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RECOMMENDED PRACTICE FOR SERIAL CONTROL AND COMMUNICATIONS VEHICLE NETWORK— PART 81—NETWORK MANAGEMENT

Foreword—This series of SAE Recommended Practices has been developed by the Truck and Bus Control and Communications Network Subcommittee of the Truck and Bus Electrical and Electronics Committee. The objectives of the subcommittee are to develop information reports, recommended practices, and standards concerned with the requirements design and usage of ECUs which transmit electronic signals and control information among vehicle components. The usage of these documents is not limited to truck and bus applications. Other applications may be accommodated with immediate support being provided for construction and agricultural equipment, and stationary power systems.

These documents are intended as a guide toward standard practice and are subject to change to keep pace with experience and technical advances.

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1. Scope—These SAE Recommended Practices are intended for light- and heavy-duty vehicles used on or off road as well as appropriate stationary applications which use vehicle derived components (e.g., generator sets). Vehicles of interest include, but are not limited to: on and off highway trucks and their trailers, construction equipment, and agricultural equipment and implements.

The purpose of these documents is to provide an open interconnect system for electronic systems. It is the intention of these documents to allow Electronic Control Units to communicate with each other by providing a standard architecture.

Network management in the SAE J1939 network is concerned with the management of source addresses and the association of those addresses with an actual function and with the detection and reporting of network related errors. Due to the nature of management of source addresses, network management also specifies initialization processes, requirements for reaction to brief power outages, and minimum requirements for ECUs on the network.

2. References—General information regarding this series of documents is found in SAE J1939.

2.1 Applicable Publications—The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest revision of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1587—Joint SAE/TMC Electronic Data Interchange Between Microcomputer Systems in Heavy-Duty Vehicle Applications
 SAE J1939—Recommended Practice for Serial Control and Communications Vehicle Network
 SAE J1939/21—Data Link Layer
 SAE J1939/31—Recommended Practice for Serial Control and Communications Vehicle Network—Part 31—Network Layer

3. Definitions

3.1 Terminology Used in Network Management—Terms are defined in SAE J1939 for use in the context of this document.

3.2 Address Configuration and Capability—Address configuration defines how a particular ECU obtains and retains its source address. Separate functions implemented within a single ECU, even though the function has only one node, may or may not have differing address capabilities for the different functions. Address configuration is distinct from the address claim procedure, which is a process whereby ECUs broadcast their intent to use a particular address. There are four distinct address configurations available to ECUs. The terms and definitions follow:

3.2.1 NON-CONFIGURABLE ADDRESS ECU—A Non-Configurable Address ECU is an ECU which has a source address(es) provided by its manufacturer. This address is not alterable by any means in the field. This includes service.

3.2.2 SERVICE CONFIGURABLE ADDRESS ECU—A Service Configurable Address ECU is an ECU whose source address(es) may be changed in the field by a service technician. The address may be altered by any one of a number of proprietary techniques or by using the Commanded Address message, while in a “service” mode of operation. It is very likely that a service tool would be involved.

3.2.3 COMMAND CONFIGURABLE ADDRESS ECU—A command Configurable Address ECU is an ECU whose source address(es) can be altered using the Commanded Address message during normal operation (as opposed to during service).

3.2.4 SELF-CONFIGURABLE ADDRESS ECU—A Self-Configurable Address ECU is an ECU which determines its source address(es) based on internal calculations and then claims that address. If a Self-Configurable Address ECU is not successful in claiming the first calculated address, then the ECU may re-calculate and claim another address. This latter type of ECU is Arbitrary Address Capable and will indicate so in the ECU’s NAME.

3.3 Types of ECUs—For the purposes of network management, there are three types of ECUs: Standard, Diagnostic/Development, and Network Interconnection ECUs.

3.3.1 STANDARD ECUs—Standard ECUs are those ECUs whose primary function is not that of network interconnection or of programming, diagnosing, or otherwise functioning as tools or network interconnection ECUs.

Standard ECUs include those used for engines, transmissions, ABS systems, virtual terminals, dashboards, and traction control systems. Data loggers and recorders are also examples of standard ECUs, but if these ECUs assume diagnostic tool functions, then they should meet requirements of diagnostic tool ECUs. Standard ECUs do not have the ability to modify the source addresses of any other ECUs except as a result of the address claiming process.

Standard ECUs then may or may not be capable of self-configurable addressing. It is not the intent of this document to require a particular address configuration capability.

- 3.3.2 **DIAGNOSTIC/DEVELOPMENT TOOL ECUs**—Diagnostic and Development Tool ECUs are those which are connected to a particular SAE J1939 subnetwork for the purpose of analyzing, debugging, developing, or monitoring any ECU on the subnetwork or the operation of the subnetwork itself. Although these tools are not expected to be permanently attached to a subnetwork, such a tool may well be a permanent part of a particular vehicle or craft. In either case, the capabilities of these tools are more extensive than those of Standard ECUs because they are primarily designed to interact with other ECUs on the network and have no other external functionality (a diagnostic tool, for example, is not expected to provide torque, plant beans, or brake a vehicle).

These tools may be intended as proprietary tools to operate on a given manufacturer's ECUs; they may be intended as a general purpose tool to operate on ECUs provided by several manufacturers, or they may be intended to work primarily on the network itself, providing network integration services for system integrators and the OEM vehicle manufacturers.

- 3.3.3 **NETWORK INTERCONNECTION ECUs**—Network Interconnection ECUs are those that exist primarily for the purpose of interconnecting networks or subnetworks. They primarily consist of repeaters, bridges, routers, and gateways. In one manner or another, all network interconnection ECUs forward messages from one subnetwork to another.

Subnetworks interconnected by Network Interconnection ECUs may have the same protocol, as in two SAE J1939 subnetworks in the same vehicle; they may have different protocols, such as from SAE J1708/J1587 to SAE J1939, or may be interconnected off-vehicle subnetworks, such as satellite links, token rings, or cellular modems.

Network Interconnection ECUs serving as gateways translate from SAE J1939 subnetworks to various other networks. This document will deal only with the SAE J1939 portions of those ECUs.

4. ***Technical Requirements***

- 4.1 **NAME and Address Requirements**—A NAME is a 64-bit entity composed of fields that are assigned by the committee. A NAME may indicate the ECU function (e.g., Engine Number 1, Engine Number 2, Transmission Number 1, Anti-Lock Brake System 1. Any Function that could be found on a network may be designated with a NAME. A NAME must be unique within a vehicle. A NAME is required for ECUs which transmit messages on a SAE J1939 network. The NAME serves two purposes, first to provide a functional description of the module and second, to provide a numerical value which may be used in arbitration for addresses. Addresses are used within SAE J1939 networks to provide uniqueness to message identifiers and to allow the source of a message to be determined. (Addresses are sometimes referred to as "Source Addresses" indicating the later use.) Address claim messages which contain both a source address and a NAME may be used to associate a NAME with a particular address on the network. The association of an address with a unique NAME (4.1.1) also provides means to associate addresses with Function. Manufacturers of ECUs and integrators of networks must assure that the NAMES of all ECUs intended to transmit on particular network are unique.

- 4.1.1 **NAME**—Source addresses in the SAE J1939 network serve to identify a particular ECU on a given network. The NAME, as opposed to the address, identifies the Function(s) that an ECU on the network serves. Address management procedures in the network management protocol primarily allow the association of individual source addresses with the Functions of the ECU, and the annunciation of that association onto the network. Appendix C provides examples of construction of Names for SAE J1939 ECUs.

