EFI Connections™

Today's Technician's Link to Marine EFI Systems

In This Issue

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EPA-Friendly Engines Push Marine EFI Technology

In the computer industry there is a commonly used term called Moore's Law that predicts the complexity of computer electronics will double every 2 years. That prediction has held true for over 40 years. While no similar term exists in the marine industry, good ol' Moore's law is extending its reach and revealing itself in the latest engine offerings from marine sterndrive and inboard engine manufacturers.

A variety of factors have pushed marine engine manufacturers to incorporate more sophisticated electronic systems into their engines and associated engine accessories. While Electronic Fuel Injection (EFI) systems have been common on marine engines since the 1990s, their sophistication has grown significantly in recent years.

Emission laws drive EFI sophistication

The largest force driving this change is an EPA emission law often referred to as OBD-M. This law requires nearly all new gasoline sterndrive and inboard engines being sold nationwide to be equipped with emission controls. Catalytic converters are now a must along with additional sensors to monitor the catalyst's efficiency, detect engine misfire and provide closed loop fuel control. The law also dictates the inclusion of a high speed CAN (Controller Area Network) port on the engine control module to facilitate engine diagnostics.

The OBD-M mandate originally took effect in California in 2008 and is now a 50-state requirement enforced by the EPA. Virtually all new sterndrive and inboard engines sold since January 2010 must be equipped with emission controls.

Emission controls are only part of the story that is driving electronic complexity. Marine engines themselves are changing and require more sophisticated control electronics to operate. Some of the newest marine engines feature variable cam timing which employs the use of an ECM operated cam angle adjustment mechanism known as a cam phaser. Also, supercharging is being offered as a factory installed option on some manufacturers' engines. Additional electronics will be used to sense and control boost pressure, operate the intercooler, read additional sensors as well as control other supercharger associated functions.

Although the increased electronic requirements mentioned so far were

Delphi Cam Phaser and Control Valve
(photo courtesy of Delphi Corp)

brought on either by legislative measures or changes in engine functionality, other vessel / watercraft changes have been spawned as a byproduct of the new engine

From the TOP

The past year has been a busy one for all of us here at Rinda Technologies. Our engineers have been immersed in adding a myriad of features and engine support to our software while our manufacturing department (yes, we actually do manufacture our tools here in Chicago!) has been busy producing the hardware needed to support all of the new features. Couple that activity with the endlessly changing world of PCs (i.e. Windows 7, etc...) and that makes for an intriguing year.

The marine engine industry itself has been rapidly evolving with new rules, new players and new systems. Marine technicians are beginning to see the service ramifications of the EPA's 2010 emission laws and there are also new names in the industry: upstart Seven Marine and veteran engine builder Ilmor with their MV8 product line. There are also new EFI systems!

This issue of EFI Connections touches on developments in marine engine technology and the diagnostic tools needed to service OBD-M compliant engines. Our article on OBD-M diagnostics is designed as a primer for technicians seeking to familiarize themselves with the new service terminology and procedures. We sincerely hope this issue provides you with a fundamental understanding of the engine technology that lies ahead.

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Ilmor introduces MV8 engine line-up powered by 4G ECM

There is a "new kid on the block" in the inboard marine engine business and you'll be seeing their line-up of powerplants soon. Ilmor, a name familiar to Indy race car fans, has introduced a series of V8 inboard marine engines named their "MV8" line.

Beginning with the 2012 model year, Ilmor will be the exclusive engine supplier to Mastercraft. This engine series complements Ilmor's existing marine engine offerings, namely their marinized versions of the Dodge Viper V-10.

Ilmor's entire line of MV8 engines are equipped with a 4th generation (4G) EFI control module developed by Econtrols of San Antonio, Texas. This control system forms the heart of a sophisticated engine management system that is fully compliant with EPA and OBD-M standards.

Advanced features of the 4G system include catalyst monitoring, misfire detection, sophisticated fault monitoring and a high speed CAN communication network. The latter enables a seamless tie-in with Mastercraft's digital helm controls, electronic displays and GPS based cruise control system.

From a service perspective, updated software will be required to communicate with and diagnose this new system. The 4G EFI system provides a wealth of features designed to assist marine technicians with engine diagnostics, monitoring and functional testing.

Software update kits are available for Rinda Technologies diagnostic tools to support both Ilmor MV8 and MV10 series engines. Please contact us for details on upgrading your tools.

