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SAE INTERNATIONAL

SURFACE VEHICLE RECOMMENDED PRACTICE

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(R) Serial Control and Communications Heavy Duty Vehicle Network - Top Level Document

RATIONALE

This document has also been updated to reference the recently published SAE J1939-16. Various content updates throughout the document, including the documentation structure and the SAE J1939 overview.

FOREWORD

The SAE J1939 communications network is defined using a collection of individual SAE J1939 documents. The SAE J1939 Top Level document is the parent document for all other SAE J1939 documents.

The SAE J1939 communications network is a high-speed ISO 11898-1 CAN-based communications network that supports real-time closed loop control functions, simple information exchanges, and diagnostic data exchanges between Electronic Control Units (ECUs) physically distributed throughout the vehicle.

The SAE J1939 communications network is developed for use in heavy-duty environments and suitable for horizontally integrated vehicle industries. The SAE J1939 communications network is applicable for light-duty, medium-duty, and heavy-duty vehicles used on-road or off-road, and for appropriate stationary applications which use vehicle derived components (e.g. generator sets). Vehicles of interest include, but are not limited to, on-highway and off-highway trucks and their trailers, construction equipment, and agricultural equipment and implements. The physical layer aspects of SAE J1939 reflect its design goal for use in heavy-duty environments. Horizontally integrated vehicles involve the integration of different combinations of loose package components, like as engine and transmissions, that are sourced from many different component suppliers. The SAE J1939 common communication architecture strives to offer an open interconnect system that allows the ECUs associated with different component manufacturers to communicate with each other.

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1. SCOPE

This top level document provides a general overview of the SAE J1939 network and describes the subordinate document structure. This document includes definitions of terms and abbreviations which are used among the various SAE J1939 subordinate documents.

1.1 Degree of Openness

An SAE J1939 network is open to the degree that any two ECUs which conform to the same SAE J1939-0*X* document can be connected via the network and communicate with each other without functional interference. The SAE J1939-0X documents describe a specific type of application, typically representing a specific industry to which it pertains such as agricultural or heavy duty trucks. ECUs which conform to a different SAE J1939-0*X* document may not be capable of communicating directly with one another and, in some cases, may cause degradation or complete disruption of the entire network.

1.2 Proof of Compliance

There is no procedure presently in place to test, validate, or provide formal approval for ECUs utilizing the SAE J1939 network. Each component developer is expected to design their products to the spirit of, as well as the specific content of, this recommended practice. Provisions are made in SAE J1939-11, SAE J1939-14, and SAE J1939-15 for self-certification to these documents. SAE J1939-82 provides methods for self-certifying compliance to several of the other SAE J1939 documents. In the future, additional procedures may be defined and implemented to test new products to ensure full compliance with all appropriate SAE J1939 documents. Until that time, compliance will be determined by the manufacturer of the component. Should questions arise regarding the use or interpretation of any part of these recommended practices they should be directed to the SAE Truck and Bus Control and Communications Committee for resolution.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J1213	Glossary of Reliability Terminology Associated with Automotice Electronics
SAE J1939DA	Digital Annex of Serial Control and Communications Heavy Duty Vehicle Network Data
SAE J1939-1	On-Highway Equipment Control and Communication Network
SAE J1939-2	Agricultural and Forestry Off-Road Machinery Control and Communication Network
SAE J1939-3	On Board Diagnostics Implementation Guide
SAE J1939-5	Marine Stern Drive and Inboard Spark-Ignition Engine On-Board Diagnostics Implementation Guide
SAE J1939-11	Physical Layer, 250 Kbps, Twisted Shielded Pair
SAE J1939-13	Off-Board Diagnostic Connector
SAE J1939-14	Physical Layer, 500 Kbps
SAE J1939-15	Physical Layer, 250 Kbps, Un-Shielded Twisted Pair (UTP)

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SAE J1939-16	Automatic Baud Rate Detection Process
SAE J1939-21	Data Link Layer
SAE J1939-31	Network Layer
SAE J1939-71	Vehicle Application Layer
SAE J1939-73	Application Layer - Diagnostics
SAE J1939-74	Application - Configurable Messaging
SAE J1939-75	Application Layer - Generator Sets and Industrial
SAE J1939-81	Network Management
SAE J1939-82	Compliance
SAE J1939-84	OBD Communications Compliance Test Cases for Heavy Duty Components and Vehicles
SAE J1939-90	OBD Traceability Matrix

2.1.2 ISO Publications

Copies of these documents are available online at http://webstore.ansi.org/.

ISO 7498	Information Processing Systems - Open Systems Interconnection (OSI) - Basic Reference Model
ISO 11898-1	Road Vehicles - Controller Area Network (CAN) - Part 1: Data Link Layer and Physical Signaling, December 2015

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J1587	Electronic Data Interchange Between Microcomputer Systems in Heavy-Duty Vehicle Applications
SAE J1708	Serial Data Communications Between Microcomputer Systems in Heavy-Duty Vehicle Applications
SAE J1922	Powertrain Control Interface for Electronic Controls Used in Medium- and Heavy-Duty Diesel On-Highway Vehicle Applications

2.2.2 ASAM (Association for Standardisation of Automation and Measuring Systems) Publications

Available from ASAM, Altlaufstr. 40, 85635 Höhenkirchen, Germany, www.asam.net

ASAM MCD-1 CCP	CAN Calibration Protocol
ASAM MCD-1 XCP	The Universal Measurement and Calibration Protocol Family

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2.2.3 ISO Publications

Copies of these documents are available online at http://webstore.ansi.org/.

ISO 11783 Tractors and Machinery for Agriculture and Forestry — Serial Control and Communications Data Network (Part 1 through 14)

ISO 11992 Road Vehicles - Electrical Connections Between Towing and Towed Vehicles - Interchange of Digital Information (Parts 1, 2, and 3)

ISO 15765-3 Road Vehicles – Diagnostics on Controller Area Network (CAN) – Part 3: Implementation of Unified Diagnostic Services (UDS on CAN)

2.2.4 NMEA (National Marine Electronics Association) Publications

Available from National Electrical Manufactureers Association, 1300 North 17th Street, Suite 900, Arlington, VA 22209, Tel: 703-841-3200, www.nema.org.

NMEA 2000 NMEA 2000 Interface Standard

3. DEFINITIONS AND ABBREVIATIONS

Definitions provided herein will supersede those contained in SAE J1213. SAE J1213 will otherwise apply throughout.

3.1 Definitions

3.1.1 ACKNOWLEDGMENT

An SAE J1939 Parameter Group (message) used to indicate the positive or negative response to a received message or a requested action.

3.1.2 ADDRESS

The 8-bit numeric value used to identify a device communicating on an SAE J1939 network, also known as an SAE J1939 Address. SAE J1939 addresses are used with SAE J1939 data frames to identify the source of a message (Source Address), and sometimes the intended destination of a message (Destination Address).

3.1.3 ARBITRATION

The SAE J1939 process for multiple ECUs to resolve conflicts when attempting to acquire an address on an SAE J1939 network.

3.1.4 BRIDGE

A network device which transfers messages between two SAE J1939 network segments, typically in a store and forward manner. The protocol and address space remain the same on both sides of the bridge. This permits changes in the media, the electrical interface, and data rate between segments. Note that a bridge may selectively filter messages going across it so that the bus load is minimized on each segment.

3.1.5 BUS

See "Segment" (3.1.50).

3.1.6 CAN DATA FRAME

The ISO 11898-1 MAC layer Protocol Data Unit (PDU) carrying user or application data over a network.

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3.1.7 CLASSICAL BASE FRAME FORMAT (CBFF)

An ISO 11898-1 CAN data frame with an 11-bit identifier, a single bit rate, and a maximum data field length of 8 bytes.

3.1.8 CLASSICAL EXTENDED FRAME FORMAT (CEFF)

An ISO 11898-1 CAN data frame with a 29-bit identifier, a single bit rate, and a maximum data field length of 8 bytes.

3.1.9 CONTROLLER APPLICATION (CA)

The software application that performs a system control function, such as controlling the transmission or engine, and communicates on the SAE J1939 network. The software in an ECU may consist of one or more Controller Applications for one or more system control functions.

3.1.10 CYCLIC REDUNDANCY CHECK (CRC)

An error control mechanism for detecting transmission errors.

3.1.11 DATA FIELD

The 0- to 1785-byte data container for the parameter data for an SAE J1939 Parameter Group. The SAE J1939 Transport Protocol permits a Parameter Group to have a data field larger than a single data frame. Data Field also describes the part of an SAE J1939 data frame or CEFF data frame that contains the data payload.

3.1.12 DATA PAGE (DP)

A 1-bit field in the 29-bit identifier in an SAE J1939 data frame to classify and indicate how the 29-bit identifier is to be interpreted. The DP is also one of the four data values that comprise the Parameter Group Number (PGN) assigned to an SAE J1939 PG.

3.1.13 DESTINATION ADDRESS (DA)

Describes the use of an SAE J1939 Address to identify the intended receiver of an SAE J1939 data frame or SAE J1939 message. Also describes the interpretation of the PDU Specific (PS) field for a PDU1 Format SAE J1939 PG or a PDU1 Format SAE J1939 data frame.

3.1.14 DEVICE

A physical component with one or more ECUs and network connections.

3.1.15 ELECTRONIC CONTROL UNIT (ECU)

A computer based electronic assembly from which SAE J1939 messages may be sent or received.

3.1.16 END OF FRAME (EOF)

A 7-bit field sequence defined by ISO 11898-1 for marking the ending of a CAN data frame.

3.1.17 EXTENDED DATA PAGE (EDP)

A specific bit in the 29-bit identifier of an SAE J1939 data frame to classify and indicate how the 29-bit identifier is to be interpreted. The EDP is also one of the four data values that comprise the Parameter Group Number (PGN) assigned to an SAE J1939 PG.

3.1.18 EXTENDED FORMAT

A CAN data frame using a 29-bit identifier as defined in the ISO 11898-1 specification. Formerly known as Extended Frame.

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3.1.19 EXTENDED FRAME

See "Classical Extended Frame Format (CEFF)" (3.1.8).

3.1.20 FUNCTION

A description of the basic purpose or activity of ECU software, relative to controlling or monitoring a particular system or subsystem. For example, “engine control” would be an appropriate function description of ECU software controlling the engine operations. Also, an 8-bit field in the NAME object that identifies the function performed by the ECU software.

3.1.21 GATEWAY

A network device which transfers messages between two dissimilar networks. A gateway repackages data into new message groups and performs address translation when transferring messages from one segment to another.

3.1.22 GROUP EXTENSION (GE)

Describes the interpretation of the PDU Specific (PS) field for a PDU2 Format SAE J1939 PG or a PDU2 Format SAE J1939 data frame. The Group Extension is the PS value of the Parameter Group Number (PGN) assigned to an SAE J1939 PG.

3.1.23 IDENTIFIER

The identifier field bits in the arbitration field of the CEFF data frame.

3.1.24 IDLE

A state on the CAN bus where no node is transmitting or attempting to transmit data.