Each ECU on a network should have at least one NAME so the ECU may be uniquely identified by its primary function. In turn, each ECU on the network will have at least one address which is unique so that it can properly arbitrate CAN Data Frames with other ECUs.

Although the entire NAME need not be field programmable, the instance fields should be alterable to allow for the correct configuration when, for example, a spare is installed in the field, or multiple instances may exist on a vehicle. Field programmability of the entire NAME field as well as the preferred address is recommended.

Listings of numerical values for Industry Groups, Vehicle Systems, Functions, and Manufacturer Codes are found in Appendix B of SAE J1939.

NAMEs are composed of fields as shown in Table 1, and are defined in the following paragraphs.

TABLE 1—NAME FIELDS

Arbitrary Address Capable	Industry Group	Vehicle System Instance	Vehicle System	Reserved	Function	Function Instance	ECU Instance	Manufacturer Code	Identity Number
1 bit 4.1.1.2	3 bit 4.1.1.3	4 bit 4.1.1.4	7 bit 4.1.1.5	1 bit 4.1.1.6	8 bit 4.1.1.7	5 bit 4.1.1.8	3 bit 4.1.1.9	11 bit 4.1.1.10	21 bit 4.1.1.11
Byte 8	byte 8	Byte 8	Byte 7	Byte 7	Byte 6	Byte 5	Byte 5	Byte 4/Byte 3	Byte 3/Byte 2/Byte 1

The byte ordering of the NAME fields in a CAN message is shown as follows, and is arranged to allow the NAME to be treated as a number in a manner consistent with SAE J1939/71.

Byte 1

Bits 8-1 Least significant byte of Identity Number (most significant at bit 8)
(Bit 8 is the bit sent closest to the DLC bits of the message.)

Byte 2

Bits 8-1 Second byte of Identity Number (most significant at bit 8)

Byte 3

Bits 8-6 Least significant 3 bits of Manufacturer Code (most significant at bit 8)
Bits 5-1 Most significant 5 bits of Identity Number (most significant at bit 5)

Byte 4

Bits 8-1 Most significant 8 bits of Manufacturer Code (most significant at bit 8)

Byte 5

Bits 8-4 Function Instance (most significant at bit 8)
Bits 3-1 ECU Instance (most significant at bit 3)

Byte 6

Bits 8-1 Function (most significant at bit 8)

Byte 7

Bit 8-2 Vehicle System (most significant at bit 8)
Bit 1 Reserved

Byte 8

Bit 8 Arbitrary Address Capable
Bits 7-5 Industry Group (most significant at bit 7)
Bits 4-1 Vehicle System Instance (most significant at bit 4)
(Bit 1 is the last of the data bits sent and is closest to the CRC in the message.)

- 4.1.1.1 *NAME Fields*—These fields are prioritized from left to right as shown in Table 1. The meaning of the contents of the Vehicle System field is dependent on the Industry Group field contents. Further, the contents of the Function field is dependent on the Vehicle System field contents when the value for Function is greater than 127 and less than 254. Figure 1 illustrates the relationship between the field definitions. If the data for any of the NAME fields except the Arbitrary Address Capable field is unknown or not available, the field should be set to binary ones indicating unknown or not available. The Arbitrary Address Capable field should be set to the appropriate value (see 4.1.1.2).

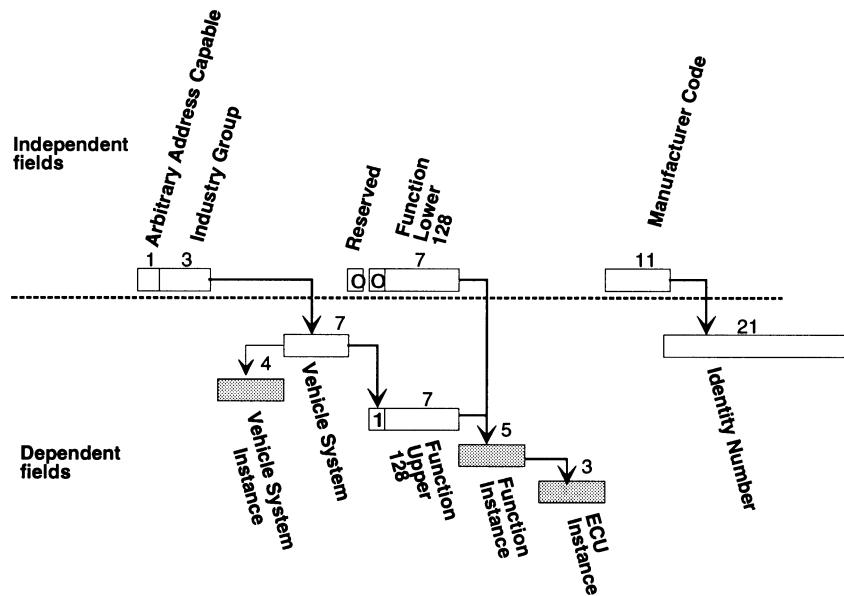


FIGURE 1—DEPENDENCIES IN THE NAME FIELDS

- 4.1.1.2 *Arbitrary Address Capable Field*—This 1-bit field indicates whether an ECU is self-configurable and can use an arbitrary source address to resolve an address claim conflict. If this bit is set to “1”, the ECU will resolve an address conflict with an ECU whose NAME has a higher priority (lower numeric value) by adopting a new source address. An ECU which computes its address and can claim only that particular address is not considered arbitrary address capable (i.e., On-Highway Trailers.) See 4.2 for details of the address claim process.
- 4.1.1.3 *Industry Group Field*—Industry Group is a 3-bit field defined and assigned by the committee. Industry Group definitions may be found in Appendix B.7 of the SAE J1939 base document. The Industry Group field identifies NAMEs associated with a particular industry that uses SAE J1939, for example: On-Highway Equipment or Agricultural Equipment.
- 4.1.1.4 *Vehicle System Instance Field*—Vehicle System Instance is a 4-bit field which indicates the occurrence of a particular Vehicle System within a connected network.

Note that in the case of single or first Vehicle System of a particular type, the instance field should be set to zero indicating the first instance.

4.1.1.5 *Vehicle System Field*—Vehicle System is a 7-bit field defined and assigned by the committee, which when combined with the Industry Group can be correlated to a common name. Vehicle System provides a common name for a group of functions within a connected network. Examples of Vehicle Systems for currently defined Industry Groups are “tractor” in the “Common” Industry Group, “Trailer” in the On-Highway Industry Group, and planter in the “Agricultural Equipment” Industry Group.

4.1.1.6 *Reserved Field*—Reserved for future definition by SAE. The reserved bit should be set to zero.

4.1.1.7 *Function Field*—Function is a 8-bit field defined and assigned by the committee. When Function has a value of 0 to 127, its definition is not dependent on any other field. When Function has a value greater than 127, its definition depends on Vehicle System. Function, when combined with the Industry Group and the Vehicle System fields can be correlated to a common name for specific hardware. The common name formed from the combination does not imply any specific capabilities.

4.1.1.8 *Function Instance Field*—The Function Instance is a 5-bit field which indicates the particular occurrence of a Function on the same Vehicle System on a given network.

Note that in the case of single or first Function of a particular type, the instance field should be set to zero indicating the first instance.

