

	<b>SURFACE VEHICLE RECOMMENDED PRACTICE</b>		<b>SAE J1939-15 AUG2008</b>
	Issued	2003-11	
	Revised	2008-08	
			Superseding J1939-15 NOV2003
Reduced Physical Layer, 250K bits/sec, UN-Shielded Twisted Pair (UTP)			

## RATIONALE

Document is being revised to accommodate new OBD regulations which require a 5-meter stub for scan tool connection.

## FOREWORD

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

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

## TABLE OF CONTENTS

1.	SCOPE.....	3
2.	REFERENCES.....	3
2.1	Applicable Publications .....	3
2.1.1	SAE Publications.....	3
2.2	Related Publications .....	3
2.2.1	ISO Publications.....	3
3.	NETWORK PHYSICAL DESCRIPTION .....	3
3.1	Physical Layer.....	4
3.2	Physical Media .....	4
3.3	Differential Voltage.....	4
3.4	Bus Levels.....	4
3.5	Bus Levels During Arbitration .....	4
3.6	Common Mode Bus Voltage Range .....	4
3.7	Bus Termination .....	4
3.8	Internal Resistance .....	4
3.9	Differential Internal Resistance .....	4

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SAE	J1939-15 Revised AUG2008	- 2 -
3.10	Internal Capacitance .....	4
3.11	Differential Internal Capacitance .....	5
3.12	Bit Time .....	5
3.13	Internal Delay Time .....	5
3.14	CAN Bit Timing Requirements .....	5
4.	FUNCTIONAL DESCRIPTION .....	6
5.	ELECTRICAL SPECIFICATION .....	6
5.1	Electrical Data .....	6
5.1.1	Electronic Control Unit .....	6
5.1.2	Bus Voltages - Operational .....	7
5.1.3	Electrostatic Discharge (ESD) .....	7
5.1.4	Example Physical Layer Circuits .....	7
5.2	Physical Media Parameters .....	7
5.2.1	Bus Line .....	9
5.2.2	Topology .....	9
5.2.3	Terminating Resistor .....	10
5.2.4	Shield Termination .....	11
5.2.5	ECU Type I and Type II Markings .....	11
5.3	Connector Specifications .....	11
5.3.1	Connector Electrical Performance Requirements .....	12
5.3.2	Connector Mechanical Requirements .....	12
6.	CONFORMANCE TESTS .....	12
6.1	Recessive Output of the ECUs .....	12
6.2	Internal Resistance of CAN_H and CAN_L .....	12
6.3	Internal Differential Resistance .....	12
6.4	Recessive Input Threshold of an ECU .....	12
6.5	Dominant Output of an ECU .....	12
6.6	Dominant Input Threshold of an ECU .....	12
6.7	Internal Delay Time .....	12
7.	DISCUSSION OF BUS FAULTS .....	12
7.1	Loss of Connection to Network .....	12
7.2	Node Power or Ground Loss .....	13
7.3	Unconnected Shield .....	13
7.4	Open and Short Failures .....	13
8.	NOTES .....	13
8.1	Marginal Indicia .....	13
APPENDIX A	- EXAMPLE PHYSICAL LAYER CIRCUITS .....	14
APPENDIX B	- RECOMMENDED CABLE TERMINATION PROCEDURE .....	15
APPENDIX C	- RECOMMENDED CABLE SPLICE PROCEDURE .....	16
APPENDIX D	- RECOMMENDED CABLE REPAIR PROCEDURE .....	17
APPENDIX E	- COMPARISON OF THE J1939-15 VERSUS THE J1939-11 PHYSICAL LAYER .....	18
APPENDIX F	- J1939-11 COMPLIANT TOOLS AND ECUS USED WITH THE J1939-15 NETWORK .....	19
TABLE 1	- AC PARAMETERS OF AN ECU DISCONNECTED FROM THE BUS LINE .....	6
TABLE 2	- PHYSICAL MEDIA PARAMETERS FOR UN-SHIELDED TWISTED PAIR CABLE .....	8
TABLE 3	- NETWORK TOPOLOGY PARAMETERS .....	10
FIGURE 1	- CABLE CROSS-SECTION AND BEND RADIUS .....	9
FIGURE 2	- WIRING NETWORK TOPOLOGY (TYPE I ECUS ONLY) .....	9
FIGURE 3	- WIRING NETWORK TOPOLOGY (ONE TYPE II ECU INSTALLED) .....	10
FIGURE 4	- WIRING NETWORK TOPOLOGY (TWO TYPE II ECUS INSTALLED) .....	10
FIGURE 5	- AN EXAMPLE OF J1939-11 CONNECTOR USAGE IN A J1939-15 NETWORK .....	11

## 1. SCOPE

As described in the SAE J1939 document, there is a minimum of seven documents required to fully define an SAE J1939 network. This document, SAE J1939-15, describes a physical layer utilizing Unshielded Twisted Pair (UTP) cable. The SAE J1939 Recommended Practice documents are intended for light- and heavy-duty vehicles on- or off-road as well as appropriate stationary applications which use vehicle derived components (e.g., generator sets). Vehicles of interest include but are not limited to: on- and off-highway trucks and their trailers; construction equipment; and agricultural equipment and implements.

The purpose of the J1939 documents is to provide an open interconnect system for electronic systems. It is the intention of these documents to allow electronic devices to communicate with each other by providing a standard architecture.

## 2. REFERENCES

General information regarding this series of recommended practices is found in SAE J1939.

### 2.1 Applicable Publications

The following publications form a part of this specification to the extent specified herein. 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 724-776-4970 (outside USA), [www.sae.org](http://www.sae.org).

SAE J1128 Low-Tension Primary Cable

SAE J1939-11 Physical Layer, 250K bits/sec, Twisted Shielded Pair

SAE J1939-13 Off-Board Diagnostic Connector

### 2.2 Related Publications

The following publication is provided for information purposes only and is not a required part of this document.

