault was triggered while the engine was in the stall state, the fault was created due to a lack of battery voltage, most likely due to a battery switch being off while the key was turned to the run position.
- ETC components failed

### Summary of Fault Correction Possibilities

- Check the throttle position sensor (TPS) values and throttle % with CDS G3.
- Check the connections and pins at the electronic throttle control (ETC).
- Inspect the ETC wiring for chaffing, opens, or a short.
- Check for obstructions at the ETC plate.

## ETC_OutputFault

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Critical | 7% | 3013-6 | Yes | 3 |

### Explanation

The electronic throttle control (ETC) does not appear to be working properly.

### Possible Causes

- If this fault was triggered while the engine was in the stall state, the fault was created due to a lack of battery voltage, most likely due to a battery switch being off while the key was turned to the run position.
- ETC components failed

### Summary of Fault Correction Possibilities

- Check the throttle position sensor (TPS) values and throttle % with CDS G3.
- Check the connections and pins at the electronic throttle control (ETC).
- Inspect the ETC wiring for chafing, opens, or a short.
- Check for obstructions at the ETC plate.

## ETC_Sticking

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Critical | 7% | 3014-6 | Yes | 4 |

### Explanation

The electronic throttle control (ETC) does not appear to be working properly.

### Possible Causes

- Obstruction in the throttle body assembly
- Wiring problem
- Defective ETC

  

### Summary of Fault Correction Possibilities

- Remove the obstruction from the throttle body assembly.
- Correct the wiring problem.
- Replace the throttle body assembly.

## ETC_TPSDisagree

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Critical | 7% | 331-6 | Yes | 4 |

### Explanation

The throttle position sensors do not agree.

### Possible Causes

- Wiring problem
- Failed ETC

### Summary of Fault Correction Possibilities

- Repair the wiring problem.
- Replace the throttle body assembly.

## EncoderFaultCrankCamTrigger

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Critical | 100% | 1052-6 | Yes | 3 |

### Explanation

Either the crankshaft position sensor (CPS) or the camshaft position sensor does not appear to be working properly.

### Possible Causes

- Wiring problem
- Defective crankshaft position sensor
- Defective camshaft position sensor
- Mechanical timing problem

### Summary of Fault Correction Possibilities

- Correct the wiring problem.
- Inspect the crankshaft position sensor.
- Inspect the camshaft position sensor.
- Correct the mechanical timing problem.

# F ..........

## FULP_OutputFault

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Critical | 100% | 3061-16 | Yes | 3 |

### Explanation

The fuel pump does not appear to be working properly. The PCM detected a problem when trying to send a signal to the fuel pump relay.

### Possible Causes

- Fuel pump relay wiring problem
- Failed fuel pump relay

  

### Summary of Fault Correction Possibilities

- Correct the wiring problem.
- Replace the fuel pump relay.

# G ..........

## Guardian_Active

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | None | 100% | 2011-23 | Yes | 4 |

### Explanation

This fault indicates that engine power is being limited by another fault. Check **Guardian Due to:** on **Live Data** for the cause. This fault will disappear when other faults are resolved.

### Possible Causes

- Active fault

### Summary of Fault Correction Possibilities

- Refer to **Section 3A** - **Troubleshooting MFD Faults**, or review the specific fault that is listed in CDS G3.

## Guardian_EGTTemp

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | Variable | 2032-23 | Yes | 4 |

### Explanation

Engine Guardian is active due to exhaust overtemperature. Power will be limited to prevent engine damage.

### Possible Causes

- Restricted water pickup
- Low cooling water flow
- Restricted or plugged exhaust water sprayer
- Sensor wiring problem
- Defective sensor

### Summary of Fault Correction Possibilities

- Clear/unclog the water pickup.
- Correct the cooling water flow problem.
- Clean the exhaust water sprayer.
- Correct the wiring problem.
- Replace the sensor.

## Guardian_OilPressure

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | Variable | 2051-23 | Yes | 4 |

### Explanation

Engine Guardian is active due to low oil pressure. Power will be limited to prevent engine damage.

### Possible Causes

- Low engine oil
- Sensor wiring problem
- Defective sensor

- Restricted oil pickup
- Mechanical problem in lubrication system

### Summary of Fault Correction Possibilities

- Fill the engine with oil.
- Correct the wiring problem.
- Replace the sensor.
- Inspect the oil pump pickup screen.
- Check the mechanical oil pressure.
- Check the bearing clearances, oil pump, and oil pump relief valve.

## Guardian_Oil_Temp_Derate

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | Variable | 2021-23 | Yes | 4 |

### Explanation

Engine Guardian is active due to excessively high or low oil temp. Power will be limited to prevent engine damage.

### Possible Causes

- Low engine oil
- High engine coolant temperature
- Sensor wiring problem
- Defective sensor

### Summary of Fault Correction Possibilities

- Fill the engine with oil.
- Repair the cooling system.
- Correct the wiring problem.
- Replace the sensor.

## Guardian_Overheat

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | Variable | 2081-23 | Yes | 4 |

### Explanation

Engine Guardian is active due to engine overtemperature. Power will be limited to prevent engine damage.

### Possible Causes

- Restricted water flow
- Restricted thermostat
- Blockage in cooling system
- Damaged water pump impeller

### Summary of Fault Correction Possibilities

- Flush the cooling system.
- Inspect the thermostat.
- Inspect the cooling system.
- Inspect the water pump impeller.

  

## Guardian_Overspeed

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | None | 100% | 2091-23 | No | 4 |

### Explanation

Engine Guardian is active due to excessive engine speed.

### Possible Causes

- Engine is improperly propped
- Engine is mounted too high
- Engine is being trimmed too high
- Propeller is cavitating

### Summary of Fault Correction Possibilities

- Install the correct propeller on the engine.
- Correct the installation issues.
- Refrain from trimming engine too high.
- Test with alternate propeller.

## Guardian_uXPowerLimit

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | None | Variable | 2101-23 | Yes | 4 |

### Explanation

Engine Guardian is active due to a helm fault. Power will be limited as the control system may be compromised.

### Possible Causes

- The command module has detected an issue and has enacted Guardian

### Summary of Fault Correction Possibilities

- Use the CDS G3 diagnostic tool to read the command module faults.
- Refer to the **DTS Diagnostic Manual P/N 8M0057654** for fault explanations.

## Guardian_Voltage

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | Variable | 2111-23 | Yes | 4 |

### Explanation

Engine Guardian is active due to high or low battery voltage. Power will be limited to prevent engine damage.

### Possible Causes

- Failed alternator
- Failed fusible link

### Summary of Fault Correction Possibilities

- Replace the alternator.
- Replace the fusible link.

  

# H ..........

## HORN_OutputFault

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | None | 100% | 3152-16 | Yes | 2 |

### Explanation

The warning horn does not appear to be working properly; the PCM detected a problem when trying to send a signal to the horn.

### Possible Causes

- Wiring problem
- Failed horn

### Summary of Fault Correction Possibilities

- Inspect the wiring to the helm.
- Replace the horn.

# I ..........

## IAT_RangeHigh

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 511-24 | Yes | 2 |

### Explanation

The intake air temperature (IAT) sensor does not appear to be working properly; the PCM received a signal that is above the valid limit.

### Possible Causes

- Wiring problem
- Defective sensor

### Summary of Fault Correction Possibilities

- Correct the sensor wiring problem.
- Replace the sensor.

## IAT_RangeLow

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 511-25 | Yes | 2 |

### Explanation

The intake air temperature (IAT) sensor does not appear to be working properly; the PCM received a signal that is below the valid limit.

### Possible Causes

- Wiring problem
- Defective sensor

### Summary of Fault Correction Possibilities

- Correct the sensor wiring problem.
- Replace the sensor.

# INJ1_OutputFault

# INJ2_OutputFault

# INJ3_OutputFault

# INJ4_OutputFault

# INJ5_OutputFault

# INJ6_OutputFault

# INJ7_OutputFault

# INJ8_OutputFault

The following information applies to **INJ1_OutputFault**, **INJ2_OutputFault**, **INJ3_OutputFault**, **INJ4_OutputFault**, **INJ5_OutputFault**, **INJ6_OutputFault**, **INJ7_OutputFault**, and **INJ8_OutputFault**.

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 201-16, 202-16, 203-16, 204-16, 205-16, 206-16, 207-16, 208-16 | Yes | 2 |

## Explanation

The respective fuel injector does not appear to be working properly; the PCM detected a problem when trying to send a signal to the indicated injector.

## Possible Causes

- Wiring problem
- Failed fuel injector

## Summary of Fault Correction Possibilities

- Correct the fuel injector wiring problem.
- Replace the fuel injector.

# L ..........

# Loss_of_Shift_Command

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Critical | 14% | 3039-23 | Yes | 3 |

## Explanation

Reverse gear is not available. Moving the control lever into reverse will result in a forward gear shift. Power will be limited to prevent engine damage.

## Possible Causes

- Shift demand sensor wiring problem
- Failed shift demand sensor

## Summary of Fault Correction Possibilities

- Correct the shift demand sensor wiring problem.
- Replace the shift demand sensor.

# M ..........

## MAP_Angle_RangeHigh

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | None | 100% | 402-24 | No | 1 |

### Explanation

The manifold absolute pressure (MAP) sensor does not appear to be working properly; the PCM received a signal that is above the valid limit.

### Possible Causes

- Sensor out of range
- Wiring problem
- Restricted sensor reference hose
- Valve train issue

### Summary of Fault Correction Possibilities

- Replace the sensor.
- Correct the wiring problem.
- Check the reference hose for leaks.
- Check the cylinder leak down.

## MAP_Angle_RangeLow

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | None | 100% | 402-25 | No | 1 |

### Explanation

The manifold absolute pressure (MAP) sensor does not appear to be working properly; the PCM received a signal that is below the valid limit.

### Possible Causes

- Sensor out of range
- Wiring problem
- Restricted sensor reference hose
- Valve train issue

### Summary of Fault Correction Possibilities

- Replace the sensor.
- Correct the wiring problem.
- Check the reference hose for leaks.
- Check the cylinder leak down.

## MAP_Time_RangeHigh

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 401-24 | Yes | 2 |

### Explanation

The manifold absolute pressure (MAP) sensor does not appear to be working properly; the PCM received a signal that is above the valid limit.

### Possible Causes

- Sensor out of range
- Wiring problem

  

- Restricted sensor reference hose
- Valve train issue

### Summary of Fault Correction Possibilities

- Replace the sensor.
- Correct the wiring problem.
- Check the reference hose for leaks.
- Check the cylinder leak down.

## MAP_Time_RangeLow

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 401-25 | Yes | 2 |

### Explanation

The manifold absolute pressure (MAP) sensor does not appear to be working properly; the PCM received a signal that is below the valid limit.

### Possible Causes

- Sensor out of range
- Wiring problem
- Restricted sensor reference hose
- Valve train issue

### Summary of Fault Correction Possibilities

- Replace the sensor.
- Correct the wiring problem.
- Check the reference hose for leaks.
- Check the cylinder leak down.

## MAPR_TPS1Rationality

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 404-6 | Yes | 2 |

### Explanation

The values received from the manifold absolute pressure (MAP) sensor and the primary encoder in the throttle position sensor (TPS) do not agree.

### Possible Causes

- MAP or ETC wiring problem
- ETC opening is restricted or airflow to the engine is restricted
- Intake manifold has vacuum leak
- MAP sensor or ETC is failed

### Summary of Fault Correction Possibilities

- Correct the MAP sensor or ETC wiring problem.
- Inspect the cold air intake assembly for obstructions.
- Inspect the intake manifold for air leaks.
- Replace the MAP sensor or throttle body assembly.

  

## MAPR_TPS2Rationality

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 405-6 | Yes | 2 |

### Explanation

The values received from the manifold absolute pressure (MAP) sensor and the secondary encoder in the throttle position sensor (TPS) do not agree.

### Possible Causes

- MAP or ETC wiring problem
- ETC opening is restricted or airflow to the engine is restricted
- Intake manifold has vacuum leak
- MAP sensor or ETC is failed

### Summary of Fault Correction Possibilities

- Correct the MAP sensor or ETC wiring problem.
- Inspect the cold air intake assembly for obstructions.
- Inspect the intake manifold for air leaks.
- Replace the MAP sensor or throttle body assembly.

## MicroChi_PWM_ADC

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Critical | 5% | 4003-6 | Yes | 4 |

### Explanation

There is a communication problem with the SmartCraft control system.

### Possible Causes

- Wiring problem
- Clean power issue
- Failed command module

### Summary of Fault Correction Possibilities

- Inspect the helm wiring.
- Inspect the clean power harness.
- Replace the command module.

# N ..........

## Neutral_Overspeed

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | None | 100% | 2092-23 | No | 1 |

### Explanation

Engine speed is above specified limits with the engine in neutral.

### Possible Causes

- Engine is not in gear
- Shift demand sensor failed

### Summary of Fault Correction Possibilities

- Shift the engine into gear.
- Inspect the shift demand sensor.

  

# O ..........

## O2Control_ITermHighPort

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | None | 100% | 902-4 | No | 5 |

### Explanation

The fuel system does not appear to be working properly; the PCM received a signal from the oxygen sensor that is valid, but is higher than expected. The system has added fuel up to its allowable limit.

### Possible Causes

- Low fuel rail pressure
- Restricted fuel injectors
- Intake manifold vacuum leak

### Summary of Fault Correction Possibilities

- Correct the fuel pressure issues.
- Service the fuel injectors.
- Correct the intake manifold vacuum leak.

## O2Control_ITermLowPort

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | None | 100% | 902-5 | No | 5 |

### Explanation

The fuel system does not appear to be working properly; the PCM received a signal from the oxygen sensor that is valid, but is lower than expected. The system has removed fuel up to its allowable limit.

### Possible Causes

- High fuel rail pressure
- Leaking fuel injectors
- Fuel being introduced from another source

### Summary of Fault Correction Possibilities

- Correct the fuel rail pressure.
- Service the fuel injectors.
- Investigate the source of the additional fuel.

## OilLevelInvalid

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | None | 100% | 711-19 | No | 2 |

### Explanation

The engine oil level could not be determined.

### Possible Causes

- Engine temperature too high to read oil level
- Engine trimmed too high to read oil level

### Summary of Fault Correction Possibilities

- Allow the engine to cool down.
- Trim the engine down.

  

## OilLevel_Critically_Low

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 713-21 | Yes | 2 |

### Explanation

The engine oil level appears to be low; the PCM received a signal from the oil level sensor that is lower than the specified threshold.

### Possible Causes

- Engine oil level low
- Wiring problem
- Defective sensor

### Summary of Fault Correction Possibilities

- Add engine oil.
- Inspect the wiring to the sensor, and repair as necessary.
- Replace the sensor.

## OilLevel_RangeHigh

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 711-24 | Yes | 2 |

### Explanation

The engine oil level sensor does not appear to be working properly; the PCM received a signal that is above the valid limit.

### Possible Causes

- Wiring problem
- Defective sensor

### Summary of Fault Correction Possibilities

- Inspect the wiring to the sensor, and repair as necessary.
- Replace the sensor.

## OilLevel_Sensor_Faulted

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 711-6 | Yes | 2 |

### Explanation

The engine oil level sensor does not appear to be working properly.

### Possible Causes

- Wiring problem
- Defective sensor

### Summary of Fault Correction Possibilities

- Inspect the wiring to the sensor, and repair as necessary.
- Replace the sensor.

  

# OilLevel_Sensor_Invalid

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | None | 100% | 711-12 | No | 2 |

## Explanation

The engine oil level sensor does not appear to be working properly.

## Possible Causes

- Wiring problem
- Defective sensor

## Summary of Fault Correction Possibilities

- Inspect the wiring to the sensor, and repair as necessary.
- Replace the sensor.

# OilPress_Low

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Critical | 5% | 431-21 | Yes | 4 |

## Explanation

The engine oil pressure appears to be low; the PCM received a signal from the oil pressure sensor that is lower than the specified threshold.

## Possible Causes

- Low oil level
- Wiring problem
- Defective sensor
- Oil pickup restricted
- Mechanical problem in powerhead/oil pump

## Summary of Fault Correction Possibilities

- Add engine oil.
- Inspect the wiring to the sensor, and repair as necessary.
- Replace the sensor.
- Check the oil pickup tube and screen for obstructions.
- Inspect the powerhead/oil pump.

# OilPress_RangeHigh

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 431-24 | Yes | 2 |

## Explanation

The oil pressure sensor does not appear to be working properly; the PCM received a signal that is above the valid limit.

## Possible Causes

- Wiring problem
- Defective sensor

## Summary of Fault Correction Possibilities

- Inspect the wiring to the sensor, and repair as necessary.
- Replace the sensor.

  

## OilPress_RangeLow

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 431-25 | Yes | 2 |

### Explanation

The oil pressure sensor does not appear to be working properly; the PCM received a signal that is below the valid limit.

### Possible Causes

- Wiring problem
- Failed sensor

### Summary of Fault Correction Possibilities

- Inspect the wiring to the sensor, and repair as necessary.
- Replace the sensor.

## OilTemp_RangeHigh

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 531-24 | Yes | 2 |

### Explanation

The oil temperature sensor does not appear to be working properly; the PCM received a signal that is above the valid limit.

### Possible Causes

- Wiring problem
- Defective sensor

### Summary of Fault Correction Possibilities

- Inspect the wiring to the sensor, and repair as necessary.
- Replace the sensor.

## OilTemp_RangeLow

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 531-25 | Yes | 2 |

### Explanation

The oil temperature sensor does not appear to be working properly; the PCM received a signal that is below the valid limit.

### Possible Causes

- Wiring problem
- Defective sensor

### Summary of Fault Correction Possibilities

- Inspect the wiring to the sensor, and repair as necessary.
- Replace the sensor.

# R ..........

## RxDoc1_SOH

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Critical | 100% | 4004-6 | Yes | 3 |

### Explanation

There is a circuit problem on CAN X.

### Possible Causes

- Open or short on CAN X (brown and yellow wires)
- Faulty terminator resistor

  *NOTE: Resistance across the bottom PCM engine harness pins A31 and A32 and across command module harness pins 6 and 7 should measure 58–60 ohms. Resistance across pins A31 and A32 at the PCM should show approximately 37.1K ohms. Resistance across the command module pins 6 and 7 should show approximately 37.1K ohms.*

### Summary of Fault Correction Possibilities

- Repair the open or short on CAN X (brown and yellow wires).
- Replace the terminator resistor.
- Replace the command module.

## RxDoc2_SOH

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 4005-6 | Yes | 2 |

### Explanation

There is a circuit problem with CAN P.

### Possible Causes

- Open or short on CAN P (blue and white wires)
- Faulty terminator resistor

  *NOTE: Resistance across the bottom PCM engine harness pins A11 and A21 and across command module harness pins 8 and 9 should measure 58–60 ohms. Resistance across pins A11 and A21 at the PCM should show approximately 37.1K ohms. Resistance across the command module pins 8 and 9 should show approximately 37.1K ohms.*

### Summary of Fault Correction Possibilities

- Repair the open or short on CAN P (blue and white wires).
- Replace the terminator resistor.
- Replace the command module.

## RxDoc3_SOH

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Critical | 100% | 4006-6 | Yes | 3 |

### Explanation

There is a circuit problem with CAN P.

### Possible Causes

- Open or short on CAN P (blue and white wires)
- Faulty terminator resistor

  *NOTE: Resistance across the bottom PCM engine harness pins A11 and A21 and across command module harness pins 8 and 9 should measure 58–60 ohms. Resistance across pins A11 and A21 at the PCM should show approximately 37.1K ohms. Resistance across the command module pins 8 and 9 should show approximately 37.1K ohms.*

### Summary of Fault Correction Possibilities

- Repair the open or short on CAN P (blue and white wires).
- Replace the terminator resistor.
- Replace the command module.

  

# RxDoc7_SOH

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Critical | 100% | 4007-6 | Yes | 3 |

## Explanation

There is a circuit problem on CAN X.

## Possible Causes

- Open or short on CAN X (brown and yellow wires)
- Faulty terminator resistor

  *NOTE: Resistance across the bottom PCM engine harness pins A31 and A32 and across command module harness pins 6 and 7 should measure 58–60 ohms. Resistance across pins A31 and A32 at the PCM should show approximately 37.1K ohms. Resistance across the command module pins 6 and 7 should show approximately 37.1K ohms.*

## Summary of Fault Correction Possibilities

- Repair the open or short on CAN X (brown and yellow wires).
- Replace the terminator resistor.
- Replace the command module.

# RxDoc9_SOH

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Critical | 100% | 4008-6 | Yes | 3 |

## Explanation

There is a circuit problem on CAN X.

## Possible Causes

- Open or short on CAN X (brown and yellow wires)
- Faulty terminator resistor

  *NOTE: Resistance across the bottom PCM engine harness pins A31 and A32 and across command module harness pins 6 and 7 should measure 58–60 ohms. Resistance across pins A31 and A32 at the PCM should show approximately 37.1K ohms. Resistance across the command module pins 6 and 7 should show approximately 37.1K ohms.*

## Summary of Fault Correction Possibilities

- Repair the open or short on CAN X (brown and yellow wires).
- Replace the terminator resistor.
- Replace the command module.

# RxDoc10_SOH

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Critical | 100% | 4009-6 | Yes | 3 |

## Explanation

There is a circuit problem on CAN X.

## Possible Causes

- Open or short on CAN X (brown and yellow wires)
- Faulty terminator resistor

  *NOTE: Resistance across the bottom PCM engine harness pins A31 and A32 and across command module harness pins 6 and 7 should measure 58–60 ohms. Resistance across pins A31 and A32 at the PCM should show approximately 37.1K ohms. Resistance across the command module pins 6 and 7 should show approximately 37.1K ohms.*

  

### Summary of Fault Correction Possibilities

- Repair the open or short on CAN X (brown and yellow wires).
- Replace the terminator resistor.
- Replace the command module.

## RxDoc11_SOH

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 4010-6 | Yes | 3 |

### Explanation

There is a circuit problem on CAN X.

### Possible Causes

- Open or short on CAN X (brown and yellow wires)
- Faulty terminator resistor

  ***NOTE:*** *Resistance across the bottom PCM engine harness pins A31 and A32 and across command module harness pins 6 and 7 should measure 58–60 ohms. Resistance across pins A31 and A32 at the PCM should show approximately 37.1K ohms. Resistance across the command module pins 6 and 7 should show approximately 37.1K ohms.*

### Summary of Fault Correction Possibilities

- Repair the open or short on CAN X (brown and yellow wires).
- Replace the terminator resistor.
- Replace the command module.

# S ..........

## Security_Device_Missing

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | None | 100% | 4501-23 | No | 3 |

### Explanation

The security device is missing or is providing no reading.

### Possible Causes

- Device offline
- Wiring problem

### Summary of Fault Correction Possibilities

- Inspect the device connectors.
- Inspect the wiring, and repair as necessary.

## Security_Locked

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | None | 5% | 4502-23 | No | 4 |

### Explanation

The security device is locked.

### Possible Causes

- Device fob incorrect
- Wiring problem

### Summary of Fault Correction Possibilities

- Use the correct fob.
- Inspect the wiring, and repair as necessary.
- Repeat the system setup.

## Security_Setup

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | None | 5% | 4503-23 | No | 4 |

### Explanation

The security device is not set up.

### Possible Causes

- Setup not completed

### Summary of Fault Correction Possibilities

- Set up security system.

## SHFT_OutputFault

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Critical | 100% | 3049-16 | Yes | 3 |

### Explanation

The shift actuator does not appear to be working properly; the PCM detected a problem when trying to send a signal to the actuator.

### Possible Causes

- Wiring problem
- Shift actuator failed
- Gearcase problem

### Summary of Fault Correction Possibilities

- Inspect the wiring to the shift actuator, repair as necessary.
- Replace the shift actuator.
- Inspect the gearcase for free shifting.

## ShiftDemandSensor_Diff

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Critical | 5% | 1077-6 | Yes | 4 |

### Explanation

The shift demand sensor does not appear to be working properly.

### Possible Causes

- Wiring problem
- Defective sensor

### Summary of Fault Correction Possibilities

- Correct the wiring problem.
- Replace the sensor.

  

## ShiftDmdSensor1_RangeHigh

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Caution | 100% | 1063-24 | Yes | 2 |

### Explanation

The primary encoder in the shift demand sensor does not appear to be working properly; the PCM received a signal that is above the valid limit.

### Possible Causes

- Wiring problem
- Defective sensor

### Summary of Fault Correction Possibilities

- Correct the wiring problem.
- Replace the sensor.

## ShiftDmdSensor1_RangeLow

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Caution | 100% | 1063-25 | Yes | 2 |

### Explanation

The primary encoder in the shift demand sensor does not appear to be working properly; the PCM received a signal that is below the valid limit.

### Possible Causes

- Wiring problem
- Defective sensor

### Summary of Fault Correction Possibilities

- Correct the wiring problem.
- Replace the sensor.

## ShiftDmdSensor2_RangeHigh

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Caution | 100% | 1064-24 | Yes | 2 |

### Explanation

The secondary encoder in the shift demand sensor does not appear to be working properly; the PCM received a signal that is above the valid limit.

### Possible Causes

- Wiring problem
- Defective sensor

### Summary of Fault Correction Possibilities

- Correct the wiring problem.
- Replace the sensor.

## ShiftDmdSensor2_RangeLow

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Caution | 100% | 1064-25 | Yes | 2 |

  

### Explanation

The secondary encoder in the shift demand sensor does not appear to be working properly; the PCM received a signal that is below the valid limit.

### Possible Causes

- Wiring problem
- Defective sensor

### Summary of Fault Correction Possibilities

- Correct the wiring problem.
- Replace the sensor.

## ShiftPos_RangeHigh

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Critical | 50% | 1021-24 | Yes | 2 |

### Explanation

The primary shift position encoder in the shift actuator does not appear to be working properly; the PCM received a signal that is above the valid limit. Power is limited to prevent engine damage.

### Possible Causes

- Wiring problem
- Mechanical issue in gearcase
- Failed shift actuator

### Summary of Fault Correction Possibilities

- Inspect the wiring to the shift actuator, repair as needed.
- Inspect the gearcase for proper shifting.
- Replace the shift actuator.

## ShiftPos2_RangeHigh

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Critical | 50% | 1023-24 | Yes | 2 |

### Explanation

The secondary shift position encoder in the shift actuator does not appear to be working properly; the PCM received a signal that is above the valid limit. Power is limited to prevent engine damage.

### Possible Causes

- Wiring problem
- Failed shift actuator

### Summary of Fault Correction Possibilities

- Inspect the wiring to the shift actuator, repair as needed.
- Replace the shift actuator.

## ShiftPos_RangeLow

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Critical | 50% | 1021-25 | Yes | 2 |

### Explanation

The primary shift position encoder in the shift actuator does not appear to be working properly; the PCM received a signal that is below the valid limit. Power is limited to prevent engine damage.

  

### Possible Causes

- Wiring problem
- Mechanical issue in gearcase
- Failed shift actuator

### Summary of Fault Correction Possibilities

- Inspect the wiring to the shift actuator, repair as needed.
- Inspect the gearcase for proper shifting.
- Replace the shift actuator.

## ShiftPos2_RangeLow

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Critical | 50% | 1023-25 | Yes | 2 |

### Explanation

The secondary shift position encoder in the shift actuator does not appear to be working properly; the PCM received a signal that is below the valid limit. Power is limited to prevent engine damage.

### Possible Causes

- Wiring problem
- Failed shift actuator

### Summary of Fault Correction Possibilities

- Inspect the wiring to the shift actuator, repair as needed.
- Replace the shift actuator.

## ShiftPositionSensor_Diff

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Critical | 100% | 1024-6 | Yes | 4 |

### Explanation

The shift position sensors located in the shift actuator do not agree.

### Possible Causes

- Wiring problem
- Faulty shift actuator

### Summary of Fault Correction Possibilities

- Inspect the shift actuator wiring, repair as needed.
- Replace the shift actuator.

## Shift_XCheck_Diff

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Critical | 5% | 4002-6 | Yes | 4 |

### Explanation

The command module is not equal to the PCM in cross-check of shift position.

### Possible Causes

- Incorrect DTS system configuration
- Faulty command module or PCM
- Wiring problem

  

- Gearcase stuck in gear
- Failed shift actuator

### Summary of Fault Correction Possibilities

- Reconfigure the DTS system.
- Replace the command module or PCM.
- Check the helm wiring.
- Check the gearcase for free shifting.
- Replace the shift actuator.

## SPI_CrosscheckData_SOH

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Critical | 5% | 4016-6 | Yes | 4 |

### Explanation

There is a communication problem with the SmartCraft control system.

### Possible Causes

- Internal engine PCM error

### Summary of Fault Correction Possibilities

- Replace the PCM.

## StbdECT_Overtemp

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Critical | 5% | 521-20 | Yes | 4 |

### Explanation

The engine appears to be overheating; the PCM received a signal from the engine coolant temperature (ECT) sensor that is higher than normal.

### Possible Causes

- Restricted cooling water flow
- Restricted thermostat
- Degraded water pump impeller

### Summary of Fault Correction Possibilities

- Check for cooling system blockage.
- Inspect the thermostat.
- Inspect the water pump impeller.

## StbdECT_RangeHigh

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 521-24 | Yes | 2 |

### Explanation

The engine coolant temperature (ECT) sensor does not appear to be working properly; the PCM received a signal that is above the valid limit.

### Possible Causes

- Wiring problem
- Defective sensor

### Summary of Fault Correction Possibilities

- Inspect the wiring to the sensor, repair as necessary.
- Replace the sensor.

## StbdECT_RangeLow

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 521-25 | Yes | 2 |

### Explanation

The engine coolant temperature (ECT) sensor does not appear to be working properly; the PCM received a signal that is below the valid limit.

### Possible Causes

- Wiring problem
- Defective sensor

### Summary of Fault Correction Possibilities

- Inspect the wiring to the sensor, repair as necessary.
- Replace the sensor.

## STRT_OutputFault

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Critical | 100% | 3171-16 | Yes | 3 |

### Explanation

The starting system does not appear to be working properly; the PCM detected a problem when trying to send a signal to the start relay. The engine may not start.

### Possible Causes

- Wiring problem
- Start relay failed
- Starter failed

### Summary of Fault Correction Possibilities

- Check the wiring to the relay and to the starter, repair as necessary.
- Replace the start relay.
- Replace the starter.

## SysVolt_FaultBlocker

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Critical | 100% | 4602-23 | Yes | 3 |

### Explanation

Battery voltage is outside of specified limits.

### Possible Causes

- Battery switch is not turned on
- Overcharging or undercharging due to faulty alternator

### Summary of Fault Correction Possibilities

- Turn the battery switch on.
- Replace the alternator.

## SysVolt_RangeHigh

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Critical | 100% | 621-4 | Yes | 3 |

### Explanation

Battery voltage is above the normal limit; the battery voltage as seen by the PCM is valid, but is higher than expected.

### Possible Causes

- Alternator failed

### Summary of Fault Correction Possibilities

- Replace the alternator.

## SysVolt_RangeLow

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Critical | 100% | 621-5 | Yes | 3 |

### Explanation

Battery voltage is below the normal limit; the battery voltage as seen by the PCM is valid, but is lower than expected.

### Possible Causes

- Alternator is not charging
- Fusible link is failed
- More current draw than alternator can supply
- Wiring problem

### Summary of Fault Correction Possibilities

- Inspect the alternator.
- Inspect the fusible link.
- Reduce the charging system draws.
- Inspect the alternator wiring for problems, and repair as necessary.

# T ..........

## TPS1_ETC_NoAdapt

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 341-6 | Yes | 2 |

### Explanation

The TPS 1 signal was outside the valid range when trying to adapt. Adapt occurs upon engine key-up.

### Possible Causes

- Low system voltage to ETC
- Defective throttle position sensor

### Summary of Fault Correction Possibilities

- Inspect the wiring for problems, and correct as necessary.
- Replace the throttle body assembly

## TPS1_RangeHigh

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Caution | 100% | 301-24 | Yes | 2 |

### Explanation

The TPS 1 sensor circuit is shorted.

### Possible Causes

- Wiring problem
- Defective throttle position sensor

### Summary of Fault Correction Possibilities

- Inspect the wiring for problems, and correct as necessary.
- Replace the throttle body assembly.

## TPS1_RangeLow

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Caution | 100% | 301-25 | Yes | 2 |

### Explanation

The TPS 1 sensor circuit is open.

### Possible Causes

- Wiring problem
- Defective throttle position sensor

### Summary of Fault Correction Possibilities

- Inspect the wiring for problems, and correct as necessary.
- Replace the throttle body assembly.

## TPS2_ETC_NoAdapt

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 342-6 | Yes | 2 |

### Explanation

The TPS 2 signal was outside the valid range when trying to adapt. Adapt occurs upon engine key-up.

### Possible Causes

- Wiring problem
- Defective throttle position sensor

### Summary of Fault Correction Possibilities

- Inspect the wiring for problems, and correct as necessary.
- Replace the throttle body assembly.

## TPS2_RangeHigh

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Caution | 100% | 302-24 | Yes | 2 |

### Explanation

The TPS 2 sensor circuit is open.

  

### Possible Causes

- Wiring problem
- Defective throttle position sensor

### Summary of Fault Correction Possibilities

- Inspect the wiring for problems, and correct as necessary.
- Replace the throttle body assembly.

## TPS2_RangeLow

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Sticky | Caution | 100% | 302-25 | Yes | 2 |

### Explanation

This fault indicates that the TPS 2 sensor circuit is shorted to power.

### Possible Causes

- Wiring problem
- Defective throttle position sensor

### Summary of Fault Correction Possibilities

- Inspect the wiring for problems, and correct as necessary.
- Replace the throttle body assembly.

## TRMD_OutputFault

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 3182-16 | Yes | 2 |

### Explanation

The trim down relay does not appear to be working properly; the PCM detected a problem when trying to send a signal to the trim down relay.

### Possible Causes

- Wiring problem
- Failed trim down relay
- Power trim is not moving when system expected movement

### Summary of Fault Correction Possibilities

- Inspect the wiring for problems, and correct as necessary.
- Replace the trim down relay.
- Inspect the power trim system for lack of movement.

## TRMU_OutputFault

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 3181-16 | Yes | 2 |

### Explanation

The trim up relay does not appear to be working properly; the PCM detected a problem when trying to send a signal to the trim up relay.

### Possible Causes

- Wiring problem
- Failed trim up relay

- Power trim is not moving when system expected movement

### Summary of Fault Correction Possibilities

- Inspect the wiring for problems, and correct as necessary.
- Replace the trim up relay.
- Inspect the power trim system for lack of movement.

## TrimPos_RangeHigh

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 1012-24 | Yes | 2 |

### Explanation

The trim position sensor circuit is shorted.

### Possible Causes

- Wiring problem
- Defective trim position sensor

### Summary of Fault Correction Possibilities

- Inspect the wiring for problems, and correct as necessary.
- Replace the trim position sensor.

## TrimPos_RangeLow

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 1012-25 | Yes | 2 |

### Explanation

The trim position sensor circuit is open.

### Possible Causes

- Wiring problem
- Defective trim position sensor

### Summary of Fault Correction Possibilities

- Inspect the wiring for problems, and correct as necessary.
- Replace the trim position sensor.

# U ..........

## UEGO1_HtrLwrLimit

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | None | 100% | 822-5 | No | 2 |

### Explanation

The oxygen (O2) sensor does not appear to be working properly; the PCM received a signal that is valid, but is lower than expected. The O2 sensor is not heating up.

### Possible Causes

- O2 sensor fuse failed
- Wiring problem
- O2 sensor failed

### Summary of Fault Correction Possibilities

- Check the O2 sensor fuse. If open, locate the source of the excess current draw. Replace the fuse.
- Inspect the O2 sensor wiring for an open or short, repair as necessary.
- Replace the O2 sensor.

## UEGO1_HtrOpnShrt

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | None | 100% | 822-16 | No | 2 |

### Explanation

The oxygen (O2) sensor does not appear to be working properly; the PCM detected a problem when trying to send a signal to the O2 sensor heater.

### Possible Causes

- O2 sensor fuse failed
- Wiring problem
- O2 sensor failed

### Summary of Fault Correction Possibilities

- Check the O2 sensor fuse. If open, locate the source of the excess current draw. Replace the fuse.
- Inspect the O2 sensor wiring for an open or short, repair as necessary.
- Replace the O2 sensor.

## UEGO1_HtrUprLimit

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | None | 100% | 822-4 | No | 2 |

### Explanation

The oxygen (O2) sensor does not appear to be working properly; the PCM received a signal that is valid, but is higher than expected. The O2 sensor is getting too hot.

### Possible Causes

- O2 sensor fuse failed
- Wiring problem
- O2 sensor failed

### Summary of Fault Correction Possibilities

- Check the O2 sensor fuse. If open, locate the source of the excess current draw. Replace the fuse.
- Inspect the O2 sensor wiring for an open or short, repair as necessary.
- Replace the O2 sensor.

## UEGO1_Sensor_Open

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | None | 100% | 821-1 | No | 2 |

### Explanation

The oxygen (O2) sensor does not appear to be working properly; the output circuit from the PCM to the O2 sensor is open or has too much resistance.

### Possible Causes

- O2 sensor fuse failed
- Wiring problem

  

- O2 sensor failed

### Summary of Fault Correction Possibilities

- Check the O2 sensor fuse. If open, locate the source of the excess current draw. Replace the fuse.
- Inspect the O2 sensor wiring for an open or short, repair as necessary.
- Replace the O2 sensor.

## UEGO1_Sensor_Short

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | None | 100% | 821-27 | No | 2 |

### Explanation

The oxygen (O2) sensor does not appear to be working properly; the output circuit from the PCM to the O2 sensor is shorted or has too little resistance.

### Possible Causes

- Wiring problem
- O2 sensor failed

### Summary of Fault Correction Possibilities

- Inspect the O2 sensor wiring for an open or short, repair as necessary.
- Replace the O2 sensor.

# W ..........

## Watchdog_Active

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Critical | 5% | 4013-23 | Yes | 4 |

### Explanation

There is a communication problem with the SmartCraft control system.

### Possible Causes

- Internal engine PCM error

### Summary of Fault Correction Possibilities

- Replace the PCM.

## WaterInFuel_RangeLow

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 1108-25 | Yes | 2 |

### Explanation

The PCM received a signal from the water-in-fuel filter that is below the valid limit.

### Possible Causes

- Wiring problem
- Defective sensor
- Contaminated fuel

### Summary of Fault Correction Possibilities

- Inspect the wiring for problems, repair as needed.
- Replace the sensor.

  

- Inspect the fuel quality.

# X ..........

## XDRPa_RangeHigh

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Critical | 100% | 601-4 | Yes | 3 |

### Explanation

The sensor power supply A (transducer power 1) voltage is high; the value is valid, but is higher than expected.

### Possible Causes

- Problem with engine wire harness

### Summary of Fault Correction Possibilities

- Inspect the engine wire harness for shorts or opens in the Sensor Power A circuit. For the circuit diagram, refer to **Section 5A** - **Sensors**.

## XDRPa_RangeLow

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Critical | 100% | 601-5 | Yes | 3 |

### Explanation

The sensor power supply A (transducer power 1) voltage is low; the value is valid, but is lower than expected.

### Possible Causes

- Problem with engine wire harness
- Shorted sensor

### Summary of Fault Correction Possibilities

- Inspect the Sensor Power A circuitry for opens and shorts. For the circuit diagram, refer to **Section 5A** - **Sensors**.
- Disconnect each sensor powered by sensor power A (refer to **Section 5A** - **Sensors**), while observing CDS G3.
  - If the fault does not disappear, reconnect the sensor and continue with the next sensor.
  - If the fault does disappear, test that sensor for a short, and replace as required.

## XDRPb_RangeHigh

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Critical | 100% | 602-4 | Yes | 3 |

### Explanation

The sensor power supply B (transducer power 2) voltage is high; the value is valid, but is higher than expected.

### Possible Causes

- Problem with engine wire harness

### Summary of Fault Correction Possibilities

- Inspect the Sensor Power B circuitry for opens and shorts. For the circuit diagram, refer to **Section 5A** - **Sensors**.

## XDRPb_RangeLow

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Critical | 100% | 602-5 | Yes | 3 |

### Explanation

The sensor power supply B (transducer power 2) voltage is low; the value is valid, but is lower than expected.

### Possible Causes

- Problem with engine wire harness
- Shorted sensor

### Summary of Fault Correction Possibilities

- Inspect the Sensor Power B circuitry for opens and shorts. For the circuit diagram, refer to **Section 5A** - **Sensors**.
- Disconnect each sensor powered by sensor power B (refer to **Section 5A** - **Sensors**), while observing CDS G3.
    - If the fault does not disappear, reconnect the sensor and continue with the next sensor.
    - If the fault does disappear, test that sensor for a short, and replace as required.

## XDRPc_RangeHigh

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 603-4 | Yes | 2 |

### Explanation

The sensor power supply C (transducer power 3) voltage is high; the value is valid, but is higher than expected.

### Possible Causes

- Problem with engine wire harness

### Summary of Fault Correction Possibilities

- Inspect the Sensor Power C circuitry for opens and shorts. For the circuit diagram, refer to **Section 5A** - **Sensors**.

## XDRPc_RangeLow

| Fault Type: | Horn: | Guardian: | UFC: | Transmission to Helm: | Freeze Frame Priority: |
|---|---|---|---|---|---|
| Nonsticky | Caution | 100% | 603-5 | Yes | 2 |

### Explanation

The sensor power supply C (transducer power 3) voltage is low; the value is valid, but is lower than expected.

### Possible Causes

- Engine wire harness issues
- Shorted sensor

### Summary of Fault Correction Possibilities

- Inspect the Sensor Power C circuitry for opens and shorts. For the circuit diagram, refer to **Section 5A** - **Sensors**.
- Disconnect each sensor powered by sensor power C (refer to **Section 5A** - **Sensors**), while observing CDS G3.
    - If the fault does not disappear, reconnect the sensor and continue with the next sensor.
    - If the fault does disappear, test that sensor for a short, and replace as required.

# Sensors, Actuators, Relays, and Accessories

## Section 5A - Sensors

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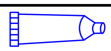
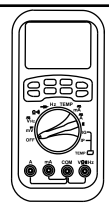
5
A

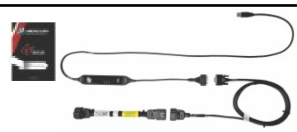
# Lubricants, Sealants, Adhesives

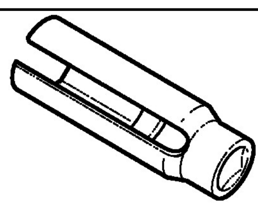
| Tube Ref No. | Description | Where Used | Part No. |
|---|---|---|---|
|  | Extreme Grease | Camshaft position sensor O-ring | 8M0071842 |

# Special Tools

| DMT 2004 Digital Multimeter | 91-892647A01 |
|---|---|
|  4516 | Measures RPM on spark ignition (SI) engines, ohms, amperes, AC and DC voltages; records maximums and minimums simultaneously, and accurately reads in high RFI environments. |

| Terminal Test Probe Kit | Bosch P/N MM- 46523 |
|---|---|
|  7915 | Test probes adapt test meter leads to harness connections without damaging harness terminals. May be used with Computer Diagnostic System (CDS). |

| CDS G3 Interface Kit | 8M0138392 |
|---|---|
|  66165 | CDS G3 License Key, Interface, Adapter, and Harness |

| Oxygen Sensor Socket | Obtain from Local Tool Supplier |
|---|---|
|  32314 | Aids in the removal and installation of oxygen sensors. |

# Sensor Tests

**IMPORTANT: The propulsion control module (PCM) is a highly dependable device and should not be replaced before testing the sensor or wiring harness. Given the corrosive operating environment and heavy vibrations to which marine engines are subjected, the highest occurrences of electrical problems are with the engine harness or the sensors themselves.**

## Swapping Sensors

The quickest and easiest ways to test a sensor are to either replace it with a known good sensor or to monitor the signal voltage to determine if it varies as expected. While actual sensor values may differ from engine to engine, different sensor types will always behave in predictable ways. For instance, the voltage drop across a temperature sensor will always vary according to applied temperature.

## General Sensor Troubleshooting

When trying to troubleshoot a sensor, try to narrow the fault to the wiring harness or the sensor. Typically, the propulsion control module (PCM) is not the source of the fault. Replacing the PCM might appear to fix an issue, but the very act of disconnecting and reconnecting components can reposition a connector with a broken wire (intermittent connection) or even clean corrosion from a connector that is the actual cause of a fault.

Note whether sensor faults occur singly or if there are multiple failures. The PCM supplies 5-volt power and ground to the variety of engine sensors through several circuits and a number of splices. A failed power supply or ground circuit will result in the appearance of multiple sensor failures. Use the sensor power wiring diagrams to identify which circuits feed power to which sensors.

To troubleshoot a given sensor circuit:

1. Disconnect the sensor from the engine harness.
2. Perform a visual inspection of the pins at the sensor and the wires coming from the sensor harness connector. Look for broken, bent, or corroded pins at the sensor and loose, broken, or corroded wires at the connector.
3. Perform a visual inspection of the harness connector at the PCM. Verify that the pins in the harness connector are properly seated. If the pins are damaged, repair or replace the harness.
4. Inspect the PCM for bent or missing pins. If connectors are damaged, repair or replace the PCM and retest.

## Three-Wire Sensor Power Supply and Ground Circuit Test

**IMPORTANT: Wiggle the harness and connector while performing the following tests. If the voltmeter readings vary during the tests, then a broken, loose, or corroded wire is likely causing the failure. Repair the problematic wire, or replace the engine harness, and retest the circuit.**

**IMPORTANT: Turn the key switch to the RUN position, but do not start the engine for the following tests.**

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

1. Measure the voltage between the power supply and ground pins of the engine harness sensor connector. The voltmeter should read 5 volts. If it does not, continue troubleshooting.
2. Measure the voltage between the power supply pin of the engine harness sensor connector and an engine ground. If the reading is 5 volts, there is an open in the ground circuit. If there is no voltage, there is either an open voltage supply circuit or a faulty splice, wire, or connector.

   **IMPORTANT: Always use appropriate probes, when testing at the engine harness PCM connectors.**
3. Check for continuity between the PCM connector and the ground pin at the sensor connector. If the circuit is open, repair or replace the engine harness and retest.

| | |
|---|---|
| Terminal Test Probe Kit | Bosch P/N MM- 46523 |

## Sensor Signal Circuit Test

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

**IMPORTANT: Always use appropriate probes, when testing at the engine harness PCM connectors.**

1. Check for continuity between the signal pin at the PCM connector and the signal pin at the sensor connector.

| | |
|---|---|
| Terminal Test Probe Kit | Bosch P/N MM- 46523 |

2. Check for continuity to ground from the signal pin.
3. If the circuit is open or grounded, repair or replace the engine harness and retest.

# Sensor Opens and Shorts

## Two-Wire Sensor Opens and Shorts

- An open 2-wire sensor circuit will cause the PCM to read 5 volts on the signal wire.
- A shorted-to-ground 2-wire sensor circuit will cause the PCM to read 0 volts on the signal wire.
- A shorted-to-power 2-wire sensor circuit will cause the PCM to read 5 volts (variable) on the signal wire.

## Three-Wire Sensor Opens and Shorts

### Power Lead

- If the power lead opens, the PCM will indicate 0 volts.
- If the power lead shorts to the ground lead or another ground source, the PCM will indicate 0 volts.
- If the power lead shorts to the signal lead or another power source, the PCM will indicate 5 volts.

### Ground Lead

- If the ground lead opens, the signal lead will indicate 5 volts.
- If the ground lead shorts to the power lead, the PCM will indicate 0 volts.

- If the ground lead shorts to the signal lead, the PCM will indicate 0 volts.

## Signal Lead

- If the signal lead opens, the PCM will read 0 volts.
- If the signal lead shorts to the power lead or another power source, the PCM will read 5 volts.
- If the signal lead shorts to the ground lead or another ground source, the PCM will read 0 volts.

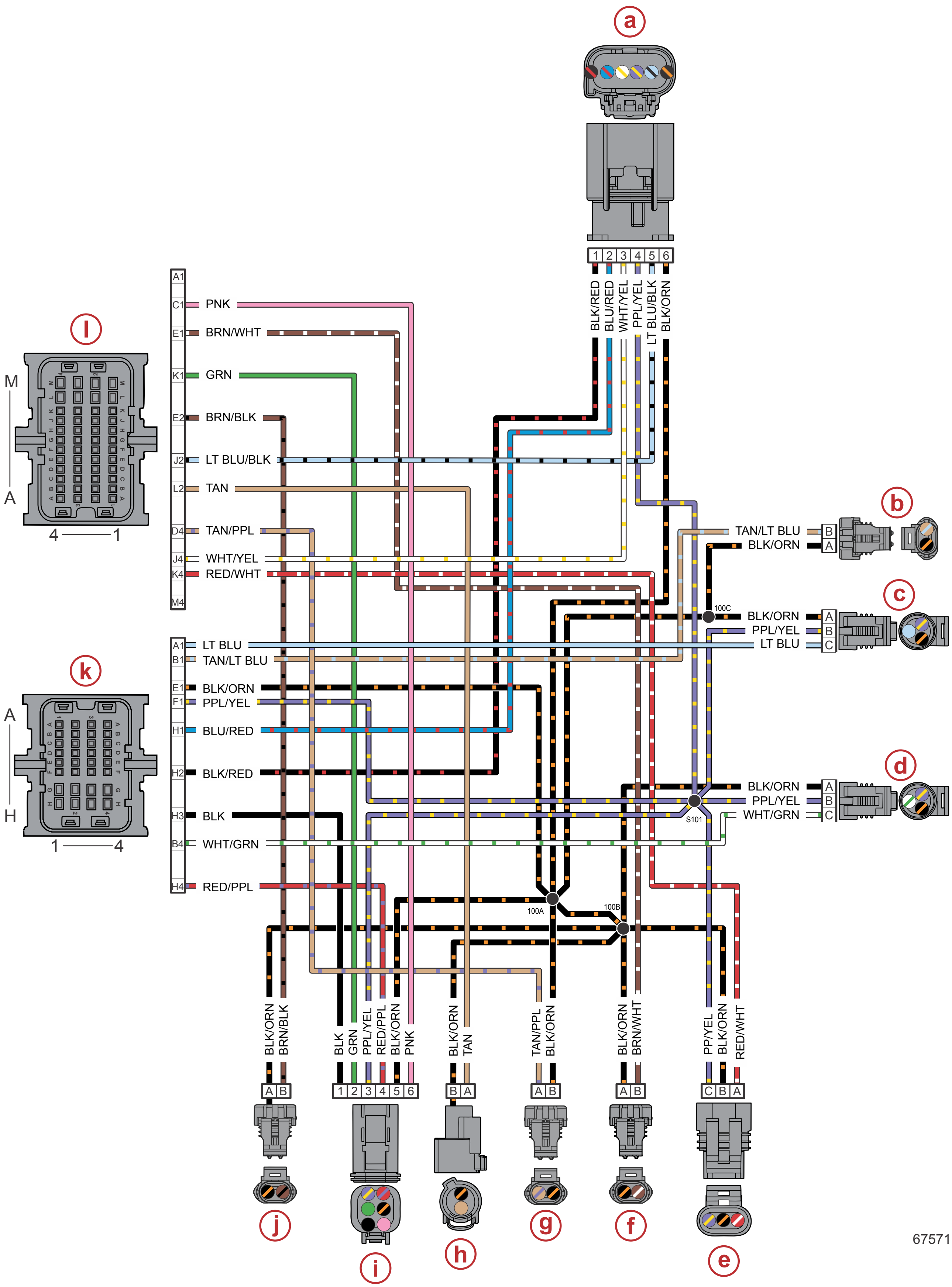
# Wire Color Code Abbreviations

| Wire Color Abbreviations | | | | | |
|---|---|---|---|---|---|
| BLK | Black | | BLU | Blue |
| BRN | Brown | | GRY or GRA | Gray |
| GRN | Green | | ORN or ORG | Orange |
| PNK | Pink | | PPL or PUR | Purple |
| RED | Red | | TAN | Tan |
| WHT | White | | YEL | Yellow |
| LT or LIT | Light | | DK or DRK | Dark |

# Notes:

# Sensor Power A - DTS



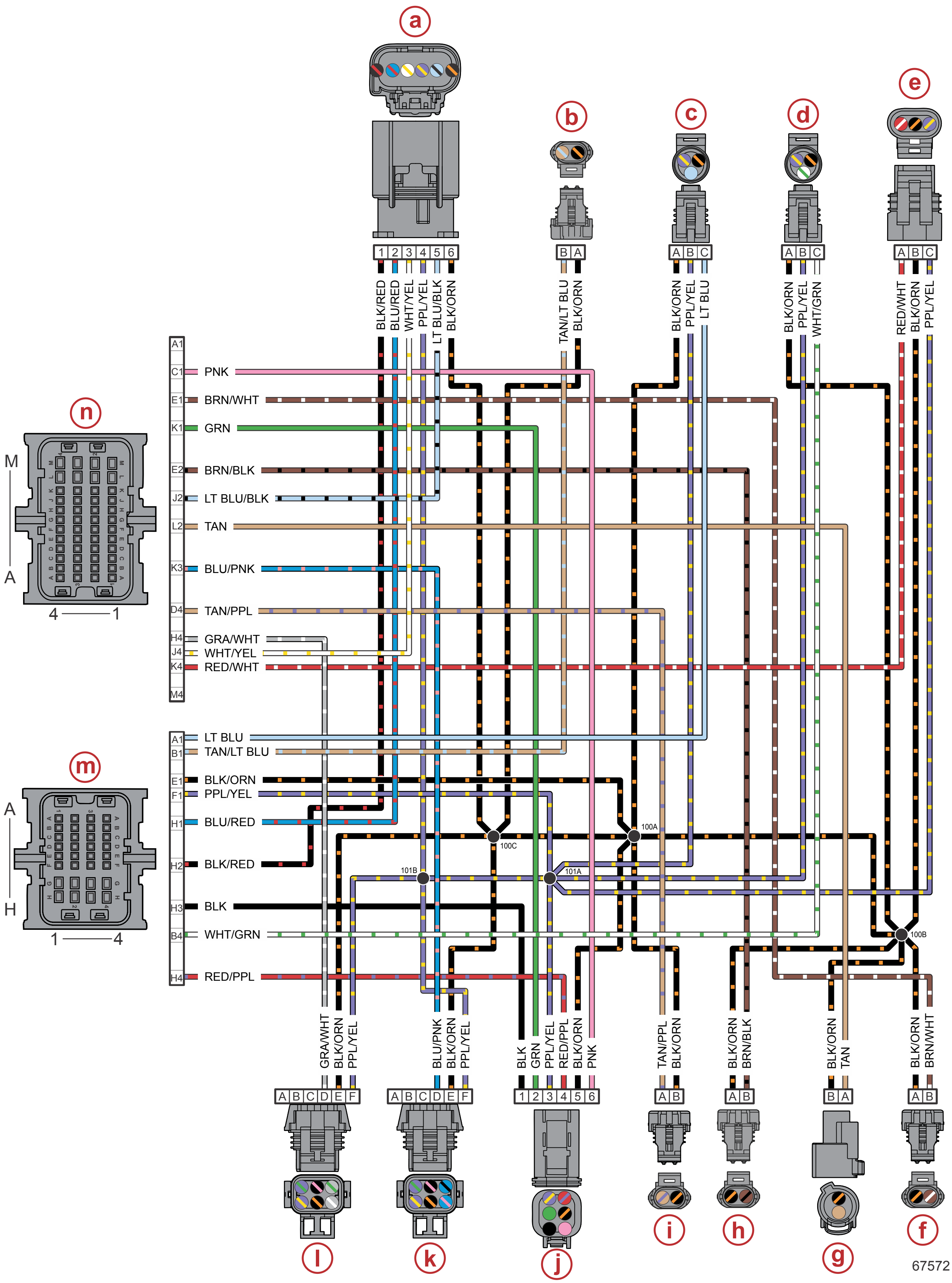
- a - Electronic throttle control (throttle position sensor)
- b - Oil temperature sensor
- c - Oil pressure sensor
- d - Block water pressure sensor
- e - Camshaft position sensor
- f - Exhaust gas temperature sensor
- g - Water-in-fuel sensor
- h - Intake air temperature sensor
- i - Shift actuator (shift position sensor)
- j - Engine coolant temperature sensor
- k - Propulsion control module connector C
- l - Propulsion control module connector B

## Circuit Description

PCM sensor power A (XDRP1) supplies 5 volts to the sensors identified on the preceding diagram. On DTS models, the purple and yellow wire from pin F1 of PCM connector C connects to splice S101, which feeds all five identified sensors.

PCM sensor ground A (XDRG1) connects all ten sensors to ground through the PCM (pin E1 of connector C). The black and orange ground circuit incorporates three splices (100A, 100B, and 100C).

# Sensor Power A - Mechanical



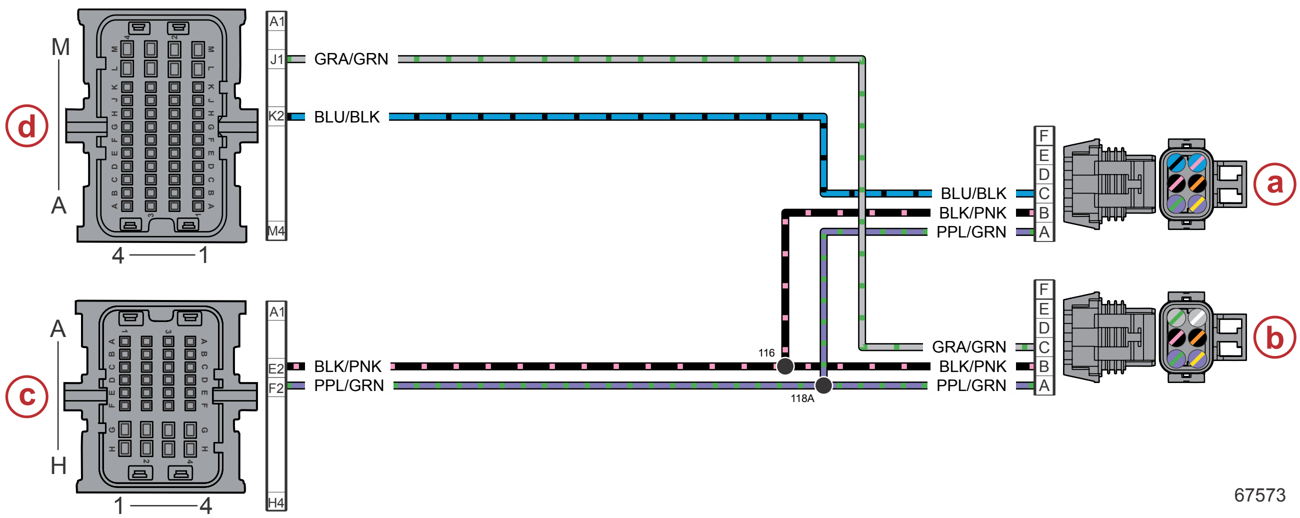
- a - Electronic throttle control (throttle position sensor)
- b - Oil temperature sensor
- c - Oil pressure sensor
- d - Block water pressure sensor
- e - Camshaft position sensor
- f - Exhaust gas temperature sensor
- g - Intake air temperature sensor
- h - Engine coolant temperature sensor
- i - Water-in-fuel sensor
- j - Shift actuator (shift position sensor)
- k - Shift demand sensor (signal A)
- l - Throttle demand sensor (signal A)
- m - Propulsion control module connector C
- n - Propulsion control module connector B

## Circuit Description

PCM sensor power A (XDRP1) supplies 5 volts to the sensors identified on the preceding diagram. On mechanical models, the purple and yellow wire from pin F1 of PCM connector C connects to splices 101A and 101B, which feed all seven identified sensors.