Individual manufacturers and integrators are advised that some agreement in the interpretation and use of Function Instances may be necessary. As an example, consider an implementation consisting of two engines and two transmissions. It may be important that engine instance 0 be physically connected to transmission instance 0 and that engine instance 1 be physically connected to transmission instance 1.

4.1.1.9 *ECU Instance Field*—The ECU Instance is a 3-bit field that indicates which one of a group of electronic control modules associated with a given Function is being referenced. For example, in the case where a single engine is managed by two separate control units, each of which is attached to the same SAE J1939 network, the ECU Instance Field will be set to 0 for the first ECU and 1 for the second ECU.

Note that in the case of single or first ECUs of a type, the instance fields should be set to zero indicating the first instance.

4.1.1.10 *Manufacturer Code Field*—The Manufacturer Code is an 11-bit field that indicates which company was responsible for the production of electronic control module for which this NAME is being referenced. Manufacturer codes are assigned by committee and may be found in the SAE J1939 base document. The Manufacturer Code field is not dependent on any other field in the NAME.

4.1.1.11 *Identity Number Field*—The Identity Number is a 21-bit field in the name assigned by the ECU manufacturer. The Identity Number is necessary in circumstances where it is possible that the NAME would not otherwise be unique (i.e., could be identical). This field should be unique and non-varying with removal of power. This field is necessary to resolve any address contention. It is the manufacturer's responsibility to provide this uniqueness among his products (for example, through the use of identity number, serial number, time/date code, etc.)

4.1.1.12 *Dependencies in the NAME Fields*—Figure 1 illustrates the dependencies of the upper 128 Functions on Vehicle System and Industry Group. In addition, the dependency of Identity Number on Manufacturer Code is shown. The Reserved field is not shown. Functions 0 through 127 are independent of Industry Group or Vehicle System. Functions 128 to 254 are dependent on both vehicle system and industry group.

- 4.1.2 **ADDRESSES**—Most ECUs that operate on a SAE J1939 network will have an assigned preferred address (see SAE J1939, Tables B2 to B9) that the ECU should attempt to use first. If the ECUs preferred address has been successfully claimed (in use) by another ECU on the network, the ECU will have the option of attempting to secure another source address or it may send a Cannot Claim Address message depending on the ECUs addressing capability and the availability of an unused address.

An ECUs initial address, the address an ECU attempts to claim on first power-up, should be set by the manufacturer to match the list of application-defined preferred addresses wherever possible (SAE J1939 Tables B2 to B9). However, an ECUs initial address should be reprogrammable to permit an OEM to properly configure a vehicle. Although this may not be necessary on “standard” vehicles, it provides flexibility for applications where multiple instances of a given ECU (i.e., when there are two engines, etc.) may exist. This reprogrammability feature is especially important for temporarily connected or aftermarket ECUs.

Source addresses must be unique within a particular vehicle. Source addresses may be associated with different ECUs after each power-up of the vehicle and may also vary from vehicle to vehicle. The NAME associated with each ECU is normally configured during initial vehicle or machine configuration (final vehicle assembly), or when the ECU is added to the vehicle. The NAME, which is associated with source addresses, identifies the Functions that ECUs serve and retains a consistent definition regardless of the address used.

Self-configurable addressing is supported in this document. Self-configurable addressing is intended primarily for use by ECUs that may be attached to an already operating network, such as data loggers, calibration ECUs, bridges, or implements.

Support for self-configurable addressing in this document is not intended to imply that a given ECU should support self-configurable addressing. SAE J1939 ECUs are not required to posses self-configurable addressing capability, however, they are required to perform the minimum Network Management functions described in 4.5.2 and may for particular applications be required by the manufacturer to have such capabilities.

- 4.2 **Network Management Procedure**—Network management procedures are the messages passed and the actions taken by individual ECUs to collectively manage the network. The primary functions of the Network Management protocol are those of Address Management and Network Error Management.

Network Management messages have the same characteristics and requirements as other SAE J1939 messages with the exceptions of the use of the null address. The request for Address Claimed message is a conventional Request message as described in SAE J1939/21. The null address (254) is acceptable in the source address field of a network management message only if the message is a request for Address Claimed or a Cannnot Claim Address message. A request directed to the null address (254) yields no responses.

The set of network management messages may be used to request addresses and NAMES in use by other ECUs on the network, claim an address for an ECU, announce the inability to claim an address, or command another ECU to assume a new address. Table 2 summarizes the messages

TABLE 2—ADDRESS MANAGEMENT MESSAGES

Message Name	PGN	PF	PS	SA	Data Length (Bytes)	Data
Request PG (request for Address Claimed)	59904 (See SAE J1939/21)	234	DA	SA ⁽¹⁾	3	PGN 60928
Address Claimed						
Address Claimed	60928	238	255	SA	8	NAME
Cannot Claim Source Address	60928	238	255	254	8	NAME
Commanded Address	65240	254	216	SA	9 ⁽²⁾	NAME, new SA

1. Source address could be set to 254 if no address has yet been claimed.
2. Commanded Address message is sent with the Transport Protocol BAM (See SAE J1939-21).

4.2.1 **REQUEST MESSAGE FOR ADDRESS CLAIMED**—The request message for Address Claimed is used by any ECU to request the NAMEs and addresses of ECUs attached to the network. Upon receipt of the request message for Address Claimed, each ECU shall transmit an Address Claimed message containing its address and its NAME. Any ECU which cannot claim an address will respond with a Cannot Claim Address message (4.2.2.2) unless the ECU has not yet attempted to claim an address. ECUs which have not yet attempted to claim an address should not participate in network communications until the ECU has attempted to claim an address. These ECUs should not send a Cannot Claim Address message or any other message until an Address Claim has been attempted.

The request for Address Claimed message may be sent to a particular address or to a global destination address (255). An ECU preparing to use a particular address may interrogate that address by sending a request for address claim to that particular address to determine if it has been claimed by another ECU. An ECU may determine the existence of a functioning ECU with a particular NAME on the network by sending a request for Address Claim to the global address (255) and examining the responses.

The source address for a request for Address Claimed message must be the null address (254) if the request is from an ECU that has not yet claimed an address.

An ECU should respond to its own request for Address Claimed message.

4.2.2 **ADDRESS CLAIMED/CANNOT CLAIM**—The Address Claimed PGN may be used in two ways, to claim an address, and to announce that an address cannot be claimed. The former case is referred to in 4.2.2.1 as the Address Claimed message and 4.2.2.2 as the Cannot Claim Address message. The Address Claimed message is used by any ECU to either respond to a received request for Address Claimed message or to simply claim a single address on the network. It must be issued by ECUs during initialization of a network or by ECUs when attached to a running network. If an ECU receives an Address Claimed message claiming its own source address, it should compare the NAME that was received in the Address Claimed message with its own NAME and determine which ECU has a higher priority NAME (lower numeric value as described in 4.4.3.3). If the ECU receiving the Address Claim determines that it has the higher priority NAME it may then transmit an Address Claimed message containing its NAME and address. However, if it has the lower priority NAME it should either attempt to claim a different address or send a Cannot Claim Address message.

Successful claiming of an address by an ECU consists of sending an Address Claim message for the address to be claimed and not receiving contending claims from other ECUs for 250 ms. An ECU should not begin or resume origination of normal network traffic until successfully claiming an address (see Figure A1.) An ECU may send the Cannot Claim Address message (see 4.2.2.2) or a Request for Address Claim using the null address as a source address (see 4.2.1) without having successfully claimed an address. A network interconnection ECU may not use its own address in communications on the network until it has successfully claimed an address. Handling messages of other ECUs is a special case for network interconnection devices. Network interconnection devices acting entirely as repeaters may pass messages before claiming their own addresses. (For further requirements for network interconnection devices, see SAE J1939/31.)

