CAN Bus for Embedded system Engineers

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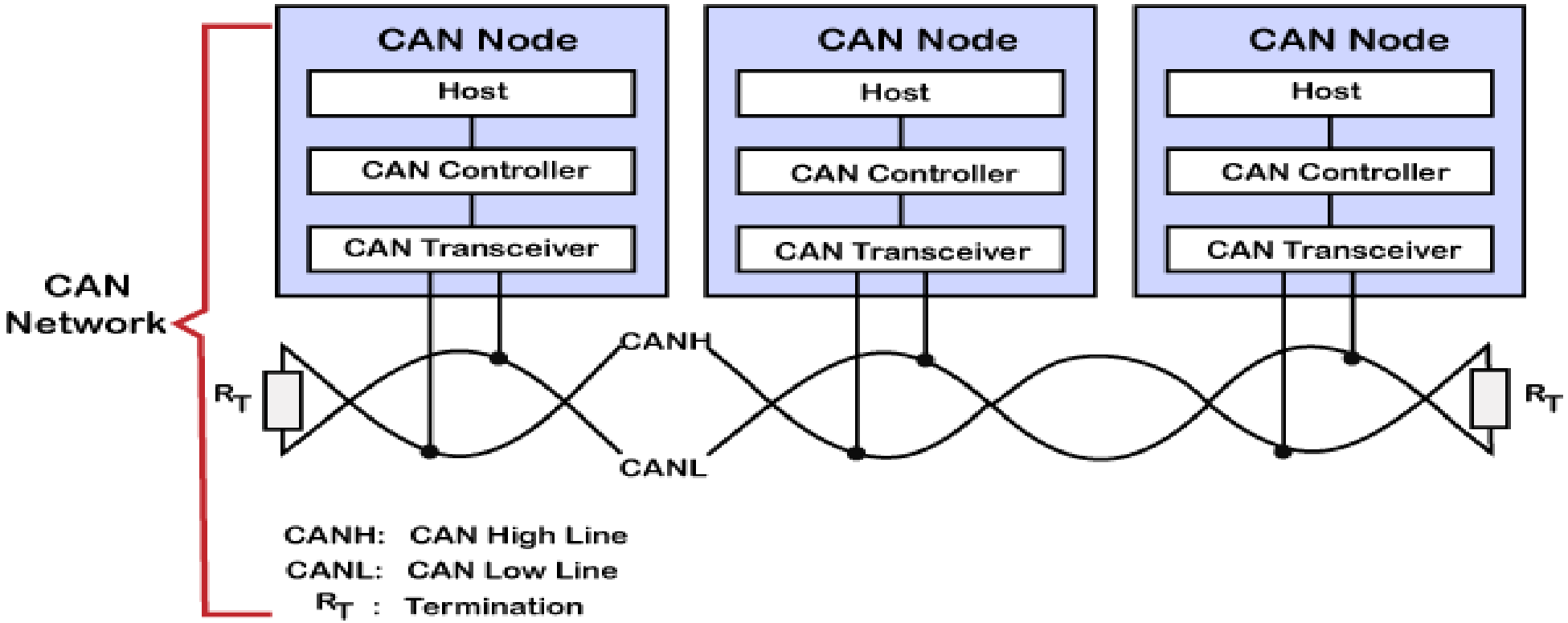
What is the CAN Bus?