3.1.25 IMPLEMENT

A tool or piece of equipment consisting of one or more ECUs which may be attached to or detached from the vehicle as a unit.

3.1.26 MEDIA

The physical entity which conveys the electrical transmission (or equivalent means of communication) between ECUs on the network. For SAE J1939-11, the media consists of shielded twisted pair copper wires. For SAE J1939-15, the media consists of un-shielded twisted pair copper wires.

3.1.27 MESSAGE

A transmitted or received instance of an SAE J1939 Parameter Group and its parameter data. The transmit of a message may require one or more SAE J1939 data frames to exchange the PG instance and its data.

3.1.28 MULTIPACKET MESSAGES

An SAE J1939 PG where multiple SAE J1939 data frames (packets) are required to transmit an instance of the PG and all of its data. A multipacket message is any SAE J1939 PG that is defined with a data content which can be greater than 8 bytes in length.

3.1.29 NAME

An 8-byte value which uniquely identifies the primary function of an ECU and its instance on the network. A device's NAME must be unique, no two devices may share the same NAME value on a given vehicle network.

3.1.30 NODE

A specific hardware connection of an ECU to the physical media. A specific node might have more than one address claimed on the network if its software consists of multiple Controller Applications for multiple system control functions.

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3.1.31 NON-VOLATILE

Retention of changeable memory values even though power is turned off for any reason. This term is used with respect to data values, such as ECU addresses or NAMEs, that are changed during use. Read Only Memory (ROM) is technically non-volatile, but is not changeable during use and thus not what is referred to by this term within these documents.

3.1.32 NEGATIVE ACKNOWLEDGE (NACK)

A form of the Acknowledgement PG that indicates a request message has not been understood or a requested action could not be performed.

3.1.33 PACKET

See "SAE J1939 Data Frame" (3.1.49).

3.1.34 PARAMETER GROUP (PG)

An SAE J1939 standardized data message object comprised of a group of zero or more data parameters. It describes a Protocol Data Unit (PDU) at the application layer and not at the data link layer, which allows a PG to be defined with a data field up to 1785 bytes in length. Parameter Groups communicate application layer operational data and commands, such as engine speed or valve actuator position, or diagnostic information, such as active diagnostic trouble codes (DTC), as well as fundamental communication services, such as PG requests, Transport Protocol, and Address Claim. The PG identifies the data in a message, regardless of whether it is a single packet or multipacket message. Parameter Groups are not defined specific to any source address thus allowing any source to send any Parameter Group.

3.1.35 PARAMETER GROUP NUMBER (PGN)

A numeric value, represented as a 3-byte value, that uniquely identifies an SAE J1939 Parameter Group. The PGN is a numeric representation of the Extended Data Page (EDP), Data Page (DP), PDU Format (PF), and PDU Specific (PS) values assigned to an SAE J1939 Parameter Group. The Parameter Group Number uniquely identifies a particular Parameter Group. For a PDU1 Format Parameter Group, the PGN number is computed using zero for the PS value.

3.1.36 PDU FORMAT (PF)

An 8-bit field in the 29-bit identifier of an SAE J1939 data frame. This field indicates the interpretation of the PS field of the 29-bit identifier and it partially identifies the Parameter Group contained in the data frame. The PDU Format value determines if the SAE J1939 data frame 29-bit identifier format is PDU1 format or PDU2 format. The value reported in the PF field is the PDU Format value assigned to the Parameter Group. The PDU format (PDU1 format or PDU2 format) indicates the addressing support, i.e., as either a destination specific PG or broadcast PG. The Parameter Group Number of a PG is partially derived from the assigned PDU Format value.

3.1.37 PDU SPECIFIC (PS)

An 8-bit field in the 29-bit identifier of an SAE J1939 data frame. The interpretation of this 29-bit identifier field differs between PDU1 format or PDU2 format. For PDU1 format, the PS field is a destination address (DA). For a PDU2 format, the PS field is a group extension (GE) used to further identify the PG being communicated in the SAE J1939 data frame. For PDU2 format, the value reported in the PS field is the PDU Specific value assigned to the Parameter Group. The Parameter Group Number of a PG is partially derived from the assigned PDU Specific value.

3.1.38 PDU1 FORMAT

A specific PDU Format of the 29-bit identifier of SAE J1939 data frame where the PS field contains the destination address for the data frame. Also, a classification of SAE J1939 Parameter Group that are capable of being sent to a destination address (DA).

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3.1.39 PDU2 FORMAT

A specific PDU Format of the 29-bit identifier of SAE J1939 data frame where the PS field contains further identification of the PG being communicated in the SAE J1939 data frame, and the SAE J1939 data frame is being broadcast to all devices on the network. Also, a classification of SAE J1939 Parameter Group that are only capable of being sent broadcast.

3.1.40 POSITIVE ACKNOWLEDGE (ACK)

A form of the Acknowledgment PG message that confirms the requested action has been understood and performed.

3.1.41 PREFERRED ADDRESS

A recommended address for an ECU to first attempt to claim during Address Claim. Preferred Addresses are assigned by the SAE J1939 Committee for system functions that are fairly common across most industries. The SAE J1939 Committee has discontinued new Industry Group-specific Preferred Addresses to the dynamic addresses.

3.1.42 PRIORITY

A 3-bit field in the 29-bit identifier of the SAE J1939 data frame. The Priority field is only used to influence which CEFF data frame gets transmitted when two or more nodes are contending to send a CEFF data frame on the bus. A default Priority is specified for each SAE J1939 Parameter Group. Applications are generally permitted to use a different Priority value from the specified Default Priority, but this should be done only as required to resolve system issues, such as bus access problems with certain messages. The Priority field is not to be used by devices when receiving an SAE J1939 data frame. The highest priority is zero and the lowest priority is seven.

3.1.43 PROTOCOL DATA UNIT (PDU)

A unit of data for communicating or exchanging data. Most commonly used in reference to an SAE J1939 data frame. At the application layer, used in reference to an instance of an SAE J1939 Parameter Group and its data.

3.1.44 RECEIVER

Any node receiving a transmitted SAE J1939 data frame on the SAE J1939 network.

3.1.45 REPEATER

A physical layer network device that regenerates the bus signal on one network segment onto another network segment. The device only electronically isolates the two network segments and permits the network to connect more electrical loads (i.e., ECUs) onto the bus, or to connect two networks of different media types (i.e., physical layer expansion). The speed (data rate), protocol (data link layer), and address space are the same on both sides of the repeater. For SAE J1939, any delays in regenerating the data signal must be kept to a very small fraction of one bit interval.

3.1.46 ROUTER

A network device transferring messages between two similar networks with independent address spaces, data rates, and media. A router may permit each segment to operate with minimum bus loading yet still obtain critical messages from remote segments. The protocol remains the same across all segments. A router must have a means, such as look up tables, to translate and route a message with ID X on segment 1 to ID Y on segment 2.

3.1.47 SAE J1939 COMMITTEE

Abbreviated reference for the SAE Truck and Bus Control and Communications Committee.

3.1.48 SAE J1939 MESSAGE

A transmitted or received instance of an SAE J1939 PG and its data. See “Message” (3.1.27).

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3.1.49 SAE J1939 DATA FRAME

A specific type of CEFF data frame where a 29-bit identifier bit, defined by SAE J1939 as the Extended Data Page (EDP), contains a value of zero.

3.1.50 SEGMENT

The physical media and attached nodes of a network not interconnected by Network Interconnection ECUs. A single segment of a network is characterized by all of the ECUs “seeing” the signal at the same time (i.e., there is no intermediate ECU between electrical sections of the network). Multiple segments can be connected together by Network Interconnection ECUs including repeaters, bridges, and routers.

3.1.51 SOURCE ADDRESS (SA)

An 8-bit field in the 29-bit identifier of an SAE J1939 data frame that identifies the SAE J1939 Address of the originator of the data frame. See also "Address" (3.1.2).

3.1.52 STANDARD FRAME

See “Classical Base Frame Format (CBFF)” (3.1.7).

3.1.53 START OF FRAME (SOF)

A 1-bit field defined by ISO 11898-1 for indicating the beginning of the frame.

3.1.54 SUSPECT PARAMETER NUMBER (SPN)

A 19-bit number used to identify a particular element, component, or parameter associated with an ECU. The primary use of the SPN is in an SAE J1939 Diagnostic Trouble Code (DTC), where the SPN identifies the element, component, or parameter suspected of exhibiting the diagnostic condition. Every assigned SPN has a text label which describes the particular element, component, parameter, or condition. A subset of SPNs are associated with SAE J1939 data parameters and those SPNs include a data encoding definition and an associated Parameter Group (PG). Each SAE J1939 data parameter has an SPN assignment to permit reporting any related diagnostics. The Parameter Group definitions use the SPN to identify or cross reference each data parameter in its data field.

3.1.55 SUBNETWORK

General term referring to a specific SAE J1939 segment on an SAE J1939 network with multiple segments. Subnetworks may include: Tractor, Trailer, Implement, and Braking System. Note that they may be separated by a bridge or router to minimize total bus loading. Collectively the subnetworks are the vehicle's SAE J1939 network.

3.1.56 TRANSMITTER

The node that is originating the SAE J1939 data frame on the SAE J1939 network.

3.1.57 VEHICLE

A machine which, in most applications, includes a capability to propel itself and includes one or more SAE J1939 segments. A vehicle may be assembled of one or more Vehicle systems which are connected together to form the whole vehicle.

3.1.58 VEHICLE SYSTEM

A subcomponent of a vehicle, or a component that is analogous to a subcomponent of a vehicle, that includes one or more SAE J1939 segments and may be connected or disconnected from the vehicle. A Vehicle System may be made up of one or more Functions, which have ECU's that are connected to an SAE J1939 segment of the Vehicle System.

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3.2 Abbreviations

ABS	Antilock Braking System
ACK	Acknowledge (Positive Acknowledge)
ASCII	American Standard Code for Information Interchange
CA	Controller Application
CAN	Controller Area Network
CBFF	Classical Base Frame Format
CEFF	Classical Extended Frame Format
Con-Ag	Construction-Agriculture Industry
CRC	Cyclic Redundancy Check
DA	Destination Address
DF	Data Frame
DLC	Data Length Code
DP	Data Page
ECM	Engine Control Module
ECU	Electronic Control Unit
EDP	Extended Data Page
EOF	End of Frame
FBFF	Flexible Data Rate Base Frame Format
FEFF	Flexible Data Rate Extended Frame Format
GE	Group Extension
ID	Identifier
LSB	Least Significant Byte or Least Significant Bit
MAC	Medium Access Control
MSB	Most Significant Byte or Most Significant Bit
NA	Not Allowed or Not Available
NACK	Negative-Acknowledge
OSI	Open System Interconnect
P	Priority
PDU	Protocol Data Unit
PF	PDU Format
PG	Parameter Group
PGN	Parameter Group Number
PID	Parameter Identifier
PS	PDU Specific
PTO	Power Take-Off
R	Reserved
SA	Source Address
SID	Subsystem Identifier
SLOT	Scaling, Limits, Offset, and Transfer Function
SP	Suspect Parameter
SPN	Suspect Parameter Number
un	Undefined

3.3 Documentation Structure and Guide

Table 1 lists all of the individual SAE J1939 documents and a brief summary of the technical content of each document. The summary lists key technical content for each document as an aid to find certain SAE J1939 technical topics.

