TROUBLE SHOOTING

Understanding MEFI Operation

Marine fuel injection technology has come a long way since the introduction of General Motors MEFI-1 engine controller back in 1992. The newest GM systems offered by marine manufacturers pack more features, have more computing power and control engine performance more precisely than ever before. While the sophistication of these engine control systems has increased dramatically over the past decade, the fundamentals of how they work (and what to look for when they don't) still remain essentially the same. This article reviews the basic concepts of how GM MEFI fuel injection modules operate in an attempt to increase your diagnostic and troubleshooting skills.

In order to properly run an engine, MEFI control modules rely on a handful of engine sensors as well as pre-programmed fuel and spark control information that is stored in the module's memory. Marine manufacturers develop this information by running their engines through a series of load and performance tests to create a computerized profile for each engine type. This profile, also known as an "engine calibration", instructs the MEFI module to deliver the correct fuel and spark amounts for all possible engine operating conditions. Knowing the basics of how the module uses this calibration and sensor information is the key to efficiently troubleshooting MEFI systems.

The fundamentals of fueling an engine have not changed since the days of the carburetor. For the most part, the greater the load an engine is placed under the more fuel it needs. Opening the throttle plate on a carbureted engine allowed more air to flow into the intake manifold along with more fuel. The fuel was essentially vacuumed out of the carburetor's jets in proportion to the intake air flow. MEFI controlled engines by contrast must sense the amount of load an engine is under, as well as determine other factors, and then "inject" the proper amount of fuel to run the engine properly.

At first glance, one might think that sensing how far the throttle plate was opened might be a good indicator for delivering the proper amount of fuel. Not exactly... Under steady running conditions, when you're not rapidly accelerating or decelerating, the Throttle Position Sensor readings have little to do in determining the correct amount of fuel needed to run an engine. Later in this article we'll see how the TPS is used by the MEFI module but for now, it's time to turn our attention elsewhere.

All MEFI control modules contain one or more numeric tables in their memory that

RPM	MAP-KPA				
	40	60	80	90	100
600	1.2970	2.4033	3.7003	5.0964	6.5002
800	1.6022	2.8000	4.0970	5.4016	6.5994
1000	1.8997	3.0975	4.4022	5.6992	6.6986
1200	2.1973	3.5019	4.8981	5.9967	6.8970
1600	2.2964	3.6011	5.0964	6.2027	7.1030
2000	2.1973	3.4027	4.7989	6.3019	7.1869
2400	2.2964	3.5019	4.6997	6.2027	7.1030
2800	2.4033	3.5019	4.7989	6.3019	7.3013
3200	2.5024	3.7003	5.2032	6.8970	7.6981
3600	2.7008	4.0970	5.7983	7.4005	8.4000
4000	2.9984	4.6005	6.2027	7.6981	8.4991
4400	3.0975	4.7989	6.4011	7.4997	8.4000
4800	2.9984	4.5013	6.2027	7.3013	8.2016
5200	2.8000	4.2038	5.9967	7.1030	7.8964

MEFI Injector Pulse Width Table

specify how much fuel should be delivered based upon engine load. While MEFI modules have continually advanced over the years and use increasingly sophisticated fueling strategies, the following fundamentals still apply: Engine load is primarily determined by sensing the current engine speed and reading the manifold pressure via the MAP sensor.

The MEFI module uses RPM and MAP to select data from a table with rows and columns of numbers that represent injector pulse width values (milliseconds of on-time). When the ECM needs to know how much fuel to deliver it reads the MAP and RPM, then it refers to the corresponding row and column in its fuel table to obtain the correct injector pulse width, also known as the "base pulse width". Once this pulse width value is obtained there are adjustments made to it based upon other engine operating conditions, however MAP and RPM are the main factors involved in selecting the base value. As you can see, if for some reason the MAP sensor was providing faulty information (i.e. bad sensor) the engine's load would be misinterpreted and as a result it would not be fueled correctly.

This is a good place to point out that the engine's spark advance is also selected in a similar fashion. Again, there is a table in the ECM's memory with rows and columns of numbers that specify degrees of advance. The desired advance value is chosen based upon RPM and MAP. Once the desired spark advance is obtained, other operating conditions are evaluated and used to adjust the value.

With these fundamental concepts stated you might ask how all of the other engine sensors come into play? In addition to a MAP sensor, MEFI systems typically include sensors for throttle position, coolant temperature, and knock detection. Also, depending upon the engine model, the system may include sensors for manifold air temperature and fuel pressure. All of these sensors play a vital role in engine operation and are used by the MEFI module to sense a variety of operating conditions. The following paragraphs will attempt to provide a basic understanding of their primary use.

The throttle position sensor (TPS) is probably the most misunderstood of all engine sensors. While readings from this sensor are important in determining idle and wide open throttle conditions (eliminating the need for mechanical switches), it's main purpose is to provide information related to engine acceleration and deceleration. Under normal running conditions, above idle and less than full throttle, the MEFI module uses TPS readings to sense if the operator is trying to rapidly accelerate or decelerate. It does this by determining how much the TPS voltage has changed since the last time the value was read. The sensor's absolute position and corresponding voltage are less important than the amount it has changed.

