SAE J1708 JAN86

Serial Data Communications Between Microcomputer Systems in Heavy Duty Vehicle Applications

RATIONALE:

Not applicable.

RELATIONSHIP OF SAE STANDARD TO ISO STANDARD:

Not applicable.

REFERENCE SECTION:

Electronic Industries Association Standard RS-485 (EIA RS-485) "Standard for Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems," April 1983

SAE J1455, Recommended Environmental Practices for Electronic Equipment Design (Heavy-Duty Trucks)

APPLICATION:

The purpose of this Recommended Practice is to define a general-purpose serial data communication link that may be utilized in heavy-duty vehicle applications. It is intended to serve as a guide toward standard practice to promote serial communication compatibility among microcomputer-based modules. The primary use of the general-purpose communications link is expected to be the sharing of data among stand-alone modules to cost-effectively enhance their operation. Communication links used to implement functions that require a dedicated communication link between specific modules may deviate from this Recommended Practice.

This document defines a Recommended Practice for implementing a bi-directional, serial communication link among modules containing microcomputers. This document defines those parameters of the serial link which relate primarily to hardware and basic software compatibility such as interface requirements, system protocol, and message format. The actual data to be transmitted by particular modules, which is an important aspect of communications compatibility is not specified in this Recommended Practice. These and other details of communication link implementation and use should be specified in the separate application documents referenced in Section 3.1.

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SERIAL DATA COMMUNICATIONS BETWEEN MICROCOMPUTER SYSTEMS IN HEAVY DUTY VEHICLE APPLICATIONS

1. **FOREWORD:** This SAE Recommended Practice has been developed by the Truck & Bus Electronic Interface Subcommittee of the Truck & Bus Electrical Committee. The objectives of the Subcommittee are to develop information reports, recommended practices, and standards concerned with the interface requirements and connecting devices required in the transmission of electronic signals and information among Truck & Bus components.

1.1 **Objectives:** Some of the goals of the Subcommittee in developing this Recommended Practice were to:

 - minimize hardware cost and overhead;

 - provide flexibility for expansion and technology advancements with minimum hardware and software impact on inplace assemblies;

 - utilize widely accepted electronics industry standard hardware and protocol to give designers flexibility in parts selection;

 - provide a high degree of electromagnetic compatability;

 - provide original equipment manufacturers, suppliers, and aftermarket suppliers the flexibility to customize for product individuality and for proprietary considerations.

2. **PURPOSE:** The purpose of this Recommended Practice is to define a general-purpose serial data communication link that may be utilized in heavy-duty vehicle applications. It is intended to serve as a guide toward standard practice to promote serial communication compatibility among microcomputer-based modules. The primary use of the general-purpose communications link is expected to be the sharing of data among stand-alone modules to cost-effectively enhance their operation. Communication links used to implement functions that require a dedicated communication link between specific modules may deviate from this Recommended Practice.

3. SCOPE: This document defines a recommended practice for implementing a
    bi-directional, serial communication link among modules containing
    microcomputers. This document defines those parameters of the serial link
    which relate primarily to hardware and basic software compatibility such as
    interface requirements, system protocol, and message format. The actual data
    to be transmitted by particular modules, which is an important aspect of
    communications compatibility, is not specified in this Recommended Practice.
    These and other details of communication link implementation and use should
    be specified in the separate application documents referenced in Section 3.1.

3.1 Related Documents:

3.1.1 Electronics Industries Association Standard RS-485 (EIA RS-485) "Standard
       for Electrical Characteristics of Generators and Receivers for Use in
       Balanced Digital Multipoint Systems," April 1983.

3.1.2 SAE J1455, Recommended Environmental Practices for Electronic Equipment
       Design (Heavy-Duty Trucks).

3.1.3 It is recommended that a separate applications document be published by
       the manufacturer for each device using the serial link. These documents
       should define the data format, message I.D.'s, message priorities, error
       detection (and correction), maximum message length, percent bus
       utilization, and methods of physically adding/removing units to/from the
       line for the particular application.

3.2 Glossary:

3.2.1 Access Time: Two bit times multiplied by the message priority (which
       ranges from 1 to 8) added to the Idle Line time.

3.2.2 Baud: The maximum number of analog signal transitions per second that can
       occur on a channel. In this coding system, this is the reciprocal of the
       bit time.

3.2.3 Bit Time: Duration or period of one unit of information.

3.2.4 Character Time: The duration of one character. The character must start
       with a low logic bit, then eight bits of data (least significant bit
       first) followed by a high logic level stop bit.

3.2.5 Contention: A state of the bus in which two or more transmitters are
       turned on simultaneously to conflicting logic states.

3.2.6 Differential Signal: A two-wire process in which both lines are switches
       as opposed to a single-ended signal wherein one line is grounded and the
       signal line is switched between logic states.

3.2.7 Idle State: The state which produces a high logic level on the input of
       the bus receiver when all transmitters on the network are turned off.