Configuration of networks with multiple bridges may create significant delay between transmission and reception of address claims which traverse the bridges. The 250 ms delay may not be adequate in these systems to prevent further arbitration after an ECU has successfully claimed an address.

Once an ECU has successfully claimed an address, it may respond to a Request for Address Claim and immediately resume transmitting other messages on the network.

Address 254, the null address, should not be claimed for use by an ECU and if an Address Claimed message is sent with address 254 as the source address, the message will be interpreted as a Cannot Claim Address message (see 4.2.2.2).

The Address Claimed message should always be sent to the global address (255) to provide all ECUs on the network the information to maintain a current address to NAME correspondence. The Address Claim message is an exception to the requirements on request messages specified in SAE J1939/21. SAE J1939/21 defines that a request message which is directed to a specific address be responded to with the destination set to the requester.

4.2.2.1 Address Claimed Message

Transmission Repetition Rate:	As required
Data Length:	8 bytes
Data Page:	0
PDU Format:	238
PDU Specific:	255 (global address)
Default Priority:	6
Parameter Group Number:	60928 (00EE00 ₁₆)
Source Address:	0 to 253
Byte:	1-8 NAME

4.2.2.2 Cannot Claim Address—The Cannot Claim Address message is the same PGN as the Address Claimed message but has a source address of 254, the null address. A Cannot Claim Address message is transmitted by any ECU which cannot claim its preferred address and does not have self-configurable addressing capability, or has self-configurable addressing capability but cannot claim an address because none are available for use.

The Cannot Claim Address message may be sent as a response to a Request for Address Claim message or to an Address Claim message. A pseudo-random delay of between 0 and 153 ms should be inserted between the reception of a message triggering the response and the Cannot Claim Address response. The delay is intended to minimize the potential that two Cannot Claim Address messages will cause bus errors. The method for generating the pseudo-random delay is described in 4.4.3.3.

An ECU which cannot claim an address shall not send any message other than the Cannot Claim Address message or a Request for Address Claim.

4.2.2.3 Cannot Claim Address Message

Transmission Repetition Rate:	As required
Data Length:	8 bytes
Data Page:	0
PDU Format:	238
PDU Specific:	255 (global address)
Default Priority:	6
Parameter Group Number:	60928 (00EE00 ₁₆)
Source Address:	254
Byte: 1-8	NAME

4.2.3 **COMMANDED ADDRESS**—A network interconnection ECU, a bridge for example, or a diagnostic or scan tool may command another ECU (Commanded ECU) to use a given source address with the Commanded Address Message. The Commanded Address message may be used to instruct an ECU with a specific NAME to use a source address (Figures 9 and 10 in Appendix A). Upon receipt of a Commanded Address message containing its own NAME, an ECU should respond in either of two ways: it may accept by initiating an address claim procedure using the new address provided in the Commanded Access message or ignore the command by sending no response. If the Commanded Address is successfully claimed, future transmissions from the ECU should use the commanded address until another Commanded Address message is received or, through power-up or address contention, another address claim process is completed. If the Commanded ECU elects to receive the Commanded Address message and cannot change to the Commanded Address, it should ignore the Commanded Address and issue an Address Claim for its current address. Note that if the Commanded ECU does not accept the Commanded Address, an operator or technician may have to modify the ECUs source address or NAME through alternate means for the network to operate. If the source address or NAME is modified, the ECU must re-issue an Address Claim before originating transmissions on the network. An ECU manufacturer may elect not to accept Commanded Address messages from ECUs other than service tools or bridges. Further, ECU manufacturers may require some type of security verification process before accepting a Commanded Address message.

The Commanded Address message contains 9 bytes of data and should be sent using the Broadcast Announce Mode (BAM) of the transport protocol (SAE J1939/21) and should be sent to the global address (255). ECUs designed to support the Commanded Address message must also support the BAM form of the Transport Protocol.

4.2.3.1 Commanded Address Message

Transmission Repetition Rate:	As required
Acknowledgment:	See Figures 9 and 10 in Appendix A
Data Length:	9 bytes
Data Page:	0
PDU Format:	254
PDU Specific:	216
Default Priority:	6
Parameter Group Number:	65240 (00FED8 ₁₆)
Byte: 8-1	NAME (5.1)
Byte 9	Address Assignment Field (new source address)

4.2.3.2 **Address Assignment Field (New Source Address)**—This 8 bit field is the 9th byte of the data field of the Commanded Address message. It contains the source address that is to be assigned to the ECU that has the NAME corresponding to the one conveyed in the first eight bytes of this Commanded Address message. All messages originating from this ECU after reception of the Commanded Address message and successful claim of that address shall use that source address.

4.3 Network Error Management—Network Error Management exists to provide a means of detecting addressing related errors, for example, failure of an ECU to successfully claim an address. Other addressing related errors, for example duplicate address claims or duplicate NAMES may be detected by a diagnostic tool through the use of the request for address claim capability.

4.3.1 **CANNOT CLAIM ADDRESS**—If an ECU has attempted and cannot successfully claim a source address because the address(s) it attempted to claim are already claimed on the network by an ECU with a higher priority NAME, a Cannot Claim Address error exists.

4.4 Address Claim and ECU Initialization Procedure—The Address Claimed message is used by each ECU to acquire a unique address on the vehicle network after completing its own Power On Self Test (POST) and before originating other communications messages. The procedure that follows, assures that any duplicate addresses are detected during initialization processes and resolved at that time.

4.4.1 **ADDRESS CLAIM REQUIREMENTS**—Every ECU is required to claim its source address upon initialization and upon any change of the ECUs NAME or source address. An ECU may support and act on a Commanded Address message, in which case, the later requirement provides confirmation that the Commanded Address message was accepted. The requirement also assures that each ECU take responsibility for obtaining a valid address and that other ECUs properly arbitrate for the address if their address claim has not yet been heard by the ECU. The destination address for an address claim should be global (255) to “announce” the claim message to all ECUs on the network.

An ECU should be able to differentiate between Address Claimed messages received that may have been sent by the ECU itself and those sent by other ECUs to allow duplicate addresses to be detected.

4.4.1.1 *Requirements for Requests for Address Claimed*—The source address for a request for Address Claimed message must be the null address (254) if the request is from an ECU that has not yet successfully claimed an address.

4.4.2 **INITIALIZATION RULES**—The following rules apply to all ECUs (minimum requirements):

4.4.2.1 *Response to a Request for Address Claimed Sent to the Global Address*—An ECU should always respond to a Request for Address Claimed directed to the global address with either an Address Claimed message or if the ECU has not been successful in claiming an address, a Cannot Claim Address message. The ECU should not respond at all if the ECU has not yet attempted to claim an address (see 4.2.1).

4.4.2.2 *Response to a Request for Address Claimed Sent to a Specific Address*—An ECU should always respond to a Request for Address Claimed where the destination address of the request is the ECUs address. The response to the request, the Address Claimed message, should be sent to the global address (255).