#### 2.2.1 ISO Publications

Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, [www.ansi.org](http://www.ansi.org).

ISO 11898 Road vehicles—Interchange of digital information—Controller Area Network (CAN) for high speed communication.

## 3. NETWORK PHYSICAL DESCRIPTION

The J1939-15 physical layer has the same characteristics as the J1939-11 physical layer except as described in this document. It is the responsibility of the vehicle manufacturer to determine when the J1939-15 physical layer should be used versus the J1939-11 physical layer. Appendix E, Table E1 contains a comparison of J1939-15 characteristics versus J1939-11.

### 3.1 Physical Layer

The physical layer is a realization of an electrical connection of a number of ECUs (Electronic Control Units) to a network. The total number of ECUs will be limited by electrical loads on the bus line. The maximum number of ECUs is fixed at 10 on a given segment. The number of ECUs were reduced from 30 (J1939-11) to 10 (J1939-15) due to the extended stub lengths from 1 meter (J1939-11) to 3 meters (J1939-15). Stub length was subsequently increased for a single stub to accommodate the 5-meter requirement for the diagnostic scan tool, per HD OBD regulations.

The J1939-15 network was designed as a reduced J1939-11 network for connecting standard ECUs on a vehicle (e.g. Engine, ABS, Transmission). The J1939-15 network allows the vehicle integrator to design a reduced network to meet design and cost goals with comparable performance to the J1939-11 network.

### 3.2 Physical Media

This document defines a physical media of jacketed un-shielded twisted pair (UTP). These 2 wires have a characteristic impedance of 120  $\Omega$  and are symmetrically driven with respect to the electrical currents. The designations of the individual wires are CAN\_H and CAN\_L. The names of the corresponding pins of the ECUs are also denoted by CAN\_H and CAN\_L, respectively.

### 3.3 Differential Voltage

Same as the J1939-11 physical layer.

### 3.4 Bus Levels

Same as the J1939-11 physical layer.

### 3.5 Bus Levels During Arbitration

Same as the J1939-11 physical layer.

### 3.6 Common Mode Bus Voltage Range

Same as the J1939-11 physical layer.

### 3.7 Bus Termination

The bus is electrically terminated at each end with a load resistor denoted by  $R_L$ . SAE J1939-11 requires that  $R_L$  be located external to ECUs. This Recommended Practice, J1939-15, defines Type I and Type II ECUs. Type I ECUs shall not contain the bus termination resistor  $R_L$ . Type II ECUs shall contain the bus termination resistor and if used shall be located only at one or both ends of an SAE J1939-15 network. Type II ECUs shall be clearly marked as specified in Section 5.2.5.

### 3.8 Internal Resistance

Same as the J1939-11 physical layer.

### 3.9 Differential Internal Resistance

Same as the J1939-11 physical layer.

### 3.10 Internal Capacitance

Same as the J1939-11 physical layer.

### 3.11 Differential Internal Capacitance

Same as the J1939-11 physical layer.

### 3.12 Bit Time

Same as the J1939-11 physical layer.

### 3.13 Internal Delay Time

For those networks utilizing a diagnostic stub which may exceed 3 meters, ECU delay time is reduced to 0.7  $\mu$ s.

### 3.14 CAN Bit Timing Requirements

The CAN bit timing requirements for the J1939-15 are the same as the J1939-11 physical layer, except Table 1 below should be used, which includes the Signal Rise / Fall Time parameter.

If a discrete circuit is used, the Signal Rise / Fall Time should be adjusted per Table 1, Note 2.

Some transceiver chips offer faster rise and fall times than are given in Table 1 without an increase in EMI. If emissions control or slope control is not integral to the transceiver, EMI performance must be equivalent.

The Signal Rise / Fall Time parameter has been included for clarity and to improve the Electromagnetic Compatibility (EMC) of the physical layer. The primary parameter for electromagnetic emission is the unbalance of the signals at CAN\_H and CAN\_L. To verify that the signals are balanced, the maximum voltage imbalance between CAN\_H and CAN\_L should not exceed 10 mV<sub>pp</sub>. The differential voltage can be measured with ac-coupling and an oscilloscope: CAN\_H minus CAN\_L inverted.

TABLE 1 - AC PARAMETERS OF AN ECU DISCONNECTED FROM THE BUS LINE

Parameter	Symbol	Min	Nom	Max	Unit	Conditions
Bit time <sup>1)</sup>	$t_B$	3.998	4.000	4.002	$\mu s$	250 Kbit/s
Internal Delay Time <sup>2)</sup>	$t_{ECU}$	0.0		0.7	$\mu s$	
Internal Capacitance <sup>3)</sup>	$C_{in}$	0	50	100	pF	250 Kbit/s for CAN_H and CAN_L relative to Ground
Differential Internal Capacitance <sup>3)</sup>	$C_{diff}$	0	25	50	pF	
Available Time <sup>4)</sup>	$t_{avail}$	2.5			$\mu s$	40 m bus length
Signal Rise, Fall Time <sup>5)</sup>	$t_R, t_F$	200		500	ns	measured from 10% to 90% of the signal

1) Including initial tolerance, temperature, aging, etc.

2) The value of  $t_{ECU}$  has to be guaranteed for a differential voltage of  $V_{diff} = 1.0V$  for a transition from recessive to dominant and of  $V_{diff} = 0.5V$  for a transition from dominant to recessive. With the bit timing from the example of note 1, a CAN-Interface delay of 500 ns is possible (controller not included) with a reserve of about 300 ns. This allows slower/longer slopes (R3 and R4 in Figures A.1 and A.2) and input filtering (R5, R6, C1, C2 in Figures A.1 and A.2). It is recommended to use this feature due to EMC. (See J1939-11 Appendix A for figures.) The minimal internal delay time may be zero. The maximum tolerable value is determined by the bit timing and the bus delay time.