3.2.8 Idle Line: The condition which exists when the bus has remained in a continuous high logic state for at least ten bit times after the end of the last Stop Bit.

  Note: The Idle Line serves as the delimiter between messages on the bus. A receiver which cannot distinguish between a Stop Bit and any other high logic state may become synchronized with the bus by noting the receipt of 12 consecutive high logic bits. In the absence of errors, the first low logic bit (0) following 12 consecutive high logic bits (1) is the Start Bit of a Message Identification Character (i.e., the first character of a message).

3.2.9 Message Priority: A measure of message criticality assigned on a scale of 1-8 by the appropriate applications document. The most critical message has a priority of one.

3.2.10 Node: A receiver or transceiver circuit connected to the bus.

3.2.11 Start Bit: Initial element of a character defined as a low logic level of one bit time duration as viewed at the output of the bus receiver.

3.2.12 Stop Bit: Final element of a character defined as a high logic level of one bit time duration as viewed at the output of the bus receiver.

4. ELECTRICAL PARAMETERS: The electrical parameters of this serial data link are a modification of the EIA RS-485 standard. In some areas this document conflicts with RS-485. This Recommended Practice shall serve as the guiding document in such cases. Appendix A details a serial data bus standard node which defines the interface circuit parameters. Operation of this standard node is detailed in this section.

4.1 Logic State: Positive True Logic will be used when referring to the states of transmitted inputs and received outputs. Referring to Appendix A, the input of the transmitter (marked as point Tx) and the output of the receiver (marked as Rx) will be in logic 1 state when driven or passively pulled to +V, and will be at a logic 0 state when driven to ground.

4.2 Bus State: The bus is in a logic 1 (high) state whenever Point A is at least 0.2 V more positive than Point B. The bus is in a logic 0 (low) state whenever Point A is at least 0.2 V more negative than Point B (Points A & B refer to Appendix A). The bus state is indeterminate when the differential voltage is less than 0.2 V.

4.2.1 Logic High State: The bus will be in a logic 1 (high) state when all connected transmitters are idle or sending logic one. An Idle State is produced when all transmitters on the network are turned off. All nodes shall include means to pull the bus to a logic 1 (high) when all transmitters are off (See Appendix A).

4.2.2 Logic Low State: The bus will be in a logic 0 (low) state when one or more transmitters are sending logic 0, which guarantees that logic 0 (low) dominates when the bus is in contention.

4.3 <u>Network Capacity</u>: The bus will support a minimum of 20 standard nodes where each node is comprised of the circuit defined in Appendix A. Deviations from this circuit must be carefully analyzed to determine impact on bus loading and noise margins over the common-mode range.

4.4 <u>Bus Termination</u>: Bus termination resistors as referenced in RS-485 are not required and shall not be used.

4.5 <u>Ground</u>: All assemblies using the link must have common ground reference.

4.6 <u>Wire</u>: A minimum of 18 gauge twisted pair wire, with a minimum of one twist per inch (2.54 cm) is required.

4.7 <u>Length</u>: This Recommended Practice is intended for but not limited to applications with a maximum length of 130 ft (40 m).

5. <u>NETWORK PARAMETERS</u>:

5.1 <u>Network Topology</u>: The network interconnect shall use a common, or global bus.

5.2 <u>Network Access</u>: The method of access to the network is random.

5.2.1 <u>Bus Access</u>: A transmitter shall begin transmitting a message only after an Idle State has continuously existed on the bus for at least a Bus Access Time. The transmitter must verify that the Idle State continues to exist immediately prior to initiating a transmission (that is, within one-half bit time).

5.2.1.1 <u>Bus Access Time</u>: Bus Access Time is a time duration equal to the minimum time of an Idle Line plus the product of two Bit Times and the Message Priority. This relationship can be expressed as:

$$T_a = T_i + 2 * T_b * P$$

where: T_a = Bus Access Time
T_b = Bit Time, or period of one unit of information
P = Message priority
T_i = Minimum time duration of an Idle Line

<u>Note</u>: The minimum time duration of an Idle Line is defined in paragraph 3.2.9. However, a transmitter which cannot distinguish between a Stop Bit and any other high logic state may not assume that Ti has elapsed until it has received 19 consecutive high logic bits.

5.2.1.2 <u>Message Priority Assignment</u>: All messages will be assigned a priority
        from 1-8 as follows:

<u>Priority</u>	<u>Message Assignment</u>
1 and 2	Reserved for messages that require immediate access to the bus
3 and 4	Reserved for messages that require prompt access to the bus in order to prevent severe mechanical damage
5 and 6	Reserved for messages that directly affect the economical or efficient operation of the vehicle
7 and 8	All other messages not fitting into the previous priority categories should be assigned a priority 7 or 8

The applications document shall define the priority associated with each
message. In the event that more than one priority could be assigned to
a particular message, the application document shall define each
priority and the circumstances in which the priority is assigned.