4.4.2.3 *Response to Address Claims of Own Address*—An ECU should transmit an Address Claim if it receives an Address Claim with a source address that matches its own, and if its own NAME is of a lower value than the NAME in the claim it received. If the ECUs NAME is of a higher value than the NAME in the claim it received, the ECU should not continue to use that address. (It may send a Cannot Claim Address message or it may attempt to claim a different address.)

- 4.4.2.4 *Contention for an Address*—An ECU that discovers it cannot use an address due to a higher priority competing claim, should either send a Cannot Claim Address message (Non-configurable, Service configurable, or Command configurable) or select another address and attempt to claim that address (Self-configurable). An ECU previously listening to this ECU should detect that the ECU has become disabled or changed its address by monitoring the Address Claim by the more dominant ECU (lower name value) as well as by monitoring the Cannot Claim Address message. Service tools, and bridges in some systems, may be expected to detect and resolve failures to claim an address. Service tools may monitor the Cannot Claim Address message and report the problem to the operator of the tool.
- 4.4.3 MESSAGE SEQUENCES FOR INITIALIZATION—Graphical schematics of the initialization sequences for the different ECUs under the various potential conditions are provided in Figures 1 to 7 in Appendix A. The conditions under which each figure applies is specified in the following paragraphs. The address and NAME prioritization process used in the figures is presented in 4.4.3.3
- 4.4.3.1 *Message Sequences for Initialization for All ECUs on the Network*—Message sequences for initialization of all ECUs using the network are shown in Appendix A, Figures 1, 2, 3, and 4. The conditions under which sequence applies is summarized in Table 3.

TABLE 3—CONDITIONS UNDER WHICH SEQUENCE IS APPLICABLE

Figure	Condition Under Which Sequence is Applicable
1	ECU with address claim where no contention occurs
2	ECUs claiming the same address, but not synchronized
3	ECU where NAME A is less than NAME B and ECU B is Self-Configurable
4	ECUs claiming the same address, synchronized

- 4.4.3.2 *Potential Identical Identifiers in Network Management Messages*—The possibility exists for messages with the same identifiers to be generated by different ECUs with three of the network management messages. These messages include: (a) request for Address Claimed, (b) Address Claimed, and (c) Cannot Claim Address messages.
- The sending of a Request for Address Claimed message simultaneously by two different ECUs which are both sending from the null address (254) is not a problem because the data field is the same for both messages.
 - The sending of an Address Claimed message simultaneously by two different ECUs which are contending for the same address will cause bus collisions because the NAMEs in the data field of the message will be different. See 4.4.3.3 for the resolution method.
 - The sending of a Cannot Claim Address message simultaneously by two different ECUs from address 254 will cause bus collisions because the NAMEs in the data field will be different. See 4.4.3.3 for the resolution method.
- 4.4.3.3 *Address Claim Prioritization*—In the event that an address is contended for by two ECUs, priority shall be allotted to the ECU with the lowest numerical value of the NAME. The NAME should be treated as a single 8-byte numerical value with the most significant bit at the Arbitrary Address Capable bit for determining numerical value. For example, should, Engine 0 and Engine 1 both desire the same address, Engine Instance 0 will have a lower absolute value NAME and therefore will win address arbitration. This process is shown in Figures A2 and A3.

Although this requires comparison of the 8-byte NAMEs in the Address Claimed Message data fields, it eliminates ambiguity in the address claiming process.

If multiple ECUs have the same address and different NAME, simultaneous Address Claimed messages will result in bus errors. To minimize the probability of modules generating bus errors until going bus off, the following special processing should be used when transmitting claim messages.

After transmitting any claim message, the transmitting ECU should monitor error code information. If the error code indicates that a bus error has occurred, any automatic retransmission attempts by the CAN peripheral should be canceled if possible.

The retransmission of the claim message should be rescheduled after end of frame plus a transmit delay.

The transmit delay will be calculated to produce a pseudo-random value between 0 and 255. The NAME, serial number, or other unique information within the ECU should be selected by the manufacturer to seed the pseudo-random number generator. The transmit delay will be added to the normal idle period before the next claim message is transmitted. The module should be able to schedule the next claim message within ± 0.6 ms of the calculated delay.

The delay will be calculated by multiplying the 0 to 255 output of the pseudo-random number generator by 0.6 ms. (The maximum time one message requires on the bus) producing a delay range of 0 to 153 ms. If a second claim message transmission results in a bus error, the process should be repeated with a new pseudo-random number.

Figure A4 illustrates the process of simultaneous claims by two ECUs of the same address.

- 4.4.3.4 An ECU Which Cannot Obtain an Address**—The message sequence for answering a request for Address Claimed for an ECU which cannot obtain an address is shown in Figure A8. The ECU should respond to a request for Address Claimed with a Cannot Claim Address message after a transmit delay (see 4.4.3.3). In the case where there is a collision of the Cannot Claim Address messages, the process in 4.4.3.3 should be used. An ECU which cannot claim an address may send no messages except (a) A Cannot Claim Address message in response to requests for Address Claimed or to Respond to a Commanded Address message or (b) A request for Address Claimed message.

- 4.4.4 REQUESTS FOR ADDRESS CLAIMED FOR SELF-CONFIGURABLE ADDRESSING ECUs**—A Self-Configurable Addressing ECU may elect to obtain a list of the addresses already claimed on the network before itself claiming an unused address. Note that the ECU may, upon discovery that its preferred address has been claimed, request the addresses of all ECUs on the network using the source address of 254 and then claim an address that was not previously claimed. Preferably, a Self-Configurable Addressing ECU will transmit a request for Address Claimed with a destination address set to the preferred address it would like to claim for the purpose of finding an unclaimed address. The Address Request sent to the global address should be used with care since it generates a response from every ECU on the network (Figure A6). The specific request can be directed at an address which is not likely to be occupied and will minimize message traffic (Figure A5).

- 4.4.4.1 ECUs Not Permanently Connected to the Network**—A request for Address Claimed message may be used to determine if an address is being used before attempting to claim that address. This process allows a self-configurable device to create less address contention when it initializes on the network. This procedure is appropriate for ECUs that are not permanently connected to the network, such as tools. Message sequences for initialization of ECUs not permanently connected to the network are shown in Figures A5, A6, and A7. The request for Address Claimed message preceding the claim can be used in identifying an unused address for ECUs that are self-configurable.

4.4.5 CONSTRUCTION OF ADDRESS TO NAME ASSOCIATION TABLES—Request for Address Claimed sent to a specific address or to the global address may be used to construct an address to NAME association table. This table may be used in some ECUs to confirm the associations for critical functions, for example, to confirm that the powertrain engine is located at address 0 to insure that torque/speed control messages from the transmission are sent to the proper destination. In ECUs where a small number of address to NAME associations are required, Requests for Address Claimed sent to a specific address should be used. In a diagnostic tool where all of the ECUs on a network need to be inventoried, a Request for Address Claimed sent to the global address is appropriate.

4.5 Minimum Network Management Functionality—The features provided by the Network Management protocol include more than the minimum required for an ECU communicating on a SAE J1939 network. The minimum network procedures are those without which an ECU cannot operate on a SAE J1939 network. They are described in the following paragraphs.