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Table 1 - Summary of SAE J1939 documents

Document	Content Summary
SAE J1939: General documents	
SAE J1939	• General introduction to SAE J1939 network
SAE J1939-0X: Industry or application network	
SAE J1939-1	• Minimum set of SAE J1939 documents for on-highway equipment
SAE J1939-02	• Application of SAE J1939 in agricultural and forestry equipment
SAE J1939-03	• Technical requirements for heavy duty vehicle use of SAE J1939 to meet OBD requirements
SAE J1939-05	• Application of SAE J1939 for compliance with OBD-M requirements for marine sterndrive and inboard spark ignited engines.
SAE J1939-1X: Physical layer documents	
SAE J1939-11	• Technical specifications for 250 Kbps SAE J1939 network with shielded twisted cable • Network topology constraints, such as number of nodes, stub lengths, backbone lengths, location of terminating resistors, etc. • CAN Bit Timing Register settings requirements • ECU electrical characteristics • Cabling electrical characteristics • Electrical signal timing requirements
SAE J1939-13	• Diagnostic connector electrical and mechanical requirements • Diagnostic connector pin assignments, connector keying, etc. • Vehicle and off-board requirements for Type I and Type II Diagnostic Connectors
SAE J1939-14	• Technical specifications for 500 Kbps SAE J1939 network • Network topology constraints, such as number of nodes, stub lengths, backbone lengths, location of terminating resistors, etc. • CAN Bit Timing Register settings requirements • ECU electrical characteristics • Cabling electrical characteristics • Electrical signal timing requirements
SAE J1939-15	• Technical specifications for 250 Kbps SAE J1939 network with unshielded twisted cable • Network topology constraints, such as number of nodes, stub lengths, backbone lengths, location of terminating resistors, etc. • CAN Bit Timing Register settings requirements • ECU electrical characteristics • Cabling electrical characteristics • Electrical signal timing requirements
SAE J1939-16	• Network requirements for baud rate detection • Process to detect the baud rate of an SAE J1939 network segment
SAE J1939-2X: Data link layer	
SAE J1939-21	• SAE J1939 Request and Acknowledgement Messages • SAE J1939 Transport Protocols (CTS/RTS and BAM) • Message Addressing • Communication behavior requirements, such as time outs, Request message response, etc. • SAE J1939 Message Format details, i.e., use of CAN 29-bit identifier bits • PDU1 and PDU2 Message Types
SAE J1939-3X: Network layer documents	
SAE J1939-31	• Services for communication between different vehicle networks • Functionality for transferring non-SAE J1939 messages over SAE J1939 networks
SAE J1939-7X: Application layer documents	
SAE J1939DA	• SAE J1939 PGN assignments • SAE J1939 SPN assignments • Technical definition details for most of the SAE J1939 PGs • Technical definition details for most of the SAE J1939 SPs • Cross reference to documents containing some PG and SP technical details • Other SAE J1939 assignments, such as Manufacturer IDs, NAME Functions, NAME Industry Groups, Preferred Source Addresses

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Document	Content Summary
SAE J1939-71	• SAE J1939 transmission rate descriptions • SAE J1939 SPN position notation descriptions • SP data byte order • SP valid data and error indicator value ranges • Unused and unsupported SPN data encoding in PG data field • Character set for text data parameters • Refer to SAE J1939DA for PG and SPN definitions
SAE J1939-73	• SAE J1939 Diagnostic Message (DM) definitions, including active DTCs, previously active DTCs, clearing DTCs, and emissions related DTC reporting services. • SAE J1939 Diagnostic Trouble Code (DTC) data format • SAE J1939 FMIs assignments and definitions
SAE J1939-74	• Technical details for configurable messages • Exchange information about parameters contained in configurable messages
SAE J1939-75	• Summary of PGs and SPs for generator and utility parameters • Refer to SAE J1939DA for PG and SPN definitions
SAE J1939-8X: Network Management and Compliance documents	
SAE J1939-81	• SAE J1939 Address Claim and Address Arbitration (method to acquire Network Address) • SAE J1939 Address Claim message definition • SAE J1939 NAME object definition • Behavior requirements when unable to claim address
SAE J1939-82	• Technical requirements for compliance self-assessment to SAE J1939 standards
SAE J1939-84	• Technical requirements for verifying vehicle compliance to OBD off-board diagnostic tool interface requirements using SAE J1939
SAE J1939-9X: Support documents	
SAE J1939-90	• Identifies SAE J1939 SPNs and PGs that may be used to satisfy ARB OBD II and HD OBD requirements

SAE J1939 is structured into several parts based on the ISO/IEC 7498 Open System Interconnect (OSI) model. The OSI model provides guidance on organizing the documentation of fundamental functionality and services in one or more standards. Resulting standards, such as SAE J1939, are not required to be explicitly partitioned into these seven layers as long as the fundamental functionality is supported. SAE J1939 uses the OSI model for guidance on partitioning functionality and services among the subordinate standards.

SAE J1939 does not necessarily have dedicated documents for each OSI model layer. Additionally, some of the functionality and services commonly associated with a particular OSI layer might be specified as part of other SAE J1939 documents identified to other OSI layers. This SAE J1939 document is the top level of a hierarchy of related documents. The related documents are identified as “SAE J1939-NX,” where the first digit “N” designates an OSI model layer (one to seven) and the second digit “X” differentiates multiple documents designated to the same OSI model layer. One exception is the SAE SAE J1939DA document which is an Application Layer (layer seven) document but does not use the “/7X” numbering standard for reasons not relevant to this introduction.

SAE J1939 documents associated with a specific OSI layer are not necessarily exclusive alternatives. In some instances, a single network may allow or may require implementation of multiple SAE J1939 documents associated with the same OSI layer. One example is application layer document for on-highway heavy duty tractor that utilizes both SAE J1939-71 for the majority of communications and SAE J1939-73 for diagnostics communications, both sets of messages being carried over the exact same network. Another example is physical layer documents for a system that utilizes SAE J1939-13 for the diagnostic connector, SAE J1939-14 for the baud rate and cabling, and SAE J1939-16 for baud rate detection by off-board diagnostic tools. Similarly, a single vehicle/application may also utilize different SAE J1939 physical layers for different SAE J1939 networks, such as an on-highway truck where the physical layer used to connect the tractor to the trailer may be different than the physical layer used on the tractor itself.

4. TECHNICAL REQUIREMENTS

This section provides general information about key aspects required for communicating over an SAE J1939 network. This section is offered as informative text for illustrating and clarifying the network and guidance for identifying the SAE J1939 documents that contain the technical specifications. This section is not a normative definition of an SAE J1939 network.

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Refer to the individual SAE J1939 documents listed in 3.3 for the complete definition and specification of each aspect of the network. In 4.14, SAE J1939-1 is used as the basis for some of the examples and not meant to infer that all SAE J1939 applications must follow SAE J1939-1. Applications may elect to utilize alternative versions of one or more layers resulting in corresponding changes to the following discussion.

4.1 SAE J1939 Introduction

SAE J1939 defines a CAN communication solution designed to support real-time closed loop control functions and information exchange, such as diagnostic data, between ECUs distributed throughout a vehicle or system or connected to the vehicle or system. Data and information are exchanged using standardized SAE J1939 messages.

SAE J1939 defines a full strategy for standardized CAN communications using the 29-bit identifier Classical Extended Frame Format (CEFF) data frame as defined by ISO 11898-1. The 11-bit identifier Classical Base Frame Format (CBFF) data frames are permitted on an SAE J1939 network for proprietary use according to the rules specified in SAE J1939-21. The Flexible Data Rate Base Frame Format (FBFF) and the Flexible Data Rate Extended Frame Format (FEFF) data frames are not permitted on an SAE J1939 network. Every CEFF data frame transmitted on an SAE J1939 network must strictly comply with SAE J1939 standards. A CEFF data frame is called an SAE J1939 data frame when a bit in the 29-bit identifier, designated by SAE J1939 as the Extended Data Page bit, contains the value zero.

An SAE J1939 Parameter Group, or SAE J1939 message, describes a standardized cohesive data object. A unique numeric value, known as the Parameter Group Number (PGN), is assigned to each defined SAE J1939 PG. The data content of an SAE J1939 PG consists of a group of zero or more data parameters. SAE J1939 specifies the placement and data encoding of every parameter in the PG data field. SAE J1939 Parameter Groups are defined as application layer entities, or A_PDU in the OSI model. In this manner, an SAE J1939 PG can be defined with data content up to 1785 bytes; an SAE J1939 PG is not limited to the 8-byte data field constraint of a CEFF data frame. An SAE J1939 PG with a data object of 8 bytes or less is transmitted, in its entirety, using a single CEFF data frame. An SAE J1939 PG with a data object longer than 8 bytes is transmitted, in its entirety, using multiple serialized CEFF data frames through the SAE J1939 Transport Protocol. While it is possible to define an SAE J1939 PG with data content up to 1785 bytes, most SAE J1939 PGs are defined with a fixed length, 8-byte data object.

Most SAE J1939 PGs are transmitted in either a continuous unsolicited manner or a solicited (requested) manner. The required transmit behavior for an SAE J1939 PG is specified by the Transmission Rate property in the Parameter Group definition. For a continuous unsolicited transmit PG, the PG is sent automatically and periodically by a transmitter. For a solicited transmit PG, the PG is only sent when requested or prompted. The Request PG (PGN 59904) provides the service for requesting (soliciting) another device to transmit a specific PG. The Request PG data field contains the PGN of the specific PG being requested to be transmitted.

For SAE J1939 data frames, the 29-bit identifier specifies the SAE J1939 Parameter Group (PG), the address of the transmitter and, conditionally, the address of the intended receiver of the CEFF data frame. The Parameter Group Number is contained in the 29-bit identifier of every SAE J1939 data frame to identify the SAE J1939 Parameter Group (PG) being communicated. The two different formats of the 29-bit identifier for SAE J1939 data frames are known as PDU1 format and PDU2 format. The PDU1 format, also known as Destination-Specific format, has two addresses, one that identifies the transmitter and one that identifies the intended receiver. PDU1 format is best suited for J1939 PG with control or command data where it might be necessary to send the same message to multiple different ECUs with different data values to each ECU, such as actuator position command to different actuators. The PDU2 format, also known as the Broadcast format, has only one address that identifies the transmitter. PDU2 format is best suited to J1939 messages with measured or status data, such as engine speed or oil temperature, where the reported data values are the same regardless of the receiver. The PDU Format used for an SAE J1939 PG is established when the PGN is assigned to the PG. Most SAE J1939 messages are defined as using PDU2 format.

