In-Vehicle Networking

Lecture 4 Introduction to SAE J1850
BAE 5030 - 003
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SAE J1850 Overview - History

- Developed as a network protocol for use in automobiles
  - Driven by:
    - Distributed controllers for engine, trans., instrumentation, etc.
    - Need to reduce wiring cost
    - Need for centralized diagnostics
    - Requirements for single point emissions diagnostics
- Proprietary networks developed
  - 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.
    - CCD (Chrysler Collision Detection)
      - Used in Deere tractors in the 1990s (7812.5 bps)
  - GM – ALDL (Assembly Line Diagnostic Link)
    - AKA 8192 UART
  - Ford - ACB / ACP (Audio Control Bus or Protocol)
    - Remote control of entertainment equipment.
  - Others
- Recommended practice in 1987, "the" class B protocol in 1994

J1850 - characteristics

- Bus architecture
- Two Physical Layers
  - VPW – Variable Pulse Width
    - 10.4 kbps
    - 40 m max length, 32 max nodes
    - Single wire voltage signaling
      - » Idles low at ground
      - » High nominally 7v, Range 4.5v to 20v
      - » Low nominally <3.5v, Range 3.5v to 0v
      - » High is dominant
    - Wide and narrow symbols
      - » Zero symbol dominant
    - Carrier Sense Multiple Access with Non-Destructive Arbitration (CSMA/NDA).
  - PWM – Pulse Width Modulated
    - 41.6 kbps
    - 40 m max length, 32 max nodes
    - Two wire differential voltage signaling
      - » Bus high is +5v differential
      - » High is dominant
- Common Data Link Layer
  - In-Frame Response
    - Ford implementation requires IFRs
    - GM does not use IFRs
    - Chrysler uses some
  - Messages frame
    - limited to 12 bytes including CRC and IFR bytes.

SAE J1850 Overview - History

- Emissions diagnostics requirements
  - Drove standardization effort
  - Administered by:
    - Originally California Air Resources Board (CARB)
    - US wide requirements from EPA
    - CARB and EPA requirements harmonized
  - Post 1996 requirements – OBD-II:
    - J1962 diagnostic connector
    - Support for at least one of three (incompatible) protocols
      - J1850 VPW (GM Class 2 and Chrysler J1850)
      - J1850 PWM (Ford Standard Corporate Protocol (SCP)
      - ISO 9141 and ISO 9141-2 (also known as ISO 9141 CARB)
        - » 10.4 kbps, single wire (similar to LIN)
        - » UART based
        - » Message frame - 12 bytes including CRC byte
    - Proper response to mandated diagnostic queries and commands.

SAE J1850 Overview - OBD-II

- Three incompatible protocols in one connector
  - J1850 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.
  - ISO 14230 - Keyword Protocol 2000 (KWP 2000)
    - Physical, data link, and application layers
    - Diagnostic services and transport
    - Developed in Europe as KWP 2000
    - Message length up to 255 bytes

OBD-II Protocol "standardization"- From Wikipedia

- SAE J1850 PWM (pulse-width modulation - 41.6 kbaud, standard of the Ford Motor Company)
  - pin 2: Bus+
  - pin 10: Bus–
  - High voltage is +5 V
  - Message length is restricted to 11 bytes, including CRC
  - Employs a multi-master arbitration scheme called 'Carrier Sense Multiple Access with Non-Destructive Arbitration' (CSMA/NDA)
- SAE J1850 VPW (variable pulse width - 10.4/41.6 kbaud, standard of General Motors)
  - pin 2: Bus+
  - Bus idles low
  - High voltage is +7 V
  - Decision point is +3.5 V
  - Message length is restricted to 11 bytes, including CRC
  - Employs CSMA/NDA
- ISO 9141-2. LIN like protocol with a data rate of 10.4 kbaud. Primarily used in Chrysler, European, and Asian vehicles.
  - pin 7: K-line
  - pin 15: L-line (optional)
  - UART signaling (though not RS-232 voltage levels)
  - K-line idles high
  - High voltage is Vbatt
  - Message length is restricted to 11 bytes, including CRC
- ISO 14230 KWP2000 (Keyword Protocol 2000)
  - pin 7: K-line
  - pin 15: L-line (optional)
  - Physical layer identical to ISO 9141-2
  - Data rate 1.2 to 10.4 kbaud
  - Message may contain up to 255 bytes in the data field
- ISO 15765 CAN (250 kbit/s or 500 kbit/s). **By 2008, all vehicles sold in the US must implement CAN.**
  - pin 6: CAN High
  - pin 14: CAN Low
- Note that pins 4 (battery ground) and 16 (battery positive) are present in all configurations. Also, ISO 9141 and ISO 14230 use the same pinout, thus the connector shape does not distinguish between the two.