PCM sensor ground A (XDRG1) connects all twelve identified sensors to ground through the PCM (pin E1 of connector C). The black and orange ground circuit incorporates three splices (100A, 100B, and 100C).

# Sensor Power B




- a - Shift demand sensor (signal B)
- b - Throttle demand sensor (signal B)
- c - Propulsion control module connector C
- d - Propulsion control module connector B

## Circuit Description

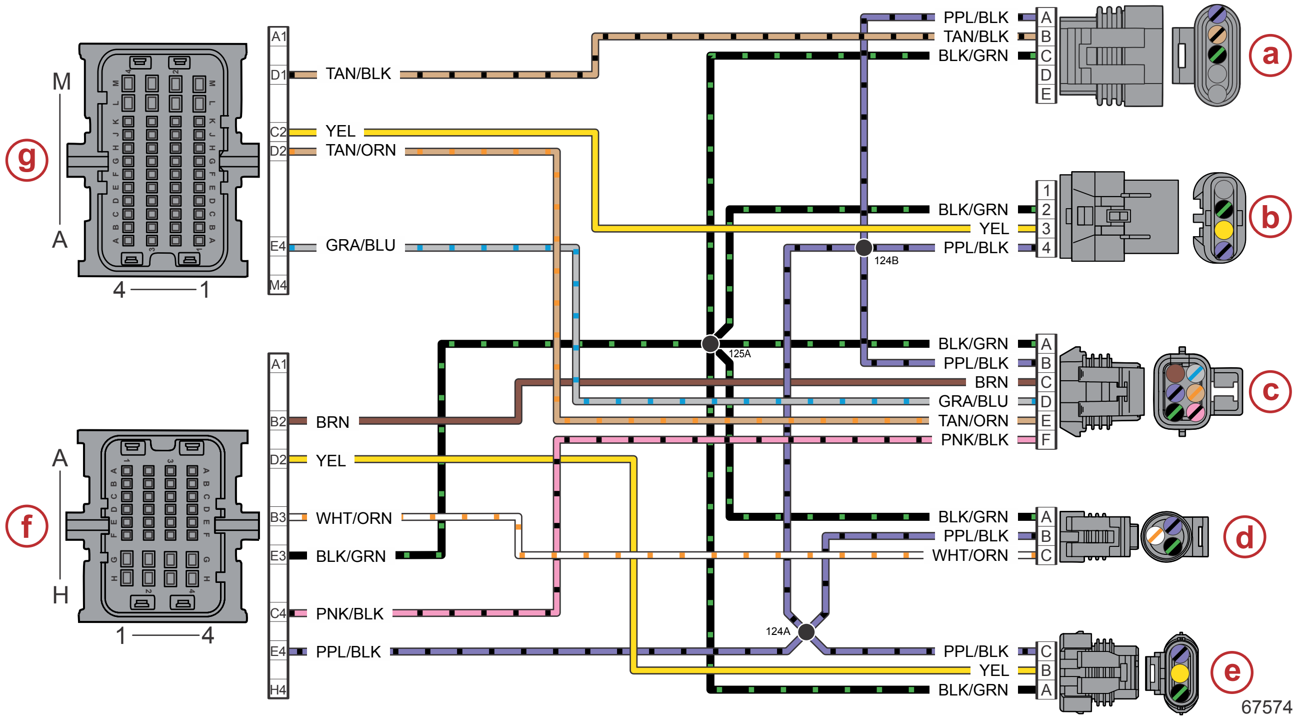
Sensor power B is used only on mechanical models.

PCM sensor power B (XDRP2) supplies 5 volts to the sensors identified on the preceding diagram. The purple and green wire from pin F2 of PCM connector C connects to splice 118A, which feeds both identified sensors.

PCM sensor ground B (XDRG2) connects both identified sensors to ground through the PCM (pin E2 of connector C). The black and pink ground circuit incorporates a single splice (116).

# Sensor Power C




**a -** Oil level sensor, if equipped
**b -** Trim position sensor
**c -** Boat harness
**d -** Pitot pressure sensor
**e -** Manifold absolute pressure sensor
**f -** Propulsion control module connector C
**g -** Propulsion control module connector B

## Circuit Description

PCM sensor power C (XDRP3) supplies 5 volts to the sensors identified on the preceding diagram. The purple and black wire from pin E4 of PCM connector C connects to splices 124A and 124B, which feed all four identified sensors, as well as the boat harness.

PCM sensor ground C (XDRG3) connects all four identified sensors and the boat harness to ground through the PCM (pin E3 of connector C). The black and green ground circuit incorporates a single splice (125A).

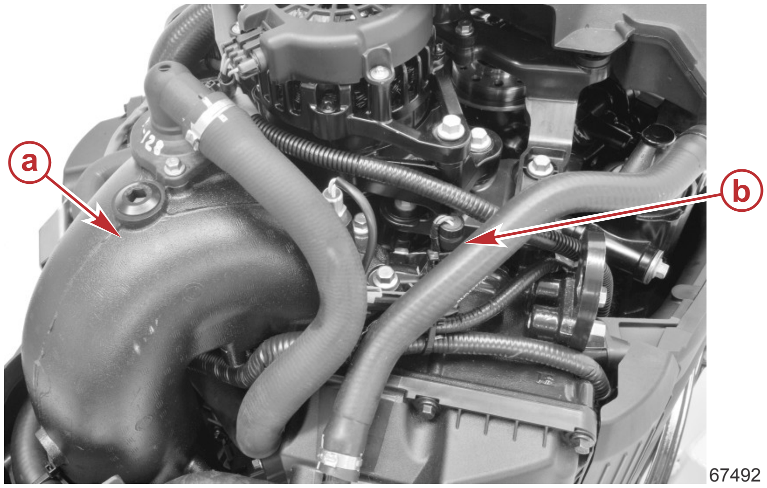
# Block Water Pressure Sensor

*NOTE: Not all models are equipped with a block water pressure sensor.*

The block water pressure sensor measures the pressure of the coolant that the water pump supplies to the cylinder block. The sensor converts the measured pressure to a voltage that is read by the PCM.

The block water pressure sensor, if equipped, is located on the top aft of the engine, near the exhaust manifold.




67492

- **a -** Exhaust manifold
- **b -** Block water pressure sensor

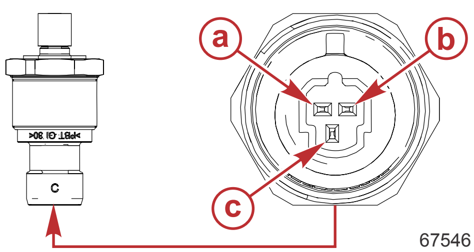
## Block Water Pressure Sensor Tests

Monitor the pressure (data item **SeaPumpPress**) on the CDS G3 **Live Data** screen. If the block water pressure sensor does not appear to indicate a pressure change when engine RPM is varied, shake or move the sensor harness and connector. If the pressure begins to change, look for a broken, loose, or corroded wire.

| | |
|---|---|
| CDS G3 Interface Kit | 8M0138392 |

Continue testing with the engine OFF:

1. Disconnect the engine harness connector from the sensor.
2. Visually inspect the sensor pins and the wires coming from the engine harness connector. Look for broken, bent, or corroded pins at the sensor and loose, broken, or corroded wires at the engine harness connector.
3. Measure the resistance between pins A, B, and C of the block water pressure sensor.




67546

- **a -** Pin A – ground (–)
- **b -** Pin B – power (+)
- **c -** Pin C – pressure signal

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

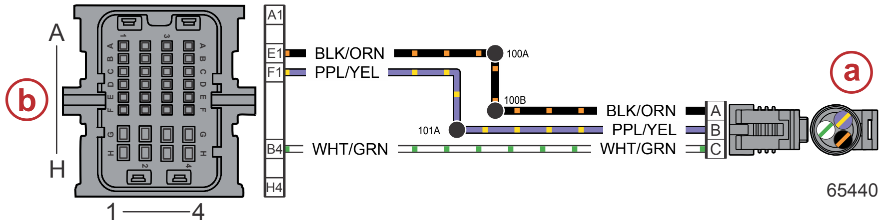
| Meter Test Leads | | Meter Scale | Reading |
|---|---|---|---|
| Red | Black | | At 21 °C (70 °F) |
| Pin A | Pin B | Auto | 78.4–145.6 kΩ |
| Pin A | Pin C | Auto | 182.0–338.0 kΩ |
| Pin B | Pin C | Auto | 100.8–187.2 kΩ |

4. Perform a continuity check of the sensor wiring in the engine harness, between the sensor connector and the PCM. Note that there are splices in both the power and ground circuits.

   ***NOTE:** Sensor power splice numbers vary between DTS and mechanical models.*

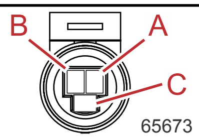
| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

| Terminal Test Probe Kit | Bosch P/N MM- 46523 |
|---|---|



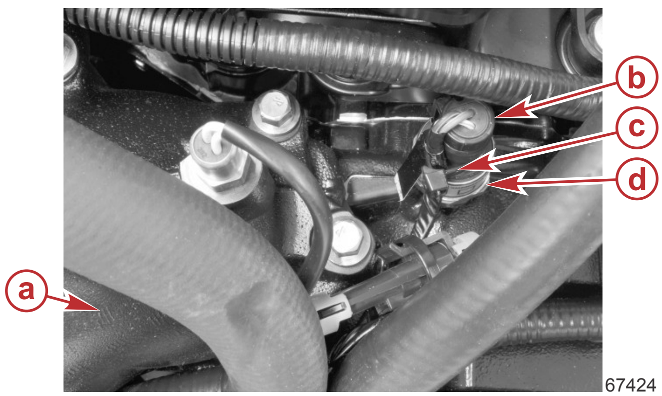

**DTS model shown; mechanical model similar**

a - Block water pressure sensor connector
b - PCM connector C

| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|  | A | Black/orange | Sensor ground A (–) | CE1 |
| | B | Purple/yellow | Sensor power A (+) | CF1 |
| | C | White/green | Block water pressure signal | CB4 |

## Block Water Pressure Sensor Removal

1. Cut the cable tie from the sensor's engine harness connector.
2. Disconnect the engine harness connector from the sensor.
3. Remove the sensor from the engine block.




a - Top of the exhaust manifold
b - Engine harness connector
c - Cable tie to secure the harness connection
d - Block water pressure sensor

## Block Water Pressure Sensor Installation

1. Ensure that the O-ring is in good condition and is installed on the sensor.
2. Install the block water pressure sensor into the engine block.
3. Tighten the sensor to the specified torque.

| Description | Nm | lb-in. | lb-ft |
|---|---|---|---|
| Block water pressure sensor | 15 | 132.8 | – |

4. Connect the engine harness to the sensor.
5. Secure the connection with a cable tie.

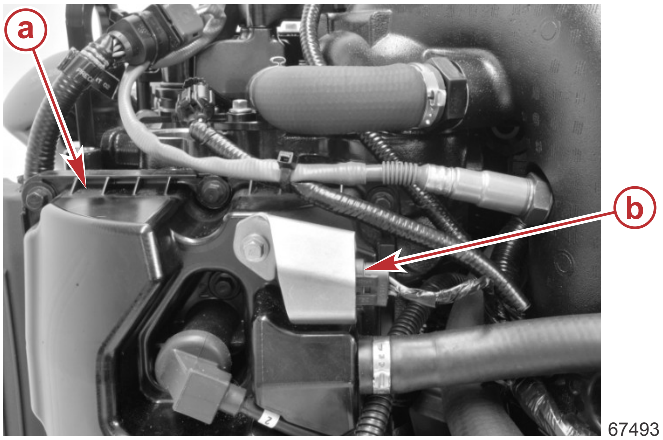
# Camshaft Position Sensor

The camshaft position sensor supplies the PCM with cam timing and RPM information. When the camshaft position sensor is functioning correctly, the PCM controls the fuel injection in a multiport timing strategy. The camshaft position sensor output to the PCM changes from +5 volts to 0 volts throughout the engine rotation.

If the camshaft position sensor fails, the PCM will control the fuel injection in a batch fire strategy. The engine may not start as quickly as normal. The PCM will generate and store a fault code, if the camshaft position sensor fails.

The camshaft position sensor is located at the top of the port valve cover.

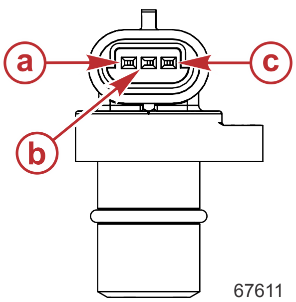



67493

a - Port valve cover
b - Camshaft position sensor

## Camshaft Position Sensor Tests

1. Disconnect the sensor from the engine harness.
2. Perform a visual inspection of the sensor pins and the wires coming from the engine harness connector. Look for broken, bent, or corroded pins at the sensor and loose, broken, or corroded wires at the connector.
3. If the pins and wiring appear serviceable, perform a resistance check on the sensor. Ensure that the resistance for the camshaft sensor at 21 °C (70 °F) is within specification.




67611

Camshaft position sensor
a - Pin A = output voltage
b - Pin B = ground
c - Pin C = reference voltage (5 V)

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

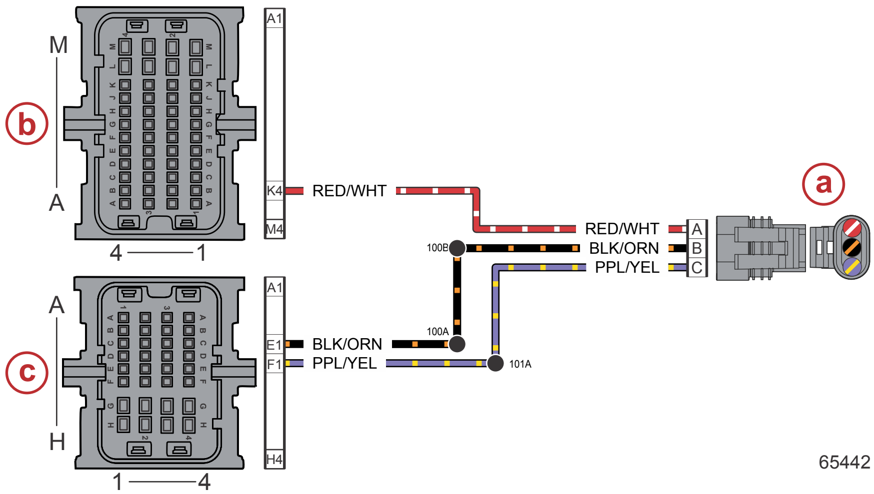
| Meter Test Leads | | Meter Scale | Reading |
|---|---|---|---|
| Red | Black | | |
| Pin A | Pin B | Auto | 5.4 MΩ ± 30% |
| Pin A | Pin C | Auto | 1.0 MΩ ± 30% |
| Pin B | Pin A | Auto | 2.9 MΩ ± 30% |
| Pin B | Pin C | Auto | 2.9 MΩ ± 30% |
| Pin C | Pin A | Auto | 1.0 MΩ ± 30% |
| Pin C | Pin B | Auto | 5.4 MΩ ± 30% |

4. Perform a continuity check of the sensor wiring between the sensor connector and the PCM. Note that there are splices in both the power and ground circuits.

   ***NOTE:** Sensor power splice numbers vary between DTS and mechanical models.*

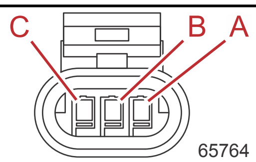
| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

| Terminal Test Probe Kit | Bosch P/N MM- 46523 |
|---|---|



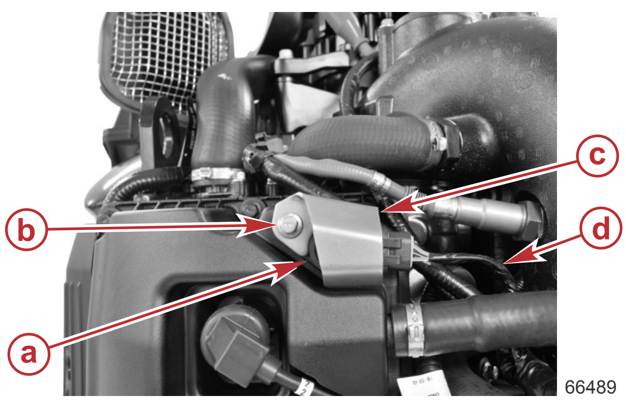

DTS model shown; mechanical model similar

- a - Camshaft position sensor
- b - PCM connector B
- c - PCM connector C

| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|   | A | Red/white | Camshaft position signal | BK4 |
| | B | Black/orange | Sensor ground A (–) | CE1 |
| | C | Purple/yellow | Sensor power A (+) | CF1 |

## Camshaft Position Sensor Removal

1. Disconnect the sensor from the engine harness.
2. Remove the M6 x 20 screw securing the camshaft position sensor, and remove the sensor and sensor bracket.




- a - Camshaft position sensor
- b - M6 x 20 screw
- c - Sensor bracket
- d - Engine harness

## Camshaft Position Sensor Installation

1. Apply Extreme Grease to the sensor O-ring.

| Tube Ref No. | Description | Where Used | Part No. |
|---|---|---|---|
| | Extreme Grease | Camshaft position sensor O-ring | 8M0071842 |

2. Install the sensor into the valve cover.
3. Place the bracket over the sensor, and secure both items with an M6 x 20 screw.
4. Tighten the screw to the specified torque.

| Description | Nm | lb-in. | lb-ft |
|---|---|---|---|
| M6 x 20 screw | 8 | 70.8 | – |

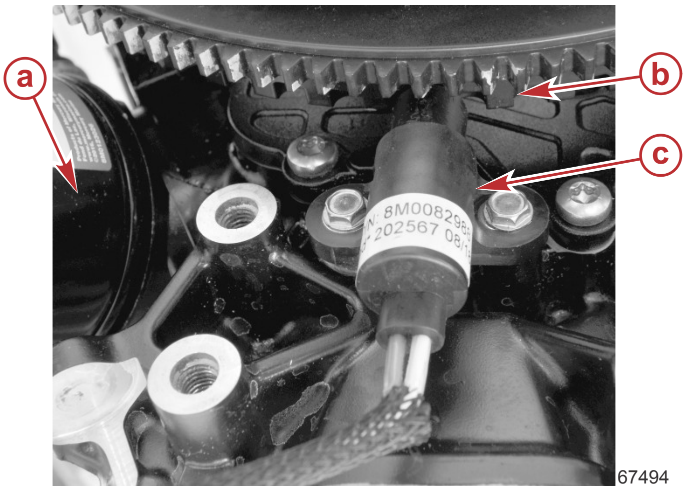
5. Connect the engine harness to the sensor.

# Crankshaft Position Sensor (CPS)

The crankshaft position sensor (CPS) contains a magnet that is positioned next to the flywheel's lower ring gear. This ring gear has 58 teeth with one gap (two missing teeth). The close proximity of the CPS magnet to the 58 teeth creates a magnetic field each time a tooth passes in front of the sensor. As each tooth moves away, the field collapses. The expanding and collapsing magnetic field creates a pulsating voltage, which is sent to the PCM. The PCM regulates ignition and fuel injector timing, based on the timing and frequency of the pulses.

If the crankshaft position sensor fails, the engine will not start. The PCM will generate and store a fault code.

The CPS is located at the top of the cylinder block underneath the alternator bracket, near the oil filter.




67494

**Alternator bracket removed for clarity**

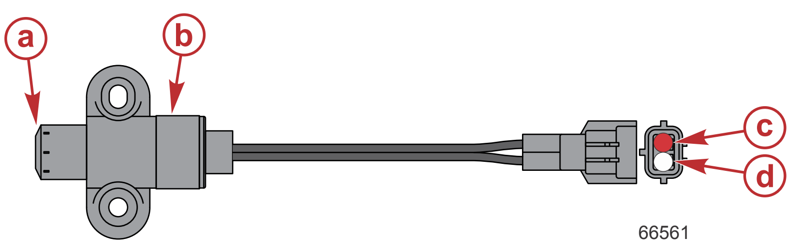
- **a -** Oil filter
- **b -** Lower ring gear on flywheel
- **c -** Crankshaft position sensor

## CPS Test

1. Perform a visual inspection of the sensor. The tip of the sensor must be flush across the end. If it is not, replace the sensor.
2. The tip of the sensor must be clean. There should be no metal debris (ring gear filings) on the sensor tip.

   ***NOTE:*** *There is a magnet mounted in the sensor's tip. If the magnet is missing, the sensor will not operate properly.*
3. Inspect the flywheel timing ring to ensure:
   - Absence of corrosion
   - Square edges on the teeth
   - Only one gap of two missing teeth

   Replace the flywheel if it does not meet inspection requirements.
4. Disconnect the sensor harness from the engine harness.
5. Perform a visual inspection of the sensor connector pins and the wires between the sensor and the connector. Look for broken, bent, or corroded pins at the sensor and loose, broken, or corroded wires at the connector.
6. Measure the resistance across the sensor pins. Replace the sensor if it is out of specification.




66561

- **a -** Magnet
- **b -** CPS
- **c -** Pin 1 (red)
- **d -** Pin 2 (white)

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

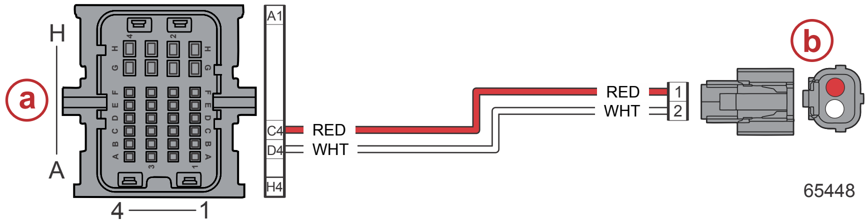
| Crankshaft Position Sensor | |
|---|---|
| Resistance at 21 °C (70 °F) | 300–350 Ω |

7. Connect the sensor harness to the engine harness, disconnect connector A from the PCM, and measure the resistance across pins C4 and D4 of the connector. Resistance must be within specification. If not, repair the wiring between the PCM and the sensor.

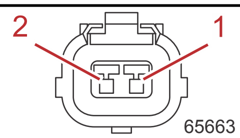
| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

| Terminal Test Probe Kit | Bosch P/N MM- 46523 |
|---|---|



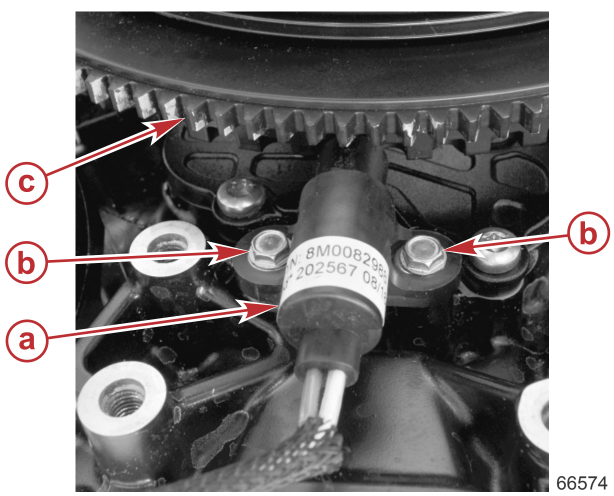

**a -** PCM connector A
**b -** Crankshaft position sensor connector

| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|   | 1 | Red | Crankshaft position sensor + | AC4 |
| | 2 | White | Crankshaft position sensor – | AD4 |

| Meter Test Leads | | Meter Scale | Reading |
|---|---|---|---|
| Red | Black | | |
| Connector A, pin C4 | Connector A, pin D4 | Auto | 300–350 Ω at 21 °C (70 °F) |

# Crankshaft Position Sensor Removal

1. Remove the cold air intake assembly:
    a. Remove the oil level dipstick.
    b. Loosen the hose clamp at the top of the throttle body assembly.
    c. Lift the assembly up to disengage the two pins from the grommets on the oil fill bracket.
    d. Swing the assembly out of the way.
2. Remove the oil fill bracket, alternator, and alternator belt. Refer to the appropriate service manual.
3. Disconnect the sensor harness from the engine harness.
4. Remove two M5 x 13 hex washer head screws, and remove the sensor.




**a -** Crankshaft position sensor
**b -** M5 x 13 hex washer head screws (2)
**c -** Flywheel

# Crankshaft Position Sensor Installation

*NOTE: Refer to the preceding illustration, as required.*

1. Position the sensor on the engine, and secure the sensor with two M5 x 13 hex washer head screws. Tighten the screws to the specified torque.

| Description | Nm | lb-in. | lb-ft |
|---|---|---|---|
| M5 x 13 hex washer head screw | 5 | 44.3 | – |

2. Connect the sensor harness to the engine harness.
3. Install the alternator, alternator belt, and oil fill bracket. Refer to the appropriate service manual.

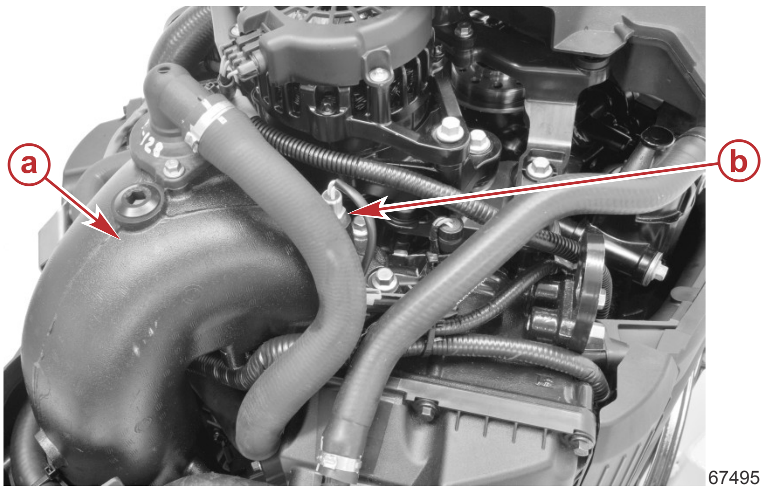
  

4. Install the cold air intake assembly. Refer to the appropriate service manual.
    - Ensure that the reference hose is secured to the assembly with a cable tie.
    - Ensure that the hose clamp is securely tightened.
    - Ensure that the oil level dipstick is properly inserted into the dipstick tube.

# Engine Coolant Temperature (ECT) Sensor

The engine coolant temperature (ECT) sensor is a thermistor immersed in the engine coolant path. It supplies the PCM with engine temperature information. The PCM adjusts the timing and the amount of fuel delivered according to the water temperature in the exhaust manifold. Low coolant temperature produces high resistance, while high temperature causes low resistance. Outside air temperature and the temperature of the water that the engine is operating in will directly affect the engine block temperature.

The engine coolant temperature (ECT) sensor is located at the top of the exhaust manifold.




67495

a - Top of the exhaust manifold
b - Engine coolant temperature sensor

## ECT Sensor Test

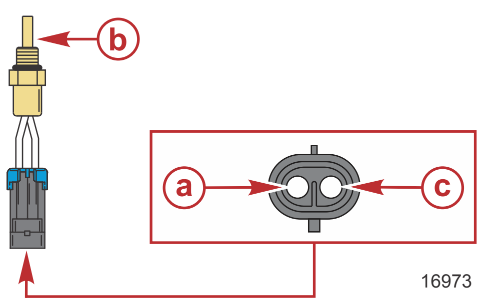
Monitor the engine coolant temperature (data item **ECT**) on the CDS G3 **Live Data** screen. With the engine not running, block temperature should be approximately the same as the ambient air temperature. After the engine is started, the temperature sensor should indicate a rise in block temperature to approximately 60–70 °C (140–158 °F).

| | |
|---|---|
| CDS G3 Interface Kit | 8M0138392 |

If there is not an obvious change in block temperature sensor values, shake or move the sensor harness and connector. If the temperature begins to change, look for a broken, loose, or corroded wire.

Continue testing with the engine OFF:

1. Disconnect the engine harness from the sensor harness.
2. Perform a visual inspection of the sensor pins and the wires coming from the connector. Look for broken, bent, or corroded pins at the sensor and loose, broken, or corroded wires at the connector.
3. Test the sensor with an ohmmeter.
    a. Remove the sensor from the cylinder block.
    b. Immerse the tip of the sensor in a controlled temperature medium. If the readings do not match those in the table, replace the sensor and retest.




16973

a - Pin A—ground (–)
b - Cylinder block temperature sensor
c - Pin B—engine coolant temperature signal (+)

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

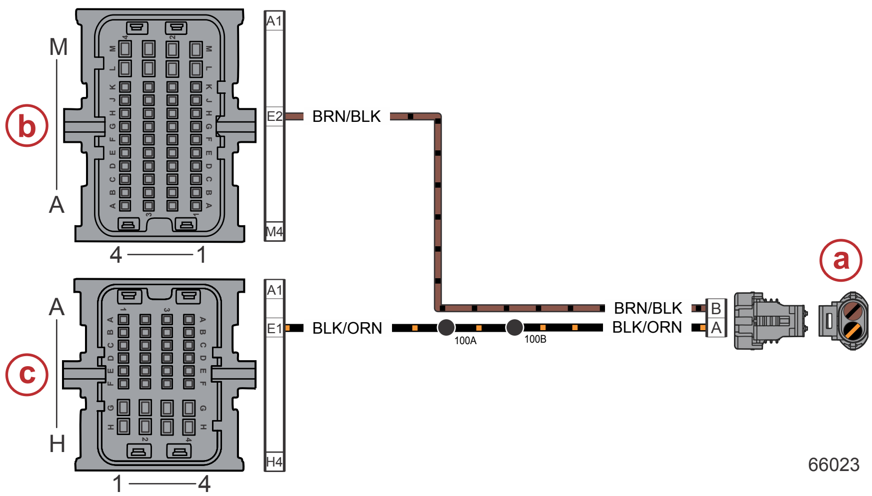
  

| ECT Sensor Resistance Test | |
|---|---|
| Temperature | Reading (nominal) |
| 0 °C (32 °F) | 32.6 kΩ |
| 20 °C (68 °F) | 12.5 kΩ |
| 40 °C (104 °F) | 5.3 kΩ |
| 65 °C (150 °F) | 2.1 kΩ |
| 95 °C (203 °F) | 786 Ω |

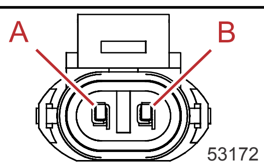
4. Perform a continuity check of the sensor wiring between the sensor connector and the PCM. Note that there are splices in the ground circuit.

   ***NOTE:*** *The quickest way to check the wiring is to measure the resistance of the thermistor at room temperature, connect the sensor to the engine harness, and measure the resistance across PCM connector sockets CE1 and BE2. If the two resistance values match, then the wiring is good.*

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |
| Terminal Test Probe Kit | Bosch P/N MM- 46523 |




a - Engine coolant temperature (ECT) sensor connector
b - PCM connector B
c - PCM connector C

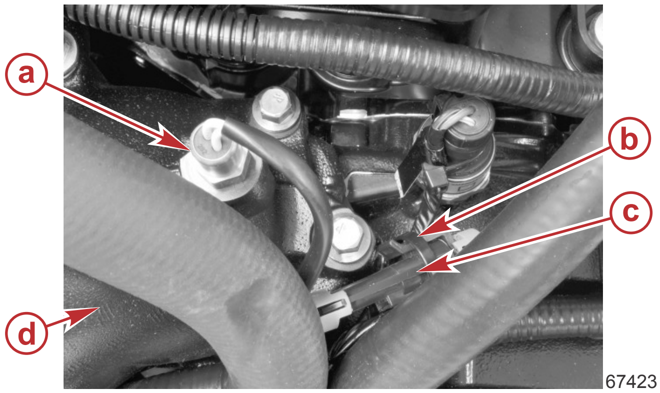
| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|   | A | Black/orange | Sensor ground A (–) | CE1 |
| | B | Brown/black | Engine coolant temperature signal | BE2 |

## ECT Sensor Removal

1. Cut the cable tie that secures the sensor harness connector to the engine harness.
2. Disconnect the sensor harness from the engine harness.

3. Remove the sensor from the exhaust manifold.




a - Engine coolant temperature sensor
b - Cable tie
c - Sensor harness connector
d - Top of the exhaust manifold

## ECT Sensor Installation

*NOTE: Refer to the preceding illustration, as required.*

1. Ensure that the O-ring is in good condition and is installed on the sensor.
2. Install the engine coolant temperature sensor into the exhaust manifold.
3. Tighten the sensor to the specified torque.

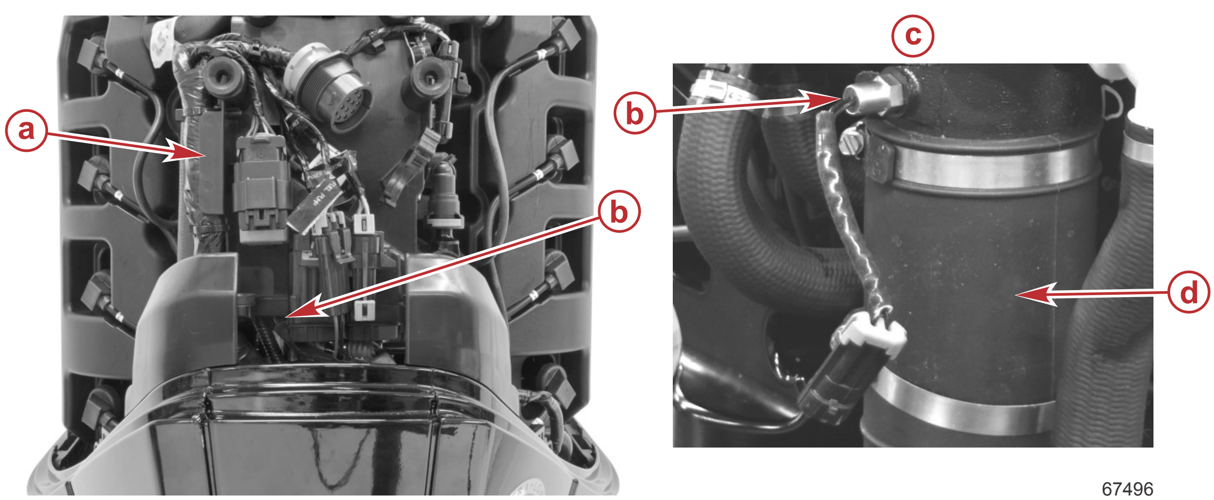
| Description | Nm | lb-in. | lb-ft |
|---|---|---|---|
| Engine coolant temperature sensor | 15 | 132.8 | – |

4. Connect the sensor harness to the engine harness.
5. Secure the sensor harness connector to the engine harness with a cable tie.

# Exhaust Gas Temperature (EGT) Sensor

The exhaust gas temperature (EGT) sensor is a thermistor inserted into the exhaust gas stream. The sensor provides exhaust temperature information to the PCM.

The EGT sensor is located in the lower port side of the exhaust manifold, above the lower exhaust tube and below the electrical panel.




a - Electrical panel
b - EGT sensor
c - View with items removed for clarity
d - Lower exhaust tube (typical)

## EGT Sensor Test

Monitor the exhaust gas temperature (data item **EGT**) on the CDS G3 **Live Data** screen. With the engine cold and not running, exhaust gas temperature should be approximately the same as the ambient air temperature. After the engine is started, the temperature sensor should indicate a rise in temperature.

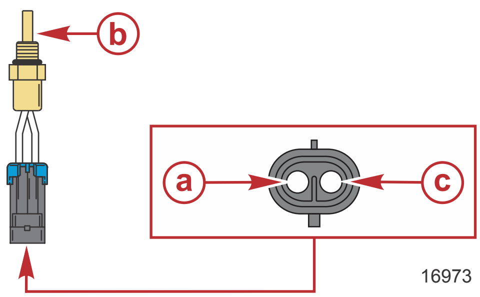
***NOTE:*** *During normal operation, exhaust gas temperature should be less than 300 °C (572 °F).*

| | |
|---|---|
| CDS G3 Interface Kit | 8M0138392 |

If there is not an obvious change in exhaust gas temperature sensor values, shake or move the sensor harness and connector. If the temperature begins to change, look for a broken, loose, or corroded wire.

Continue testing with the engine OFF:

1. Disconnect the engine harness from the sensor harness.
2. Perform a visual inspection of the sensor pins and the wires coming from the connector. Look for broken, bent, or corroded pins at the sensor and loose, broken, or corroded wires at the connector.
3. Test the sensor with an ohmmeter.
   a. Remove the sensor from the exhaust manifold.
   b. Immerse the tip of the sensor in a controlled temperature medium. If the readings do not match those in the table, replace the sensor and retest.




16973

a - Pin A—ground (–)
b - Exhaust gas temperature sensor
c - Pin B—exhaust gas temperature signal (+)

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

| EGT Sensor Resistance Test | |
|---|---|
| **Temperature** | **Reading (nominal)** |
| 0 °C (32 °F) | 1,000 Ω |
| 100 °C (212 °F) | 1,385 Ω |

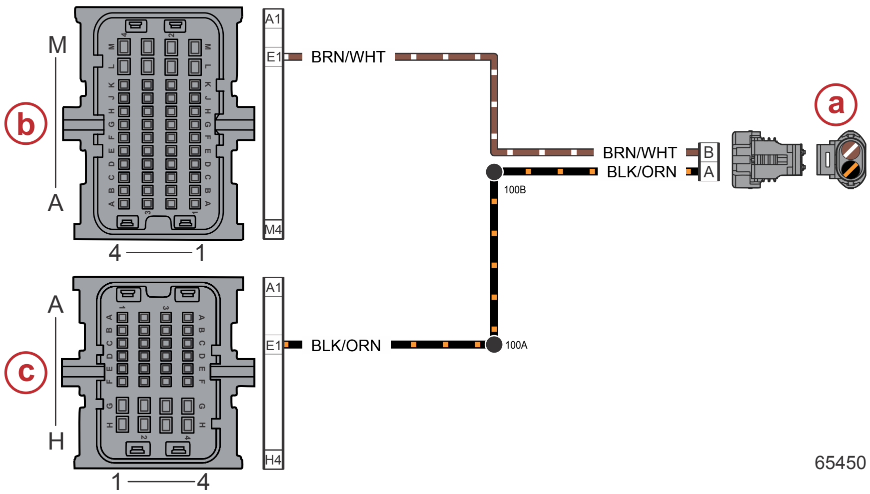
4. Perform a continuity check of the sensor wiring between the sensor connector and the PCM. Note that there are splices in the ground circuit.

   ***NOTE:*** *The quickest way to check the wiring is to measure the resistance of the thermistor at room temperature, connect the sensor to the engine harness, and measure the resistance across PCM connector sockets CE1 and BE1. If the two resistance values match, then the wiring is good.*

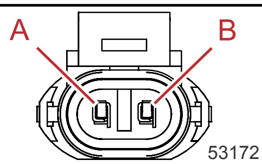
| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

| Terminal Test Probe Kit | Bosch P/N MM- 46523 |
|---|---|

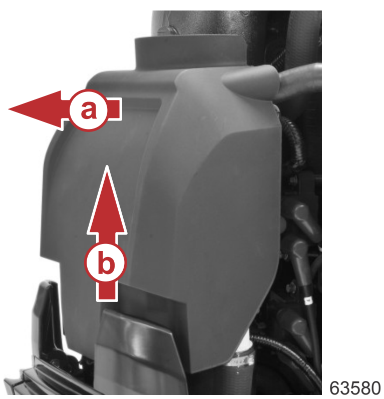



a - Exhaust gas temperature (EGT) sensor connector
b - PCM connector B
c - PCM connector C

| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|   | A | Black/orange | Sensor ground A (–) | CE1 |
| | B | Brown/white | Exhaust gas temperature | BE1 |

## EGT Sensor Removal

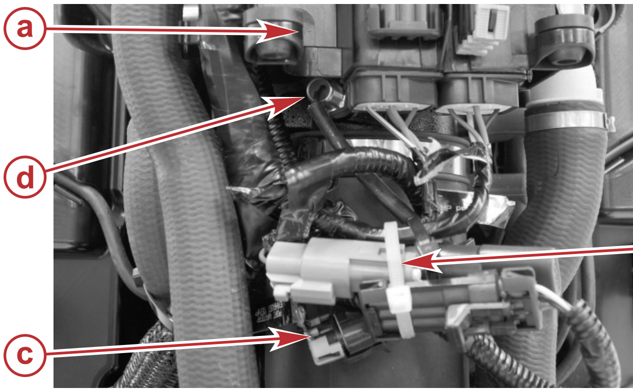
1. Remove the engine cowls. Refer to the appropriate service manual.
2. Remove the electrical panel cover.
   - On V8 models, pull the top aft until the pins are clear of the grommets, and then lift up.




V8 models
a - Pull aft
b - Lift up

   - On V6 models, pull the panel aft.

3. Cut the cable tie that secures the electrical connector bundle below the electrical plate, locate the EGT sensor harness, and disconnect it from the engine harness.



67429

- a - Electrical panel
- b - Cable tie
- c - EGT sensor connector (location varies)
- d - EGT sensor

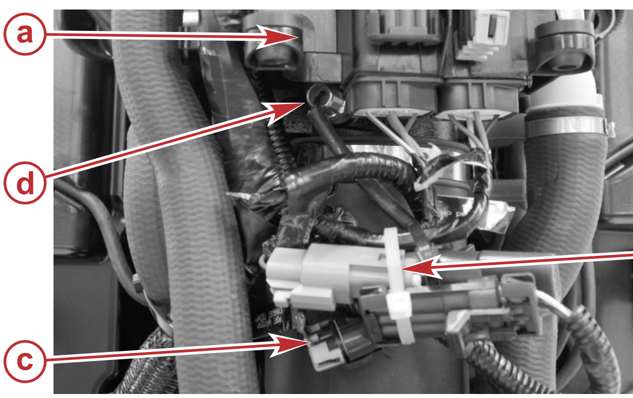
4. Remove the top two T30 Torx screws and washers securing the electrical plate to the exhaust tube.
5. Slide the electrical plate upward to gain additional access to the EGT sensor.
6. Remove the EGT sensor from the exhaust tube.

## EGT Sensor Installation

1. Ensure that the O-ring is in good condition and is present on the sensor.
2. Install the EGT sensor into the exhaust tube.
3. Tighten the sensor to the specified torque.

| Description | Nm | lb-in. | lb-ft |
|---|---|---|---|
| EGT sensor | 15 | 132.8 | – |

4. Connect the sensor harness to the engine harness.
5. Secure the electrical connector bundle with a cable tie.



67429

- a - Electrical panel
- b - Cable tie to secure electrical connector bundle
- c - EGT sensor connector (location varies)
- d - EGT sensor

6. Slide the electrical panel into position, and secure it to the exhaust tube with two T30 Torx screws and washers. Tighten the screws to the specified torque.

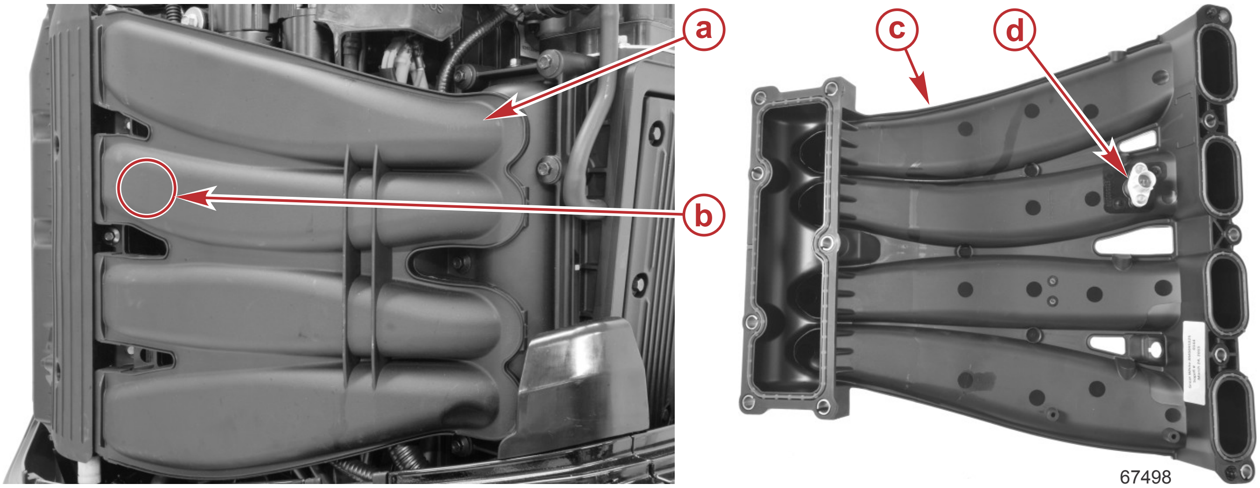
| Description | Nm | lb-in. | lb-ft |
|---|---|---|---|
| T30 Torx screws | 10 | 88.5 | – |

# Intake Air Temperature (IAT) Sensor

The intake air temperature (IAT) sensor is a thermistor that is inserted into the incoming air stream, immediately before the fuel injectors. The PCM receives the data from the IAT, and adjusts the fuel injection duration needed to run the engine at optimum efficiency. When intake air is cold, the sensor resistance is high. As the air temperature rises, resistance lowers. Outside air temperature directly affects the engine intake air temperature.

The IAT sensor is located in the starboard intake manifold, close to the fuel rail.




a - Starboard intake manifold, installed on engine (V8 shown, V6 similar)
b - Approximate location of IAT sensor
c - Starboard intake manifold, removed from engine (V8 shown, V6 similar)
d - IAT sensor

## IAT Sensor Test

Monitor the intake air temperature (data item **IAT**) on the CDS G3 **Live Data** screen. With the engine cold and not running, intake air temperature should be approximately the same as the ambient air temperature. After the engine is started, the temperature sensor should indicate a rise in air intake temperature.

| | |
|---|---|
| CDS G3 Interface Kit | 8M0138392 |

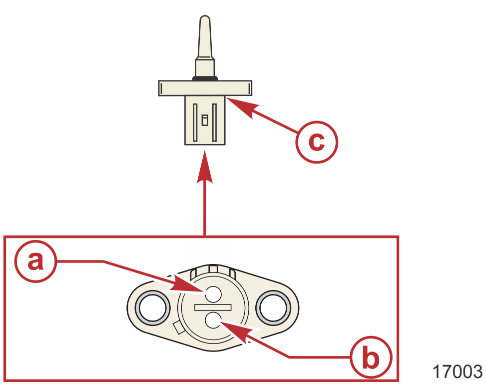
If the IAT sensor does not indicate a temperature change, shake or move the harness. If the temperature begins to change, look for a broken, loose, or corroded wire.

Continue testing with the engine OFF:

1. Disconnect the engine harness connector from the IAT sensor.
2. Visually inspect the sensor pins and the wires coming from the engine harness connector. Look for broken, bent, or corroded pins at the sensor and loose, broken, or corroded wires at the engine harness connector.
3. Test the sensor with an ohmmeter.
   a. Remove the sensor from the intake manifold.

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

   b. Immerse the sensor into a temperature controlled medium. If the readings do not match those in the table, replace the sensor and retest.




a - Pin A (signal)
b - Pin B (ground)
c - IAT sensor

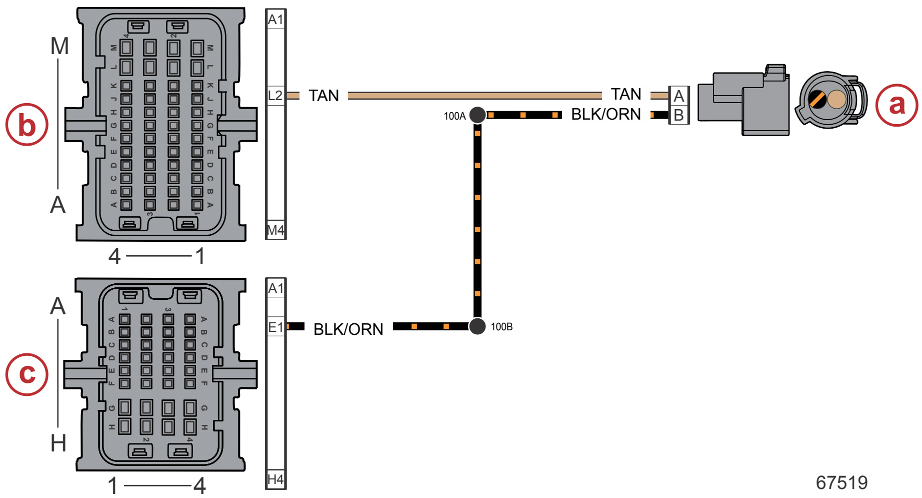
  

| Intake Manifold Air Temperature Sensor Resistance Test | |
|---|---|
| Temperature | Reading |
| 0 °C (32 °F) | 6.18–6.83 kΩ |
| 15 °C (59 °F) | 3.04–3.36 kΩ |
| 25 °C (77 °F) | 2.00–2.21 kΩ |
| 100 °C (212 °F) | 0.14–0.16 kΩ |

4. Perform a continuity check of the sensor wiring between the sensor connector and the PCM. Note that there are splices in the sensor ground circuit.

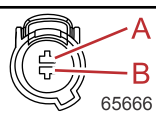
   ***NOTE:*** *The quickest way to check the wiring is to measure the resistance of the thermistor at room temperature, connect the sensor to the engine harness, and measure the resistance across PCM connector sockets CE1 and BL2. If the two resistance values match, then the wiring is good.*

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |
| Terminal Test Probe Kit | Bosch P/N MM- 46523 |




67519

a - Intake air temperature (IAT) sensor connector
b - PCM connector B
c - PCM connector C

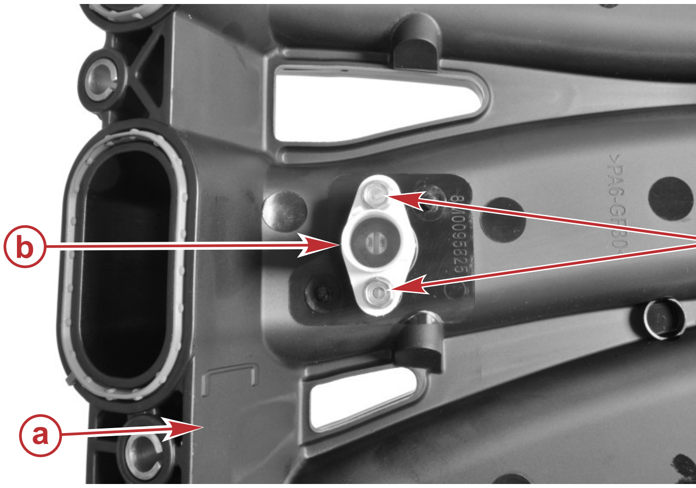
| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|  A B 65666 | A | Tan | Air temperature signal | BL2 |
| | B | Black/orange | Sensor ground A (–) | CE1 |

# IAT Sensor Removal

1. Remove the starboard air intake runner. Refer to the appropriate service manual.
2. Disconnect the engine harness connector from the IAT sensor.

3. Remove two M4 x 16 screws securing the sensor and remove the sensor.

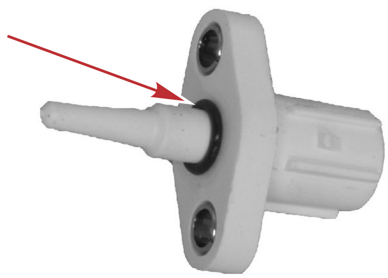



66553

- **a -** Starboard air intake runner
- **b -** IAT sensor
- **c -** M4 x 16 screws (2)

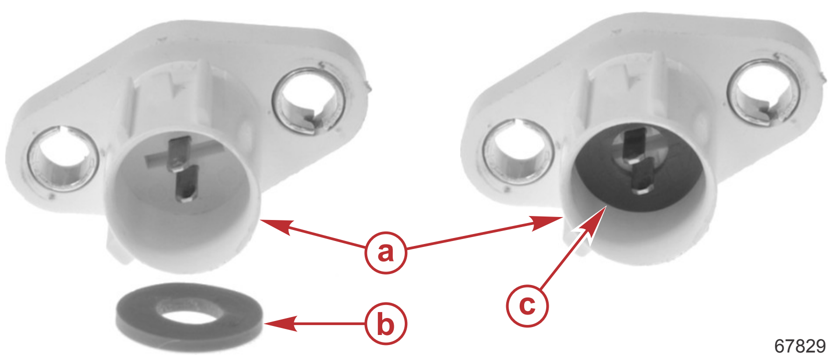
## IAT Sensor Installation

1. Install a new O-ring onto the IAT sensor.



13378

2. Ensure that the gasket is installed in the IAT sensor connector.




67829

- **a -** IAT sensor connector
- **b -** Gasket
- **c -** Gasket installed in the IAT sensor connector

*NOTE: The IAT sensor does not come with a gasket. It must be ordered separately.*

3. Install the sensor into the starboard intake runner. Tighten the M4 x 16 screws to the specified torque.

| Description | Nm | lb-in. | lb-ft |
|---|---|---|---|
| M4 x 16 screw | 1.7 | 15 | – |

4. Connect the engine harness to the sensor.

   **IMPORTANT: The intake runner fasteners must be tightened to the specified torque in the specified order. Refer to the appropriate service manual.**

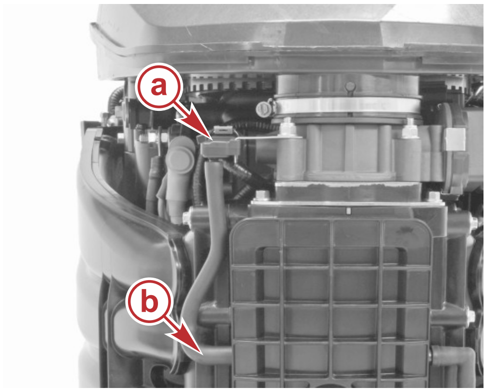
5. Install the starboard air intake runner. Refer to the appropriate service manual.

# Manifold Absolute Pressure (MAP) Sensor

The manifold absolute pressure (MAP) sensor measures the absolute atmospheric pressure in the intake manifold pressure. When the ignition key switch is first turned ON, the MAP sensor reads the ambient atmospheric pressure, which the PCM records as **BARO** (viewable in CDS G3 **Live Data**). When the engine is running, the PCM uses the MAP sensor to monitor changes in manifold pressure as the throttle opens and adjusts fuel delivery accordingly. The MAP sensor also allows the system to compensate for variations in altitude and weather.

The MAP sensor is located next to the throttle body, and it is connected to the intake manifold via a reference hose.



65096

a - MAP sensor
b - Reference hose

## MAP Sensor Test

Monitor the manifold absolute pressure (data item **MAP_Angle**) in the CDS G3 **Live Data** screen. The value should vary between idle and wide-open throttle RPMs, as shown following.

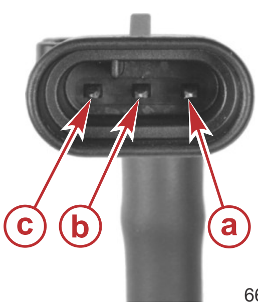
| Example MAP Sensor Readings | |
|---|---|
| At idle | 35–48 kPa (5–7 psi) |
| At wide-open throttle | Within 15% of **BARO** |

| | |
|---|---|
| CDS G3 Interface Kit | 8M0138392 |

If the **MAP_Angle** does not appear to vary with engine RPM, shake or move the sensor harness and connector. If the pressure begins to change, look for a broken, loose, or corroded wire.

Continue testing with the engine OFF:

1. Disconnect the engine harness connector from the sensor.
2. Visually inspect the sensor pins and the wires to the connector. Look for broken, bent, or corroded pins at the sensor and loose, broken, or corroded wires at the connector.
3. Check the MAP sensor with a digital ohmmeter between pins A, B, and C.



66570

MAP sensor with attached hose
a - Pin A
b - Pin B
c - Pin C

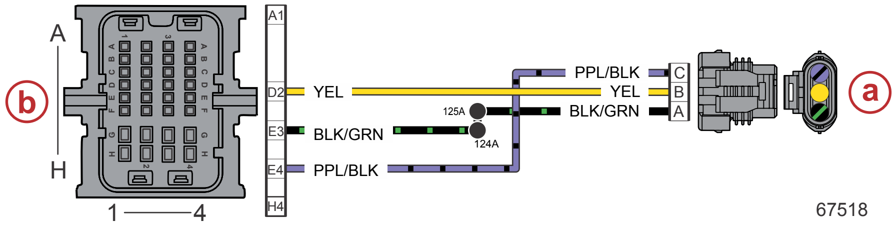
| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

| Meter Test Leads | | Meter Scale | Reading |
|---|---|---|---|
| Red | Black | | At 21 °C (70 °F) |
| Pin A | Pin B | Auto | 4.28 kΩ ± 30% |
| Pin A | Pin C | Auto | 1.93 kΩ ± 30% |
| Pin B | Pin C | Auto | 6.48 kΩ ± 30% |

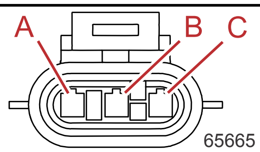
  

4. Perform a continuity check on the sensor wiring between the sensor connector and the PCM. Note that there are splices in the sensor ground circuit.

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |
| Terminal Test Probe Kit | Bosch P/N MM- 46523 |

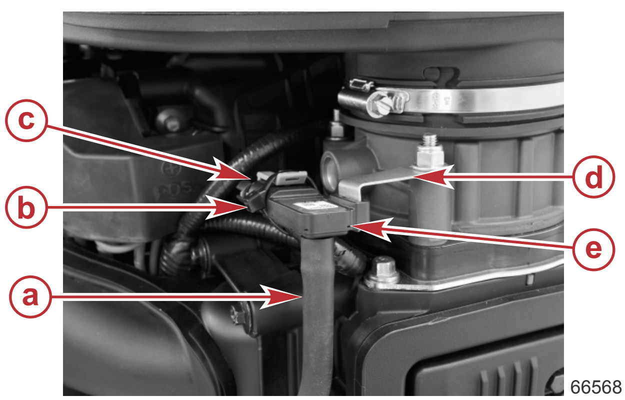



**a -** Manifold absolute pressure (MAP) sensor connector
**b -** PCM connector C

| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|   | A | Black/green | Sensor ground C (–) | CE3 |
| | B | Yellow | MAP signal | CD2 |
| | C | Purple/black | Sensor power C (+) | CE4 |

## MAP Sensor Removal

1. Cut the cable tie, and disconnect the engine harness connector.
2. Disconnect the hose from the sensor.
3. Remove the sensor from the bracket.