4.5.1 REACTION TO POWER SUPPLY AND OTHER RELATED ECU DISTURBANCES—Due to the questionable integrity of power supplied to ECUs on towed vehicles and the time required for address re-arbitration, the following criteria are established. For all ECUs which are powered through a tractor interface connector on a towed sub-network (corresponding to a breakaway connector for the agricultural industry group), any disturbance, such as momentary power loss, that lasts less than 2 ms (with 10 ms recommended) should not result in network re-initialization (a new round of address claim). This does not preclude an ECU from performing any degree of reset or re-initialization within the ECU. The ECU must retain its NAME, address, and any NAME/address tables used by that ECU through such a disturbance. For disturbances of longer duration or higher frequency, network reinitialization may be performed and is required if the disturbance is longer than 1 s. The required reinitialization after 1 s is needed to force towed vehicle systems to reinitialize after disconnection from the towing vehicle.

There is no requirement for towing vehicles.

4.5.2 MINIMUM NETWORK MANAGEMENT CAPABILITY—The following section describes minimum network management capability for ECUs to operate on a SAE J1939 network. A summary of the requirements and capabilities for SAE J1939 ECUs is provided in Appendix B.

4.5.2.1 *Request for Address Claimed Message*—Upon receipt of a Request for Address Claim message, an ECU must transmit an Address Claimed message containing its current address, or if it cannot claim an address for whatever reason, it should transmit a Cannot Claim Address message using the null address in the source address field unless the ECU has not yet attempted to claim an address. ECUs which have not yet attempted to claim an address should not participate in network communications until the ECU has attempted to claim an address. These ECUs should not send a Cannot Claim Address message or any other message until an Address Claim has been attempted.

Note that an ECU should also respond to its own request for Address Claimed message.

4.5.2.2 *Address Claimed Message Before Using a Source Address*—No ECU may originate a message on the network until 250 ms after it has transmitted an Address Claimed message without address contention with three exceptions. First, if a Cannot Claim Address message has been issued by the ECU, it should respond to a request for Address Claimed message directed to the global address (255) by retransmitting the Cannot Claim Address message. The ECU may also transmit a Request for Address Claim but should not transmit other messages. Second, the ECU may transmit a Request for Address Claim using the null address as a source address. Third, a network interconnection device acting entirely as a repeater may pass messages before claiming its own address. (For further requirements for network interconnection devices, see SAE J1939/31.)

Once an ECU has successfully claimed an address, it may respond to a Request for Address Claim and immediately resume transmitting other messages on the network.

If the source address or NAME of an ECU is modified, (for example, through the Commanded Address message or through proprietary techniques) the ECU must re-issue an Address Claim before originating transmissions on the network.

- 4.5.2.3 *Disruption of the Network During Connection or Disconnection of an ECU*—Connection, disconnection, or power-up of the ECU should not disrupt network communications. Disruption of the network would consist of uncontrolled transmission of a bit stream to the network during the power-up of an ECU.
- 4.5.2.4 *Continuity of Addresses Across Power-Down and Power-Up Cycles*—ECUs should be able to maintain their source address and any addresses for ECUs that are communicated with so that the ECU can attempt to use the same addresses at the next power-up. This should be done except in cases where special requirements override this recommendation, for example, in towed subnetworks of Off-Highway trailers where the instance and associated addresses of the trailer may change at each power-up.

PREPARED BY THE SAE TRUCK AND BUS CONTROL AND COMMUNICATIONS SUBCOMMITTEE
OF THE SAE TRUCK AND BUS ELECTRICAL AND ELECTRONICS COMMITTEE

APPENDIX A
INITIALIZATION SEQUENCE TIMING DIAGRAMS

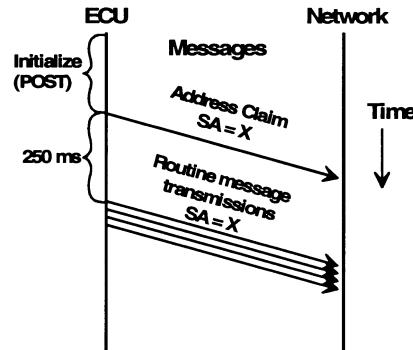


FIGURE A1—INITIALIZATION OF AN ECU WITH ADDRESS CLAIM AND NO CONTENTION

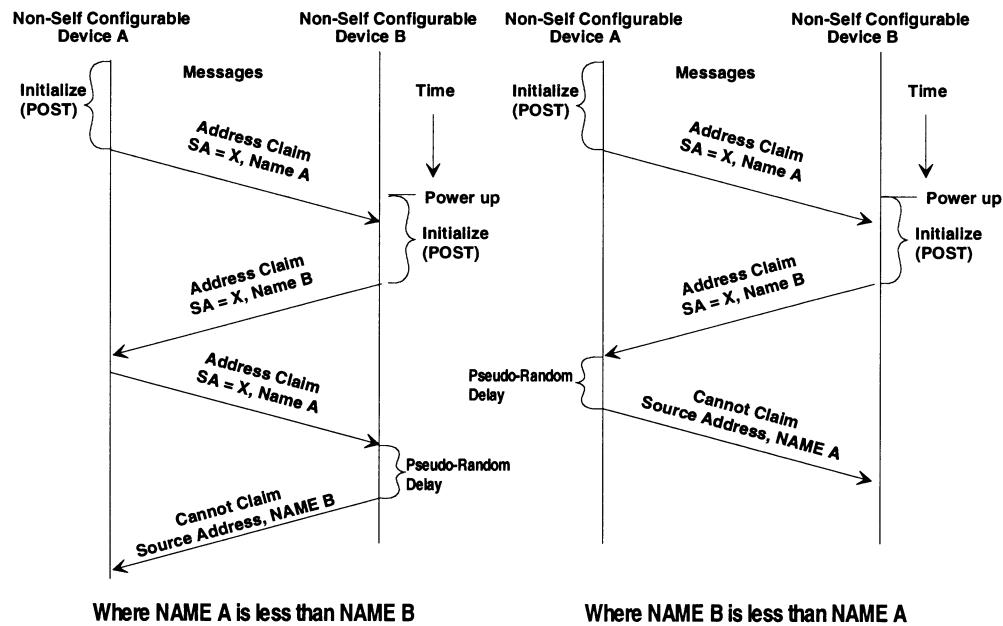


FIGURE A2—INITIALIZATION OF AN ECU WHERE TWO NON-SELF-CONFIGURABLE ECUS ATTEMPT TO CLAIM THE SAME ADDRESS BUT ARE NOT SYNCHRONIZED