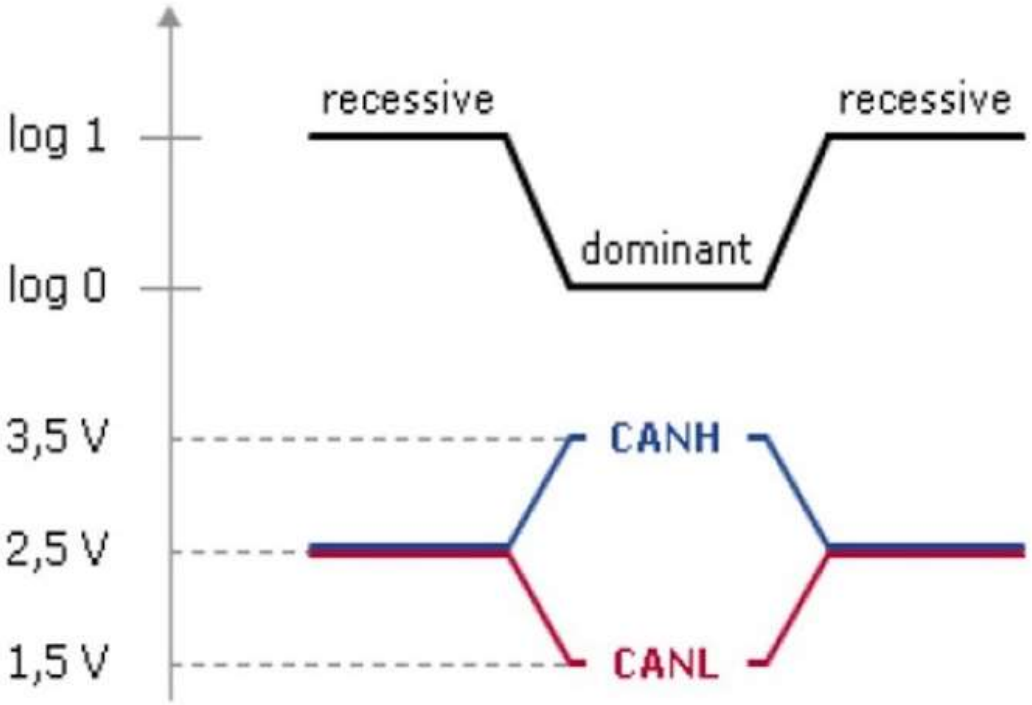
- CAN is the short form of Controller Area Network.
  The design is to make devices communicate to each other without having single host PC.
  Mainly targeted for microcontroller-based applications and widely used in automotive, medical and networking applications.
- CAN interface is used with CAN bus, it is a differential 2 wire interface. Data communication over CAN uses NRZ(Non-Return Zero) encoding for bit encoding.