5.2.2 <u>Bus Contention</u>: All transmitters shall monitor the message identification
      portion of their message to determine if another transmitter has attempted
      to gain access to the bus at the same time. If a transmitter detects a
      collision, the transmitter shall relinquish control of the bus after
      completing the transmission of the current character or sooner if
      possible. After relinquishing control, the transmitter may attempt to
      regain access to the bus after a Bus Access Time has elapsed. An example
      bus reaccess procedure is shown in Appendix B.

6. <u>PROTOCOL</u>:

6.1 <u>Bit Time</u>: A Bit Time shall be 104.17 μs $\pm$ 0.5% (+500 ns). This is
    equivalent to a baud rate of 9600 bits per second.

6.2 <u>Character Format</u>: A character shall consist of 10 Bit Times. The first bit
    shall always be a low logic level and is called the Start Bit. The last
    (tenth) bit shall always be a high logic level and is called the Stop Bit.

    This convention is consistent with standard UART operation. The remaining
    eight center bits are Data Bits that are transmitted Least Significant Bit
    (LSB) first.

6.3 Message Format:

6.3.1 Message Content: A message appearing on the communication bus shall consist of the following:

Message Identification Character
Data Characters
Checksum

As indicated in paragraph 5.2.1, a message shall always be preceeded by an Idle State of duration equal to or greater than the appropriate Bus Access Time. The length of time between characters within a message shall not exceed 2 bit times.

6.3.2 Message Identification Character: The first character of every message shall be a Message Identification Character (MID). The permitted range of MIDs shall include the numbers 0-255. The MIDs 0-68 shall be assigned to transmitter categories as identified in Table 1. These assignments have been made to accommodate existing systems, or systems that may presently be under development, and to avoid conflicts which otherwise might arise if indiscriminate use of MIDs were permitted.

Message IDs 69-111 shall be allocated as reserved MIDs for transmitter categories beyond those which are identified in Table 1. These MIDs shall be individually assigned by the SAE Truck & Bus Electrical Committee, Electronics Interface Subcommittee upon petition by a manufacturer at the time a new transmitter category is identified, or when additional MIDs are required within a previously identified category. The content and format of the messages using the above assigned MIDs (0-111) is the responsibility of the transmitter. Content of format of the data within these messages is not defined in this Recommended Practice but should be identified in an appropriate applications document as described in paragraph 3.1.3.

Message IDs 112-127 are not assigned to any category and are not reserved for future assignment. These MIDs are available to any manufacturer or user for any message identification purpose outside the scope of this document.

Message IDs in the 0-127 range shall be defined in the manufacturer's applications document. It shall be the responsibility of the systems integrator or user to ensure that a particular MID is not used by more than one device on the same vehicle.

Message IDs in the range 128-255 shall be reserved for applications using formatted data as set forth in a Recommended Practice to be issued by the SAE Truck & Bus Electrical Committee Data Format Subcommittee. These MIDs shall only be used when the data format set forth within that Recommended Practice is strictly followed.

Table 1

MESSAGE IDENTIFICATION CHARACTER ALLOCATION

MID RANGE	TRANSMITTER CATEGORY
00-07	ENGINE
08-09	BRAKES, TRACTOR
10-11	BRAKES, TRAILER
12-13	TIRES, TRACTOR
14-15	TIRES, TRAILER
16-17	SUSPENSION, TRACTOR
18-19	SUSPENSION, TRAILER
20-27	TRANSMISSION
28-29	ELECTRICAL CHARGING SYSTEM
30-32	ELECTRICAL
33-35	CARGO REFRIGERATION/HEATING
36-40	INSTRUMENT CLUSTER
41-45	DRIVER INFORMATION CENTER
46-47	CAB CLIMATE CONTROL
48-55	DIAGNOSTIC SYSTEMS
56-61	TRIP RECORDER
62-63	TURBO-CHARGER
64-68	OFF-BOARD DIAGNOSTICS
69-111	RESERVED TO BE ASSIGNED BY ELECTRONIC INTERFACE SUB-COMMITTEE (See paragraph 6.3.2, paragraph 2).
112-127	UNASSIGNED - AVAILABLE FOR USE
128-255	TO BE ASSIGNED BY DATA FORMAT SUBCOMMITTEE (See paragraph 6.3.2, paragraph 5).

6.3.3 Data Characters: Data Characters shall be characters that convey the intelligence of the message and shall conform to the Character Format as defined in paragraph 6.2 of this document. The eight bit Data Character may be given any value from O-255. The Data Characters shall be defined in an appropriate applications document at the option of the supplier. The application document shall define parameters, parameter order, scaling and error detection/correction coding if applicable.

6.3.4 Checksum: The last character of each message shall be the two's complement of the sum of the MID and the Data Characters. Simple message error detection may be implemented by adding the Checksum to the sum of all previous message characters (including the MID). The eight bit sum will be zero, neglecting the CARRY, for a correctly received message.

6.3.5 Message Length: Total message length, including MID and Checksum, shall not exceed 21 characters. Exceptions may be made when the engine/vehicle is not running.