RATIONALE

This SAE standard is being revised to incorporate technical revisions and clarifications.

The title of this Standard is being changed from the original "*70 MPa Compressed Hydrogen Surface Vehicle Fuelling Connection Device and Optional Vehicle to Station Communicationss*" to the more appropriate title "*Hydrogen Surface Vehicle to Station Communications Hardware and Software*" for reasons explained in the following paragraphs.

The original Section 4, "70MPa fueling connection device", has been deleted from this standard and all material regarding the 70MPa fueling device (receptacle geometry specifications, verification testing, tooling fixture dimensions and marking requirements) has been incorporated into SAE J2600, *Standard for Compressed Hydrogen Surface Vehicle Fueling Connection Devices.* The rationale for moving this material was to aggregate the hardware specifications and validation requirements for all pressure classes of hydrogen fueling devices into one document.

The original Section 5 (now 6), "Vehicle to Station Communications Device," presents communications hardware requirements as well as the software and design verification test criteria. This section has been revised to reflect field experiences gained since early implementation of these communications protocols and hardware devices. Validation of dispenser side communications is to be defined by other standards, such as HGV 4.3.

The physical and functional requirements are unchanged but some of the figures and tables in the standard have been improved. The original communications protocol from the TIR J2799 is being updated in this version V.1.1 mainly to increase the amount of OD characters (for use as per SAE J2601) and remove unused characters.

TABLE OF CONTENTS

1.   SCOPE

This standard specifies the communications hardware and software requirements for fueling Hydrogen Surface Vehicles (HSV), such as fuel cell vehicles, but may also be used where appropriate, with heavy duty vehicles (e.g., busses) and industrial trucks (e.g., forklifts) with compressed hydrogen storage. It contains a description of the communications hardware and communications protocol that may be used to refuel the HSV. The intent of this standard is to enable harmonized development and implementation of the hydrogen fueling interfaces.

This standard is intended to be used in conjunction with the hydrogen fueling protocol, SAE J2601, Compressed Hydrogen Light Duty Vehicle Fueling Protocol and SAE J2600, Compressed Hydrogen Surface Vehicle Fueling Connection Devices.

1.1   Gaseous Hydrogen Fueling System Background

The overall hydrogen fueling system consists of a dispenser, HSV, and hydrogen fueling coupling. The nozzle and receptacle mechanically couples the hydrogen fueling system (dispenser) and the HSV, and allows hydrogen gas to flow between them. The interface between the two is defined as the fueling interface. The data is transmitted from the IR Transmitter on the HSV to the IR Receiver on the dispenser. See Figure 1.
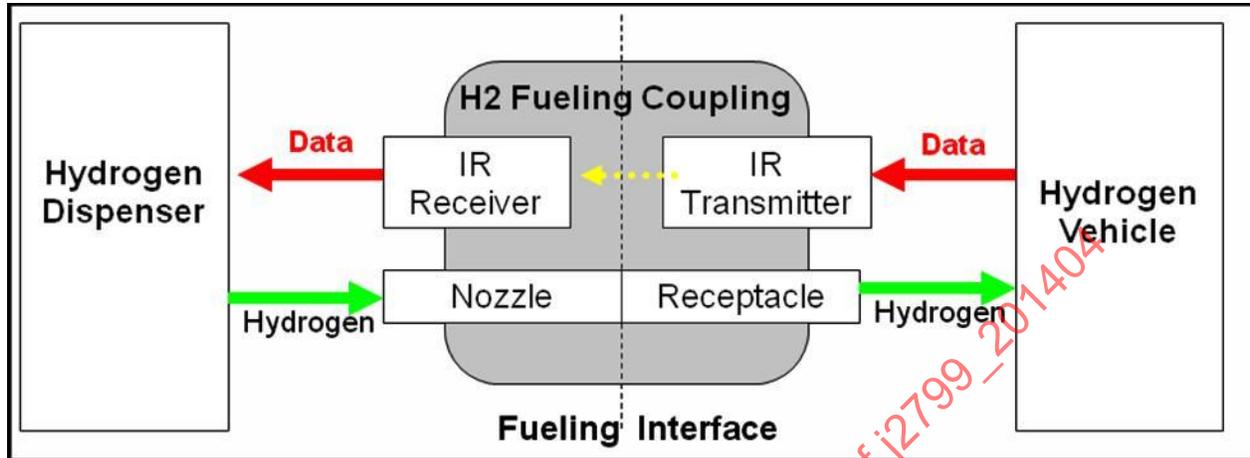
FIGURE 1 - OVERALL GASEOUS HYDROGEN FUELING SYSTEM

