CAN and Multiplexing

Hydro Electronic Devices, Inc.

CAN and Multiplexing

Training Objectives

- **Summarize CAN multiplexing history & origins**
- **Explain CAN technology**
- **Explain CAN benefits**

What is CAN

- **CAN stands for Controller Area Network**
- **Definition: Serial bus communication for real-time control application.**

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What do we mean by CAN?

- **CAN is a communication across a pair of wires to different nodes/microprocessors**
- **Messages on the CAN bus do not carry addresses, only identifiers**
- **Every node sees every message on the CAN bus**
- **CAN is a differential signal on two wires**

History

- CAN (Controller Area Network) was created by Robert Bosch Gmbh in mid 1980's
- Version 1.2 had 11 bit identifiers
- Version 2.0B released Sept. 1991 provided for 11 bit and 29 bit identifiers
- Base patent still held by Bosch

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History

- 1983 Developed by Bosch
- 1987 First CAN chips by Intel & Philips
- 1992 CAN is introduce to automation
- 1992 First car with CAN (Mercedes Benz)
- 1994 SAE J1939 released
- 1995 ISO 11898 is released

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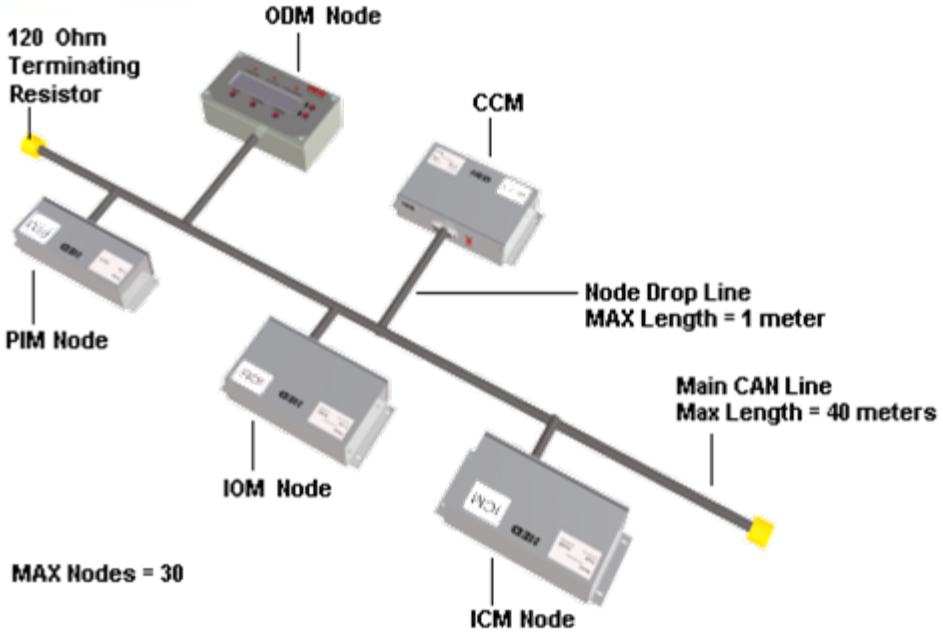
CAN System



Where is CAN used?

General Applications

- Cars
- Packaging equipment
- Medical systems
- Photo copiers
- Marine controls and navigation systems
- Elevator controls

HED examples

- Military vehicles
- Agriculture machinery
- Construction equipment
- On and off highway equipment