3) In addition to the internal capacitance restrictions a bus connection should also have an inductance as low as possible. The minimum values of  $C_{in}$  and  $C_{diff}$  may be 0, the maximum tolerable values are determined by the bit timing and the network topology parameters L and d (see Table 3). Proper functionality is guaranteed if occurring cable resonant waves do not suppress the dominant differential voltage level below  $V_{diff} = 1V$  and do not increase the recessive differential voltage level above  $V_{diff} = 0.5V$  at each individual ECU (see J1939-11 Tables 3 and 4).

4) The available time results from the bit timing unit of the protocol IC. For a typical example, this time in most controller ICs corresponds to TSEG1. Due to mis-synchronization it is possible to lose the length of SJW. So the available time ( $t_{avail}$ ) with one mis-synchronization is TSEG1-SJW ms. A tq time of 250 ns and SJW = 1 tq, TSEG1 = 13 tq, TSEG2 = 2tq results in  $t_{avail} = 3.00 \mu s$ .

5) A signal rise/fall time between 200-500 ns is required for the J1939-15 network if using adjustable circuits. Signal rise/fall times closer to 500 ns are preferred. Slower/longer signal rise/fall times improve the electromagnetic compatibility of the network by reducing radiated emissions and radiated susceptibility. The load on the ECU for the purpose of this parameter should be 60 ohms between CAN\_H and CAN\_L in parallel with 200 pf of capacitance (see Appendix A).

#### 4. FUNCTIONAL DESCRIPTION

Same as the J1939-11 physical layer.

#### 5. ELECTRICAL SPECIFICATION

##### 5.1 Electrical Data

The parameter specifications in Tables 1 through 10 of J1939-11 must be fulfilled throughout the operating temperature range of every ECU. These parameters allow up to a maximum of 10 ECUs to be connected to a given bus segment.

##### 5.1.1 Electronic Control Unit

Same as the J1939-11 physical layer.

#### 5.1.1.1 Absolute Maximum Ratings

Same as the J1939-11 physical layer.

#### 5.1.1.2 DC Parameters

Same as the J1939-11 physical layer.

#### 5.1.1.3 AC Parameters

Same as the J1939-11 physical layer.

#### 5.1.2 Bus Voltages - Operational

The parameters specified in Table 5 and Table 6 of J1939-11, apply when all ECUs (between 2 and 10) are connected to a correctly terminated bus line. The maximum allowable ground offset between any ECUs on the bus is 2 Volts. The voltage extremes associated with this offset would occur in the dominant state (see Table 6 in J1939-11).

#### 5.1.3 Electrostatic Discharge (ESD)

Same as the J1939-11 physical layer.

#### 5.1.4 Example Physical Layer Circuits

The J1939-15 ECU physical layer circuits are the same as the J1939-11 ECU physical layer circuits.

If using a discrete transceiver circuit, or if an integrated circuit provides for adjusting the rise and fall time, the J1939-15 ECU physical layer parameters are required to be adjusted so the signal rise/fall time is between 200-500ns to improve the J1939-15 network Electromagnetic Compatibility. See Appendix A, Figure A1 for the preferred signal rise and signal fall waveforms.

The J1939-15 network (backbone and stubs) will not be connected to the CAN\_SHLD terminal on the ECU physical layer circuit.

### 5.2 Physical Media Parameters

The following sections describe the characteristics of the cable, termination, and topology of the network. Table 2 contains the physical media parameter values for the J1939-15 cable. Figure 1 shows the cable cross-section and the bend radius of the J1939-15 cable.

Physical parameters not specified herein should meet requirements of SAE J1128 for type TXL, GXL, or SXL wire. These requirements include resistance to flame propagation, fluid compatibility, resistance to ozone, resistance to pinch, resistance to sandpaper abrasion, and resistance to hot water.

TABLE 2 - PHYSICAL MEDIA PARAMETERS FOR UN-SHIELDED TWISTED PAIR CABLE

Parameter	Symbol	Min	Nom	Max	Unit	Conditions
Impedance	Z	108	120	132	$\Omega$	Three meter sample length measured at 1 Mhz between the two signal wires, using open/short method.
Specific Resistance	$r_b$	0	25	50	m $\Omega$ /m	1) measured at 20 °C
Specific Line Delay	$t_p$		5.0		ns/m	2)
Specific Capacitance	$c_b$	0	40	75	pF/m	
Cable size						3)
0.5 mm <sup>2</sup> Conductor (20 AWG)	$a_c$	0.508			mm <sup>2</sup>	4) (see Figure 1)
Wire insulation dia.	$d_{ci}$	1.90		2.8	mm	
Cable diameter	$d_c$	5.08		7.6	mm	
0.8 mm <sup>2</sup> Conductor (18 AWG)	$a_c$	0.760			mm <sup>2</sup>	4) (see Figure 1)
Wire insulation dia.	$d_{ci}$	2.03		3.05	mm	
Cable diameter	$d_c$	5.3		8.2	mm	
Temperature Range	°C	-40		+125	deg C	5)
Lay Length		28	33	38	mm	0.67 to 0.91 twist per 25.4mm
Cable Bend Radius	r	4x dia. of cable			mm	90 degree bend radius without cable performance or physical degradation. (see Figure 1)

1) The differential voltage on the bus line seen by a receiving ECU depends on the line resistance between it and the transmitting ECU. Therefore, the total resistance of the signal wires is limited by the bus level of the parameters of each ECU.

2) The minimum delay time between two points of the bus line may be zero. The maximum value is determined by the bit time and the delay times of the transmitting and receiving circuitry.

3) For environmental sealing applications, other cable and component insulation diameters may be available. Design engineers should ensure compatibility between cables, connectors and contacts.

4) Meet dimensional requirements of SAE J1128 for types TXL, GXL, or SXL.

5) 125 °C or per OEM specification.