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   IrDA Publications

IrDA IrPHY 1.4   IrDA Serial Infrared Physical Layer Specification

IrDA IrLAP 1.1   Serial Infrared Link Access Protocol

IrDA   Physical Layer Measurement Guidelines V1.1, 8 Sept 2000

2.1.2   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.

The following publications are for information purposes only and are not a required part of this standard.

J2574	Information Report - Fuel Cell Vehicle Terminology
J2578	Recommended Practice for General Fuel Cell Vehicle Safety
J2579	Standard for Hydrogen Storage Safety
J2600	Standard- Compressed Hydrogen Surface Vehicle Fueling Connection Devices
J2601	Fueling Protocols for Light Duty Gaseous Hydrogen Surface Vehicles
J2601-2	Fueling Protocols for Heavy Duty Gaseous Hydrogen Surface Vehicles
J2601-3	Fueling Protocols for Heavy Duty Gaseous Industrial Trucks
J2760	Information Report – Pressure Terminology Used in fuel Cells and Other Hydrogen Vehicle Applications
AS568	Size Standard for O-Rings

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

2.1.3   SAE Technical Papers

SAE Paper 2014-01-1833 - "Validation and Sensitivity Studies of SAE J2601, the Light Duty Vehicle Fueling Standard", Schneider, J., Meadows, G. Mathison, S., Greisel, M., Veenstra, M., Wistoft-Ibsen, M.. et al.

2.1.4   WE-NET Publications

WE-NET Task 7A-13, "Communication Between Vehicle Onboard Tanks and a Hydrogen Fueling System", 2002, Lynch, F, HCI

3.   DEFINITIONS

3.1   AMBIENT TEMPERATURE

The ground-level temperature of the air measured at the hydrogen fueling station dispenser, not in direct sunlight.

3.2   CHSS AVERAGE VEHICLE GAS TEMPERATURE (Tvehicle)

The average temperature of the hydrogen gas in the vehicle CHSS.

NOTE: If the vehicle contains a temperature measurement device for the purpose of sending a temperature signal to the dispenser during fueling, this temperature is also assumed to be the (nominal) average temperature of the gas in the vehicle. Due to accuracy and sensor reliability concerns, the vehicle manufacturer should consider the tolerances of the temperature measurement and include them as criteria for the abort signal.

3.3   MEASURED TEMPERATURE

The measured temperature of the gas in the vehicle CHSS.

3.4

3.5   COMPRESSED HYDROGEN STORAGE SYSTEM (CHSS)

As defined in SAE J2579, the Compressed Hydrogen Storage System consists of the pressurized containment vessel(s), Pressure Relief Devices (PRDs), shut off devices(s), and all components, fittings and fuel lines between the containment vessel(s) and these shut off device(s) that isolate the stored hydrogen from the remainder of the fuel system and the environment.

3.6   COMPRESSED HYDROGEN STORAGE SYSTEM (CHSS) CAPACITY

The total amount of gas stored in the CHSS by weight when it is at its nominal working pressure at 15C which is equivalent to the CHSS 100% state of charge.

3.7   COUPLING or CONNECTION

A joined assembly of a nozzle and receptacle which permits rapid coupling (or connecting) and decoupling (or disconnecting) of fuel supply hose to the vehicle fuel system, as per SAE J2600.

3.8   NOZZLE

Device connected to a fuel dispensing system which engages the HSV receptacle and permits transfer of fuel. See Coupling.

3.9   RECEPTACLE

Device connected to a vehicle or storage system that receives the dispenser nozzle and permits transfer of fuel. This may also be referred to as a fueling inlet.