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Every ECU communicating on an SAE J1939 network is required to have a unique SAE J1939 Source Address; the same address may not be used by two or more ECUs on the same SAE J1939 network. Any device that may transmit a CEFF data frame (29-bit identifier) or a CBFF data frame (11-bit identifier) onto the SAE J1939 network is required to have an SAE J1939 Source Address. The SAE J1939 Source Addresses are divided into two classes - Global Preferred Addresses (or Fixed Function addresses) and Arbitrary Addresses (or Dynamic Function addresses). The Global Preferred Addresses range from 0 to 127 and 248 to 253, and may only be claimed by an ECU performing the function assigned to that address by SAE J1939. The Arbitrary Addresses range from 128 to 247 and can be claimed by any ECU performing any function. The Address Claim process, defined in SAE J1939-81, is used by every ECU to announce and claim an SAE J1939 Source Address on the network. After an ECU successfully claims an SAE J1939 Address, the ECU uses that claimed address as the source address in every CEFF data frame it transmits and uses that address when determining if a destination specific (PDU1) CEFF data frame is addressed to the ECU.

Most SAE J1939 Parameter Group definitions are documented in SAE J1939DA or one of the other SAE J1939 documents, namely SAE J1939-21, SAE J1939-73, and SAE J1939-81. Some SAE J1939 PGs are assigned to other industry standards, such as ISO 11783 or NMEA 2000, and the definition for those SAE J1939 Parameter Groups are maintained within the respective industry standard documents. For SAE J1939 Parameter Groups fully defined within SAE J1939 documents, the PG definition specifies the data field parameter content, parameter data placement in data field, message transmission rate, PDU Format, and the assigned PGN. Individual parameter data in a PG data field is identified by its position within the data field. SAE J1939 has a standardized bit encoding that is used for indicating unused or unsupported data field bits. SAE J1939 assigns a Suspect Parameter Number (SPN) to every PG data field parameter, and each SPN definition specifies the data length and data encoding for the data. The SPN assignment allows diagnostic reporting against the parameter and serves as a cross reference to the data definition. Most of the SAE J1939 Parameter Groups are defined to communicate application layer operational data and commands, such as engine speed or valve actuator position, or diagnostic information, such as active diagnostic trouble codes (DTC). A few of the SAE J1939 PG support fundamental communication services, such as PG requests, Transport Protocol, and Address Claim.

The SAE J1939 Committee is the data registration authority for all Parameter Groups (PG) assignments for SAE J1939 networks. The collection of all assigned SAE J1939 Parameter Groups only represents the available SAE J1939 messages for use on SAE J1939 networks. The actual SAE J1939 messages used on any SAE J1939 network is determined by the system integrators and component designers for that application. SAE J1939 does not specify the SAE J1939 messages to be supported by components, sub-systems, or systems. The SAE J1939 Committee meets regularly to review submitted requests to add new SAE J1939 PG and SPN assignments to its dictionary, revise existing PG and SPN definitions, and assign other standardized SAE J1939 identifiers, such as Manufacturer Codes and NAME Functions.

An SAE J1939 Diagnostic Trouble Code (DTC) is the data structure used by SAE J1939 to describe a detected failure for a suspected parameter or system condition. A DTC consists of a 19-bit Suspect Parameter Number (SPN) and a 5-bit Failure Mode Indicator (FMI), where the SPN identifies the item for the diagnostic is being reported and FMI identifies the type of failure detected in the subsystem identified by the SPN. SAE J1939 maintains standard SPN and FMI assignments; however, SAE J1939 does not specify the combinations SPN and FMI. SAE J1939 assigns an SPN to every parameter (data element) defined within a Parameter Group. SAE J1939 also assigns SPNs to items that are relevant to diagnostics but not parameters in a Parameter Group. Suspect Parameter Number assignments are documented in SAE J1939DA or one of the other SAE J1939 documents, namely SAE J1939-21, SAE J1939-73, and SAE J1939-81. SAE J1939 DTCs are communicated as part of the data field content of a Diagnostic Message PG, such as Diagnostic Message 1 (DM1) for reporting active DTCs. The Diagnostic Messages are a set of SAE J1939 Parameter Groups where the data field contains diagnostic details, such as a list of active DTCs, instead of operational data, like temperatures or pressures.

An SAE J1939 network may consist of a single SAE J1939 segment or multiple SAE J1939 segments connected through Network Interconnection ECUs. Each SAE J1939 segment is a multidrop bus using a single, linear, twisted-pair cable backbone with terminating resistors at each end of the bus. The SAE J1939 physical layer standard specified for an SAE J1939 segment, e.g., SAE J1939-11, SAE J1939-14, or SAE J1939-15, defines the ECU characteristics, bit rate, bus length, node count, cabling, and other network topology requirements for that segment. SAE J1939-13 specifies the requirements for a standard diagnostic connector for connecting a diagnostic tool to an SAE J1939 network.

4.2 Standard and Preassigned Values

Most of the identifiers and data elements used in communications on an SAE J1939 network are standardized by the SAE J1939 Committee. SAE J1939 fully defines messages, parameters, and other data elements to establish a well-known information interface that enables components and subsystems from different manufacturers to be integrated and able to interoperate. Communications on an SAE J1939 network is limited to these standardized identifiers and information elements.

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The SAE J1939 Committee administers and maintains the assignments of SAE J1939 Parameter Groups, data parameters, diagnostic identifiers, global preferred source addresses, and several SAE J1939 NAME data components. Some of these identifiers are briefly discussed in 4.4.1, 4.4.2, 4.5, 4.6, and 4.7. The assignments and definitions for most identifiers and data elements are documented in SAE J1939DA or one of the other SAE J1939 documents, namely SAE J1939-21, SAE J1939-73, and SAE J1939-81. Some are assigned to other industry standards, such as ISO 11783 or NMEA 2000, and the definition for those are maintained within the respective industry standard documents.

Some Parameter Groups, identifiers, and other data elements used in SAE J1939 communications are not assigned by the SAE J1939 Committee, and the values used are at the discretion of the application or developer. Some examples are the four SAE J1939 Proprietary PG (PropA, PropA2, PropB, and PropB2), the Manufacturer Specific Diagnostic SPNs, Instance numbers in the NAME object, and Identity Number in the NAME object.

4.3 Message Frame Format

SAE J1939-21 provides the technical specifications on the use of the 29-bit identifier Classical Extended Frame Format (CEFF) data frame on SAE J1939 networks. SAE J1939-21 also provides requirements for the use of 11-bit identifier Classical Base Frame Format (CBFF) data frames on SAE J1939 networks. Every CEFF data frame transmitted on an SAE J1939 network must strictly comply to SAE J1939 standards.

SAE J1939 is a CAN communication network that uses the 29-bit identifier Classical Extended Frame Format (CEFF) data frame as defined by ISO 11898-1. The 11-bit identifier Classical Base Frame Format (CBFF) data frames are permitted on SAE J1939 networks when used according to SAE J1939-21 requirements. The Flexible Data Rate Base Frame Format (FBFF) and the Flexible Data Rate Extended Frame Format (FEFF) data frames are not permitted on an SAE J1939 network.

Every CEFF data frame transmitted on an SAE J1939 network must strictly comply with SAE J1939 standards. SAE J1939 uses two bits of the 29-bit identifier of the CEFF data frame to classify and indicate how the 29-bit identifier of the CEFF data frame is to be interpreted. The two bits are identified by SAE J1939 as the Extended Data Page (EDP) and the Data Page (DP) bits. When the EDP bit is zero, then the CEFF data frame is an SAE J1939 data frame and is interpreted as defined within the SAE J1939-21 document. When the EDP bit is one and DP bit is zero, then the CEFF data frame is an SAE J1939 reserved data frame and the interpretation of the 29-bit identifier has not yet been defined by SAE J1939. When the EDP bit is one and DP bit is one, then the CEFF data frame is an ISO 11992-4 defined data frame and the interpretation of the 29-bit identifier is defined in ISO 11992-4.

For SAE J1939 data frames, the 29-bit identifier identifies the SAE J1939 Parameter Group (PG), data frame priority, the address of the transmitter and, conditionally, the address of the intended receiver of the SAE J1939 data frame. For SAE J1939 data frames, the 29-bit identifier consist of six fields: Priority (P), Extended Data Page (EDP), Data Page (DP), PDU Format (PF), PDU Specific (PS), and Source Address (SA). SAE J1939-21 specifies how these fields are mapped into the CEFF data frame 29-bit identifier. The Priority field specifies the data frame priority only to influence which CEFF data frame gets transmitted when two or more nodes are contending to send a CEFF data frame on the bus. The Priority is not used by receivers for any purpose.

The 29-bit identifier of an SAE J1939 data frame has two different PDU Formats, known as PDU1 format and PDU2 format. The only difference between the two PDU Formats is their use or interpretation of the PDU Specific (PS). These formats provide different addressing capability and have different SAE J1939 PG identification methods. The PDU Format for an SAE J1939 data frame is indicated by the numeric value in the PF field in the 29-bit identifier. The 29-bit identifier is PDU1 Format when the EDP field value is zero and the PF field value is 239 or less. The 29-bit identifier is PDU2 Format when the EDP field value is zero and the PF field value is 240 or greater.

PDU Format used with an SAE J1939 PG is defined as part of the PG definition. The PDU Format for a PG is established when the PGN is assigned to the SAE J1939 PG since the PGN value is a numerical representation of the combined EDP, DP, PF, and PS values.

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4.3.1 PDU1 Format (Destination Specific Format)

The PDU1 Format, known as Destination Specific format, provides the ability to send the same message to one or another destination. The destination specific PDU1 format is best suited for SAE J1939 PG with control or command data where it might be necessary to send the same message to different ECUs with different data values being sent to each ECU. For example, sending actuator position commands to different actuators. A PDU1 format SAE J1939 data frame can be directed to all nodes by specifying the Global Destination Address (FFh) as the destination address.

The PDU1 Format uses part of the 29-bit identifier content to identify the SAE J1939 Source Address of the intended receiver. In a PDU1 format 29-bit identifier, the 10 bits of the EDP, DP, and PF fields identify the SAE J1939 PG; the SA field identifies the transmitter address; and the PS field identifies the intended receiver's source address. To determine the PGN specified in a PDU1 Format data frame, the PGN is computed from the EDP, DP, and PF field values together with a value of zero as the PS value, regardless of the actual value in the PS field of the 29-bit identifier.

4.3.2 PDU2 Format (Broadcast Format)

The PDU2 format, known as Broadcast format, only allows the SAE J1939 data frame to be sent to all nodes on the network. A PDU2 format data frame cannot be directed only to a specific receiver. PDU2 format is best suited to SAE J1939 messages with measured or status data, such as engine speed or oil temperature, where the reported data values are the same regardless of the receiver.

In a PDU2 format 29-bit identifier, the 18 bits of the EDP, DP, PF, and PS fields identify the SAE J1939 PG; and the SA field identifies the transmitter address. Most SAE J1939 PGs are defined for PDU2 format.

4.4 Source Addresses and NAME

The SAE J1939 Source Address is the numeric value used to uniquely identify each ECU application, or Controller Application (CA), communicating on an SAE J1939 network. An SAE J1939 Address cannot be used by two or more ECUs on the same SAE J1939 network. The Source Address (SA) is used in SAE J1939 message frames to indicate the transmitter of the frame and the intended destination of the frame (for PDU1 Format frames). The SAE J1939 NAME uniquely identifies the primary function performed by the controller application CA using an SAE J1939 Address. The SAE J1939 NAME is communicated when claiming an SAE J1939 Source Address. The SAE J1939 NAME provides a more complete description of the primary function of the ECU and the SAE J1939 Source Address is used to identify SAE J1939 data frames sent by or directed to the ECU.

