In-Vehicle Computer Networks

An Overview

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In The Beginning . . .

- **Automotive electronics make an appearance**
  - **Microprocessors appear.**
  - **Sensor and Control applications.**
  - **Non-entertainment applications.**
- **Engine computer**
  - **Primarily to improve emissions.**
  - **Connected only to the sensors near it.**
  - **Diagnostic connection to special equipment.**
- **Drive train computer(s)**
  - **Engine and transmission.**
  - **Improve emissions and enhance performance.**
  - **Individual processors, only connected to the sensors near it.**
  - **Minimal interaction between processors.**
  - **Individual diagnostic connections to special equipment.**

Early Data Comm's and 'Networks'

- **GM - ALDL**
  - » **Assembly Line Diagnostic Link. Also known as 8192 UART.**
  - » **Still in use.**
- **Chrysler - SCI**
  - » **Serial Communications Interface (Motorola SCI port), 62.5 kbps.**
  - » **A dedicated high-speed link.**
  - » **Between an engine controller and off-board test equipment.**
- **Chrysler - CCD**
  - » **Chrysler Collision Detection. 7812.5 bps**
  - » **Still in use.**
- **Ford - ACB / ACP**
  - » **Audio Control Bus or Protocol**
  - » **Remote control of entertainment equipment.**
- **There are / were others . . .**

On-Board Diagnostics Phase 2 (OBD-II)

- **Increased processing power, enhanced algorithms, and improved control**
- **A desire to utilize the new capabilities**
- **EPA and CARB**
  - **» EPA - Environmental Protection Agency**
    - Cite: 40 CFR Part 86 Section 86.094
    - Note that these requirements are minimum functionality issues.
  - **» CARB - California Air Resources Board**
    - California Code of Regulations (CCR) Title 13 Section 1968.1
    - Changes made in both CFR and CCR so that they are compatible. (Eliminate contentions, jurisdiction, and precedence issues.)
  - **» To paraphrase the law . . .**
    - If thou maketh a car or light truck for sale in this country (m.y. 1996 and later) then:
    - The vehicle shall have a J1962 diagnostic connector in it.
    - The connector shall support at least one of three approved communications standards.
    - The vehicle shall properly respond to (at least) the mandated diagnostic queries and commands.

On-Board Diagnostics Phase 2 (OBD-II)

- **OBD-II Network Standards**
  - **J1850 VPW**
    - Adopted by GM; also known as Class 2.
    - Adopted by Chrysler (known as J1850).
    - Some references to VPW mode heard about in regards to Toyota (and Honda ?).
    - 10.4 kbps, single wire.
  - **J1850 PWM**
    - Adopted by Ford; also known as Standard Corporate Protocol (SCP).
    - Also seen in some Mazda products.
    - Some references to PWM mode heard about in regards to Mitsubishi.
    - 41.6 kbps, two wire balanced signal.
  - **ISO 9141 and ISO 9141-2 (also known as ISO 9141 CARB)**
    - Seen in some Chrysler and Mazda products.
    - Seems to be more common in Europe.
    - 10.4 kbps, single wire.

On-Board Diagnostics Phase 2 (OBD-II)

- **OBD-II Network Standards**
  - **» The three network protocols are totally incompatible**
  - **» Common characteristics**
    - – The network standards describe primarily the physical and data link layers
    - – The application layer is referenced, usually for specific messages.
    - – For more detail about the application and other layers, refer to: J1979, J2012, J2178 (three parts), and J2190.
  - **» Details on J1850 and ISO on slides #16 and #17**

Other Network Standards

- **Refer to J2056/2 Survey of Known Protocols**
  - Last updated April 1993.
- **Non - OBD Networks**
  - **» Keyword Protocol 2000 (ISO 14230, three parts)**
    - Uses the same physical layer as ISO 9141.
    - Standard addresses physical, data link, and application layers.
  - **» CAN - Controller Area Network**
    - Developed by Robert Bosch GmbH.
    - Been around since the late 80's.
    - Addresses data link and application layers.
    - Does not address physical layer or speed parameters.
    - Multiple versions: 1.0, 2.0A, and 2.0B.
    - Has been adopted as a basis for several national (SAE) and international standards (ISO).
    - ISO 11898 (High Speed) and ISO 11519 (Low Speed).

Other Network Standards

- **Class 2**
  - GM standard using the J1850 VPW implementation.
  - True Class 2 implementation and design is actually physical layer and data link layer independent.
  - Note that this protocol is a "Superset" of the minimum required OBD-II.
  - J1850 VPW version: 10.4 kbps and 41.6 kbps (in special diagnostic mode).
- **Single Wire CAN**
  - The new standard at GM to replace J1850 VPW.
  - Physical layer is a single wire CAN implementation.
  - Class 2 messaging strategy most likely to remain unchanged. (My guess.)
  - SAE draft standard: J2411.
  - 25.0 kbps and 80.0 kbps (in special diagnostic mode).
- **SCP**
  - Standard Corporate Protocol.
  - Ford's messaging strategy implemented using J1850 PWM.
  - Note that this protocol is a "Superset" of the minimum required OBD-II.

Other Network Standards

- **DeviceNet**
  - A CAN network designed for industrial machine control.
  - CiA - CAN in Automation.
- **J1939**
  - A CAN network for heavy trucks and buses.
  - References CAN version 2.0B.
  - Baud rate: 250 kbps.
  - Two wire balanced signal.
- **J1708**
  - Promoted for use in heavy truck and bus applications.
  - The bus structure is, essentially, EIA-RS-485.
  - Baud rate: 9600 bps.
- **TTP - Time Triggered Protocol**
  - Developed and promoted by Technical University of Vienna.
  - Designed for Class C network applications.
  - Motorola has announced support.