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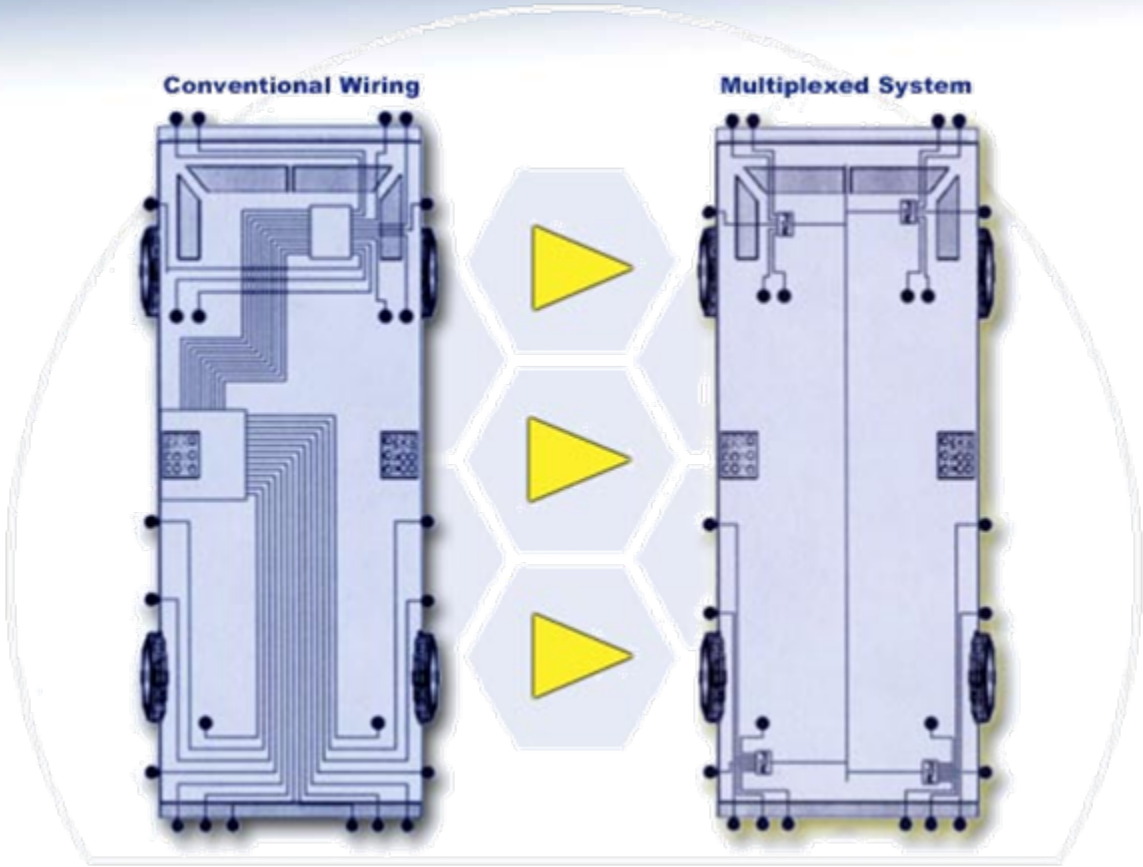
CAN application

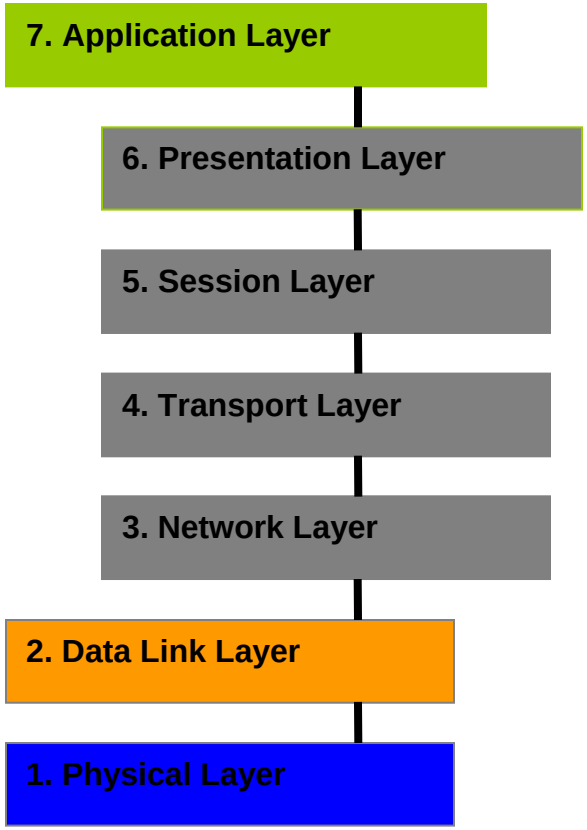


General Specifications of CAN/J1939

- **Communication rate is 250Kbits/second-J1939**
  - **CAN max is 2Mbits/second**
- **11 or 29 bit identifier**
  - **CANOpen is only 11 bit identifier**
  - **CAN 2.0 is backward compatible**
- **120 ohm terminating resistors**

Different layers of CAN

- **We are interested:**
  - **Physical**
  - **Data Link**
  - **Application**
- **All the layers together make up the OSI (open system interconnect)**