3.10   DATA COMMUNICATIONS LINK

The data communications portion of the connector consists of an infrared emitter that is mounted in the HSV in close proximity to the receptacle and infrared receivers that are located in the nozzle. These devices allow the HSV to send data to the fuel dispensing system. Figure 2 illustrates the emitter and receiver placement.
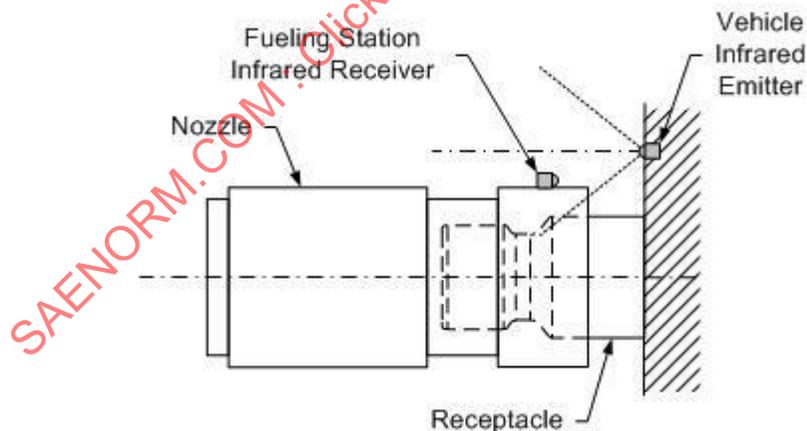

FIGURE 2 - CONNECTOR WITH INFRARED COMMUNICATIONS LINK

3.11   DESIGN VERFICATION TEST

A method of testing a product to assure that it meets all of its design specifications

3.12   HYDROGEN DISPENSING SYSTEM (DISPENSER)

The equipment required to condition and transfer fuel from the station to vehicle storage for the purpose of fueling the vehicle.

3.13 HYDROGEN SURFACE VEHICLE (HSV)

Land Surface Vehicle using hydrogen storage as a fuel for propulsion. An example of HSV is a Fuel Cell Vehicle (FCV).

3.14 SIL/ASIL REFERENCES

The following are some of the guidelines that may be used to qualify components and systems for the station side SIL: IEC 61508 / 61511 and for vehicle side ASIL ISO 26262.

3.15 TYPES OF FUELING PROTOCOLS

Fueling Protocols are definined in J2601. A general description of fueling protocols is below.

3.16 COMMUNICATIONS FUELING

"Communications," when used in combination with a fueling procedure or fueling type, means that a valid data connection has been established from vehicle to fueling station dispenser as described in SAE J2799.

3.17 NON-COMMUNICATIONS FUELING:

"Non-Communications," when used in combination with a fueling procedure or fueling type, means that no valid data connection from vehicle to fueling station dispenser as per SAE J2799 exists, or that the received data has not been recognized as valid by the dispenser.

4. COMPRESSED HYDROGEN SURFACE VEHICLE TO STATION COMMUNICATIONS DEVICE

4.1 PHYSICAL AND FUNCTIONAL REQUIREMENTS

4.1.1 Physical Layer Protocol Specification

The infrared data link uses an optical interface based on the 38400-baud interface specified by IrDA physical layer specification, IrDA IrPHY 1.4. The physical layer implements only a portion of the IrPHY specification and it is not meant to be compatible with standard IrDA devices.

4.1.1.1 Modulation SCHEME

The modulation scheme defined below is described in section 2.3 of IrPHY 1.4. A Return-To-Zero-Inverted (RZI) modulation scheme is used where a "0" is represented by a light pulse and a "1" is represented by no light pulse. The optical pulse duration is nominally 3/16 of the bit duration. The maximum pulse duration is 3/16 of the bit duration, plus a tolerance of 0.60 microseconds.