Other Network Standards

- **ITS Data Bus**
  - Intelligent Transportation Systems Data Bus (IDB).
  - PC's and other peripherals involved.
  - Used to tie together ITS, information, entertainment, and other computer and peripheral equipment.
  - Intel, Microsoft, GM, and Ford are very active here.
  - Standards under development include: J2355, J2366, J2367, and J2368.
  - Information sources: http://www.itsa.org
    http://www.itsa.org/usstandcat.nsf
- **PC type networks**
  - USB - Universal Serial Bus; possible companion to IDB.
  - FireWire - IEEE1394; possible use in IDB-M (multimedia).
- **and there are more**
  - Old ones, new ones, . . .

Crystal Ball

- **What's been heard and who'll be using what**
  - **GM**
    - Single Wire CAN.
    - Predicted for model year 2000.
    - To replace J1850 VPW.
  - **Ford**
    - CAN bus.
    - Predicted within 3 years.
    - To replace J1850 PWM.
  - **Chrysler**
    - Still migrating toward J1850 VPW.
    - Little further information available.

Architecture

- **Now On-The-Road**
  - » **Processors galore**
    - – Engine, transmission, ABS, air bag, driver door, passenger door, body control, cell phone, entertainment system, information system, ...
    - – Processors may be networked, but only by function.
    - – Data may be shared, but only within a single network.
    - – Control may be distributed, but only within a single network.
  - » **Multiple but <u>Isolated</u> networks**
    - – Network #1: Safety
      (e.g. CAN - ABS, air bag, ...).
    - – Network #2: Emissions, diagnostics, comfort
      (e.g. J1850 - engine, body, ... controllers)
    - – Little to no connection/interaction between networks.

Architecture

- **Coming Down the Pike**
  - **» Multiple and <u>Connected</u> networks**
    - Network #1: Safety
      (e.g. CAN - ABS, air bag, ...).
    - Network #2: Emissions, diagnostics, comfort
      (e.g. J1850 - engine, body, ... controllers)
    - Network #3: Entertainment, information, ...
      (e.g. IDB - stereo, cell phone, driver information, ...)
    - All networks tied together via gateways / firewalls.
    - Information sharing among and between networks.
    - Test equipment may be more generic in nature.
    - Single point communications to external test equipment.
    - Single point access to all vehicle network(s) and all connected modules.

Architecture

» **Expectations and Predictions (?)**

– GM:

Plans to replace J1850 VPW with Single Wire CAN (SWC)
by model year 2000.
Has already built an IDB gateway for the Cadillac demonstrator.
Has stated they are
"ready to put IDB gateways in any GM car worldwide by model year 2000."

– Ford:

Plans to use CAN as the basic vehicle bus within the next 3 years.
(to replace J1850 PWM).
Plans to use IDB for convenience.
Plan to develop their own gateway.

– Chrysler:

Supports IDB.
Developed a Jeep demonstrator.
Plans to develop their own gateway.

Additional Information

- **Device database on our web site**
  - http://www2.ari.net/avt-inc/devices.htm
- **Evaluation Engineering magazine**
  - Two articles about J1850 and ISO 9141.
  - January and March of 1998.
  - http://www.nelsonpub.com/ee/

Technical Details

- **J1850 VPW (Variable Pulse Width)**
  - Symbols are defined in J1850 specification.
  - Nominal 10.4 kbps.
  - Single wire with ground reference.
  - Bus idles low (ground potential).
  - Bus high is +7v, +3.5v decision threshold.
  - Bus high is dominant. Zero bits are dominant. (Bus high is not zero !)
  - GM does not use IFRs. Chrysler uses a few.
  - Messages limited to 12 bytes including CRC and IFR bytes.
  - Carrier Sense Multiple Access with Non-Destructive Arbitration (CSMA/NDA).
- **J1850 PWM (Pulse Width Modulation)**
  - Symbols are defined in J1850 specification.
  - 41.6 kbps.
  - Two wire differential signal (ground referenced).
  - Bus high is +5v. (There is a dominant state.)
  - Ford implementation requires IFRs.
  - Messages limited to 12 bytes including CRC and IFR bytes.
  - CSMA/NDA.

Technical Details

- **ISO 9141-2**
  - UART based.
  - 10.4 kbps.
  - K-line required, ground referenced.
  - K-line only used for normal communications.
  - *L-line only required on tester, ground referenced.*
  - *L-line is only used for initialization.*
  - K-line idles high.
  - K-line high is Vbatt.
  - K-line low is dominant.
  - Diagnostic messages are limited to 12 bytes including CRC byte.
- **Keyword Protocol 2000**
  - Physical and data link same as ISO 9141.
  - Baud rate is 1.2 to 10.4 kbps.
  - Messages may contain up to 255 bytes in the data field.

Contact information

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- **SAE**
  - **SAE and ISO specifications.**
  - **http://www.sae.org**
  - **724-776-4841**
- **ANSI**
  - **ANSI and ISO specifications.**
  - **http://www.ansi.org**

Warnings

- **Terminology**
  - » **Beware of mis-use and confusion.**
  - » **Often used incorrectly and/or differently by different people.**
- **Information provided is up-to-date (best of my knowledge).**
  - » **Use this information with caution.**
  - » **Things change, sometimes quickly, oft times quietly.**
  - » **Manufacturers operate in their own world, usually.**
  - » **There are many more players in the field than there used to be.**