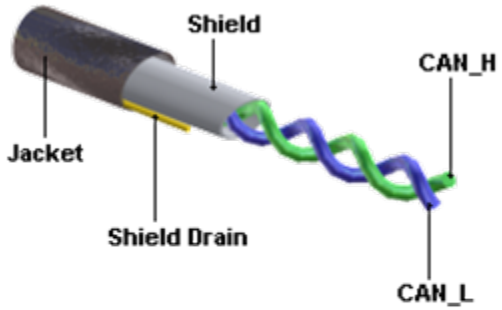
CAN standardization

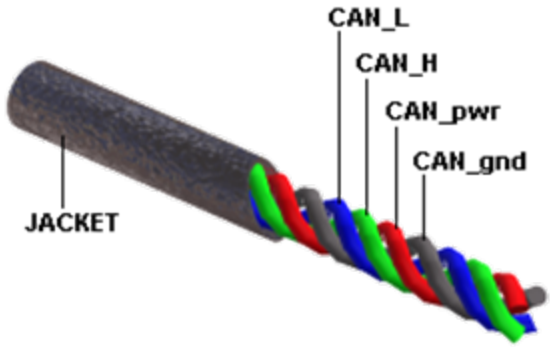
Application Profile				CANopen application profiles	SAE J1939 -based application profiles
Device Profile			DeviceNet device profiles	CANopen device profiles	
Application Layer		SDS EN 50325-3	DeviceNet EN 50325-2	CANopen EN 50325-4	
Data Link Layer	ISO 11898-1 (11-bit ID)			ISO 11898-1 (11-bit *and* 29-bit ID)	ISO 11898-1 (29-bit ID)
Physical Layer	ISO 11898-2				ISO 11898-2

Physical Layer of CAN

- **Consist of the hardware needed to communicate from node to node**
  - **Physical/driver chip**
    - **Converts 1's & 0's to differential voltage**
  - **Twisted pair of wire**
  - **Connectors**

CAN Wire

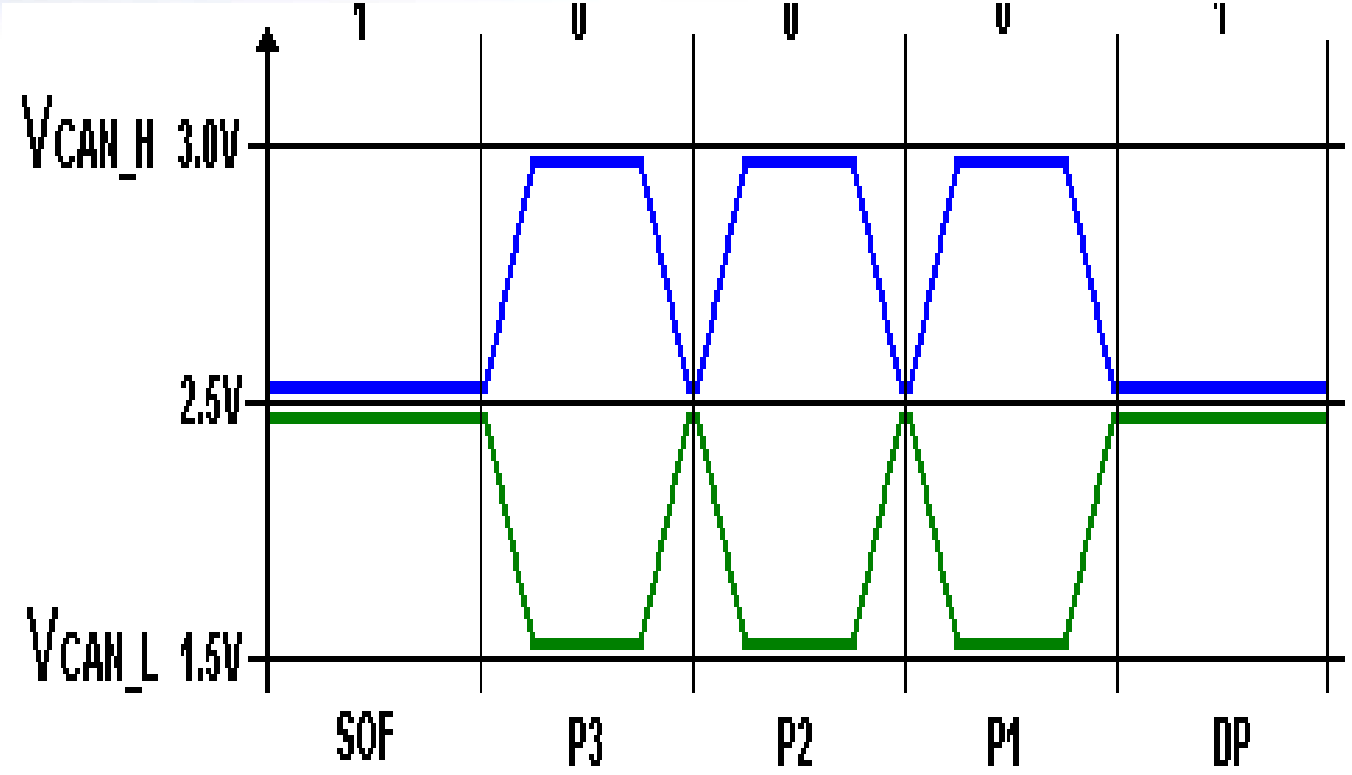




2 Conductor

4 Conductor

CAN Signal



Data Layer of CAN

- **The layer that defines data, remote, error, and overload frames.**
- **Layer that turns the data into raw bits**
- **Also part of the error detection**

