

## BI-FUEL INTERFACE MODULE (BFIM) PROJECT

<b>Customer</b>	Ford Motor Company
<b>Duration</b>	September 1999 – December 2002, for Model Year 2003.5

### CHALLENGE

A major Automotive OEM needed an under-hood hardware module, software, and integration to add Bi-Fuel capability to an existing engine. The solution would go into production for Model Year 2003 in the Ford F-150 with Bi-Fuel capability of either CNG or Gasoline. The module to be designed must meet all requirements for automotive under-hood application with projected quantities of about 15,000 per year. The module would need to control up to 10 Gasoline Fuel Injectors and up to 10 Alternative Fuel Injectors. Alternative Fuel Injectors are usually low impedance injectors, which require high current to control. Because of the high current involved, additional design effort is required to avoid EMC and temperature issues.

### RESULTS

MAHLE Powertrain successfully delivered the hardware and software on time and at the agreed-upon price. The vehicle had the capability to be powered from either the CNG or gasoline tank with a selection switch in the cab of the vehicle. The MAHLE Bi-Fuel Interface Module (BFIM) hardware and software were designed from a blank sheet and tested, validated, and integrated into the vehicle. In addition, the team jointly developed an automatic switchover feature. This feature would detect when the CNG tank was near empty and automatically coordinate with the Engine Control Module to switch the engine fuel source to Gasoline.

A photograph of the production module is included in Figure 1.



Figure 1 – BFIM Production Module

### DETAILS

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MAHLE Powertrain was given the task of creating a production module that would allow an existing 5.4L 10 Cylinder engine to be used with either Gasoline or CNG fuel. The vehicle had two fuel tanks and a switch in the cab of the vehicle that selected the fuel to be used.

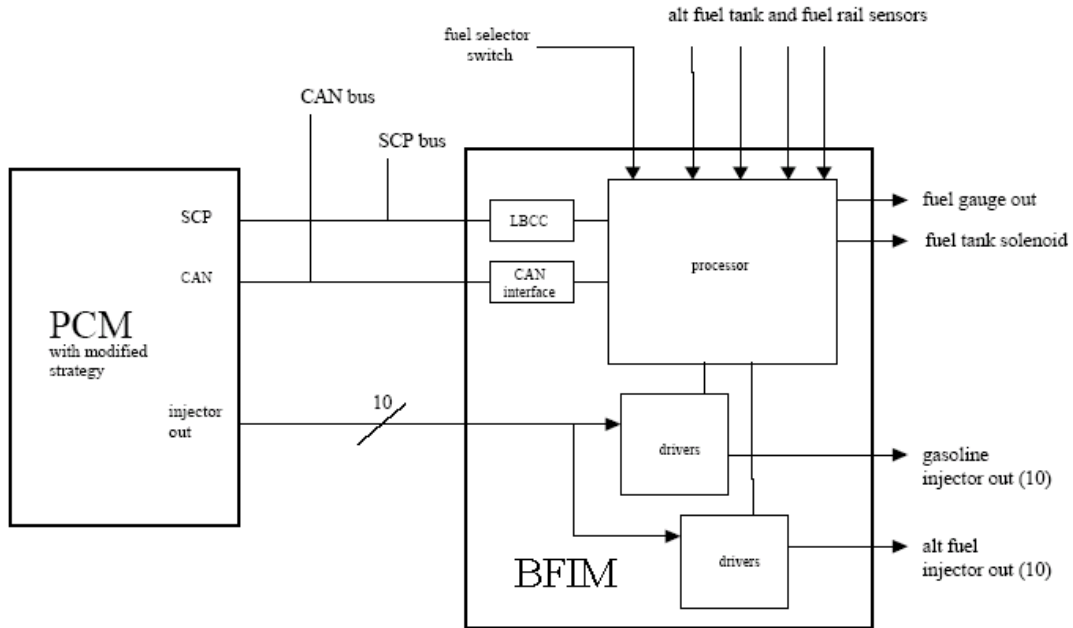
Switching between the two fuels could only be done after the ignition key was switched to the off position, except when the CNG tank was empty. When the CNG tank was empty, the system automatically switched the fuel source of the engine over to gasoline. The BFIM coordinated this switchover with the Powertrain Control Module. This switchover feature was jointly designed with the customer, including FMEAs and architectural analysis.

The MAHLE Powertrain team was constrained by the production requirements – timing, validation, and process. Additionally, the design had to be OBD 2 compliant and read and provide the fuel level of the CNG tank to the vehicle network.

MAHLE Powertrain performed the detailed electrical design and layout of the module. MAHLE Engineers also designed the case for the new module. In addition, the software was designed and implemented for the module by the MAHLE team.

Starting with a blank sheet, MAHLE Powertrain designed the module in 18 months, including prototype and Design Validation Test hardware phases. The module is manufactured by a third party hardware vendor. MAHLE Engineers also created and implemented a test bench designed to validate the final product before shipping to the customer. The software was designed and implemented in 12 months and was integrated into the vehicle successfully. The module met PPAP and environmental validation tests - including EMC and temperature – successfully. All production timing milestones were met.

In Figure 2, a block diagram of the Alternative Fuel electrical architecture is presented.



**Figure 2 – Block Diagram of the BFIM Alternative Fuel Architecture**

The module can control up to 20 Fuel Injectors, including low impedance alternative fuel injectors for CNG and LPG. It is rated for automotive under-hood temperature specifications and uses 12 VDC input power, including transient protection. The software and hardware are designed to be modular and can be customized for other applications.