# On-Board Diagnostics-II



William Quinn, July 15, 2020 --- Lexington Computer & Technology Group

# What is OBD-II?

- OBD-II systems are in most cars and light trucks today

- During the 1970s and 1980s manufacturers started using electronic means to control engine functions and diagnose engine problems

- This was primarily to meet EPA emission standards

- OBD-II, a new standard introduced in the mid-'90s, provides almost complete engine control and also monitors part of the chassis, body and accessory devices, as well as the diagnostic control network of the car

# What is the OBD-II port and what is it used for?

- Is an on-board computer-based system that monitors emissions, mileage, speed, and other data about your car

- Is the language of the Engine Control Unit (ECU) and was designed to help fight emissions and engine failures

- It allows a mechanic or anyone else to read the Diagnostic Trouble Codes (DTC) using a special scan tool

- It allows you to determine what the Malfunction Indicator Light (MIL) (aka the Check Engine Light) on your dash is referring to when it detects a problem

- Unfortunately, the actual protocols themselves are not available publicly (if only they'd open source!)

# Where did it come from?

- The State of California started requiring emission control systems on 1966 model cars to combat the smog problem in the LA basin

- To meet the EPA Clean Air Act of 1970, manufacturers turned to electronically controlled fuel feed and ignition systems. Sensors measured engine performance and adjusted the systems to provide minimum pollution. These sensors were also accessed to provide early diagnostic assistance

- At first there were few standards and each manufacturer had their own systems and signals. In 1988, the Society of Automotive Engineers (SAE) set a standard connector plug and set of diagnostic signals

- OBD-II is an expanded set of standards and practices developed by SAE and adopted by the EPA and the California Air Resource Board for implementation by January 1, 1996

# Why do we need it?

- The Environmental Protection Agency has been charged with reducing "mobile emissions" from cars and trucks and given the power to require manufacturers to build cars which meet increasingly stiff emissions standards

- OBD-II provides a universal inspection and diagnosis method to be sure the car is performing to OEM standards

- While there is argument as to the exact standards and methodology employed, the fact is there is a need to reduce vehicle emitted pollution levels in our cities, and we have to live with these requirements

# Does my car have OBD-II?

- All cars built since January 1, 1996 have OBD-II systems

- The OBD-II port is usually located under the dashboard, beneath the steering wheel column

- The port is called the Data Link Connector (DLC) and is a 16 pin connector

- Manufacturers started incorporating OBD-II in various models as early as 1994

- There are five basic OBD-II protocols in use, each with minor variations on the communication pattern between the on-board diagnostic computer and the scanner console or tool

- The **ISO 15765 CAN protocol**: Controller Area Network, is used on all vehicles manufactured after 2008

- While there are OBD-II electrical connection protocols, the command set is fixed according to the SAE J1979 standard
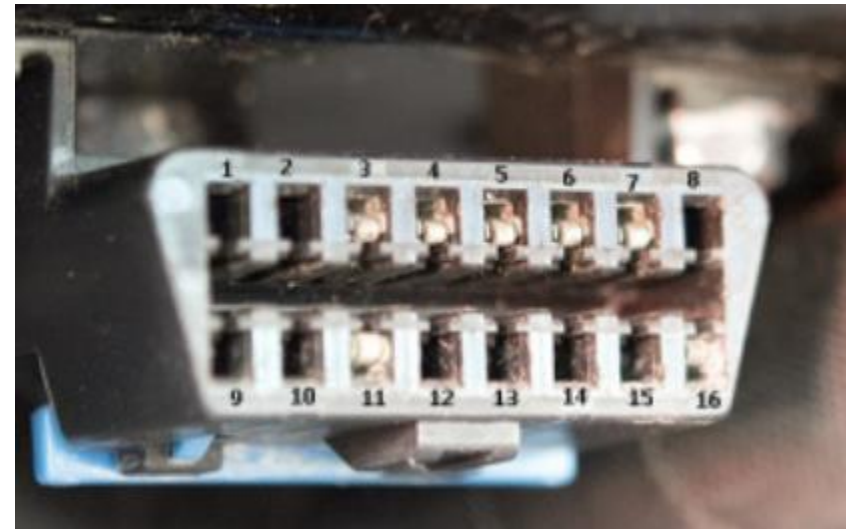
# How do we measure or view OBD-II output?