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Error Detection

- **Bit Monitoring**
  - **Any node automatically monitors and compares the actual bit level on the bus with the level that it transmitted. If the two are not the same, a bit error is flagged.**
- **Stuff Error**
  - **If five consecutive identical bit levels have been transmitted, the transmitter will automatically inject (stuff) a bit of opposite polarity into the bit stream. The receive node will automatically de-stuff.**

Error Detection

- **Cyclic Redundancy Check Field (CRC)**
  - **Every message transmitted contains a 15 bit CRC code. If the receivers calculate a different CRC, a error flag is raised.**
- **Form Error**
  - **Violation of fixed format Bit fields**
- **Acknowledge Error (ACK)**
  - **If a node determines a message has not been ACKnowledged then the ACK error is flagged.**

Application Layer of CAN

- **The application layer is the communication layer of the OSI.**
  - **Performs common end user services**
  - **HED application code**

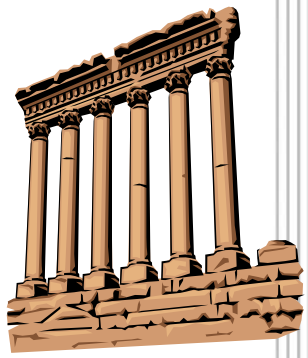
High Language Protocols

- **J1939**
  - **Diesel engines, busses, fire trucks, cranes, etc…**
- **CAN Kingdom**
- **CANOpen**
  - **Used in Europe especially Germany**
- **DeviceNet**
  - **Used in USA and Asia for PLC controllers**
- **Proprietary**
  - **HED**

HLP history

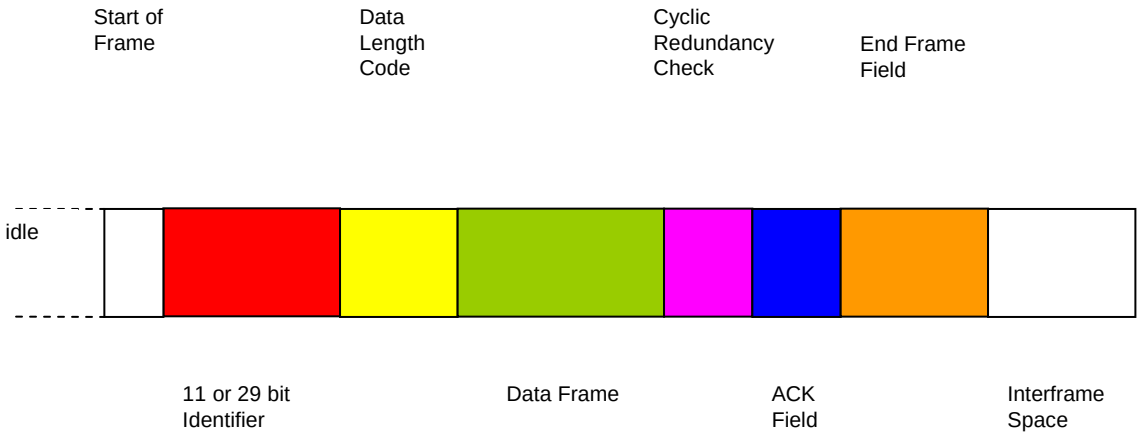
HLP = Higher-layer protocol

- 1991: CAN Kingdom
- 1992: CAN Application Layer (CiA 20X series)
- 1994: Smart Distributed System (IEC 62026, EN 50325)
- 1994: DeviceNet (IEC 62026, EN 50325)
- 1994: Truck and bus (SAE J1939, ISO 11898)
- 1995: CANopen (CiA 301, EN 50325)
- 1997: OSEK-COM/NM (ISO 17356 series)
- 1999: Truck/trailer (ISO 11992-1/-2/-3)
- 2001: Diagnostics on CAN (ISO 15765)
- 2002: ISOBUS (ISO 11783 series)
- 2006: Re-creation vehicle CAN (CiA 501/2)