J1850 Message Frame

| IFS | S O F | Header (8/24) | Data | CRC (8) | E O D | N B | IFR Data | CRC (8) | E O F | IFS |

12 bytes or less
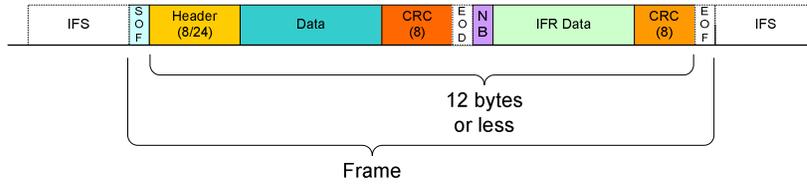
Frame

- SOF – Start of Frame 200 us at HIGH potential followed by the remaining frame encoded as bit symbols
- Header – One or three byte identifier
  - Priority (3bits) (000 = high)
  - Header length (1 bit)
  - In-Frame Response (IFR) Required? (1 bit)
  - Address Mode (1 bit, 1=Physical, 0=Functional)
  - Message Type (2 bits)
  - Additional two bytes (If Physical address)
    - Physical addressing, destination address (8 bits) and source address (8 bits)
- Data bytes
- CRC – Cyclical Redundancy Check value for header plus data
- NB – Normalization Bit
- IFR Data
- IFR CRC - Cyclical Redundancy Check value IFR data

SAE J1850 Bus Signals

- **J1850 VPW Bus Symbols**
  - Bus alternates between passive and active for each bit
  - High bus voltage is dominant
  - Dominant symbols
    - Active bus: Long dominates short pulses
    - Passive bus: Short dominates long pulses

- **J1850 PWM Bus Symbols**
  - Fixed bit time
 - Short or long pulse beginning at start of bit time
  - Long dominates short

Logic 0   Logic 1

Passive Bus   64us   128us

Active Bus   128us   64us

Dominant State   Passive State

Dominant
1
Passive

Dominant
0
Passive

Bit Length
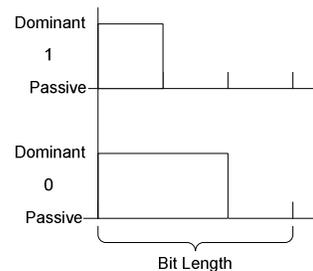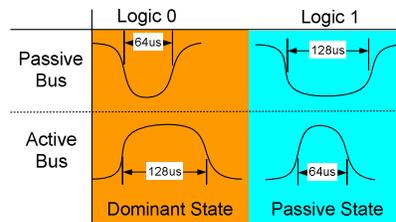
SAE J1850 Bus Arbitration - VPW

- Lower numbered identifier = higher priority
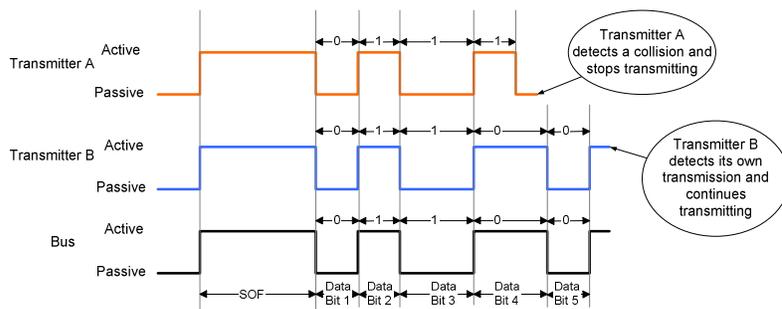
SAE J1850 Bus Arbitration - PWM