An ECU must successfully claim an SAE J1939 Address before using that address for any SAE J1939 message exchanges. An ECU is required to claim an SAE J1939 Source Address if it will transmit any SAE J1939 data frame or any CBFF data frame onto the SAE J1939 network, including sending the Request PG in order to request another device to transmit an SAE J1939 PG. Every ECU communicating an SAE J1939 data frame on an SAE J1939 network is required to claim at least one unique SAE J1939 Source Address before transmitting any SAE J1939 data frame on to the network, except for SAE J1939 data frames for Address Claim and a global Request for Address Claim.

Colloquially, SAE J1939 often associates an SAE J1939 Source Address to an ECU. This informal language, while not technically accurate, is often used since most ECU software performs only one primary control function, such as transmission control, so there is only one SAE J1939 Source Address for the only CA in the ECU. Technically, an SAE J1939 Source Address is associated to each Controller Application (CA) and not with a physical ECU. A Controller Application describes the software within an ECU that performs a particular control function, like controlling the engine or monitoring operator cab controls. It is allowable for ECU software that is performing multiple Controller Applications, such as engine control and engine retarder control, to claim an SAE J1939 Source Address for each CA so each CA may be separately addressed on the SAE J1939 network.

4.4.1 Addresses

SAE J1939 Addresses are divided into two main ranges. The SAE J1939 Addresses from 0 to 127 and 248 to 253 are known as Global Preferred Addresses. The SAE J1939 Addresses from 128 to 247 are known as Dynamic Addresses. The SAE J1939 Addresses 254 and 255 have serve special addressing needs.

SAE J1939DA provides the preferred Source Address lists. SAE J1939DA provides the standard value assignments for several of the fields in the SAE J1939 NAME object.

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4.4.1.1 Global Preferred Addresses (0 to 127 and 248 to 253)

The SAE J1939 Addresses from 0 to 127 and 248 to 253 are known as Global Preferred Addresses. Global Preferred Addresses are assigned for system functions that are fairly common across most industries, such as engine, transmission, service tool, or display. Since there is a small finite set of Global Preferred Addresses, SAE J1939 only assigns these addresses to system functions that are considered common across most industries and usually only for the first instance of such a function.

A Global Preferred Address may be claimed and used only by a CA that performs the described function and function instance assigned to that address by SAE J1939.

4.4.1.2 Dynamic Addresses (128 to 247)

The SAE J1939 Addresses from 128 to 247 are known as Dynamic Addresses. SAE J1939 Addresses in this range can be claimed and used by any CA performing any system function. The supplier of a CA may use any strategy for selecting the initial address to claim within the range of 128 to 247.

Historically, SAE J1939 had made industry group specific Preferred Address assignments to addresses in the Dynamic Address range. This practice was abandoned around 2003. The industry group specific Preferred Addresses were intended as a means to minimize address arbitration on the SAE J1939 network by suggesting an initial (first) SAE J1939 Address to claim for certain functions and instances. However, it became obvious that it was not sustainable to uniquely issue Preferred Address assignments within most industry groups. In addition, too many components and systems were incorrectly treating these as fixed or absolute address assignments, often hard coding these addresses as the required address for certain system functions on the network.

4.4.1.3 Global Destination Address (255)

SAE J1939 Address 255 is the Global Destination Address and may only be used as the Destination Address to indicate a PDU1 Format SAE J1939 data frame is directed to all ECUs on the network.

4.4.1.4 Null Address (254)

SAE J1939 Addresses 254 is the Null Address and may only be used as a Source Address. The only permitted uses of the Null Address are as the source address of an Address Claim PG when an ECU must report it is unable to claim an SAE J1939 Address and as the source address of a Request for Address Claimed message transmitted by an ECU before it has claimed a Source Address.

4.4.2 NAME

SAE J1939-81 provides the technical specifications on SAE J1939 NAME object. SAE J1939DA provides the assignments for the standardized values used in several of the fields in the SAE J1939 NAME object.

The NAME is an 8-byte object that identifies the primary system function of the controller application (CA) executing within an ECU. NAME is communicated as part of Address Claim to describe the system function associated with a claimed address. In this manner, other controller applications on the network can catalog the NAME description associated with each SA, enabling them to fully identify the source of a J1939 message frame or to determine the SA to use when sending a destination specific J1939 message frame. NAME must be unique for every CA on an SAE J1939 network.

NAME is comprised of 10 data elements. The values for the NAME Function, Vehicle System, Industry Group, and Manufacturer Code elements may only be values assigned and defined by SAE J1939. Values for the remaining elements are specified by the component or system designer as appropriate for component or system. The NAME for a CA is typically established during software design, but the value for some fields might be determined at run time. There are several instance data elements in the NAME object for differentiating multiple instances of a control function within a system, such as two engine ECUs, one to control each engine in a system with two engines.

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NAME is generally considered an attribute of the CA executing within the ECU. Consequently, the NAME reported from an ECU might change when different application software loaded onto an ECU. It is common for a blank ECU, i.e., an ECU running only basic operating system application, to have a NAME so the CA can claim a network address in order for application software to be loaded at the factory or in the field. The NAME used by a blank ECU, i.e., an ECU running only basic operating system application, might be different than the NAME used when the application software is loaded and executing on that same ECU.

Manufacturer Code permits NAME uniqueness between manufacturers of similar Controller Applications where the other NAME elements might likely use the same values. Manufacturer Code typically is an attribute of the CA executing within the ECU. It should identify the OEM or the final product company owning the CA application, even if the software was actually written by a different company. In some instances, Manufacturer Code has implemented as an attribute of the ECU; in which case, it generally identifies the OEM or the final product company owning or marketing the ECU rather than the supplier that manufactured the ECU. The Manufacturer Code value reported from an ECU might change as different application software loaded onto the ECU.

4.4.3 Address Claim

SAE J1939-81 provides the technical specifications on SAE J1939 Address Claim procedure.

Address Claim is SAE J1939 process used by Controller Applications to announce and claim an SAE J1939 Address on the SAE J1939 network and associate a NAME to that address. Address Claim includes behaviors to resolve conflicts when multiple CA attempt to claim the same SAE J1939 Address. Address Claim is required to be performed by all ECUs or controller applications, regardless if using a Global Preferred Address or a Dynamic Address. An ECU must successfully claim an SAE J1939 Address before using that address for any SAE J1939 message exchanges. An ECU may send a request for the Address Claimed PG in order to determine addresses claimed by other ECUs.

The Address Claim process consists of Address Claimed message exchanges together with some CA behaviors to resolve address claim conflicts. A CA sends the Address Claimed (AC) message under several situations. A CA sends an Address Claimed message when it first connects to an SAE J1939 network to attempt to claim its initial SA. A CA sends an Address Claimed message when it receives the Request PG requesting the Address Claimed PG. A CA sends an Address Claimed PG for the same SA (to defend its claimed address) when it receives an Address Claimed PG from another CA and the NAME of this CA is a lower numeric value compared to the NAME of the other CA. A CA sends an Address Claimed PG for a different SA (since it lost arbitration to another CA) when it receives an Address Claimed PG from another CA and the NAME of this CA is a higher numeric value compared to the NAME of the other CA. A CA successfully claims a Source Address when a specified period of time lapses with no other Address Claimed messages for that same Source Address. The last SA successfully claimed by a CA should be the first address the CA attempts to claim on next power up.

4.5 Parameter Group (PG) and Parameter Group Number (PGN)

An SAE J1939 Parameter Group is a standardized data message object comprised of a group of zero or more data parameters. The majority of SAE J1939 PG communicate application layer operational data and commands, such as engine speed or valve actuator position, or diagnostic information, such as active diagnostic trouble codes (DTC). A few of the SAE J1939 PG support fundamental communication services, such as PG requests, Transport Protocol, and Address Claim.

Almost every SAE J1939 PG describes as a Protocol Data Unit (PDU) at the application layer and not at the data link layer. This means an SAE J1939 PG data field is not constrained to the 8-byte data length limitation of a single CEFF data frame. Since an SAE J1939 PG describes an application layer PDU, the PG can be defined with a data field up to 1785 bytes in length. An SAE J1939 PG with a data field up to 8 bytes is transmitted using a single SAE J1939 data frame. An SAE J1939 PG with a data field greater than 8 bytes is transmitted using multiple J1939 data frames through the SAE J1939 Transport Protocol. The SAE J1939 Transport Protocol is discussed in more detail in 4.9.

SAE J1939 fully defines the Parameter Groups and parameters which establishes a well-known information interface that enables components and subsystems from different manufacturers to be integrated and able to interoperate. All transmitted SAE J1939 PG on an SAE J1939 network must only be standardized SAE J1939 PG and must conform to the SAE J1939 defined characteristics including, but not limited to, transmission rate, data content, data placement, and data encoding. The data field of each transmitted SAE J1939 PG must only contain data for the parameters defined for that SAE J1939 PG and encoded as defined for each parameter. The only exception is the data communicated using SAE J1939 PG defined as proprietary messages, i.e., PropA, PropA1, PropB, and PropB1 PG, where the parameter data is defined by the transmitter of the proprietary messages.

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The SAE J1939 Committee is the data registration authority for all SAE J1939 Parameter Groups and their Parameter Group Number (PGN) assignments. SAE J1939 maintains a dictionary with every approved SAE J1939 PG together with its unique Parameter Group Number (PGN). The list of all approved SAE J1939 Parameter Groups is provided in SAE J1939DA.

The definitions for most of the SAE J1939 Parameter Groups are documented in SAE J1939DA or one of the other SAE J1939 documents, namely SAE J1939-21, SAE J1939-73, and SAE J1939-81. SAE J1939-71 discusses transmission rates, data field position notation, parameter data byte ordering, and the special encodings for parameter data and unsupported data field bits. Some SAE J1939 PGs are assigned to other industry standards, such as ISO 11783 or NMEA 2000, and the definition for those SAE J1939 Parameter Groups are maintained within the respective industry standard documents.

An SAE J1939 PG definition specifies the identification characteristics, such as assigned PGN and message acronym; the structural characteristics of the data field, such as length, data parameters, parameter data placement; and the behavioral characteristics, such as message transmission rate. Strict conformance to the PG definition is required. Applications are generally permitted to use a different Priority value from the specified Default Priority, but this should be done only as required to resolve system issues, such bus access problems with certain messages.

4.5.1 PG Identification Characteristics

The identification characteristics for a Parameter Group include the Parameter Group Number, its name, and its acronym.