**a -** Sensor hose
**b -** Cable tie
**c -** Engine harness connector
**d -** Sensor bracket
**e -** MAP sensor

## MAP Sensor Installation

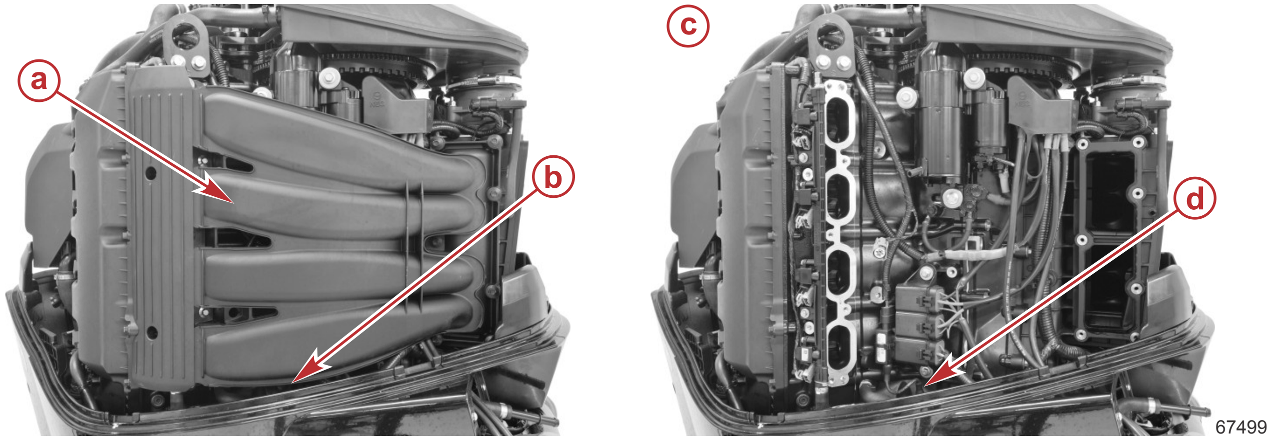
1. Install the sensor onto the bracket.
2. Connect the hose to the sensor.
3. Connect the engine harness connector to the sensor.
4. Secure the harness connection with a cable tie.

# Oil Level Sensor

***NOTE:*** *The oil level sensor is not present on all models.*

The oil level sensor is immersed into the oil sump. It acts as an electronic dipstick, sensing the level of the oil in the sump. When the oil level is low, the propulsion control module (PCM) sets a fault and notifies the boat operator to check the oil level.

The oil level sensor, if equipped, is located on the starboard side of the powerhead, at the base of the cylinder block. The starboard air intake runner must be removed to access the oil level sensor.




**a -** Starboard air intake runner
**b -** Location of the oil level sensor
**c -** Starboard view of engine with intake runner removed
**d -** Top of the oil level sensor

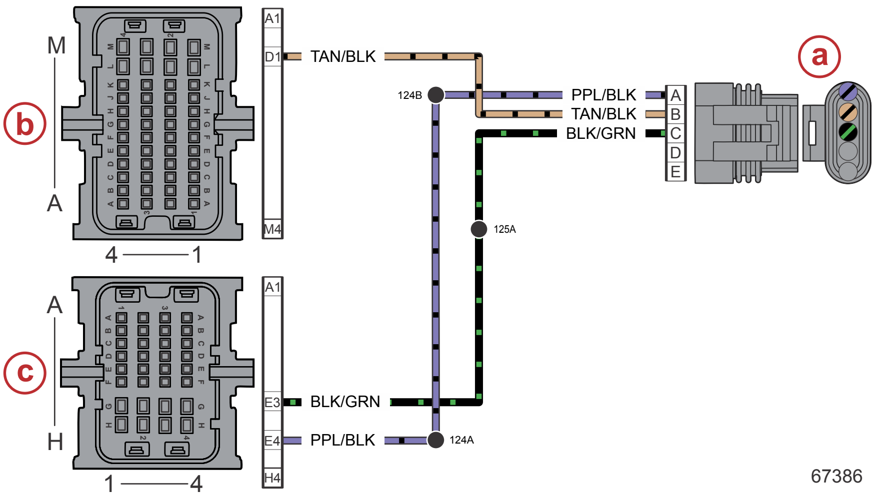
## Oil Level Sensor Test

Use the mechanical dipstick to ensure the oil level in the sump is within the standard operating range. Refer to the appropriate Operation and Maintenance Manual or service manual for more information.

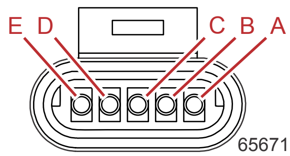
1. Use CDS G3 Live Data to read the value of the oil level sensor. The count range is 0–1024, with a normal oil level having a value of roughly 500 counts. If the oil level is correct on the dipstick but significantly out of range on the Live Data value, the wiring, connections, or sensor is likely at fault.
2. Disconnect the engine harness connector from the sensor.
3. Visually inspect the sensor pins and the wires coming from the engine harness connector. Look for broken, bent, or corroded pins at the sensor and loose, broken, or corroded wires at the engine harness connector.
4. Perform a continuity check of the sensor wiring between the sensor connector and the PCM. Note that there are splices in both the power and ground circuits.

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

| Terminal Test Probe Kit | Bosch P/N MM- 46523 |
|---|---|



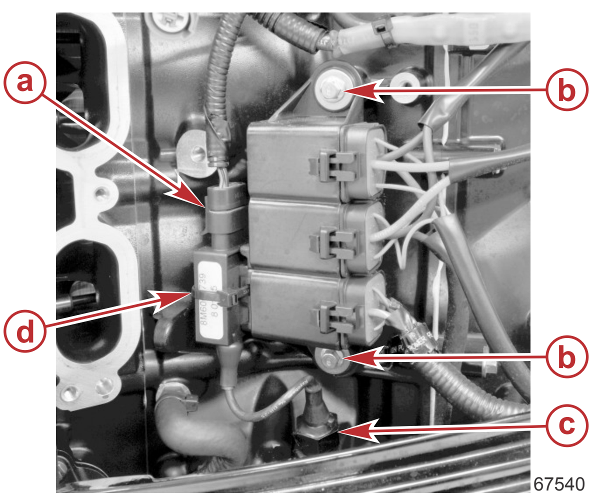

a - Oil level sensor connector
b - PCM connector B
c - PCM connector C

| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|  | A | Purple/black | Sensor power C (+) | CE4 |
| | B | Tan/black | Oil level signal | BD1 |
| | C | Black/green | Sensor ground C (–) | CE3 |
| | D | N/A | Not used | – |
| | E | N/A | Not used | – |

5. If no faults are found in the wiring and connections, replace the oil level sensor and retest.

## Oil Level Sensor Removal

1. Remove the starboard air intake runner. Refer to the appropriate service manual.
2. Cut the cable tie that secures the oil level sensor module to the relay bracket.
3. Remove two screws and remove the relay bracket from the engine.
4. Disconnect the oil level sensor harness from the engine harness.
5. Remove the oil level sensor from the engine.




a - Oil level sensor harness connection to engine harness
b - Screws (2)
c - Oil level sensor
d - Cable tie around the oil level sensor module

## Oil Level Sensor Installation

1. Insert the oil level sensor into the engine, and tighten it to the specified torque.

| Description | Nm | lb-in. | lb-ft |
|---|---|---|---|
| Oil level sensor | 20 | 177 | – |

2. Use two screws to attach the relay bracket to the engine. Tighten the screws to the specified torque.

| Description | Nm | lb-in. | lb-ft |
|---|---|---|---|
| Screws | 10 | 88.5 | – |

3. Use a cable tie to secure the oil level sensor module to the relay bracket.
4. Connect the oil level sensor harness to the engine harness.

   **IMPORTANT: The intake runner fasteners must be tightened to the specified torque in the specified order. Refer to the appropriate service manual.**
5. Install the starboard air intake runner. Refer to the appropriate service manual.

# Oil Pressure Sensor

The oil pressure sensor measures the engine oil pressure. In the event of low oil pressure, the PCM will limit engine power, based on the amount of oil pressure available at a specific engine RPM.

The oil pressure sensor is located next to the oil filter, near the top of the port side of the engine.


67501

**Port top view of engine (V8 shown, V6 similar)**

a - Oil pressure sensor

b - Oil filter

## Oil Pressure Sensor Test

Monitor the oil pressure (data item **OilPressure**) on the CDS G3 **Live Data** screen. The oil pressure should decrease as the engine warms, and should increase as the engine RPM is increased. Typical oil pressure readings are shown in the following table.

| Condition | Specification |
|---|---|
| At idle RPM (oil cold or warm*) | 150–650 kPa (21–95 psi) |
| At WOT RPM (oil cold or warm*) | 400–900 kPa (58–130 psi) |
| At idle RPM (oil hot) | 60–150 kPa (8–22 psi) |
| At WOT RPM (oil hot) | 350–550 kPa (50–80 psi) |
| **When the oil is cold, the pressure will be toward the upper end of the range. As the oil warms, the pressure will be toward the lower end of the range.* | |

| | |
|---|---|
| CDS G3 Interface Kit | 8M0138392 |

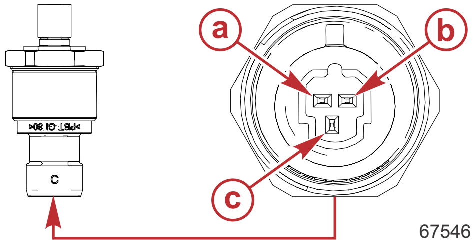
If the oil pressure sensor does not indicate a pressure change with the engine running at a normal operating temperature, shake or move the sensor harness and connector. If the pressure begins to change, look for broken, loose, or corroded wires.

Continue testing with the engine OFF:

1. Disconnect the engine harness connector from the sensor.
2. Visually inspect the pins of the oil pressure sensor and the wires coming from the engine harness connector. Look for broken, bent, or corroded pins at the oil pressure sensor and loose, broken, or corroded wires at the engine harness connector.

3. Measure the resistance between pins A, B, and C of the oil pressure sensor.




a - Pin A – ground (–)
b - Pin B – power (+)
c - Pin C – pressure signal

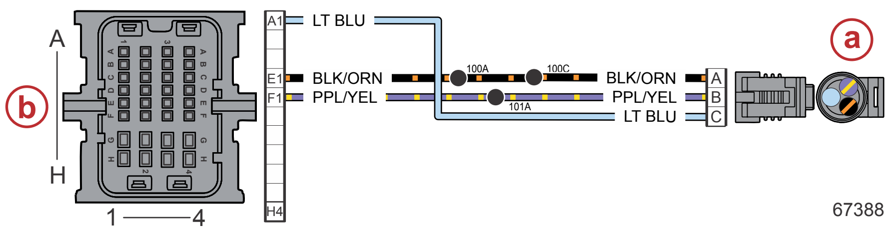
| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

| Meter Test Leads | | Meter Scale | Reading |
|---|---|---|---|
| Red | Black | | At 21 °C (70 °F) |
| Pin A | Pin B | Auto | 78.4–145.6 kΩ |
| Pin A | Pin C | Auto | 182.0–338.0 kΩ |
| Pin B | Pin C | Auto | 100.8–187.2 kΩ |

4. Perform a continuity check of the sensor wiring between the sensor connector and the PCM. Note that there are splices in both the power and ground circuits.

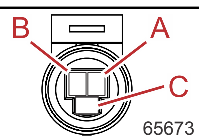
*NOTE: The diagram shown below is for DTS models. Mechanical models have only a single splice in the ground circuit, between the oil pressure sensor connector and the PCM connector. Refer to* ***Sensor Power A - Mechanical****.*

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |
| Terminal Test Probe Kit | Bosch P/N MM- 46523 |



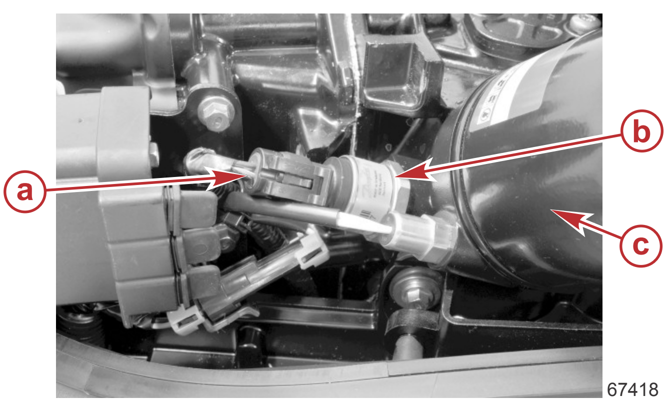

**DTS model shown; mechanical model similar**

a - Oil pressure sensor connector
b - PCM connector C

| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|   | A | Black/orange | Sensor ground A (–) | CE1 |
| | B | Purple/yellow | Sensor power A (+) | CF1 |
| | C | Light blue | Oil pressure signal | CA1 |

## Oil Pressure Sensor Removal

1. Disconnect the engine harness from the sensor.
2. Remove the sensor from the engine.




a - Oil pressure sensor connector on the engine harness
b - Oil pressure sensor
c - Oil filter

## Oil Pressure Sensor Installation

1. Ensure that the O-ring is in good condition and is installed on the sensor.
2. Install the oil pressure sensor into the engine.
3. Tighten the sensor to the specified torque.

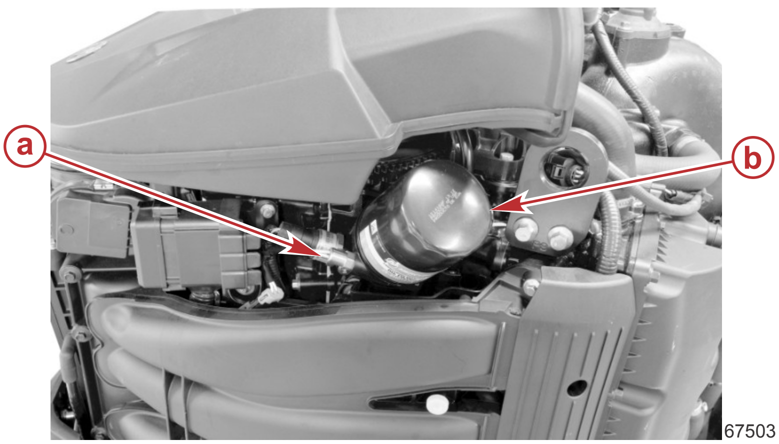
| Description | Nm | lb-in. | lb-ft |
|---|---|---|---|
| Oil pressure sensor | 15 | 132.8 | – |

4. Connect the engine harness to the sensor.

# Oil Temperature Sensor

The oil temperature sensor is a thermistor immersed in the engine oil passageway. It supplies the PCM with engine oil temperature information. Low oil temperature produces high resistance, while high temperature causes low resistance. Outside air temperature and the temperature of the water that the engine is operating in will directly affect the engine oil temperature.

The oil temperature sensor is located next to the oil filter, near the top of the port side of the engine.




Port top view of engine (V8 shown, V6 similar)

a - Oil temperature sensor

b - Oil filter

## Oil Temperature Sensor Test

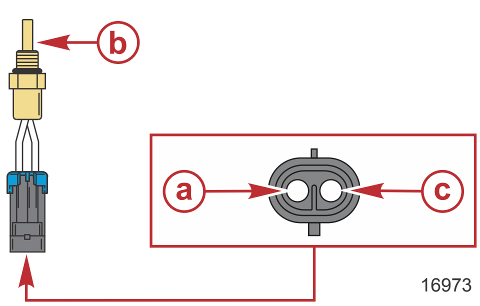
Monitor the oil temperature (data item **OilTemp**) on the CDS G3 **Live Data** screen. With the engine not running and cold, the oil temperature should be approximately the same as the ambient air temperature. After the engine is started, the temperature sensor should indicate a rise in oil temperature to approximately 75–110 °C (167–230 °F).

| | |
|---|---|
| CDS G3 Interface Kit | 8M0138392 |

If the oil temperature sensor does not indicate a temperature change, shake or move the sensor harness and connector. If the temperature begins to change, look for a broken, loose, or corroded wire.

Continue testing with the engine OFF:

1. Disconnect the engine harness connector from the sensor.
2. Visually inspect the sensor pins and the wires to the engine harness connector. Look for broken, bent, or corroded pins at the sensor and loose, broken, or corroded wires at the engine harness connector.
3. Test the sensor with an ohmmeter.
   a. Disconnect the engine harness connector from the sensor and remove the sensor.
   b. Immerse the tip of the sensor in a controlled temperature medium. If the readings do not match those in the table, replace the sensor and retest.




a - Pin A—ground (–)

b - Oil temperature sensor

c - Pin B—oil temperature signal (+)

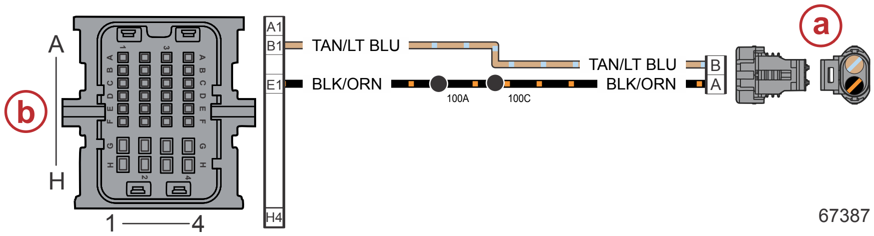
| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

| Oil Temperature Sensor Resistance Test | |
|---|---|
| Temperature | Reading (nominal) |
| 0 °C (32 °F) | 32.6 kΩ |
| 20 °C (68 °F) | 12.5 kΩ |
| 40 °C (104 °F) | 5.3 kΩ |
| 65 °C (150 °F) | 2.1 kΩ |
| 95 °C (203 °F) | 786 Ω |

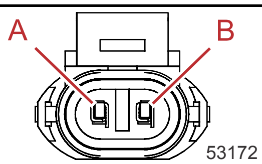
4. Perform a continuity check of the sensor wiring between the sensor connector and the PCM. Note that there are splices in the ground circuit.

   ***NOTE:*** *The quickest way to check the wiring is to measure the resistance of the thermistor at room temperature, connect the sensor to the engine harness, and measure the resistance across PCM connector sockets CE1 and CB1. If the two resistance values match, then the wiring is good.*

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |
| Terminal Test Probe Kit | Bosch P/N MM- 46523 |

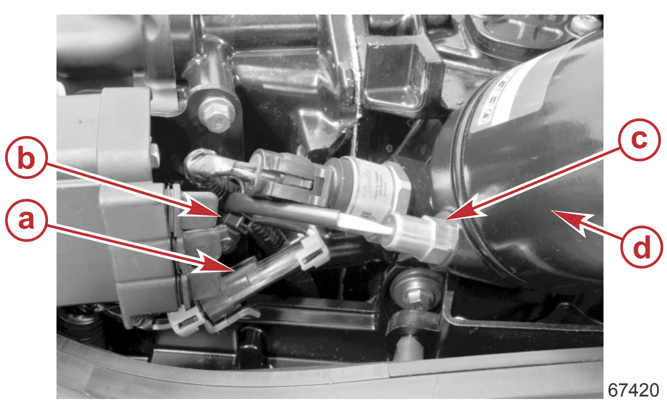



a - Oil temperature sensor connector
b - PCM connector C

| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|  A B 53172 | A | Black/orange | Sensor ground A (–) | CE1 |
| | B | Tan/light blue | Oil temperature signal | CB1 |

## Oil Temperature Sensor Removal

1. Cut the cable tie that secures the sensor harness to the engine harness.
2. Disconnect the sensor harness from the engine harness.
3. Remove the sensor from the engine.




a - Oil temperature sensor connection to engine harness
b - Cable tie
c - Oil temperature sensor
d - Oil filter

## Oil Temperature Sensor Installation

1. Ensure that the O-ring is in good condition and is installed on the sensor.
2. Install the oil temperature sensor into the engine.
3. Tighten the sensor to the specified torque.

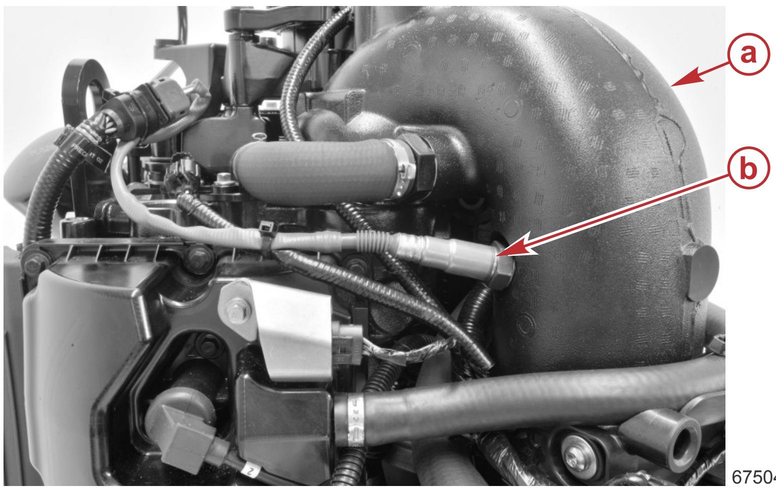
| Description | Nm | lb-in. | lb-ft |
|---|---|---|---|
| Oil temperature sensor | 15 | 132.8 | – |

4. Connect the sensor harness to the engine harness.
5. Secure the sensor harness to the engine harness with a cable tie.

# Oxygen (O2) Sensor

The PCM uses a single oxygen sensor to measure the amount of hydrocarbons and nitrous oxides in the exhaust. If there are excess hydrocarbons (unburned fuel), the air/fuel ratio is too rich. If there are too many nitrous oxides, the mixture is too lean. The PCM can use these measurements to add or subtract fuel by changing the time the fuel injectors are open.

The oxygen (O2) sensor is located at the top of the engine, in the port side of the exhaust manifold.




67504

a - Exhaust manifold
b - Oxygen (O2) sensor

## O2 Sensor Test

Monitor the operation of the O2 sensor heater on the CDS G3 **Live Data** screen. The heater should cycle on and off as seen as a number between 0 and 100 for the data item **UEGO1_HeaterDutyCycle**. As the engine warms, the value of data item **UEGO1_Ri_Temp** should rise to a steady state of approximately 768–791 °C (1416–1456 °F).

| | |
|---|---|
| CDS G3 Interface Kit | 8M0138392 |

If the O2 sensor does not appear to be working correctly, shake or move the sensor harness and connector. If the sensor appears to begin working correctly, look for a broken, loose, or corroded wire. If there is no change, replace the sensor with a known good sensor and retest.

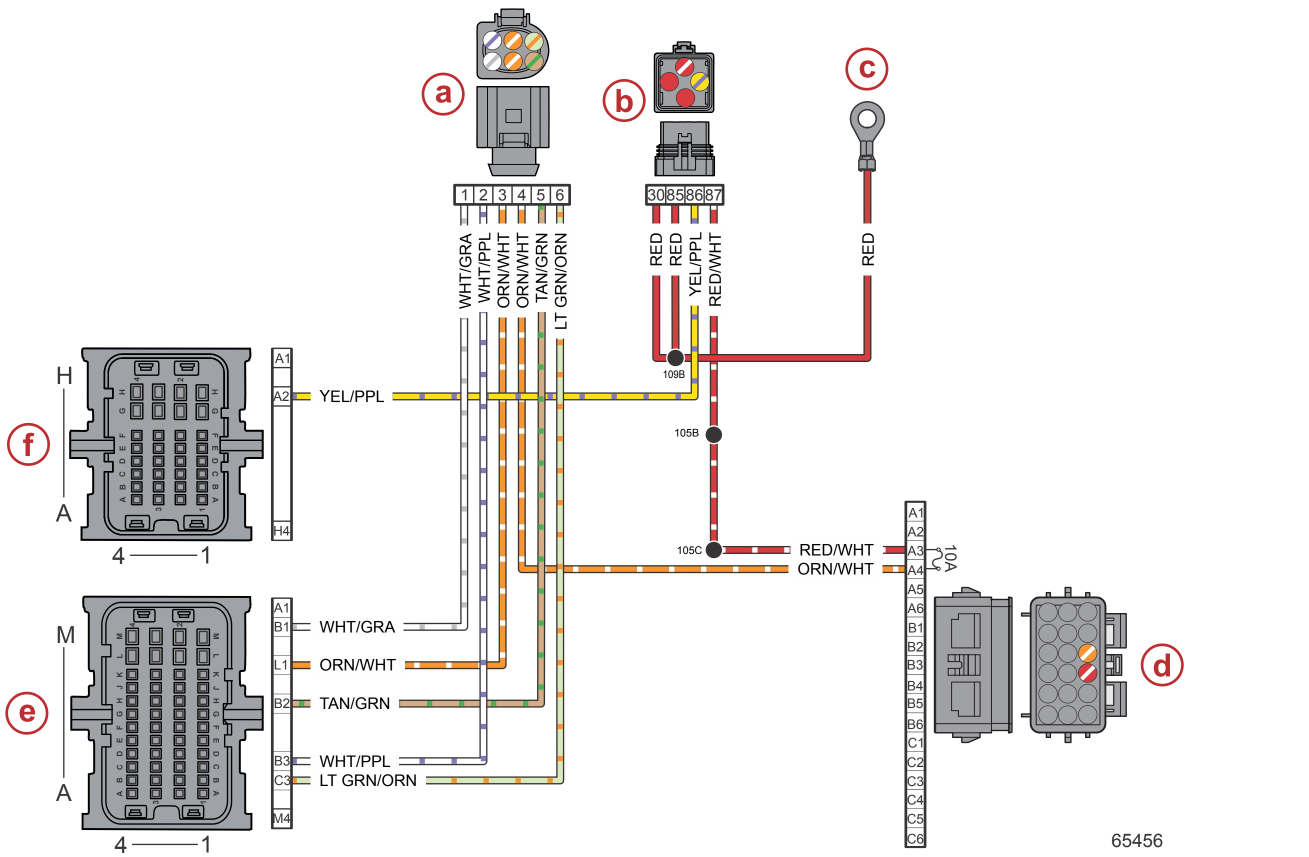
Continue testing with the engine OFF:

1. Disconnect the sensor from the engine harness.
2. Perform a continuity check of the relevant circuitry in the engine harness. Note that the sensor receives fused 12-volt power via the main power relay.

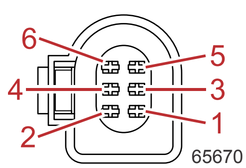
| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

| Terminal Test Probe Kit | Bosch P/N MM- 46523 |
|---|---|



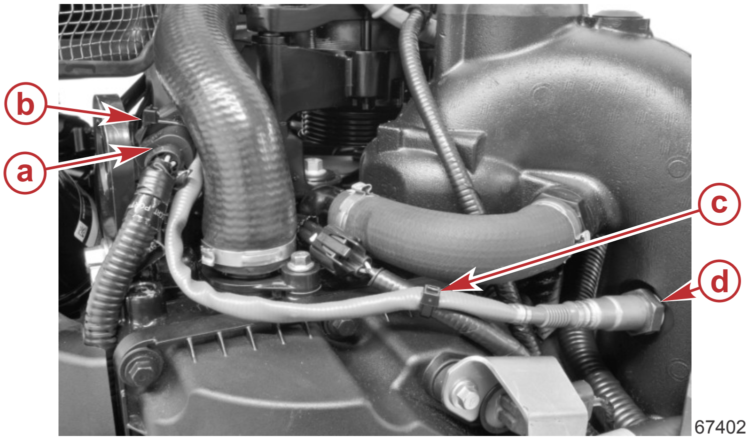

**a -** O2 sensor connector
**b -** Main power relay (MPR)
**c -** Hot stud (battery +)
**d -** Fuses: 10-amp fuse
**e -** PCM connector B
**f -** PCM connector A

| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|  | 1 | White/gray | UEGO (1) - port | BB1 |
| | 2 | White/purple | UEGO (2) - port | BB3 |
| | 3 | Orange/white | UEGO port heat | BL1 |
| | 4 | Orange/white | Fused (10 A) 12 V power (+) | – |
| | 5 | Tan/green | UEGO (5) - port | BB2 |
| | 6 | Light green/orange | UEGO (6) - port | BC3 |
| Hot stud ring terminal | – | Red | 12 V battery power (+) | – |
| MPR | 86 | Yellow/purple | MPR control signal | AA2 |
| MPR | 87 | Red/white | Switched 12 V power (+) | – |

## O2 Sensor Removal

1. Cut the cable tie that secures the O2 sensor harness to the harness connector.
2. Cut the cable tie that secures the O2 sensor harness to the crankshaft position sensor (CPS) leg of the engine harness.
3. Disconnect the O2 sensor harness from the engine harness.
4. Use an appropriate oxygen sensor socket to remove the O2 sensor from the exhaust manifold.

| Oxygen Sensor Socket | Obtain from Local Tool Supplier |
|---|---|



67402

a - O2 sensor connector on the engine harness
b - Cable tie securing the O2 sensor harness to the connector
c - Cable tie securing the O2 sensor harness to the CPS leg of the engine harness
d - O2 sensor

## O2 Sensor Installation

1. Ensure that the O2 sensor sealing washer is installed on the sensor and is in good condition.
2. Carefully thread the O2 sensor into the exhaust tube. Use an appropriate oxygen sensor socket to tighten the sensor to the specified torque.

| Oxygen Sensor Socket | Obtain from Local Tool Supplier |
|---|---|

| Description | Nm | lb-in. | lb-ft |
|---|---|---|---|
| O2 sensor | 18 | 159.3 | – |

3. Connect the O2 sensor harness to the engine harness. Route the harness as shown in the preceding illustration.
4. Secure the O2 sensor harness to the connector with a cable tie.
5. Secure the O2 sensor harness to the CPS leg of the engine harness with a cable tie.

# Pitot Pressure Sensor

The pitot pressure sensor measures the force of the water at the front of the gear housing. The sensor converts this pressure to a voltage that is read by the PCM. The PCM uses this voltage signal to determine boat speed.

The pitot pressure sensor is located on the port side of the engine, near the flush hose and behind the intake runner.

## Pitot Pressure Sensor Test

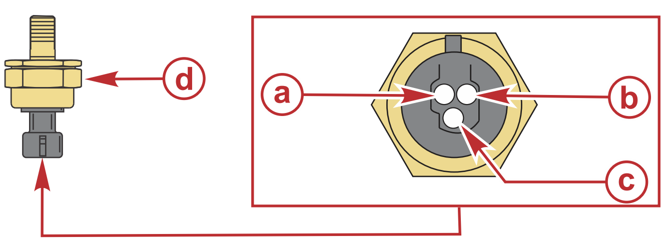
Monitor the pitot pressure (data item **PitotPres_ADC**, measured in counts) on the CDS G3 **Live Data** screen.

| CDS G3 Interface Kit | 8M0138392 |
|---|---|

If the counts do not increase as boat speed increases, shake or move the sensor harness and connector. If the speed begins to change, look for a broken, loose, or corroded wire.

Continue testing with the engine OFF:

1. Disconnect the engine harness connector from the sensor.
2. Visually inspect the sensor pins and the wires coming from the engine harness connector. Look for broken, bent, or corroded pins at the sensor and loose, broken, or corroded wires at the engine harness connector.
3. Check the resistance of the pitot pressure sensor between pins A, B, and C.



17006

a - Pin A
b - Pin B
c - Pin C
d - Pitot pressure sensor

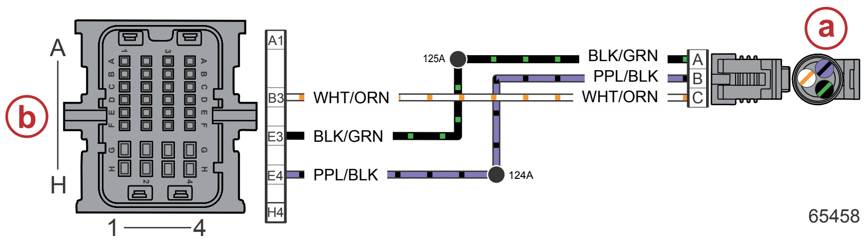
| DMT 2004 Digital Multimeter | 91-892647A01 |
|---|---|

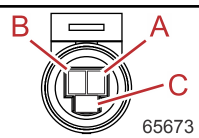
| Meter Test Leads | | Meter Scale | Reading |
|---|---|---|---|
| Red | Black | | At 21 °C (70 °F) |
| Pin A | Pin B | Auto | 78.4–145.6 kΩ |
| Pin A | Pin C | Auto | 182.0–338.0 kΩ |
| Pin B | Pin C | Auto | 100.8–187.2 kΩ |

4. Perform a continuity check of the sensor wiring between the sensor connector and the PCM. Note that both the power and ground circuits have splices.

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |
| Terminal Test Probe Kit | Bosch P/N MM- 46523 |

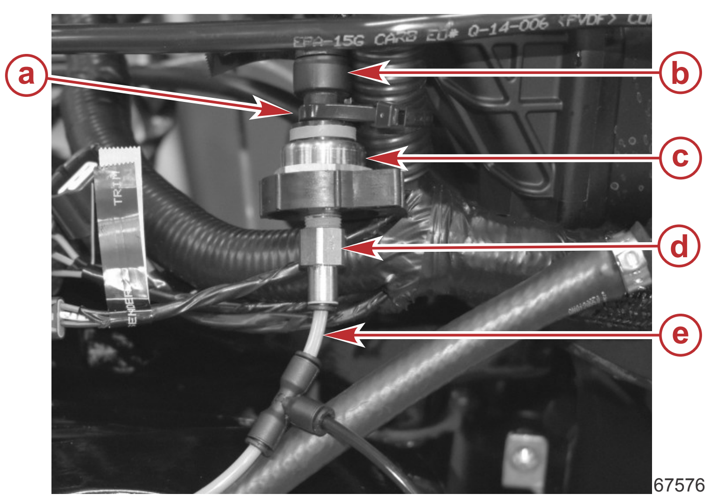



a - Pitot pressure sensor connector
b - PCM connector C

| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|   | A | Black/green | Sensor ground C (–) | CE3 |
| | B | Purple/black | Sensor power C (+) | CE4 |
| | C | White/orange | Pitot pressure signal | CB3 |

## Pitot Pressure Sensor Removal

1. Remove the port intake runner. Refer to the appropriate service manual.
2. Disconnect the pitot tube from the sensor.
3. Disconnect the engine harness connector from the sensor.
4. Cut the cable tie to remove the sensor from the engine.
5. Remove the sensor adapter from the pitot pressure sensor.




Items removed for clarity

a - Cable tie
b - Sensor connector
c - Sensor adapter
d - Flush hose
e - Pitot tube

## Pitot Pressure Sensor Installation

1. Install the sensor adapter onto the pitot pressure sensor. Tighten the sensor adapter to ensure the adapter will not leak.


13401

a - Pitot pressure sensor
b - Sensor adapter

2. Connect the engine harness to the sensor.
3. Connect the pitot tube.
4. Use a cable tie to secure the sensor to the engine harness.
5. Install the port intake runner. Refer to the appropriate service manual.

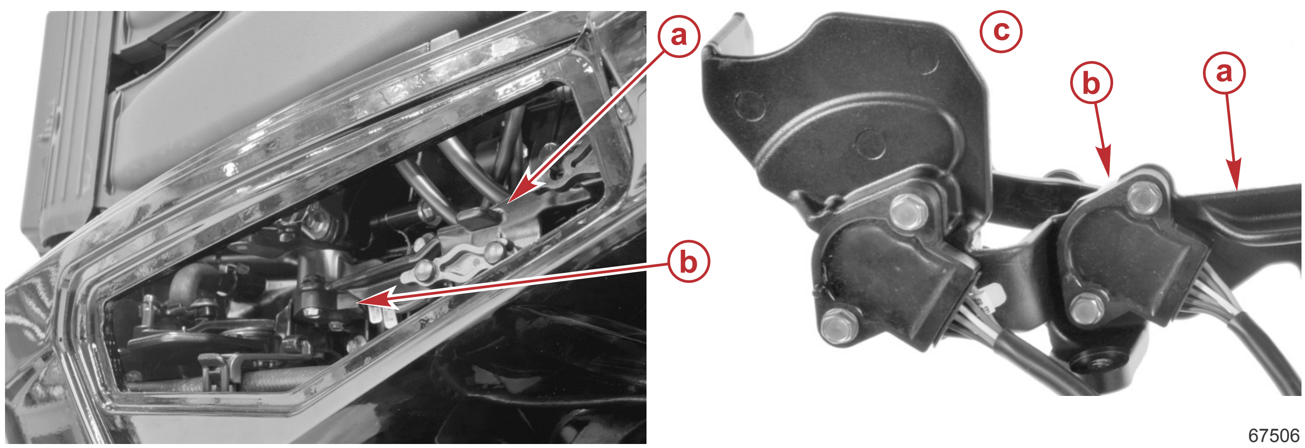
# Shift Demand Sensor

*NOTE: The shift demand sensor is only on models with mechanical throttle and shift controls.*

The demand sensors used for the throttle and shift demand are identical. They consist of two hall-effect sensors in a single housing, configured such that the value of the output signal of one sensor increases (from 0.5 VDC to 4.5 VDC) as the other decreases (from 4.5 VDC to 0.5 VDC), and vice versa.

The sensors can be swapped for diagnostic purposes. Exercise special care to ensure that the sensor connections to the engine harness are correct, prior to attempting to run the engine.

The shift demand sensor is the foremost of the two sensors on the throttle and shift bracket.




67506

a - Throttle and shift bracket
b - Shift demand sensor
c - Underside of throttle and shift bracket

## Shift Demand Sensor Testing

Monitor the operation of the shift demand sensor by viewing the **CTRL_Gear** and **ActualGear** data items on the CDS G3 **Live Data** screen. If the shift demand sensor is operating correctly and with the engine running, both items should indicate the gear as requested by the remote control.

| | |
|---|---|
| CDS G3 Interface Kit | 8M0138392 |

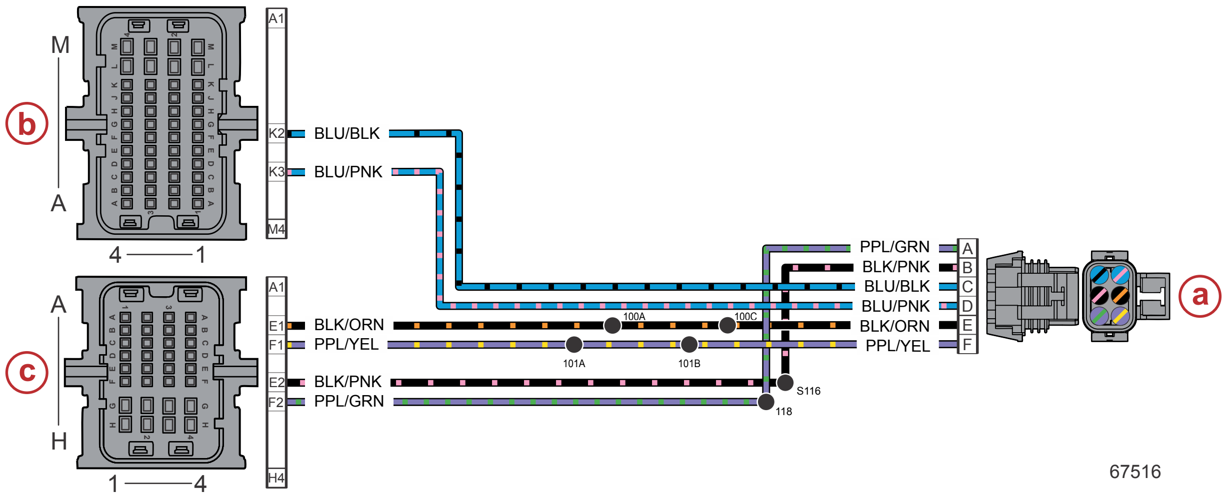
If the value of **CTRL_Gear** does not change as the shift lever is moved between forward, neutral, and reverse, shake or move the sensor harness and connector. If the value of **CTRL_Gear** begins to change, look for a broken, loose, or corroded wire.

Continue testing with the engine OFF:

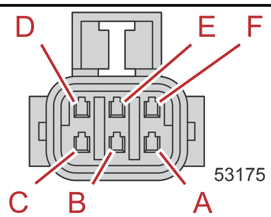
1. Disconnect the engine harness connector from the shift demand sensor.
2. Visually inspect the sensor pins and the wires coming from the engine harness connector. Look for broken, bent, or corroded pins at the sensor and loose, broken, or corroded wires at the engine harness connector.

3. Perform a continuity check of the sensor wiring in the engine harness, between the sensor connector and the PCM. Note that there are splices in both the power and ground circuits.

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |
| Terminal Test Probe Kit | Bosch P/N MM- 46523 |

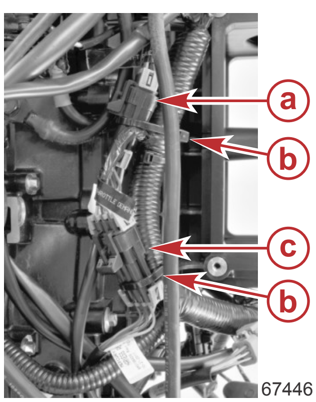



**a -** Shift demand sensor connector
**b -** PCM connector B
**c -** PCM connector C

| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|   | A | Purple/green | Sensor power B (+) | CF2 |
| | B | Black/pink | Sensor ground B (–) | CE2 |
| | C | Blue/black | Shift request 2 | BK2 |
| | D | Blue/pink | Shift request 1 | BK3 |
| | E | Black/orange | Sensor ground A (–) | CE1 |
| | F | Purple/yellow | Sensor power A (+) | CF1 |

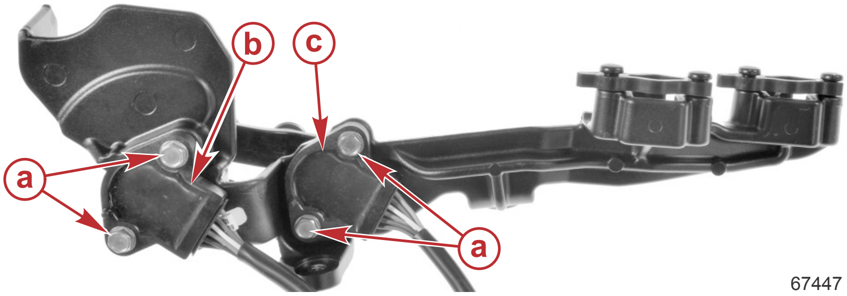
## Shift Demand Sensor Removal

1. Cut the cable tie that secures the shift demand sensor harness to the engine harness.
2. Disconnect the shift demand sensor harness from the engine harness.




**a -** Shift demand sensor connection
**b -** Cable ties (2)
**c -** Throttle demand sensor connection

3. Remove the two M5 x 16 hex washer head screws that secure the shift demand sensor to the underside of the throttle and shift bracket, and remove the sensor.




67447

Throttle and shift bracket, shown removed for clarity

a - M5 x 16 hex washer head screws (2 per sensor, 4 total)
b - Throttle demand sensor
c - Shift demand sensor

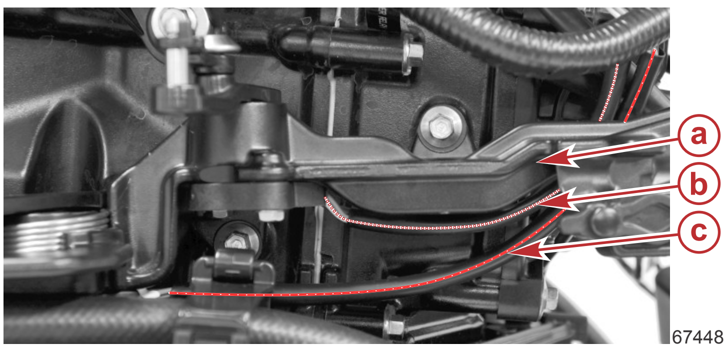
## Shift Demand Sensor Installation

*NOTE: Refer to previous illustrations as required.*

1. Attach the shift demand sensor to the underside of the throttle and shift bracket, using two M5 x 16 hex washer head screws. Tighten the screws to the specified torque.

| Description | Nm | lb-in. | lb-ft |
|---|---|---|---|
| M5 x 16 hex washer head screw | 1.7 | 15 | – |

2. Route the shift demand sensor harness between the throttle and shift bracket and the engine block.




67448

a - Throttle and shift bracket
b - Shift demand sensor harness
c - Throttle demand sensor harness

3. Connect the shift demand sensor harness to the engine harness. Use a cable tie to secure the connection to the engine harness.

# Throttle Demand Sensor

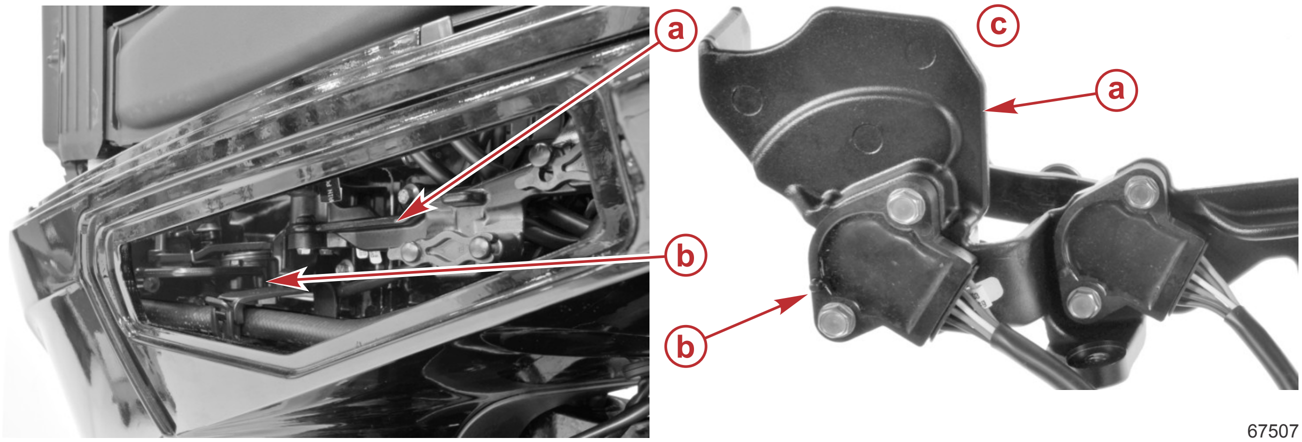
*NOTE: The throttle demand sensor is only on models with mechanical throttle and shift controls.*

The demand sensors used for the throttle and shift demand are identical. They consist of two hall-effect sensors in a single housing, configured such that the value of the output signal of one sensor increases (from 0.5 VDC to 4.5 VDC) as the other decreases (from 4.5 VDC to 0.5 VDC), and vice versa.

The sensors can be swapped for diagnostic purposes. Exercise special care to ensure that the sensor connections to the engine harness are correct, prior to attempting to run the engine.

The throttle demand sensor is the aftmost of the two sensors on the throttle and shift bracket.




a - Throttle and shift bracket
b - Throttle demand sensor
c - Underside of throttle and shift bracket (removed from engine)

## Throttle Demand Sensor Testing

Monitor the operation of the throttle demand sensor by viewing the **DemandLinear** data item on the CDS G3 **Live Data** screen. The value of this data item should rise and fall (as a percent) with the movement of the operator throttle control.

| | |
|---|---|
| CDS G3 Interface Kit | 8M0138392 |

If the value of **DemandLinear** does not change as the throttle control is moved, shake or move the sensor harness and connector. If the value of **DemandLinear** begins to change, look for a broken, loose, or corroded wire.

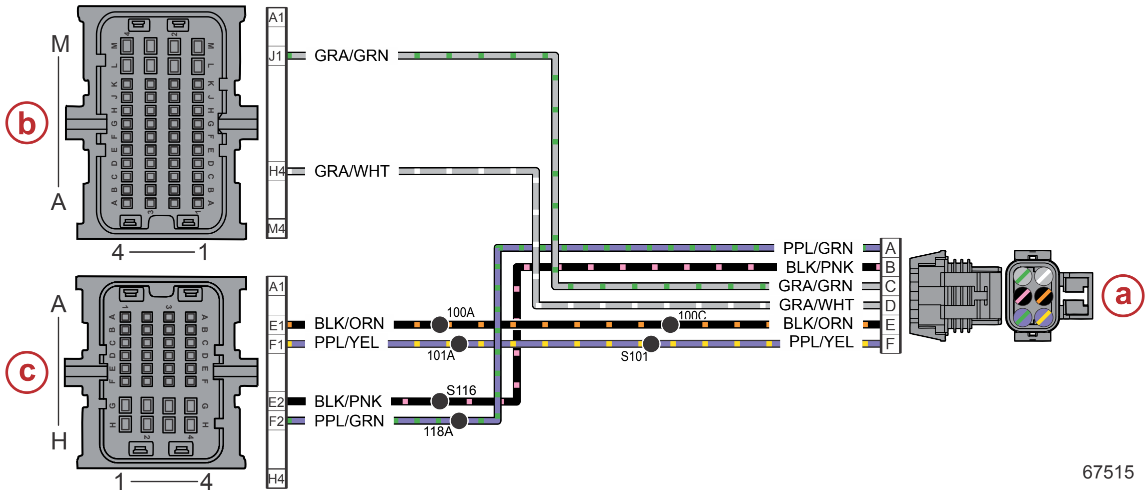
Continue testing with the engine OFF:

1. Disconnect the engine harness connector from the throttle demand sensor.
2. Visually inspect the sensor pins and the wires coming from the engine harness connector. Look for broken, bent, or corroded pins at the sensor and loose, broken, or corroded wires at the engine harness connector.
3. Perform a continuity check of the sensor wiring in the engine harness, between the sensor connector and the PCM. Note that there are splices in both the power and ground circuits.

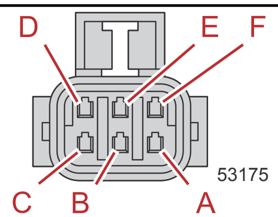
| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

| Terminal Test Probe Kit | Bosch P/N MM- 46523 |
|---|---|

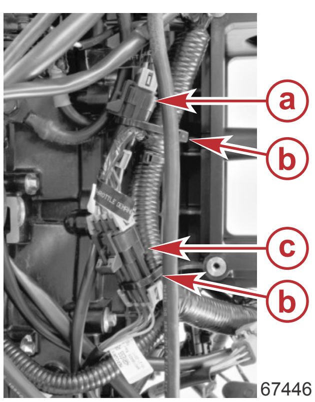



**a -** Throttle demand sensor connector
**b -** PCM connector B
**c -** PCM connector C

| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|   | A | Purple/green | Sensor power B (+) | CF2 |
| | B | Black/pink | Sensor ground B (–) | CE2 |
| | C | Gray/green | Throttle demand position 2 | BJ1 |
| | D | Gray/white | Throttle demand position 1 | BH4 |
| | E | Black/orange | Sensor ground A (–) | CE1 |
| | F | Purple/yellow | Sensor power A (+) | CF1 |

## Throttle Demand Sensor Removal

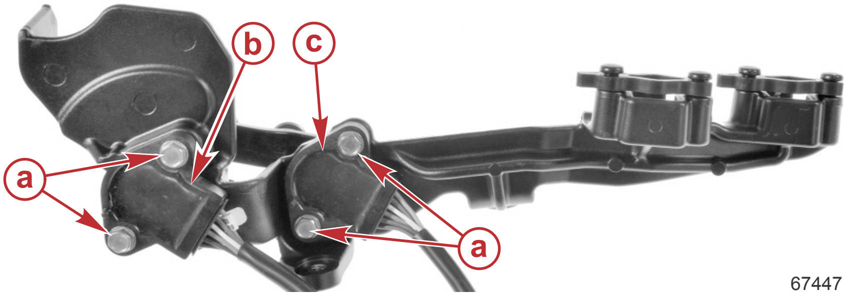
1. Cut the cable tie that secures the throttle demand sensor harness to the engine harness.
2. Disconnect the throttle demand sensor harness from the engine harness.




**a -** Shift demand sensor connection
**b -** Cable ties (2)
**c -** Throttle demand sensor connection

3. Remove the two M5 x 16 hex washer head screws that secure the throttle demand sensor to the underside of the throttle and shift bracket, and remove the sensor.




**Throttle and shift bracket, shown removed for clarity**

a - M5 x 16 hex washer head screws (2 per sensor, 4 total)

b - Throttle demand sensor

c - Shift demand sensor

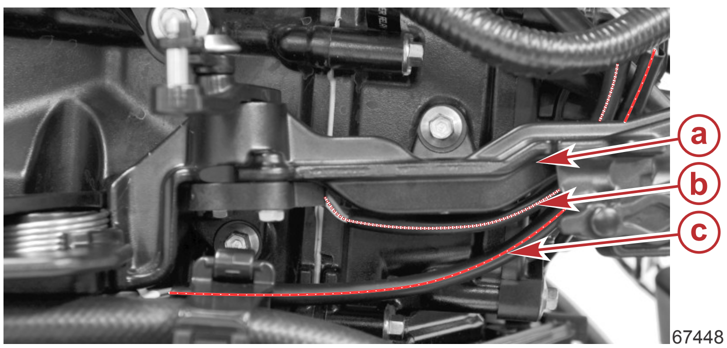
## Throttle Demand Sensor Installation

*NOTE: Refer to previous illustrations as required.*

1. Attach the throttle demand sensor to the underside of the throttle and shift bracket, using two M5 x 16 hex washer head screws. Tighten the screws to the specified torque.

| Description | Nm | lb-in. | lb-ft |
|---|---|---|---|
| M5 x 16 hex washer head screw | 1.7 | 15 | – |

2. Route the throttle demand sensor harness between the throttle and shift bracket and the engine block.




a - Throttle and shift bracket

b - Shift demand sensor harness

c - Throttle demand sensor harness

3. Connect the throttle demand sensor harness to the engine harness. Use a cable tie to secure the connection to the engine harness.

# Trim Position Sensor

For information on the trim position sensor, refer to the appropriate section of this manual:

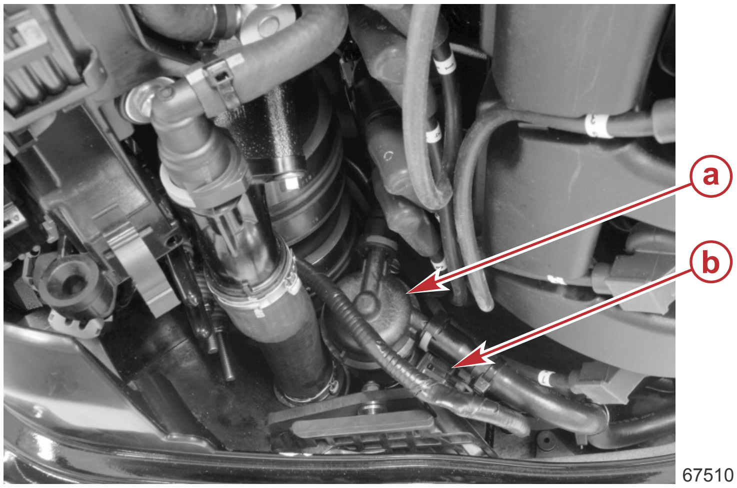
- Section 6C - Conventional Midsection (CMS) Power Trim
- Section 6D - Advanced Midsection (AMS) Power Trim

# Water-in-Fuel (WIF) Sensor

**IMPORTANT: SeaPro models are equipped with a vessel mounted water-separating fuel filter that has a water-in-fuel (WIF) sensor located on the filter drain knob. The engine mounted WIF sensor on SeaPro models is disconnected and is not used.**

The water-in-fuel (WIF) sensor is a normally open switch with two highly conductive probes. Water completes a 5-volt negative reference to the PCM. When water is present, the PCM generates an error history and activates a warning horn to inform the operator. If SmartCraft gauges are installed, the display will flash a visual warning to the operator.

The WIF sensor is integral to the fuel filter housing, located on the starboard side of the engine.



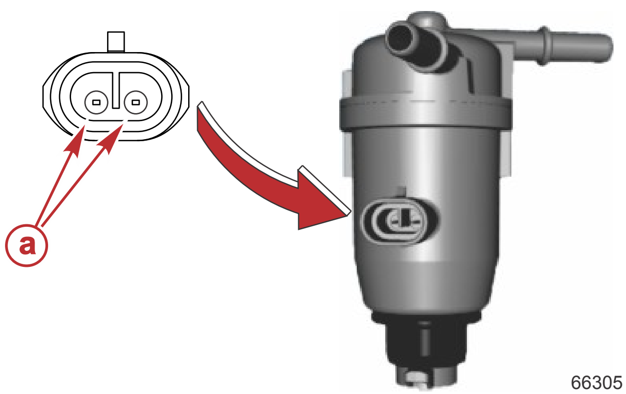

67510

**a -** On-engine fuel filter
**b -** Connector for integral water-in-fuel sensor

***NOTE:*** *If a boat-mounted water-separating fuel filter with a water-in-fuel sensor is used, the sensor harness will be connected to the boat-mounted filter.*

## WIF Sensor Test

1. If the WIF warning horn activates, remove the fuel filter assembly from the engine and pour the contents into a clear container. If no water is present, disconnect the WIF sensor harness and perform a continuity check between the two sensor pins. There should be no continuity. If there is continuity, the sensor is defective and the fuel filter assembly must be replaced.




66305

**a -** WIF sensor pins

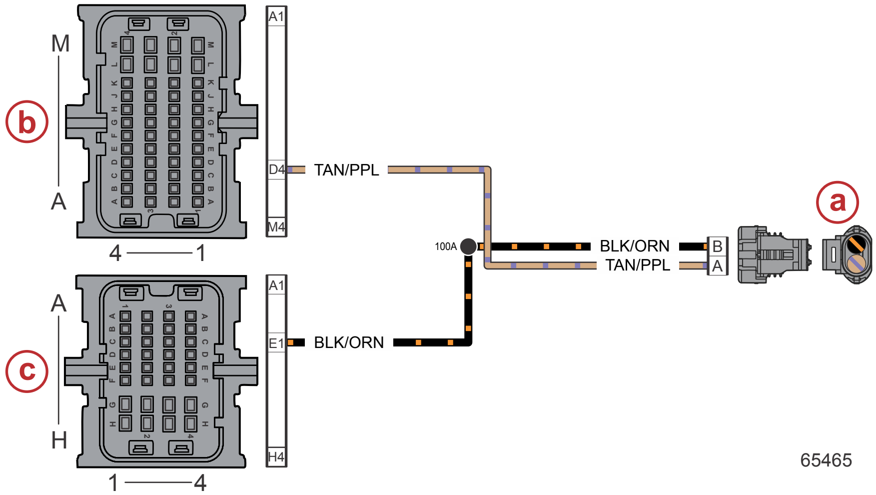
| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

2. If the sensor is serviceable, perform a continuity check on the sensor harness between the sensor connector and the PCM. Check for shorts to ground. Note that there is a splice in the ground circuit.