4.1.1.2 Byte Framing

The signal is organized into IR frames, as shown in Figure 4, that have a direct correlation to UART frames as described in section B.3 of IrPHY 1.4. Each byte is transmitted asynchronously with a start bit, 8 data bits, and a stop bit. Data bits are transmitted in serial byte order, with the least significant bit (LSB) transmitted first and the most significant bit (MSB) transmitted last. Bits are transmitted at a rate of 38400 bits per second.
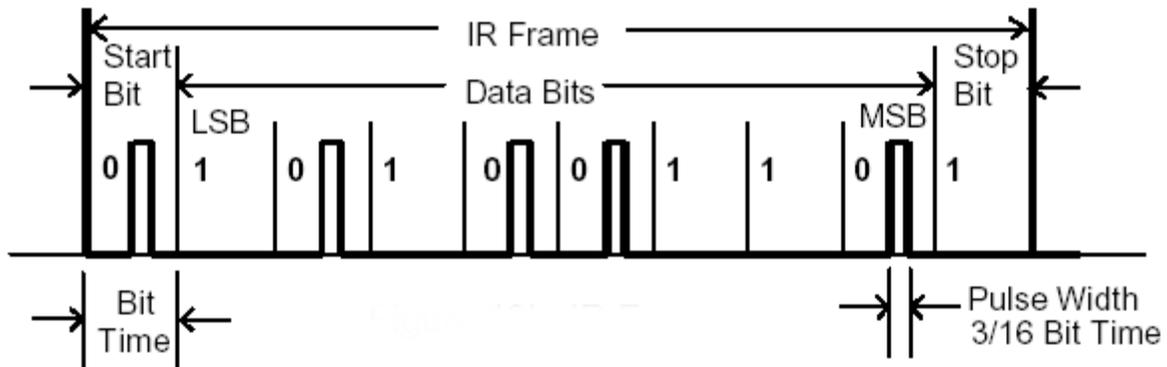
FIGURE 4 - IR FRAME.

4.1.2   Data Link Layer Protocol Specification

The purpose of the data link layer is to ensure valid application data is transferred from the transmitting side to the receiving side of the data link. The data link defined below is based on the low speed asynchronous data link specified by IrDA IrLAP 1.1. The data link implements only a portion of the IrDA specification and it is not meant to be compatible with standard IrDA devices.

4.1.2.1 Data Link Control Characters

The following control characters are used for the data link framing as described in section 10.1 of IrLAP 1.1.

- XBOF – Extra Begin of Frame character shall be 0xFF hexadecimal.
- BOF - Beginning of Frame character shall be 0xC0 hexadecimal.
- EOF – End of Frame character shall be 0xC1 hexadecimal.
- CE – Control Escape character shall be 0x7D hexadecimal (see appendix A1.1).

4.1.2.2 Frame Check Sequence (FCS) Field

The frame check sequence field detects errors in the received frame as described in section 10.1.2 of IrLAP 1.1. The FCS field shall be a 16-bit CRC-CCITT cyclic redundancy check computed on the bytes in the application data. The polynomial for the CRC shall be $X16 + X12 + X5 + 1$. The FCS is transmitted with the least significant byte first followed by the most significant byte.

An implementation of the CRC-CCITT FCS algorithm for calculating the CRC has been provided in the FAST FRAME CHECK SEQUENCE (FCS) Implementation section of the appendix.

4.1.2.3 Data Link Frame

The application data packets are transmitted in data link frames as described in section 10 of IrLAP 1.1. The application data packets shall be transmitted in data link frames. Five XBOF characters shall precede the data link frame transmission. A single BOF character shall be transmitted at the start of the data link frame. The application data packet shall be transmitted immediately following the BOF character. A frame check sequence field shall be transmitted immediately following the application data packet. The data link frame shall be terminated with an EOF character as shown in Table 1.

TABLE 1 - DATA LINK FRAMING

XBOFs	BOF	Application Data	FCS	EOF

4.1.2.4 Transparency

A transparency character is defined to transform application data bytes (and FCS field bytes) which correspond to data link control characters as described in section 10.1.3 of IrLAP 1.1. The transmitting side of the data link shall transform any data bytes, or FCS bytes, corresponding to control characters XBOF, BOF, EOF or CE into non-control characters prior to transmitting the data link frame.

The transformation method on the transmitting side shall be:

a. Insert a control escape (CE) byte preceding the data byte.

b. Exclusive OR the data byte with 0x20 hexadecimal.

