CONTROLLER AREA NETWORK (CAN BUS)

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Overview

The Controller Area Network (the CAN bus) is a serial communications bus for real-time control applications; operates at data rates of up to 1 Megabits per second, and has excellent error detection and confinement capabilities.

CAN was originally developed by the German company, Robert Bosch, for use in cars, to provide a cost-effective communications bus for in-car electronics and as alternative to expensive, cumbersome and unreliable wiring looms and connectors. The car industry continues to use CAN for an increasing number of applications, but because of its proven reliability and robustness, CAN is now also being used in many other control applications.

CAN is an international standard and is documented in ISO 11898 (for high-speed applications) and ISO 11519 (for lower-speed applications).

Low-cost CAN controllers and interface devices are available as off-the-shelf components from several of the leading semiconductor manufacturers. Custom built devices and popular microcontrollers with embedded CAN controllers are also available. There are many CAN-related system development packages, hardware interface cards and easy-to-use software packages that provide system designers, builders and maintainers with a wide range of design, monitoring, analysis, and test tools. [1]

CAN in Cars

To satisfy customer requirements for greater safety, comfort, and convenience, and to comply with increasingly stringent government legislation for improved pollution control and reduced fuel consumption, the car industry has developed many electronic systems. Anti-lock Braking, Engine Management, Traction Control, Air Conditioning Control, central door locking, and powered seat and mirror controls are just some examples.

The complexity of these controls systems, and the need to exchange data between them meant that more and more hard-wired, dedicated signal lines had to be provided. Sensors had to be duplicated if measured parameters were needed by different controllers. Apart from the cost of the wiring looms needed to connect all these components together, the physical size of the wiring looms sometimes made it impossible to thread them around the vehicle (to control panels in the doors, for example). In addition to the cost, the increased number of connections posed serious reliability, fault diagnosis, and repair problems during both manufacture and in service. [1]

Industrial Applications of CAN

CAN controllers and interface chips are physically small. They are available as low-cost, off-the-shelf components. They will operate at high, real-time speeds, and in harsh environments. All these properties have led to CAN also being used in a wide range of applications other than the car industry.

The benefits of reduced cost and improved reliability that the car industry gains by using CAN are now available to manufacturers of a wide range of products.

For example:

- Marine control and navigation systems
- Elevator control systems
- Agricultural machinery
- Production line control systems
- Machine tools
- Large optical telescopes

Using CAN to network controllers, actuators, sensors, and transducers, manufacturers of all the above-mentioned computer controlled products have benefited from:

- Reduced design time (readily available, multi sourced components, and tools)
- Lower connection costs (lighter, smaller cables and connectors)
- Improved reliability (fewer connections.)

User Groups

To cater for the growth in the use of CAN and to provide a forum for discussion, several User Groups have been formed. One of the first to be formed was the CAN Textile Users Group, but the principal international Users Group is *CAN in Automation* (CiA). [1]

How CAN works

Principle

Data messages transmitted from any node on a CAN bus do not contain addresses of either the transmitting node, or of any intended receiving node.

Instead, the content of the message (e.g. Revolutions Per Minute, Hopper Full, X-ray Dosage, etc.) is labelled by an identifier that is unique throughout the network. All other nodes on the network receive the message and each performs an acceptance test on the identifier to determine if the message, and thus its content, is relevant to that particular node.

If the message is relevant, it will be processed; otherwise it is ignored. The unique identifier also determines the priority of the message. The lower the numerical value of the identifier, the higher the priority.

In situations where two or more nodes attempt to transmit at the same time, a non-destructive arbitration technique guarantees that messages are sent in order of priority and that no messages are lost. [1]

Bit encoding

CAN uses Non Return to Zero (NRZ) encoding (with bit-stuffing) for data communication on a differential two wire bus. The use of NRZ encoding ensures compact messages with a minimum number of transitions and high resilience to external disturbance.

The physical bus

The two wire bus is usually a twisted pair (shielded or unshielded). Flat pair (telephone type) cable also performs well but generates more noise itself, and may be more susceptible to external sources of noise.

The Benefits

Non-destructive bitwise arbitration provides bus allocation on the basis of need, and delivers efficiency benefits that cannot be gained from either fixed time schedule allocation (e.g. Token ring) or destructive bus allocation (e.g. Ethernet.)

With only the maximum capacity of the bus as a speed limiting factor, CAN will not collapse or lock up. Outstanding transmission requests are dealt with in their order of priority, with minimum delay, and with maximum possible utilisation of the available capacity of the bus.

CAN Message Format

Message Frames

In a CAN system, data is transmitted and received using Message Frames. Message Frames carry data from a transmitting node to one, or more, receiving nodes.

The Standard CAN protocol (version 2.0A), also now known as Base Frame Format, supports messages with 11 bit identifiers.

The Extended CAN protocol (version 2.0B), also now known as Extended Frame Format, supports both 11 bit and 29 bit identifiers.

Most 2.0A controllers transmit and receive only Standard format messages, although some (known as 2.0B passive) will receive Extended format messages - but then ignore them. 2.0B controllers can send and receive messages in both formats. [1]

2.0A Format

A Standard CAN (Version 2.0A) Message Frame consists of seven different bit fields:

- A Start of Frame (SOF) field - which indicates the beginning of a message frame.
- An Arbitration field, containing a message identifier and the Remote Transmission Request (RTR) bit. The RTR bit is used to discriminate between a transmitted Data Frame and a request for data from a remote node.

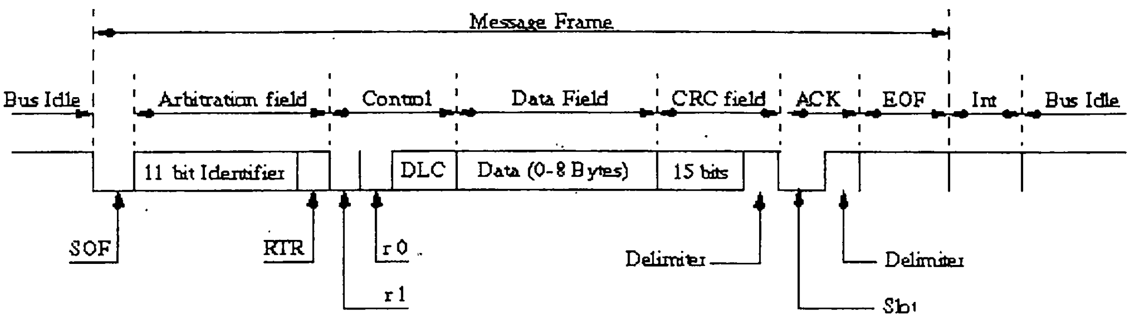

Fig 1.CAN 2.0A Message Frame

Error Detection

CAN implements five error detection mechanisms; three at the message level and two at the bit level.

At the message level:

- Cyclic Redundancy Checks (CRC)
- Frame Checks
- Acknowledgment Error Checks

At the bit level:

- Bit Monitoring, Bit Stuffing

References:

1). http://www.mjschofield.com/