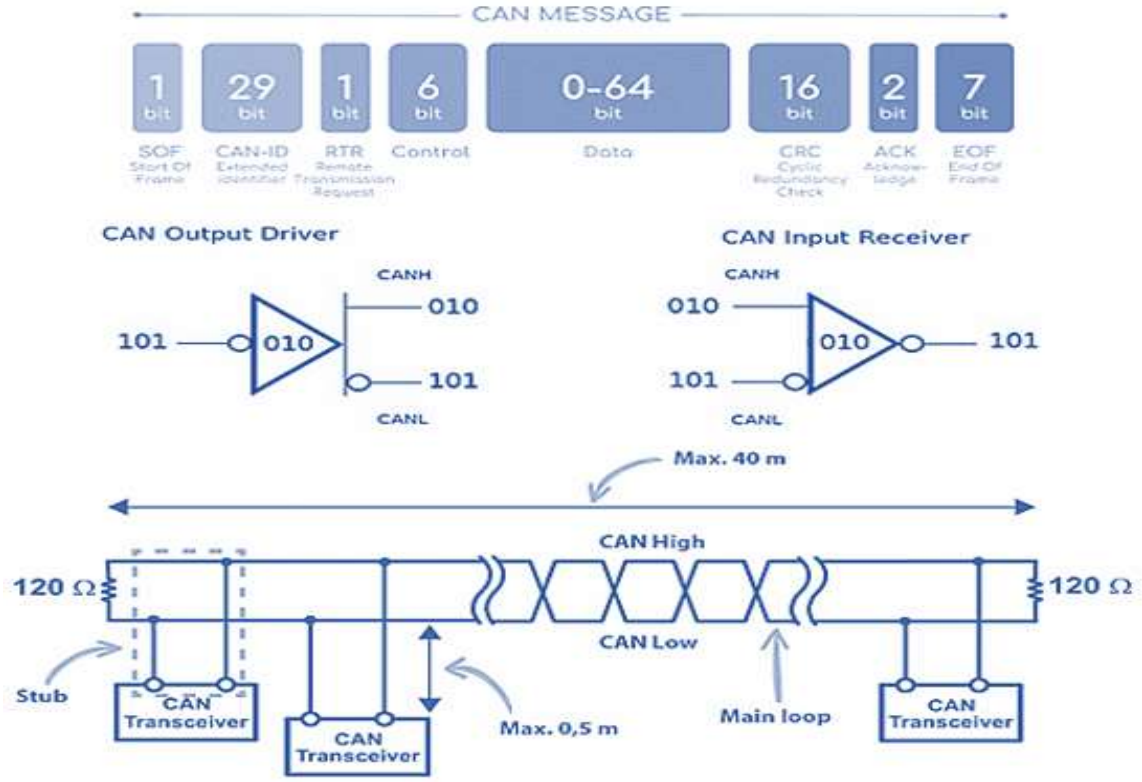
CAN Physical Construction



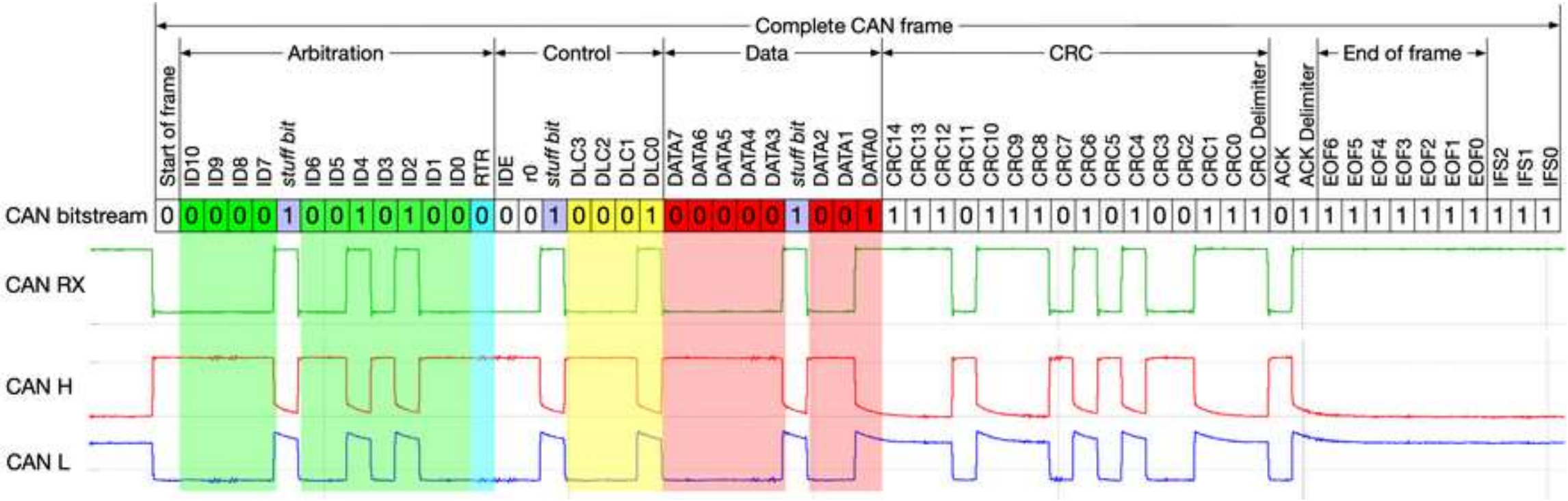
CAN Logic Level:

- **Recessive State** or **Logic 1** when both CANH, and CANL is 2.5V.
- **Dominant State** or **Logic 0** when both CANH =3.5v, and CANL =1.5v or is the Inverting of Each other.