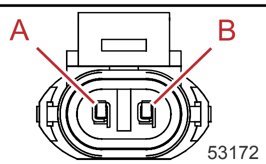
| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

| | |
|---|---|
| Terminal Test Probe Kit | Bosch P/N MM- 46523 |




**a -** Water-in-fuel sensor connector
**b -** PCM connector B
**c -** PCM connector C

| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|   | A | Tan/purple | Water-in-fuel signal | BD4 |
| | B | Black/orange | Sensor ground A (–) | CE1 |

## WIF Sensor Removal and Installation

IMPORTANT: The engine mounted water-separating fuel filter WIF sensor is not replaceable as an individual component. It must be replaced as part of the fuel filter assembly. Refer to the appropriate service manual.

# Notes:

# Sensors, Actuators, Relays, and Accessories

## Section 5B - Actuators and Relays

## Table of Contents

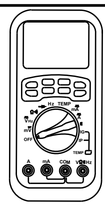


5
B

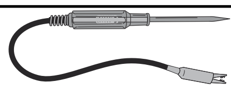
# Special Tools

| CDS G3 Interface Kit | 8M0138392 |
|---|---|
|  66165 | CDS G3 License Key, Interface, Adapter, and Harness |

| DMT 2004 Digital Multimeter | 91-892647A01 |
|---|---|
|  4516 | Measures RPM, ohms, amperes, AC and DC voltages; records maximums and minimums simultaneously, and accurately reads in high RFI environments. |

| Terminal Test Probe Kit | Bosch P/N MM- 46523 |
|---|---|
|  7915 | Test probes adapt test meter leads to harness connections without damaging harness terminals. May be used with Computer Diagnostic System (CDS). |

| Shift Actuator Harness | 8M0150597 |
|---|---|
|  67850 | Used to perform shift actuator circuit test. |

| Test Light | Obtain locally |
|---|---|
|  67851 | Applies an electrical load to a circuit, and visually indicates whether voltage is present. |

# Electronic Throttle Control (ETC)

## Overview

The ETC is controlled through the PCM. The PCM receives information from the throttle demand sensor, and the PCM activates the ETC motor to open or close the throttle valve. The two throttle valve position sensors in the ETC are also monitored by the PCM.

The ETC functions as an idle air control (IAC) valve. During hard deceleration, the ETC will remain open slightly until the engine RPM has stabilized, to eliminate engine stalling.

The ETC has a built-in fail-safe: the ETC is spring-loaded to an off idle position to maintain engine RPM at approximately 1200 RPM in gear.

The ETC can be tested with the computer diagnostic system (CDS G3).

| CDS G3 Interface Kit | 8M0138392 |
|---|---|

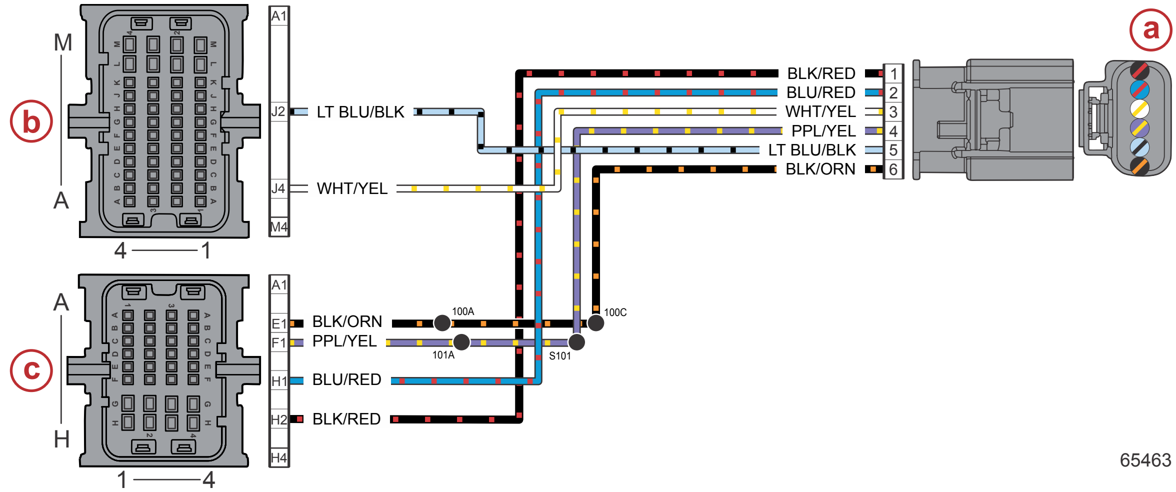
## Troubleshooting the ETC

**IMPORTANT: The ETC is integral to the throttle body assembly, and cannot be serviced separately. If the ETC fails, the entire throttle body assembly must be replaced. Refer to the appropriate service manual for throttle body assembly replacement procedures.**

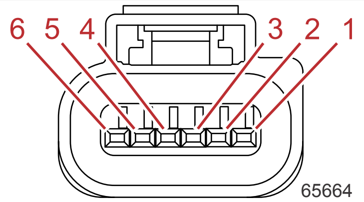
  

Use the DMT 2004 digital multimeter and test probe kit to check for continuity between the ETC and the PCM.

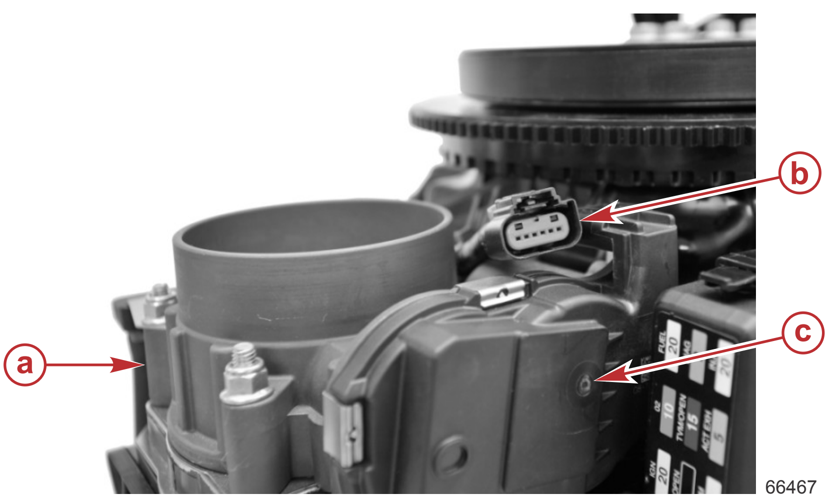
| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |
| Terminal Test Probe Kit | Bosch P/N MM- 46523 |




**a -** ETC connector
**b -** PCM connector B
**c -** PCM connector C

| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|   | 1 | Black/red | Throttle actuator A (+) | CH2 |
| | 2 | Blue/red | Throttle actuator B (–) | CH1 |
| | 3 | White/yellow | Throttle position 2 | BJ4 |
| | 4 | Purple/yellow | Sensor power A (+) | CF1 |
| | 5 | Light blue/black | Throttle position 1 | BJ2 |
| | 6 | Black/orange | Sensor ground A (–) | CE1 |

1. Remove the cold air intake assembly. Refer to the appropriate service manual for details.
2. Disconnect the ETC from the engine harness.




**a -** Throttle body
**b -** ETC connector on the engine harness
**c -** ETC

3. Remove the port intake manifold runner assembly. Refer to the appropriate service manual for details.
4. Disconnect the PCM from the engine harness. The connectors must be removed in sequence: A, B, and then C. Refer to the appropriate service manual for details.
5. Test the engine harness for continuity between each of the ETC connector pins and the PCM connectors:

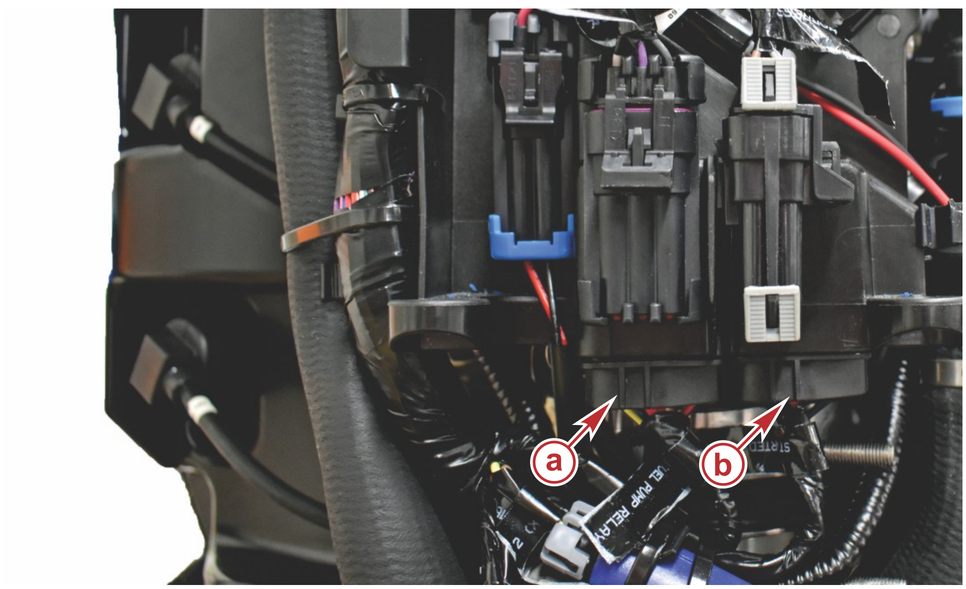
  

| Meter Test Leads | | Meter Scale | Reading |
|---|---|---|---|
| ETC connector pin | PCM connector-pin | | |
| 1 | C-H2 | Auto (Ω) | Continuity |
| 2 | C-H1 | Auto (Ω) | Continuity |
| 3 | B-J4 | Auto (Ω) | Continuity |
| 4 | C-F1 | Auto (Ω) | Continuity |
| 5 | B-J2 | Auto (Ω) | Continuity |
| 6 | C-E1 | Auto (Ω) | Continuity |

- If any of the readings fail, then the problem is in the engine harness. Troubleshoot accordingly.
- If all of the readings are good, then the failure is most likely mechanical.

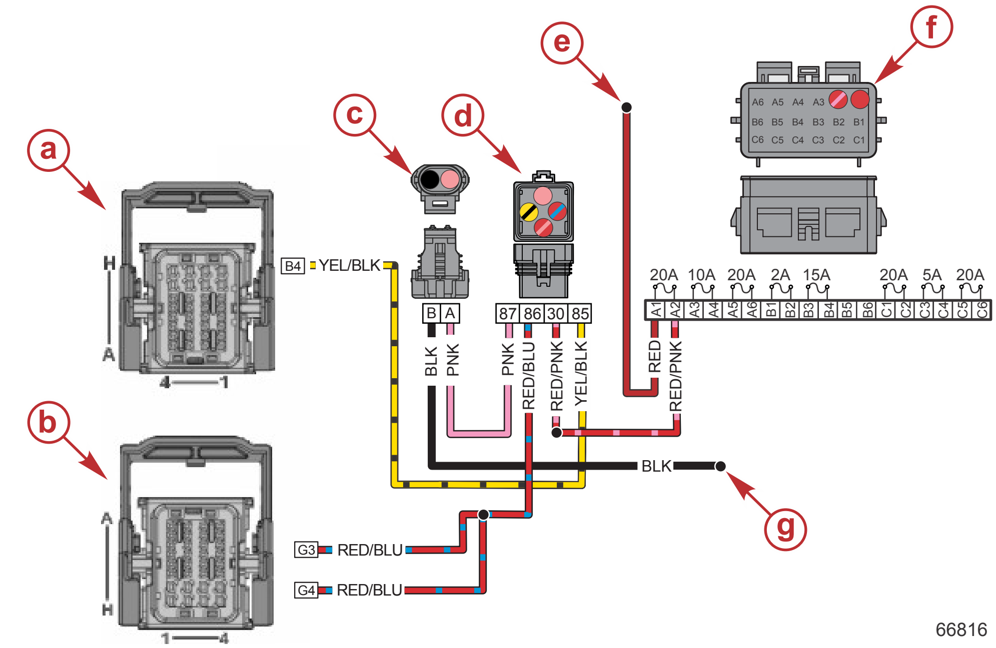
# Fuel Pump Relay

The engine wire harness has a relay for fuel pump control, located on the electrical panel at the rear of the engine. The incorporation of the fuel pump relay eliminates the possibility of pump damage when the key switch is turned to the ON position and the fuel supply module (FSM) is empty of fuel. The fuel pump operation is indirectly controlled by the PCM. The PCM completes the ground connection of the fuel pump relay, which in turn delivers power from the main power relay (MPR) to the FSM. A 20-amp fuse is in line with the power wire, between the MPR and the fuel pump relay. The fuel pump programmed logic limits the initial fuel pump use at key ON for five seconds. After the initial five seconds, the fuel pumps will not be active until engine RPM is recognized by the PCM.




65378

a - Fuel pump relay
b - Starter relay




a - PCM connector A
b - PCM connector C
c - Fuel pump connector
d - Fuel pump relay
e - 12 volt to fuse
f - Fuses
g - Ground

The following table identifies the function of each fuel pump relay contact point:

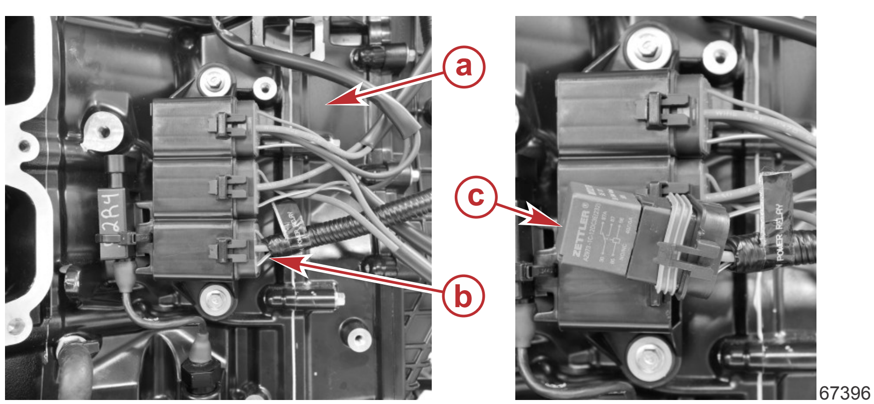
| Contacts | Description |
|---|---|
| 85 and 86 | Coil contacts. Grounds the PCM connection and activates the relay, which closes the circuit contacts. |
| 30 and 87 | Circuit contacts. When the coil is activated these contacts form a closed circuit. |

The fuel pump relay receives driver power from the red/blue wire. The PCM grounds pin AB4 (yellow/black wire) to complete the driver power circuit and close the fuel pump relay. If the PCM does not detect an RPM signal, the pump will turn off after several seconds. When the relay is closed, battery power flows from the fuse on the red/pink wire and through the relay to the fuel pump on the pink wire.

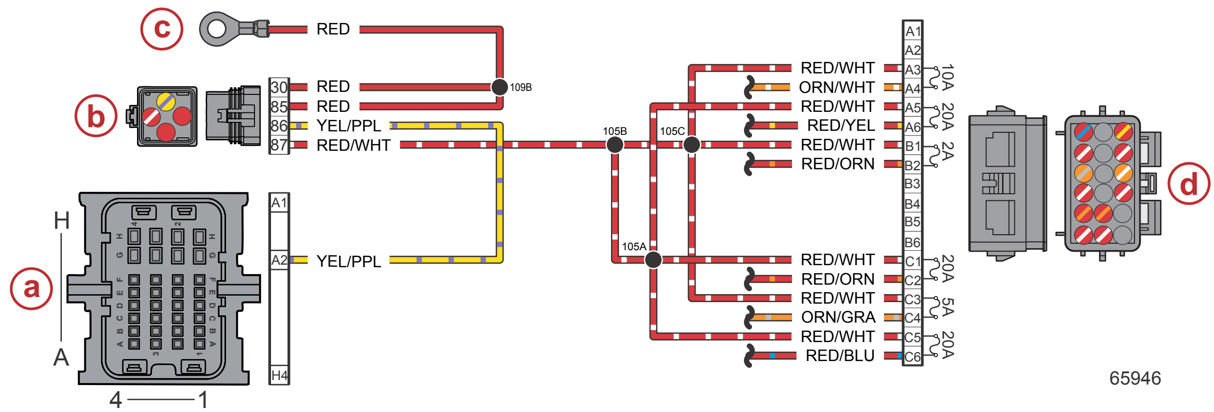
| Wire Color Code | PCM Connector Pin | Function |
|---|---|---|
| Yellow/black | AB4 | Fuel pump relay control |
| Red/blue | CG3 and CG4 | Driver power |
| Pink | – | Fuel pump power from relay |
| Black | – | Engine ground |
| Red/pink | – | 12 V from fuse |
| Red | – | 12 V to fuse |

# Main Power Relay (MPR)

The main power relay (MPR) is activated by the PCM and supplies power to the ignition and fuel injection components through the fuse block. The relay is supplied with power from the hot stud and positive battery cable. It is located behind the starboard intake runner. To remove and install the starboard intake runner, refer to the appropriate outboard service manual.

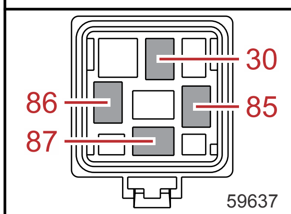
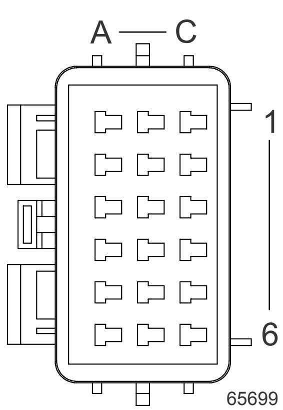



a - Starboard side of powerhead, intake runner removed
b - MPR socket on the engine harness
c - MPR




V8 DTS model shown, others similar

- **a -** PCM connector A
- **b -** Main power relay (MPR)
- **c -** Hot stud (battery +)
- **d -** Fuse block

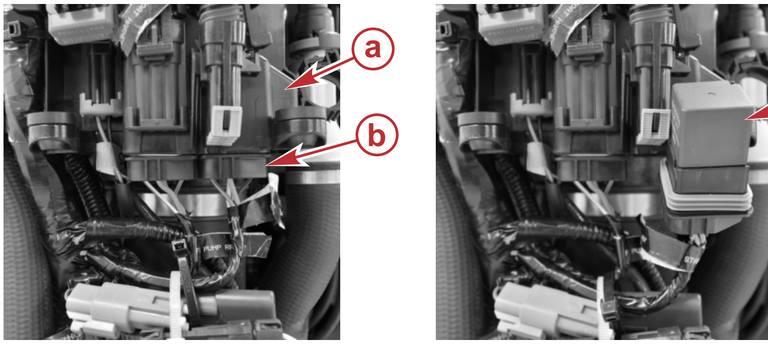
| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|  | 30 | Red | 12 V battery power (+) | – |
| | 85 | Red | 12 V battery power (+) | – |
| | 86 | Yellow/purple | Main power relay (MPR) control signal | AA2 |
| | 87 | Red/white | Switched 12 V power (+) | – |
|  | A1 | Red | Not shown | – |
| | A2 | Red/pink | Not shown | – |
| | A3 | Red/white | Switched 12 V power (+) | – |
| | A4 | Orange/white | Fused (10 A) 12 V power (+) - O2 sensor | – |
| | A5 | Red/white | Switched 12 V power (+) | – |
| | A6 | Red/yellow | Fused (20 A) 12 V power (+) - ignition coils | – |
| | B1 | Red/white | Switched 12 V power (+) | – |
| | B2 | Red/orange | Fused (2 A) 12 V power (+) - RS48 diagnostic | – |
| | B3 | Red | DTS only; not shown | – |
| | B4 | Red/purple | DTS only; not shown | – |
| | B5 | N/A | Not used | – |
| | B6 | N/A | Not used | – |
| | C1 | Red/white | Switched 12 V power (+) | – |
| | C2 | Red/orange | Fused (2 A) 12 V power (+) - fuel injectors | – |
| | C3 | Red/white | V8 only; switched 12 V power (+) | – |
| | C4 | Orange/gray | V8 only; fused (5 A) 12 V power (+) - advanced sound control | – |
| | C5 | Red/white | Switched 12 V power (+) | – |
| | C6 | Red/blue | Fused (20 A) 12 V power (+) - driver power | CG3, CG4 |

## Start Relay

The start relay is controlled directly by the engine PCM. When the PCM receives a start request, it sends a ground to the start relay. The relay closes and sends power to the starter solenoid to crank the engine. Once the PCM determines that the engine has started, it removes the ground from the start relay and the starter motor stops cranking.

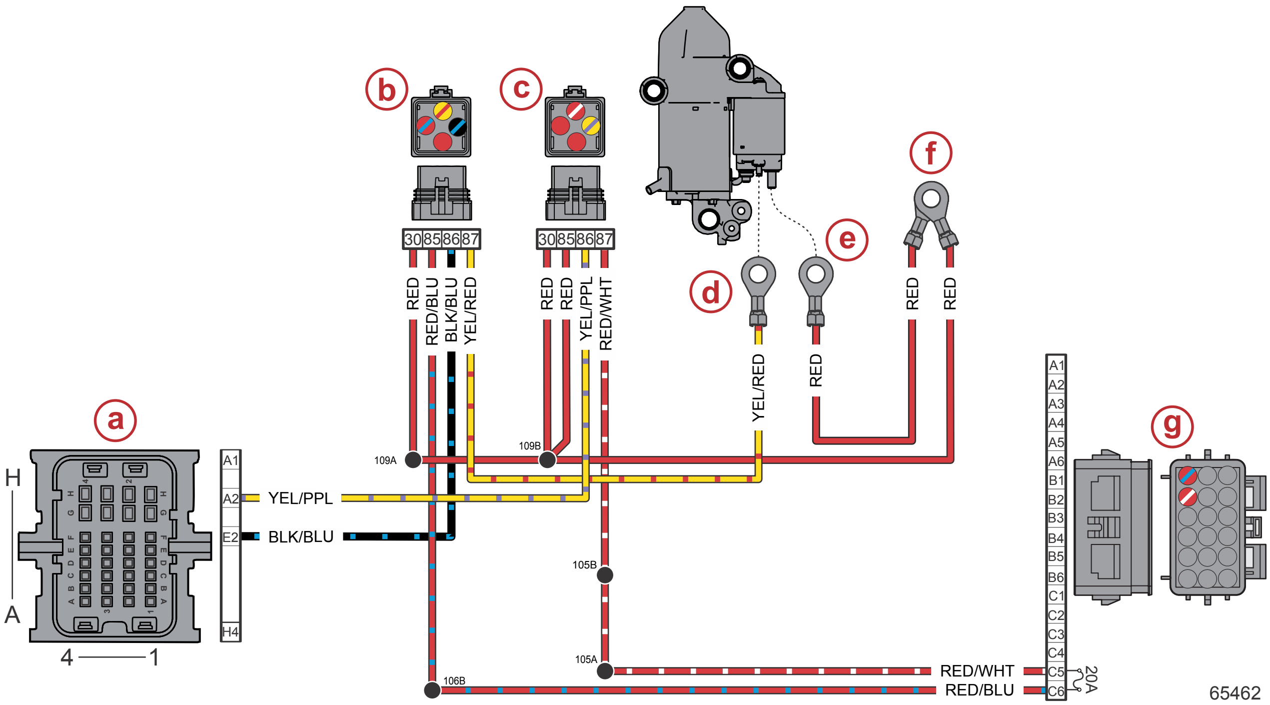
  

The start relay is located in the bottom of the electrical panel, at the rear of the engine.



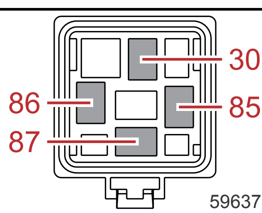

66554

- **a -** Electrical panel
- **b -** Start relay socket on the engine harness
- **c -** Start relay




65462

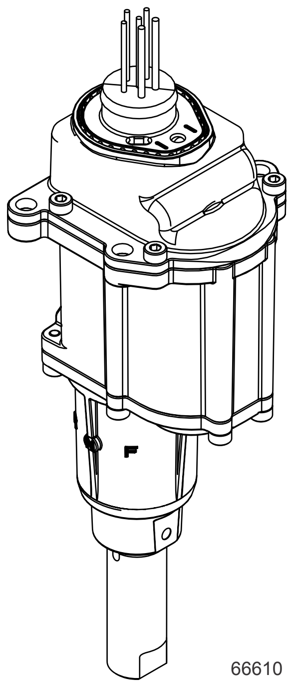
- **a -** PCM connector A
- **b -** Start relay socket
- **c -** Main power relay (MPR) socket
- **d -** Starter solenoid
- **e -** Starter power stud (+)
- **f -** Hot stud (battery +)
- **g -** Fuses - 20-amp fuse

| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|   59637 | 30 | Red | 12 V battery power (+) | – |
| | 85 | Red/blue | Fused (20 A) 12 V power (+) | – |
| | 86 | Black/blue | Start relay control | AE2 |
| | 87 | Yellow/red | Starter solenoid power (+) | – |
| MPR | 86 | Yellow/purple | MPR control signal | AA2 |
| MPR | 87 | Red/white | Switched 12 V power (+) | – |

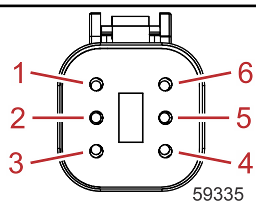
# Shift Actuator

The shift actuator is used to shift the gearcase into forward, neutral, and reverse gears. The actuator is mounted on the bottom of the driveshaft housing so that it protrudes into the gearcase. When it receives a signal from the PCM, it acts directly on the lower shift shaft. Hall-effect position sensors built into the shift actuator assembly receive a reference voltage (5.0 volts) from the PCM, and their signals confirm the position of the actuator shaft. The PCM uses an H-bridge to drive the motor inside the actuator one direction or the other.



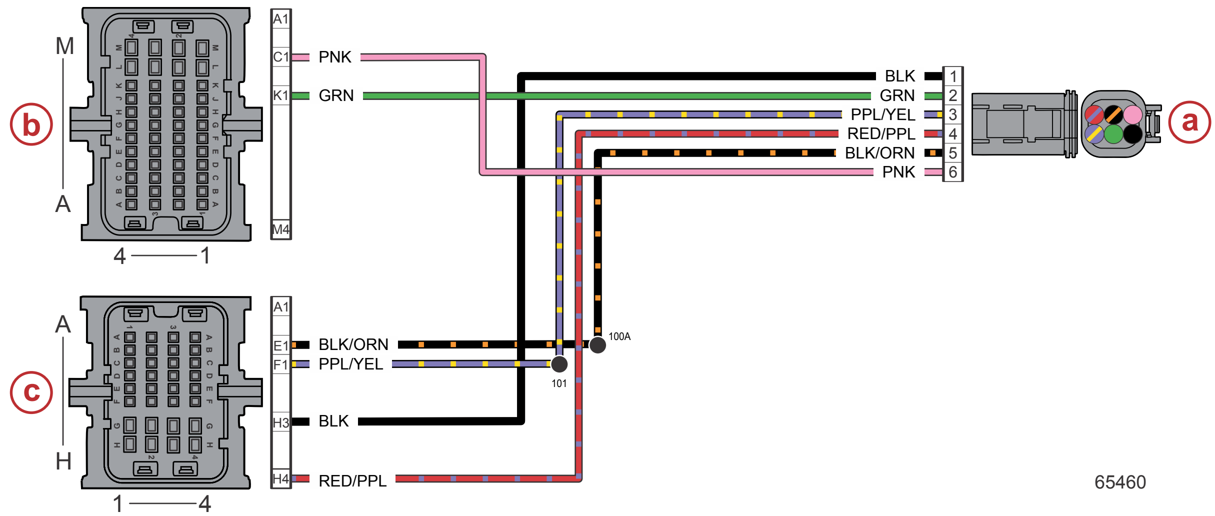
66610

## Shift Actuator Harness Connector Pin Out

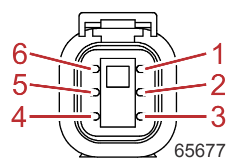
| Connector | Pin | Wire Color | Function |
|---|---|---|---|
|  59335 | 1 | Red | DC motor (+) |
| | 2 | Green | Sensor output 1 (shift position 1) |
| | 3 | Orange | Sensor +5V power |
| | 4 | Black | DC motor (–) |
| | 5 | White | Sensor ground (–) |
| | 6 | Yellow | Sensor output 2 (shift position 2) |

## Shift Control




**a -** Shift actuator connector
**b -** PCM connector B
**c -** PCM connector C

| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|   | 1 | Black | Shift actuator B | CH3 |
| | 2 | Green | Shift position 1 | BK1 |
| | 3 | Purple/yellow | Sensor power A (+) | CF1 |
| | 4 | Red/purple | Shift actuator A | CH4 |
| | 5 | Black/orange | Sensor ground A (–) | CE1 |
| | 6 | Pink | Shift position 2 | BC1 |

## Shift Actuator Troubleshooting

Before attempting to diagnose the shift actuator on an engine that does not shift, ensure that the PCM is receiving the shift signal from the helm control. On DTS engines, this would include the electronic remote control (ERC), command module, and CAN circuits. On mechanical engines, this would include the remote control, shift cable, and the shift demand sensor. Use CDS G3 Live Data to ensure that the PCM is receiving the proper shift signal.

Any malfunction of the shift actuator will likely cause a fault to be set in the PCM. Use CDS G3 to read all active faults and diagnose according to the descriptions in **Section 4A** - **Fault Codes**.

The output of the two shift position sensors can be viewed in CDS G3 Live Data. The sensors should be in the range of values shown below during the specified shift position:

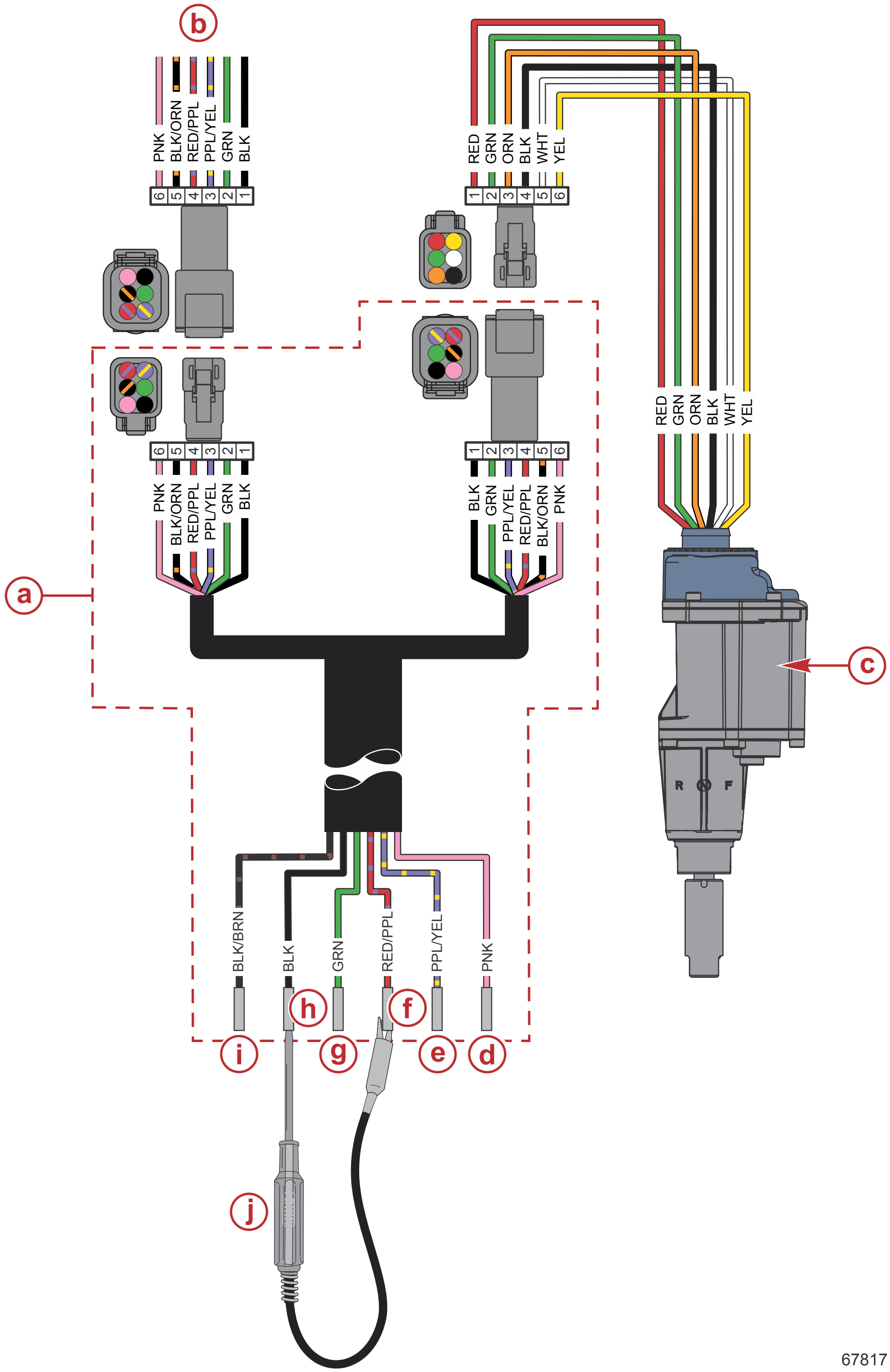
- Forward: 750–965 ADC
- Neutral: 465–550 ADC
- Reverse: 60–275 ADC

*NOTE: The sensors should not differ more than 50 ADC from each other in any given shift position.*

If the shift actuator does not perform correctly, use the preceding Shift Control circuit diagram to inspect the connections and perform a continuity check of the wires back to the PCM connectors. The shift actuator does not have any internal serviceable components.

## PCM Shift Actuator Circuit Test

Refer to the following illustration for the PCM shift actuator circuit test.


b
PNK
BLK/ORN
RED/PPL
PPL/YEL
GRN
BLK
6 5 4 3 2 1
RED
GRN
ORN
BLK
WHT
YEL
1 2 3 4 5 6
a
c
R N F
BLK/BRN
BLK
GRN
RED/PPL
PPL/YEL
PNK
h
f
i
g
e
d
j
67817

- a - Shift actuator harness (8M0150597)
- b - Engine harness
- c - Shift actuator and wiring
- d - Shift position sensor 2
- e - Sensor power A
- f - H-bridge (+)
- g - Shift position sensor 1
- h - H-bridge (–)
- i - Sensor power ground
- j - Test light

1. Insert the Y-harness between the shift actuator and the engine harness.

| | |
|---|---|
| Shift Actuator Harness | 8M0150597 |

2. Connect a test light across the red/purple and black wires of the Y-harness. Also connect a DMT 2004 digital multimeter black lead to the black wire and red lead to the red/purple wire.

| | |
|---|---|
| Test Light | Obtain locally |
| DMT 2004 Digital Multimeter | 91-892647A01 |

3. Perform the indicated actions and use the test light to interpret the PCM shift actuator driver output.

   ***NOTE:*** *The engine will not shift into forward gear unless it is running.*

| Action | Expected Test Light Pattern | Measured voltage |
|---|---|---|
| Neutral | No light | 0 |
| Neutral to forward | Light on for one second | Positive (+) |
| Forward to neutral | Light on for one second | Negative (–) |
| Neutral to reverse | Light on for one second | Negative (–) |
| Reverse to neutral | Light on for one second | Positive (+) |
| Engine power up | No light | 0 |

4. If the light functions as expected, the PCM H-bridge and actuation wires are operating correctly. Replace the shift actuator after confirming that the gearcase is mechanically sound.

## Shift Position Sensor Circuit Test

The Y-harness may be used to break out the shift position sensor circuits for testing purposes. Connect a DMT 2004 digital multimeter black lead to the sensor ground wire (black/orange) and the red meter lead to the wire as indicated in the table below.

***NOTE:*** *The engine will not shift into forward gear unless it is running.*

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

### Shift Position Sensor Voltages

| Shift Actuator Position | Red Meter Lead Location | | |
|---|---|---|---|
| | Sensor power A (purple/yellow) | Sensor 1 (green) | Sensor 2 (pink) |
| Neutral | 5.0 V | 2.271–2.686 V | 2.314–2.729 V |
| Forward | 5.0 V | 3.662–4.712 V | 0.288–1.338 V |
| Reverse | 5.0 V | 0.293–1.343 V | 3.657–4.707 V |

If the 5.0 volt reference voltage is present at sensor power A, but either position sensor feedback voltage is outside of the range for the specified shift position, replace the shift actuator. The shift position sensors are not individually serviceable components.

# Notes:

# Sensors, Actuators, Relays, and Accessories

## Section 5C - Accessories

## Table of Contents



5
C

# Special Tools

| Power Steering Module Primer Kit | 91-895040K01 |
|---|---|
|  5547 | Bleeds power steering system without running engine. |

# Advanced Sound Control

Advanced sound control (ASC) is an exclusive feature on select horsepower Verado V8 engines.

*NOTE: This feature is not available on SeaPro models.*

- ASC allows the vessel operator to toggle between two modes of operation: **stealth** or **sport** mode.
- The mode of operation can be selected with an accessory dash switch, VesselView, or SmartCraft gauge; off = stealth mode, on = sport mode.
- When stealth mode is active, the engine noise levels are low (the typical smooth sound of Verado FourStroke power).
- When sport mode is active, the engine noise levels are higher (a definitive audible indicator of the engine's power).

*NOTE: Stealth or sport modes does not affect the engine horsepower or the running characteristics of the engine.*

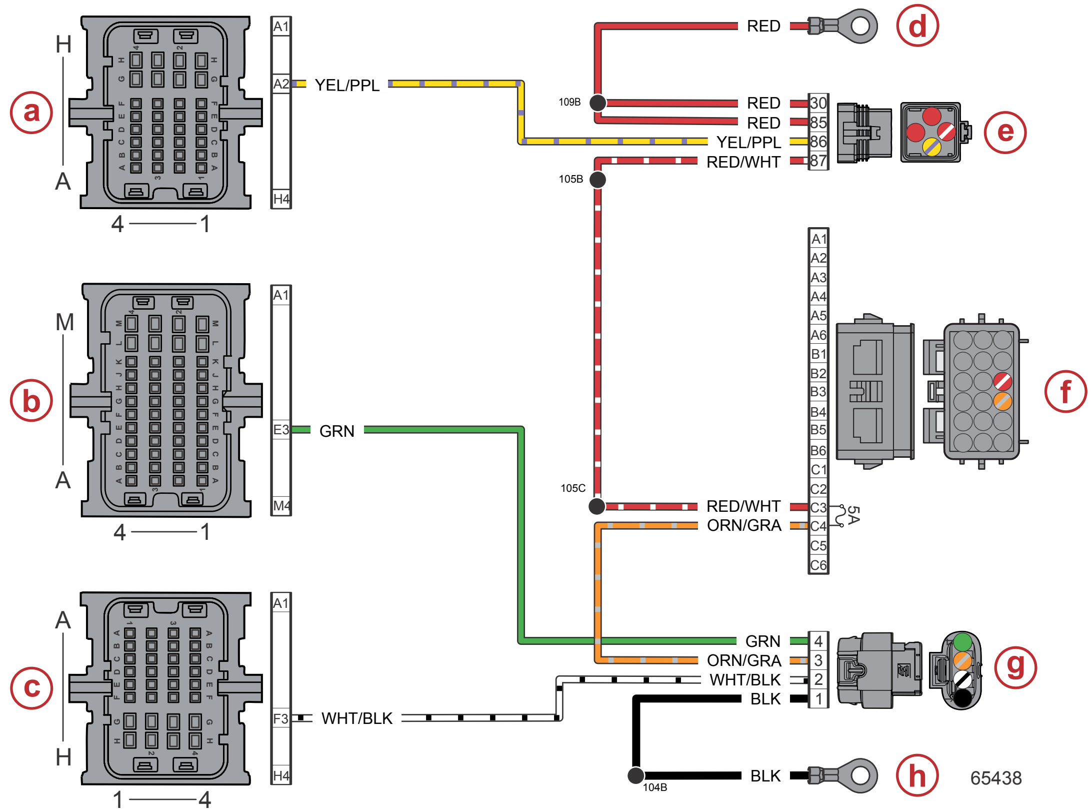
When the engine is started, ASC will remain in the selected mode at the time when the engine was turned off.

## Troubleshooting

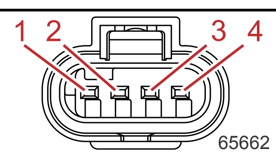
If the advanced sound control modes do not appear to be changing, first inspect the 5-amp fuse in the fuse block. If the fuse has opened, inspect the wiring and connections for the cause. If the fuse checks good, connect CDS G3 and navigate to the diagnostics screen. Perform the diagnostic test, and either listen for the actuator to respond while the engine is off, or listen for a change in the exhaust noise while the engine is running and in the water. If the actuator does not appear to be responding, use the following wiring diagram to check for power at the connector and continuity on the wires back to the PCM. If no issues are discovered, replace the advanced sound control actuator and retest.

***NOTE:*** *Advanced Sound Control features are identified as "AEV" in CDS G3; AEV_DutyCycle, AEV_OutputFault, AEV valve, etc.*



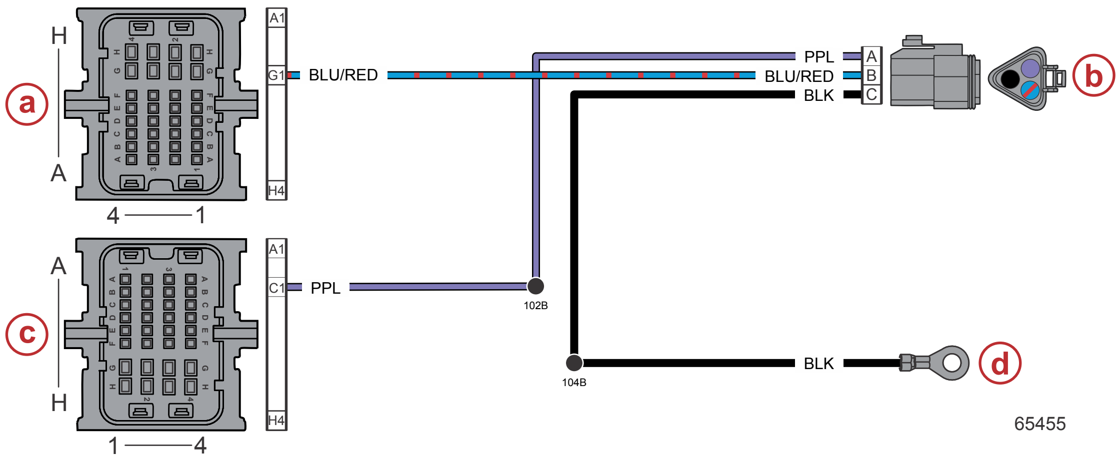

- **a -** PCM connector A
- **b -** PCM connector B
- **c -** PCM connector C
- **d -** Hot stud
- **e -** Main power relay (MPR)
- **f -** Engine fuses: 5-amp fuse
- **g -** Advanced sound control (ASC) connector
- **h -** Chassis ground

| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|   | 1 | Black | Chassis ground (–) | – |
| | 2 | White/black | Advanced sound control (ASC) | CF3 |
| | 3 | Orange/gray | Fused (5 A) 12 V power (+) | – |
| | 4 | Green | ASC diagnostic | BE3 |
| MPR | 87 | Red/white | Switched 12 V power (+) | – |
| MPR | 86 | Yellow/purple | Main power relay (MPR) control signal | AA2 |
| Hot stud ring terminal | – | Red | 12 V battery power (+) | – |

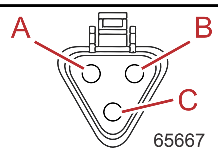
  

# Moving Propeller (MP) Alert

The engine harness is equipped with a lead for direct connection to a moving propeller light. The light is an accessory that must be purchased separately.

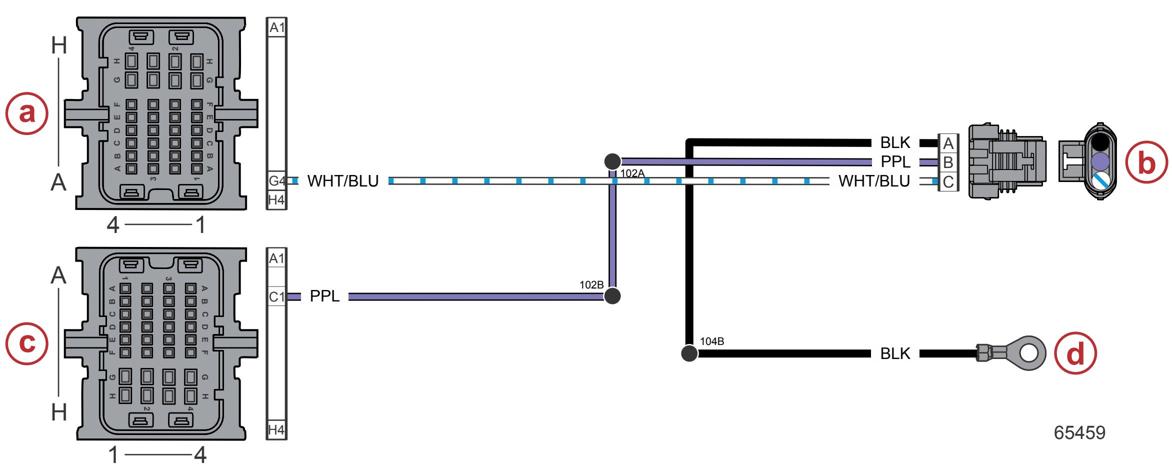



**a -** PCM connector A
**b -** Moving propeller (MP) alert connector
**c -** PCM connector C
**d -** Chassis ground (–)

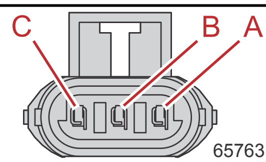
| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|   | A | Purple | 12 V wake circuit (+) | CC1 |
| | B | Blue/red | MP alert signal | AG1 |
| | C | Black | Chassis ground (–) | – |

# Power Steering

Electric power steering is standard and required on all advanced midsection (AMS) models. It may also be optionally installed on conventional midsection (CMS) models. The electric pump receives a signal to turn on from the 3-pin signal harness on the engine. The pump should only operate while the engine is running. Refer to the troubleshooting procedure below if the pump is not operating.

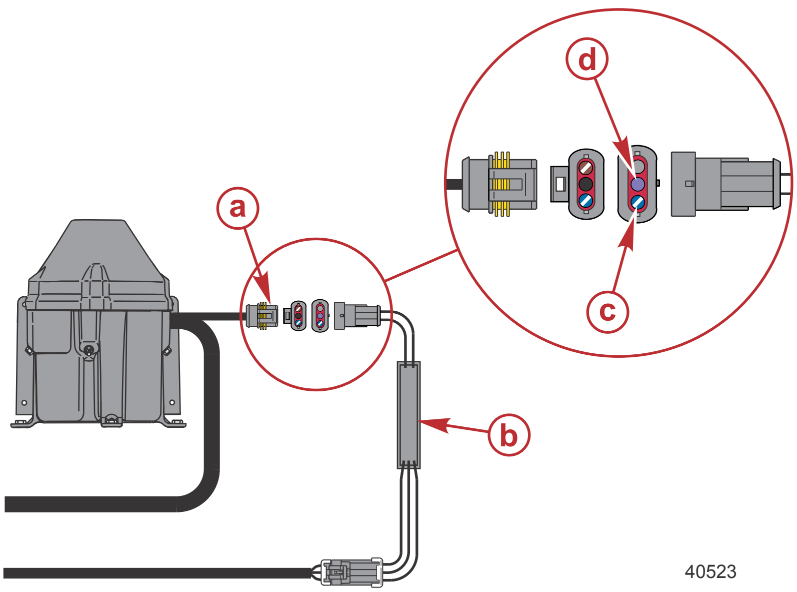



**a -** PCM connector A
**b -** Power steering connector
**c -** PCM connector C
**d -** Chassis ground (–)

| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|   | A | Black | Chassis ground (–) | – |
| | B | Purple | 12 V wake circuit (+) | CC1 |
| | C | White/blue | Power steering | AG4 |

## Troubleshooting an Inoperable Power Steering Pump

1. Verify that battery cables, power steering pump signal harnessing, and driver module are installed according to the engine's installation/service manual architecture.
2. Verify that battery voltage is present on the battery cables leading to the power steering pump (be sure to check the voltage on the power steering pump side of the fuse located on the positive cable).
   a. When battery voltage is present on these leads, indicating a good fuse, the power steering pump will actuate when the expected voltage is completed from the power steering signal harness/driver module. This voltage is sent in a two-step process: Step 1 - key on, then Step 2 - engine starts and runs.
      - The power steering pump may ramp-up slowly if this two-step process is not performed as instructed.
      - The power steering pump will not actuate unless the engine is running.
3. Check for proper voltage across the power steering driver module. To test, break the connection point between the driver module and the power steering pump wiring.




a - Power steering pump harness connector
b - Power steering driver module
c - Pin 1 (blue/white)
d - Pin 2 (purple)

   a. With the key in the off position, no voltage should be present across the blue/white to purple wire or across either of these wires to ground.
   b. With the key on and the engine off, battery voltage must be present across the purple lead and the engine/battery ground.
      - There should be less than 1 volt (< 1 volt) across the blue/white wire and battery ground.

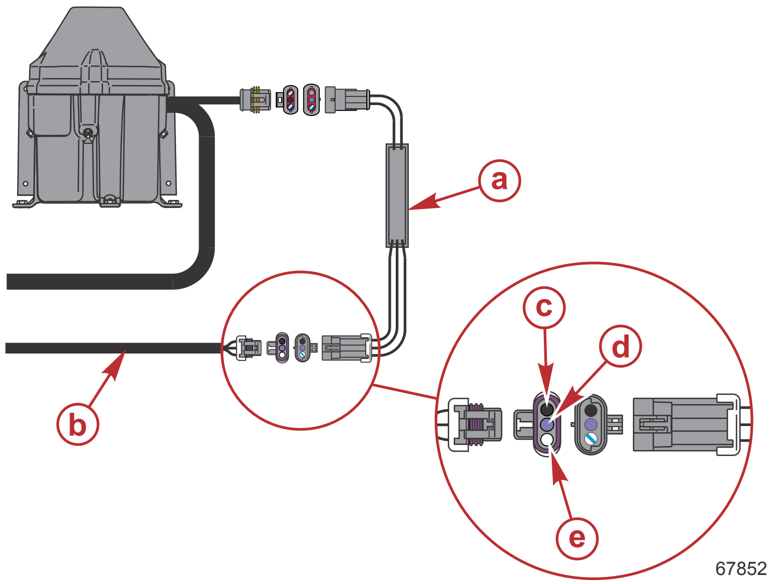
| DMT Meter Leads | | | |
|---|---|---|---|
| | Red | Black | Circuit voltage = |
| Power steering driver module - key on and engine off | Purple | Engine/battery ground | Battery voltage |
| | Blue/white | Engine/battery ground | < 1 volt |

   c. With the engine running, battery voltage should be present across the blue/white lead and engine/battery ground and across the purple lead to the engine/battery ground.

| DMT Meter Leads | | | |
|---|---|---|---|
| | Red | Black | Circuit voltage = |
| Power steering driver module - engine starts and runs | Purple | Engine/battery ground | Battery voltage |
| | Blue/white | Engine/battery ground | Battery voltage |

- If these voltages are not observed, as listed, with a good battery and key switch harness, continue with testing the power steering signal harness circuit.
- If the voltages are correct across the driver module, the power steering pump may be the problem. Use the **Power Steering Module Primer Kit** to confirm a power steering pump failure.

4. Check for proper voltage across the power steering signal harness. To test, break the connection point between the signal harness and the driver module.




a - Power steering driver module
b - Power steering signal harness - to engine
c - Pin A (black)
d - Pin B (purple)
e - Pin C (white)

*NOTE: These procedures cover a single engine application. A multiengine signal harness adapter will be installed on boats powered by multiple outboards. Be sure to check for voltages listed before and after the multiengine adapter harness.*

a. With the key in the off position, no voltage should be present across any wire pair of the three signal harness wires or across any of these wires to ground.

b. With the key on and the engine off, battery voltage should be present across the purple and black wires.
   - There should be less than 1 volt (< 1 volt) between the purple and white wires.

| DMT Meter Leads | | | |
|---|---|---|---|
| | Red | Black | Circuit voltage = |
| Power steering signal harness - key on and engine off | Purple | Black | Battery voltage |
| | Purple | White | < 1 volt |

c. With the engine running, battery voltage should be present across the purple and white wires as well as across the purple and black wires.

| DMT Meter Leads | | | |
|---|---|---|---|
| | Red | Black | Circuit voltage = |
| Power steering signal harness - engine starts and runs | Purple | Black | Battery voltage |
| | Purple | White | Battery voltage |

- If these voltages are not observed, as listed, with a good battery and key switch harness, check for the same voltages at the engine wire harness which connects to the signal harness. If the listed voltages are still not present, a problem may exist within the 3-wire circuit on the engine wire harness or the PCM. With the PCM disconnected, complete an ohms/continuity check on these wires. If the circuits have no shorts to ground and less than one ohm of resistance, a PCM may be the problem.

## Power Steering Module Primer Kit

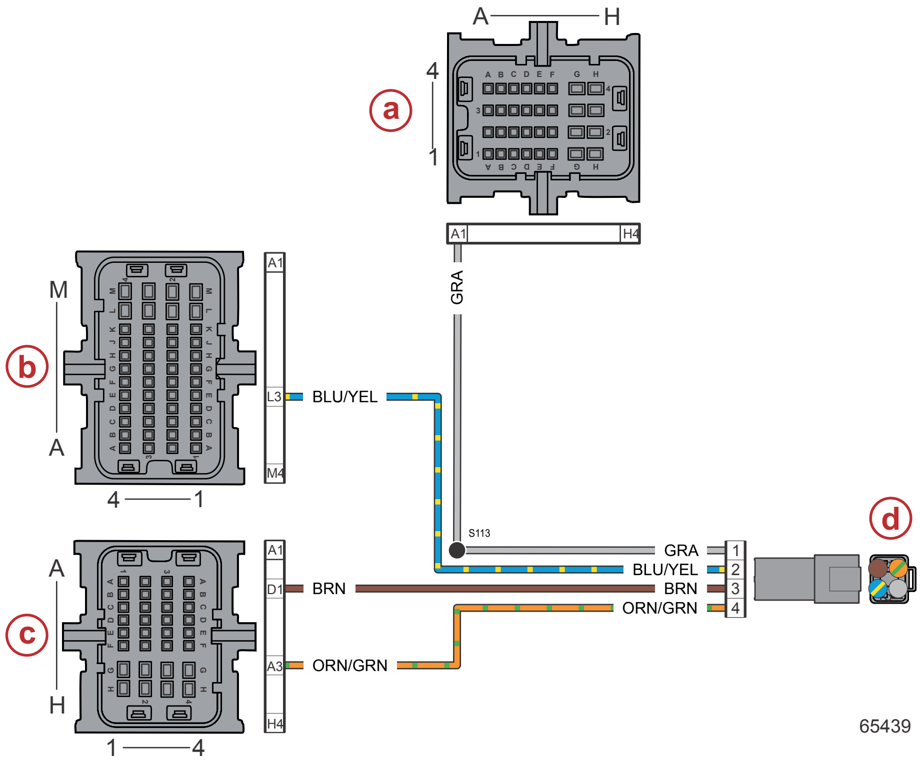
If the power steering pump is inoperable, a great way to test the power steering pump directly is to utilize the power steering primer module to bypass the engine and all boat harnessing. With battery power hooked to the power steering pump and the primer module installed, a working power steering pump will operate when the two-stage module is activated in the proper sequence. See the instruction sheet supplied with the power steering module primer kit.

| | |
|---|---|
| Power Steering Module Primer Kit | 91-895040K01 |

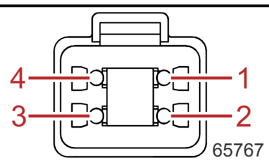
  

# Analog Gauges (DTS only)

All PCM 112 engines have the ability to drive analog gauges without the need for an external analog gauge interface (AGI). However, DTS engines are unable to send these signals up the 14-pin harness and require an additional 4-pin analog gauge harness to be routed to the dash. Use the following wire diagram to troubleshoot the engine harness side if a problem is detected. CDS G3 can also display the voltage parameters for the signal being sent to the coolant, oil pressure, and trim position gauges under the vessel tab of the live data display.




- a - PCM connector A
- b - PCM connector B
- c - PCM connector C
- d - Analog gauge connector

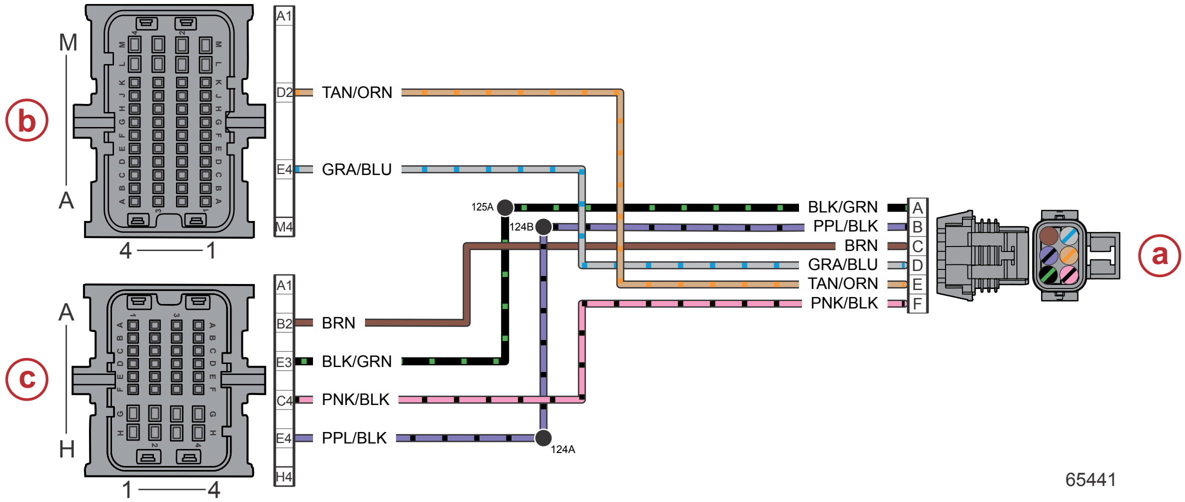
| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|  | 1 | Gray | Tachometer signal | AA1 |
| | 2 | Blue/yellow | Oil pressure analog gauge | BL3 |
| | 3 | Brown | Coolant temperature analog gauge | CD1 |
| | 4 | Orange/green | Trim position analog gauge | CA3 |

**IMPORTANT: Refer to CDS G3 for the tachometer, oil pressure, coolant temperature, and trim position output values.**

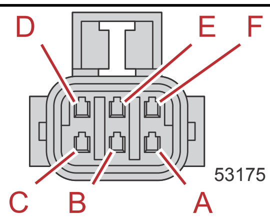
  

# Boat Harness

The 6-pin boat harness connection allows for accessory sensors (tank level, paddle wheel, and sea temperature) to be connected and the information displayed on the SmartCraft network. For diagnostic purposes, the data from these sensors may also be viewed with CDS G3 under the Vessel tab of the Live Data display.