The receiving side shall reverse the transformation whenever a CE byte is received in the data stream.

See Appendix B.2 for an IrDA Frame example with the maximum transparency characters possible.

The receiving side shall reverse the transformation using the following method:

a. Discard the control escape (CE) byte.

b. Exclusive OR the data byte with 0x20 hexadecimal.

The state machine shown in Figure 5, is an example of what must be implemented by the receiver to properly decode received characters as described in section 10.1.3 and 10.1.5 of IrLAP 1.1.

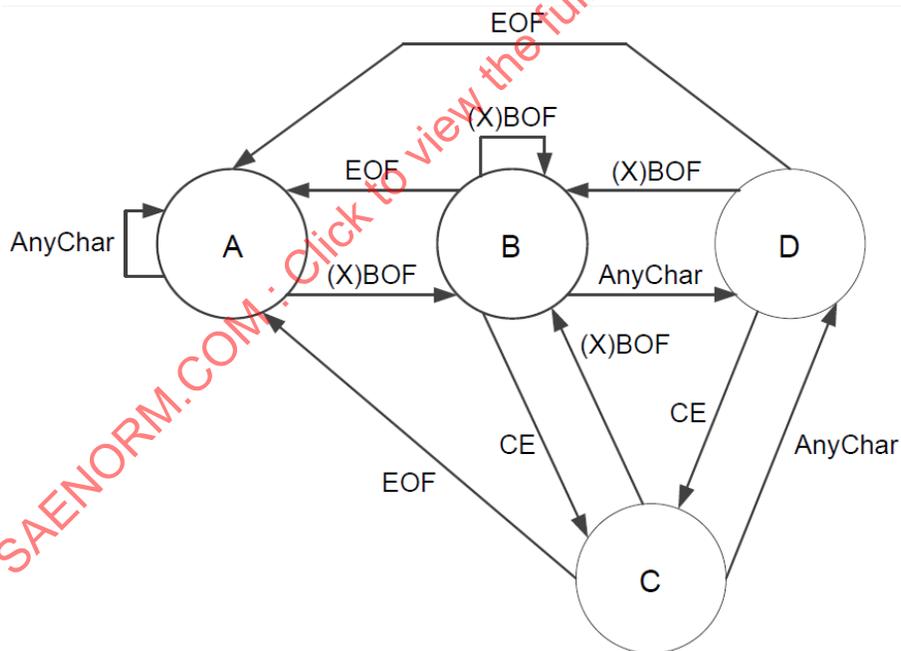FIGURE 5 - RECEIVER TRANSPARENCY STATE MACHINE

All bytes received are discarded in state A until a BOF (or XBOF) is received. All bytes received on the AnyChar events (which cause a transition from state B to state D, or from state C to state D) are inserted into the receive data packet. A complete data packet has been decoded on the EOF event (which causes a transition from state D to state A).

4.1.3   Presentation Layer Protocol Specification

The dispenser shall attempt to support the standard-communications fueling process, as defined in SAE J2601 for which it has received all the required data that meet the required data integrity checks.

4.1.3.1 Data Integrity Checks

4.1.3.1.1   Data Type

All data shall be transmitted in ASCII format.

4.1.3.1.2   Proper Delimiter Check

A single pipe character ("|" ASCII, $7C hexadecimal) shall be used to delimit all pieces of data. All valid data shall be contained between two pipe characters, as shown in Table 2.

TABLE 2 - DELIMITER PERMUTATIONS AND INTERPRETATIONS

|MP=010.0|VN=02.99|	Proper format, both valid
MP=010.0|VN=02.99|	MP not valid due to no leading delimiter
|MP=010.0|VN=02.99	VN not valid due to no trailing delimiter
|MP=010.0||VN=02.99|	All data valid, redundant delimiter is not required

4.1.3.1.3   Proper Tag Check

The first two characters after the data delimiter shall contain a defined data tag. All tags comparisons shall be case sensitive. The third character after the delimiter shall be the "=" character (hexadecimal $3D). Any deviations from this format shall result in all data between the delimiters being discarded.