CAN Frame:


Complete CAN frame
Arbitration
Control
Data
CRC
End of frame
Start of frame
ID10 ID9 ID8 ID7 stuff bit ID6 ID5 ID4 ID3 ID2 ID1 ID0 RTR
IDE r0 stuff bit DLC3 DLC2 DLC1 DLC0
DATA7 DATA6 DATA5 DATA4 DATA3 stuff bit DATA2 DATA1 DATA0
CRC14 CRC13 CRC12 CRC11 CRC10 CRC9 CRC8 CRC7 CRC6 CRC5 CRC4 CRC3 CRC2 CRC1 CRC0 CRC Delimiter
ACK ACK Delimiter
EOF6 EOF5 EOF4 EOF3 EOF2 EOF1 EOF0
IFS2 IFS1 IFS0
CAN bitstream
0 0 0 0 0 1 0 0 1 0 1 0 0 0 0 0 1 0 0 1 0 0 0 1 0 0 0 0 0 1 0 0 1 1 1 1 0 1 1 1 0 1 0 1 0 0 1 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1
CAN RX
CAN H
CAN L

Termination Resistors:

- CAN Termination Resistors are used for Various Reasons:

1. To Avoid the **reflection** of signal to the Transmitter that can damage the transmitter.
2. To Construct the **Differential Voltage** on the Termination resistor.
3. To help in **Hardware System diagnostics** of misconnection using only multimeter on ohmmeter mode and measure the resistance between the two lines when the system is not powered, if the total resistance is:
   - ❑ **Equal 60 ohm or near than 60 ohm** it means that the connection is good and **no problem with hardwired connections**.
   - ❑ **Equal 120 ohm or near than 120 ohm** it means that the connection is not good and **only one wired is connected**.
   - ❑ **Equal or near than 1 ohm, or short-circuit** it means that the connection is not good, and **the two wires is Shorted together**.

Advantages of CAN Bus:

- It allows **1Mbps** data rate.
- **CAN FD** (flexible data rate) version **supports more than this speed** supports.
- **CAN FD** will support more **bandwidth which is eight times more than standard CAN bus**.
- It is used to **reduce wiring** in various **automotive applications**.
- Due to **less complex interface**, it is widely **used across various industries**.
- It saves overall cost and time due to **less and simple wiring as well as use of flash programming**.
- **Standard CAN** protocol **supports 8 bytes** while **CAN FD** protocol **supports 64 bytes** in the **data field part**.
- Supports **auto retransmission of lost messages**.
- It works in various electrical environments without any issues as it is a **Low voltage differential Signa**l.
- The protocol **supports different error detection capabilities** such as **bit error**, **ack error**, **form error**, **CRC error and stuff error**.

Disadvantages of CAN Bus:

- maximum number of nodes are not specified for the network. It **supports up to 64 nodes due to electrical loading**.
- It supports **maximum length of 40 meters**.
- It is likely to **have undesirable interactions between nodes**.
- It incurs more expenditure for software development and maintenance.
- CAN driver **must produce at least 1.5V across typical 60 Ohm**.
- Network **should be wired in topology which limits stubs as much as possible**.
- In order **to reduce signal integrity issues such as reflections CAN bus should be properly terminated at both the ends with resistors**.
- **Node removal requires use of termination resistors of 120 Ohm value at appropriate places on the CAN bus**.

Types of CAN Protocols and Difference between them

- There are several versions of CAN bus in use today **According to frame size**, which include:
- **CAN 2.0A** – Uses an **11-bit** Message Identifier.
- **CAN 2.0B** - Uses a **29-bit** Message Identifier.
- **CAN FD** - Uses a Flexible Data Rate.

- There are three different **speed types** for CAN buses which are:
- **Low Speed** - **125 kbps** data rate and **500 meters maximum bus length**.
- **High Speed** (or Hi-Speed) - **1 Mbps** data rate and **40 meters maximum bus length**.
- **Flexible Data Rate** - **15 Mbps** data rate and **10 meters maximum bus length**.

The standard **OBD2** automobile connector includes the CAN Bus differential pair pins for use for diagnosis or software control purposes