- Lower numbered identifier = higher priority
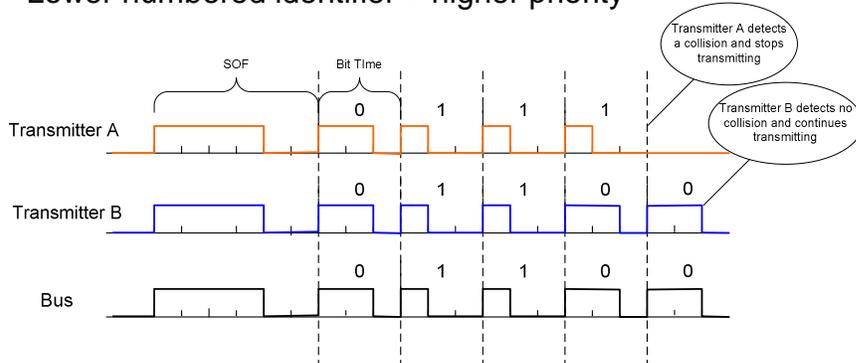
SAE J1850 Bus Drivers

PWM

VPW
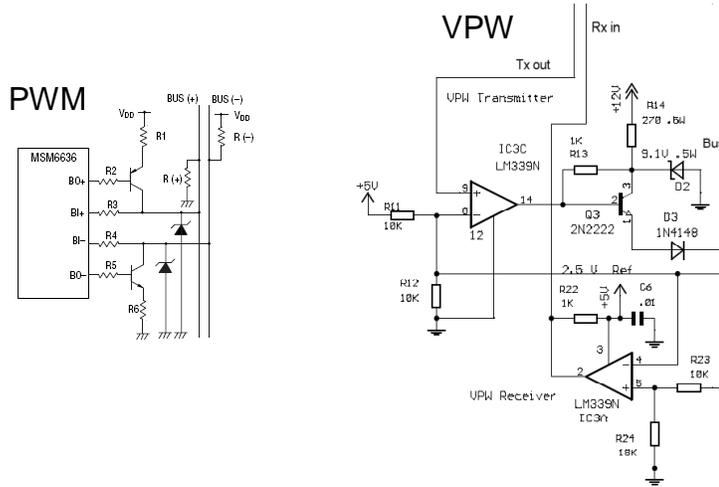
Costs and Speeds for Automotive Networks

D2B, MOST
token ring
optical bus

Byteflight
optical bus

TTx (in definition)
time triggered
fault tol, dependable
2x2 wire

CAN-C
event triggered
dual wire

CAN-B

J1850
pier to pier
prioritized messages

LIN
master-slave
single wire bus
no quartz

Speed [bit/s]

25.6M
2M
1M
125K
20K

1   2   4.5   10

incremental cost per node [$]

7
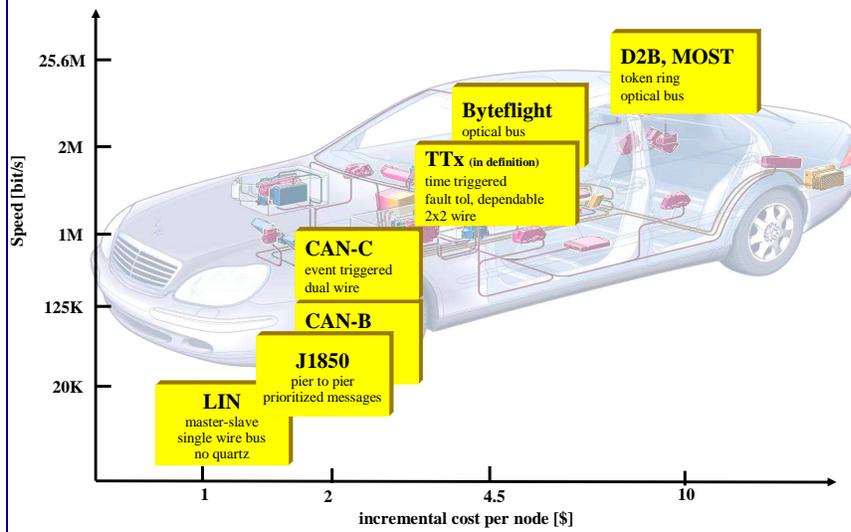
J1850 to ISO 7498 Mapping

ISO 7498 Part 1