4.1.3.1.4   Properly Defined Value Check for Required Character Data

All character data for a required data field shall be an exact match for a defined value. All defined data comparisons shall be case sensitive. Extra spaces or characters shall invalidate the data.

4.1.3.1.5   Properly Defined Value Check for Required Numerical Data

All defined numerical data positions shall be fueled using leading and following zeros as required to fueled the defined format. Extra spaces or characters shall invalidate the data. All defined numerical data shall be greater than or equal to the minimum defined value and less than or equal to the maximum defined value, as shown in Table 3.

TABLE 3 - VALUE CHECK PERMUTATIONS AND INTERPRETATIONS

|MP=035.0|	Proper format
|MP=35.0|	Not valid due to lack of leading zero
|MP=035|	Not valid due to lack of decimal point and trailing zero
|MP= 035.0|	Not valid due to extra space before numerical data.
|MP=3.5E1|	Not valid, scientific notation not supported
|MP=035.0|	Proper range
|MP=100.1|	Not valid, data outside of defined data range (000.0 – 100.0)

4.1.3.2 Data Interval Check

All required data fields for a given fueling process shall be updated with properly formatted message data within 5 times the nominal transmission interval (5 x 100ms) to be considered valid, except for the OD data field, where the data interval requirement is to be 10 x 100ms. All required data fields for a given fueling process shall be updated with properly formatted message data within 5 times the nominal transmission interval (5 x 100ms) to be considered valid, except for the OD data field, where the data interval requirement is to be 10 x 100ms. If none of the message meets this requirement within 5x 100ms, the communications shall be considered lost.

The only other exception to this requirement is that dispenser shall respond to any properly formatted abort command (FC=Abort) from the vehicle regardless of whether the data has been received within its nominal transmission interval.

4.1.3.2.1   Communications Interval Tolerence

The signal interval tolerance shall be within ± 20% of interval time.

4.2   Communications Hardware for Gaseous Fueling

4.2.1   Vehicle Transmitter Requirements

4.2.1.1 The vehicle shall have at least 1 infrared transmitter as shown in Figure 7.

4.2.1.2 The sum of the infrared transmitter(s) on the vehicle shall have an effective half angle of a=55°, see Figure 9.

4.2.1.3 The center of the transmitter element(s) shall be located on the mounting surface at a radius of $rv=22 \pm 4$ millimeters from the axis of the receptacle, see Figure 7.

4.2.1.4 The external chassis of the vehicle transmitter(s) facing the receiver shall be at least $dv,min=0$ millimeters from reference plane z=0 which is 50 millimeters from the plane defined by the leading edge of the receptacle, see Figure 9.

4.2.1.5 The external chassis of the vehicle transmitter(s) facing the reciever shall be at most $dv,max=20$ millimeters from reference plane z=0 which is 50 millimeters from the plane defined by the leading edge of the receptacle, see Figure 9.

4.2.1.6 The minimum intensity of the vehicle infrared emitter shall be 40 mW/sr within the range of the half angle. The maximum intensity of the vehicle infrared emitter shall be 100 mW/sr within the range of the half angle.

4.2.2   Nozzle Receiver Requirements

4.2.2.1 The nozzle shall have at least 3 infrared receivers. The infrared receivers on the nozzle shall have a minimum half angle of b=55°, see Figure 9.

4.2.2.2 The angle between adjacent nozzle infrared receivers shall be no more than c=120°, see Figure 8.

4.2.2.3 The nozzle receiver elements shall be located $rn=22 \pm 4$ millimeters from the axis of the nozzle, see Figure 8.

4.2.2.4 When the nozzle is fully engaged with the receptacle, the external chassis of the receivers on the nozzle facing the transmitter shall be at least $dn,min=15$ millimeters from the reference plane z=0, see Figure 9.

4.2.2.5 When the nozzle is fully engaged with the receptacle, the external chassis of the receivers on the nozzle facing the transmitter shall be no more than $dn,max=35$ millimeters from the reference plane z=0, see Figure 9.

4.2.2.6 For the above specified geometry the minimum irradiance that the nozzle receiver will be required to detect will be 100 µW/cm2 and the maximum irradiance that the nozzle receiver will be required to detect will be 50 mW/cm2.