- A cable is plugged into the OBD-II J1962 connector and connected to the scan tool

- Scan tools on the market range from simple hand-held meters that display trouble codes, to computer-based systems, to smartphone apps

- Smartphone apps use a Bluetooth connection between the smartphone and the dongle that is plugged into the OBD-II connector to display the data in the app

- [OBD-ii port on Golf R-1.mp4](OBD-ii port on Golf R-1.mp4)

# What good does it do to measure OBD-II output?

- OBD-II signals are most often sought in response to a "Check Engine" light appearing on the dashboard

- The data provided by OBD-II can often pinpoint the specific component that has malfunctioned

- Provide valuable information on the condition of a used card purchase

- **https://www.youtube.com/watch?v=U2fygPCavq0**

# Tell me about that "Check Engine" light

- The Check Engine light is an Malfunction Indicator Light (MIL)
- There are three different types of signals/light
  - Occasional flashes show momentary malfunctions
  - It stays on if the problem is of a more serious nature, affecting the emissions output or safety of the vehicle
  - A constantly flashing MIL is a sign of a major problem that can cause serious damage if the engine is not stopped immediately
- In all cases a freeze frame of all sensor readings at the time is recorded in the central computer of the car
- Hard failure signals caused by serious problems will cause the MIL to stay on any time the car is running until the problem is repaired and the MIL reset
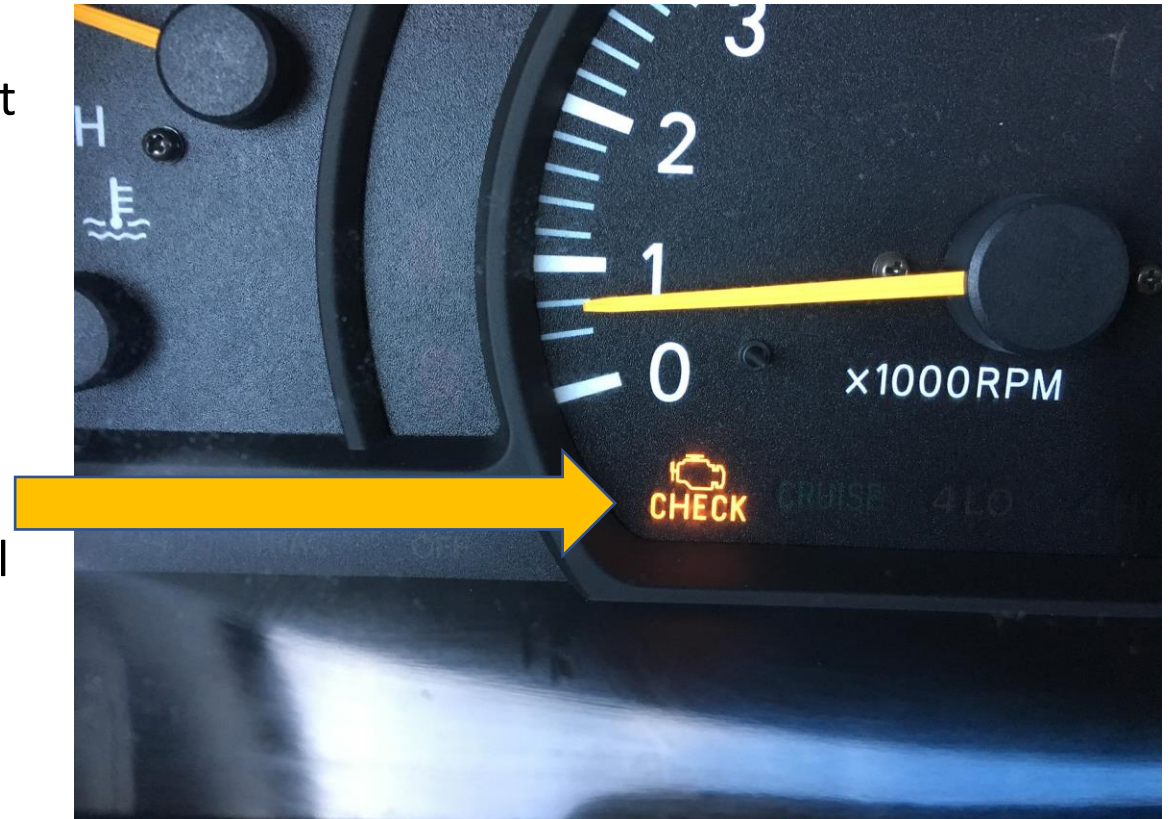
# Tell me about that "Check Engine" light, continued

- Intermittent failures cause the MIL to light momentarily and they often go out before the problem is located

- The freeze frame of the car's condition captured in the computer at the time of the malfunction can be very valuable in diagnosing intermittent problems