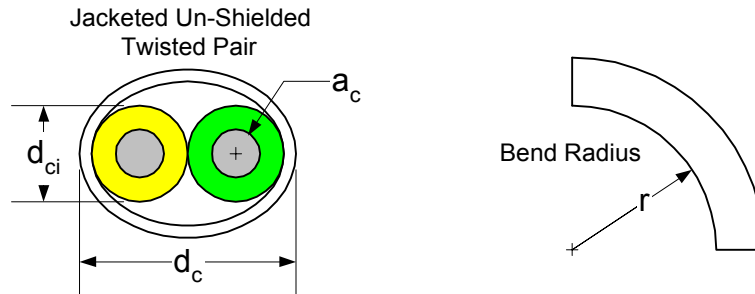


FIGURE 1 - CABLE CROSS-SECTION AND BEND RADIUS

### 5.2.1 Bus Line

The bus line consists of a CAN\_H and CAN\_L conductors. The CAN\_H conductor wire should be yellow in color while the CAN\_L conductor wire should be green.

### 5.2.2 Topology

Figures 2 through 4 show the different wiring topologies with different combinations of network terminations. The figures contain ECU 1, ECU 2, ECU n-1 and ECU n, which are Type I ECUs. ECU A and ECU B in Figures 3 and 4 are Type II ECUs. The dimensional requirements of the network are shown in Table 3.

The wiring topology of this network should be as close as possible to a linear structure in order to avoid cable reflections. In practice, it may be necessary to connect short cable stubs to a main backbone cable, as shown in the figures. To minimize standing waves, nodes should not be equally spaced on the network and cable stub lengths, dimension S, should not all be the same length.

The vehicle manufacturer shall control the J1939-15 cable routing to prevent mutual inductance and / or capacitive coupling of unwanted signals onto the CAN\_H and CAN\_L wires. Coupled signals may interfere with communications and may degrade or damage the CAN transmission line transceivers over an extended period of time. The risk of coupling can be reduced by routing the J1939-15 cable away from high current, rapidly switched loads and the wires connected to these devices, including return paths of ECU ground or power. Examples of the devices and associated wiring to avoid include: starter motors, wiper relays, turn signal (flasher) relays, and lamp relays. Additionally, the routing of the network and stubs should avoid close proximity to emission sensitive components (e.g. radios, CBs, and other electronic components).

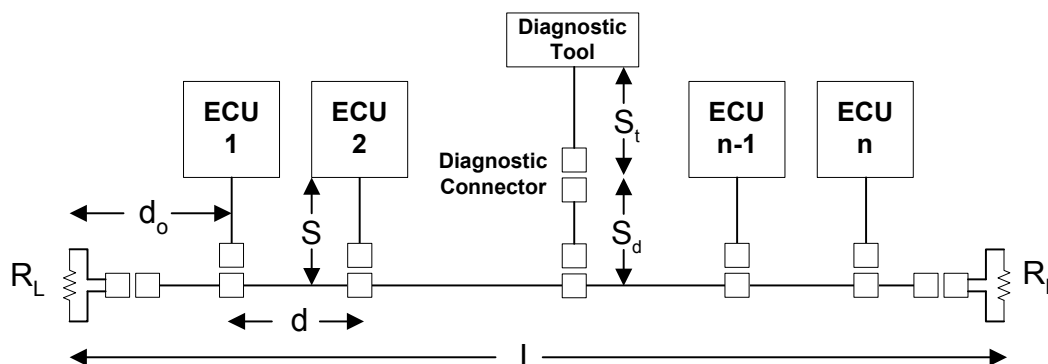


FIGURE 2 - WIRING NETWORK TOPOLOGY (TYPE I ECUS ONLY)

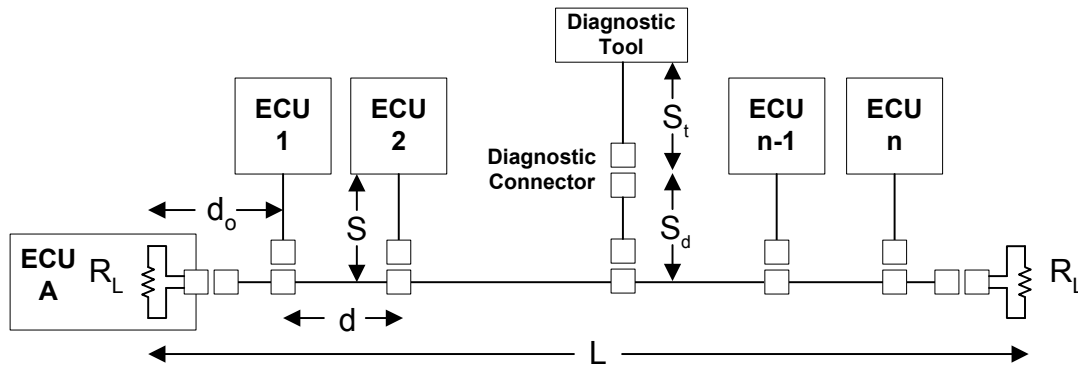


FIGURE 3 - WIRING NETWORK TOPOLOGY (ONE TYPE II ECU INSTALLED)

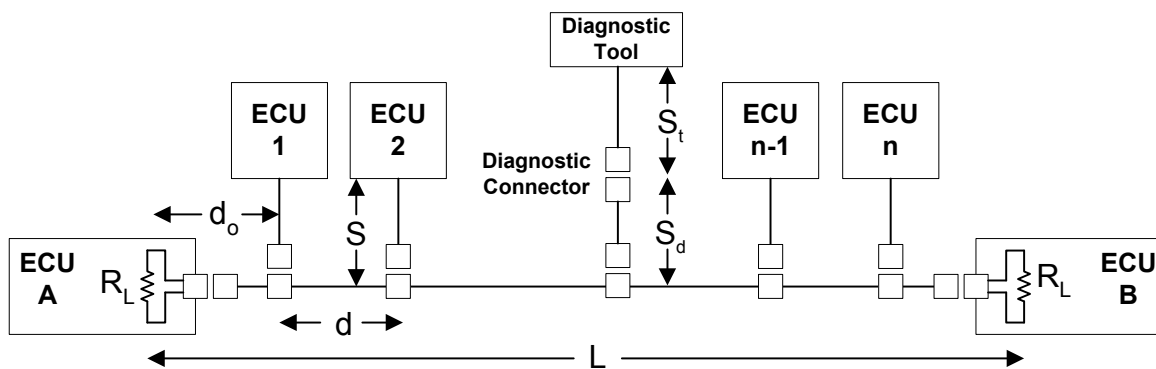


FIGURE 4 - WIRING NETWORK TOPOLOGY (TWO TYPE II ECUS INSTALLED)