The Parameter Group Number (PGN) uniquely identifies each SAE J1939 PG. The PGN value is used within SAE J1939 messages to identify the PG and data content of the CEFF data frame. The PGN value is a number computed from the EDP, DP, PF, and PS values that shall be used in the respective fields of the 29-bit identifier of an SAE J1939 data frame (for PG requiring only a single SAE J1939 data frame). The PGN value is occasionally communicated as part of the data field content of another PG when making reference to a PG. For example, the data field of the Request PG (PGN 59904) consists of the PGN of the PG being sought or requested. The PS value for PDU1 Format PGs is indicated as zero when the PGN number is reported as a data parameter within the data field of another PG.

A name and acronym are assigned to each Parameter Group. The name provides a referential title to the Parameter Group. The acronym for a Parameter Group is an aid for referring to the PG in documentation, specifications, and dialog. For example, the acronym TSC1 refers to the Torque Speed Control PG (PGN 0), and the acronym DM1 refers to the Diagnostic Message 1 PG (PGN 65225) used to report active diagnostic trouble codes.

4.5.2 PG Behavioral Characteristics

The transmission rate is the primary behavioral characteristics for all SAE J1939 PGs. The transmission rate defines the transmit behavior and timing requirements for the PG. The required transmit behavior for an SAE J1939 PG is specified by the Transmission Rate property in the Parameter Group definition.

Most SAE J1939 PGs are transmitted in either a continuous unsolicited behavior or a solicited (requested) behavior. While there are numerous Transmission Rate models, the most common transmission rate models are a fixed interval period, a fixed interval period with event-driven updates, and on request. A transmission rate defined with a fixed interval period or a fixed interval period with event-driven updates are examples of continuous unsolicited transmit behavior. For a PG with continuous unsolicited transmit behavior, a source (or transmitter) of the PG sends it automatically and periodically. A transmission rate defined as on request is an example of a solicited transmit behavior. For a PG with solicited transmit behavior, a source (or transmitter) of the PG sends it only when requested or prompted. If an ECU is designed as a transmitter of a continuous unsolicited transmit PG, then the ECU shall automatically and periodically transmit the PG when the ECU is communicating on the SAE J1939 network.

Some SAE J1939 PGs are defined with other behavioral requirements, such as specific destination addresses or special responses. For example, the Address Claim PG and the Acknowledgement PG each require using the Global Address (255) as the destination address. Another example, the DM3 PG has special response behaviors.

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4.5.3 PG Structural Characteristics

4.5.3.1 Message Data Length

The data length specifies the required byte length of the data field transmitted for a Parameter Group. An SAE J1939 PG can be defined with a data field length from 0 to 1785 bytes. As mentioned in 4.5, the length of a PG data field can be larger than 8 bytes (i.e., the maximum byte length for a data field in a CEFF data frame). While there are numerous different byte length specifications among all SAE J1939 PG, the most common byte length models are a fixed data length of 8 bytes, a fixed data length of more than 8 bytes, and variable data length.

Most SAE J1939 PGs are defined with a fixed data length 8-byte data field, which means there will always be 8 bytes transmitted as the data field for the PG; however, its does not necessarily mean that SAE J1939 has assigned parameter data to all 8 bytes in the data field. SAE J1939 uses a bit encoding method for populating data field bits not yet assigned to a data parameter. In this manner, additional data parameters can be added to the PG data content as system designs and technology change. An SAE J1939 PG with a data length of 8 bytes or less is transmitted using a single SAE J1939 data frame.

SAE J1939 PGs in which the data field length can be greater that 8 bytes are also known within SAE J1939 as “multipacket messages” because the entire PG is transmitted using a series of multiple SAE J1939 data frames (packets), via Transport Protocol. When an SAE J1939 PG is defined with a fixed data length of more than 8 bytes, the data field for the PG shall be transmitted with the defined number of bytes in the data field. When an SAE J1939 PG is defined with variable length data content, the data content length might vary each time the PG is communicated and the data content length might vary from each ECU sending the PG.

4.5.3.2 Parameter Data Content and Position

The data content for a PG consists of zero or more individual data parameters. The PG definition identifies each data parameter and the position in the PG data field of the data for each data parameter. The PG definition identifies each data parameter by the Suspect Parameter Number (SPN) assigned to the data parameter. Section 4.6 describes the technical details provided in the definition for a data parameter, such as data encoding and data length. Data parameters are generally grouped into a PG because (1) the parameter data is associated to a common subsystem (e.g.,ss likely sent by the same ECU), (2) the parameter data has similar update rate requirements, or (3) the parameter data has a common function or context (e.g., oil, coolant, fuel). The PG definition uses the SPN as a means of referring to the specific data parameter and its definition. The actual SPN value is, however, never included in the message data field.

The data field location of the data for each parameter is specified by position. For most data parameters, the data for the parameter is located at a fixed (or absolute) position within the data field, such as ‘”bytes 4 to 5” or “byte 2 bits 5 and 6.” For example, the data for Engine Speed (SPN 190) will always be reported in bytes 4 and 5 of the data field of EEC1 PG (PGN 61444). In some instances, the location of the data for a parameter is not at fixed position. This usually occurs when the parameter data is located after the data for a parameter with variable length data, such as text string, or the parameter data is part a repeating set of parameters, such as a listing of detected diagnostic trouble codes. For example, the data for Model (SPN 587) is located between the first and second asterisk (*) characters in the data field of the Component Identification PG (PGN 65259). When the parameter data location is not at a fixed position, the PG definition will define the method for locating the parameter data.

SAE J1939 uses Least Significant Byte first ordering when placing parameter data into the data field for parameter data longer than 1 byte. The exceptions are parameters with textual data and parameters with data length of 1 byte or shorter.

Many PG definitions have data field bits that are not yet assigned to any parameter. SAE J1939 refers to these as unused or SAE J1939 reserved bits in the data field. A bit value of one is reported for each unused or reserved bit in accordance with the SAE J1939 data encoding method to indicate data not available. These unused bits are strictly reserved for future assignment by SAE J1939; these bits shall not be used at the discretion of component and system designers. This practice allows SAE J1939 to assign additional parameters to the unused bits in order to fully use the message data fields and minimize network bus loading.

The source of an SAE J1939 PG is not required to support every parameter defined in the data content of the PG. SAE J1939 has a standardized data encoding method populating data field bits that are not supported by the transmitter or are not yet assigned to a data parameter. This data encoding enables consumers of the PG to identify which data parameters have data provided and which data parameters do not have data provided.

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4.6 Data Parameter Definitions

This section is limited to the definition practices for SAE J1939 data parameters that have their definition documented within SAE J1939 documents. The definitions for most of the SAE J1939 data parameters are documented in SAE J1939DA or one of the other SAE J1939 documents, namely SAE J1939-21, SAE J1939-73, and SAE J1939-81. SAE J1939-71 discusses parameter data byte ordering, the special parameter data value encodings, and encoding uns/pported data field bits.

SAE J1939 specifies the definition for every parameter contained within an SAE J1939 PG. Each parameter definition provides the technical details for parameter name, data size, data encoding, scaling and offset, units, state value enumerations, and Suspect Parameter Number (SPN) assignment. The SPN assignment permits reporting any related diagnostics. The Parameter Group definitions cite SPNs to identify or cross reference each data parameter in its data field. The SAE J1939 parameter definition establishes a well-defined interface and strict compliance to the specified characteristics is mandatory. See 4.7 for more description about Suspect Parameter Numbers.

As general policy, SAE J1939 will have only one data parameter defined for a specific piece of system data and that defined data parameter will be contained in only one Parameter Group. This policy supports interoperability between ECU and subsystems from different manufacturers. In some instances, SAE J1939 has defined a second data parameter for reporting a specific piece of system data where technical and system design advances warrant the ability to report the data with better resolution and/or a larger range of valid values.

The data encoding for each data parameter is derived from a standard data encoding is called a SLOT (Scaling, Length, Offset, Transfer Function). A SLOT defines the data bit size, bit value scaling factor, conversion offset, engineering data units, and range of valid engineering values. SLOTs are used to manage and minimize the number of different data encodings used by SAE J1939 data parameters. SAE J1939 maintains a list of defined SLOTs and defines new SLOTs as required. When assigning a new SAE J1939 data parameter, SAE J1939 is use an existing SLOT when the scaling factor, units, and engineering data range satisfies the needs for the data parameter. The list of all defined SLOT is documented in SAE J1939DA.

For scaled data parameters, the parameter definition specifies the data bit size, the bit scaling factor, offset value, engineering data units, and the SLOT associated with the encoding. SAE J1939 uses a scaled with offset (linear equation) model for encoding the engineering data of scaled data parameters. The data scaling factor for a parameter only specifies the finest resolution that can be reported for the data. The scaling factor does not impose a requirement on the measurement capability of the reporting device.

For state value data parameters, the parameter definition specifies the data bit size, the assigned meaning for each value state, and the SLOT indicating a state value encoding of the specific bit size.

All possible data bit values are not available for reporting valid parameter data. SAE J1939 assigns part of the data bit values for reporting data validity indicators in place of valid data for a parameter. Data validity indicator values are used to indicate valid data is not provided for a parameter, for reasons such as parameter is not supported, data is not available, or valid parameter data is not available due to some condition, like a detected sensor failure. For some parameters, this encoding method requires the parameter to be defined with a larger bit length. For example, a simple two state parameter reporting “on” and “off” would be defined by SAE J1939 as a 2-bit parameter, where two of the four values (00 and 01) report the “on” and “off” states, one value (10) indicates data error, and one value (11) indicates not available or unsupported.

4.7 Suspect Parameter Number (SPN)

A Suspect Parameter Number (SPN) is a unique 19-bit number used to identify the item for which a diagnostic is being reported. Each assigned SPN has a name or description describing the parameter, component, event, or condition. A unique SPN is assigned to individual parameters within an SAE J1939 PG. A unique SPN is also assigned to a component, event, or condition that is relevant to diagnostics but does not exist as a data parameter in a PG. The SPN is one numeric component of an SAE J1939 Diagnostic Trouble Code (DTC). See 4.8 for an overview of SAE J1939 Diagnostic Trouble Codes.

SAE J1939 maintains a dictionary of every assigned Suspect Parameter Number (SPN). The list of all assigned SAE J1939 Suspect Parameter Numbers is provided in SAE J1939DA. The definition details for SAE J1939 SPN are documented in SAE J1939DA or one of the other SAE J1939 documents, namely SAE J1939-21, SAE J1939-73, and SAE J1939-81.

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Suspect Parameter Numbers are described as either a diagnostic-only SPN or a data parameter SPN. A diagnostic-only SPN is an SPN for a component, event, or condition that is relevant for diagnostic reporting but is not associated to parameter within an SAE J1939 PG. A data parameter SPN is an SPN assigned to a data parameter within the data field. These formats provide different addressing capability and have different SAE J1939 PG identification methods. The assignment of an SPN to each parameter within an SAE J1939 PG allows reporting against the data parameter. The assignment of an SPN to each parameter within an SAE J1939 PG also serves as a cross reference to the data parameter definition, such as data bit length and data encoding. A diagnostic-only SPN can be changed to data parameter SPN by adding a data parameter definition and making it a parameter within a PG.