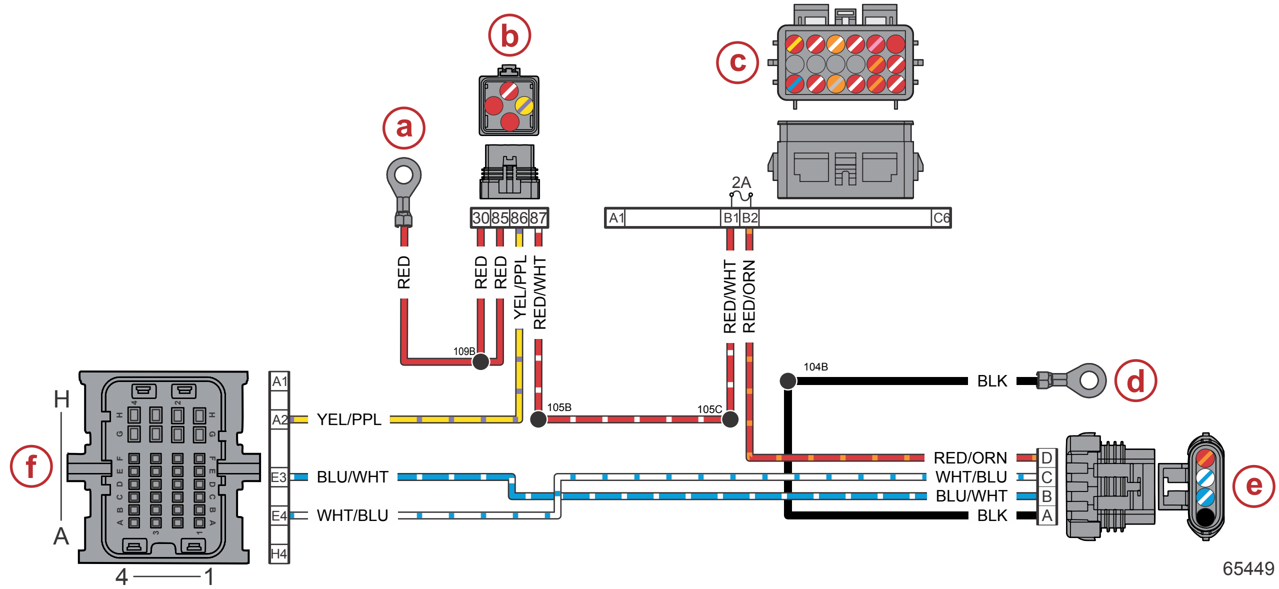

**a -** Boat harness connector
**b -** PCM connector B
**c -** PCM connector C

| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|   | A | Black/green | Sensor ground (–) | CE3 |
| | B | Purple/black | Sensor power (+) | CE4 |
| | C | Brown | Fuel level 2 signal | CB2 |
| | D | Gray/blue | Paddle wheel signal | BE4 |
| | E | Tan/orange | Sea temperature signal | BD2 |
| | F | Pink/black | Fuel level 1 signal | CC4 |

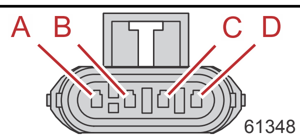
  

# Diagnostics (RS48)

This connector is labeled as "Diagnostics RS48," however Mercury's CDS G3 diagnostic tool always connects to the 10-pin SmartCraft connection. This connector is used instead for the connection of a depth transducer. The PCM communicates with the transducer and then broadcasts the information onto the SmartCraft network for display at the helm. CDS G3 will also display the depth data under the Vessel tab of the Live Data display for troubleshooting purposes.




- **a -** Hot stud (battery +)
- **b -** Main power relay (MPR)
- **c -** Fuse block: 2-amp fuse
- **d -** Chassis ground (–)
- **e -** Diagnostic (RS48) connector
- **f -** PCM connector A

| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|  | A | Black | Chassis ground (–) | – |
| | B | Blue/white | Serial communications + | AE3 |
| | C | White/blue | Serial communications – | AE4 |
| | D | Red/orange | Fused (2 A) 12 V power (+) | – |
| Hot stud ring terminal | – | Red | 12 V battery power (+) | – |
| MPR | 86 | Yellow/purple | Main power relay (MPR) control signal | AA2 |
| MPR | 87 | Red/white | Switched 12 V power (+) | – |

# Battery Isolator Troubleshooting

Battery isolators allow a single alternator to charge two batteries, while ensuring that the engine essential loads are isolated to the engine starting battery. Vessel or "house" loads are isolated to the house battery. This makes certain that the engine starting battery will have a sufficient charge to start the engine even if the house battery was depleted. Battery isolators also ensure that the starting battery receives a charge from the alternator while the engine is running, and excess available charge from the alternator is directed to the house battery. If the engine alternator is functioning correctly but one or both batteries fail to receive a charge, then perform the following test of the battery isolator.

| Engine Off Test | | Engine Key On Test | | Engine Running Test | |
|---|---|---|---|---|---|
| 1. | Turn off the battery charger. | 1. | Turn off the battery charger. | 1. | Turn off the battery charger. |
| 2. | Disable any parallel switches or VSR's. | 2. | Disable any parallel switches or VSR's. | 2. | Disable any parallel switches or VSR's. |
| 3. | Turn on the engine battery switch. | 3. | Turn on the engine battery switch. | 3. | Turn on the engine battery switch. |
| 4. | Turn on the house battery switch. | 4. | Turn on the house battery switch. | 4. | Turn on the house battery switch. |

| Engine Off Test | | Engine Key On Test | | Engine Running Test | |
|---|---|---|---|---|---|
| 5. | Record the voltage of the house battery. *NOTE: The voltage should be 11.5–12.5 V. If voltage is lower than 11.5 V, charge the battery.* | 5. | Record the voltage of the engine battery. | 5. | Start the engine and allow it to run at idle speed. |
| 6. | Record the voltage of the engine battery. *NOTE: The voltage should be 11.5–12.5 V. If voltage is lower than 11.5 V, charge the battery.* | 6. | Record the voltage of the house battery. | 6. | Record the voltage of the engine battery. |
| 7. | Check for continuity from all isolator posts to common boat ground. *NOTE: Each "output" post should read the respective battery voltage and the "input" should read 0.* | 7. | Trim the engine down and stall the trim in the down position. Verify that only the engine battery has voltage drop. | 7. | Record the voltage of the house battery. *NOTE: Voltages should be slightly above what was noted in the* ***Engine Key On Test****. If not, check the voltage on the input stud. The input stud voltage should be 13.5 V or higher. If voltage does not make it "through" the isolator, replace the isolator.* |
| 8. | If voltage is found on the input stud, replace the isolator. | 8. | If voltage drops on both batteries replace the isolator. | 8. | Place the engine in throttle only mode and increase the engine speed to 1000 RPM. |
| 9. | If no voltage is found on the input stud, proceed to **Engine Key On Test**. | 9. | If voltage drops on the engine battery only, proceed to **Engine Running Test**. | 9. | Record the voltage of the engine battery. |
| | | | | 10. | Record the voltage of the house battery. *NOTE: Voltage at both the engine and house batteries should be higher than what was recorded in the idle test. If not, check the voltage on the input stud. The input stud voltage should be 14.5 V ± 0.5V. If voltage is not making it "through" the isolator, replace the isolator.* |

# Electrical Systems

## Section 6A - Ignition

## Table of Contents





# Ignition Specifications - V6 Models

| Description | | Specification |
|---|---|---|
| Full throttle RPM range | 200 SeaPro | 4600–5400 |
| | 175 and 200 | 5000–5800 |
| | 175 Pro XS | 5400–6000 |
| | 225 | 5200–6000 |
| Idle RPM (see NOTE) | | 600 |
| Ignition type | | Digital inductive |
| Spark plug type | | NGK LKAR7C-9 |
| Spark plug gap | | 0.9 mm (0.035 in.) |
| Spark plug hex size | | 14 mm |
| Spark plug torque | | 20 Nm (177 lb-in.) |
| Firing order | | 1-2-3-4-5-6 |
| Ignition timing at idle | | Not adjustable; PCM controlled (approximately 2° ATDC) |
| Ignition timing at WOT | | Not adjustable; PCM controlled |
| PCM overspeed limiter | | See chart |

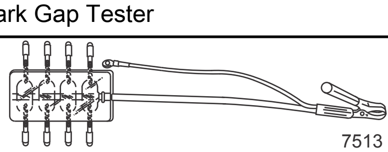
*NOTE: The idle RPM set point may increase due to the low battery voltage ramp-up strategy.*

# Ignition Specifications - V8 Models

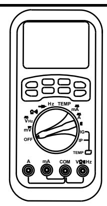
| Description | | Specification |
|---|---|---|
| Full throttle RPM range | SeaPro | 4800–5600 |
| | 250 and 300 | 5200–6000 |
| | Pro XS | 5600–6200 |
| Idle RPM (see NOTE) | | 600 |
| Ignition type | | Digital inductive |
| Spark plug type | | NGK LKAR7C-9 |
| Spark plug gap | | 0.9 mm (0.035 in.) |
| Spark plug hex size | | 14 mm |
| Spark plug torque | | 20 Nm (177 lb-in.) |
| Firing order | | 1-2-7-3-4-5-6-8 |
| Ignition timing at idle | | Not adjustable; PCM controlled (approximately 2° ATDC) |
| Ignition timing at WOT | | Not adjustable; PCM controlled |

# Special Tools

| CDS G3 Interface Kit | 8M0138392 |
|---|---|
|  66165 | CDS G3 License Key, Interface, Adapter, and Harness |

| Spark Gap Tester | 91-850439T 1 |
|---|---|
|  7513 | Provides a visual indication of spark/coil efficiency. |

| DMT 2004 Digital Multimeter | 91-892647A01 |
|---|---|
|  4516 | Measures RPM, ohms, amperes, AC and DC voltages; records maximums and minimums simultaneously, and accurately reads in high RFI environments. |

# Ignition Coils

The primary (+) side of the ignition coil receives battery voltage from the main power relay. When the key switch is turned ON, the main power relay ground circuit is completed through the PCM. The main power relay transfers battery voltage to the coils. The coils are protected by a 20-amp fuse. The negative side of each coil is connected to the engine ground through the PCM. When this circuit is closed, a magnetic field is built up in the ignition coil. When the PCM is supplied with a trigger signal, the PCM opens the circuit and the magnetic field collapses across the coil secondary winding, creating a high voltage charge that is sent to the spark plugs. Each coil supplies spark to two cylinders. The ignition system is a wasted spark design, where each coil fires once every revolution.

## Ignition Coil Test - CDS G3

The ignition coils can be tested with the CDS G3 diagnostic interface tool. Follow the on-screen instructions in CDS G3.

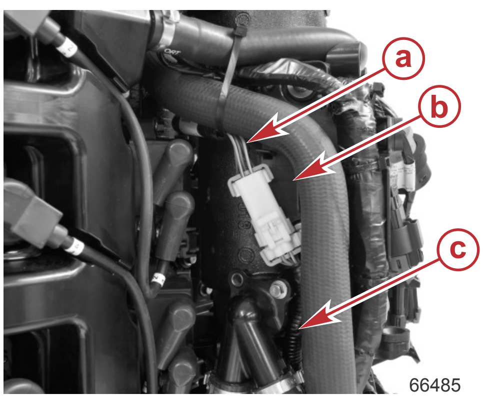
| CDS G3 Interface Kit | 8M0138392 |
|---|---|
| Spark Gap Tester | 91-850439T 1 |

## Ignition Coil Tests - Digital Multimeter

| DMT 2004 Digital Multimeter | 91-892647A01 |
|---|---|

*NOTE: Refer to the wiring diagram, following.*

1. Cut the cable tie that secures the coil harness, and disconnect the coil harness from the side of the engine harness.
2. Remove the coil harness connector from the anchor on the electrical panel.



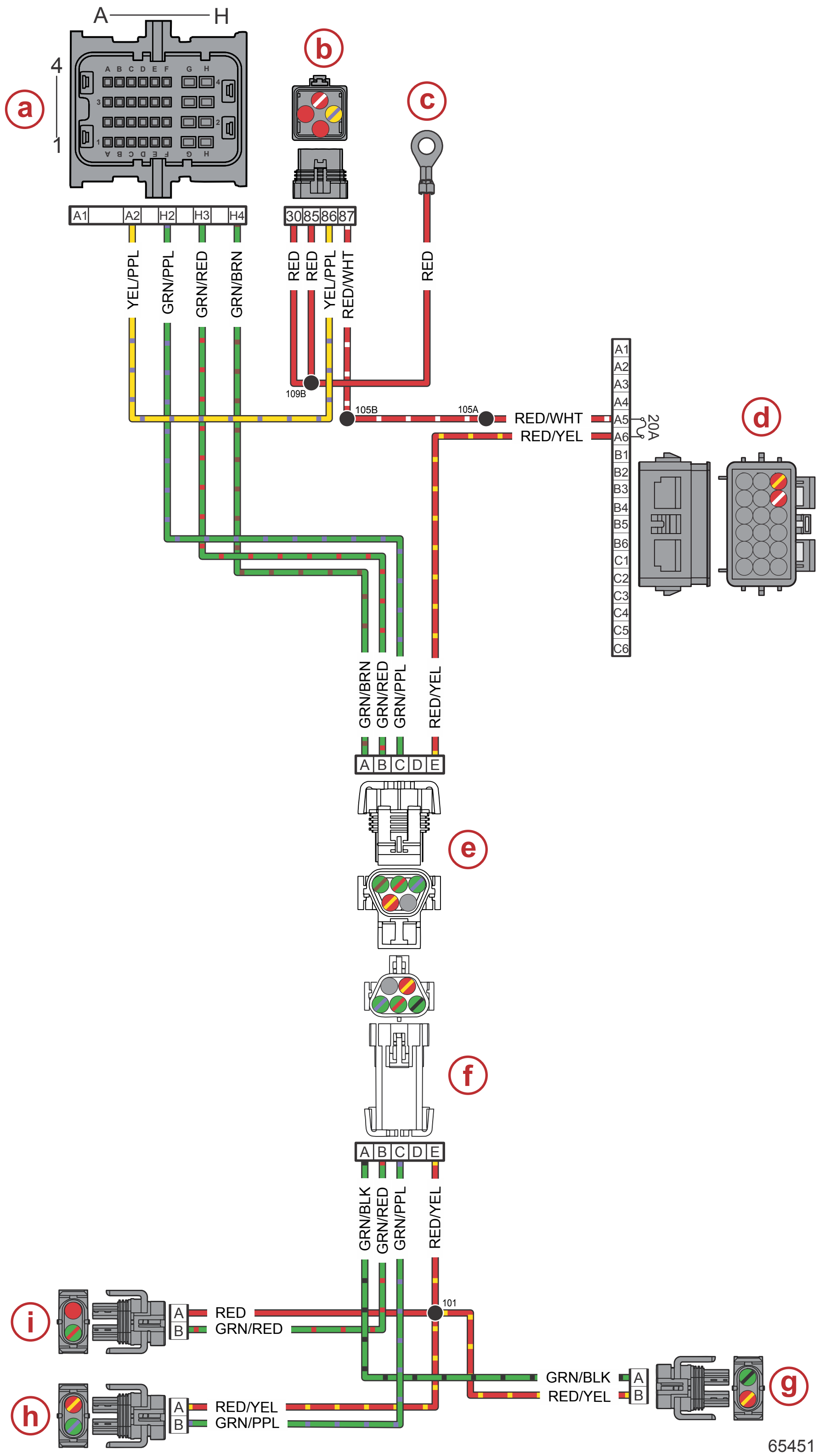

66485

a - Coil harness
b - Side of the electrical panel
c - Engine harness

3. Perform a visual inspection of the pins and sockets on the connectors. Look for loose, broken, bent, or corroded pins.
4. Use a DMT 2004 digital multimeter to perform the following tests:
   a. Set the meter to DC volts, turn the ignition key switch on, and check for battery voltage between socket E of the engine harness connector and chassis ground. If voltage is not present, then there is an open somewhere in the positive circuit from the hot stud to socket E of the connector. Refer to the wiring diagram, following.
   b. With the meter still set to DC volts and the ignition key still on, check for battery voltage between socket E and each of the other sockets in the connector. If voltage is not present for a pin, then there is an open between that socket and the PCM.
   c. Turn off the ignition key and change the meter to ohms. Measure the resistance between pin E of the coil harness and each of the other pins. The resistance should be approximately that of the primary coil (0.3–0.5 ohms).

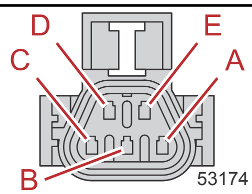
  

# Ignition Coil Wiring Diagram - V6



- **a -** Propulsion control module (PCM), connector A
- **b -** Main power relay
- **c -** Hot stud
- **d -** Engine fuses
- **e -** Coil harness connector
- **f -** Ignition coil adapter harness
- **g -** Coil A connector (cylinders 1 and 4)
- **h -** Coil C connector (cylinders 3 and 6)
- **i -** Coil B connector (cylinders 2 and 5)

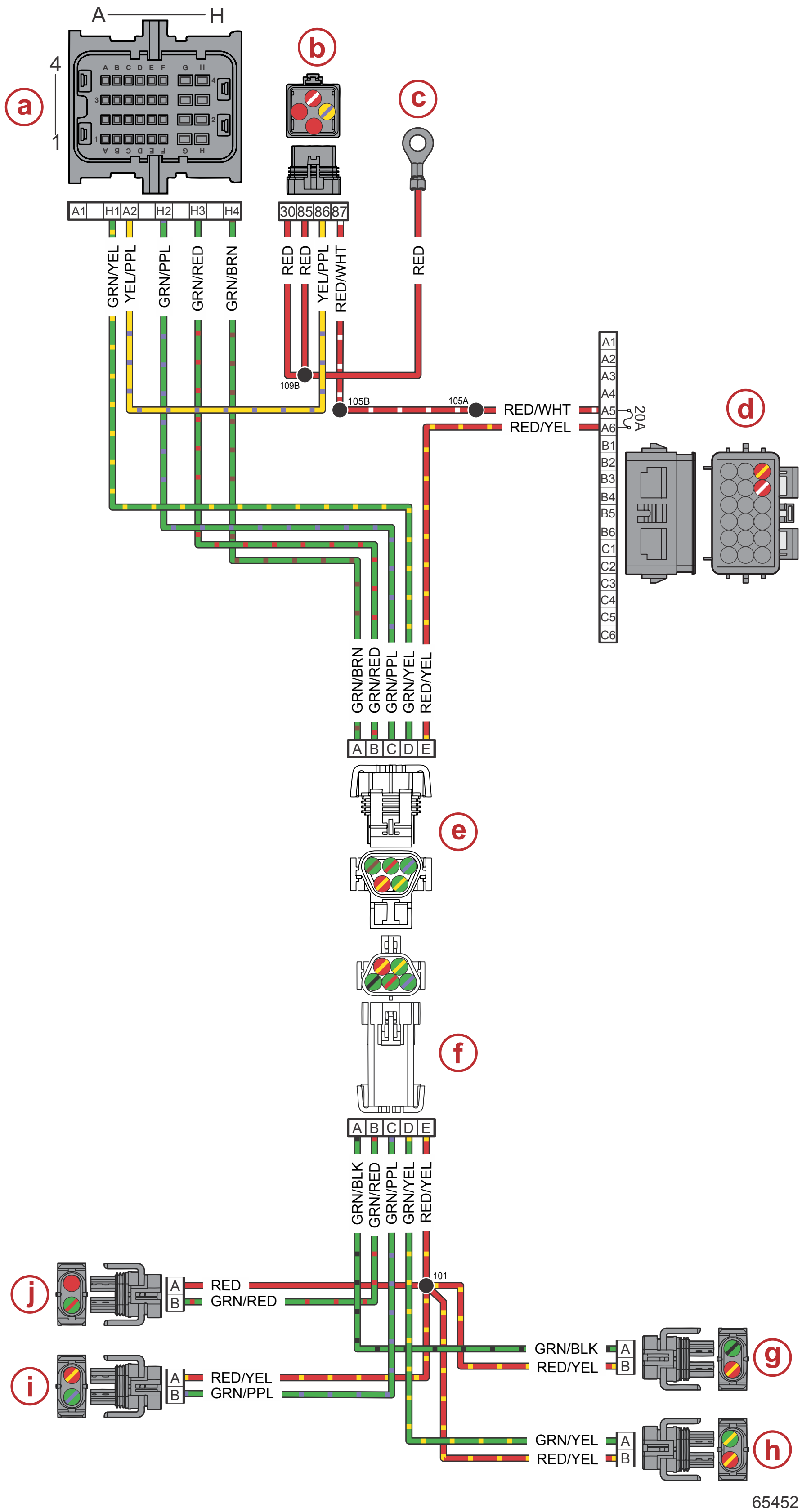
| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|   | A | Green/brown | Coil A | AH4 |
| | B | Green/red | Coil B | AH3 |
| | C | Green/purple | Coil C | AH2 |
| | D | N/A | Not used | – |
| | E | Red/yellow | Fused (20 A) 12 V power (+) | – |
| Hot stud ring terminal | – | Red | 12 V battery power (+) | – |
| MPR | 86 | Yellow/purple | Main power relay (MPR) control signal | AA2 |
| MPR | 87 | Red/white | Switched 12 V power (+) | – |
| Ignition coil B | A | Red | Fused (20 A) 12 V power (+) | – |

# Wire Color Code Abbreviations

| Wire Color Abbreviations | | | | |
|---|---|---|---|---|
| BLK | Black | | BLU | Blue |
| BRN | Brown | | GRY or GRA | Gray |
| GRN | Green | | ORN or ORG | Orange |
| PNK | Pink | | PPL or PUR | Purple |
| RED | Red | | TAN | Tan |
| WHT | White | | YEL | Yellow |
| LT or LIT | Light | | DK or DRK | Dark |

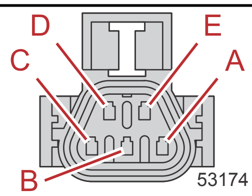
  

# Ignition Coil Wiring Diagram - V8



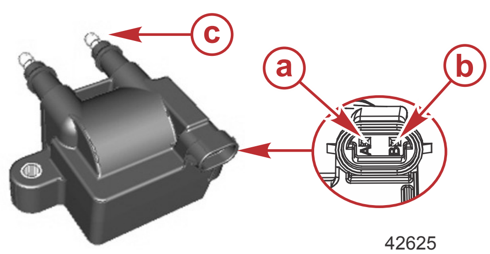

  

- **a -** Propulsion control module (PCM), connector A
- **b -** Main power relay
- **c -** Hot stud
- **d -** Engine fuses
- **e -** Coil harness connector
- **f -** Ignition coil adapter harness
- **g -** Coil A connector (cylinders 1 and 4)
- **h -** Coil D connector (cylinders 3 and 8)
- **i -** Coil C connector (cylinders 6 and 7)
- **j -** Coil B connector (cylinders 2 and 5)

| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|  | A | Green/brown | Coil A | AH4 |
| | B | Green/red | Coil B | AH3 |
| | C | Green/purple | Coil C | AH2 |
| | D | Green/yellow | Coil D | AH1 |
| | E | Red/yellow | Fused (20 A) 12 V power (+) | – |
| Hot stud ring terminal | – | Red | 12 V battery power (+) | – |
| MPR | 86 | Yellow/purple | Main power relay (MPR) control signal | AA2 |
| MPR | 87 | Red/white | Switched 12 V power (+) | – |
| Ignition coil B | A | Red | Fused (20 A) 12 V power (+) | – |

# Ignition Coil Resistance Test

1. Remove the spark plug lead from the ignition coil. Twist the ignition coil boot slightly while removing.
2. Use a DMT 2004 digital multimeter and perform the following test.



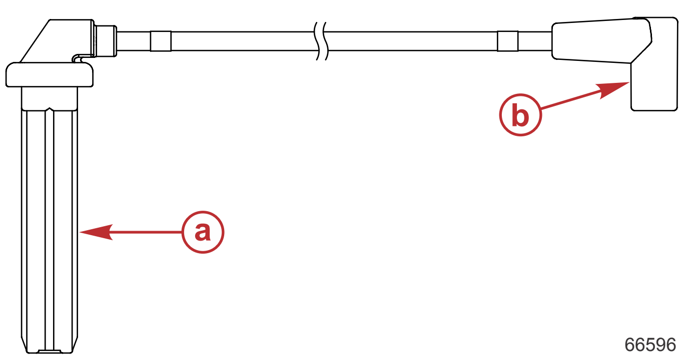

- **a -** Pin A
- **b -** Pin B
- **c -** Coil towers

| Ignition Coil Resistance Test (Ω) | |
|---|---|
| Between coil towers | 7200–8800 |
| Between pin A and B | 0.3–0.5 |

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

# Spark Plug Wires

The spark plug wires are of differing lengths, and therefore have different resistance values. The cylinder number is clearly marked on each end of every spark plug wire. Always ensure that you use the correct wire to connect a given spark plug to its corresponding ignition coil. After installing each spark plug wire, ensure that the terminal has engaged by lightly tugging on each connection.




- **a -** Spark plug end
- **b -** Ignition coil end

## Measuring Spark Plug Wire Resistance

- Resistance values vary by spark plug location (refer to specification table)
- Measure resistance from end to end (coil boot to plug boot)
- Never penetrate wire insulation with meter probes
- Digital meters are more accurate than analog meters
- Different meters may show different resistance values
- Any value within 10% of the specification should be considered acceptable

# Spark Plug Wire Resistance - V6 Models

| Cylinder | Length (see NOTE) | Resistance |
|---|---|---|
| 1 | 18.4 cm (7.25 in.) | 1,613–7,833 Ω |
| 2 | 21.6 cm (8.5 in.) | 1,800–8,667 Ω |
| 3 | 17.8 cm (7.0 in.) | 1,575–7,667 Ω |
| 4 | 59.7 cm (23.5 in.) | 4,050–18,667 Ω |
| 5 | 48.26 cm (19.0 in.) | 3,375–15,667 Ω |
| 6 | 43.2 cm (17.0 in.) | 3,075–14,333 Ω |

*NOTE: The length of each spark plug wire is measured between the coil terminal (center of the coil boot) and the plug boot (center of the plug boot). Each stated length is plus or minus 0.6 cm (0.25 in.).*

# Spark Plug Wire Resistance - V8 Models

| Cylinder | Length (see NOTE) | Resistance |
|---|---|---|
| 1 | 35.56 cm (14.0 in.) | 2,625–12,333 Ω |
| 2 | 27.3 cm (10.75 in.) | 2,138–10,167 Ω |
| 3 | 35.56 cm (14.0 in.) | 2,625–12,333 Ω |
| 4 | 66.0 cm (26.0 in.) | 4,425–20,333 Ω |
| 5 | 66.0 cm (26.0 in.) | 4,425–20,333 Ω |
| 6 | 24.1 cm (9.5 in.) | 1,950–9,333 Ω |
| 7 | 48.26 cm (19.0 in.) | 3,375–15,667 Ω |
| 8 | 41.3 cm (16.25 in.) | 2,963–13,833 Ω |

*NOTE: The length of each spark plug wire is measured between the coil terminal (center of the coil boot) and the plug boot (center of the plug boot). Each stated length is plus or minus 0.6 cm (0.25 in.).*

# Electrical Systems

## Section 6B - Charging and Starting System

## Table of Contents



6
B

# Charging and Starting Specifications

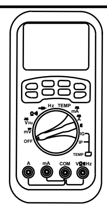
| Description | | Specification | |
|---|---|---|---|
| Alternator model series | | 8Si | 9Si |
| Alternator output (regulated) | 1800 RPM | 37 A | 42 A |
| | 6000 RPM | 85 A | 115 A |
| Regulator voltage set point | | 14.5 ± 0.25 V | |
| Starter current draw | Under load | 170–190 A | |
| | No load | 60–80 A | |

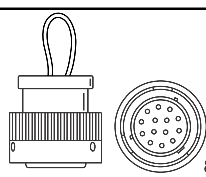
# Battery Specifications

## Required Starting Battery

| Description | | Specification |
|---|---|---|
| Battery type | | 12-volt absorbed glass mat (AGM) battery |
| Rating | USA and Canada (SAE) | 800 minimum marine cranking amps (MCA)<br>with a minimum reserve capacity of 135 RC25 rating |
| | International (EN) | 975 minimum cold cranking amps (CCA) with a minimum of 65 ampere hour (Ah) |

# Special Tools

| DMT 2004 Digital Multimeter | 91-892647A01 |
|---|---|
|  4516 | Measures RPM on spark ignition (SI) engines, ohms, amperes, AC and DC voltages; records maximums and minimums simultaneously, and accurately reads in high RFI environments. |

| 12 Volt Shunt Tool | 91-889675A01 |
|---|---|
|  8036 | Connects to the 14 pin engine harness. Turns on the ECM/PCM without the use of the vessel engine control harness. Used for troubleshooting purpose only. |

# Battery

## Battery Cable Test

This test is used to determine if there is excessive resistance in the battery's positive or negative cables, or if the cable is sized properly to carry the necessary current needed to crank the engine at the proper RPM.

**IMPORTANT: This test must be performed while the key switch is in the "START" position. Ignore any voltage readings taken without the circuit under load.**

| ⚠ WARNING |
|---|
| **Moving parts can cause serious injury or death. Wear eye protection and keep hands, hair, and clothing away from moving parts when performing tests or checking adjustments on an operating engine.** |

1. Perform a load test on the battery following the instructions supplied with the load tester. Ensure the battery is brought to a full charge after being tested.
2. With the key switch in the "START" position, measure the voltage across the battery posts, not the cable clamps. Record the voltage reading. If the voltage is less than 10 VDC, replace the battery.

*NOTE: The voltage reading in step 2 is the base voltage. The base voltage reading will be compared to the voltage readings obtained in the following steps.*

3. With the key switch in the "START" position, measure the voltage from the battery positive post (not the cable clamp) to the starter post (the stud where the battery positive cable is connected). Record the voltage reading.
4. With the key switch in the "START" position, measure the voltage from the starter case to the battery negative post (not the cable clamp). Record the voltage reading.
5. If the voltage reading in step 3 was more than 1.0 VDC:
   a. Check the cable connections for tightness and corrosion.
   b. If the cable is tight and not corroded, replace the cable with a larger diameter cable.
6. If the voltage reading in step 4 was more than 1.0 VDC:
   a. Check the cable connections for tightness and corrosion.
   b. If the cable is tight and not corroded, replace the cable with a larger diameter cable.

Resistance in the cables can cause a voltage drop and limit current to the starter. If corrosion is present, or if the starter is worn, there may not be enough amperage to turn the starter motor.

*NOTE: If the voltage at the starter is less than 11 VDC, the engine may not start.*

## Replacement Parts

| ⚠ WARNING |
|---|
| **Avoid fire or explosion hazard. Electrical, ignition, and fuel system components on Mercury Marine products comply with federal and international standards to minimize risk of fire or explosion. Do not use replacement electrical or fuel system components that do not comply with these standards. When servicing the electrical and fuel systems, properly install and tighten all components.** |

**IMPORTANT: Deep-cycle batteries are not suitable for use as engine starting batteries or for use as accessory batteries that are connected to high output engine charging systems. Deep-cycle battery life may be shortened by high output engine charging systems. Refer to individual battery manufacturer instructions for specific battery charging procedures and applications.**

## Battery Precautions

| ⚠ WARNING |
|---|
| **An operating or charging battery produces gas that can ignite and explode, spraying out sulfuric acid, which can cause severe burns. Ventilate the area around the battery and wear protective equipment when handling or servicing batteries.** |

When charging batteries, an explosive gas mixture forms in each cell. Part of this gas escapes through holes in the vent plugs and may form an explosive atmosphere around the battery if ventilation is poor. This explosive gas may remain in or around the battery for several hours after it has been charged. Sparks or flames can ignite this gas and cause an internal explosion, which may shatter the battery.

The following precautions should be observed to prevent an explosion:

1. Do not smoke near batteries being charged or which have been charged very recently.
2. Do not break live circuits at terminals of batteries, because a spark usually occurs at the point where a live circuit is broken. Always be careful when connecting or disconnecting cable clamps on chargers. Poor connections are a common cause of electrical arcs which cause explosions.
3. Do not reverse polarity of battery terminal to cable connections.

## Charging a Discharged Battery

| ⚠ WARNING |
|---|
| **An operating or charging battery produces gas that can ignite and explode, spraying out sulfuric acid, which can cause severe burns. Ventilate the area around the battery and wear protective equipment when handling or servicing batteries.** |

The following basic rules apply to any battery charging situation:

1. Any battery may be charged at a maximum rate of 10 amperes, or as long as spewing of electrolyte (from violent gassing) does not occur, and for as long as electrolyte temperature does not exceed 52 °C (125 °F). If spewing of electrolyte occurs, or if electrolyte temperature exceeds 52 °C (125 °F), charging rate (in amperes) must be reduced or temporarily halted to avoid damage to the battery.

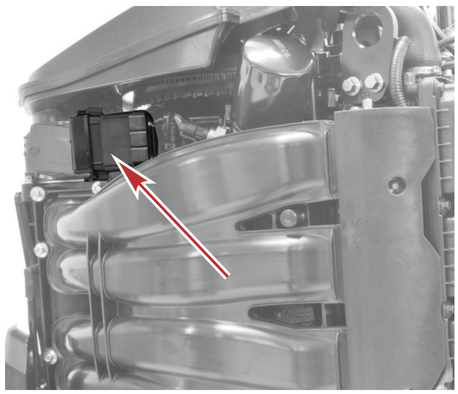
  

2. The battery is fully charged when, over a two hour period at a low charging rate (in amperes), all cells are gassing freely (not spewing liquid electrolyte), and no change in specific gravity occurs. Full charge specific gravity is 1.260–1.275, corrected for electrolyte temperature with electrolyte level at 4.8 mm (3/16 in.) over plate, unless electrolyte loss has occurred (from age or overfilling), in which case, specific gravity reading will be lower. For most satisfactory charging, lower charging rates in amperes are recommended.
3. If, after prolonged charging, specific gravity of at least 1.230 on all cells cannot be reached, battery is not in optimum condition and will not provide optimum performance; however, it may continue to provide additional service, if it has performed satisfactorily in the past.
4. To check the battery voltage while cranking the engine with an electric starting motor at ambient air temperature of 23.8 °C (75 °F), place the red (+) lead of the tester on the positive (+) battery terminal and the black (–) lead of the tester on the negative (–) battery terminal. If the voltage drops below 10-1/2 volts while cranking, the battery is weak and should be recharged or replaced.

# Fuses

Fuses protect the electrical circuits on the outboard from overload. If a fuse is open, try to locate and correct the cause of the overload. If the cause is not found, the fuse may open again.

1. Remove the top cowl. Locate the fuse holder on the port side of the engine.



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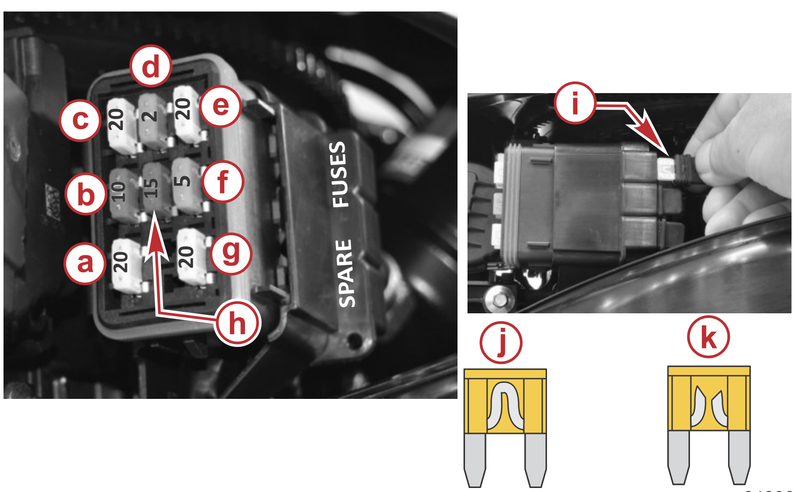
2. Remove the plastic cover from the fuse holder.
3. Remove the suspected open fuse to determine if the metal band is broken.
4. If necessary, replace the fuse with a new fuse of the same amperage rating.




64390

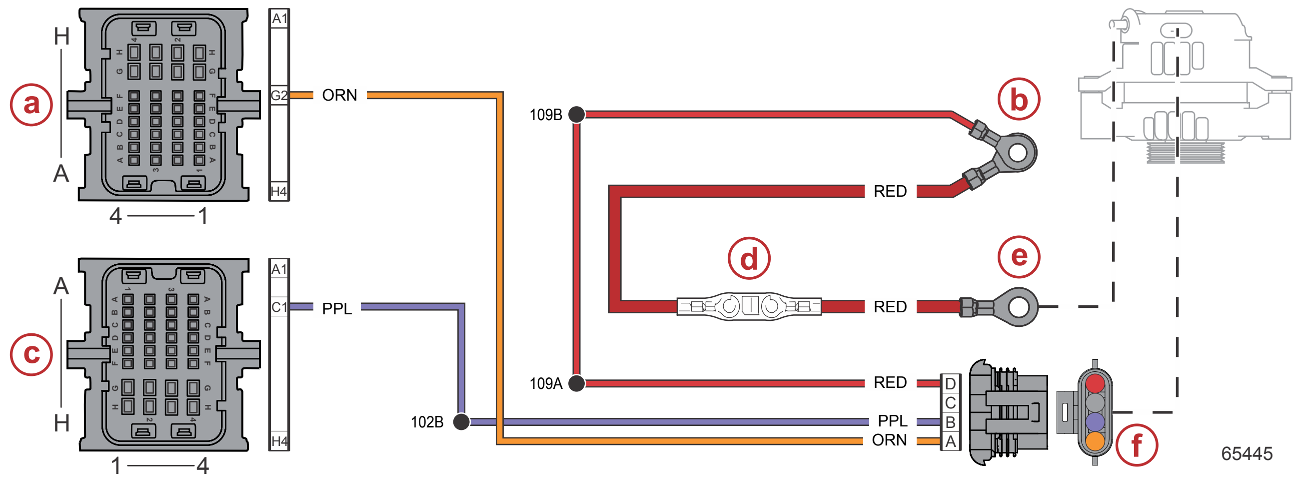
- a - Ignition coils—20 amp
- b - Oxygen sensor—10 amp
- c - Fuel pump—20 amp
- d - Diagnostics—2 amp
- e - Fuel injectors—20 amp
- f - Advanced sound control—5 amp (not used on all models)
- g - Driver power—20 amp (start relay, fuel pump relay, PCM drivers)
- h - TVM power—15 amp (not used on all models)
- i - Spare fuses (3)
- j - Good fuse
- k - Open fuse

# Charging System

## Charging System Components

The charging system consists of the alternator, starting battery, 150-amp fusible link, propulsion control module (PCM), and the wiring that connects these components. The wiring diagram is shown, following.




**a -** PCM connector A (engine harness)
**b -** Hot stud (battery +)
**c -** PCM connector C (engine harness)
**d -** Fusible link (150 amp)
**e -** Alternator output
**f -** Alternator 4-pin connector (engine harness)

### Precautions

Observe the following precautions when working on the charging system. Failure to observe these precautions may result in serious damage to the charging system.

- Do not attempt to polarize the alternator.
- Do not short across or ground any of the terminals on the alternator, except as specifically instructed.
- Never disconnect the alternator output lead, engine harness, or battery cables when the alternator is being driven by the engine.
- Always remove the negative (–) battery cable from the battery before working on the charging system.

**⚠ CAUTION**

**Disconnecting or connecting the battery cables in the incorrect order can cause injury from electrical shock or can damage the electrical system. Always disconnect the negative (-) battery cable first and connect it last.**

- When installing the battery, be sure to connect the negative (–) battery cable to the negative (–) battery terminal and the positive (+) battery cable to the positive (+) battery terminal. Connecting the battery cables to the battery in reverse will melt the 150-amp fusible link in the output lead of the alternator. The alternator will not be able to charge the battery, and the battery will be quickly discharged if the engine is run.
- When using a charger or booster battery, connect it in parallel with the existing battery (positive to positive; negative to negative).

## Alternator Description

The alternator consists of a rotor, three-phase stator, and rectifier bridge. As it is spun, the electromagnetic field in the rotor induces an AC voltage in the stator, which is then converted to a DC voltage by the rectifier. The diodes in the rectifier also prevent the battery from discharging back through the stator.

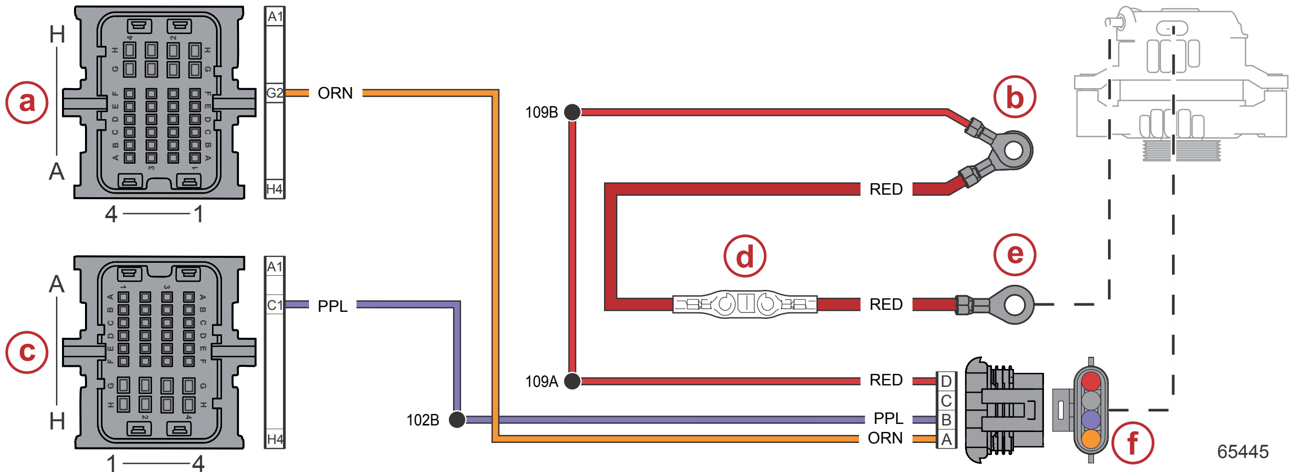
A voltage regulator controls the alternator's output to ensure that the battery is neither overcharged nor undercharged. The regulator does this by sensing the voltage at the battery and limiting the rotor's field current accordingly. The alternator self-limits current: as long as the voltage is regulated within the prescribed limits, the alternator cannot produce excessive current.

An excitation circuit supplies a small amount of current to the rotor field to initially start the electromagnetic field. Once the alternator begins to produce output, field current is supplied solely by the rectifier diodes.

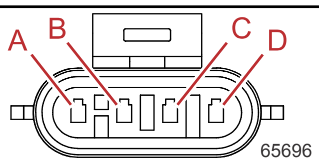
  

The alternator is equipped with two fans that induce air flow through the alternator to remove heat.

## Alternator



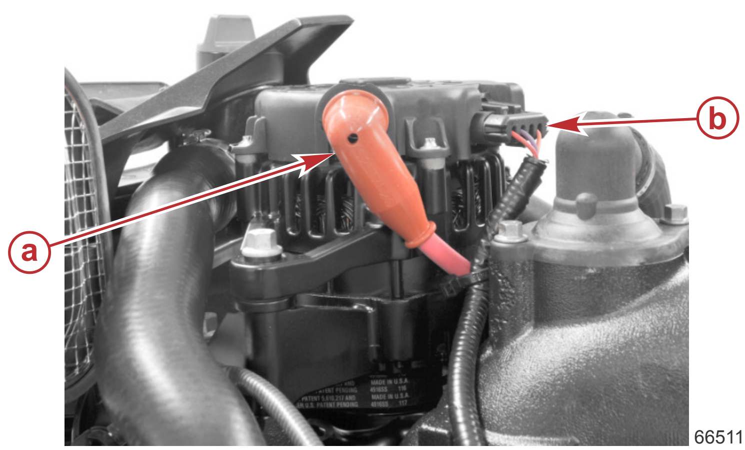

- **a -** PCM connector A
- **b -** Hot stud (battery +)
- **c -** PCM connector C
- **d -** Fusible link
- **e -** Alternator output
- **f -** Alternator 4-pin connector

| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|   | A | Orange | Not connected at the alternator; not used | AG2 |
| | B | N/A | Not used | – |
| | C | Purple | 12 V wake circuit (+) - used as the excitation lead | CC1 |
| | D | Red | 12 V battery power (+) - used as the alternator sense lead | – |

## Charging System Inspection

1. If the problem is an undercharged battery, verify the condition has not been caused by excessive accessory current draw or by accessories that have been left on.
2. Check the physical condition and state of charge of the battery. The battery must be at least 75% (1.230 specific gravity) charged to obtain valid results in the following tests. If not, charge the battery before testing the system.
3. Inspect the entire charging system wiring for defects. Check all connections for tightness and cleanliness, particularly the battery cable clamps and battery terminals.

   **IMPORTANT: The alternator output lead (black with red sleeve) connection must be tight. A darkened red sleeve indicates the lead was loose and became hot. Verify the output lead attaching nut is tightened to the specified torque.**

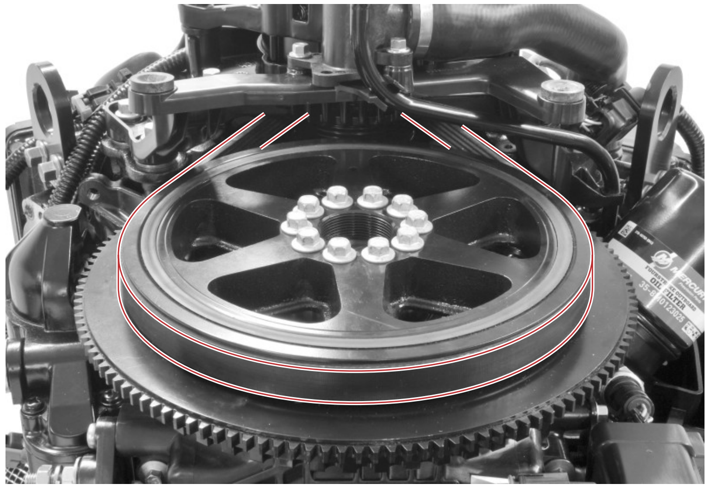



- **a -** Alternator output lead/fusible link, to hot stud
- **b -** Alternator connection to engine harness (excitation and sense leads)

| Description | Nm | lb-in. | lb-ft |
|---|---|---|---|
| Nut | 7 | 62 | – |

4. Check the alternator drive belt for excessive wear, cracks, glazed surfaces, and fraying. Replace if necessary.



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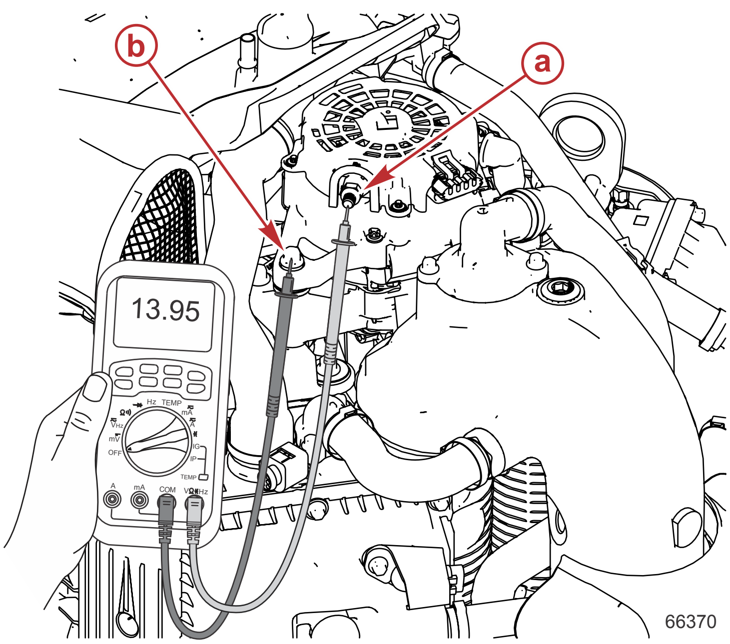
## Charging System Circuitry Tests

Perform the following tests with a DMT 2004 digital multimeter, to ensure that all of the circuits between the alternator and the other components within the charging system are in good condition.

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

### Output Circuit

1. Connect the DMT positive (+) lead to the battery positive (+) post.
2. Connect the DMT negative (–) lead to the battery negative (–) post.
3. Supply cooling water to the engine.
4. Start the engine and increase engine speed to approximately 1300 RPM.
5. Observe the voltage reading.
    a. If the reading is below 13.5 volts:
        i. Connect the positive (+) DMT lead to the alternator output post.
        ii. Connect the negative (–) DMT lead to the ground post on the alternator.




a - Alternator output post
b - Alternator ground post

iii. Wiggle the engine wiring harness while observing the voltmeter. The meter should indicate the approximate battery voltage and should not vary. If no reading is obtained or if the reading varies, inspect the wiring harness for loose connections, corrosion, breaks, or shorts. Repair or replace the harness as required.

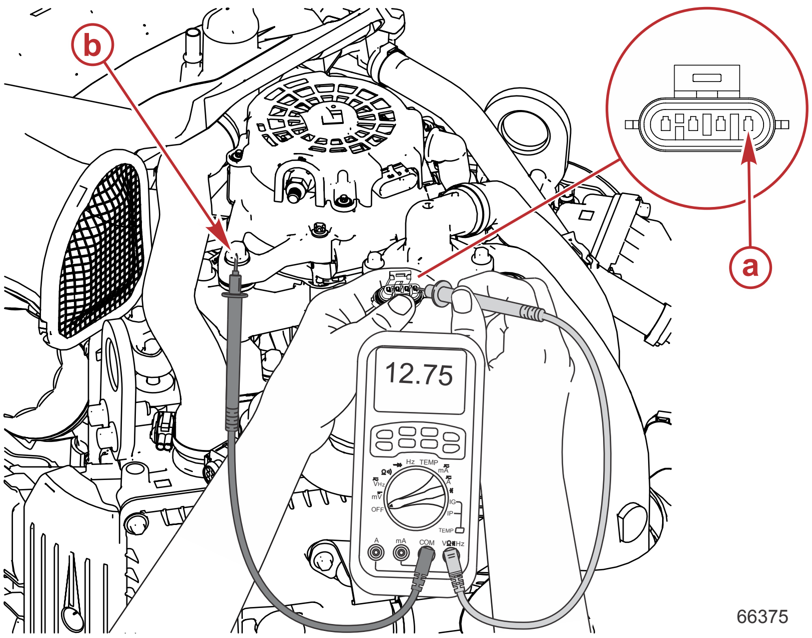
iv. If the reading is 18 volts or above at the alternator output stud, test the fusible link for continuity. A failed fusible link will prevent the alternator's charge from reaching the battery.

b. If the reading is between 13.5 and 14.8 volts, switch the DMT to the AC volt position. A reading of 0.25 VAC or less indicates the alternator diodes are fully functional. A reading above 0.25 VAC indicates the diodes are faulty and the alternator must be replaced.

c. If the reading is above 15 volts at the battery, the alternator is overcharging and must be replaced.

## Sensing Circuit

1. Unplug the engine harness connector from the alternator.
2. Connect the positive (+) DMT lead to the red pin (pin D) and the negative (–) DMT lead to the alternator ground post.
3. The DMT should indicate the battery voltage. If battery voltage is not present, check the red lead for a loose or dirty connection or damaged wiring.




a - Sensing circuit red lead
b - Alternator ground post

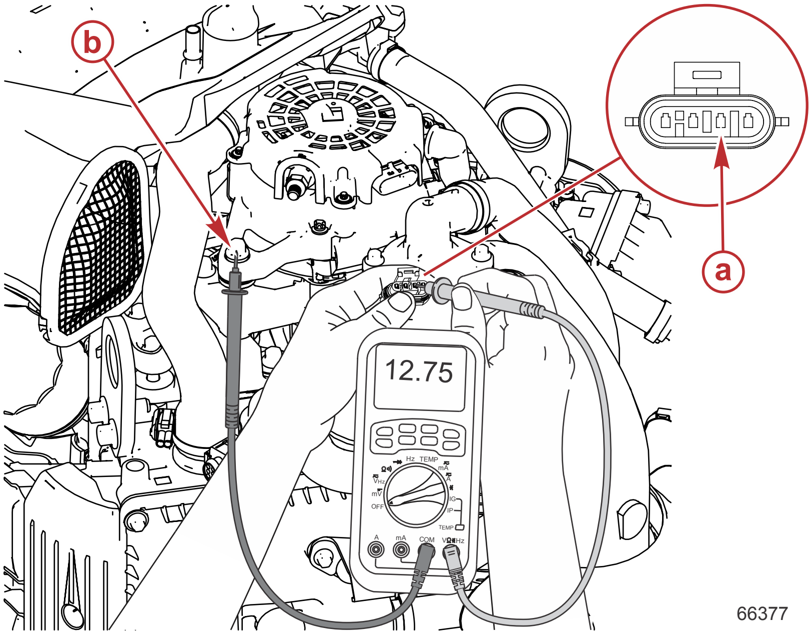
## Excitation Circuit

*NOTE: The ignition key must be in the ON position (engine not running).*

1. Unplug the engine harness connector from the alternator.
2. Connect the positive (+) DMT lead to the purple pin (pin C) and the negative (–) DMT lead to the alternator ground post.

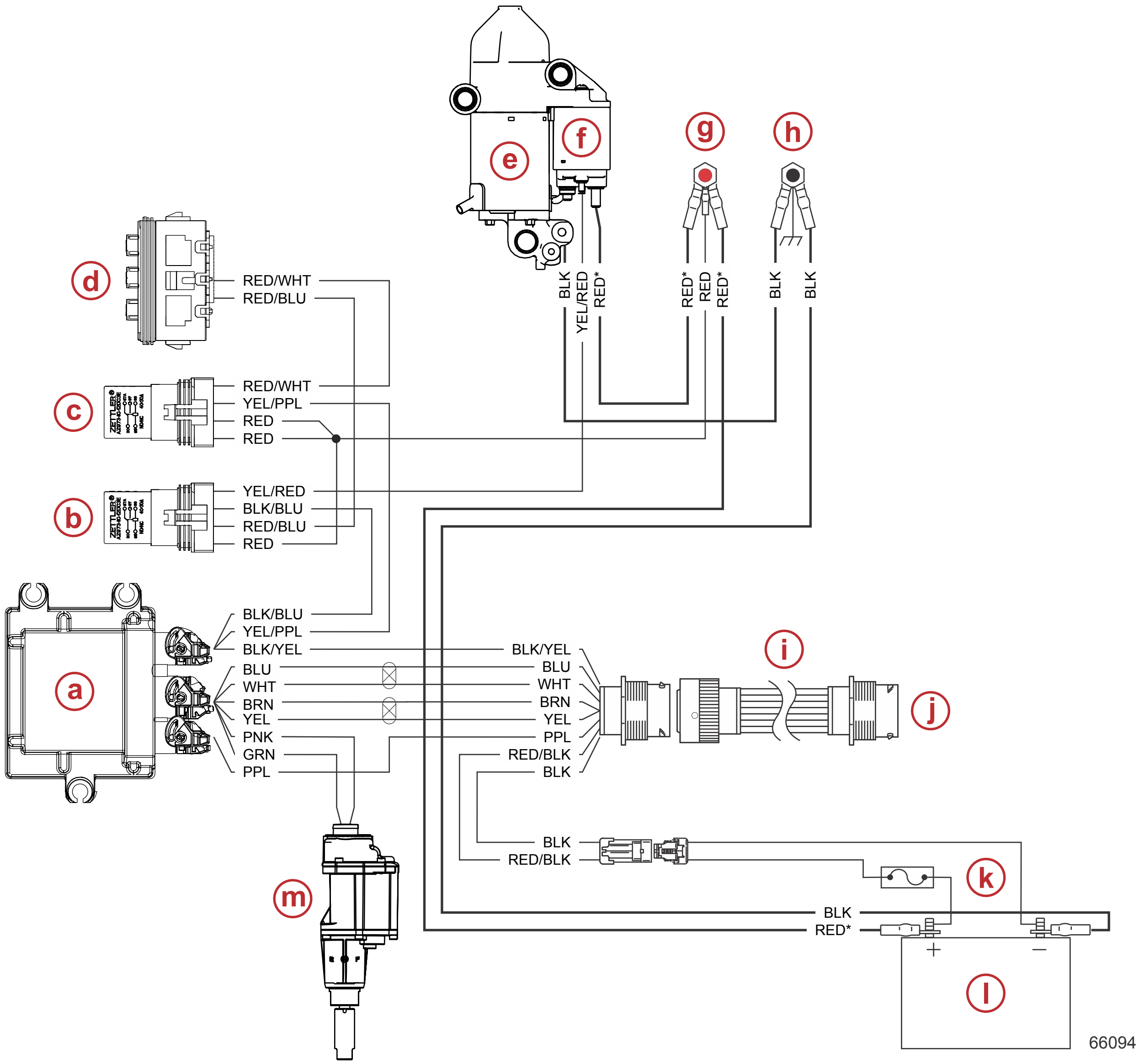
3. The DMT should indicate battery voltage. If battery voltage is not present, check the purple lead for a loose or dirty connection or damaged wiring.