TABLE 3 - NETWORK TOPOLOGY PARAMETERS

Parameter	Symbol	Min	Max	Unit	Conditions
Bus Length	L	0	40	m	The distance between the two Load Resistors ( $R_L$ ), or between any two nodes (including the diagnostic scan tool), shall not exceed 40 meters.
Node Stub Length	S	0	3	m	
Diagnostic Stub Length	$S_d$	0	2.66	m	
Diagnostic Tool Cable Length	$S_t$	0	5	m	
Stub Distance	d	0.1	40	m	The distance between stubs on the backbone.
Stub Distance from $R_L$	$d_0$	0		m	$R_L$ may be located within an ECU, but the ECU shall be marked as a Type II J1939-15 ECU.

### 5.2.3 Terminating Resistor

Same as the J1939-11 physical layer.

### 5.2.4 Shield Termination

Not Applicable to the J1939-15 physical layer.

### 5.2.5 ECU Type I and Type II Markings

An ECU that does not contain an internal Load Resistor ( $R_L$ ) shall be designated as a Type I J1939 ECU and does not require a marking. An ECU that contains an internal  $R_L$  shall be designated as a Type II J1939 ECU. The Type II ECU shall have a unique marking on the outside housing to easily determine the internal  $R_L$  feature.

### 5.3 Connector Specifications

The type of connector is not specified for implementing the J1939-15 network and a "standard" connector is not required. An ECU may be connected to the network with either a hard splice or connector. If a connector is used, the connector shall meet the Connector Electrical Performance Requirements in J1939-11. If the three-pin connector described in the J1939-11 document is installed on the J1939-15 network, the drain wire CAN\_SHLD terminal will not be used and a sealing plug will be installed.

It is the responsibility of the vehicle manufacturer to design the network with different keying structures to eliminate the possibility of connecting the network in a method that would be detrimental to proper communications. The connectors shall provide for the electrical connections of CAN\_H and CAN\_L conductor wires.

A J1939-11 compliant ECU may require a three-pin connector described in the J1939-11 document for connecting onto the J1939-15 network. If the three-pin connector is required, the mating connector will not contain the drain wire CAN\_SHLD terminal and a sealing plug will be installed. Figure 5 shows some examples of the J1939-11 three-pin connector concept used in a J1939-15 network.

See Figure 5 for the following connector usage descriptions:

The J1939-11 connector used to connect the ECU to the 'backbone' of the network is called the 'Stub Connector' and is designated "A". The J1939-11 connector used to connect the termination resistor to the ends of the backbone cable is called the 'Through Connector' and is designated "B". ECU 1 is installed onto the J1939-15 'backbone' using a splice. ECU 2 is installed onto the J1939-15 'backbone' using a two-pin connector concept. ECU 3 is installed onto the J1939-15 'backbone' using a J1939-11 three-pin connector concept including a terminating resistor.

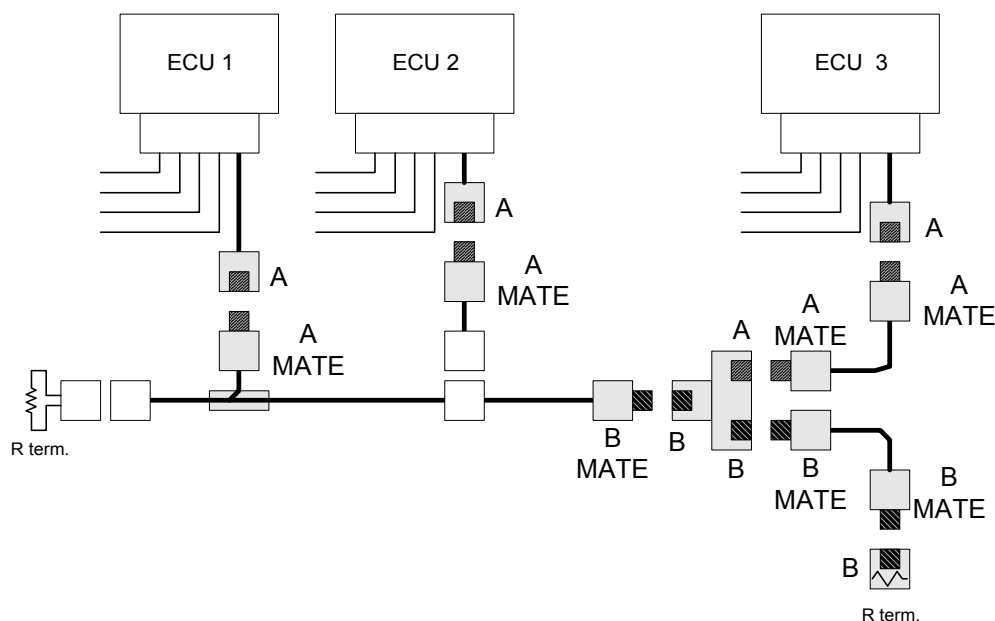


FIGURE 5 - AN EXAMPLE OF J1939-11 CONNECTOR USAGE IN A J1939-15 NETWORK

### 5.3.1 Connector Electrical Performance Requirements

Same as the J1939-11 physical layer.

### 5.3.2 Connector Mechanical Requirements

When connectors are used in a cable network, the connectors should have locking, polarizing, stub connector versus backbone connector type keying, and retention devices that meet the requirements of the specific application. These connectors should also incorporate environmental protection appropriate for the application.