4.8 Diagnostic Trouble Code (DTC)

The SAE J1939 Diagnostic Trouble Code (DTC) is the data structure used to describe a detected failure for a parameter, component, event, or system condition. A DTC consists of a Suspect Parameter Number (SPN) and a Failure Mode Indicator (FMI), where the SPN identifies the item for the diagnostic is being reported and FMI identifies the type of failure detected in the subsystem identified by the SPN. SAE J1939 maintains standard assignments of both SPNs and FMIs; however, SAE J1939 does not specify standard combinations SPN and FMI.

Refer to SAE J1939-73 for documentation on the SAE J1939 Diagnostic Trouble Code (DTC) structure and the SAE J1939 PG for communicating DTCs. The list of all assigned SAE J1939 SPN is provided in SAE J1939DA. The list and description of all assigned FMIs is provided in SAE J1939-73.

An ECU communicates DTC using the appropriate SAE J1939 Diagnostic Message, such as Diagnostic Message 1 (DM1) for reporting the list of active DTCs. Diagnostic Messages are SAE J1939 Parameter Groups where the data field contains diagnostic details, such as a list of DTCs, rather than operational data, like temperatures or pressures.

4.9 Communication Methods

The section discusses the basic communication methods for SAE J1939 PG exchanges. Refer to SAE J1939-21 and SAE J1939-71 for the technical requirements and documentation.

4.9.1 Transmitting Messages

An SAE J1939 Parameter Group (message) is transmitted using either a single SAE J1939 data frame or multiple SAE J1939 data frames. The length of the data in the PG data field determines how the message is transmitted. When the data length of the PG data field is 8 bytes or less, then the PG is transmitted in a single SAE J1939 data frame and the PG is identified in the 29-bit identifier of the SAE J1939 data frame. When the data length of the PG data field is greater than 8 bytes, then Transport Protocol is used to reliably transfer the PG and its data using multiple SAE J1939 data frames. The ECU transmitting the PG is required to provide the entire data field required for the PG. The ECU must provide either parameter data or a “not available” indicator value for every byte and bit in the data field. The transmitting ECU shall indicate “not available” for any data field bits where the ECU is not providing parameter data. This applies to data field bits associated to parameters not supported by the ECU as well as data field not yet defined by SAE J1939. This allows receivers of the PG to know data is not provided for those parameters.

4.9.2 Periodic Messaging

Periodic messaging describes the communications method where an SAE J1939 PG is transmitted automatically and continuously without the need for a request or solicitation to initiate the transmits. Periodic messaging applies to any SAE J1939 PG where its Transmission Rate specifies some type of periodic transmission rate, such as “100 ms” or “every 100 ms and on change not to exceed 20 ms.” When an ECU is designed as a transmitter of an SAE J1939 PG of this type, then the ECU automatically transmits the PG when connected to the network and continues to transmit the PG according to the specific Transmission Rate. When an ECU is designed to receive an SAE J1939 PG of this type, then that ECU should not send out a request or solicitation for the PG.

If the length of the PG data field is 8 bytes or less, then the PG will be transmitted with a single SAE J1939 data frame and the PG will be identified in the 29-bit identifier of the SAE J1939 data frame. If the length of the PG data field is greater than 8 bytes, then the PG will be transmitted using multiple SAE J1939 data frames (multi-packet) by the Transport Protocol service where the PG will be reported in the body of the SAE J1939 data frame for the TP.CM Parameter Group.

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4.9.3 Requests and Acknowledgement

The Request PG (PGN 59904) is the SAE J1939 PG for requesting or soliciting the transmit of an SAE J1939 PG by one or more devices on an SAE J1939 network. The Request PG should only be used to request SAE J1939 PG with a Transmission Rate that describes some type of transmit on request behavior, such as “On request.” The Request PG data field contains the PGN of the specific PG being requested to be transmitted. When requesting a PDU1 format PG, the PS value is reported as zero when specifying the PGN number in the Request PG data field. The Request PG is a PDU1 format PG to enable the request to be sent to a single ECU or to be sent to all ECU. The response by ECUs to the request depends upon numerous factors, such as the destination address of the Request, requested PG support by ECUs, the data field size for requested PG, and any special transmit behavior associated with the requested PG.

For a destination-specific Request PG (i.e., destination address is a specific Source Address and not the Global Destination Address), the observed response shall be only one of the following:

- The requested PG and its data sent by the specified Source Address using a single SAE J1939 data frame.
- The requested PG and its data sent by the specified Source Address using the RTS/CTS Transport Protocol service.
- The Acknowledgement PG sent by the specified Source Address with the requested PGN in its data field along with an explanation on why the requested PG and its data was not provided.
- The Acknowledgement PG sent by the specified Source Address with the requested PGN in its data field along with a Positive Acknowledge, but only if this is the required behavior specified for the requested PG.

For a global Request PG (i.e., destination address is the Global Destination Address), the observed response shall be only one of the following:

- One or more instances of the requested PG and its data, where each instance is sent using a single SAE J1939 data frame from each Source Address that supports the requested PG.
- One or more instances of the requested PG and its data, where each instance is sent using the BAM Transport Protocol service from each Source Address that supports the requested PG.
- One or more instances of the requested PG and its data, with an instance from each Source Address that supports the requested PG. Some instances are sent as using a single SAE J1939 data frame and other instances are sent using the BAM Transport Protocol service. For example with a global Request for DM2 message, the DM2 PG will be sent using a single SAE J1939 data frame from ECUs with zero or one previously active DTC and the DM2 PG will be sent using BAM from ECUs with two or more previously active DTCs.
- No responses, since the Acknowledgement PG is not sent by ECUs in response to a global Request. No responses generally means the requested PG is not be supported by any of the ECUs or ECUs might not be able to send the requested PG due to an issue, such a access denied.

4.9.4 Transport Protocol

The SAE J1939 Transport Protocol (TP) is the data service for exchanging an SAE J1939 PG that has a data field greater than 8 bytes in length. When the length of the PG data field is 8 bytes or less, then the PG is transmitted in a single SAE J1939 data frame and the PG is identified in the 29-bit identifier of the SAE J1939 data frame. When the length of the PG data field is greater than 8 bytes, then the Transport Protocol is used to reliably transfer the PG and its data over the network.

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The Transport Protocol transfers the PG and its data by fragmenting the PG data field into multiple serialized 7-byte data fragments. There are two Transport modes: RTS/CTS (connection oriented) and BAM (connectionless). RTS/CTS (Ready to Send/Clear to Send) mode allows a connection oriented transfer between two ECUs and includes flow control and lost packet recover capabilities. BAM (Broadcast Announce Message) mode only allows transfer to all ECUs and has no flow control and no lost packet recovery capabilities. The Transport Protocol mode used depends upon the PDU Format of the PG being transmitted and how the PG transmit was initiated. For example, when the exchange was initiated by a Request PG directed to an ECU, then the RTS/CTS mode is generally required; but when the exchange was initiated by a Request PG directed to the Global Destination Address, then the BAM mode is generally required. The technical details for the proper Transport Protocol mode are documented in SAE J1939-21.

The Transport Protocol uses two SAE J1939 PG: TP Connection Management (TP.CM) and TP Data Transfer (TP.DT). The TP.CM Parameter Group is used to manage the data exchange and the TP.DT Parameter Group is used for transmitting the serialized data fragments. Operationally, the originating ECU sends a TP.CM PG message, using a single SAE J1939 data frame, to start the transport and to identify the PGN for the data fragments, passed as part of the TP.CM PG data field. Next, the originating ECU sends a series of TP.DT PG messages, each as a single SAE J1939 data frame, with the serialized 7-byte data fragments. Finally, the sending ECU sends the TP.CM PG to announce the end of the transfer. At the receiving ECU, the serialized 7-byte data fragments are extracted from each TP.DT PG and reassembled into the original data field and the PGN identity for the data is the PGN identified in the initial TP.CM message data field. This is a simplified explanation of the Transport Protocol service; however, it does cover the general method used to transfer PG with more than 8 bytes of data.

4.9.5 Receiving Messages

There are several general observations and behaviors regarding receiving SAE J1939 data frames and SAE J1939 PG (SAE J1939 message).

1. The Priority bits shall be ignored when receiving any SAE J1939 data frame.

2. When a destination specific (PDU1 Format) SAE J1939 PG is received and the destination Source Address of the SAE J1939 message does not match the Source Address claimed by this ECU (CA), then the ECU (CA) should disregard the message.

3. When a destination specific Request PG (PGN 59904) is received and the destination Source Address of the Request PG message matches the Source Address claimed by this ECU (CA), then ECU (CA) must process the message and provide an appropriate response, as discussed in 4.9.3.

4. When a global Request PG (PGN 59904) is received (i.e., Global Destination Address is the destination address), then the ECU (CA) must process the message and respond appropriately, as discussed in 4.9.3.

5. When a global Request PG (PGN 59904) is received (i.e., Global Destination Address is the destination address), then every ECU, even the transmitter of the Request PG, must process the Request and respond appropriately, as discussed in 4.9.3.

6. When a broadcast (PDU2 Format) SAE J1939 PG is received, the ECU must determine if the PG is relevant and process the message accordingly.

4.9.6 Proprietary Messages

SAE J1939 has defined 514 SAE J1939 PG for communicating proprietary information over an SAE J1939 network. The SAE J1939 Proprietary PGs are denoted with the acronyms PropA, PropA2, PropB, and PropB1. The PropA and PropA2 PGs are PDU1 Format and PropB and PropB1 PGs are PDU2 Format.

The use of standardized SAE J1939 Parameter Group is preferred and should be used whenever practical; however, the proprietary messages offer a means of solving unique problems and situations. If the information is not proprietary and is of general interest or generally applicable to similar system functions, then a standardized SAE J1939 Parameter Group should be sought. The proprietary messages are intended for communicating truly proprietary information or communicating information that is not of general interest. For example, if the communications between ECUs of a single manufacturer exchange information that is very specific to their solution and not generally useful to other ECUs on the network, then proprietary Parameter Groups might be a reasonable solution.

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Proprietary message use should be considered carefully and used sparingly, and software safeguards are strongly suggested, such as Source Address filtering or restrictions, when receiving proprietary PG. The same 514 SAE J1939 PG have been assigned for use by all manufacturers. The interpretation of the data field of a proprietary PG is dependent on the manufacturer associated with Source Address sending the message and, for PDU1 Format PG, possibly by manufacturer associated with the destination Source Address.

4.10 ECU Design

Although every manufacturer will have different performance requirements for the ECU contained within their product, several observations should be made regarding the resources needed to support SAE J1939.

Even though every SAE J1939 PG is not relevant to an ECU, the receiving processor must still be able to handle (or buffer) multiple back to back SAE J1939 messages. As described in the Processing Requirements section in SAE J1939-21, devices must be designed so no messages will be lost due to ECU hardware or software design limitations. This requirement will require some RAM space as well as processor time for the memory transfers. SAE J1939-11 and SAE J1939-15 networks operate at 250 kbps so an ECU could receive a new CEFF data frame every 250 μs for the shortest SAE J1939 PG with 0 data bytes and an ECU could receive a new CEFF data frame every 500 μs for typical SAE J1939 PG with 8 data bytes. SAE J1939-14 networks operate at 500 kbps so an ECU could receive a new CEFF data frame every 125 μs for the shortest SAE J1939 PG with 0 data bytes and an ECU could receive a new CEFF data frame every 250 μs for typical SAE J1939 PG with 8 data bytes.