Mercury Outboard support arrives in Rinda service tools

Marine technicians yearning for broad diagnostic support of Mercury's outboard product line-up can now exuberate. The latest versions of Diacom Marine as well as our hand held scan tools now feature support for Mercury outboard engines.

Mercury has been equipping many of its outboard engines with microprocessor based electronic controls since the mid-1990s. Beginning with the 3.0L carbureted outboard in 1994 though the latest Verado and Optimax models, Mercury has used a wide variety of electronic control systems sometimes requiring different service tools for different models.

First debuting in late 2010, comprehensive support for 1994 and newer Mercury

outboards is now available in Rinda Technologies engine service tools.

Support covers virtually all outboard engines that were equipped with electronic diagnostic capabilities. These include Verado, Optimax / DFI, Mercury 2-stroke, 4-stroke as well as Mercury branded engines equipped with Yamaha and Tohatsu powerheads. Detailed engine support listings along with information on the required diagnostic adapters is available on our website.

Mercury outboard support is now included as a standard feature in our Diacom Marine PC diagnostic system as well as our hand held TechMate and MerCruiser scan tools. This support is in addition to all of the existing sterndrive and inboard systems presently covered by our tools.

OBD-M Diagnostics

SPN's, FMI's and more...

Lets face it, we all know it's just a matter of time before a catalytic converter equipped, OBD-M compliant engine makes its grand entry into our lives. It may sneak in under the hatch of one of those slick new wakeboard boats or it may surprise you as a recent re-power in a decades old cabin cruiser. Nevertheless, if it's in your shop for service your customer will likely want it repaired immediately or sooner. In an effort to reduce some of the diagnostic shock you may experience when trouble-shooting one of these new engines for the first time we have put together a short primer on OBD-M diagnostics and its associated terminology.

OBD-M background

OBD-M is an acronym for On-Board Diagnostics - Marine. In much the same fashion as OBD-II for automobiles, the OBD-M standard was born out of a California Air Resources Board requirement for controlling emissions on gasoline sterndrive and inboard marine engines. Although its intention is similar to OBD-II, namely standardized diagnostics, OBD-M shares very little in common with automotive OBD-II standards. You cannot use an automotive OBD-II diagnostic scan tool to service an OBD-M compliant marine engine.

The foundation of OBD-M diagnostics is derived from a SAE standard used in the trucking and heavy equipment industries. Therefore the terminology and conventions used for OBD-M differ in many cases from that used by the automotive service industry. Following is an overview of the basics.

Suspect Parameter Numbers

As a marine technician your first inclination when troubleshooting an EFI equipped engine is usually to scan for fault codes. A single fault code number normally identifies the type of failure an EFI system is experiencing. OBD-M now divides the fault code system into two parts, the first part of which is referred to as a Suspect Parameter Number or SPN. A SPN represents a parameter, such as engine throttle position, that has had a unique identification number assigned to it. The SPN for engine throttle position is 51 for example.

SPN numbers are assigned either by the SAE, for standardized parameters or by a vehicle / engine manufacturer for "manufacturer specific" parameters. SPNs

Indmar ETX/CAT catalyst equipped engine

can have anywhere from 1 to 6 digits so don't be surprised to see a SPN such as 521153 which is MerCruiser's SPN for "Drive Lube".

A SPN is intended to direct service technicians to the specific parameter or component that the engine control module "suspects" is malfunctioning. However, unlike fault codes used in the past, a SPN typically does not indicate how a component has failed. That job is left to the Failure Mode Indicator.

Failure Mode Indicator

A Failure Mode Indicator or "FMI" is a number that ranges from 0 to 31 and is used in conjunction with a SPN to indicate how a component has malfunctioned. FMI numbers would reflect if a component's voltage, current, frequency, etc. was out of normal operating range. The SAE presently defines 22 of the 32 possible Failure Mode Indicator values. These 22 FMIs describe most common modes of sensor and component failures.

Assembling the pieces

Moving beyond the technical background associated with SPN and FMI values, let's look at a real-world example of how your first OBD-M fault might appear.

SPN: 100 FMI: 4

Your OBD-M compliant service tool (Diacom, TechMate, etc..) will provide a description for SPN 100 which equates to **"Engine Oil Pressure"**. A FMI value of 4 will produce a failure mode description stating **"Voltage below normal or shorted low"**.

At this point it is up to the technician to identify the device that is monitoring oil pressure and also determine the cause of the low voltage reading.