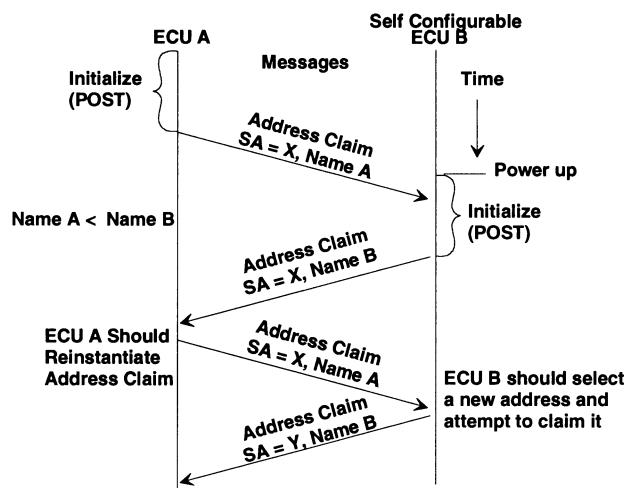


FIGURE A3—INITIALIZATION OF AN ECU WHERE NAME A IS LESS THAN NAME B AND ECU B IS SELF-CONFIGURABLE

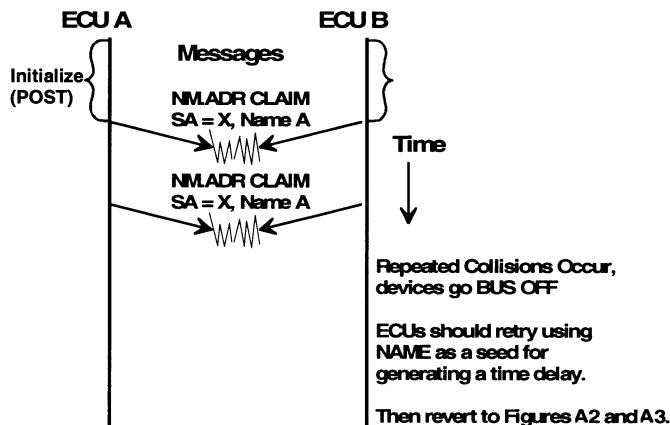


FIGURE A4—INITIALIZATION OF AN ECU WITH TWO ECUs ATTEMPTING TO CLAIM THE SAME ADDRESS BUT WITH SYNCHRONIZED CLAIMS

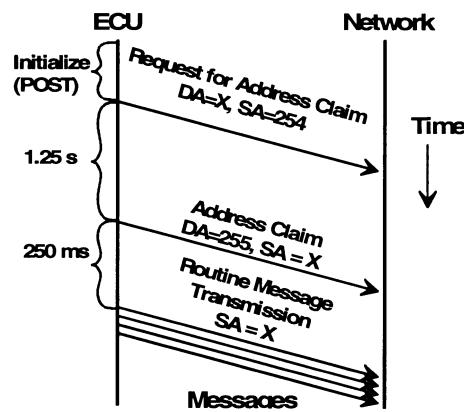


FIGURE A5—INITIALIZATION OF A SELF-CONFIGURABLE ECU WITH NO CONTENTION

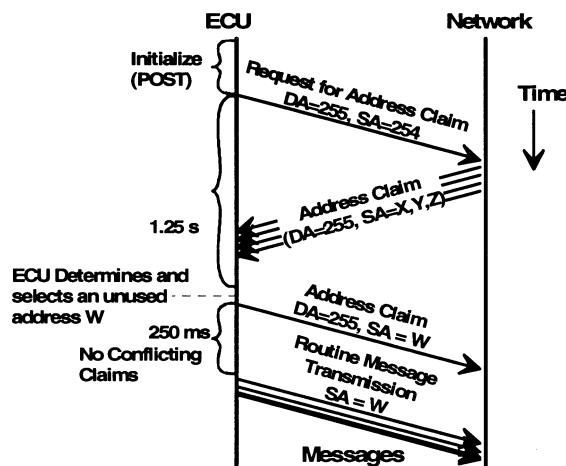


FIGURE A6—INITIALIZATION OF A SELF-CONFIGURABLE ECU WITH A REQUEST FOR ADDRESS CLAIMED SENT TO THE GLOBAL ADDRESS

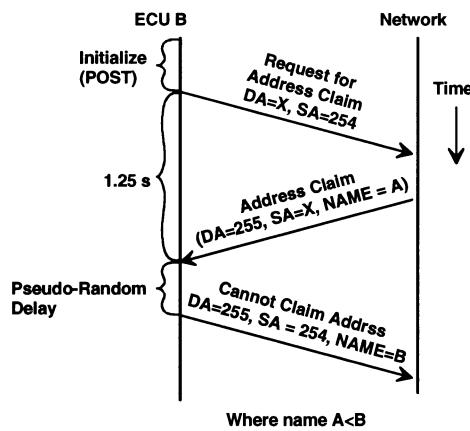


FIGURE A7—INITIALIZATION OF A NON-SELF-CONFIGURABLE ECU WITH A REQUEST FOR ADDRESS CLAIMED WHERE ADDRESS IS IN USE

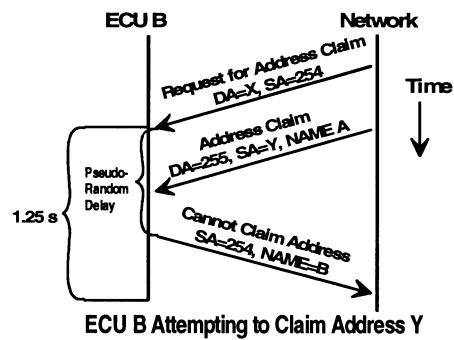


FIGURE A8—RESPONSE TO A REQUEST FOR ADDRESS CLAIMED BY AN ECU WHICH HAS BEEN EARLIER UNSUCCESSFUL IN CLAIMING AN ADDRESS

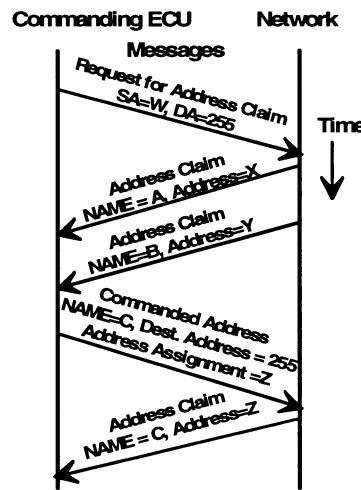


FIGURE A9—COMMANDING AN ADDRESS OF AN ECU WHICH DOES NOT HAVE AN ADDRESS AND SUPPORTS THE COMMANDED ADDRESS MESSAGE

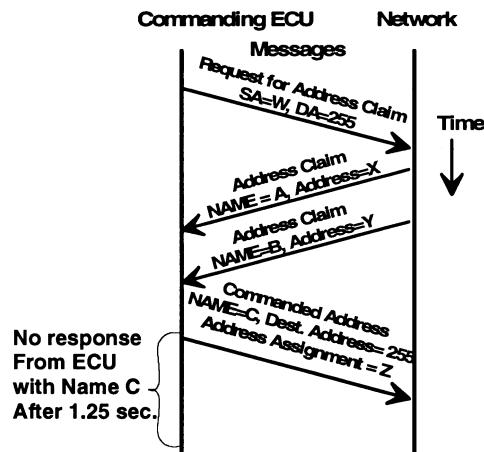


FIGURE A10—COMMANDING AN ADDRESS OF AN ECU WHICH DOES NOT HAVE AN ADDRESS AND THE COMMANDED ECU DOES NOT SUPPORT A COMMANDED ADDRESS MESSAGE

NOTE—The Commanded ECU may elect not to support the Commanded Address message, in which case the Commanded Address message will be ignored.