- In some cases, if the car completes three driving cycles without a re-occurrence of the problem, the freeze frame will be erased
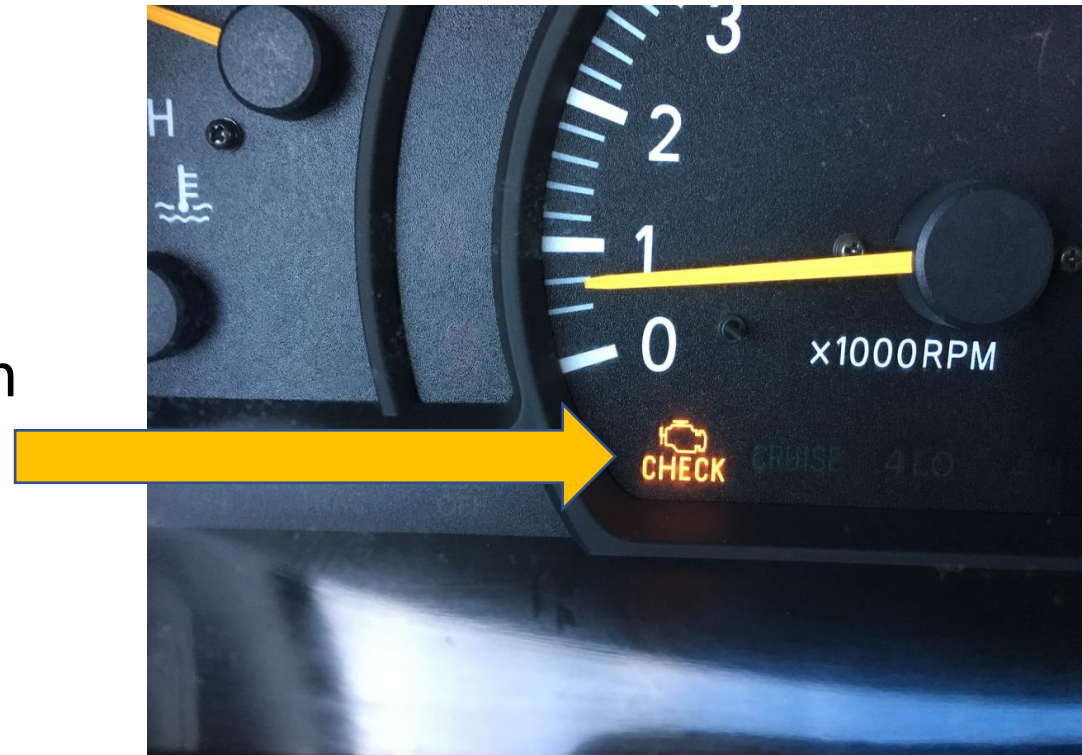
# OBD-II and your car's health

- Because of their investment in the equipment required, most repair shops charge a fee, some-times substantial, to attach the scanning equipment and diagnose problems using the OBD-II system signals

- Home mechanics and small shop technicians had been restricted from working with these signals by the cost and technical complexity of the equipment.

- With the introduction of more economical and user friendly scanning devices, it is now practical for almost anyone to access OBD-II signals and use them for their own testing and repairs.

- Scanners vary greatly in their complexity. The best connect easily and use software to quickly and automatically call up the OBD-II information

- A system connecting to a laptop or smartphone provides expanded memory for data and a graphing utility

- **https://www.youtube.com/watch?v=b6W3AUS76Pg**

**Bluetooth dongle**

# Proprietary Sensor Readings

- Though not part of the EPA's OBD II standard, the diagnostic read-outs used by dealership technicians are also read through the OBD II connector

- These service codes show you such things as knock sensor operation, ignition voltage, individual cylinder misfires, transmission shift points and ABS (Antilock Braking System) brake condition

- There can be over 300 readings available, depending on the vehicle manufacturer and model

- Scanners vary widely in the number of these signals that they can read.  Some show just the basic OBD or OBD II signals, others show the full range of service codes

# OBD-II and performance tuning

- Some people use the OBD-II to program extra performance from the car

- Earlier on-board computer systems had chips that could be replaced to adjust engine parameters for extra speed and power

- While the OBD-II systems are sealed and do not allow chip replacement, they do provide a real time data acquisition system that is useful to tuners

- Power loaders can actually reprogram the performance parameters of the OBD-II system to accommodate performance options

- At the current time the number of models they can service is limited, but the range is being extended. Be sure the person doing your reprogramming keeps the car in compliance with EPA emission standards

# Engine/Electronic Control Unit (ECU)

- The ECU can refer to a single module or a collection of modules

- These are the brains of the vehicle. They monitor and control many functions of the car. These can be standard from the manufacturer, reprogrammable, or have the capability of being daisy-chained for multiple features