Notice that low or high pressure is not mentioned in the FMI description. SAE does not define FMIs related to pressure since pressure is normally conveyed to the ECM as a voltage output from a pressure sensor. It is therefore also up to the technician to determine if "low voltage" means low or high oil pressure in this case. Depending upon the type of sensor used this can vary. For example, in the case of most coolant temperature sensors, a high voltage output actually means a low temperature and vice versa. Always refer to the engine manufacturer's service manual for details on the sensors and interpretation of their output signals.

Fault Code Categories

Not only are OBD-M fault codes divided into two parts, SPNs and FMIs, they are also grouped into three general categories. The categories are **Active Faults**, **Previously Active Faults** and **Pending Faults**. The first two fault categories,

Active and **Previously Active** faults, are similar to the Active / History fault code categories used in past. It's the third category, **Pending Faults**, that is the new "kid" on the block.

Soon to be Active…

Pending Faults are a by-product of OBD-M's stringent requirements for monitoring any engine components that may affect emissions. OBD-M compliant engine control modules use more sophisticated techniques for monitoring sensors and components than were used in the past. Similar to modern automotive systems, OBD-M marine ECMs may now require an engine to be running for a predetermined time and under specific operating conditions before a particular component's diagnostic test is run. In addition, some engine components must now fail their test on two consecutive engine operating cycles before they are considered to be malfunctioning and then categorized as an Active Fault. This is where Pending Faults come into play.

Pending Faults are used for engine sensors and components that require test failures on two consecutive engine operating cycles to be considered faulty. A fault is categorized as "Pending" when the sensor or component fails its test on the first engine operating cycle. If the test fails again on the second operating cycle the Pending Fault is then converted to an Active Fault and the vessel's Malfunction Indicator would be activated.

Pending faults that have not been converted to an Active Fault can linger in the ECMs fault memory for up to 40 engine operating cycles upon which they are automatically cleared by the ECM. This situation can occur if a component failed its test on the first engine operating cycle but did not fail on the next consecutive operating cycle or subsequently thereafter.

Verifying OBD-M Repairs

Technicians will now need to refine their repair verification techniques to ensure that an OBD-M system malfunction has actually been solved. In the past, replacing a sensor and then running the engine for a short time while checking for the absence of fault codes related to that sensor usually meant the problem was fixed. This technique will not be sufficient when working on OBD-M compliant engines. Technicians will now require some insight into how and when the ECM runs its component diagnostic tests.

OBD-M repair verification is complicated by the fact that the ECM may require an engine to attain specific operating conditions before the component that was replaced is actually tested. Technicians will need to consult factory service documentation specific to the engine being repaired to determine when specific sensor and component tests are scheduled to be run by the ECM. Only then will you be assured that the repair you have just made passed the ECM's diagnostic test.

In addition, technicians must remember that the component they replaced may require two engine operating cycles to show up as an Active Fault so it is crucial to monitor the Pending Codes for that system. Remember, Pending Codes will allow you to identify a potential problem on the engine's first operating cycle.

Beyond the Faults

OBD-M entails much more than the new fault code system we have just described here. The incorporation of catalysts, oxygen sensors and closed-loop fuel control systems present entirely new challenges in the diagnosis and maintenance of marine engines.

Technicians will need additional training to learn new troubleshooting and repair techniques to successfully maintain these systems. Be sure to stay informed on the engine manufacturer's training schedules and also stay abreast of any new repair manuals, bulletins and related service publications.

EFI Service Tools

Updated service tools are also essential, so be sure to review your current
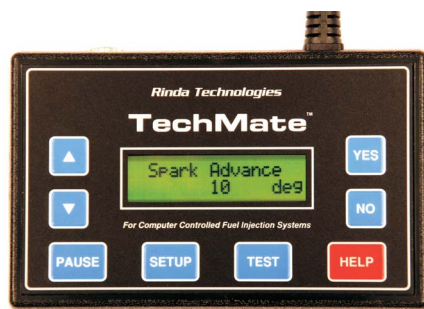
diagnostic tools and software to ensure it is updated to support the new engine models. Please contact us for details or visit our website at www.rinda.com.

control module's capabilities. For example, OBD-M's requirement for the incorporation of a high speed CAN communication port on every ECM has also fostered the growth of in-vessel networking.