Additional ECU design considerations and resources may be necessary to support other aspects of SAE J1939, such as Address Claim and NAME discussed in SAE J1939-81, Requests and Acknowledgements as described in SAE J1939-21, and any applicable data and diagnostics as described in the SAE J1939-7X documents. For example, the ECU design might need to include non-volatile memory to retain the last successfully claimed Source Address. Or perhaps if it is possible for a network to have multiple instances of the ECU, then the ECU design might need some external inputs for determining part or all of its SAE J1939 NAME. The requirements for any ECU design are the responsibility of the ECU designers.

4.11 Network Topology

SAE J1939-11, SAE J1939-14, and SAE J1939-15 specify the requirements for different physical layers which can be used for an SAE J1939 network segment. An SAE J1939 network may consist of one SAE J1939 segment or multiple SAE J1939 segments connected by Network Interconnection ECUs. The SAE J1939-1 provides examples of systems with one SAE J1939 segment and systems with multiple SAE J1939 segments connected by Network Interconnection ECUs. Each SAE J1939 segment consists of a single, linear, twisted pair of wires running around a section of the vehicle to each ECU. A short stub is permitted to connect this “bus” to each ECU. This simplifies the routing of the main bus wiring by not requiring it to come in direct proximity with each ECU. The linear bus is necessary at a data rate of 250 Kbps and 500 Kbps in order to minimize reflections of the electrical signals. The termination resistor at each end of the bus also reduces reflections.

The SAE J1939 network may thus be composed of multiple segments, with a Network Interconnection ECU (bridge) between them, as defined in SAE J1939-31. These segments need not be directly compatible with each other, as they may operate at different data rates or use different physical media. For example, a bridge provides electrical isolation between segments, provides initialization support for the subnetwork connected to it, and can provide message filtering to prevent unnecessary message traffic on the subnetworks. In the event of a bus failure on the wires exposed between the tractor and trailer, the main SAE J1939 subnetwork on the tractor will continue to function.

The SAE J1939-13 document specifies the requirements for the standard diagnostic connector used for connecting a diagnostic tool to the SAE J1939-11, SAE J1939-14, and SAE J1939-15 networks of a system.

4.12 SAE J1939DA Spreadsheet

The SAE J1939DA Digital Annex is an electronic spreadsheet document used to publish SPNs, PGNs, SLOTs, NAME field enumerations, and Preferred Address assignments made by the SAE J1939 Committee. The content in SAE J1939DA is fully approved and balloted by the SAE J1939 Committee. The SAE J1939DA is the only publication for

- All SPN assignments
- SPN definition details for most SAE J1939 data parameters

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- SPNs assigned for use by other industry standards documents
- All SAE J1939 PG and PGN assignments
- PG definition details for most SAE J1939 PG
- PGNs assigned to and defined by other industry standards documents
- NAME standardized values (Functions, Vehicle Systems, Industry Groups, Manufacturer Codes)
- Preferred Address

4.13 Requests for New Assignments

Applications shall use existing SAE J1939 Parameter Groups, data parameters, diagnostic IDs, and other standardized identifiers whenever available. If new standardized identifier assignments are required for data that is not already assigned,, developers may request new values to be assigned by the SAE J1939 Committee. If changes to standardized identifier assignments are required, developers may also request changes to be made by the SAE J1939 Committee.

New requests and changes are submitted using the SAE J1939 Request Form. The latest version of the SAE J1939 Request Form is available from SAE International or on the SAE J1939 Discussion Forum portion of the SAE Web Site (www.sae.org). In addition, the SAE J1939 Committee also publishes a guidelines document, "J1939_Request_Processing_Guidelines," to help new requesters with the request process. The latest version of this guideline document is also available from SAE or on the SAE J1939 Discussion Forum portion of the SAE Web Site (www.sae.org).

The SAE J1939 Request Form contains sections for requesting Parameter Group Numbers (PGNs), Suspect Parameter Numbers (SPNs) for data parameter and diagnostics, Manufacturer Codes, NAME Functions, NAME Vehicle Systems, and Preferred Source Addresses. When requesting multiple new assignments, the individual item requests can be included within a single Request Form document or submitted in multiple separate Request Form documents. When requesting a new PGN, the request for the PGN and request for the parameters (SPNs) to be contained within the new PGN should be submitted together within the same Request Form document. When requesting several diagnostic SPNs, it is acceptable to include all of them within the same Request Form document. When requesting multiple new PGNs, it is often easier to submit each PGN request in a separate Request Form document; however, this is not required.

The SAE J1939 Request Form is the only document that is required to be submitted for a request. For some requests, the SAE J1939 Request Form is sufficient. For other requests, the SAE J1939 Committee encourages requesters to provide supplemental documentation to help the committee fully understand what is being requested. Requesters should take care to avoid disclosing any trade secret or intellectual property information when they construct their SAE J1939 Request Form and any supplemental documents. Supplemental documents provide a means for the requester to explain the request and provide any relevant technical explanations or illustrations. Supplemental documentation also provides a means for the requester to present their justification for the new assignment, such as when the requester is aware of existing assignments that may appear to be similar to the new requests but the requester has reasons explaining the technical difference between the existing assignment and the requested item.

The SAE J1939 Discussion Forum portion of the SAE Web Site is used by the SAE J1939 Committee for working through most of the technical issues and questions related to an SAE J1939 Request. Requesters are encouraged to be active in leading technical review discussions of their request, usually via teleconference calls. Requesters are also invited to attend SAE J1939 Committee meetings should they wish to make a personal presentation of their request and answer questions about it. Experience has shown that supporting a request in person or by teleconference at the SAE J1939 Committee request review meeting often results in committee questions being resolved immediately with an approval at that time rather than waiting three to four months for the next committee meeting to take place. If the committee cannot fully understand the request or resolve their issues and questions, it will be necessary to table the request until the committee’s questions are answered by the requester, resulting in months of delay before the request can be resolved. All too often, requests have been tabled so that questions arising from committee discussion can be resolved. Once an assignment has been made, it cannot be deleted or significantly altered because systems using this definition may have already been fielded. Consequently, this forces the committee to seriously challenge any request that is not fully understood or which might result in a future request that is very similar.

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4.13.1 Parameter Data Field Grouping

Minimizing message overhead with CAN based systems requires full use of the data fields of messages. Except in the case of very time critical messages, parameters should be grouped to fill the 8-byte data field. Following this principle conserves PGNs for future assignment and allows for minimum network loading when all data bytes are known by and sent from the same address. Strong justification is needed to allow definition of Parameter Group Numbers that result in sparsely used data fields.

When requesting new data parameters, requesters should look for spare bytes or bits in an existing SAE J1939 Parameter Group. Since all parameters defined in SAE J1939 have a technique for identifying when they are not available, it is not critical that all of the parameters in one Parameter Group come from the same ECU. When data parameters are needed at a fast update rate, it is desirable to make sure a Parameter Group is fully utilized (i.e., uses all 8 data bytes) before defining another PG and preferable that all parameters are normally coming from one specific ECU. For data with a slower update rate, it is not as critical that all of the parameters in a Parameter Group come from the same ECU. Even though it is desirable to have parameters come from one ECU, the intention of SAE J1939 is to provide a means for communicating the data and not dictating which ECU is to send what data.

The following guidelines should be used when grouping parameters together into an existing SAE J1939 PG or a new SAE J1939 PG. Parameters should be grouped as follows:

1. By common subsystem (the ECU likely to measure and send the data)

2. With similar update rates (to minimize unnecessary overhead)

3. By function (Oil, Coolant, Fuel, etc.)

It should be recognized that, while these are guidelines, in most cases, when parameters are grouped together, they will end up violating one or more of the above rules.

4.14 Application Examples

A typical shift sequence consists of a series of commands from the transmission to the engine for controlling engine RPM and torque. Messages from the engine provide status and information which is used to determine when a particular condition has occurred. Other messages may also be sent regularly to disable the engine retarder at the proper time interval, or to inhibit Acceleration Slip Regulation (ASR) functions which might affect engine demand during portions of the shift sequence.

Table 2

Parameter Group	Msg. Type	Transmitter	Using ECU	Action/Function
ETC1	Info	Trans	Eng, ASR	Transmission decision to shift (Shift in progress)
TSC1	Cmd	Trans	Eng.	Override Priority bits set for Trans. (01 priority) Torque control, Torque = 0
TSC1	Cmd	Trans	Retarder (Eng.)	Disable Mode, Torque = 0
EEC1	Info	Eng.	Trans	Torque = 0 (Clutch may be disengaged)
TSC1	Cmd	Trans	Eng	Speed Control Mode, Requested Speed = X
EEC1	Info	Eng	Trans	Speed = X (Clutch may be engaged)
TSC1	Cmd	Trans	Eng	Speed/Torque Limit Mode (11 priority)
ETC1	Info	Trans	ASR	Allow ASR (11 priority)
TSC1	Cmd	Trans	Ret (Eng)	Enable Mode
TSC1	Cmd	Trans	Eng	Override Disable
ETC1	Info	Trans	Eng, ASR	Shift complete

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A typical ABS sequence will cause a message to be transmitted which indicates that the engine should reduce torque and the driveline (transmission) to remain in its existing (stable) state. If the ABS condition is "significant" (i.e., not just bouncing tires), it may request that the driveline also be disengaged. Note that this message must be sent at regular intervals to maintain the condition. Once the event is over, the ABS inactive indicates that the transmission and engine may return to "normal" operation.

Table 3

Parameter Group	Msg. Type	Transmitter	Using ECU	Action/Function
				ABS decision to modulate brakes
EBC1	Info	ABS	Eng, Trans	ABS active
TSC1	Cmd	ABS	Retarder (Eng.)	Disable Mode, Torque = 0 (Prevent engine stall)
TC1	Cmd	ABS	Trans	Disengage Driveline
				ABS event over
EBC1	Info	ABS	Eng, Trans	ABS inactive

A typical ASR sequence will attempt to reduce torque by sending torque limit messages to the engine. Torque can also be reduced by requesting more driveline retardation or permitting some clutch slip. Ultimately an upshift may be requested in order to achieve acceptable torque values. Note that the transmission takes over engine control during the shift.

Table 4

Parameter Group	Msg. Type	Transmitter	Using ECU	Action/Function
				ASR Torque Reduction Decision
EBC1	Info	ASR	Eng, Trans, Retarder (Drvl)	ASR Torque control active
TSC1	Cmd	ASR	Eng	Torque Limit
TSC1	Cmd	ASR	Retarder (Drvl.)	Request more retardation
TC1	Cmd	ASR	Trans	Request more clutch slip
TC1	Cmd	ASR	Trans	Request new gear selection, No clutch slip reque Shift if possible Shift complete, ASR continues torque limit ASR event over
EBC1	Info	ASR	Eng, Trans, Retarder (Drvl)	ASR inactive, disable override

5. NOTES

5.1 Revision Indicator

A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

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