**a -** Excitation circuit purple lead
**b -** Alternator ground post

# Starting System

## Starting System Components and Connections - DTS

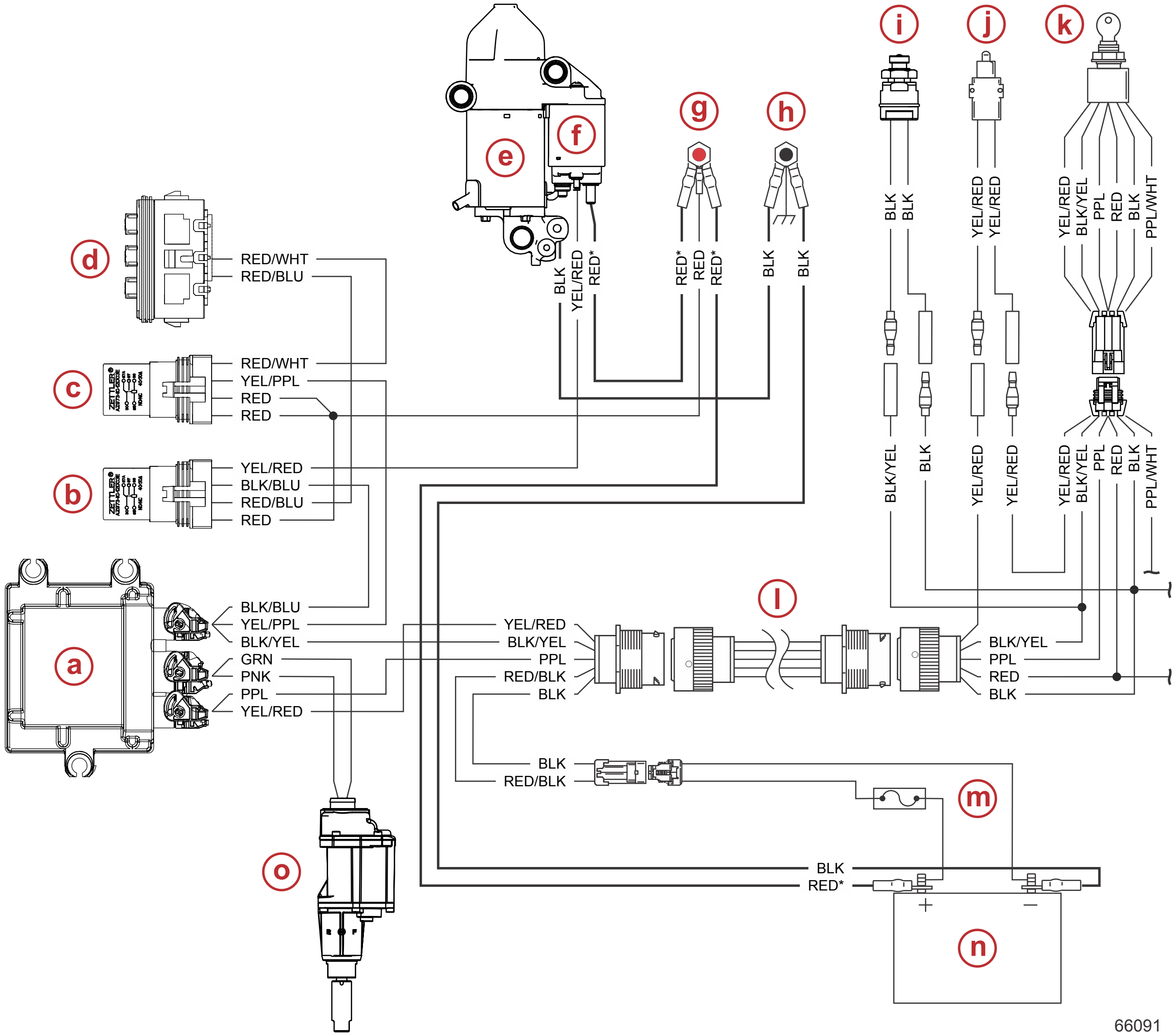



- **a -** Propulsion control module (PCM)
- **b -** Start relay
- **c -** Main power relay (MPR)
- **d -** Fuse block - 20-amp fuse used for the start circuit
- **e -** Starter motor
- **f -** Starter solenoid
- **g -** Hot stud

  *NOTE: RED* indicates a black cable with red sleeves at the ring terminals.*
- **h -** Chassis ground stud
- **i -** 14-pin data harness (engine to helm)
- **j -** To helm components; refer to **DTS Diagnostic Manual** 8M0057654
- **k -** Clean power harness with 5-amp fuse
- **l -** Engine starting battery
- **m -** Shift actuator

## Starting System Components and Connections - Mechanical




Typical mechanical engine controls

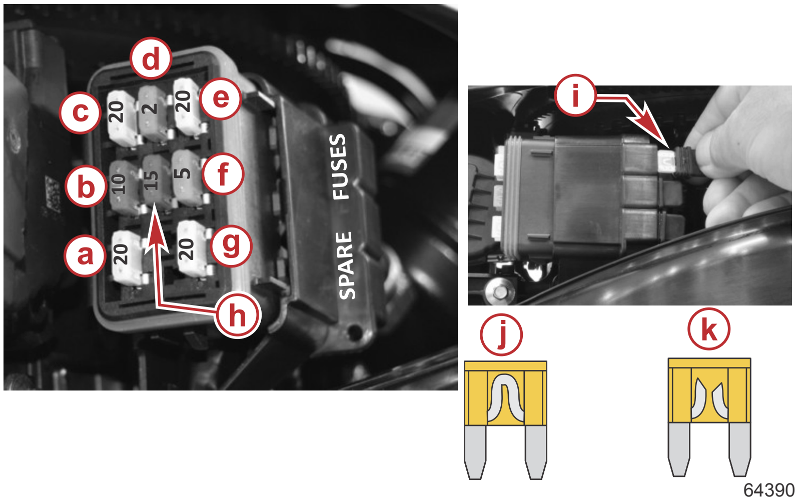
- a - Propulsion control module (PCM)
- b - Start relay
- c - Main power relay (MPR)
- d - Fuse block - 20-amp fuse used for the start circuit
- e - Starter motor
- f - Starter solenoid
- g - Hot stud

  *NOTE: RED* indicates a black cable with red sleeves at the ring terminals.*
- h - Chassis ground stud
- i - E-stop switch (lanyard type shown)
- j - Neutral start switch (typically integral to the remote control)
- k - Ignition key switch (typical)
- l - 14-pin data harness (engine to helm)
- m - Clean power harness with 5-amp fuse
- n - Engine starting battery
- o - Shift actuator

## Starting System Electrical Checks

1. Inspect the 20-amp driver power fuse.

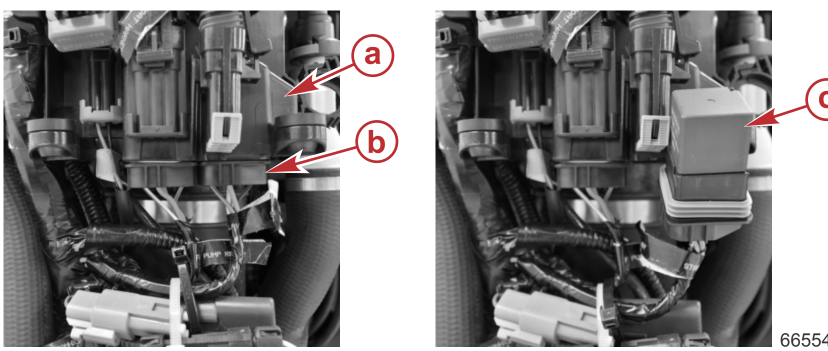



- a - Ignition coils - 20 amp
- b - Oxygen sensor - 10 amp
- c - Fuel pump - 20 amp
- d - Diagnostics - 2 amp
- e - Fuel injectors - 20 amp
- f - Advanced sound control - 5 amp (V8 only)
- g - Driver power (starter relay, fuel pump relay, PCM drivers)
- h - TVM power - 15 amp (DTS models only)
- i - Spare fuses (3)
- j - Good fuse
- k - Open fuse

2. Inspect the 5-amp clean power fuse located near the engine starting battery.
3. The battery must deliver a minimum of 11 VDC to the starter. Perform a load test on the battery following the instructions supplied with the load tester.
4. Install the shunt tool to the engine harness 14-pin connector and perform the Smart Start test in the Diagnostic screen of the CDS G3. If the starter engages, the problem lies in the hull wiring or helm harness. Refer to the preceding Starting System Components and Connections diagrams. If the starter does not engage, continue to step 5.

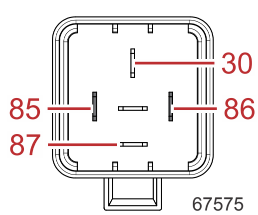
| | |
|---|---|
| 12 Volt Shunt Tool | 91-889675A01 |

5. Inspect all connections at the battery, start relay, starter solenoid, starter motor, PCM, and the 14-pin engine wiring harness connector for tightness and corrosion. Clean or repair as necessary.
6. Remove the start relay and socket from behind the electrical panel (press the tab to release), and remove the relay from the socket.




- a - Electrical panel
- b - Start relay socket on the engine harness
- c - Start relay

7. Measure the resistance of the relay's coil, between terminal 86 and terminal 85. Replace the relay, if the coil's resistance is not within specification.

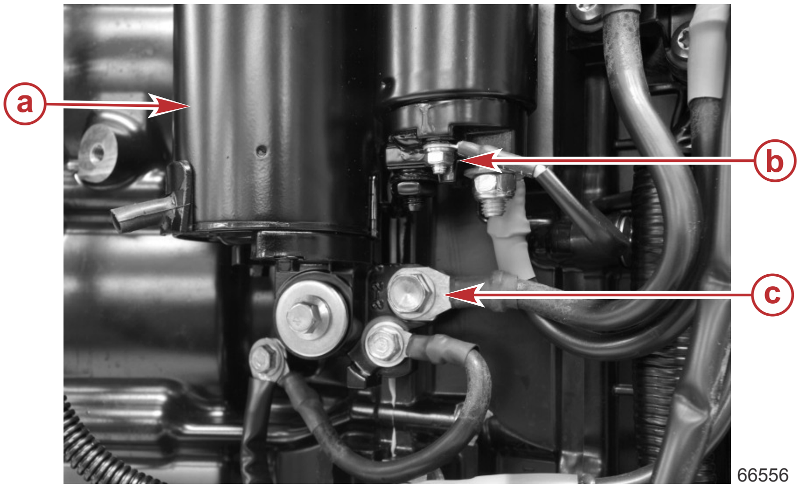



Four-pin relay pin identification

| Start Relay | |
|---|---|
| Coil resistance (terminal 86 to terminal 85) | 80–100 Ω |

8. With the key switch in the START position, the starter drive should engage the engine flywheel. If not, turn off the key switch, and measure the resistance between the yellow/red terminal on the starter solenoid and engine ground. If resistance is not within specification, the starter solenoid is defective and must be replaced.




a - Starter motor
b - Starter solenoid yellow/red terminal
c - Engine ground

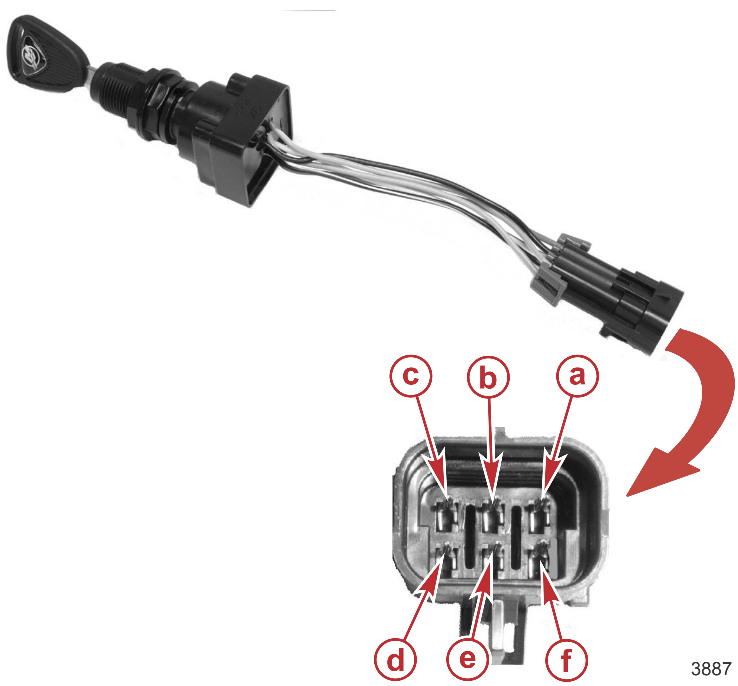
| Starter Solenoid | |
|---|---|
| Coil resistance (yellow/red terminal to ground) | 0.2–0.4 Ω |

9. If the starter drive audibly engages the engine flywheel, but the starter does not rotate, remove the starter and test the no load current draw. If the current draw is not within specification, replace the starter assembly.

| Starter | |
|---|---|
| No load current draw | 60–80 A |

## Key Switch Test (Four Position)

1. Disconnect the key switch from the command module harness.
2. Set ohmmeter on R x 1 scale for the following tests.
3. If meter readings are other than specified in the following tests, verify that the switch and not the wiring is faulty. If the wiring checks OK, replace the switch.



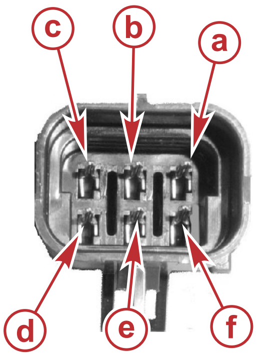

a - Pin A - Red
b - Pin B - Black
c - Pin C - Purple/white
d - Pin D - Purple
e - Pin E - Black/yellow
f - Pin F - Yellow/red

| Key Position | Continuity should be indicated at the following points: | |
|---|---|---|
| Off | B | E |

| Key Position | Continuity should be indicated at the following points: | |
|---|---|---|
| Accessories | A | C |
| Run | A | D |
| Start | A | F |
| | F | D |
| | A | D |

## Key Switch Test (Three Position)




a - Pin A
b - Pin B
c - Pin C
d - Pin D
e - Pin E
f - Pin F

| Ref. No. | Pin | Wire Color | Description |
|---|---|---|---|
| a | A | Red | 12 volts |
| b | B | Black | Ground |
| c, d | C, D | Purple | Run |
| e | E | Black/yellow | Off |
| f | F | Yellow/red | Start |

| Meter Test Leads | | Key Position | Reading (Ω) |
|---|---|---|---|
| Red | Black | | |
| Pin B | Pin E | Off | Continuity |
| Pin A | Pin F | Run | Continuity |
| Pin A | Pin C, D | | |
| Pin A | Pin F | Start | Continuity |
| Pin F | Pin C, D | | Continuity |
| Pin A | Pin C, D | | Continuity |

# Electrical Systems

## Section 6C - Conventional Midsection (CMS) Power Trim

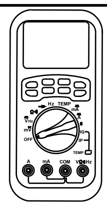
## Table of Contents

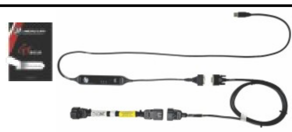


6
C

# Special Tools

| DMT 2004 Digital Multimeter | 91-892647A01 |
|---|---|
|  4516 | Measures RPM on spark ignition (SI) engines, ohms, amperes, AC and DC voltages; records maximums and minimums simultaneously, and accurately reads in high RFI environments. |

| CDS G3 Interface Kit | 8M0138392 |
|---|---|
|  66165 | CDS G3 License Key, Interface, Adapter, and Harness |

# Electrical System Troubleshooting

## General Checks

Before troubleshooting the power trim electrical system, check for the following:

- Disconnected wires
- Battery is fully charged
- Battery cable connections are tight and corrosion-free
- Battery cables are secured with hex nuts, not wing nuts
- Connections are tight and corrosion-free
- Plug-in connections are fully engaged
- Clean power is connected

## Condition/Problem

| Condition of Trim System | Problem No. |
|---|---|
| Trim motor does not run when trim button is depressed | 1, 2, 4, 5, 6, 7 |
| Trim system trims opposite of buttons | 3 |
| Cowl-mounted trim buttons do not activate trim system | 2, 4, 5, 6 |

## Problem/Solution

| No. | Problem | Solution |
|---|---|---|
| 1. | Battery low or discharged | Check the battery. |
| 2. | Open circuit in trim wiring | Check for an open connection. |
| 3. | Wiring reversed in remote control, cowl switch, or trim leads | Verify connections. |
| 4. | Wire harness corroded through | Replace wire harness. |
| 5. | Internal motor problem (brushes, shorted armature) | Check for an open connection. Test and replace the power trim motor if necessary. |
| 6. | Trim switch failure | Replace the switch. |
| 7. | Relay not operating | Verify relays are functioning correctly. Check voltage at the power trim bullet connectors. |

## Power Trim Electrical Circuit

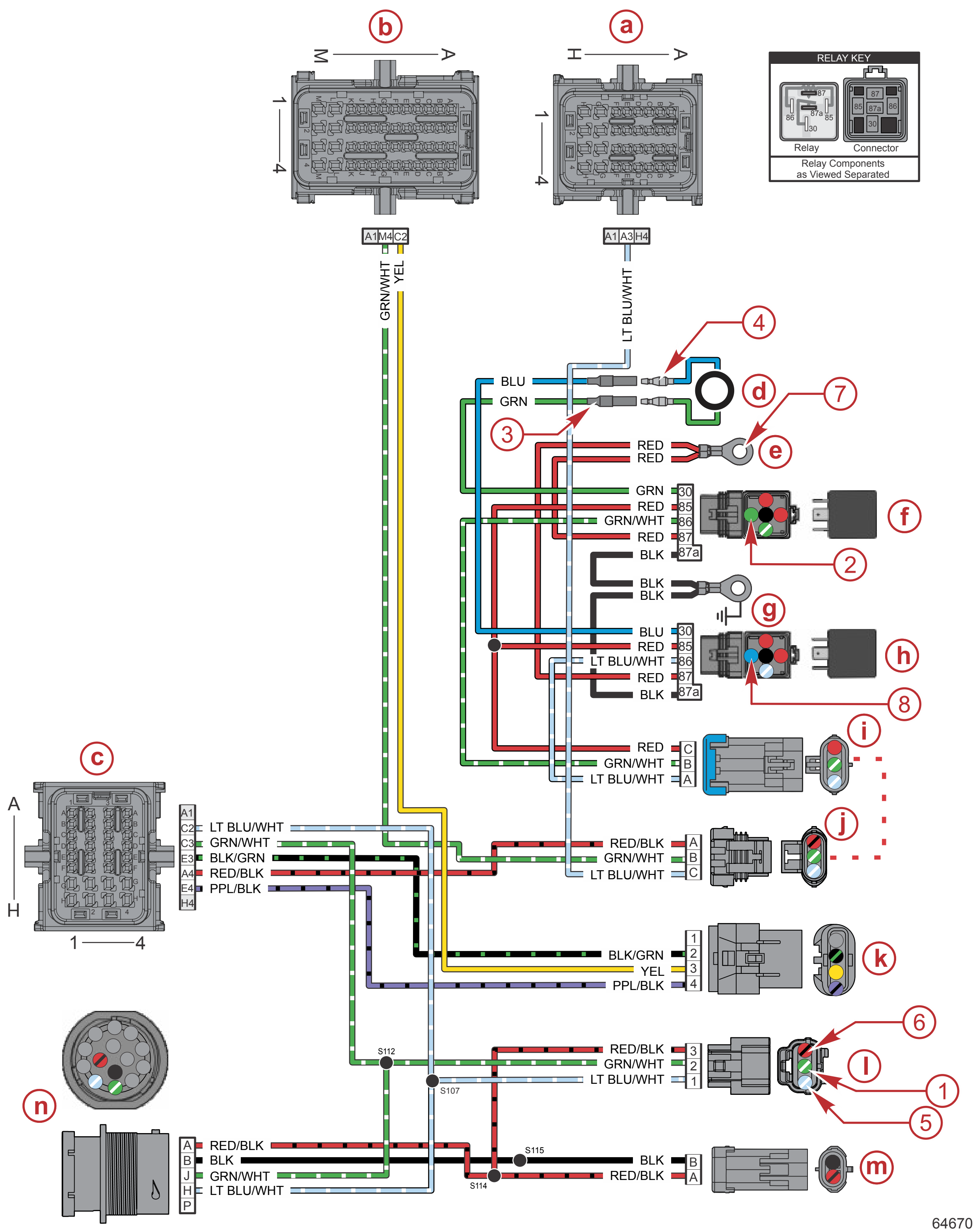
IMPORTANT: Numerical callouts shown in the circuit diagrams are test points. Refer to **Troubleshooting the Down Circuit** or **Troubleshooting the Up Circuit.**

# Notes:

## Mechanical Power Trim Wiring Diagram

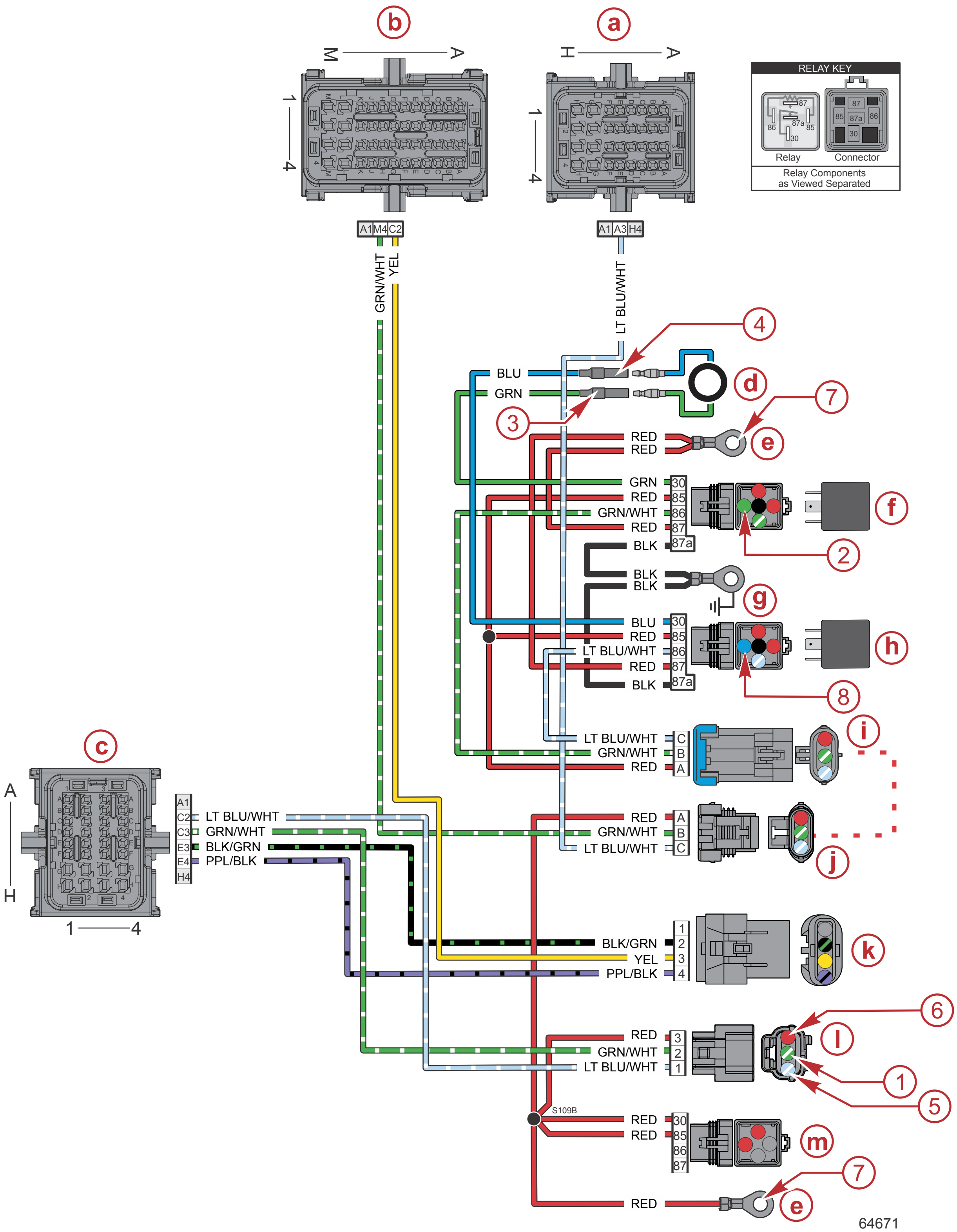


Mechanical Power Trim Wiring Diagram

- a - PCM connector A
- b - PCM connector B
- c - PCM connector C
- d - Power trim motor
- e - +12 volts power
- f - Down relay
- g - –12 volts ground
- h - Up relay
- i - Power trim harness connector
- j - Power trim harness connector—PCM side
- k - Trim position sensor connector
- l - Cowl tilt switch
- m - Clean power connector
- n - 14-pin connector

IMPORTANT: Numerical callouts shown in the circuit diagrams are test points. Refer to **Troubleshooting the Down Circuit** or **Troubleshooting the Up Circuit**.

## DTS Power Trim Wiring Diagram



DTS Power Trim Wiring Diagram

- a - PCM connector A
- b - PCM connector B
- c - PCM connector C
- d - Power trim motor
- e - +12 volts power
- f - Down relay
- g - –12 volts ground
- h - Up relay
- i - Power trim harness connector
- j - Power trim harness connector—PCM side
- k - Trim position sensor connector
- l - Cowl tilt switch
- m - Main power relay

IMPORTANT: Numerical callouts shown in the circuit diagrams are test points. Refer to **Troubleshooting the Down Circuit** or **Troubleshooting the Up Circuit**.

## Troubleshooting the Down Circuit

IMPORTANT: Refer to the preceding wiring diagrams for connection points when troubleshooting the electrical systems. Connection points are specified by number. Refer to the correct diagram for your engine (mechanical or DTS).

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

IMPORTANT: Perform the following tests with the engine off and the 14-pin connector disconnected from the outboard. This will isolate the outboard from the boat. If the engine tilts when using the cowl trim switch, the problem is related to the trim switch at the helm.

*NOTE: To access test points 2 and 8, partially remove the relay from the connector just far enough to reach the electrical contacts with the voltmeter lead.*

| Step | Test Procedure | Test Result |
|---|---|---|
| **Step 1**: Check for battery voltage at Point 1 by back probing. | 1. Connect the voltmeter black lead to ground and the red lead to Point 1.<br>2. Depress the down trim button. | Battery voltage measured:<br>• Go to Step 2.<br>No battery voltage measured:<br>• Go to Step 3. |
| **Step 2**: Check for battery voltage at Point 2. | 1. Connect the voltmeter black lead to ground and the red lead to Point 2.<br>2. Depress the down trim button. | Battery voltage measured:<br>• Go to Step 5.<br>No battery voltage measured:<br>• There is an open circuit between Point 2 and the PCM.<br>• Check for loose or corroded connections.<br>• Inspect the wiring harness for opens, shorts, or damage. Repair or replace the harness. |
| **Step 3**: Check for continuity between Point 1 and Point 5. | 1. Disconnect the 3-pin connector.<br>2. Connect the voltmeter black lead to Point 1 and the red lead to Point 5. | Continuity measured (resistance should be 5.6 kΩ ± 20%):<br>• Harness and PCM are OK.<br>• Go to Step 4.<br>No continuity measured (resistance should be 5.6 kΩ ± 20%):<br>• Inspect the wiring harness for opens, shorts, or damage. Repair or replace the harness. |
| **Step 4**: Check for battery voltage at Point 6. | 1. Connect the voltmeter red lead to Point 6 and black lead to ground. | Battery voltage measured:<br>• Trim switch is faulty.<br>No battery voltage measured:<br>• Check for loose or corroded wire at Point 6.<br>• Open circuit in wire supplying current between Point 6 and Point 7. |
| **Step 5**: Check for battery voltage at Point 3. | 1. Connect the voltmeter red lead to Point 3 (female bullet connector) and black lead to ground.<br>2. Depress the down trim button. | Battery voltage measured:<br>• Go to Step 6.<br>No battery voltage measured:<br>• Relay is defective. |

| Step | Test Procedure | Test Result |
|---|---|---|
| **Step 6**: Check the up relay. | 1. Connect the voltmeter red lead to Point 4 (female bullet connector) and black lead to ground.<br>2. Depress the up trim button. | Relay is good (battery voltage measured):<br>• Pump motor wiring is defective.<br>• Pump motor is defective.<br>Relay is faulty (no battery voltage measured):<br>• Replace relay. |

## Troubleshooting the Up Circuit

**IMPORTANT: Refer to the preceding wiring diagrams for connection points when troubleshooting the electrical systems. Connection points are specified by number. Refer to the correct diagram for your engine (mechanical or DTS).**

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

**IMPORTANT: Perform the following tests with the engine off and the 14-pin connector disconnected from the outboard. This will isolate the outboard from the boat. If the engine tilts when using the cowl trim switch, the problem is related to the trim switch at the helm.**

*NOTE: To access test points 2 and 8, partially remove the relay from the connector just far enough to reach the electrical contacts with the voltmeter lead.*

| Step | Test Procedure | Test Result |
|---|---|---|
| **Step 1**: Check for battery voltage at Point 5 by back probing. | 1. Connect the voltmeter black lead to ground and the red lead to Point 5.<br>2. Depress the up trim button. | Battery voltage measured:<br>• Go to Step 2.<br>No battery voltage measured:<br>• Go to Step 3. |
| **Step 2**: Check for battery voltage at Point 8. | 1. Connect the voltmeter black lead to ground and the red lead to Point 8.<br>2. Depress the up trim button. | Battery voltage measured:<br>• Go to Step 5.<br>No battery voltage measured:<br>• There is an open circuit between Point 8 and the PCM.<br>• Check for loose or corroded connections.<br>• Inspect the wiring harness for opens, shorts, or damage. Repair or replace the harness. |
| **Step 3**: Check for continuity between Point 1 and Point 5. | 1. Disconnect the 3-pin connector.<br>2. Connect the voltmeter black lead to Point 1 and the red lead to Point 5. | Continuity measured (resistance should be 5.6 kΩ ± 20%):<br>• Harness and PCM are OK.<br>• Go to Step 4.<br>No continuity measured (resistance should be 5.6 kΩ ± 20%):<br>• Inspect the wiring harness for opens, shorts, or damage. Repair or replace the harness. |
| **Step 4**: Check for battery voltage at Point 6. | 1. Connect the voltmeter red lead to Point 6 and black lead to ground. | Battery voltage measured:<br>• Trim switch is faulty.<br>No battery voltage measured:<br>• Check for loose or corroded wire at Point 6.<br>• Open circuit in wire supplying current between Point 6 and Point 7. |
| **Step 5**: Check for battery voltage at Point 4. | 1. Connect the voltmeter red lead to Point 4 (female bullet connector) and black lead to ground.<br>2. Depress the up trim button. | Battery voltage measured:<br>• Go to Step 6.<br>No battery voltage measured:<br>• Relay is defective. |
| **Step 6**: Check the down relay. | 1. Connect the voltmeter red lead to Point 3 (female bullet connector) and black lead to ground.<br>2. Depress the down trim button. | Relay is good (battery voltage measured):<br>• Pump motor wiring is defective.<br>• Pump motor is defective.<br>Relay is faulty (no battery voltage measured):<br>• Replace relay. |

## Troubleshooting the Down and Up Circuits (All Circuits Inoperative)

IMPORTANT: Refer to the preceding wiring diagrams for connection points when troubleshooting the electrical systems. Connection points are specified by number. Refer to the correct diagram for your engine (mechanical or DTS).

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

| Problem | Possible Cause | Remedy |
|---|---|---|
| The up and down trim switches are both inoperative, but the cowl switch does operate. | 1. Faulty trim switch.<br>2. A wire is open between the trim pump motor and the trim switch. | 1. Replace the trim switch.<br>2. Check for a loose or corroded connection. |
| Trim switch and cowl switch are both inoperative. | 1. One of the trim pump motor wires is open between the motor and the relays.<br>2. A wire is open between the trim pump motor and the trim switch.<br>3. Faulty trim relay.<br>4. Faulty trim pump motor. | 1. Check the wire connections at point 2 or 8 for loose or corroded condition.<br>2. If voltage is present at the connections at point 2 or 8 when the appropriate trim button is pressed, the relays are okay.<br>3. Check if voltage is present at point 3 or 4 when the appropriate trim button is pressed. If voltage is not present, check for an open connection or a cut wire.<br>4. If voltage is present at point 3 or 4 when the appropriate trim button is pressed, replace the trim pump motor. |
| Trim system operates (trim motor runs) without pressing the trim switch at the helm or the cowl trim switch. | The trim switch at the helm or the cowl trim switch is shorted. | Disconnect each trim switch. If the trim motor stops running when either trim switch is disconnected, replace the trim switch. |

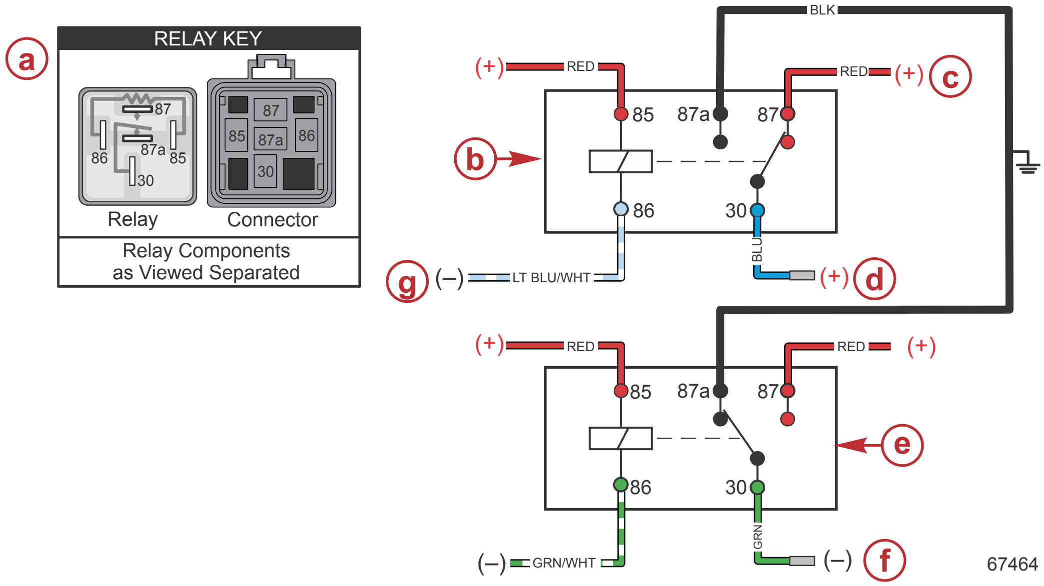
# Trim Circuit

When the trim relays are de-energized, contacts 30 and 87a of both relays complete the circuit to the trim motor leads. Both trim motor leads are to ground.

## Trim Up Circuit

When contact 86 of the trim up relay is energized from the trim switch, the trim up relay is energized. Contacts 30 and 87 of the trim up relay close, completing the circuit to 12 volts (+) to the blue trim motor lead. The trim down relay remains de-energized. The trim motor tilts the engine up.

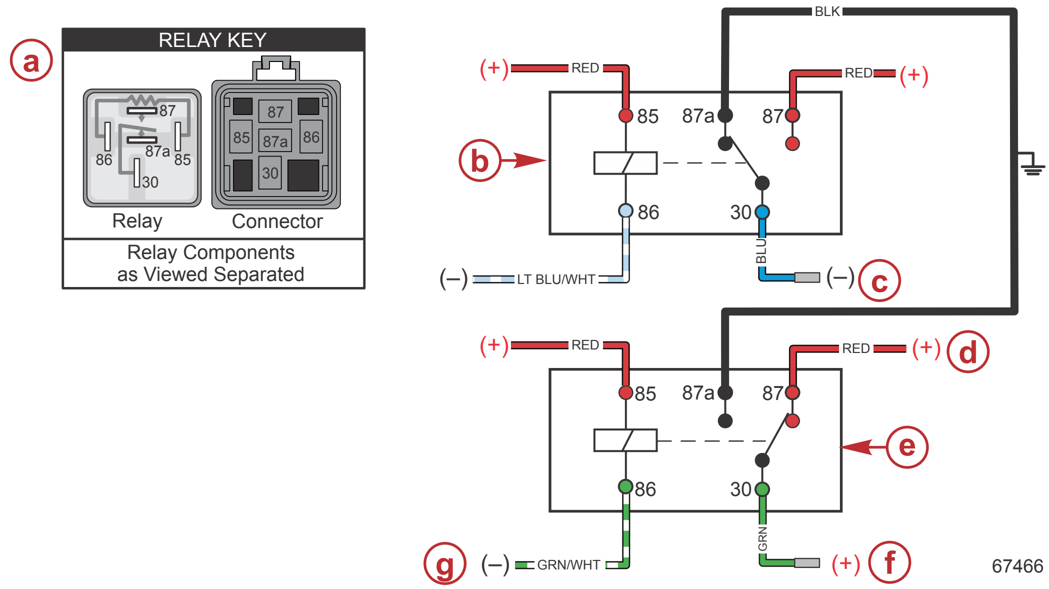



**Trim up circuit**

- **a -** Trim relay contacts
- **b -** Trim up relay
- **c -** 12 volts (+)
- **d -** To trim motor (+)
- **e -** Trim down relay
- **f -** To trim motor (–)
- **g -** From PCM

## Trim Down Circuit

When contact 86 of the trim down relay is energized from the trim switch, the trim down relay is energized. Contacts 30 and 87 of the trim down relay close, completing the circuit to 12 volts (+) to the green trim motor lead. The trim up relay remains de-energized. The trim motor tilts the engine down.



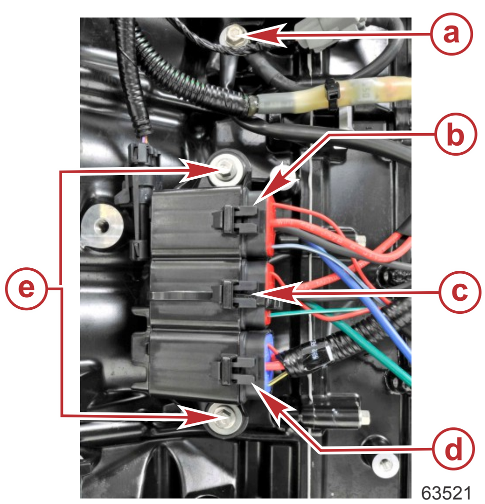

Trim down circuit

- a - Trim relay contacts
- b - Trim up relay
- c - To trim motor (–)
- d - 12 volts (+)
- e - Trim down relay
- f - To trim motor (+)
- g - From PCM

# Power Trim Relay Test

**IMPORTANT: The starboard intake plenum must be removed to access the power trim relays. Refer to the appropriate service manual for instructions.**

**IMPORTANT: To remove the power trim relays, press the relay lock tab with your finger and pull the relay out of the bracket. Do not pull with the wires.**




- a - Trim relay ground wire screw
- b - Trim up relay
- c - Trim down relay
- d - Main power relay
- e - Relay bracket screws

The trim motor relay system, used on permanent magnet trim systems, connects each of the two wires from the trim motor to either ground or positive to allow the motor to run in both directions.

If the motor will not run in the up direction, it may be either the up relay is not making contact to 12 volts or the down relay is not making contact to ground. The opposite is true if the system will not run down. When the system is not energized, both relays should connect the heavy trim motor leads to ground.

To test which relay is faulty if the trim system does not operate in one direction:

1. Remove the starboard intake plenum. Refer to the appropriate service manual for instructions.
2. Remove the relay from the bracket.
3. Partially remove the relay from the connector just far enough to reach the electrical contacts with the voltmeter lead.
4. Check for continuity between the heavy leads from the trim relays to ground.

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

| Meter Test Leads | | Meter Scale | Reading (Ω) |
|---|---|---|---|
| **Red** | **Black** | | |
| Green | Ground | Full continuity (R x 1) or Auto | < 0.5 Ω |
| Blue | Ground | Full continuity (R x 1) or Auto | < 0.5 Ω |

5. Replace the relay that does not have continuity.
6. Connect a voltmeter to the heavy blue lead and to ground. There should be 12 volts on the blue lead when the up switch is pushed and 12 volts on the green lead when the down switch is pushed. Replace the relay that does not switch the lead to positive.
7. Install the starboard intake plenum. Refer to the appropriate service manual for instructions.

# Trim Position Sensor Troubleshooting

## Trim Position Sensor

The trim position sensor (TPS) is located on the port side of the outboard. It supplies the propulsion control module (PCM) with trim position information. The PCM will generate and store a failure code when the TPS fails, and the alarm horn will sound. The trim position sensor affects trim functions controlled by the helm trim switch and the cowl tilt switch.

With the engine running below 2000 RPM, the outboard can be tilted to any position in the trim range or the trailer range. If above 2000 RPM, the trim range will be limited to prevent the outboard from reaching the trailer range. However, if you are loading the boat onto the trailer for example, and tilt the outboard up into the trailer range while below 2000 RPM, the throttle can be advanced to a maximum of 4400 RPM.

The following are some of the problems encountered with a faulty trim position sensor:

- Engine will trim higher than the set trim limit at speeds above 2000 RPM
- Engine trims past the maximum trailer limits
- Engine trims normally, but there are no trailer limits

## Troubleshooting the Trim Position Circuit

Monitor the trim position sensor analog-to-digital counts (ADC) with CDS G3. Verify wiring harness integrity with a DMT 2004 digital multimeter or equivalent.

| | |
|---|---|
| CDS G3 Interface Kit | 8M0138392 |
| DMT 2004 Digital Multimeter | 91-892647A01 |

| Step | Test Procedure | Test Result |
|---|---|---|
| **Step 1**: Check trim position sensor using the trim gauge. | 1. Turn key to the ON position.<br>2. Trim the engine up and down.<br>3. Observe the trim position gauge on the instrument panel. | Trim position gauge varies with engine trim position:<br>• Trim position sensor is good.<br>• Go to Step 2.<br>Trim position gauge does not vary with engine trim position:<br>• Go to Step 2. |
| **Step 2**: Check trim position sensor using CDS G3. | 1. Turn key to the OFF position.<br>2. Connect the CDS G3 to the engine.<br>3. Turn key to the ON position.<br>4. Observe the trim position sensor counts on the CDS G3.<br>5. Trim the engine up and down. | Count increases as engine trims up and decreases as engine trims down:<br>• Trim position sensor is good.<br>Count does not vary with engine trim position:<br>• Go to Step 3. |
| **Step 3**: Check sensor voltage. | 1. Turn key to the OFF position.<br>2. Connect the trim position sensor connector.<br>3. Turn key to the ON position.<br>4. Check the sensor power between purple/black and black/green wires. | Voltage measured is 4.0–5.0 VDC:<br>• Go to Step 4.<br>Voltage measured is out of specified range:<br>• Monitor the 5 V reference at the PCM with CDS G3. If reference voltage is OK, inspect the PCM harness for opens or shorts. Repair or replace as necessary.<br>• If the 5 V reference at the PCM is not present or is out of range, PCM replacement may be necessary. |
| **Step 4**: Inspect the magnet in the trim rod eye pin. | 1. Remove the trim position sensor.<br>2. Inspect the magnet in the trim rod eye pin. If the magnet is corroded, damaged, or missing, there will not be a normal trim signal. | Magnet is present and not damaged or corroded:<br>• Go to Step 5.<br>Magnet is missing, damaged, or corroded:<br>1. Replace the trim rod eye pin and magnet and install the trim position sensor.<br>2. Tilt the engine and monitor the trim position. If the trim position indicated does not change while tilting the engine, go to Step 5. |
| **Step 5**: Check PCM harness for open or short circuit. | 1. Turn key to the OFF position.<br>2. Disconnect the CDS G3 from the engine.<br>3. Disconnect the trim position sensor connector. Refer to **Trim Position Sensor Location,** following.<br>4. Check the resistance from the TPS connector to the PCM harness connector pins (PCM harness side):<br>a. PCM C, pin E3 to black/green wire.<br>b. PCM B, pin C2 to yellow wire.<br>c. PCM C, pin E4 to purple/black wire. | Resistance measured is less than 0.8 ohms:<br>• Replace trim position sensor.<br>Resistance measured is greater than 0.8 ohms:<br>• PCM harness may be faulty. |

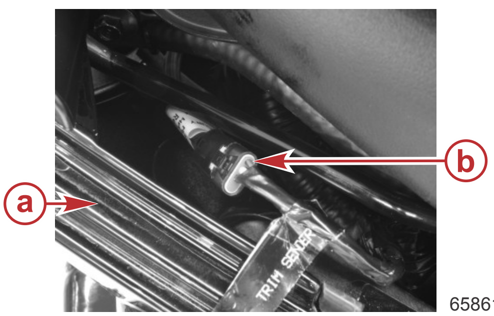
  

## Trim Position Sensor Location


63439

Conventional Midsection (CMS)

- **a -** Screw
- **b -** Screws (2)
- **c -** Trim position sensor
- **d -** Tilt lock lever




65861

Trim position sensor connector

- **a -** Port lower cowl
- **b -** Trim position sensor connector

## Testing the Trim Position Sensor Circuit with DMT 2004A

The trim position sensor requires a 5 volt reference signal from the PCM.

Check for reference signal voltage with the ignition switch in the RUN position and using an appropriate probe (paper clip, etc.) inserted at the trim position sensor harness connector.

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

| Meter Test Leads | | Meter Scale | Reading |
|---|---|---|---|
| Red | Black | | |
| Purple/black | Black/green | VDC | 5.0 ± 0.1 |

If voltage is not as indicated or voltage is erratic, inspect the sensor wiring and connections.

**IMPORTANT: The 5 volt reference at the PCM can be monitored by the CDS G3. Voltage should be 5.0 VDC ± 0.1 VDC. Any other voltage indicates a defective PCM. If the PCM reference voltage is correct, but voltage at the trim sensor is low or nonexistent, inspect the sensor wiring and connections.**

Check the resistance of the trim position sensor circuit harness and PCM.

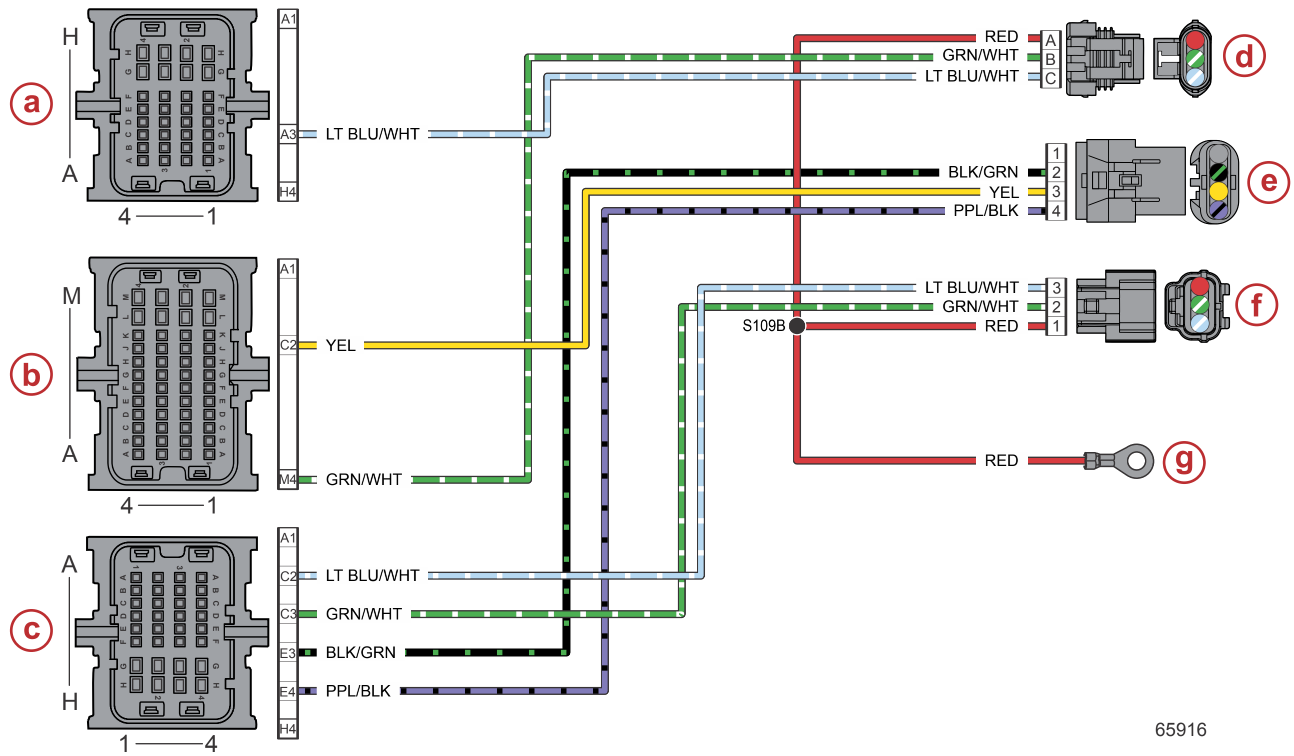
| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

| Meter Test Leads | | Meter Scale | Reading |
|---|---|---|---|
| Red | Black | | |
| Yellow | Black/green | Ohms | 210 kΩ ± 20% |

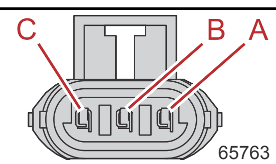
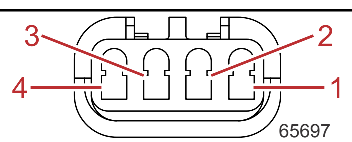
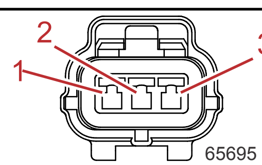
  

If the resistance is not as indicated, inspect the sensor wiring and connections.

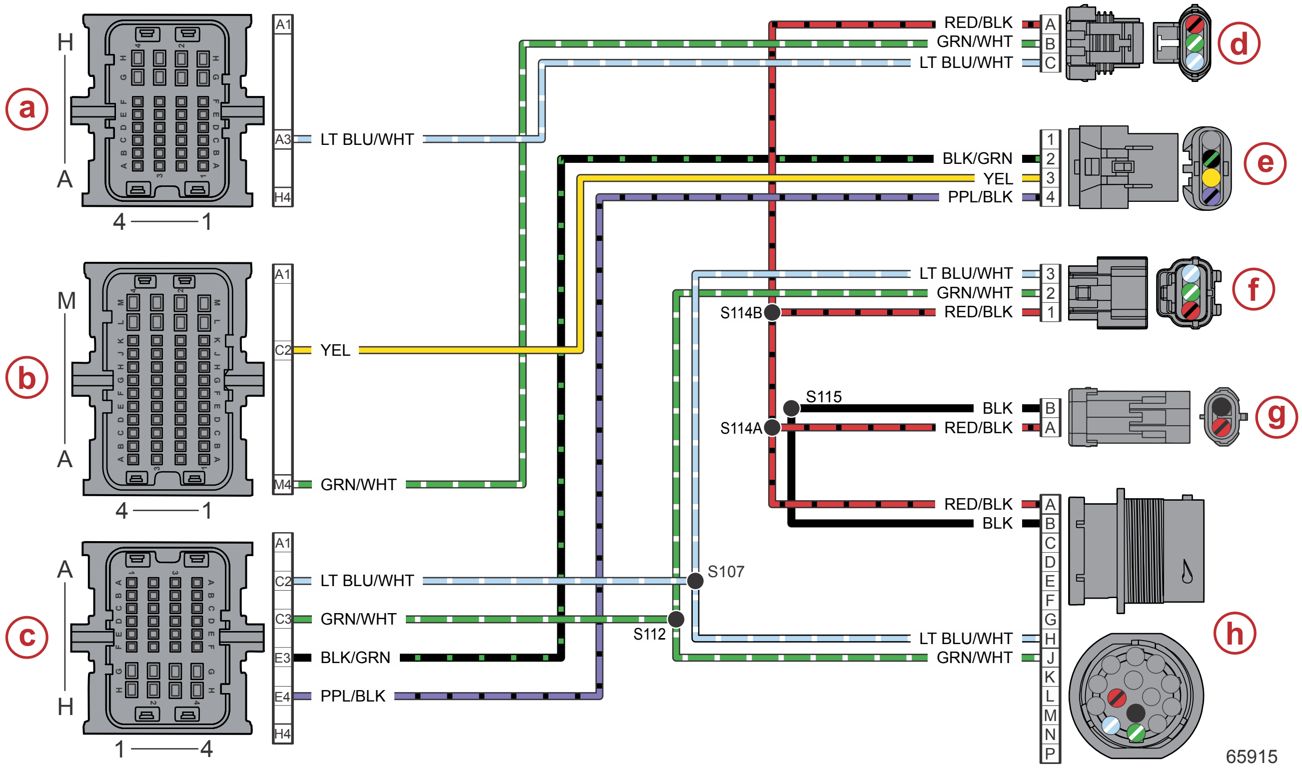
# Trim Switches and Sensor - DTS



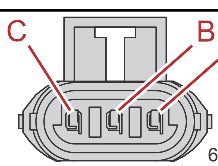
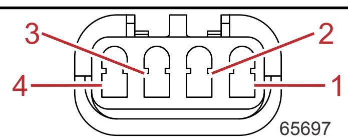
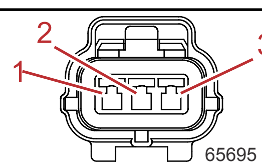

**a -** PCM connector A
**b -** PCM connector B
**c -** PCM connector C
**d -** Trim harness connector
**e -** Trim position sensor connector
**f -** Cowl tilt switch connector
**g -** Hot stud (battery +)

| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|   | A | Red | 12 V battery power (+) | – |
| | B | Green/white | Trim down relay control | BM4 |
| | C | Light blue/white | Trim up relay control | AA3 |
|   | 1 | N/A | Not used | – |
| | 2 | Black/green | Sensor ground C (–) | CE3 |
| | 3 | Yellow | Trim position sensor signal | BC2 |
| | 4 | Purple/black | Sensor power C (+) | CE4 |
|   | 1 | Red | 12 V battery power (+) | – |
| | 2 | Green/white | Trim down (from switch) | CC3 |
| | 3 | Light blue/white | Trim up (from switch) | CC2 |

# Trim Switches and Sensor - Mechanical




- **a -** PCM connector A
- **b -** PCM connector B
- **c -** PCM connector C
- **d -** Trim harness connector
- **e -** Trim position sensor connector
- **f -** Cowl tilt switch connector
- **g -** Clean power harness connector
- **h -** 14-pin data harness connector

| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|   | A | Red/black | 12 V clean power (+) | * |
| | B | Green/white | Trim down relay control | BM4 |
| | C | Light blue/white | Trim up relay control | AA3 |
|   | 1 | N/A | Not used | – |
| | 2 | Black/green | Sensor ground C (–) | CE3 |
| | 3 | Yellow | Trim position sensor signal | BC2 |
| | 4 | Purple/black | Sensor power C (+) | CE4 |
|   | 1 | Red/black | 12 V clean power (+) | * |
| | 2 | Green/white | Trim down (from switch) | CC3 |
| | 3 | Light blue/white | Trim up (from switch) | CC2 |
| Clean power harness | B | Black | Clean power ground (–) | – |
| **Clean power is in input to the PCM at pin CA4, not shown.* | | | | |

# Electrical Systems

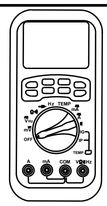
## Section 6D - Advanced Midsection (AMS) Power Trim

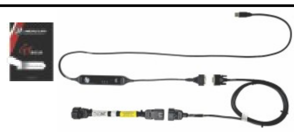
## Table of Contents



6
D

# Special Tools

| DMT 2004 Digital Multimeter | 91-892647A01 |
|---|---|
|  4516 | Measures RPM on spark ignition (SI) engines, ohms, amperes, AC and DC voltages; records maximums and minimums simultaneously, and accurately reads in high RFI environments. |

| CDS G3 Interface Kit | 8M0138392 |
|---|---|
|  66165 | CDS G3 License Key, Interface, Adapter, and Harness |

# Electrical System Troubleshooting

## General Checks

Before troubleshooting the power trim electrical system, check for the following:

- Disconnected wires
- Battery is fully charged
- Battery cable connections are tight and corrosion-free
- Battery cables are secured with hex nuts, not wing nuts
- Connections are tight and corrosion-free
- Plug-in connections are fully engaged
- Clean power is connected

## Condition/Problem

| Condition of Trim System | Problem No. |
|---|---|
| Trim motor does not run when trim button is depressed | 1, 2, 4, 5, 6, 7 |
| Trim system trims opposite of buttons | 3 |
| Cowl-mounted trim buttons do not activate trim system | 2, 4, 5, 6 |

## Problem/Solution

| No. | Problem | Solution |
|---|---|---|
| 1. | Battery low or discharged | Check the battery. |
| 2. | Open circuit in trim wiring | Check for an open connection. |
| 3. | Wiring reversed in remote control, cowl switch, or trim leads | Verify connections. |
| 4. | Wire harness corroded through | Replace wire harness. |
| 5. | Internal motor problem (brushes, shorted armature) | Check for an open connection. Test and replace the power trim motor if necessary. |
| 6. | Trim switch failure | Replace the switch. |
| 7. | Relay not operating | Verify relays are functioning correctly. Check voltage at the power trim bullet connectors. |

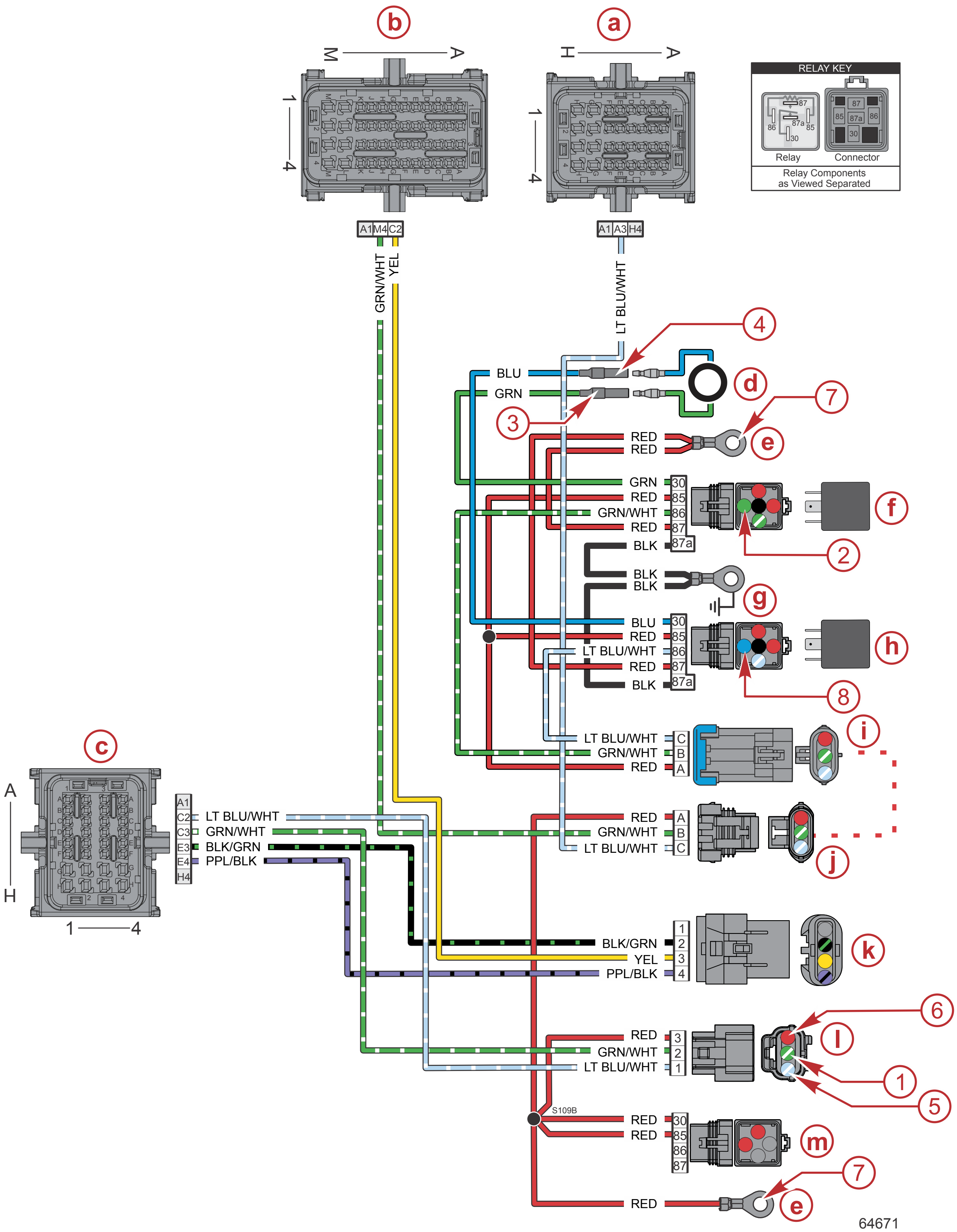
## Power Trim Electrical Circuit

IMPORTANT: Numerical callouts shown in the circuit diagrams are test points. Refer to **Troubleshooting the Down Circuit** or **Troubleshooting the Up Circuit.**

# Notes:

## DTS Power Trim Wiring Diagram



DTS Power Trim Wiring Diagram

a - PCM connector A
b - PCM connector B
c - PCM connector C
d - Power trim motor
e - +12 volts power
f - Down relay
g - –12 volts ground
h - Up relay
i - Power trim harness connector
j - Power trim harness connector—PCM side
k - Trim position sensor connector
l - Cowl tilt switch
m - Main power relay

IMPORTANT: Numerical callouts shown in the circuit diagrams are test points. Refer to **Troubleshooting the Down Circuit** or **Troubleshooting the Up Circuit**.