## 6. CONFORMANCE TESTS

Same as the J1939-11 physical layer.

### 6.1 Recessive Output of the ECUs

Same as the J1939-11 physical layer.

### 6.2 Internal Resistance of CAN\_H and CAN\_L

Same as the J1939-11 physical layer.

### 6.3 Internal Differential Resistance

Same as the J1939-11 physical layer.

### 6.4 Recessive Input Threshold of an ECU

Same as the J1939-11 physical layer.

### 6.5 Dominant Output of an ECU

Same as the J1939-11 physical layer.

### 6.6 Dominant Input Threshold of an ECU

Same as the J1939-11 physical layer.

### 6.7 Internal Delay Time

Same as the J1939-11 physical layer.

## 7. DISCUSSION OF BUS FAULTS

Same as the J1939-11 physical layer.

### 7.1 Loss of Connection to Network

Same as the J1939-11 physical layer.

## 7.2 Node Power or Ground Loss

Same as the J1939-11 physical layer.

## 7.3 Unconnected Shield

Not Applicable to the J1939-15 physical layer.

## 7.4 Open and Short Failures

Same as the J1939-11 physical layer.

# 8. NOTES

## 8.1 Marginal Indicia

A change bar (I) 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.

PREPARED BY SAE TRUCK AND BUS CONTROL AND COMMUNICATIONS NETWORK SUBCOMMITTEE  
OF SAE TRUCK AND BUS ELECTRICAL/ELECTRONIC COMMITTEE

## APPENDIX A - EXAMPLE PHYSICAL LAYER CIRCUITS

There are many possible discrete and integrated ECU physical layer circuits which meet the previous requirements. See J1939-11, Appendix A for examples of discrete physical layer circuits which meet the electrical specifications contained within this document. J1939 physical layer integrated CAN Transceiver products are also available from semiconductor manufacturers. Figure A1 shows the preferred signal rise and fall times for a J1939-15 network.

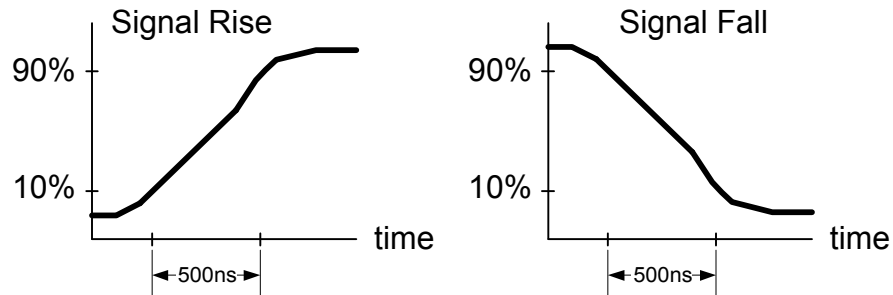


FIGURE A1 - EXAMPLE OF PREFERRED SIGNAL RISE/FALL WAVEFORMS

## APPENDIX B - RECOMMENDED CABLE TERMINATION PROCEDURE

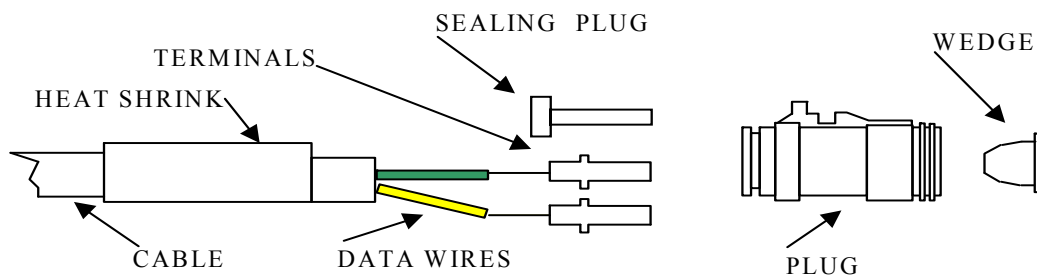


FIGURE B1 - CABLE TERMINATION 3 CAVITY CONNECTOR

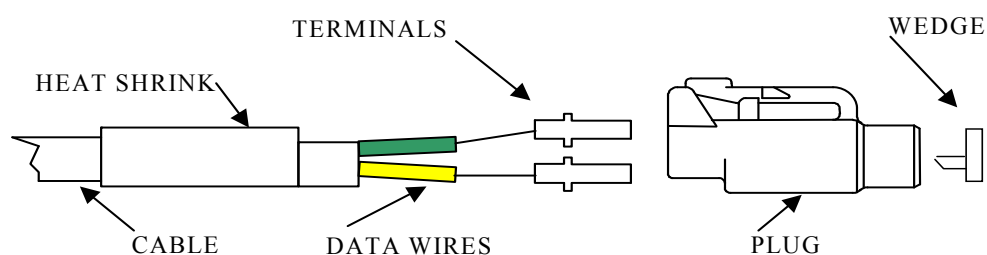


FIGURE B2 - CABLE TERMINATION OF A TYPICAL 2 CAVITY CONNECTOR

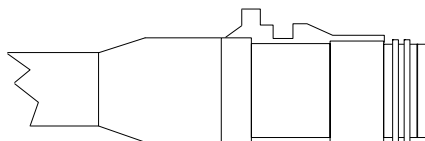


FIGURE B3 - TYPICAL FINISHED ASSEMBLY

1. Install sealing plug in un-used cavity of connector if it is a 3 pin (not required for 2 pin) type.
2. Remove cable outer jacket approximately 40-100 mm.
3. Strip insulation from wires  $7 \text{ mm} \pm 0.8 \text{ mm}$ .
4. Crimp a terminal on each wire per manufacturer's recommendation.
5. Slide adhesive-lined heat-shrinkable tubing onto the cable.
6. Install terminals into connector body per manufacturer's instructions. Isopropyl alcohol may be used to aid in assembly.
7. To maintain cable twisting, install the adhesive-lined heat-shrinkable tubing over the assembly and apply per manufacturer's recommendation. Cable twisting must begin at least 50 mm from the connector terminals. The maximum distance between the wires, over the untwisted length, is 3 mm.
8. If required, install wedge in front of connector body per manufacturer's instructions.