- Tuning features on the ECU can allow the user to make the engine function at various performance levels and various economy levels. On new cars, these are all typically microcontrollers

- Some of the more common ECU types include
    - **Engine Control Module (ECM)** - This controls the actuators of the engine, affecting things like ignition timing, air to fuel ratios, and idle speeds
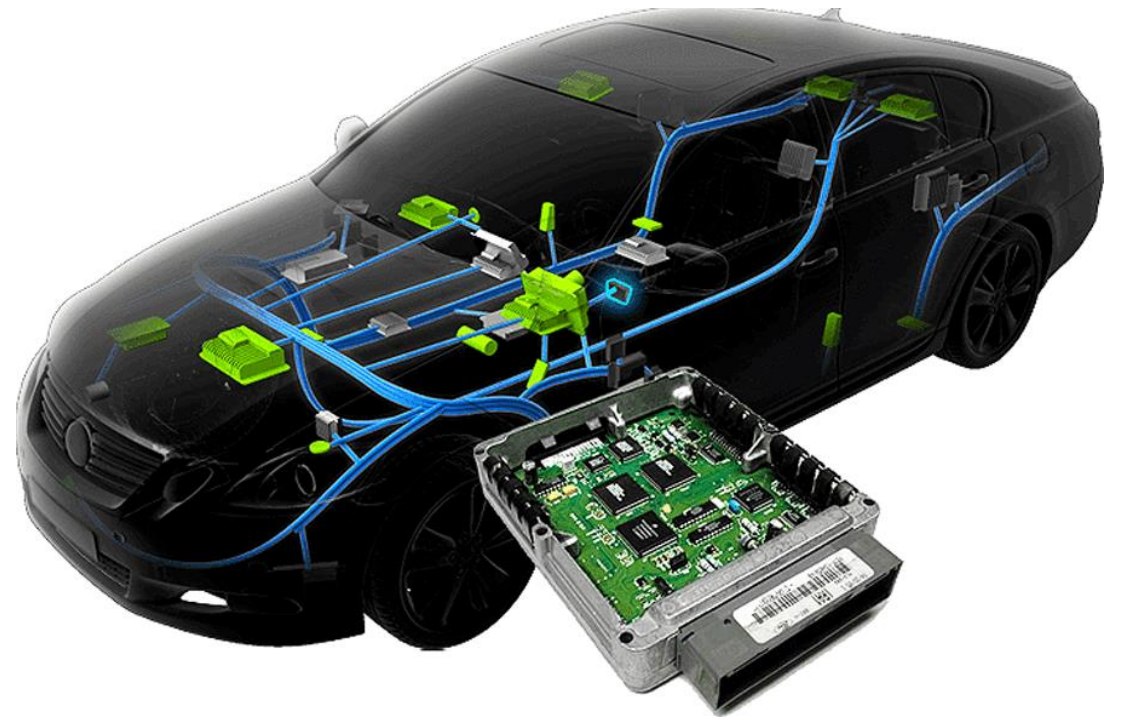
# Engine/Electronic Control Unit (ECU), continued