With the CAN hardware built into the engine controller for diagnostics use, its capabilities can also be used to economically implement features such as electronic throttle and cruise controls, networked instrument panel displays, remote helm stations, networked vessel sensors, etc.

Keyless start systems, cruise control units and speed sensors that once required dedicated wiring connections to the engine control module are instead being connected to the vessel's CAN network. All of these devices share their data with the ECM via a high-speed 2 wire CAN data link. This greatly simplifies vessel wiring, reduces cost and makes accessory installation much easier.

This dramatic shift in both engine technology and vessel wiring poses broad challenges for marine service technicians. Not only have the electronic systems changed, the troubleshooting skills and diagnostic service tools needed to support these systems have also changed.

A thorough understanding of new engine technology (i.e. emission controls, closed loop operation, variable cam timing, supercharging) will be required. In addition, fault detection, retrieval and diagnosis methods have changed significantly, especially on catalyst equipped engines.

Technicians will need up to date factory training on these new systems to understand how and when faults are set, learn how the ECM handles emission vs non-emission related faults and learn how to take advantage of new engine diagnostic capabilities. We urge you to contact the marine engine manufacturers and obtain their training schedules.

Software updates for Rinda Technologies service tools are available for the latest generation OBD-M compliant marine engines. Please contact us for details or visit our website at www.rinda.com.

     EFI Connections

GM Debuts MEFI-6

GM's MEFI-6 Engine Control Module

GM Powertrain has introduced a powerful successor to their venerable MEFI-5 series of engine control modules. Named MEFI-6, the new ECM is targeted at both marine and industrial engine applications.

MEFI-6 is based on Delphi corporation's new E78 engine controller which can be found on 2011 GM vehicles such as the 6.0L Chevy Silverado and GMC Sierra 2500. However, the MEFI-6 version of the E78 has completely re-engineered software that is tailored for marine and industrial use.

The new ECM boasts a faster microprocessor and more memory than its MEFI-5 predecessor. This enables faster computational speed providing more precise engine control. MEFI-6 is fully OBD-M compliant and also features two independent CAN (Controller Area Network) busses which allow enhanced in-vessel networking and can provide redundancy for critical networked systems.

From a service perspective, it is important for marine technicians to note that MEFI-6 modules are NOT pin compatible with prior generation MEFI-5 modules. The new MEFI-6 ECM looks very similar to MEFI-5 however a keen eye will be able to spot a few physical differences such as redesigned cooling fins and module mounting tabs.

MEFI-6 began shipping to marine engine builders in January. Software updates for Rinda Technologies service tools supporting MEFI-6 are available. Please contact us for details.

Diacom® training videos now on Rinda Tech website

A suite of Diacom Marine training videos is now available on our website. The videos are viewable via any web browser, such as Internet Explorer or Firefox, and touch on various aspects of installing and using the Diacom Marine diagnostic system.

Presently, five videos are available that are designed to quickly familiarize marine technicians with Diacom and point out key features of the software.

Video 1 covers the installation of the Diacom software on your PC. Video 2 provides an overview of the program emphasizing important features and functions. This video also provides insight into useful aspects of the software that you may not have been aware of. Even if you are a seasoned Diacom user, be sure to watch this 12 minute feature tour.
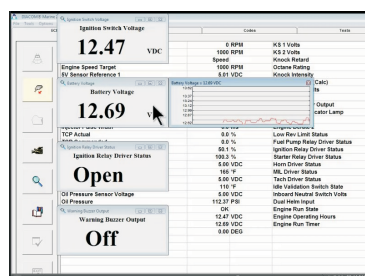
Videos 3 and 4 focus on selecting an EFI system type for diagnosis. These two tutorials provide detailed information on inboard / sterndrive and Mercury outboard system selection requirements. Choosing a correct EFI system type is the single most important step in utilizing Diacom to communicate with and diagnose an engine. Follow along as each system type is explained in detail.

Video 5 provides instructions on how to record live engine data, thereby allowing Diacom to serve as a flight recorder. Emailing the recorded data is also covered in this tutorial.

More videos are planned, please check the "Training" section of our website for updates and additions to this video series.

Important facts when buying a 64-bit PC for use with Diacom®

Keeping up with the fast paced changes in personal computer technology has always been challenging. Both the hardware and Windows operating system powering it continue to evolve at a rapid pace. Since Diacom Marine's inception, initially as a MS-DOS program in the early 1990's and then as a Windows based program later that decade, there have been PC industry advancements which drove changes in Diacom and its connection hardware.