## APPENDIX C - RECOMMENDED CABLE SPLICE PROCEDURE

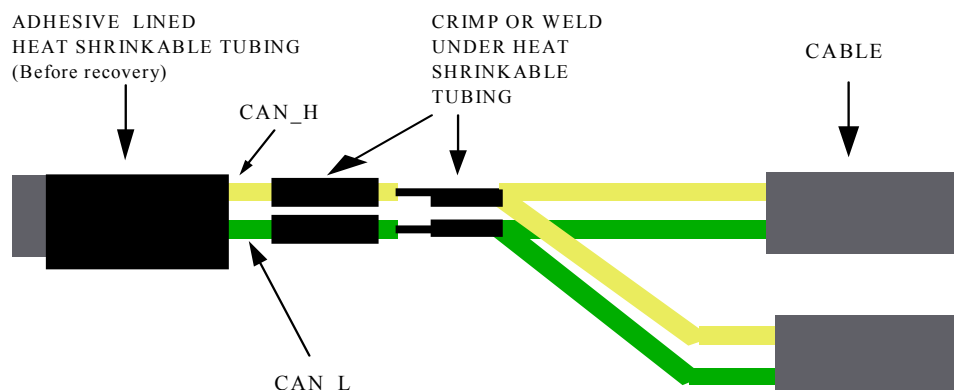


FIGURE C1 - CABLE SPLICE

1. Cut the end of the cable cleanly. Measure back approximately 40-100 mm and mark the cable jacket. Remove this section of cable jacket.
2. Remove  $7 \text{ mm} \pm 0.8 \text{ mm}$  of insulation on the data wire CAN-H.
3. Measure back approximately 21 mm on data wire CAN-L and cut it. Remove  $7 \text{ mm} \pm 0.8 \text{ mm}$  of insulation on this wire.
4. Repeat steps 1 through 3 for the other two cables that will be spliced, but Replace CAN-H with CAN-L in step 2, and Replace CAN-L with CAN-H in step 3. (The overall length of the assembly is minimized by offsetting the crimps or welds)
5. Slide the two pieces of insulating heat-shrinkable tubing over the CAN-H and CAN-L data wires.
6. Slide the one piece of adhesive-lined heat-shrinkable tubing onto the cable.
7. Crimp, or weld, the three CAN-H data wires together, and the three CAN-L data wires together.
8. Solder the connections if desired.
9. Center the insulating heat-shrinkable tubing over the two crimped or welded data wires.
10. Center the adhesive-lined heat-shrinkable tubing over the assembly and apply per manufacturer's recommendation.



FIGURE C2 - SEALED CABLE SPLICE-FINISHED ASSEMBLY



## APPENDIX D - RECOMMENDED CABLE REPAIR PROCEDURE

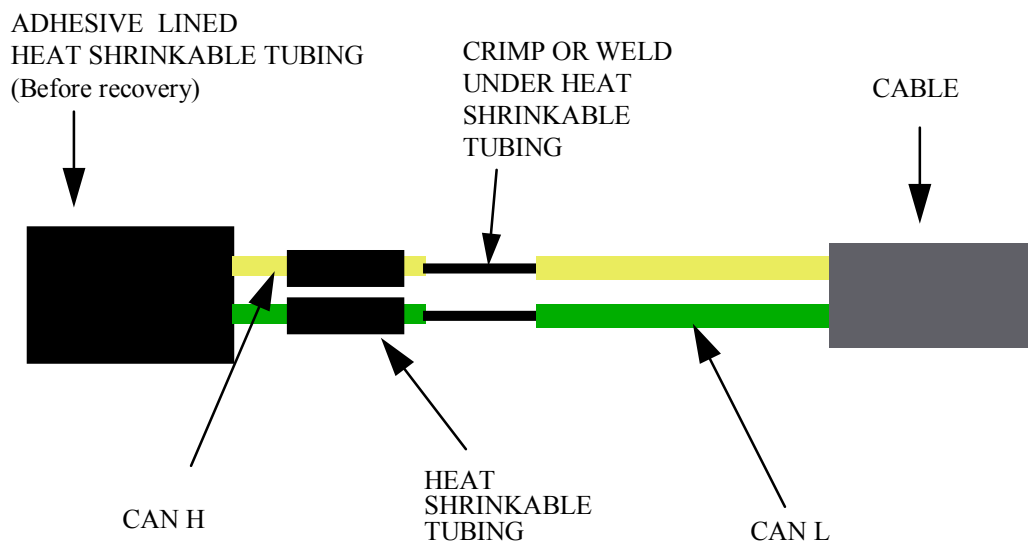


FIGURE D1 - CABLE SPLICE

- A. Cut the end of the cables cleanly. Measure back approximately 40-100 mm and mark the cable jacket. Remove this section of cable jacket.
- B. Strip the insulation of both data wires back  $7 \text{ mm} \pm 0.8 \text{ mm}$ .
- C. Repeat this procedure for the other cable.
- D. Install one end of a crimp on each of the data wires, on either cable. (The overall length of the assembly is minimized by offsetting the crimps or welds)
- E. Slide the (2) pieces of insulating heat-shrinkable tubing over the crimps and onto the data wires.
- F. Slide the (1) piece of adhesive-lined heat-shrinkable tubing onto the cable.
- G. Insert the wires from the other cable into the appropriate crimp and install the crimp, maintaining polarity (CAN-H, CAN-L).
- H. Center the insulating heat-shrinkable tubing over the two crimps and install the tubing per the manufacturer's recommendation.
- I. Center the adhesive-lined heat-shrinkable tubing over the assembly and apply per manufacturer's recommendation.