4.3   Communications Definition Version 01.00

4.3.1   Gaseous Fueling Communications

4.3.1.1 Data Definitions

4.3.1.2 Protocol Identifier

Tag: ID=
Units: Not Applicable
Range: SAE J2799
Example: |ID=SAE ⌴ J2799|
Interval: 100 ms
Direction: Vehicle to Dispenser

The vehicle shall transmit the protocol identifier to the dispenser to aid in the decoding of the transmitted data. For this revision of this standard the ID shall be "SAE J2799". The "⌴"symbol is to denote a space and used after SAE in the identifier.

4.3.1.3 Data Communications Software Version Number

Tag: VN=
Units: Not Applicable
Format: ##.##
Range: 00.00 – 99.99
Example: |VN=01.00|
Interval: 100 ms
Direction: Vehicle to Dispenser

The vehicle shall transmit its version number to the dispenser to aid in the decoding of the transmitted data. The major revision shall be defined as the whole number portion of the version number. The minor revision shall be defined as the decimal portion of the version number. Example: For version number 10.02, the major revision is 10 and the minor revision is 02.

For this version of the communications definition, VN = 1.00

4.3.1.4 Tank Volume

Tag: TV=
Units: Liters
Format: ####.#
Range: 0000.0 – 5000.0
Example: |TV=0200.0|
Interval: 100 ms
Direction: Vehicle to Dispenser

The vehicle shall transmit the storage volume of the hydrogen tank in liters at the nominal working pressure to the dispenser.

4.3.1.5 Receptacle Type

Tag: RT=
Units: Not Applicable
Range: H25, H35, H50, H70 (As defined by the SAEJ2600 standard)
Example: |RT=H70|
Interval: 100 ms
Direction: Vehicle to Dispenser

The vehicle shall transmit the SAE J2600 pressure class for the vehicle's original fuel receptacle that shall correspond to the CHSS NWP.

4.3.1.6 Fueling Command

Tag: FC=
Units: Not Applicable
Range (VN=01.00):Dyna, Stat, Halt, Abort
Example: |FC=Dyna|
Interval: 100 ms
Direction: Vehicle to Dispenser

The vehicle shall transmit the fueling command signal to inform the dispenser on how to handle the fuel flow. All stations which are compliant with J2799 shall use the following commands:

- FC=Dyna - The dispenser shall dispense fuel based upon the procedures defined in the appropriate fueling protocol in SAE J2601.
- FC=Stat—The dispenser shall dispense fuel based upon the procedures defined in the appropriate fueling protocol in SAE J2601
- FC=Halt– The dispenser shall pause the fueling process, using the procedures defined in the appropriate fueling protocol in SAE J2601.
- FC=Abort – The dispenser shall terminate the fueling process and shall not dispense fuel until the dispenser fueling process is restarted by the operator.

4.3.1.7 Measured Pressure

Tag: MP=
Units: MPa
Format: ###.#
Range: 000.0 – 100.0
Example: |MP=043.7|
Interval: 100 ms
Direction: Vehicle to Dispenser

The vehicle shall transmit the measured pressure of hydrogen gas in the vehicle's storage tank in MPa.

4.3.1.8 Measured Temperature

Tag: MT=
Units: Kelvin
Format: ###.#
Range: 16.0 – 425.0
Example: |MT=353.0|
Interval: 100 ms
Direction: Vehicle to Dispenser

The vehicle shall transmit the measured gas temperature of the hydrogen gas in the vehicle's storage tank in Kelvin.

4.3.1.9 Optional Data

Tag: OD=
Units: None
Range: Any 0 to 16 Characters not including "|"
Example: |OD=Parameter(s)|
Interval: 100 ms minimum
Direction: Vehicle to Dispenser

The vehicle may transmit this optional data set to the dispenser. The data shall contain any character except the delimiter character ("|" ASCII, $7C hexadecimal). The optional data should not be viewed as an open configurable signal without a secondary identification of the vehicle (to avoid misinterpetation of multiple signal signal definitions). Refer to SAE J2601 for the OD format.