CAN Message

Full CAN message scheme:



CAN Message

What we are interested in:

11 or 29 bit
Identifier

0-8 bytes Data Frame

Example J1939 Message

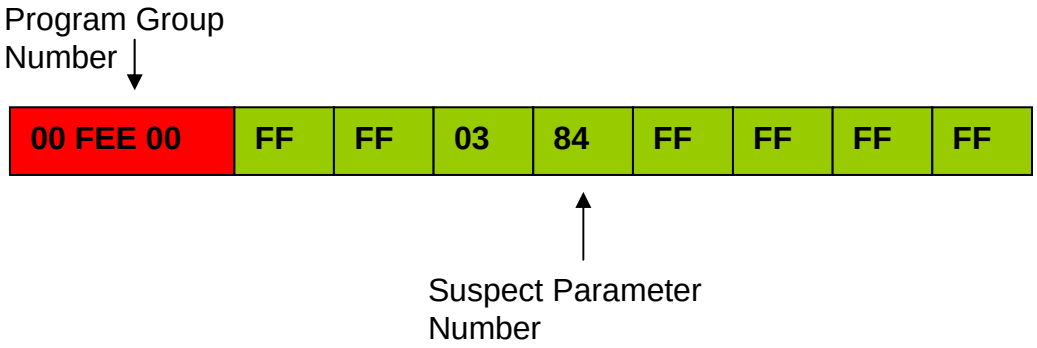
Program Group Number (pgn) 65262 **– Engine Temperature 1 – ET1**

Transmission rate:	**1 sec**
Data Length:	**8 bytes**
Data Page:	**0**
PDU Format:	**254**
PDU Specific:	**238**
Default Priority:	**6**
Parameter Group Number:	**65262 (00FEEE hex)**

Bit Start Position	Bytes Length	Suspect Parameter Number SPN Description	SPN
1	**1 byte**	**Engine Coolant Temperature**	**110**
2	**1 byte**	**Fuel Temperature**	**174**
3-4	**2 bytes**	**Engine Oil Temperature 1**	**175**
5-6	**2 bytes**	**Turbo Oil Temperature**	**176**
7	**1 byte**	**Engine Intercooler Temperature**	**52**
8	**1 byte**	**Engine Intercooler Thermostat Opening**	**1134**

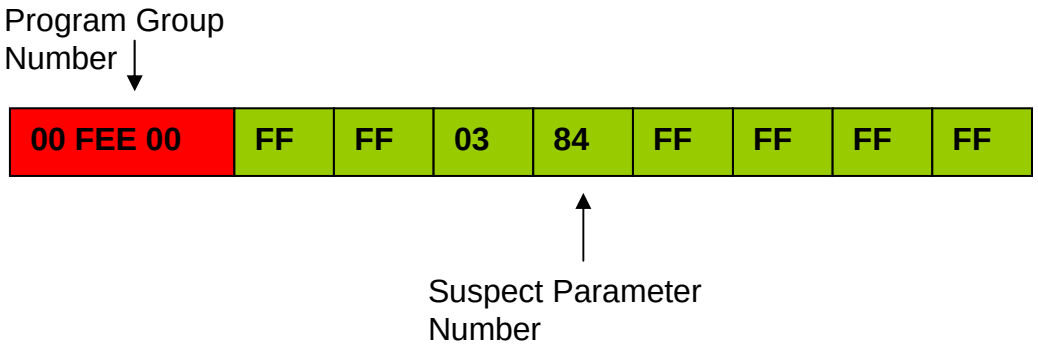
Example J1939 Message

- Suspect Parameter Number 175 **– Engine Oil Temperature 1**
- **Data Length:** **2 bytes**
- **Resolution:** **0.03125 deg C/bit, -273 deg C offset**
- **Data Range** **-273 to 1735 deg C**
- **Type:** **Measured**
- **Suspect Parameter Number:** **175**
- **Parameter Group Number:** **[65262]**



Example of a J1939 Message

As the engine oil temperature changes, then bytes 3 & 4 change to show the value in HEX.



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Organizations that use CAN

- **SAE (Society of Automobile Engineers)**
- **CiA (CAN in Automation)**
- **ODVA (DeviceNet)**

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Why do we use CAN?

- **Industry proven**
- **Bit collision detection and handling**
- **Cost saving**
- **Diagnostics for multiple module systems**
- **EMI/RFI**

Want to learn more?

- **Check these websites for more information**
  - **www.sae.org**
  - **www.can-cia.org**
  - **www.hedonline.com**
- **HED papers**
  - **Large Scale Applications of J-1939 CAN**

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