Serial ports, once common on all notebook PCs, have vanished. They have been replaced by USB ports, thereby driving the change in Diacom's communication cable from a serial port type to USB type.

Today yet another change is underway with the advent of 64 bit PCs and 64 bit versions of Windows 7 (and Vista) . While some 32 bit PCs are still sold, if you shop for a new notebook PC you will likely find the 64 bit version as your only option.

Diacom has been redesigned to run on both older 32 bit PCs as well as the new 64 bit models. However, if you are transitioning into a new 64 bit PC you will need to use a redesigned version of our Diacom USB communication cable, part number 94073, as shown below.

#94073 cable required for 64 bit PCs

A cable upgrade program is available to assist in this transition. The program involves sending your present cable to us and purchasing a replacement for a nominal fee. A software update charge may also apply. Please call us for full details.

Note, we must receive your old USB cable in order to qualify. Also note, our new outboard engine support requires the use of the 94073 USB cable type.

Tech Tip

Qualifying
Static Engine Data

We regularly receive calls from marine technicians seeking advice when diagnosing engine related problems. It may be a hard-start condition, rough idle, excessive fuel consumption or even a no-start situation. Searching for solutions, technicians often call us eagerly looking for help.

Since we do not design, build or service engines (we're software engineers!), we advise technicians that engine related issues are best answered by the engine manufacturer. We do however like to point out that there are quick observations a technician can make to reveal acute EFI system problems. These simple observations apply to nearly any EFI equipped engine and are often overlooked during the initial troubleshooting process.

While many engine related problems are not electronic in nature and do not involve the engine's ECM or sensors, the EFI system is often the easiest to check for malfunctions. Using one of our diagnostic tools, technicians can quickly assess basic EFI system "health" by observing a handful of parameters displayed by the tools.

No Faults Found…
The most obvious item to check for when diagnosing an EFI engine is fault codes. Fault codes quickly point out EFI problems and are invaluable for pinpointing failed components. But what if no fault codes are present?

Technicians should be aware that sensor fault codes on many engines are

Diagnostic support for Volvo Penta OceanX drives

Volvo Penta's innovative OceanX series drives represent a new chapter in sterndrive technology. Featuring an advanced titanium-ceramic exterior coating along with two electronic monitoring sensors, OceanX drives represent the state-of-the-art in corrosion resistance, performance and durability.

In addition to the drive's tough electrically deposited coating, Volvo Penta engineers equipped OceanX drives with two types of sensors designed to detect water intrusion. One sensor monitors the drive oil, the second sensor monitors the bellows. This system is designed to provide an "early warning" to boat operators and help avoid costly repairs.

OceanX drive monitoring sensors are connected to an electronic OceanX module which is typically mounted on the engine. A

Drive Oil Quality (DOQ) sensor, located in the upper drive housing, measures the electrical conductivity of the drive oil and is thereby able to detect signs of water in the lubrication system. A second sensor, called the Water In Bellows (WIB) sensor, is located in the transom shield and is designed to detect the presence of water in the driveshaft U-joint bellows.

The OceanX system provides diagnostic information to technicians including sensor data, fault codes and other DOQ status information. OceanX diagnostics are available in both our hand held scan tools as well as our Diacom Marine PC diagnostic system.

Service tool software update kits supporting OceanX drives are immediately available. Please contact us for details.

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only set after the complete failure of a sensor. But what if a sensor hasn't completely failed? Instead, the sensor may be functional but sending incorrect information to the ECM.

Your next step should be to verify that the EFI system's critical sensors are providing reasonable static information to the ECM. Static sensor assessment should be done with Key-On and Engine-Off with the engine at ambient temperature. You can ideally perform the following steps first thing in the morning after the engine has sat overnight.

Step 1: Manifold Pressure
Look at the Manifold Pressure sensor reading. Since the engine is not running the MAP reading should reflect the barometric pressure at your location. If you are at sea level it should read about 30 inches of mercury or 101 kilopascals. A Faulty MAP sensor will affect the engine's fuel delivery schedule, from idle to full speed operation.

Step 2: Coolant Temperature
Now proceed to observe the Engine Coolant Temperature sensor reading. The temperature should be close to the ambient temperature where the engine is located. A misbehaving ECT sensor can produce start-up problems, overly rich fuel delivery

as well as other performance issues.

