# APPLICATION OF CONTROLLER AREA NETWORK IN ENTERTAINMENT CONTROL SYSTEMS

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## 1. ABSTRACT

There is a need to establish an open standard for the data bus control of electronic equipment in the entertainment industry (e.g. audio controls, lighting controls, etc.). Controller Area Network (CAN) has been approved by various industries as the basis for industrial control data buses. This paper proposes that CAN is best suited as the basis for the application protocol for controlling and monitoring audio systems (AES-24).

## 2. INTRODUCTION

Controller Area Networking (CAN) was originally developed for automotive applications to reduce the complex wiring systems in vehicles with multiple microcomputer/microcontroller based control systems (e.g. engine management, ABS, suspension control, etc.). The evolution of electronic systems integration has necessitated the use of a serial data bus for sensor information sharing and distributed control. The concept is very similar to the office LAN (Local Area Network) where all the Personal Computers are linked together via a single wire. In the modern car, there are many computerised control systems that share information.

The advantages of the networked system over the traditional point to point wiring harness system are:

- Reduces wiring harness weight.
- Increases wiring harness reliability.
- Supports efficient assembly techniques.
- Eliminates duplicated processing power.
- Allows increased options and enhancements with very little or no physical change to the system.
- Provides centralized collection and processing of diagnostic information.
- More economical in many cases.

CAN is now an ISO standard for vehicle computer networking [1], and it is widely recognised throughout the general industrial sector. There are many current non-automotive applications for CAN in use today. These include:

- Agricultural machinery
- Automotive systems

- Lift control systems
- Measurement systems
- Medical systems
- Packaging control systems
- P C controlled manufacturing systems
- Robot control systems
- Textile manufacturing systems

## 3. THE CAN PROTOCOL

Various studies have been performed on CAN to verify that it is robust in extreme conditions [ref 2, 3, 4, 5]. The bit coding method used for CAN (NRZ - Non Return to Zero) produces less electromagnetic emissions at higher transfer rates than the other recommended bit coding methods (e.g. Manchester and PWM - Pulse Width Modulation). NRZ coding offers a higher transport capacity while offering clock accuracy tolerance which is as good as the other coding methods. CAN has been shown to be a very efficient media for error detection and fault tolerance. Fault tolerance allows operation under failure modes (e.g. shorted or opened signal wires). Extensive electromagnetic compatibility susceptibility testing has demonstrated the robustness of this protocol where it was capable to recover rapidly under error conditions.

Of the three ISO accepted protocols for vehicle networking (CAN, VAN, and J1850), CAN is considered the most popular standard in the European community because of the reasons mentioned above and its real time control capabilities. It is also gaining acceptance among the American automotive giants, even though they have there own protocol (i.e. SAE J1850).

CAN is a multi-master bus topology that incorporates the first two layers of the OSI seven layer model: the physical layer and the data-link layer. Figure 1 illustrates the relationship between the CAN layered structure and the OSI seven layer model where the CAN application layers are specific to the system designer. As presented later, various application layers have been specified for CAN for several industries.

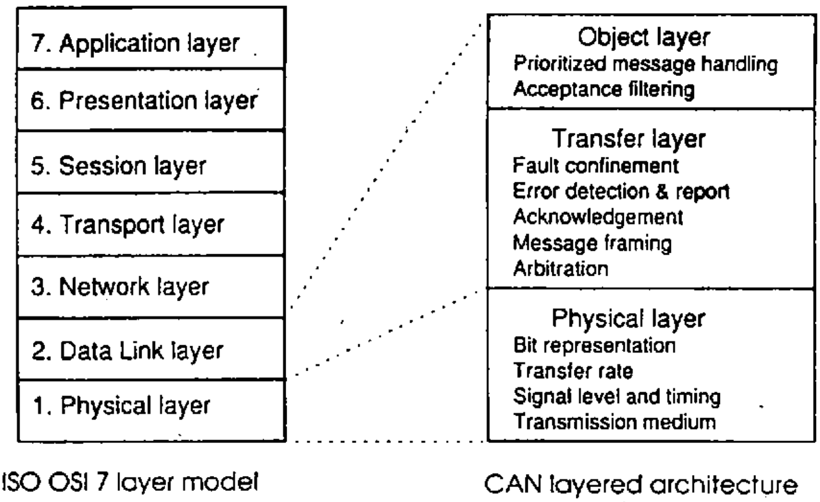



**Figure 1 CAN & the ISO Seven Layer Model**

There are four types of message frames specified in the CAN protocol:

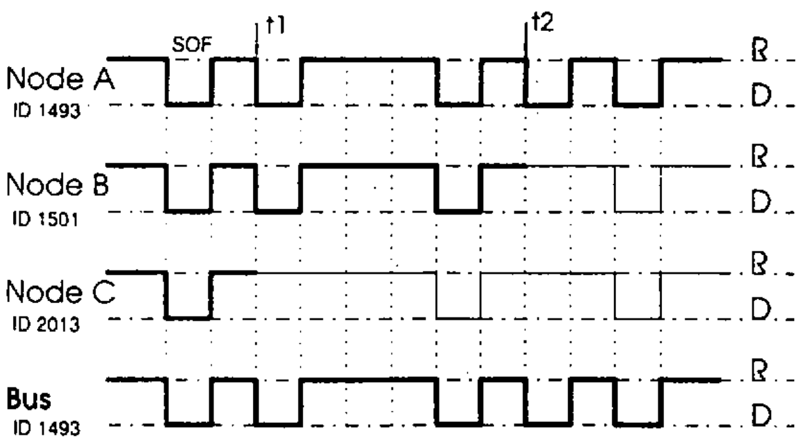
- Data Frame - carries data from a transmitter to the receivers.
- Remote Frame - transmitted by a node to request the transmission of the Data Frame with the same ID.
- Error Frame - transmitted by any unit on detecting a bus error.
- Overload Frame - used to provide for an extra delay between the preceding and the succeeding Data and Remote Frames.

Figure 2 shows the basic layout of the data frame. The eleven bit identifier allows for 2032 possible functions in a system. The remote frame is the same as the data frame except there is no data field. The error frame and the overload frame consist of an inordinate length of bits without a transition to indicate to the other nodes in system to stop transmission and resend the frame.

| Bus Idle | SOF | Arbitration Field 12 bits | Control Field 6 bits | Data Field 0 - 8 Bytes | CRC Field 16 bits | ACK Field 2bits | End of Frame 7 bits | Inter Frame Space |
|---|---|---|---|---|---|---|---|---|

**Figure 2. CAN Data Frame**

CAN uses CSMA/CD (carrier sense multiple access with collision detect) with non-destructive bit wise arbitration for bus contention. Arbitration occurs only during the arbitration field of the data frame. The bit wise arbitration guarantees that the highest priority frame is not delayed during collisions. In bit wise arbitration the highest priority frame continues transmitting during a collision. This characteristic is illustrated in figure 3. CAN utilises broadcast type functional addressing for quicker through-put of real time information. The CAN protocol uses the NRZ (non-return to zero) data format with bit stuffing at data rates ranging between 15 Kbps and 1 Mbps.




Keys: R - Recessive, D - Dominant

t1 & t2 , Node C and Node B lost arbitration

**Figure 3. Bitwise Arbitration**

## 4. CAN INTERFACING

Due to the increasing popularity of this protocol, there are many microchip manufacturers that produce various types of a CAN controllers. These include Intel, Motorola, NEC, National Semiconductor, Philips, and Siemens. Because of the increase in competition, the cost of implementing a CAN bus has decreased significantly in the past several years. There are three main CAN chip configurations:

- Stand alone CAN controller.
- CAN controller integrated into a host microcontroller.
- CAN serial linked I/O (SLIO).

Figure 4 illustrates the basic configuration for the stand alone controller where the CAN chip is interfaced with a host microcontroller via the address and data buses. This configuration is essential for upgrading existing systems. It implies that the controller must be interfacable, i.e. a simple controller with I/O only cannot be used.

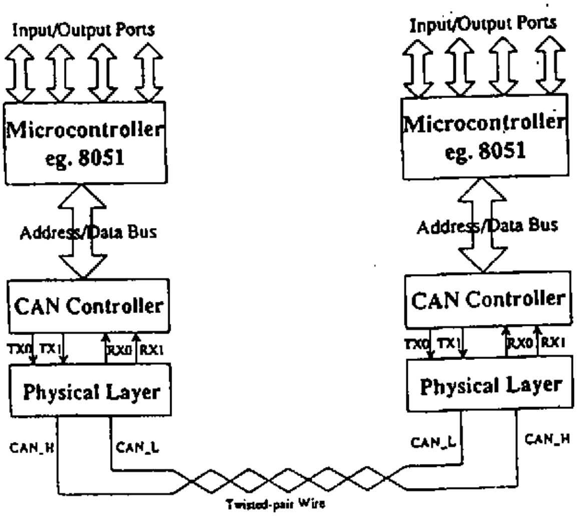



**Figure 4. Standalone CAN Configuration**

If a system is in the design/redesign stages, the setup in Figure 5 can be used where the microcontroller and the CAN controller are built into one package. The address and data interface between them is performed internally, i.e. it has DMA capability. Options are available for controllers with full address/data bus interfacing capability as well as the much simpler I/O only version.