## Troubleshooting the Down Circuit

IMPORTANT: Refer to the preceding wiring diagram for connection points when troubleshooting the electrical systems. Connection points are specified by number.

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

IMPORTANT: Perform the following tests with the engine off and the 14-pin connector disconnected from the outboard. This will isolate the outboard from the boat. If the engine tilts when using the cowl trim switch, the problem is related to the trim switch at the helm.

*NOTE: To access test points 2 and 8, partially remove the relay from the connector just far enough to reach the electrical contacts with the voltmeter lead.*

| Step | Test Procedure | Test Result |
|---|---|---|
| **Step 1**: Check for battery voltage at Point 1 by back probing. | 1. Connect the voltmeter black lead to ground and the red lead to Point 1.<br>2. Depress the down trim button. | Battery voltage measured:<br>• Go to Step 2.<br>No battery voltage measured:<br>• Go to Step 3. |
| **Step 2**: Check for battery voltage at Point 2. | 1. Connect the voltmeter black lead to ground and the red lead to Point 2.<br>2. Depress the down trim button. | Battery voltage measured:<br>• Go to Step 5.<br>No battery voltage measured:<br>• There is an open circuit between Point 2 and the PCM.<br>• Check for loose or corroded connections.<br>• Inspect the wiring harness for opens, shorts, or damage. Repair or replace the harness. |
| **Step 3**: Check for continuity between Point 1 and Point 5. | 1. Disconnect the 3-pin connector.<br>2. Connect the voltmeter black lead to Point 1 and the red lead to Point 5. | Continuity measured (resistance should be 5.6 kΩ ± 20%):<br>• Harness and PCM are OK.<br>• Go to Step 4.<br>No continuity measured (resistance should be 5.6 kΩ ± 20%):<br>• Inspect the wiring harness for opens, shorts, or damage. Repair or replace the harness. |
| **Step 4**: Check for battery voltage at Point 6. | 1. Connect the voltmeter red lead to Point 6 and black lead to ground. | Battery voltage measured:<br>• Trim switch is faulty.<br>No battery voltage measured:<br>• Check for loose or corroded wire at Point 6.<br>• Open circuit in wire supplying current between Point 6 and Point 7. |
| **Step 5**: Check for battery voltage at Point 3. | 1. Connect the voltmeter red lead to Point 3 (female bullet connector) and black lead to ground.<br>2. Depress the down trim button. | Battery voltage measured:<br>• Go to Step 6.<br>No battery voltage measured:<br>• Relay is defective. |

| Step | Test Procedure | Test Result |
|---|---|---|
| **Step 6**: Check the up relay. | 1. Connect the voltmeter red lead to Point 4 (female bullet connector) and black lead to ground.<br>2. Depress the up trim button. | Relay is good (battery voltage measured):<br>• Pump motor wiring is defective.<br>• Pump motor is defective.<br>Relay is faulty (no battery voltage measured):<br>• Replace relay. |

## Troubleshooting the Up Circuit

IMPORTANT: Refer to the preceding wiring diagram for connection points when troubleshooting the electrical systems. Connection points are specified by number.

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

IMPORTANT: Perform the following tests with the engine off and the 14-pin connector disconnected from the outboard. This will isolate the outboard from the boat. If the engine tilts when using the cowl trim switch, the problem is related to the trim switch at the helm.

*NOTE: To access test points 2 and 8, partially remove the relay from the connector just far enough to reach the electrical contacts with the voltmeter lead.*

| Step | Test Procedure | Test Result |
|---|---|---|
| **Step 1**: Check for battery voltage at Point 5 by back probing. | 1. Connect the voltmeter black lead to ground and the red lead to Point 5.<br>2. Depress the up trim button. | Battery voltage measured:<br>• Go to Step 2.<br>No battery voltage measured:<br>• Go to Step 3. |
| **Step 2**: Check for battery voltage at Point 8. | 1. Connect the voltmeter black lead to ground and the red lead to Point 8.<br>2. Depress the up trim button. | Battery voltage measured:<br>• Go to Step 5.<br>No battery voltage measured:<br>• There is an open circuit between Point 8 and the PCM.<br>• Check for loose or corroded connections.<br>• Inspect the wiring harness for opens, shorts, or damage. Repair or replace the harness. |
| **Step 3**: Check for continuity between Point 1 and Point 5. | 1. Disconnect the 3-pin connector.<br>2. Connect the voltmeter black lead to Point 1 and the red lead to Point 5. | Continuity measured (resistance should be 5.6 kΩ ± 20%):<br>• Harness and PCM are OK.<br>• Go to Step 4.<br>No continuity measured (resistance should be 5.6 kΩ ± 20%):<br>• Inspect the wiring harness for opens, shorts, or damage. Repair or replace the harness. |
| **Step 4**: Check for battery voltage at Point 6. | 1. Connect the voltmeter red lead to Point 6 and black lead to ground. | Battery voltage measured:<br>• Trim switch is faulty.<br>No battery voltage measured:<br>• Check for loose or corroded wire at Point 6.<br>• Open circuit in wire supplying current between Point 6 and Point 7. |
| **Step 5**: Check for battery voltage at Point 4. | 1. Connect the voltmeter red lead to Point 4 (female bullet connector) and black lead to ground.<br>2. Depress the up trim button. | Battery voltage measured:<br>• Go to Step 6.<br>No battery voltage measured:<br>• Relay is defective. |
| **Step 6**: Check the down relay. | 1. Connect the voltmeter red lead to Point 3 (female bullet connector) and black lead to ground.<br>2. Depress the down trim button. | Relay is good (battery voltage measured):<br>• Pump motor wiring is defective.<br>• Pump motor is defective.<br>Relay is faulty (no battery voltage measured):<br>• Replace relay. |

## Troubleshooting the Down and Up Circuits (All Circuits Inoperative)

IMPORTANT: Numerical callouts shown in the circuit diagrams are test points. Refer to **Troubleshooting the Down Circuit** or **Troubleshooting the Up Circuit.**

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

| Problem | Possible Cause | Remedy |
|---|---|---|
| The up and down trim switches are both inoperative, but the cowl switch does operate. | 1. Faulty trim switch.<br>2. A wire is open between the trim pump motor and the trim switch. | 1. Replace the trim switch.<br>2. Check for a loose or corroded connection. |
| Trim switch and cowl switch are both inoperative. | 1. One of the trim pump motor wires is open between the motor and the relays.<br>2. A wire is open between the trim pump motor and the trim switch.<br>3. Faulty trim relay.<br>4. Faulty trim pump motor. | 1. Check the wire connections at point 2 or 8 for loose or corroded condition.<br>2. If voltage is present at the connections at point 2 or 8 when the appropriate trim button is pressed, the relays are okay.<br>3. Check if voltage is present at point 3 or 4 when the appropriate trim button is pressed. If voltage is not present, check for an open connection or a cut wire.<br>4. If voltage is present at point 3 or 4 when the appropriate trim button is pressed, replace the trim pump motor. |
| Trim system operates (trim motor runs) without pressing the trim switch at the helm or the cowl trim switch. | The trim switch at the helm or the cowl trim switch is shorted. | Disconnect each trim switch. If the trim motor stops running when either trim switch is disconnected, replace the trim switch. |

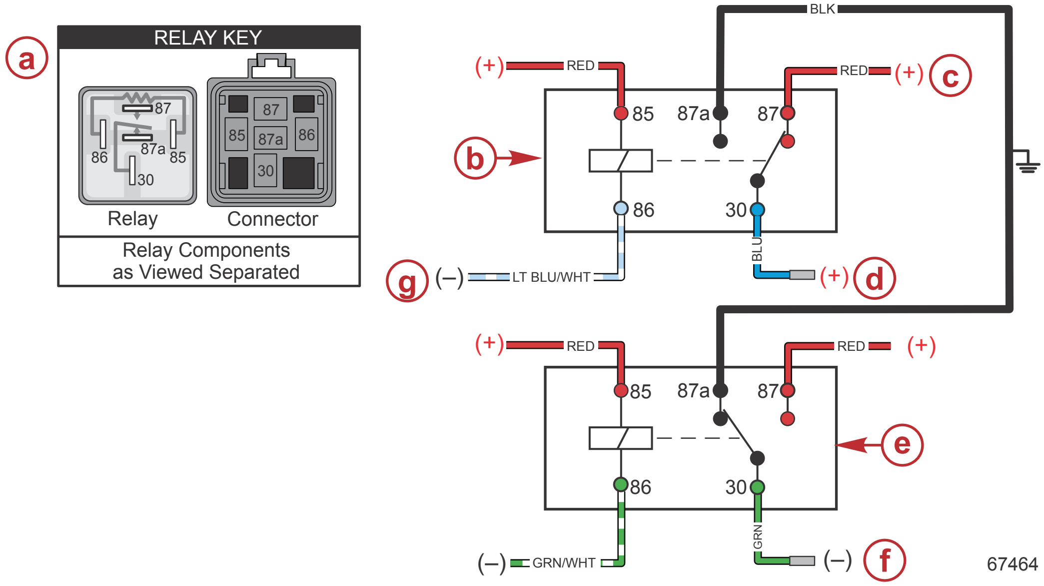
# Trim Circuit

When the trim relays are de-energized, contacts 30 and 87a of both relays complete the circuit to the trim motor leads. Both trim motor leads are to ground.

## Trim Up Circuit

When contact 86 of the trim up relay is energized from the trim switch, the trim up relay is energized. Contacts 30 and 87 of the trim up relay close, completing the circuit to 12 volts (+) to the blue trim motor lead. The trim down relay remains de-energized. The trim motor tilts the engine up.

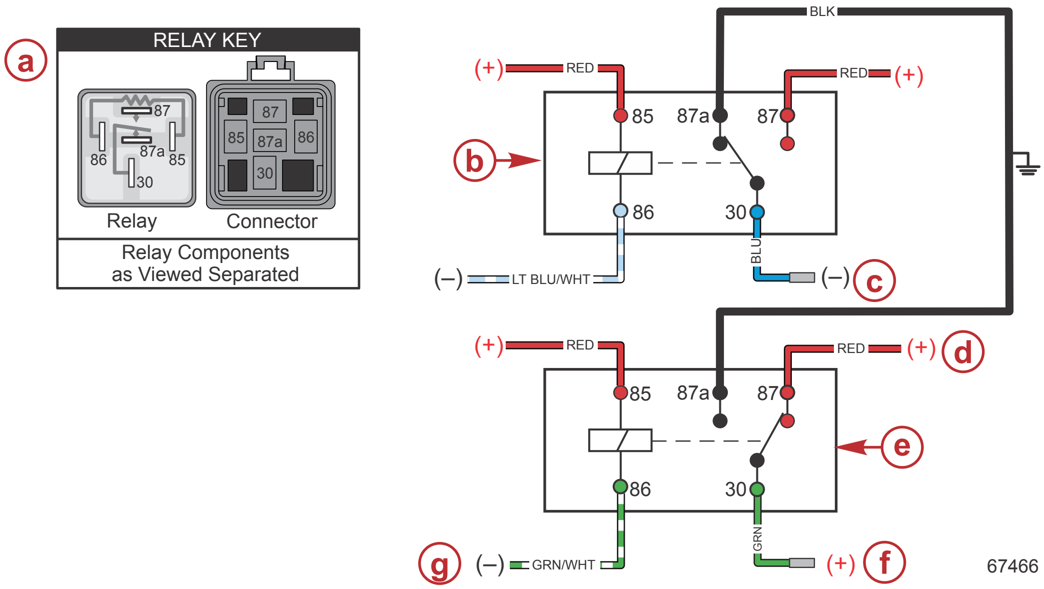



**Trim up circuit**

- a - Trim relay contacts
- b - Trim up relay
- c - 12 volts (+)
- d - To trim motor (+)
- e - Trim down relay
- f - To trim motor (–)
- g - From PCM

## Trim Down Circuit

When contact 86 of the trim down relay is energized from the trim switch, the trim down relay is energized. Contacts 30 and 87 of the trim down relay close, completing the circuit to 12 volts (+) to the green trim motor lead. The trim up relay remains de-energized. The trim motor tilts the engine down.




67466

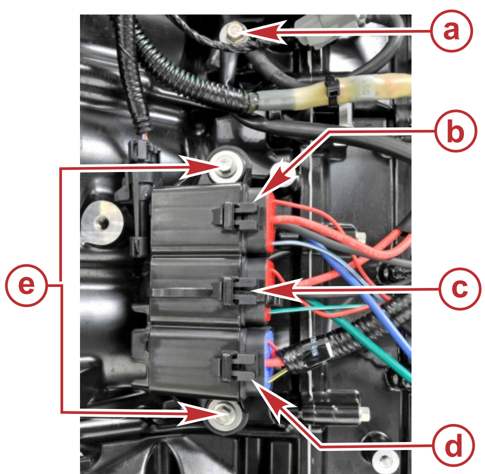
Trim down circuit

- **a -** Trim relay contacts
- **b -** Trim up relay
- **c -** To trim motor (–)
- **d -** 12 volts (+)
- **e -** Trim down relay
- **f -** To trim motor (+)
- **g -** From PCM

# Power Trim Relay Test

**IMPORTANT: The starboard intake plenum must be removed to access the power trim relays. Refer to the appropriate service manual for instructions.**

**IMPORTANT: To remove the power trim relays, press the relay lock tab with your finger and pull the relay out of the bracket. Do not pull with the wires.**




63521

- **a -** Trim relay ground wire screw
- **b -** Trim up relay
- **c -** Trim down relay
- **d -** Main power relay
- **e -** Relay bracket screws

The trim motor relay system, used on permanent magnet trim systems, connects each of the two wires from the trim motor to either ground or positive to allow the motor to run in both directions.

If the motor will not run in the up direction, it may be either the up relay is not making contact to 12 volts or the down relay is not making contact to ground. The opposite is true if the system will not run down. When the system is not energized, both relays should connect the heavy trim motor leads to ground.

To test which relay is faulty if the trim system does not operate in one direction:

1. Remove the starboard intake plenum. Refer to the appropriate service manual for instructions.
2. Remove the relay from the bracket.
3. Partially remove the relay from the connector just far enough to reach the electrical contacts with the voltmeter lead.
4. Check for continuity between the heavy leads from the trim relays to ground.

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

| Meter Test Leads | | Meter Scale | Reading (Ω) |
|---|---|---|---|
| **Red** | **Black** | | |
| Green | Ground | Full continuity (R x 1) or Auto | < 0.5 Ω |
| Blue | Ground | Full continuity (R x 1) or Auto | < 0.5 Ω |

5. Replace the relay that does not have continuity.
6. Connect a voltmeter to the heavy blue lead and to ground. There should be 12 volts on the blue lead when the up switch is pushed and 12 volts on the green lead when the down switch is pushed. Replace the relay that does not switch the lead to positive.
7. Install the starboard intake plenum. Refer to the appropriate service manual for instructions.

# Trim Position Sensor Troubleshooting

## Trim Position Sensor

The trim position sensor (TPS) is located on the bottom of the mount cradle. It supplies the propulsion control module (PCM) with trim position information. The PCM will generate and store a failure code when the TPS fails, and the alarm horn will sound. The trim position sensor affects trim functions controlled by the helm trim switch and the cowl tilt switch.

With the engine running below 2000 RPM, the outboard can be tilted to any position in the trim range or the trailer range. If above 2000 RPM, the trim range will be limited to prevent the outboard from reaching the trailer range. However, if you are loading the boat onto the trailer for example, and tilt the outboard up into the trailer range while below 2000 RPM, the throttle can be advanced to a maximum of 4400 RPM.

The following are some of the problems encountered with a faulty trim position sensor:

- Engine will trim higher than the set trim limit at speeds above 2000 RPM
- Engine trims past the maximum trailer limits
- Engine trims normally, but there are no trailer limits

## Troubleshooting the Trim Position Circuit

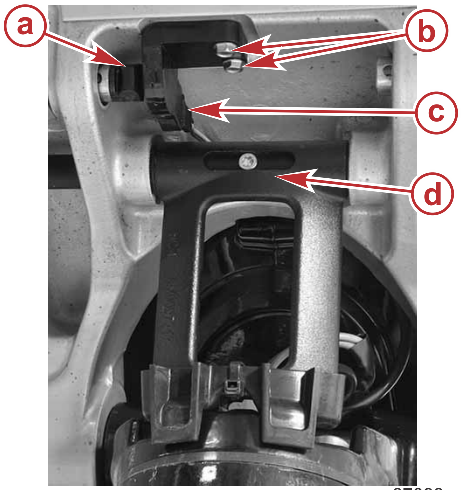
Monitor the trim position sensor analog-to-digital counts (ADC) with the CDS G3. Verify wiring harness integrity with a DMT 2004 digital multimeter or equivalent.

| | |
|---|---|
| CDS G3 Interface Kit | 8M0138392 |
| DMT 2004 Digital Multimeter | 91-892647A01 |

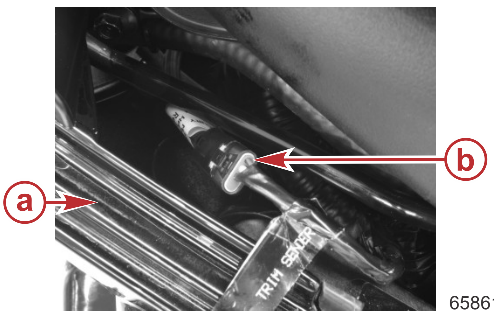
| Step | Test Procedure | Test Result |
| --- | --- | --- |
| **Step 1**: Check trim position sensor using the trim gauge. | 1. Turn key to the ON position.<br>2. Trim the engine up and down.<br>3. Observe the trim position gauge on the instrument panel. | Trim position gauge varies with engine trim position:<br>• Trim position sensor is good.<br>• Go to Step 2.<br>Trim position gauge does not vary with engine trim position:<br>• Go to Step 2. |
| **Step 2**: Check trim position sensor using CDS G3. | 1. Turn key to the OFF position.<br>2. Connect the CDS G3 to the engine.<br>3. Turn key to the ON position.<br>4. Observe the trim position sensor counts on the CDS G3.<br>5. Trim the engine up and down. | Count increases as engine trims up and decreases as engine trims down:<br>• Trim position sensor is good.<br>Count does not vary with engine trim position:<br>• Go to Step 3. |
| **Step 3**: Check sensor voltage. | 1. Turn key to the OFF position.<br>2. Connect the trim position sensor connector.<br>3. Turn key to the ON position.<br>4. Check the sensor power between purple/black and black/green wires. | Voltage measured is 4.0–5.0 VDC:<br>• Go to Step 4.<br>Voltage measured is out of specified range:<br>• Monitor the 5 volt reference at the PCM with CDS G3. If reference voltage is OK, inspect the PCM harness for opens or shorts. Repair or replace as necessary.<br>• If the 5 volt reference at the PCM is not present or is out of range, PCM replacement may be necessary. |
| **Step 4**: Inspect the magnet in the trim rod eye pin. | 1. Remove the trim position sensor.<br>2. Inspect the magnet in the trim rod eye pin. If the magnet is corroded, damaged, or missing, there will not be a normal trim signal. | Magnet is present and not damaged or corroded:<br>• Go to Step 5.<br>Magnet is missing, damaged, or corroded:<br>1. Replace the trim rod eye pin and magnet and install the trim position sensor.<br>2. Tilt the engine and monitor the trim position. If the trim position indicated does not change while tilting the engine, go to Step 5. |
| **Step 5**: Check PCM harness for open or short circuit. | 1. Turn key to the OFF position.<br>2. Disconnect the CDS G3 from the engine.<br>3. Disconnect the trim position sensor connector. Refer to **Trim Position Sensor Location,** following.<br>4. Check the resistance from the TPS connector to the PCM harness connector pins (PCM harness side):<br>a. PCM C, pin E3 to black/green wire.<br>b. PCM B, pin C2 to yellow wire.<br>c. PCM C, pin E4 to purple/black wire. | Resistance measured is less than 0.8 ohms:<br>• Replace trim position sensor.<br>Resistance measured is greater than 0.8 ohms:<br>• PCM harness may be faulty. |

## Trim Position Sensor Location




67093

- a - Trim position sensor magnet
- b - Screws (2)
- c - Trim position sensor
- d - Tilt lock bracket




65861

Port side of outboard
- a - Port lower cowl
- b - Trim position sensor connector

## Testing the Trim Position Sensor with DMT 2004A

The trim sensor requires a 5 volt reference signal from the PCM.

Check for reference signal voltage with the ignition switch in the run position and using an appropriate probe (paper clip, etc.) inserted in parallel at the trim sensor connector.

| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

| Meter Test Leads | | Meter Scale | Reading |
|---|---|---|---|
| Red | Black | | |
| Purple/black | Black/green | VDC | 5.0 ± 0.1 |

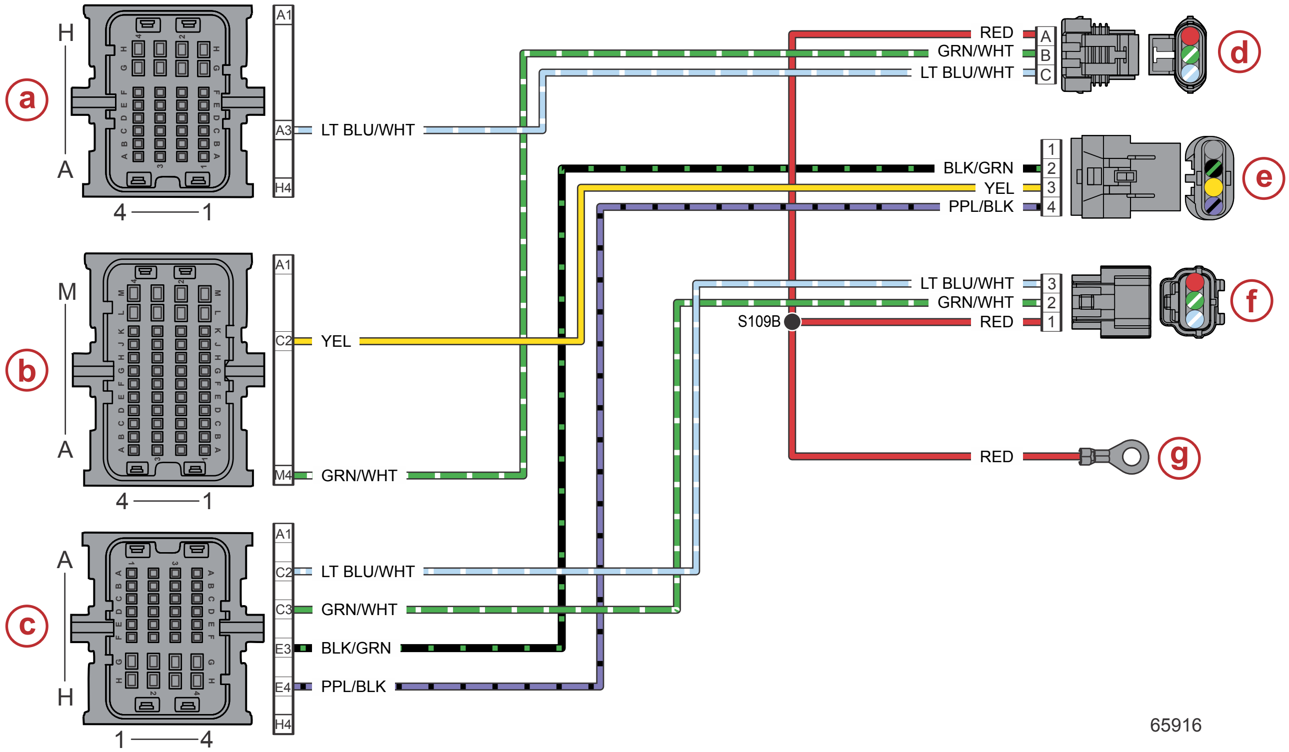
**IMPORTANT: The 5 volt reference at the PCM can be monitored by the CDS G3. Voltage should be 5 VDC ± 0.1 VDC. Any other voltage indicates a defective PCM. If the PCM reference voltage is correct, but voltage at the trim sensor is low or nonexistent, inspect the sensor wiring and connections.**

Check the resistance of the trim position sensor circuit harness and PCM.

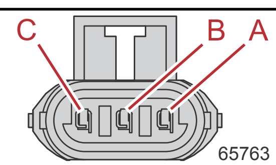
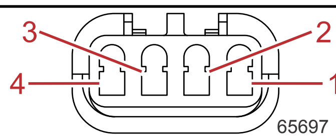
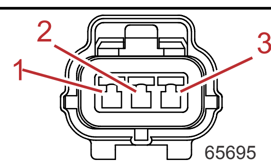
| | |
|---|---|
| DMT 2004 Digital Multimeter | 91-892647A01 |

| Meter Test Leads | | Meter Scale | Reading |
|---|---|---|---|
| Red | Black | | |
| Yellow | Black/green | Ohms | 210 kΩ ± 20% |

# Trim Switches and Sensor - DTS




- **a -** PCM connector A
- **b -** PCM connector B
- **c -** PCM connector C
- **d -** Trim harness connector
- **e -** Trim position sensor connector
- **f -** Cowl tilt switch connector
- **g -** Hot stud (battery +)

| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|   | A | Red | 12 V battery power (+) | – |
| | B | Green/white | Trim down relay control | BM4 |
| | C | Light blue/white | Trim up relay control | AA3 |
|   | 1 | N/A | Not used | – |
| | 2 | Black/green | Sensor ground C (–) | CE3 |
| | 3 | Yellow | Trim position sensor signal | BC2 |
| | 4 | Purple/black | Sensor power C (+) | CE4 |
|   | 1 | Red | 12 V battery power (+) | – |
| | 2 | Green/white | Trim down (from switch) | CC3 |
| | 3 | Light blue/white | Trim up (from switch) | CC2 |

# Notes:

# Fuel System

## Section 7A - Fuel System

## Table of Contents





# Fuel System Specifications

| Fuel System Specifications | |
|---|---|
| Recommended fuel octane rating | 87 (R+M)/2, 91 RON |
| Approximate fuel pressure at idle | 290–340 kPa (42.1–43.9 psi) |
| Approximate fuel pressure engine not running | 340–370 kPa (49.3–53.7 psi) |
| Fuel filtration | |
| Inlet filter, engine mounted | 10 microns |
| Inlet filter, remote boat mounted | 10 microns |
| High-pressure, at fuel rail inlet | 46 microns |
| Fuel pump current draw | 12 A ± 2 A (at 14.4 V) |
| Maximum fuel system inlet vacuum | 10.16 kPa (3.0 in. Hg), (1.47 psi) |

# Fuel System Overview

## Theory of Operation

The sequential multiport fuel injection system uses an electronic propulsion control module (PCM) and multiple input sensors to maintain optimum injector volume (pulse width) and injection timing control.

Two fuel pumps are located inside a sealed, water-cooled, fuel supply module (FSM). The FSM contains a fuel lift pump, a high-pressure fuel pump, a fuel pressure regulator, and a fuel cooler. The FSM is mounted in front of the exhaust tube in the midsection of the engine. A reference hose on the intake manifold is connected to the fuel pressure regulator inside the FSM. Fuel is recirculated inside the FSM to regulate fuel rail pressure.

The PCM uses data collected from the manifold absolute pressure (MAP) sensor to determine the ambient barometric (BARO) pressure and monitor pressure changes inside the plenum. An intake air temperature (IAT) sensor, located on the starboard intake runner, sends air temperature data to the PCM. Engine speed and valve position are monitored by a crankshaft position sensor (CPS) and a camshaft position sensor. An O2 sensor is mounted in the exhaust manifold to help monitor fuel delivery and maintain the ideal fuel-to-air ratio at the desired emissions target.

Electronic throttle control (ETC) is modulated by the PCM. The PCM converts digital position signals from the ERC (DTS models) or throttle demand sensor (mechanical throttle and shift models) and positions the throttle plate accordingly. Two throttle position sensors (TPS) are used to ensure the accuracy of the throttle plate position. ETC also acts as an idle air control, increasing or decreasing the throttle plate opening as necessary to ensure optimum idle and performance characteristics.

## Fuel System

| ⚠ WARNING |
|---|
| **Fuel is flammable and explosive. Ensure that the key switch is off and the lanyard is positioned so that the engine cannot start. Do not smoke or allow sources of spark or open flame in the area while servicing. Keep the work area well ventilated and avoid prolonged exposure to vapors. Always check for leaks before attempting to start the engine, and wipe up any spilled fuel immediately.** |

**IMPORTANT: Use an approved container to collect and store fuel. Wipe up spilled fuel immediately. Material used to contain spilled fuel must be disposed of in an approved receptacle.**

Before servicing any part of the fuel system:

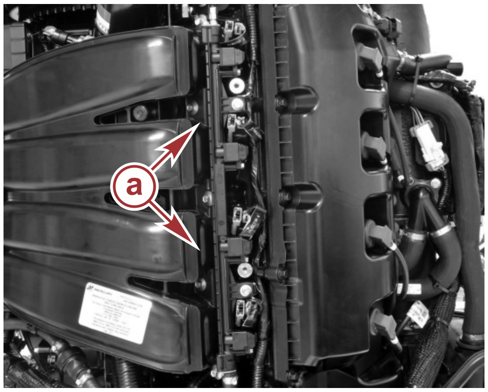
1. Stop engine and disconnect the battery.
2. Perform fuel system service in a well-ventilated area.
3. Inspect any completed service work for sign of fuel leakage.

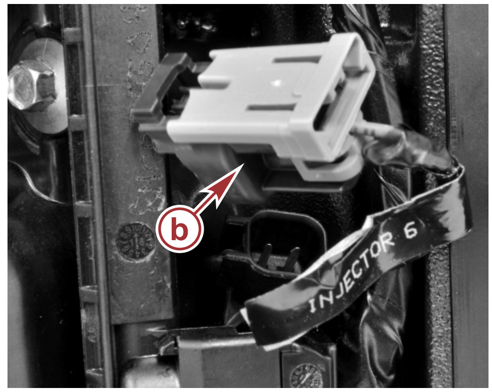
## Fuel Injector

The fuel injector is an electrically operated, spring-loaded solenoid that delivers a metered amount of fuel into the intake manifold runner just ahead of the intake valves. The fuel injector is electrically charged when the key switch is set to the RUN position. The PCM completes the ground circuit of the injector, activating the injector's solenoid and allowing the flow of high-pressure fuel into the combustion chamber. The PCM then opens the ground circuit, allowing the spring to close the injector and stop the fuel flow. There are two separate streams of fuel aimed at the intake valves, for better atomization of the fuel. The fuel injector is not serviceable.

The fuel injectors are not common to any other engine. Each fuel rail contains three fuel injectors on V6 models, or four fuel injectors on V8 models.



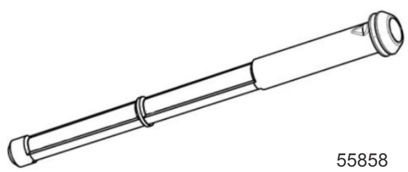




66273

**a -** Fuel rail
**b -** Fuel injector

## In-line Fuel Filter

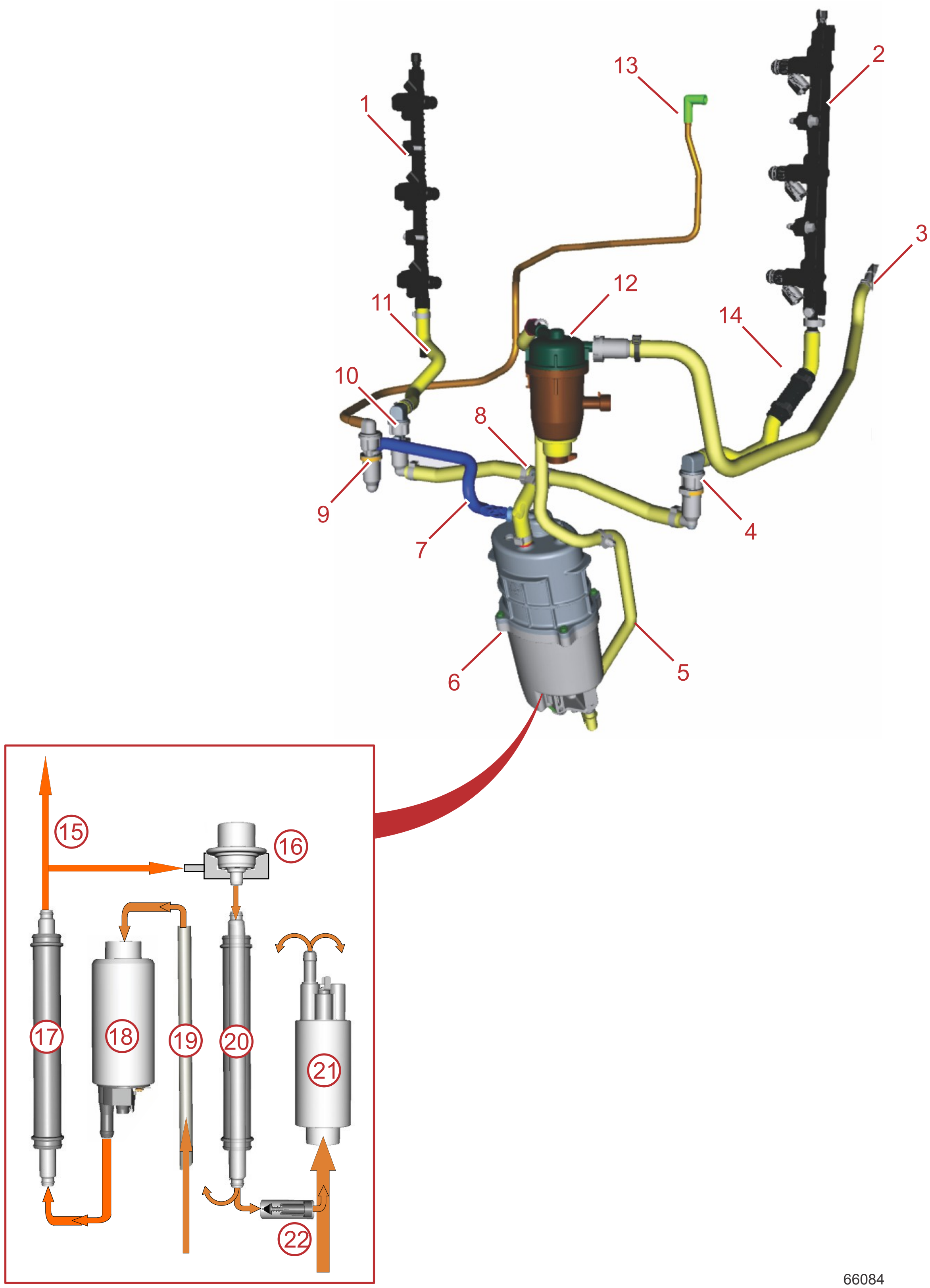
The in-line fuel filter is located inside the inlet end of each fuel rail. This in-line fuel filter consists of a one-way, reusable filter element. In the event of fuel contamination, the filter element can be cleaned by backflushing the element with a locally available fuel system cleaner. Replacement is not required unless the in-line fuel filter is damaged, punctured, or otherwise unsuitable for use.



55858

In-line fuel filter

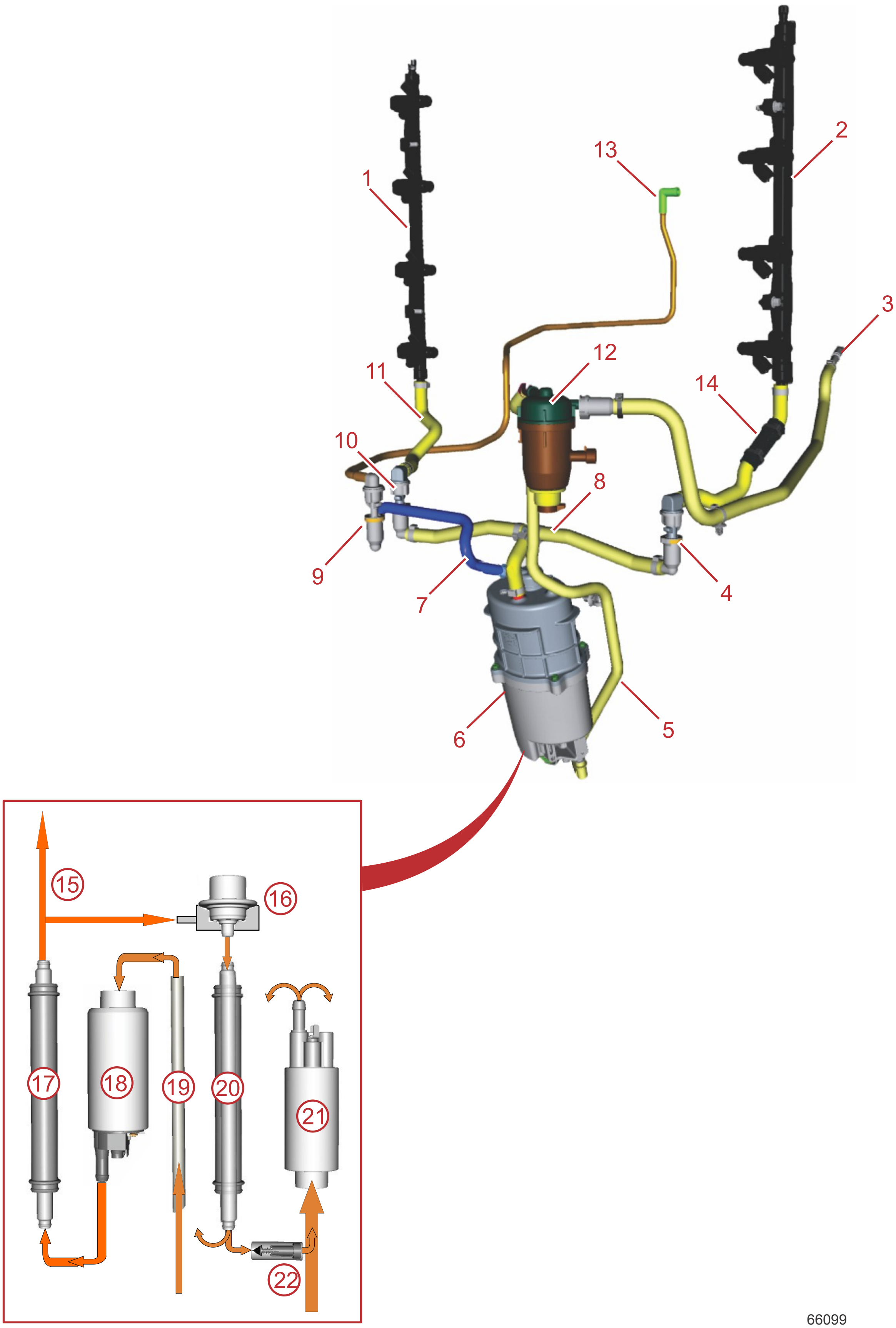
# V6 Fuel Flow Diagram



1 - Port fuel rail
2 - Starboard rail and injectors
3 - Fuel inlet from vessel
4 - Starboard rail hose quick-connect
5 - Filter to fuel supply module (FSM) hose
6 - FSM
7 - Manifold reference base hose
8 - FSM T-fitting
9 - Manifold reference quick-connect
10 - Port rail hose quick-connect
11 - Port rail hose
12 - Water-separating fuel filter
13 - Manifold reference
14 - Starboard rail hose
15 - High-pressure to fuel rails
16 - Fuel pressure regulator
17 - Fuel cooler
18 - High-pressure fuel pump
19 - Siphon tube
20 - Fuel cooler
21 - Fuel lift pump
22 - Recirculation check valve

## V8 Fuel Flow Diagram



1 - Port fuel rail
2 - Starboard rail and injectors
3 - Fuel inlet from vessel
4 - Starboard rail hose quick-connect
5 - Filter to fuel supply module (FSM) hose
6 - FSM
7 - Manifold reference base hose
8 - FSM T-fitting
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15 - High-pressure to fuel rails
16 - Fuel pressure regulator
17 - Fuel cooler
18 - High-pressure fuel pump
19 - Siphon tube
20 - Fuel cooler
21 - Fuel lift pump
22 - Recirculation check valve

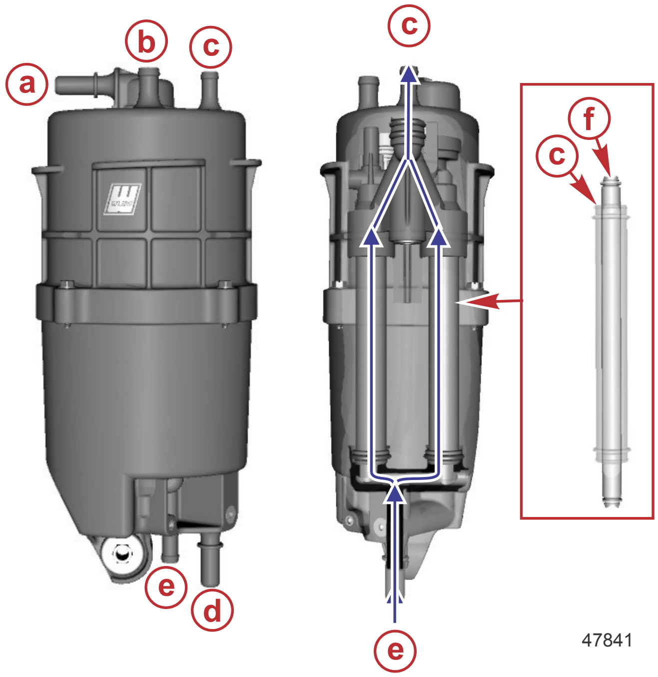
# Fuel Supply Module (FSM)

## Fuel Supply Module (FSM) Description

The FSM contains the fuel lift pump, high-pressure fuel pump, fuel pressure regulator, and the fuel cooler. The filling of the FSM is provided by the positive displacement fuel lift pump. Modulation of the fuel lift pump is not required.

The volume of entrained air in the FSM, high-pressure fuel line, and fuel rail must be purged to allow the fuel to reach the top fuel injector on the fuel rail. When the FSM is properly purged, it is almost always completely filled. The fuel lift pump and the high-pressure fuel pump are both powered by the same electrical circuit inside the FSM. Power from the fuel pump relay activates the fuel lift pump and the high-pressure fuel pump. Fuel pressure is controlled by the fuel pressure regulator located inside the FSM.

Cooling of the fuel occurs with a bi-level heat transfer. Inside the FSM are four metal tubes: two that are large diameter and two that are smaller diameter. The smaller diameter tubes are inside the large diameter tubes. The large diameter metal tubes pass water that cools the reservoir fuel and the fuel that passes through the smaller diameter tubes from the high-pressure pump and fuel pressure regulator.

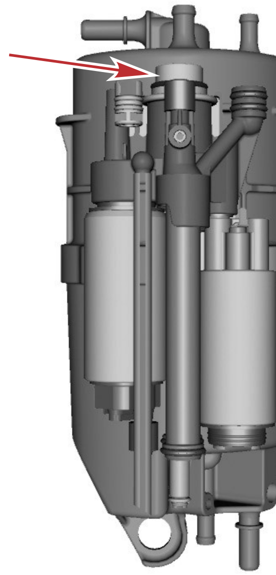



a - Fuel pressure regulator manifold reference port
b - High-pressure fuel out port
c - Fuel cooler water out port to the water pump indicator
d - Fuel lift pump (from vessel)
e - Fuel cooler water in port from strainer
f - Fuel cooler fuel tube

## Fuel Pressure Regulator

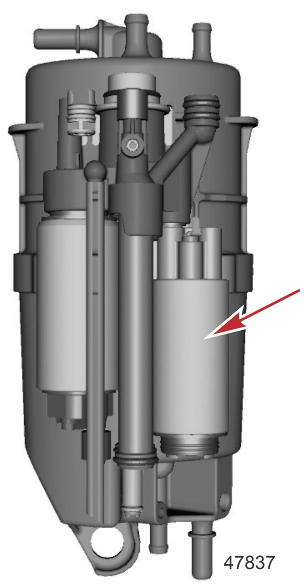
The fuel pressure regulator, located inside the fuel supply module, controls the amount of fuel pressure required for the engine to run efficiently. The fuel pressure regulator changes the pressurization of the fuel depending on the demands of the engine. Air pressure in the intake manifold changes to a higher or lower pressure during RPM changes. These manifold air pressure changes are linked to the fuel pressure regulator. The changes that take place at the fuel pressure regulator are managed by a hose that is connected to the intake manifold. The air pressure change that is positive or negative on the fuel pressure regulator diaphragm, increases or decreases the amount of fuel that is returned back into the FSM. The fuel pressure dumped by the fuel pressure regulator passes through a fuel cooler. Passing the excessive fuel through the fuel cooler prevents the high-pressure and low-pressure fuel pumps from overheating.


47840

## Fuel Lift Pump

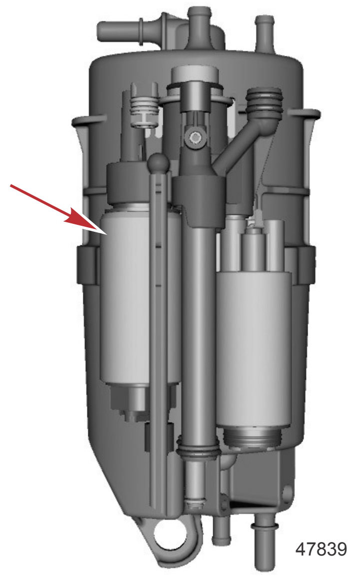
The fuel lift pump located inside the FSM pulls fuel from the fuel tank. The fuel lift pump is activated with 12 volts through the main power relay and the fuel pump control relay when there is no engine rotation, and the key is turned to the ON position for approximately three seconds. The propulsion control module (PCM) does not have the logic to detect the fuel lift pump operation. In the event of a fuel lift pump failure, no fault will be generated and the engine will not run.

The fuel lift pump has fuel passing through it constantly when the FSM is full of fuel. A fuel recirculating check valve inside the FSM is conjoined with the fuel lift port passage. When fuel cannot be pulled into the FSM from the fuel tank (FSM is full), the check valve opens and allows the cooled fuel inside the FSM to pass through the fuel lift pump, preventing the pump from overheating. The FSM is a volume displacement module, which replaces the fuel inside the FSM automatically without the installation of a float switch or needle and seat.


47837

## High-Pressure Fuel Pump

When the ignition key is turned ON, the high-pressure fuel pump is active for approximately three seconds. After the first three seconds, the high-pressure fuel pump will not run until the PCM recognizes engine RPM. The PCM does not have the logic to detect the high-pressure fuel pump operation. In the event of a high-pressure fuel pump failure, no fault will be generated and the engine will not run. The high-pressure fuel pump sends the fuel through a 20 micron fuel filter and into the bottom of the fuel rail. There is an internal overpressure relief of 689.5 kPa (100 psi) for the high-pressure pump. The fuel rail pressure is controlled by a fuel pressure regulator. The fuel pressure dumped by the fuel pressure regulator passes through a fuel cooler. Passing the excessive fuel through the fuel cooler prevents the high-pressure fuel pump from overheating.



# Notes:

# Fuel System

## Section 7B - Troubleshooting and Diagnostics

## Table of Contents

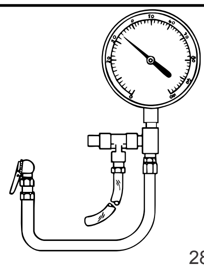


7
B

# Special Tools

| CDS G3 Interface Kit | 8M0138392 |
|---|---|
|  66165 | CDS G3 license key, interface, adapter, and harness |

| Fuel Pressure Gauge Kit | 91-881833A03 |
|---|---|
|  2807 | Tests the fuel pump pressure; can be used to relieve fuel pressure. |

# Fuel Component Troubleshooting and Diagnostics

## Antisiphon Valves

Antisiphon valves can be helpful from a safety standpoint, however, they can clog with debris, may be restrictive, or have too heavy a spring. The pressure drop across these valves can create operational problems and/or powerhead damage by restricting fuel to the fuel lift pump, and the high-pressure fuel pump. Some symptoms of restricted (lean) fuel flow, possibly caused by use of an antisiphon valve, are:

- Severe fuel rail pressure fluctuation
- Loss of fuel pump pressure
- High-speed surging
- Outboard cuts out or hesitates upon acceleration
- Outboard runs rough
- Outboard quits and cannot be restarted
- Outboard will not start
- Vapor lock

Antisiphon valves are typically installed between the fuel tank outlet and the engine fuel inlet. Use an alternative fuel supply, such as a remote tank, to determine if bad fuel or a malfunctioning antisiphon valve is causing the problem.

If it is found that the antisiphon valve is the cause of the problem, replace the antisiphon valve with one that has a lighter spring tension, or replace it with a solenoid-operated fuel shutoff valve.

## Fuel Supply Module (FSM)

The fuel supply module (FSM) that contains the fuel lift pump and the high-pressure fuel pump is energized by a 12-volt circuit that is controlled by the fuel pump relay (FPR). When the key switch is turned to the ON position, the PCM activates the FPR to energize the FSM for approximately three seconds before the engine is started. When the PCM receives a signal from the crankshaft position sensor, the FPR is activated again, and the FSM runs continuously until the key switch is turned off. The fuel pump circuit is protected by a 20-amp fuse.

If fuel starvation is indicated, verify high-pressure pump operation by testing the lift pump with a vacuum gauge and checking fuel pressure on one of the fuel rails. The fuel pump circuit can be activated using the CDS G3 diagnostic interface tool.

## Fuel Lift Pump

The fuel lift pump and high-pressure pump are on the inside of the fuel supply module. The fuel lift pump cannot be electrically tested separately from the high-pressure pump when installed as part of the fuel supply module assembly. The fuel lift pump can be tested for operation electrically with the CDS G3 diagnostic interface tool.

| CDS G3 Interface Kit | 8M0138392 |
|---|---|

***NOTE:*** *This test should be completed during engine idle or light load operation. If no fuel demand exists and the FSM is filled, the lift pump will not pull fuel to create a vacuum. At engine idle, inlet vacuum may build slowly.*

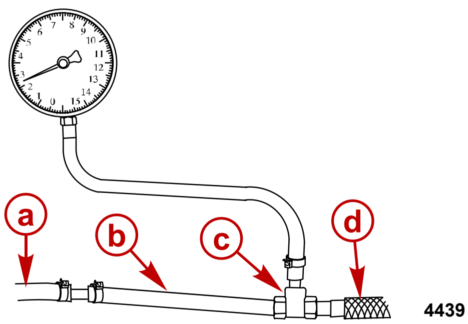
Test the fuel system inlet vacuum as described following. The fuel lift pump can be tested by measuring its ability to create vacuum. Create an artificial restriction in the fuel supply line to observe how much vacuum the fuel lift pump produces. The vacuum will build slowly as the engine is consuming fuel. The fuel lift pump should be capable of achieving a vacuum of 33.68 kPa (10 in. Hg) (4.91 psi).

## Testing Fuel System Inlet Vacuum

**⚠ CAUTION**

**Failure to release pressure from the fuel system will result in fuel spraying out, which can cause a fire or explosion. Allow the engine to cool completely and release all fuel pressure before servicing any part of the fuel system. Always protect eyes and skin from pressurized fuel and vapors.**

1. Separate the engine fuel line from the boat fuel line at the engine fuel inlet connection (inside the cowling).
2. Install a T-fitting on the boat fuel line.
3. Install a clear fuel line on the opposite side of the T-fitting. Connect the clear fuel line to the engine fuel line.
4. Install a fuel vacuum gauge (obtain locally) on the T-fitting.
5. Clamp all fuel line connections securely to prevent vacuum leaks.
6. Start the engine and observe the clear fuel line for air bubbles. If the engine does not start, use the CDS G3 diagnostic interface tool.
7. At maximum fuel flow (full-throttle engine operation), the vacuum gauge reading should not exceed the listed specification.




a - Engine fuel line
b - Clear fuel line
c - T-fitting
d - Boat fuel line

| Description | Specification |
|---|---|
| Maximum fuel system inlet vacuum (see NOTE) | 10.16 kPa (3.0 in. Hg) (1.47 psi) |

*NOTE: This maximum value applies only to measurements taken at the engine, not to measurements taken elsewhere in the boat. The maximum value is with the fuel tank at half volume.*

A restriction in the fuel system will result in a vacuum reading higher than the allowable maximum. Some common causes of excessive vacuum include:

- Restricted antisiphon valve
- Restricted or malfunctioning primer bulb
- Kinked or collapsed fuel hose
- Plugged water-separating fuel filter (in the boat)
- Restriction in the fuel line through-the-hull fitting
- Restriction in the fuel tank switching valves
- Plugged fuel tank pick-up screen

# High-Pressure Fuel Pump

The high-pressure fuel pump and fuel lift pump are inside the fuel supply module. The high-pressure fuel pump cannot be electrically tested separately from the fuel lift pump when installed as part of the fuel supply module assembly. The high-pressure fuel pump can be tested for operation electrically with the CDS G3 diagnostic interface tool.

| | |
|---|---|
| CDS G3 Interface Kit | 8M0138392 |

There is no logic in the engine control module to know if the high-pressure fuel pump is functioning or not. No fault will be set if the high-pressure fuel pump fails.

1. Connect a fuel pressure gauge to the fuel rail Schrader valve.

| | |
|---|---|
| Fuel Pressure Gauge Kit | 91-881833A03 |

2. Perform the fuel pump load test with CDS G3.
3. The reading on the fuel pressure gauge should be within specifications.

| High-Pressure Fuel Pump | |
|---|---|
| Fuel pressure, engine not running | 340–370 kPa (49.3–53.7 psi) |
| Fuel pressure, engine running at idle | 290–340 kPa (42.1–49.3 psi) |
| Fuel pressure, engine running under load | Pressure dependent on manifold vacuum pressure, use calculation (refer to **Fuel Pressure Calculations, Engine Running**) |

4. If there is little or no pressure reading on the gauge, ensure the fuel supply module has enough fuel to supply the high-pressure fuel pump. It may be necessary to prime the fuel supply module to verify the system is purged of entrained air. Refer to the previous procedure to ensure that the fuel lift pump is operating properly.

## Fuel Pressure Calculations, Engine Running

A simple formula can be used to determine what the approximate fuel pressure should be at different points in the engine RPM range: (MAP – Baro) + regulator set point.

**IMPORTANT: The actual regulator set point will vary according to engine fuel consumption. The actual fuel pressure may therefore fall anywhere within a 90 kPa (13.04 psi) range. In other words, fuel pressures calculated with this formula have a tolerance of ± 45 kPa (6.52 psi).**

The following examples assume an ambient barometric pressure of 98 kPa (14.21 psi) and an average fuel pressure set point of 363 kPa (52.65 psi).

If CDS G3 displays a manifold absolute pressure of 38 kPa (5.51 psi), then:

- **kPa**: (38 – 98) + 363 = 303. The calculated fuel pressure reading is 303 kPa; actual fuel pressure is 303 ± 45 kPa.
- **psi**: (5.51 – 14.21) + 52.65 = 43.95. The calculated fuel pressure reading is 43.95 psi; actual fuel pressure is 43.95 ± 6.52 psi.

## Fuel Injector Resistance Test

*NOTE: A fuel injector test can be performed with the CDS G3 diagnostic interface tool.*

Use a digital ohmmeter to test the resistance of the fuel injector.

