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Controller Area Networks (CAN)

What is CAN?

Controller Area Network (CAN) is a serial network technology that was originally designed for the automotive industry, especially for European cars, but has also become a popular bus in industrial automation as well as other applications. The CAN bus is primarily used in embedded systems, and as its name implies, is a network technology that provides fast communication among microcontrollers up to real-time requirements, eliminating the need for the much more expensive and complex technology of a Dual-Ported RAM (CopperHillTech, 2020).

CAN is a messaged based protocol which was designed to save on copper in vehicle networks. A Controller Area Network is a serial networking technology for embedded solutions. They need only two wires named CAN_H and CAN_L usually giving the values 1 and 0. They operate at rates of up to 1 Megabit per second. CAN supports a maximum of 8 bytes per message frame. It does not support node IDs, only message IDs. One application can support multiple message IDs. It supports message priority, i.e. the lower the message ID the higher its priority (Natale et al., 2012).

Where is CAN used?

CAN is used commonly in the modern automotive industry. Cars have as many as 70 ECUs (electronic control units) for systems within the vehicle. For example, the engine control unit, ADAS, audio systems, power supply system and antilock braking. Many of these can form independent systems but, in some cases, communication is essential between ECUs. A subsystem may have the requirement to control actuators or receive information from sensors in control systems. CAN allows for interconnection between different systems which improves safety, economy and convenience using software alone which is cheaper than if these features were hard wired using traditional electronics (Wikipedia, 2020).

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CAN is also used in video game production, for example, in Gran Turismo 6 to recreate real-life racing laps (Playstation, 2020). It has also been used at Johns Hopkins University MPL (Modular Prosthetic Limb) to communicate between servos and microcontrollers (University, 2016).

CAN Benefits

Low Cost & Lightweight

CAN is low-cost and lightweight. It provides an inexpensive and durable network that helps CAN devices communicate with each other. An advantage is that each ECU can have a single interface rather than analogue and digital inputs for every device. This, in turn decreases cost.

Broadcast Communication

All devices on the network see all transmitted messages. Each device can decide if a message is relevant or if it should be filtered. This structure allows modifications to CAN networks with minimal impact. Additional non-transmitting nodes can be added without modification to the network (NationalInstruments, 2019).

Priority

Every message has a priority, so if two devices try to broadcast a message at the same time, the one with higher priority will be transmitted to other nodes and the lower priority will be postponed.

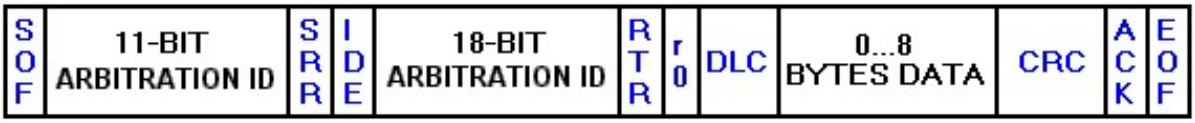
Error Capabilities

CAN includes to the capability to perform error checking on each frame's contents. Frames that contain errors are ignored by all nodes and then an error frame is transmitted to show there is an error in the network.

How does CAN work?

CAN has some physicals layers available for use. These physical layers classify certain aspects of the CAN network, such as electrical levels, signalling schemes, cable impedance, maximum baud rates, and more (NationalInstruments, 2019). The most widely used layers are: High-speed, Low-speed, Single-Wire and Software Selectable.

CAN devices send data across the CAN network in packets called frames. A CAN frame consists of the following sections. Arbitration ID, data bytes, acknowledge bit, and so on. Frames also are referred to as messages.



CAN is a peer-to-peer network. There is no master/slave configuration in CAN. When a node wants to transmit data, it checks to see if the bus is busy and then will write a frame onto the network. There is no receiving or transmitting ID only a frame ID. Each node on the network receives the frame and then depending on the ID the node decides whether to accept the frame.

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CAN Vs Ethernet

Ethernet is being used more and more in the automotive industry. Modern vehicles contain cameras, OBDs, ADAS, touch screens and more. Due to this added hardware and software there is a higher demand for bandwidth on our networks. Using ethernet allows for future proofing and scalable architecture than can handle multiple systems. Most of these requirements stated are beyond the capability of CAN technologies. Ethernet allows for enhanced performance under more stress, however, it cannot match the safety and performance of CAN (Voss, 2019).

CSMA/CD (Carrier Sense Multiple Access/Collision Detection) is a procedure that regulates how communication takes places in a network. It also regulates how to deal with collision if and when they occur. When two or more nodes to try to send data simultaneously they interfere with each other (Ionos, 2019). However, in CAN the nodes just wait for the bus to be available.

Ethernet and WIFI use MAC (Media Access Control) addresses to identify individual devices. A MAC address is the hardware address which is typically assigned to the network interface card. MAC addresses are usually six sets of two-digits in hexadecimal. MAC addresses are very useful in diagnosing network issues, such as problems with IP addresses as MAC addresses do not change (WhatIsMyIPAddress, 2020).

However, with regards to CAN, the software in each node must be able to decide what message ID (arbitration ID) they would like to accept and the message does not know where it has come from or where it needs to go to.

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