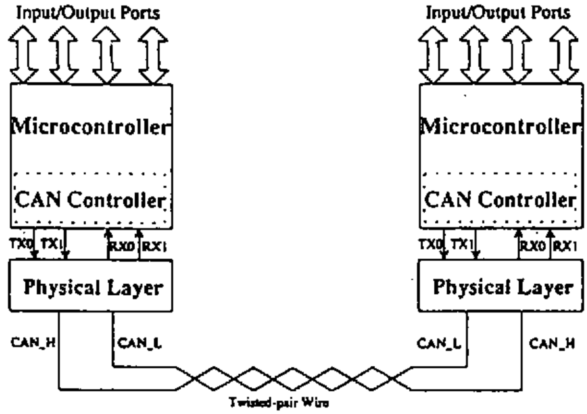



**Figure 5. Integrated CAN Configuration**

A simple, low cost means of extending the I/O of a central controller via a CAN bus is shown in Figure 6. Here the SLIO CAN chip is a low intelligence controller that is programmed from the central controller via the CAN bus. There are eight I/O and sixteen I/O versions of this chip.

In all of these configurations, a physical layer transceiver must be connected to the CAN controller. The limit of nodes on a bus depends on the capability of the transceiver. There are integrated circuit versions of the CAN transceiver that can handle up to 110 nodes on a bus.

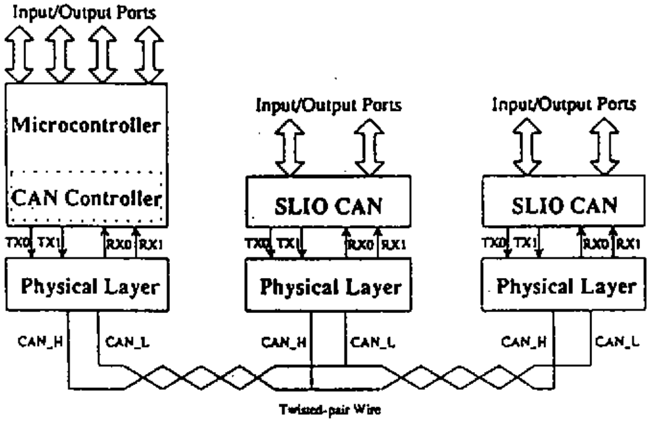



Figure 6. SLIO CAN Configuration

## 5. "ENTERTAINMENT-NET" - THE CASE FOR CAN

Several organisations have championed CAN as the basis for an open standard for a widespread application. The American Society of Automotive Engineers have established CAN as the basis for their Truck and Bus Data-bus standard [6]. A consortium of companies worldwide headed by Allen Bradley have sanctioned CAN as the basis for DeviceNet. DeviceNet was developed to provide interconnections between simple low level industrial devices (e.g. sensors & actuators) and higher level devices (e.g. logic controllers). The application layers of these two open systems are becoming accepted worldwide. For example, the current list for DeviceNet participants stands at 70 companies worldwide, and the number is growing daily. Companies are eager to agree on an open system for ease of compliancy.

After reviewing the AESSC Request for Technology [7], it is evident that the entertainment industry is in need of an open system. Past experience has shown that CAN is an excellent platform for this purpose. It is powerful, robust, versatile, and it is inexpensive to implement. The application layer for an "EntertainmentNet" could be very similar to that defined by the DeviceNet standard. There are many parallels between the DeviceNet standard [8] and the AES information document for sound system control [9]. Both advocate the Object Oriented approach where the protocol evolves around a class structure.

Controller Area Network has proved to be the most popular network protocol for many different industrial applications to date. The case for CAN has taken many twists in the past, as the many references in this document indicates. It is an ISO standard. It is supported by many chip manufacturers. It is proven robust. It has many users worldwide to prove its abilities. There is no license fee to use it. It is very inexpensive to implement.

## 6. REFERENCES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