FIGURE D2 - CABLE SPLICE-FINISHED ASSEMBLY

## APPENDIX E - COMPARISON OF THE J1939-15 VERSUS THE J1939-11 PHYSICAL LAYER

TABLE E1 - COMPARISON J1939-15 VS J1939-11

Parameter	Network	Min	Max	Units	Conditions	Same as J1939-11 or Different
Bus Length	J1939-15	0	40	m	Backbone cable length between the two Load Resistors ( $R_L$ )	Same
	J1939-11	0	40	m		
Cable Stub Length	J1939-15	0	3	m		Different
	J1939-11	0	1	m		
Node Distance	J1939-15	0.1	40	m		Same
	J1939-11	0.1	40	m		
Minimum Distance from $R_L$	J1939-15	0		m		Same
	J1939-11	0		m		
Number of Nodes	J1939-15		10			Different
	J1939-11		30			
Physical Media	J1939-15				Jacketed Un-shielded Twisted Pair (UTP) Jacketed Shielded Twisted Pair (STP)	Different
	J1939-11					
Network Connections	J1939-15				Connector must meet requirements in 5.3, 5.3.1, and 5.3.2 Required 3-pin connector concept when used	Different
	J1939-11					
ECU Physical Layer Circuit	J1939-15 J1939-11					Same
ECU CAN_SHLD Terminal	J1939-15 J1939-11				Not connected to network Connected to network drain wire	Different
Signal Rise/Fall Time	J1939-15				200-500 ns Required (if adjustable) 200-500 ns Recommended	Different
	J1939-11					

## APPENDIX F - J1939-11 COMPLIANT TOOLS AND ECUS USED WITH THE J1939-15 NETWORK

A mixed physical layer can occur when either a J1939-11 compliant diagnostic tool or a J1939-11 compliant ECU (with pigtail cable) is connected to the J1939-15 network. The following figures show the recommended mixed physical layer configurations. Figure F1 shows a typical mixed physical layer configuration of a J1939-11 compliant diagnostic tool connected to the J1939-15 network. Figure F2 shows a typical mixed physical layer configuration of a J1939-11 compliant ECU (using a J1939-11 pigtail and 3-pin connector) connected to the J1939-15 network. The J1939-11 part of the connection will contain a CAN\_SHLD terminal and drain wire, but the J1939-15 mating part of the network will not contain a CAN\_SHLD terminal or drain wire.

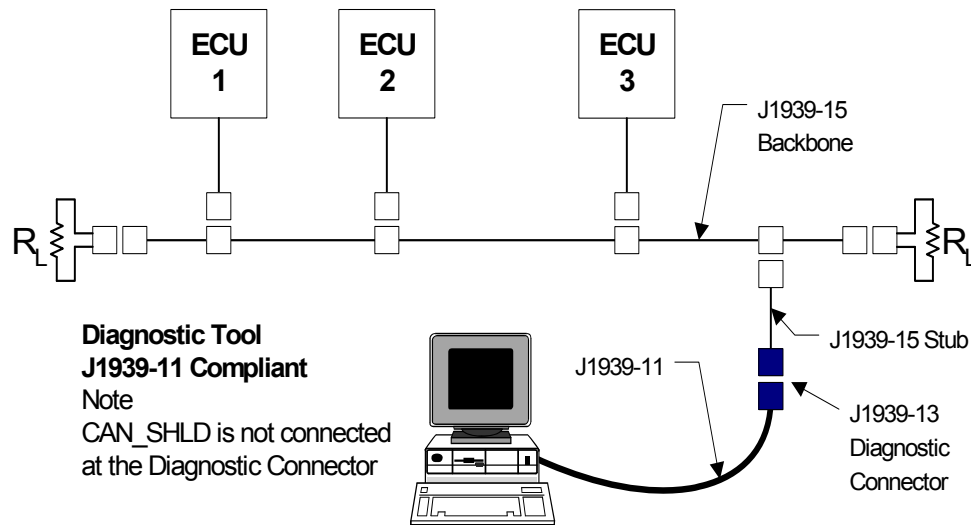


FIGURE F1 - J1939-11 TOOL CONNECTED TO THE J1939-15 NETWORK

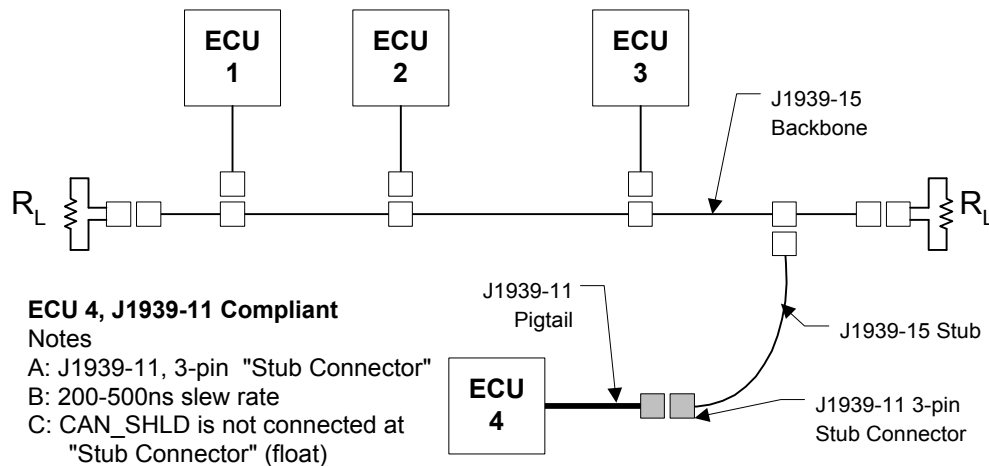


FIGURE F2 - ECU (USING J1939-11 PIGTAIL AND 3-PIN CONNECTOR) CONNECTED TO THE J1939-15 NETWORK