Step 3: Throttle Sensor Voltage
Check the Throttle Position Sensor voltage. Most engines require the TPS sensor voltage to be between 0.3 and 0.9 volts. Make sure the helm throttle lever is in neutral (closed throttle) prior to performing this check.

Step 4: Intake Air Temperature
If the engine is equipped with an Intake Air Temperature sensor, (some engines do not have one) take a look at its temperature. Similar to the ECT sensor, the IAT reading should be close to the ambient temperature.

Step 5: Engine Tach Signal
Lastly, if the engine won't start, observe the engine's RPM reading while cranking it. You should see the RPM value reflect the engine's cranking speed. This verifies that the ECM is receiving a tach signal from either the distributor module or crank position sensor.

In summary: Prior to engine start-up, just a few quick checks allow you to determine if critical ECM sensor readings "make sense". Some engines employ additional sensors such as fuel pressure and boost so be sure to observe all critical inputs needed for basic EFI system operation.

EFI Toolbox

Products for Marine Service Technicians
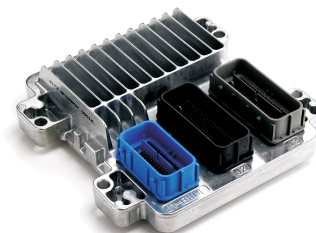
MerCruiser - Scan Tool

NEW *Version 6 software now supports Mercury outboards.*

Developed specifically for MerCruiser dealerships worldwide, this scan tool packs powerful diagnostic features and provides support for sterndrive and inboard EFI systems from virtually all major marine engine manufacturers. Version 6 software also includes support for Mercury outboard engines. The MerCruiser scan tool displays EFI system information allowing quick problem diagnosis. This tool also features functional test capabilities to exercise ECM outputs, has a built-in fuel injector tester and is supplied in a padded hard shell carrying case.

#94050m   **$399.00**

TechMate - Scan Tool

NEW *Version 6 software now supports Mercury outboards.*

Designed for independent repair shops, this close cousin of the MerCruiser scan tool displays complete EFI system information and supports all major sterndrive and inboard manufacturers. Version 6 software also includes support for Mercury outboard engines. TechMate displays live sensor readings, ECM fault codes and provides fault code explanations. Its built-in fuel injector tester performs single pulse and multi-pulse tests to locate injector problems. Functional test capabilities allow EFI outputs to be exercised for component testing. TechMate is supplied in a padded hard shell carrying case.

#94040   **$399.00**

Diacom® Marine - PC software

NEW *Version 2.5 software now supports Mercury outboards.*

Diacom Marine harnesses the power of your notebook PC to form a sophisticated EFI diagnostic system. In addition to supporting all major sterndrive and inboard engine manufacturers, version 2.5 now supports Mercury outboards. Diacom Marine allows a technician to quickly view engine performance data and zero in on malfunctions. Easily record and graph data from all accessible EFI system sensors and controls to capture elusive intermittent problems. Diacom Marine includes an extensive set of diagnostic features and has the broadest engine support in the marine industry.

#94010   **(standard kit)**   **$579.00**
#94030   **(includes CAN network adapter #94029)**   **$699.00**

EFI Diagnostic Adapters

#94005 GM-Delphi MEFI 1 - MEFI 4b	**$39.00**	
#94006 MerCruiser PCM / ECM 555	**$39.00**	
#94014 MerCruiser 2.8L / 4.2L D-tronic diesel	**$39.00**	
#94020 MerCruiser Thunderbolt V	**$49.00**	
#94021 MerCruiser 7.3L D-tronic diesel	**$49.00**	
#94023 Diacom Marine CAN adapter (gen 1)	**$249.00**	
#94024 2006-07 Volvo Penta EGC	**$49.00**	
#94026 2007-08 PCM / Crusader ECM-07	**$49.00**	
#94027 Merc / TechMate scan tool CAN adapter	**$169.00**	
#94029 Diacom Marine CAN adapter (gen 2)	**$249.00**	
#94011 Mercury outboard 4-pin adapter	**$39.00**	
#94013 Mercury Racing 2.5L outboard	**$39.00**	
#94028 Mercury outboard 2-pin adapter	**$49.00**	
#94037 In-line power adapter	**$49.00**	
#94038 Mercury outboard 3-pin adapter	**$39.00**	
#94039 Mercury outboard 18-pin adapter	**$49.00**	

For a complete product listing please visit: www.rinda.com

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