APPENDIX B

SUMMARY OF REQUIREMENTS AND CAPABILITIES OF ECUs

Capability	Standard				Diagnostic/ Development		Network			
					Tools					
					Command Configurable	Service-Configurable	Non-Configurable			
Key:	R - Required	P - Permissible	D - Desirable	N - Not recommended or required	NA - Not Applicable					
Upon receipt of a request for Address Claimed message, an ECU should transmit an Address Claimed or a Cannot Claim SA Message (4.5.2.1)	R	R	R	R	R	R	R	R	R	R
Support Commanded Address Message Containing Own NAME (4.2.3)	NA	P	R	P	NA	D	R	D	NA	D
Issue a Valid Address Claimed Message before using a Source Address (4.5.2.2)	R	R	R	R	R	R	R	R	R	R
Support transmission of Commanded Address Message (4.2.3)	P	P	P	P	D	D	D	D	P	P
Send Request for Address Claim before attempting to claim (4.4.5)	P	P	P	P	D	D	D	D	P	P
Monitor and correct situations where ECUs cannot claim addresses (4.2.3)	N	N	N	N	D	D	D	D	P	P
Address configuration capability (3.2)	P	P	P	P	N	P	D	D	P	P
Name field programmability (4.1.1)	NA	D	D	D	NA	D	D	D	NA	D
Address retained across power up cycle (4.5.2.4)	R	R	R	D	R	R	R	D	R	R
Name retained across power up cycle (4.1)	R	R	R	D	R	R	R	D	R	R
Address table retained across powerup (4.5.2.4)	P	P	P	D	P	P	P	D	P	P

1. Other than the required categories (R), the classifications are provided for general guidance only.

FIGURE B1—SUMMARY OF REQUIREMENTS AND CAPABILITIES OF ECUs

APPENDIX C

NAME EXAMPLES

C.1 Name Examples—Three examples of the NAMEs are shown as follows, ranging from a very simple case to a very complex case. Due to the nature of the naming convention, NAMEs in these examples are expressed in binary. Appendix B of SAE J1939 should be used as a source when constructing a NAME.

C.1.1 Example 1—Single ECU Serving an Engine on an On-Highway Heavy-Duty Truck—From Appendix B, Table B1 of SAE J1939, the Industry Group for this application is Global and has an Industry Group Code of 0. (Other Industry Groups may be applicable for an engine which has a Function between 0 and 127.) For a tractor in this Industry Group, the Vehicle System Name code is 1 from Appendix B, Table B11 of SAE J1939. The Vehicle System Instance is also 0 for the first instance. From the same table, engines are given the Function Name Code of 0. As this is a single-engine vehicle, the Function Instance field is set to 0. Since there is only one ECU, the ECU Instance field is 0. The Manufacturer Code, and the Identity Number bits are shown in a generic form. This yields the ECU name as shown in Figure C1:

Self-Configurable Address	Industry Group	Vehicle System Instance	Vehicle System	Reserved	Function	Function Instance	ECU Instance	Mfg. Code	Identity Number
1 bit 0	3 bit 000	4 bit 0000	7 bit 0000001	1 bit 0	8 bit 00000000	5 bit 00000	3 bit 000	11 bit mm...m	21 bit ii...i

FIGURE C1—SINGLE ECU SERVING AND ENGINE ON AN ON-HIGHWAY HEAVY-DUTY TRUCK

C.1.2 ABS on the First Trailer of Heavy-Duty Truck—This example illustrates NAME assignment for a single non-Self-Configurable ECU serving an ABS on the first trailer of heavy-duty truck. From Appendix B, Table B1 of SAE J1939, the Industry Group for this application is Global and has an Industry Group Code of 0. The Vehicle System Name code for a trailer, which is 2, is found in Appendix B, Table B11 of SAE J1939 under the On-Highway Industry Group. The Vehicle System Instance is 0 for the first Instance of trailer. ABS units on a trailer have Function Name of 129. Assuming this is the only ABS unit on the trailer, the Function Instance field is set to 0. Since there is only one ECU for this ABS function, the ECU Instance field is 0. The Manufacturer Code, and the Identity Number bits are again shown in generic form. See Figure C2.

Self-Configurable Address	Industry Group	Vehicle System Instance	Vehicle System	Reserved	Function	Function Instance	ECU Instance	Mfg. Code	Identity Number
1 bit 0	3 bit 000	4 bit 0000	7 bit 0000010	1 bit 0	8 bit 10000001	5 bit 00000	3 bit 000	11 bit mm...m	21 bit ii...i

FIGURE C2—ABS ON THE FIRST TRAILER OF HEAVY-DUTY TRUCK

C.1.3 Agricultural Planters with Separate Row Guidance—This example illustrates NAME assignment for two agricultural planters connected together in a system with separate row guidance on eight individual rows, each row with two ECUs. From Appendix B, Table B1 of SAE J1939, the Industry Group for this application is Agricultural Equipment and has an Industry Group Code of 2. For a planter in this Industry Group, the Vehicle System Name code is 5 from Appendix B, Table B11 of SAE J1939. Since this is an agricultural implement, "Self-Configurable Addressing" is assumed and the Arbitrary Address Capable bit is set. Since there are two planters, the Vehicle System Instances would be 0 for ECUs on planter 1 and 1 for ECUs on planter 2. Since the Function is Row Guidance, the Function Name code is not yet defined and represented generically in the name here. The Function Instance field would run from 0 to 7 on each of the planters. Since there are two ECUs per row, the ECU instances of 0 and 1 would occur for each of the eight Functions. The Manufacturer Code and the Identity Number bits are shown in a generic form. The resulting NAMES are shown in Figure C3:

	Self-Config. Address	Ind. Group	Vehicle System Instance	Vehicle System	Reserved	Function	Function Instance	ECU Instance	Mfg. Code	Identity Number
	1 bit	3 bit	4 bit	7 bit	1 bit	8 bit	5 bit	3 bit	11 bit	21 bit
	1	010	No.	Planter	0	Row Guidance	No.	No.	mm...m	Mfg. Assigned
Planter '1', Row '1', ECU '1'	1	010	0000	0000101	0	ff...f	00000	000	mm...m	ii...i
Planter '1', Row '1', ECU '2'	1	010	0000	0000101	0	ff...f	00000	001	mm...m	ii...i+n
Planter '1', Row '2', ECU '1'	1	010	0000	0000101	0	ff...f	00001	000	mm...m	ii...i+p
Planter '1', Row '2', ECU '2'	1	010	0000	0000101	0	ff...f	00001	001	mm...m	ii...i+q

Planter '2', Row '8', ECU '1'	1	010	0001	0000101	0	ff...f	00111	000	mm...m	ii...i+r
Planter '2', Row '8', ECU '2'	1	010	0001	0000101	0	ff...f	00111	001	mm...m	ii...i+s

FIGURE C3—AGRICULTURAL PLANTERS WITH SEPARATE ROW GUIDANCE

Rationale—Not applicable.

Relationship of SAE Standard to ISO Standard—Not applicable.

Application—These SAE Recommended Practices are intended for light- and heavy-duty vehicles used on or off road as well as appropriate stationary applications which use vehicle derived components (e.g., generator sets). Vehicles of interest include, but are not limited to: on and off highway trucks and their trailers, construction equipment, and agricultural equipment and implements.

The purpose of these documents is to provide an open interconnect system for electronic systems. It is the intention of these documents to allow Electronic Control Units to communicate with each other by providing a standard architecture.

Network management in the SAE J1939 network is concerned with the management of source addresses and the association of those addresses with an actual functional and with the detection and reporting of network related errors. Due to the nature of management of source addresses, network management also specifies initialization processes, requirements for reaction to brief power outages, and minimum requirements for ECUs on the network.

Reference Section

SAE J1587—Joint SAE/TMC Electronic Data Interchange Between Microcomputer Systems in Heavy-Duty Vehicle Applications

SAE J1939—Recommended Practice for Serial Control and Communications Vehicle Network

SAE J1939/21—Data Link Layer

SAE J1939/31—Recommended Practice for Serial Control and Communications Vehicle Network—Part 31—Network Layer

Developed by the SAE Truck and Bus Control and Communications Subcommittee

Sponsored by the SAE Truck and Bus Electrical and Electronics Committee