- **Vehicle Control Module (VCM)** - Another module name that controls the engine and vehicle performance
- **Transmission Control Module (TCM)** - This handles the transmission, including items like transmission fluid temperature, throttle position, and wheel speed
- **Powertrain Control Module (PCM)** - Typically, a combination of an ECM and a TCM. This controls your powertrain.
- **Electronic Brake Control Module (EBCM)** - This controls and reads data from the anti-lock braking system (ABS).
- **Body Control Module (BCM)** - The module that controls vehicle body features, such as power windows, power seats, etc.
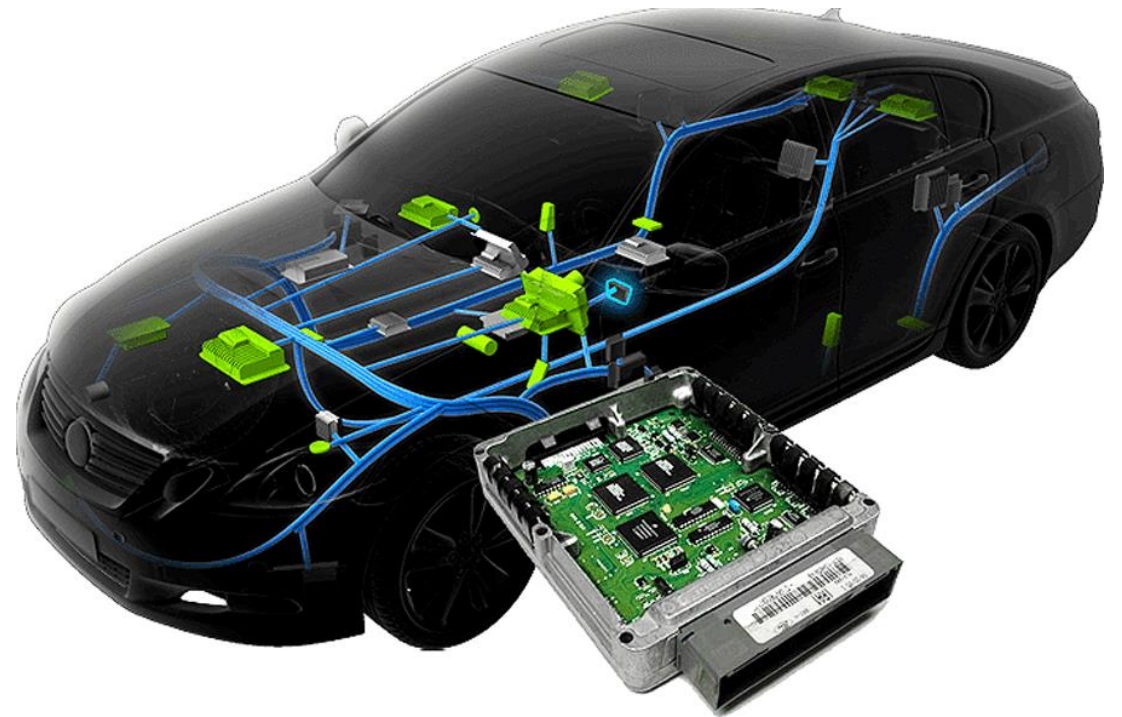
# Diagnostic Trouble Code (DTC)

- These codes are used to describe where an issue is occurring on the vehicle and are defined by SAE (you can find the whole spec here for a cost). These codes can either be generic or unique to the vehicle manufacturer

- These codes take the following format: XXXXX

- First unit identifies the type of error code:
  - **P**xxxx for powertrain
  - **B**xxxx for body
  - **C**xxxx for chassis
  - **U**xxxx for class 2 network

# Diagnostic Trouble Code (DTC), continued

- Second digit shows whether the code is manufacturer unique or not:
  - x**0**xxx for government-required code
  - x**1**xxx for manufacturer-specific code
- Third digit shows us what system the trouble code references:x**0**xxx for government-required code
  - xx**1**xx/xx**2**xx show air and fuel measurements
  - xx**3**xx shows ignition system
  - xx**4**xx shows emissions systems
  - xx**5**xx references speed/idle control
  - xx**6**xx deals with computer systems
  - xx**7**xx/xx**8**xx involve the transmission
  - xx**9**xx notates input/output signals and controls

# Diagnostic Trouble Code (DTC), continued

- Digits four and five show the specific failure code:
  - Xxx**00** to xxx**99** - these are based on the systems defined in the third digit

# Emission testing

- In the U. S., many states now use OBD-II testing instead of tailpipe testing in OBD-II compliant vehicles (1996 and newer)

- Since OBD-II stores trouble codes for emissions equipment, the testing computer can query the vehicle's onboard computer and verify there are no emission related trouble codes and that the vehicle is in compliance with emission standards for the model year it was manufactured

# Data loggers

- Data loggers are designed to capture vehicle data while the vehicle is in normal operation, for later analysis

    - Engine and vehicle monitoring under normal operation, for the purpose of diagnosis or tuning.

    - Some US auto insurance companies offer reduced premiums if OBD-II vehicle data loggers[20][21] or cameras[22] are installed - and if the driver's behavior meets requirements. This is a form of auto insurance risk selection

# Security issues

- Researchers at the [University of Washington](#) and [University of California](#) examined the security around OBD-II, and found that they were able to gain control over many vehicle components via the interface

- They were able to upload new [firmware](#) into the [engine control units](#)

- There have been reports of thieves using specialist OBD-II reprogramming devices to enable them to steal cars without the use of a key

- Security through obscurity - [is the reliance in security engineering on design or implementation secrecy as the main method of providing security to a system or component](#)

# Sources

- http://www.obdii.com/background.html#Why%20Measure
- https://learn.sparkfun.com/tutorials/getting-started-with-obd-ii/all
- https://en.wikipedia.org/wiki/On-board_diagnostics
- https://www.youtube.com/watch?v=b6W3AUS76Pg
- https://www.youtube.com/watch?v=U2fygPCavq0
- https://www.youtube.com/watch?v=EXYcPuB_quY
- https://www.youtube.com/watch?v=fNbrDiZvjrA

# Questions?

End of the presentation

William Quinn, July 15, 2020 --- Lexington Computer & Technology Group