*NOTE: A resistance test can be performed while the fuel injector is mounted to the fuel rail. It is not necessary to remove the fuel injector from the fuel rail when checking the resistance of the fuel injector. The fuel injector is not polarity sensitive.*


Removed from fuel rail for clarity

a - Fuel injector pins

| Fuel Injector | |
|---|---|
| Resistance at 21 °C (71 °F) | 12.5 ± 0.6 Ω |

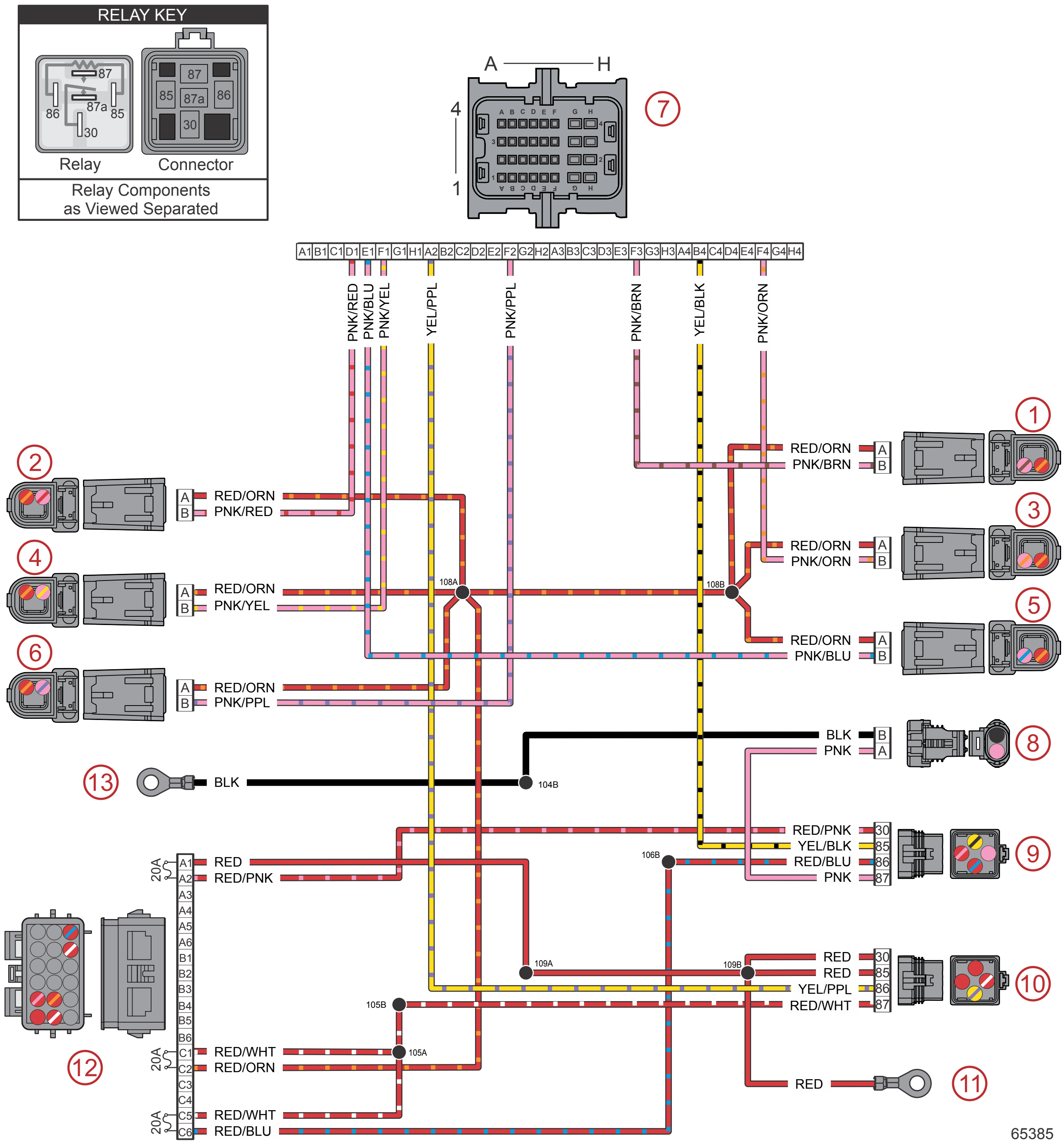
  

# Wire Color Code Abbreviations

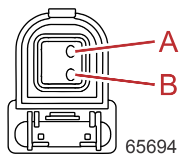
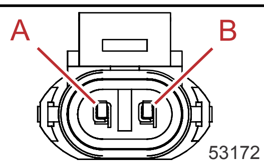
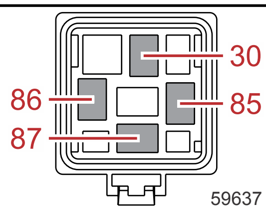
| Wire Color Abbreviations | | | | | |
|---|---|---|---|---|---|
| BLK | Black | | BLU | Blue |
| BRN | Brown | | GRY or GRA | Gray |
| GRN | Green | | ORN or ORG | Orange |
| PNK | Pink | | PPL or PUR | Purple |
| RED | Red | | TAN | Tan |
| WHT | White | | YEL | Yellow |
| LT or LIT | Light | | DK or DRK | Dark |

# Fuel Injector Circuits

## V6 Fuel Injector Circuits



1 - Fuel injector 1
2 - Fuel injector 2
3 - Fuel injector 3
4 - Fuel injector 4
5 - Fuel injector 5
6 - Fuel injector 6
7 - PCM connector A
8 - Fuel supply module
9 - Fuel pump relay
10 - Main power relay
11 - Hot stud
12 - Fuse holder - three 20-amp fuses shown
13 - Chassis ground

<table>
<tr><th>Connector</th><th>Pin</th><th>Wire Color</th><th>Function</th><th>PCM</th></tr>
<tr><td rowspan="7"></td><td>A</td><td>Red/orange</td><td>Fused (20 A) 12 V power (+)</td><td>–</td></tr>
<tr><td rowspan="6">B</td><td>Pink/brown</td><td>Fuel injector 1</td><td>AF3</td></tr>
<tr><td>Pink/red</td><td>Fuel injector 2</td><td>AD1</td></tr>
<tr><td>Pink/orange</td><td>Fuel injector 3</td><td>AF4</td></tr>
<tr><td>Pink/yellow</td><td>Fuel injector 4</td><td>AF1</td></tr>
<tr><td>Pink/blue</td><td>Fuel injector 5</td><td>AE1</td></tr>
<tr><td>Pink/purple</td><td>Fuel injector 6</td><td>AF2</td></tr>
<tr><td rowspan="2"></td><td>A</td><td>Pink</td><td>Fuel pump 12 V power (+)</td><td>–</td></tr>
<tr><td>B</td><td>Black</td><td>Chassis ground (–)</td><td>–</td></tr>
<tr><td rowspan="4"></td><td>30</td><td>Red/pink</td><td>Fused (20 A) 12 V power (+)</td><td>–</td></tr>
<tr><td>85</td><td>Yellow/black</td><td>Fuel pump relay (FPR) control</td><td>AB4</td></tr>
<tr><td>86</td><td>Red/blue</td><td>Fused (20 A) 12 V power (+)</td><td>–</td></tr>
<tr><td>87</td><td>Pink</td><td>Fuel pump 12 V power (+)</td><td>–</td></tr>
<tr><td>Hot stud ring terminal</td><td>30</td><td>Red</td><td>12 V battery power (+)</td><td>–</td></tr>
<tr><td>MPR</td><td>86</td><td>Yellow/purple</td><td>Main power relay (MPR) control signal</td><td>AA2</td></tr>
<tr><td>MPR</td><td>87</td><td>Red/white</td><td>Switched 12 V power (+)</td><td>–</td></tr>
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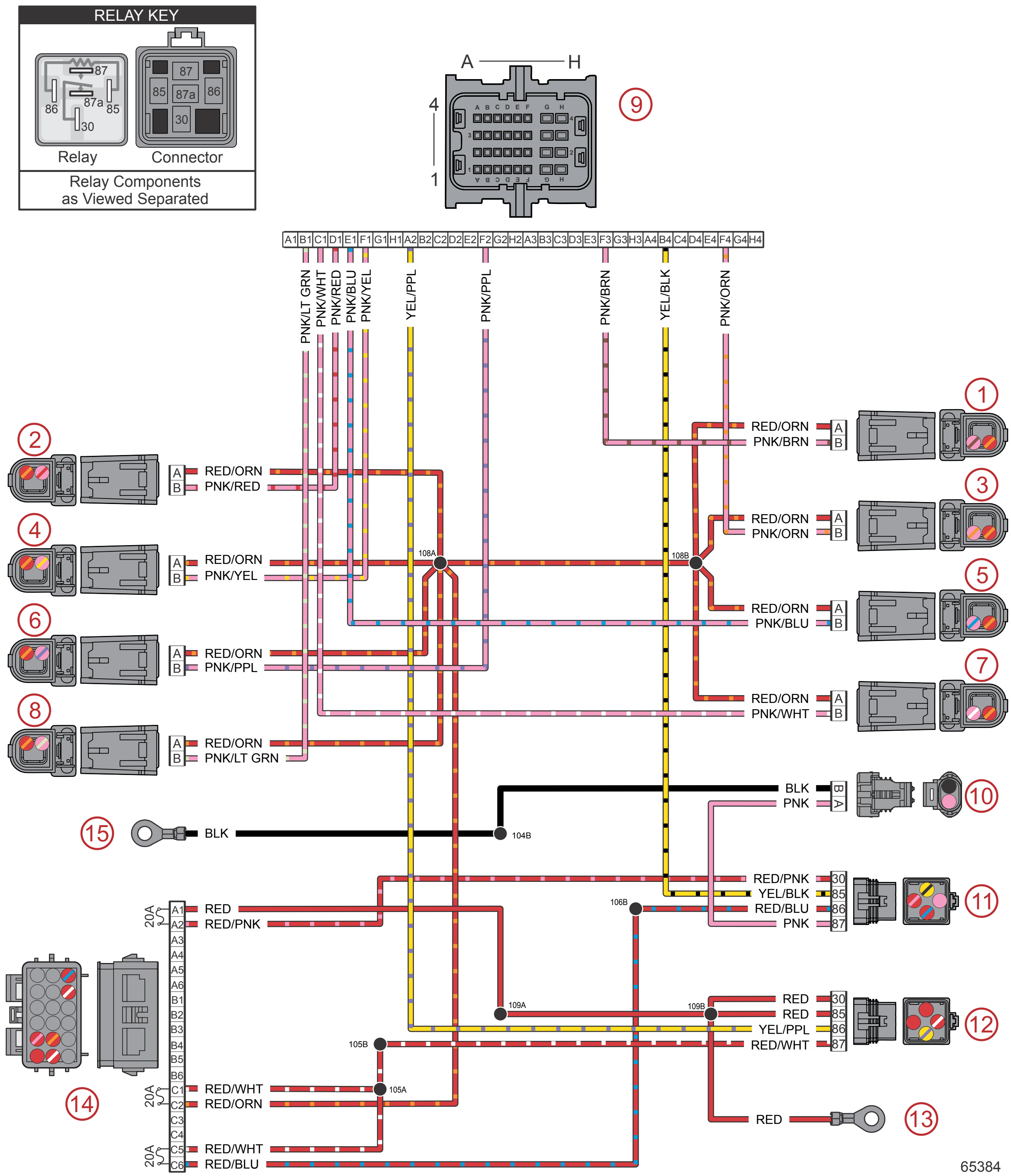
## V8 Fuel Injector Circuits



1 - Fuel injector 1
2 - Fuel injector 2
3 - Fuel injector 3
4 - Fuel injector 4
5 - Fuel injector 5
6 - Fuel injector 6
7 - Fuel injector 7
8 - Fuel injector 8
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13 - Hot stud
14 - Fuse holder - three 20-amp fuses shown
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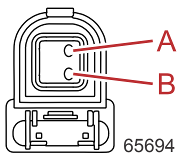
<tr><td rowspan="9"></td><td>A</td><td>Red/orange</td><td>Fused (20 A) 12 V power (+)</td><td>–</td></tr>
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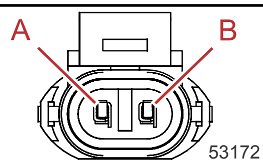
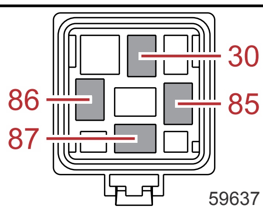
<tr><td>Pink/blue</td><td>Fuel injector 5</td><td>AE1</td></tr>
<tr><td>Pink/purple</td><td>Fuel injector 6</td><td>AF2</td></tr>
<tr><td>Pink/white</td><td>Fuel injector 7</td><td>AC1</td></tr>
<tr><td>Pink/light green</td><td>Fuel injector 8</td><td>AB1</td></tr>
<tr><td rowspan="2"></td><td>A</td><td>Pink</td><td>Fuel pump 12 V power (+)</td><td>–</td></tr>
<tr><td>B</td><td>Black</td><td>Chassis ground (–)</td><td>–</td></tr>
<tr><td rowspan="4"></td><td>30</td><td>Red/pink</td><td>Fused (20 A) 12 V power (+)</td><td>–</td></tr>
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<tr><td>MPR</td><td>87</td><td>Red/white</td><td>Switched 12 V power (+)</td><td>–</td></tr>
</table>

  

# Notes:

  

# Color Diagrams

## Section 8A - SmartCraft Circuit Diagrams

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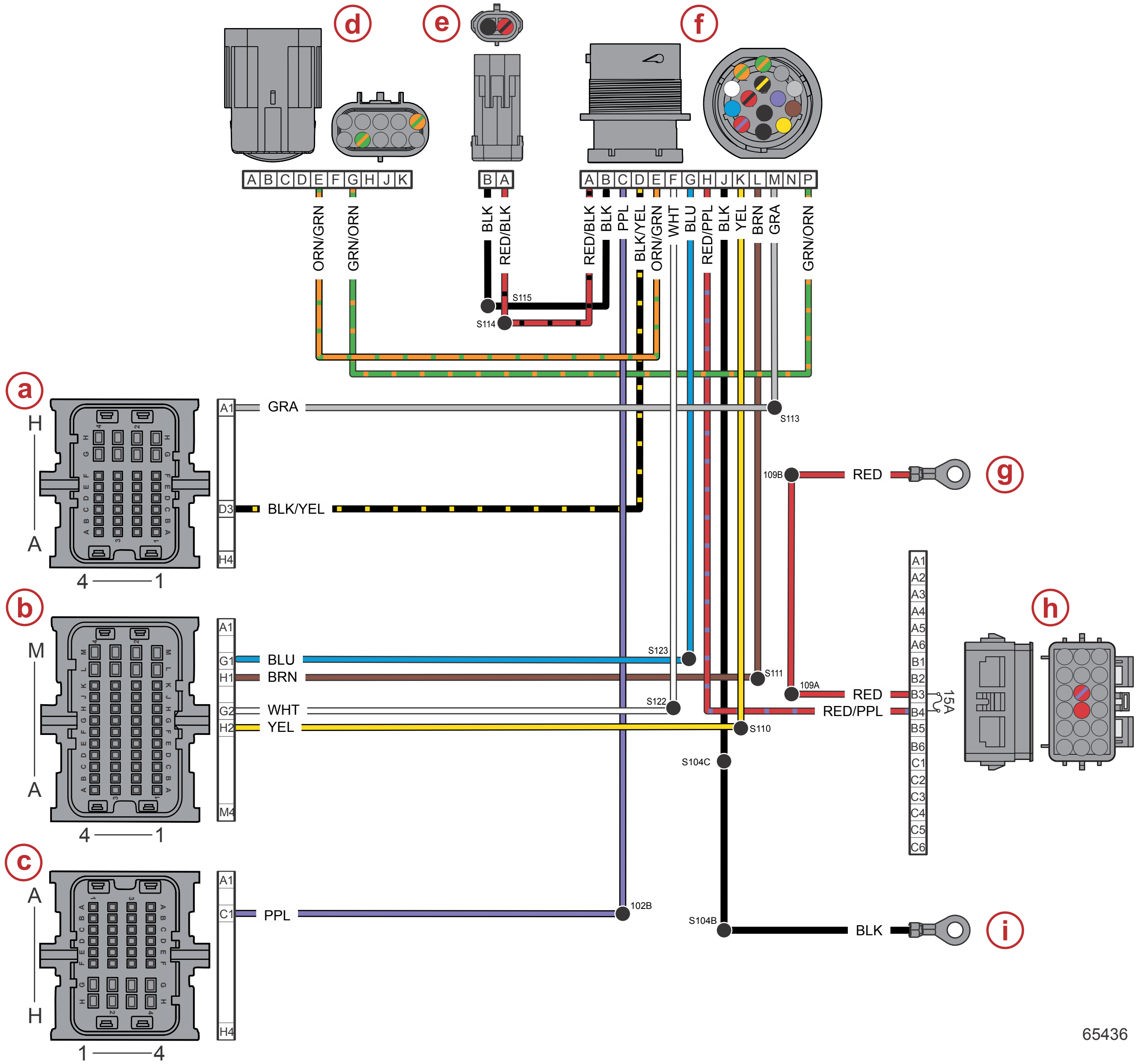
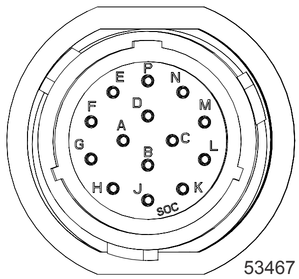
8
A

# 14-Pin Data Harness - DTS



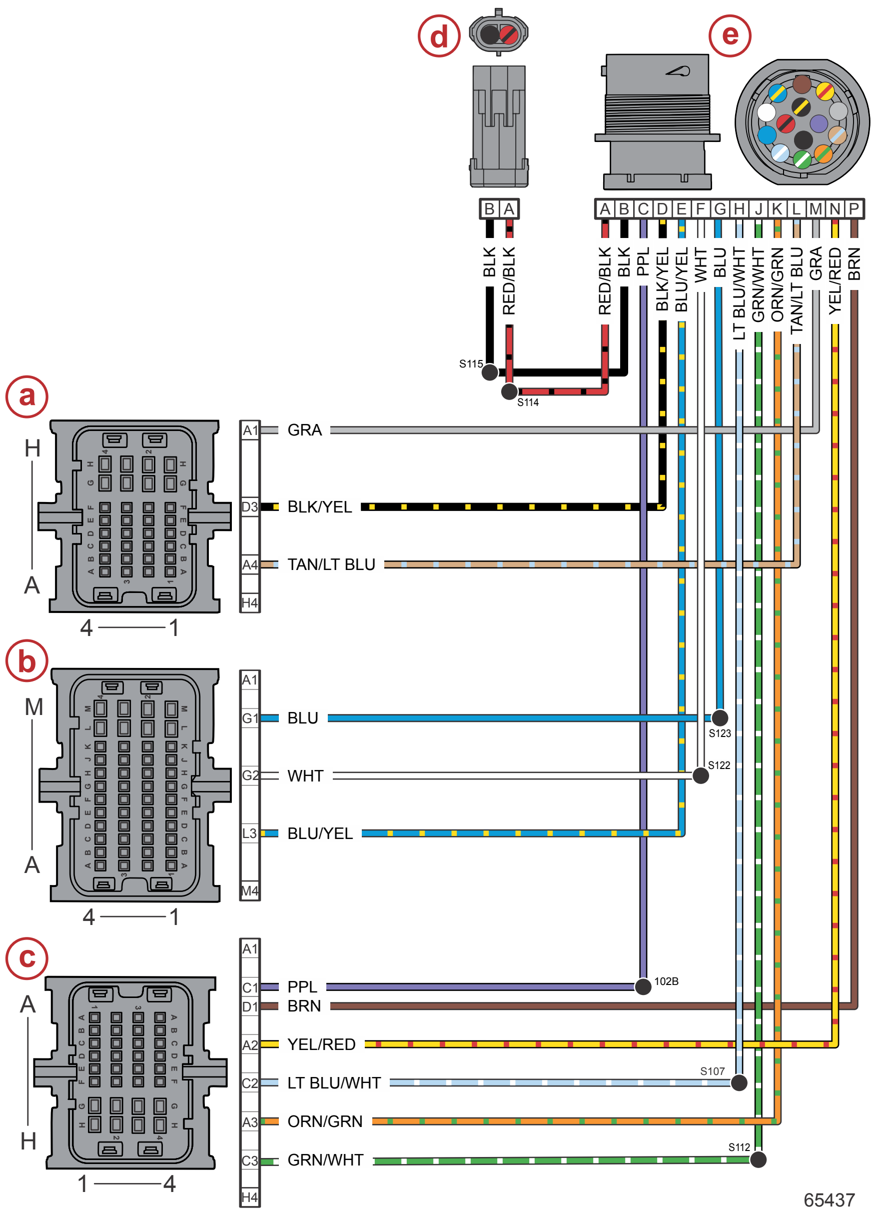

a - PCM connector A
b - PCM connector B
c - PCM connector C
d - CAN P and H terminator
e - CAN X terminator
f - 14-pin connector
g - Hot stud
h - Engine fuses - 15-amp fuse
i - Chassis ground

| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|  | A | Red/black | 12 V clean power (+) | – |
| | B | Black | Clean power ground (–) | – |
| | C | Purple | 12 V wake circuit (+) | CC1 |
| | D | Black/yellow | E-stop signal | AD3 |
| | E | Orange/green | CAN H high | – |
| | F | White | CAN P high | BG2 |
| | G | Blue | CAN P low | BG1 |
| | H | Red/purple | Fused (15 A) 12 V power (+) | – |
| | J | Black | Chassis ground (–) | – |
| | K | Yellow | CAN X high | BH2 |
| | L | Brown | CAN X low | BH1 |
| | M | Gray | Tachometer signal | AA1 |
| | N | N/A | Not used | – |
| | P | Green/orange | CAN H low | – |
| Hot stud ring terminal | – | Red | 12 V battery power (+) | – |

# Wire Color Code Abbreviations

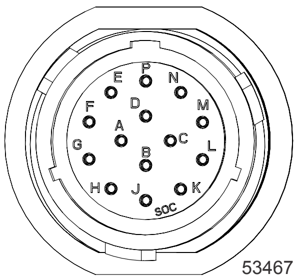
| Wire Color Abbreviations | | | | |
|---|---|---|---|---|
| BLK | Black | | BLU | Blue |
| BRN | Brown | | GRY or GRA | Gray |
| GRN | Green | | ORN or ORG | Orange |
| PNK | Pink | | PPL or PUR | Purple |
| RED | Red | | TAN | Tan |
| WHT | White | | YEL | Yellow |
| LT or LIT | Light | | DK or DRK | Dark |

# 14-Pin Data Harness - Mechanical

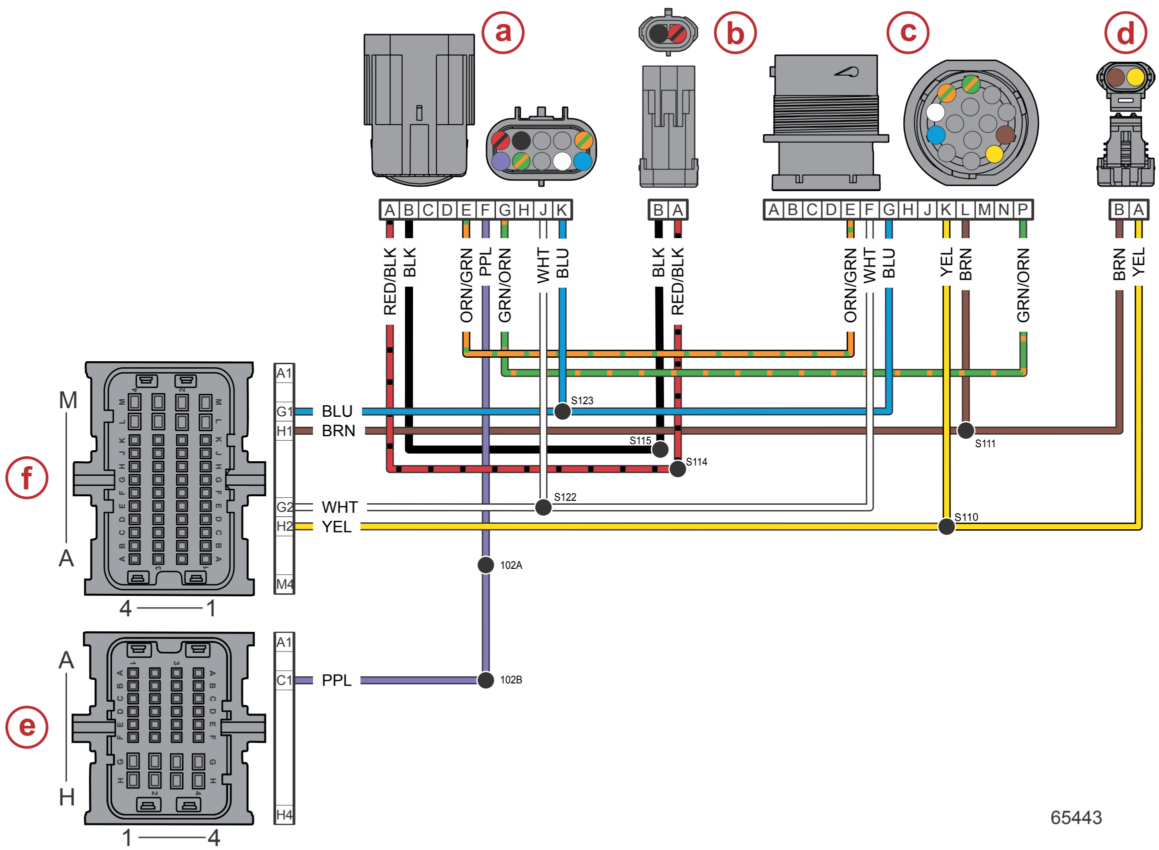


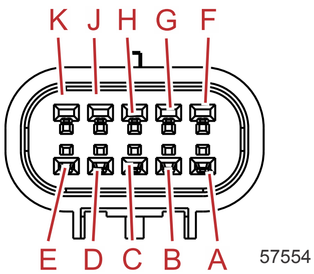
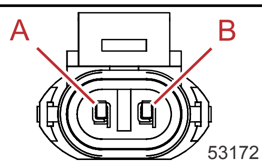
a - PCM connector A
b - PCM connector B
c - PCM connector C
d - Clean power connector
e - 14-pin connector

| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|   | A | Red/black | 12 V clean power (+) | – |
| | B | Black | Clean power ground (–) | – |
| | C | Purple | 12 V wake circuit (+) | CC1 |
| | D | Black/yellow | E-stop signal | AD3 |
| | E | Blue/yellow | Oil pressure analog gauge | BL3 |
| | F | White | CAN P high | BG2 |
| | G | Blue | CAN P low | BG1 |
| | H | Light blue/white | Trim up command | CC2 |
| | J | Green/white | Trim down command | CC3 |
| | K | Orange/green | Trim position analog gauge | CA3 |
| | L | Tan/light blue | Horn | AA4 |
| | M | Gray | Tachometer signal | AA1 |
| | N | Yellow/red | Start/stop signal | CA2 |
| | P | Brown | Coolant temperature analog gauge | CD1 |

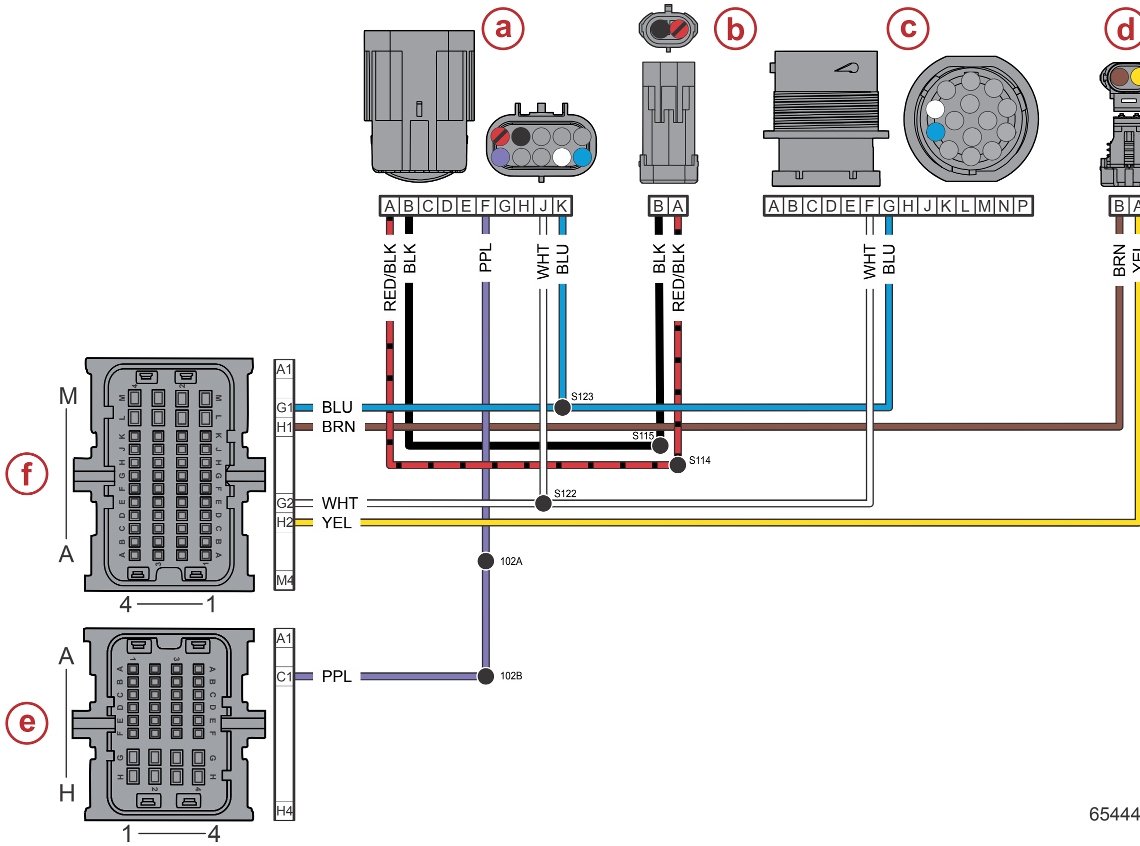
# CAN Circuits - DTS



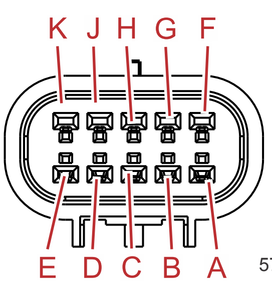
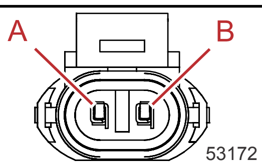
**a -** CAN P/H terminator
**b -** Clean power connector
**c -** 14-pin connector
**d -** CAN X terminator
**e -** PCM connector C
**f -** PCM connector B

<table>
<tr><th>Connector</th><th>Pin</th><th>Wire Color</th><th>Function</th><th>PCM</th></tr>
<tr><td rowspan="10">
</td><td>A</td><td>Red/black</td><td>12 V clean power (+)</td><td>–</td></tr>
<tr><td>B</td><td>Black</td><td>Clean power ground (–)</td><td>–</td></tr>
<tr><td>C</td><td>N/A</td><td>Not used</td><td>–</td></tr>
<tr><td>D</td><td>N/A</td><td>Not used</td><td>–</td></tr>
<tr><td>E</td><td>Orange/green</td><td>CAN H high</td><td>–</td></tr>
<tr><td>F</td><td>Purple</td><td>12 V wake circuit (+)</td><td>CC1</td></tr>
<tr><td>G</td><td>Green/orange</td><td>CAN H low</td><td>–</td></tr>
<tr><td>H</td><td>N/A</td><td>Not used</td><td></td></tr>
<tr><td>J</td><td>White</td><td>CAN P high</td><td>BG2</td></tr>
<tr><td>K</td><td>Blue</td><td>CAN P low</td><td>BG1</td></tr>
<tr><td rowspan="2">
</td><td>A</td><td>Yellow</td><td>CAN X high</td><td>BH2</td></tr>
<tr><td>B</td><td>Brown</td><td>CAN X low</td><td>BH1</td></tr>
</table>

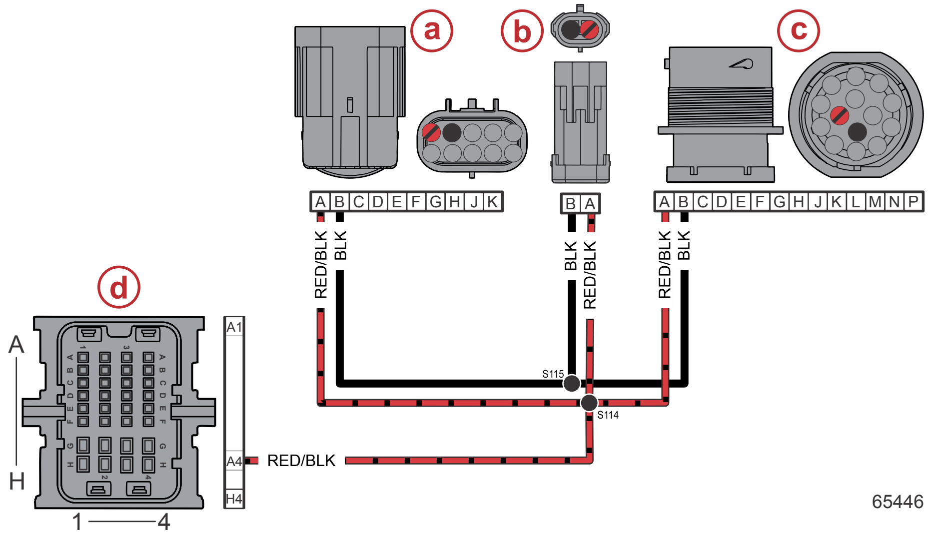
# CAN Circuits - Mechanical




- **a -** CAN P/H terminator
- **b -** Clean power connector
- **c -** 14-pin connector
- **d -** CAN X terminator
- **e -** PCM connector C
- **f -** PCM connector B

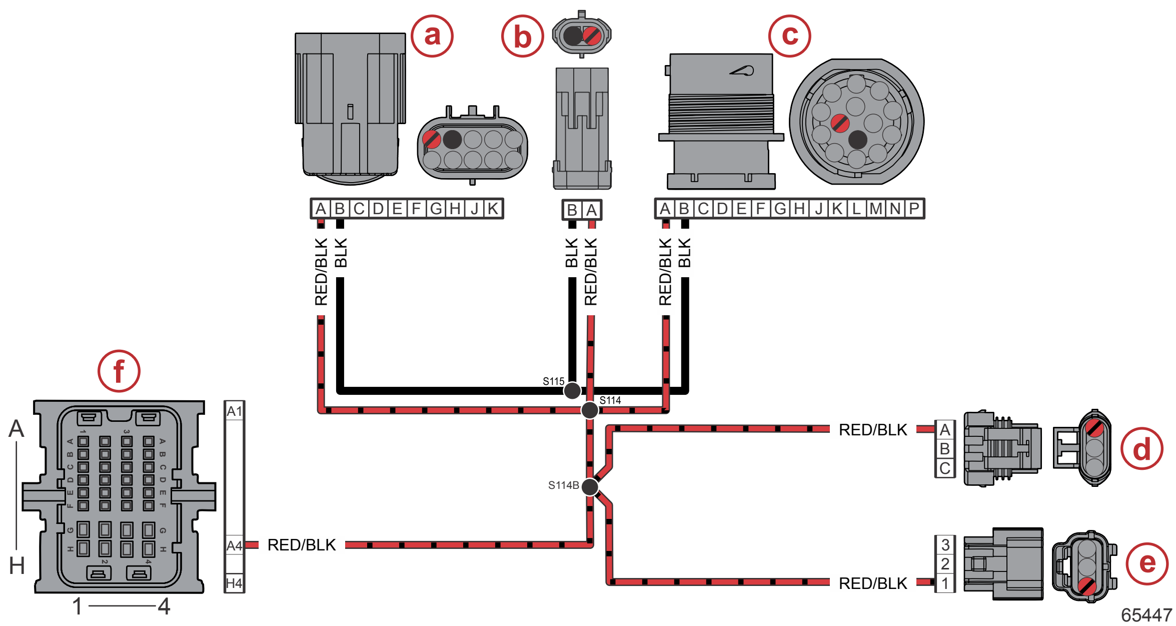
| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|   | A | Red/black | 12 V clean power (+) | – |
| | B | Black | Clean power ground (–) | – |
| | C | N/A | Not used | – |
| | D | N/A | Not used | – |
| | E | N/A | Not used | – |
| | F | Purple | 12 V wake circuit (+) | CC1 |
| | G | N/A | Not used | – |
| | H | N/A | Not used | – |
| | J | White | CAN P high | BG2 |
| | K | Blue | CAN P low | BG1 |
|   | A | Yellow | CAN X high | BH2 |
| | B | Brown | CAN X low | BH1 |

# Clean Power



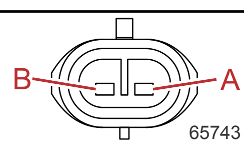

**DTS models**

- **a -** CAN P/H terminator
- **b -** Clean power connector
- **c -** 14-pin connector
- **d -** PCM connector C




**Mechanical models**

- **a -** CAN P/H terminator
- **b -** Clean power connector
- **c -** 14-pin connector
- **d -** Trim harness connector
- **e -** Cowl trim switch connector
- **f -** PCM connector C

| Connector | Pin | Wire Color | Function | PCM |
|---|---|---|---|---|
|   | A | Red/black | 12 V clean power (+) | CA4 |
| | B | Black | Clean power ground (–) | – |

# Notes:

# Color Diagrams

## Section 8B - Engine Harness Diagrams

## Table of Contents





# Notes:

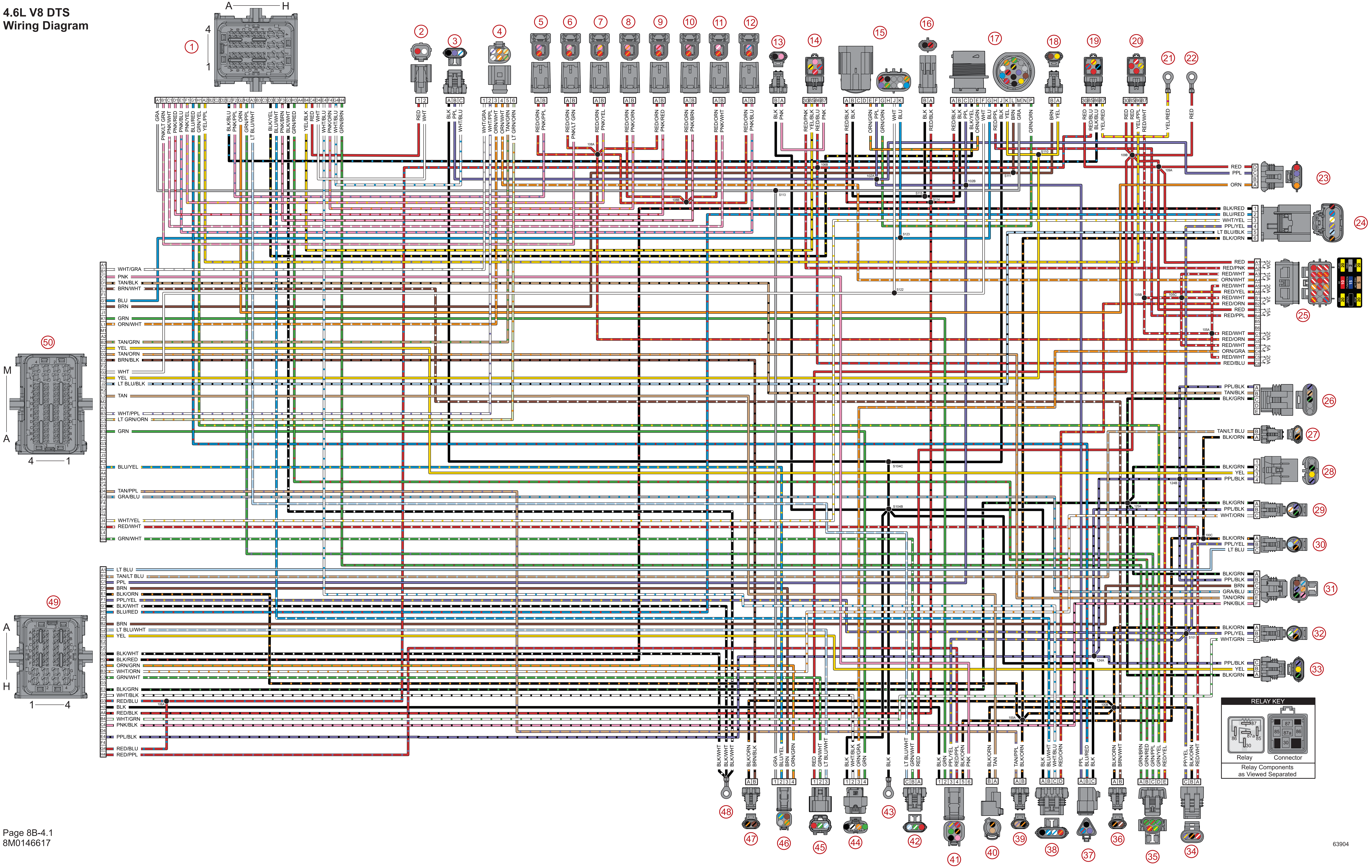
# Notes:

# 4.6L V8 DTS Wiring Diagram

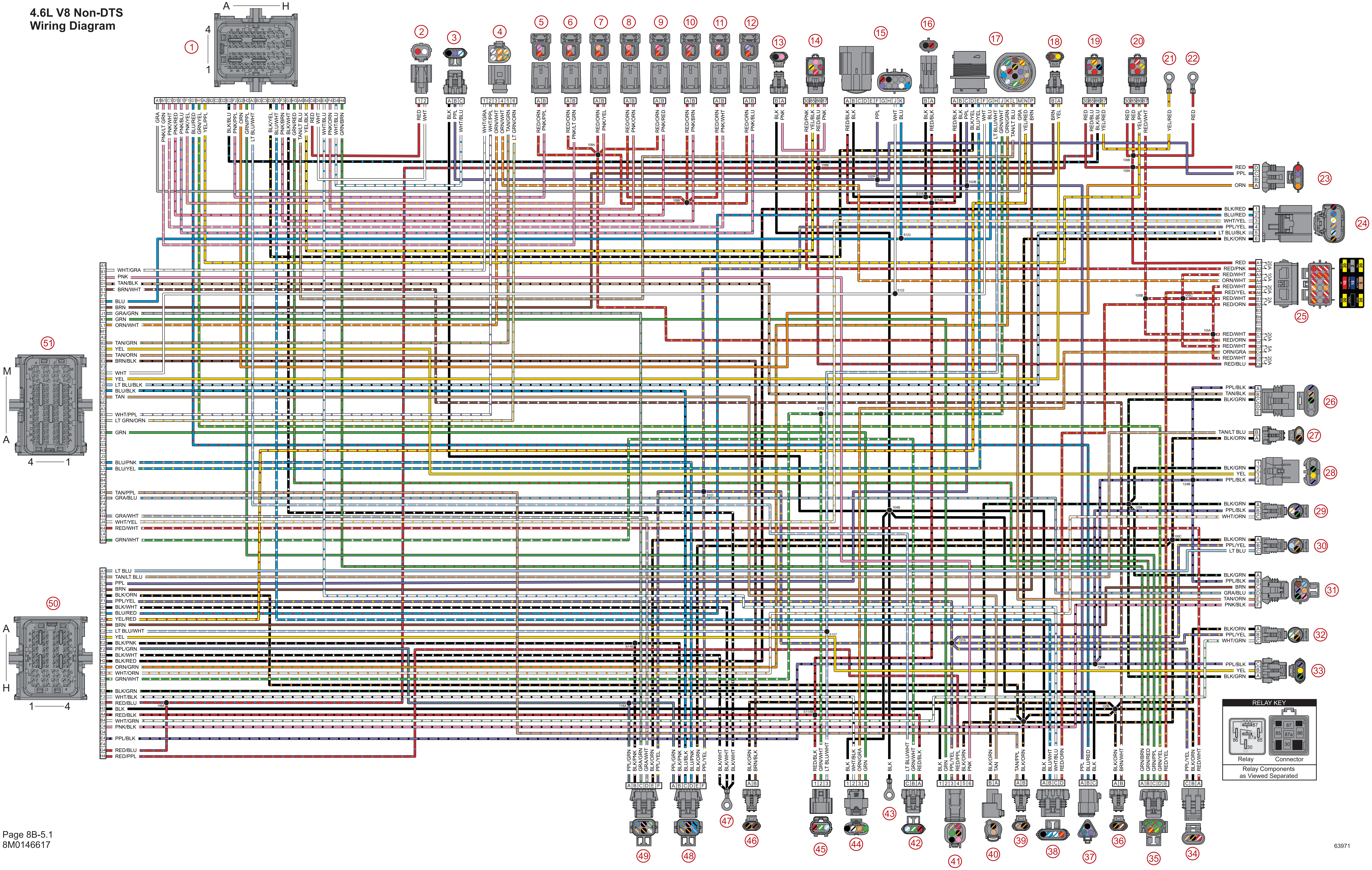
1 - Propulsion control module (PCM) connector A
2 - Crankshaft position sensor (CPS)
3 - Power steering
4 - O2 sensor
5 - Fuel injector 6
6 - Fuel injector 8
7 - Fuel injector 4
8 - Fuel injector 3
9 - Fuel injector 2
10 - Fuel injector 1
11 - Fuel injector 7
12 - Fuel injector 5
13 - Fuel pump
14 - Fuel pump relay
15 - CAN P and CAN H terminator (SmartCraft connector)
16 - Clean power harness
17 - 14-pin data harness
18 - 2-pin CAN X terminator
19 - Start relay
20 - Main power relay (MPR)
21 - Starter solenoid
22 - Hot stud (+)
23 - Alternator
24 - Electronic throttle control (ETC)
25 - Engine fuses
26 - Oil level sensor
27 - Oil temperature sensor
28 - Trim sensor
29 - Pitot pressure
30 - Oil pressure sensor
31 - Boat harness
32 - Engine block pressure sensor
33 - Manifold absolute pressure (MAP) sensor
34 - Camshaft position sensor
35 - Ignition coil harness
36 - Exhaust gas temperature (EGT) sensor
37 - Moving propeller (MP) alert
38 - Depth transducer connector
39 - Water-in-fuel sensor
40 - Intake air temperature (IAT) sensor
41 - Shift actuator
42 - Trim harness
43 - Chassis ground (–)
44 - Advanced sound control actuator—used on AMS models only
45 - Cowl trim switch
46 - Analog gauge harness
47 - Engine coolant temperature (ECT) sensor
48 - PCM ground (–)
49 - PCM connector C
50 - PCM connector B

## 4.6L V8 DTS Wiring Diagram



**4.6L V8 Non-DTS**
**Wiring Diagram**



# 4.6L V8 Non-DTS Wiring Diagram

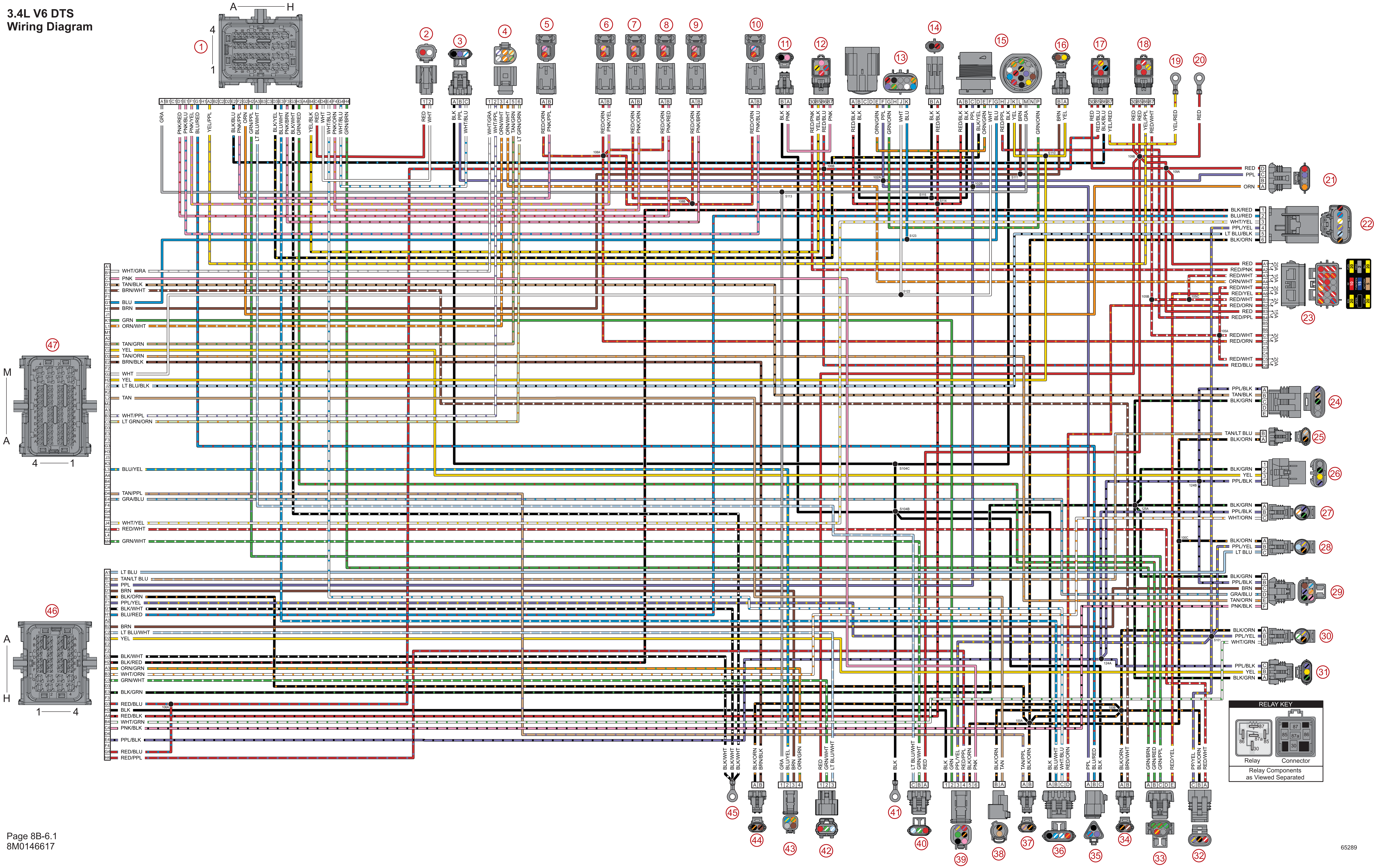
1 - Propulsion control module (PCM) connector A
2 - Crankshaft position sensor (CPS)
3 - Power steering
4 - O2 sensor
5 - Fuel injector 6
6 - Fuel injector 8
7 - Fuel injector 4
8 - Fuel injector 3
9 - Fuel injector 2
10 - Fuel injector 1
11 - Fuel injector 7
12 - Fuel injector 5
13 - Fuel pump
14 - Fuel pump relay
15 - CAN P and CAN H terminator (SmartCraft connector)
16 - Clean power harness
17 - 14-pin data harness
18 - 2-pin CAN X terminator
19 - Start relay
20 - Main power relay (MPR)
21 - Starter solenoid
22 - Hot stud (+)
23 - Alternator
24 - Electronic throttle control (ETC)
25 - Engine fuses
26 - Oil level sensor
27 - Oil temperature sensor
28 - Trim sensor
29 - Pitot pressure
30 - Oil pressure sensor
31 - Boat harness
32 - Engine block pressure sensor
33 - Manifold absolute pressure (MAP) sensor
34 - Camshaft position sensor
35 - Ignition coil harness
36 - Exhaust gas temperature (EGT) sensor
37 - Moving propeller (MP) alert
38 - Depth transducer connector
39 - Water-in-fuel sensor
40 - Intake air temperature (IAT) sensor
41 - Shift actuator
42 - Trim harness
43 - Chassis ground (–)
44 - Advanced sound control actuator—used on AMS models only
45 - Cowl trim switch
46 - Engine coolant temperature (ECT) sensor
47 - PCM ground (–)
48 - Shift demand sensor
49 - Throttle demand sensor
50 - PCM connector C
51 - PCM connector B

# 3.4L V6 DTS Wiring Diagram

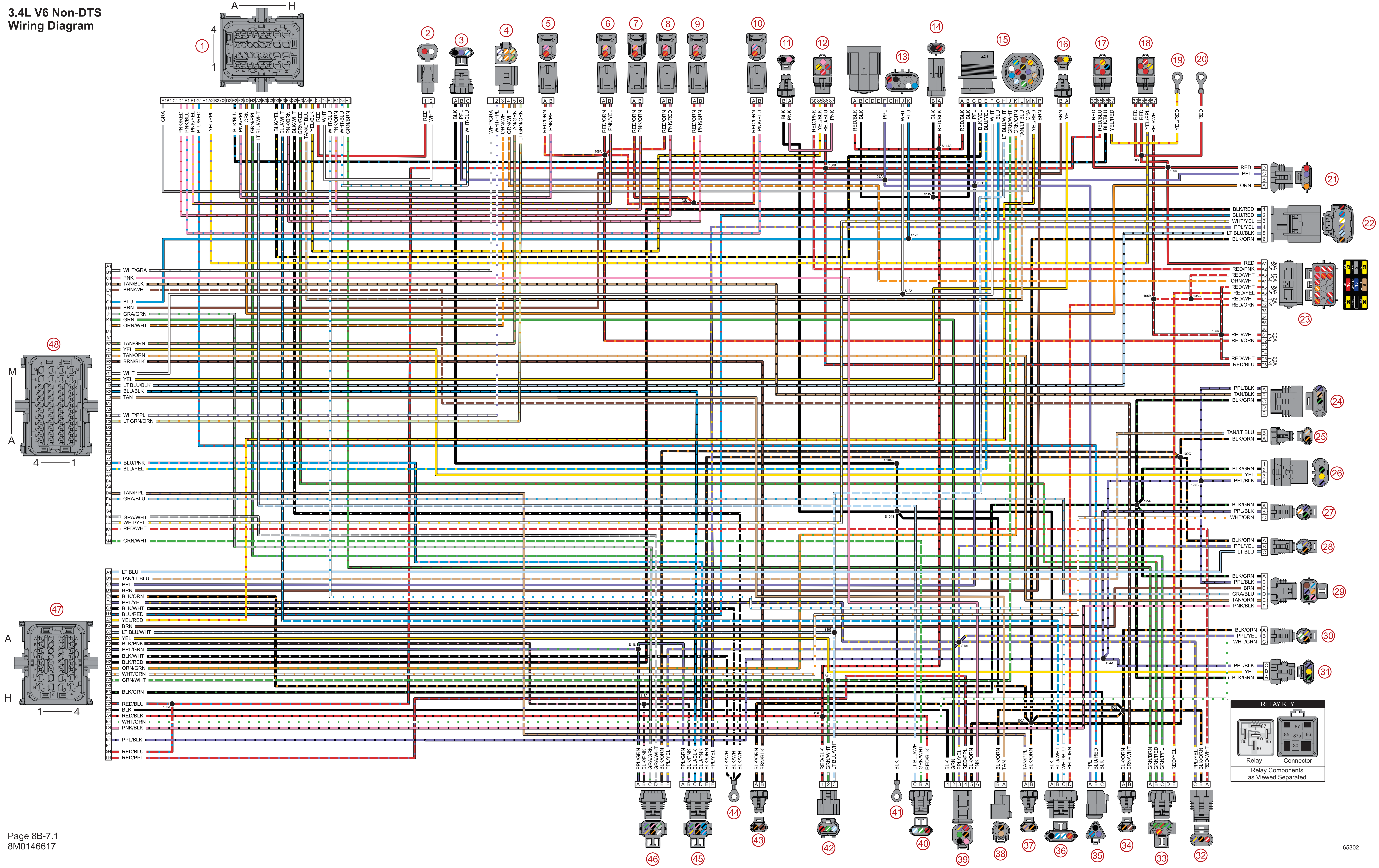
1 - Propulsion control module (PCM) connector A
2 - Crankshaft position sensor (CPS)
3 - Power steering
4 - O2 sensor
5 - Fuel injector 6
6 - Fuel injector 4
7 - Fuel injector 3
8 - Fuel injector 2
9 - Fuel injector 1
10 - Fuel injector 5
11 - Fuel pump
12 - Fuel pump relay
13 - CAN P and CAN H terminator (SmartCraft connector)
14 - Clean power harness
15 - 14-pin data harness
16 - 2-pin CAN X terminator
17 - Start relay
18 - Main power relay (MPR)
19 - Starter solenoid
20 - Hot stud (+)
21 - Alternator
22 - Electronic throttle control (ETC)
23 - Engine fuses
24 - Oil level sensor
25 - Oil temperature sensor
26 - Trim sensor
27 - Pitot pressure
28 - Oil pressure sensor
29 - Boat harness
30 - Engine block pressure sensor
31 - Manifold absolute pressure (MAP) sensor
32 - Camshaft position sensor
33 - Ignition coil harness
34 - Exhaust gas temperature (EGT) sensor
35 - Moving propeller (MP) alert
36 - Depth transducer connector
37 - Water-in-fuel sensor
38 - Intake air temperature (IAT) sensor
39 - Shift actuator
40 - Trim harness
41 - Chassis ground (–)
42 - Cowl trim switch
43 - Analog gauge harness
44 - Exhaust coolant temperature (ECT) sensor
45 - PCM ground (–)
46 - PCM connector C
47 - PCM connector B

**3.4L V6 DTS**
**Wiring Diagram**



## 3.4L V6 Non-DTS Wiring Diagram



# 3.4L V6 Non-DTS Wiring Diagram

1 - Propulsion control module (PCM) connector A
2 - Crankshaft position sensor (CPS)
3 - Power steering
4 - O2 sensor
5 - Fuel injector 6
6 - Fuel injector 4
7 - Fuel injector 3
8 - Fuel injector 2
9 - Fuel injector 1
10 - Fuel injector 5
11 - Fuel pump
12 - Fuel pump relay
13 - CAN P and CAN H terminator (SmartCraft connector)
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16 - 2-pin CAN X terminator
17 - Start relay
18 - Main power relay (MPR)
19 - Starter solenoid
20 - Hot stud (+)
21 - Alternator
22 - Electronic throttle control (ETC)
23 - Engine fuses
24 - Oil level sensor
25 - Oil temperature sensor
26 - Trim sender
27 - Pitot pressure sensor
28 - Oil pressure sensor
29 - Boat harness
30 - Engine block pressure sensor
31 - Manifold absolute pressure (MAP) sensor
32 - Camshaft position sensor
33 - Ignition coil harness
34 - Exhaust gas temperature (EGT) sensor
35 - Moving propeller (MP) alert
36 - Depth transducer connector
37 - Water-in-fuel sensor
38 - Intake air temperature (IAT) sensor
39 - Shift actuator
40 - Trim harness
41 - Chassis ground (–)
42 - Cowl trim switch
43 - Engine coolant temperature (ECT) sensor
44 - PCM ground (–)
45 - Shift demand sensor
46 - Throttle demand sensor
47 - PCM connector C
48 - PCM connector B

  

# Notes:

  

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