The MEFI module reads the TPS voltage every few milliseconds and calculates the difference between the current and last readings. If a large enough change is detected, adjustments are then made to the fuel injector's base pulse width value to provide extra fuel for rapid acceleration or a decrease in fuel for deceleration. Again, the exact TPS voltage is important at idle or wide open throttle, however during normal running conditions it's the change and rate of change in TPS voltage that matters most.

The coolant temperature sensor (CTS) provides important fueling information to the ECM when the engine is below it's normal operating temperature. Cold engines require more fuel to operate so the ECM uses the CTS information to enrich the air/fuel mixture in much the same way an automatic choke did on carbureted engines. Depending upon how cold the engine is, the MEFI module will increase the base pulse width values obtained from it's main fuel table and then gradually taper off the increase as the engine warms up. The CTS is also used for several other temperature dependent purposes including the modification of idle speed, IAC motor position, and spark advance as well as detecting engine overheat situations.

So far we have reviewed some of the main factors and sensors involved in fueling an engine correctly. Another important aspect is providing correct spark advance and control. As stated earlier, spark advance values, which are programmed into a table in the MEFI module's memory, are selected based upon engine RPM and MAP. These

RPM	KPA-MAP				
	40	60	80	90	100
600	16.88	16.88	16.88	16.88	16.88
800	16.88	16.88	16.88	16.88	16.88
1000	20.04	20.04	20.04	20.04	20.04
1200	22.15	22.15	22.15	22.15	22.15
1600	26.02	26.02	26.02	26.02	26.02
2000	35.86	34.10	33.05	31.99	29.88
2400	36.91	35.16	34.10	33.05	30.94
2800	36.91	35.16	34.10	33.05	30.94
3200	35.86	34.10	33.05	31.99	29.88
3600	35.16	33.05	30.94	29.88	28.83

MEFI Spark Advance Table

values specify the desired advance to apply to the engine but they can be reduced due to readings from the Knock Sensor (KS). The MEFI module monitors the knock sensor for signs of engine detonation. When detonation is detected it causes the desired spark advance values to be reduced (retarded) until the detonation ceases. The amount of retardation depends upon the duration and frequency of the KS signal. Once detonation ceases the spark advance is then gradually ramped back up to its original level after a short period of time. This type of system allows the engine to run at an optimum spark advance level as well as self adjust to different operating conditions and variations in fuel quality. A correctly functioning knock sensor is crucial to engine operation and performance. A malfunctioning sensor can lead to severe engine damage if engine detonation occurs and is not detected by the sensor.

Two other sensors that are optionally used in a MEFI system are a manifold air temperature sensor (MAT) and fuel pressure sensor (FPS). The MAT sensor, sometimes referred to as an intake air temperature sensor (IAT), is used in conjunction with the coolant temperature sensor to fine tune fuel delivery based upon the temperature of the air entering the engine. As with the CTS, this is accomplished by modifying the base injector pulse width values obtained from the MEFI module's main fuel table. MAT sensors are commonly found on multi-port engines and rarely used on throttle body injected systems.

Fuel pressure sensors are the most recent addition to some MEFI systems. Installed in the engine's fuel rail, FPS readings are compared to a table that contains nominal fuel pressure values for various manifold pressure levels. This system allows base injector pulse width values to be adjusted for fuel pressure regulator variations as well as changes in atmospheric pressure (altitude). Engines without fuel pressure sensors rely entirely on the MAP sensor for altitude compensation whereas the addition of a FPS allows more accurate adjustments to be made.

We hope this summary has increased your understanding of MEFI engine control systems. Always refer to engine manufacturer's service documentation for recommended diagnostic and service procedures.

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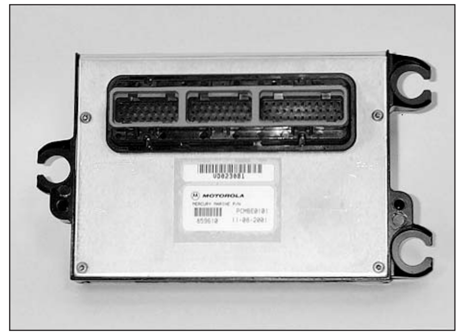
diagnostic tool (MerCruiser / TechMate scan tool or Diacom PC software). This eliminates the need to unbolt the MEFI module and check it's part number which is located on the module's bottom side.



Mercury Marine's PCM-555
Propulsion Control Module

MerCruiser has taken a completely new direction in engine control with the introduction of their PCM-555 propulsion control module. Designed by Mercury Marine and manufactured by Motorola, PCM-555 forms the foundation of Mercury's SmartCraft vessel management system. Sometimes referred to by industry insiders as the "Triple Nickels" module, PCM-555 and it's smaller brother ECM-555 now supplant all General Motors MEFI control modules on newly manufactured MerCruiser gasoline EFI engines.

Service technicians familiar with prior GM MEFI systems should note that these new Mercury modules require different troubleshooting procedures and updated diagnostic tool software for proper

Mercury Marine's ECM-555
Engine Control Module

diagnosis and service. PCM-555 and ECM-555 are unique to Mercury Marine products. Currently, PCM-555 is installed on all MerCruiser 496 cid V8 sterndrives and inboards. ECM-555 can be found on all other MerCruiser EFI engines.