4.4   Communications Definition (Version 01.10)

4.4.1   Gaseous Fueling Communications

4.4.1.1 Data Definitions

4.4.1.2 Protocol Identifier

Tag: ID=
Units: Not Applicable
Range: SAE J2799
Example: |ID=SAE ⌣ J2799|
Interval: 100 ms
Direction: Vehicle to Dispenser

The vehicle shall transmit the protocol identifier to the dispenser to aid in the decoding of the transmitted data. For this revision of this standard the ID shall be "SAE J2799". The "⌣"symbol is to denote a space and used after SAE in the identifier.

4.4.1.3 Data Communications Software Version Number

Tag: VN=
Units: Not Applicable
Format: ##.##
Range: 00.00 – 99.99
Example: |VN=01.10|
Interval: 100 ms
Direction: Vehicle to Dispenser

The vehicle shall transmit its version number to the dispenser to aid in the decoding of the transmitted data. The major revision shall be defined as the whole number portion of the version number. The minor revision shall be defined as the decimal portion of the version number. Example: For version number 10.02, the major revision is 10 and the minor revision is 02.

For this version of the communications definition, VN = 1.10

4.4.1.4 Tank Volume

Tag: TV=
Units: Liters
Format: ####.#
Range: 0000.0 – 5000.0
Example: |TV=0200.0|
Interval: 100 ms
Direction: Vehicle to Dispenser

The vehicle shall transmit the storage volume of the hydrogen tank in liters at the nominal working pressure to the dispenser.

4.4.1.5 Receptacle Type

Tag: RT=
Units: Not Applicable
Range: H25, H35, H50, H70 (As defined by the SAEJ2600 standard)
Example: |RT=H70|
Interval: 100 ms
Direction: Vehicle to Dispenser

The vehicle shall transmit the receptacle code for the vehicle's original fuel receptacle that shall correspond to the rated pressure of the vehicle's fueling system.

4.4.1.6 Fueling Command

Tag: FC=
Units: Not Applicable
Range (VN=01.00): Dyna, Stat, Halt, Abort
Example: |FC=Dyna|
Interval: 100 ms
Direction: Vehicle to Dispenser

The vehicle shall transmit the fueling command signal to inform the dispenser on how to handle the fuel flow. All stations which are compliant with J2799 shall use the following commands:

- FC=Dyna - Dispenser shall dispense fuel based upon the procedures defined in the appropriate fueling protocol in SAE J2601.
- FC=Stat - The dispenser shall dispense fuel based upon the procedures defined in the appropriate fueling protocol in SAE J2601
- FC=Halt - The dispenser shall pause the fueling process, using the procedures defined in the appropriate fueling protocol in SAE J2601.
- FC=Abort - The dispenser shall terminate the fueling process and shall not dispense fuel until the dispenser fueling process is restarted by the operator.

4.4.1.7 Measured Pressure

Tag: MP=
Units: MPa
Format: ###.#
Range: 000.0 – 100.0
Example: |MP=043.7|
Interval: 100 ms
Direction: Vehicle to Dispenser

The vehicle shall transmit the measured pressure of hydrogen gas in the vehicle's storage tank in MPa.

4.4.1.8 Measured Temperature

Tag:	MT=
Units:	Kelvin
Format:	###.#
Range:	16.0 – 425.0
Example:	|MT=353.0|
Interval:	100 ms
Direction:	Vehicle to Dispenser

The vehicle shall transmit the measured gas temperature of the hydrogen gas in the vehicle's storage tank in Kelvin.

4.4.1.9 Optional Data

Tag:	OD=
Units:	None
Range:	Any 0 to 74 Characters not including "|"
Example:	|OD=Parameter(s)|
Interval:	100 ms minimum
Direction:	Vehicle to Dispenser

The vehicle may transmit this optional data set to the dispenser. The data shall contain any character except the delimiter character ("|" ASCII, $7C hexadecimal). The optional data should not be viewed as an open configurable signal without a secondary identification of the vehicle (to avoid misinterpetation of multiple signal signal definitions). Refer to SAE J2601 for the OD format.

4.5   Verification Tests

4.5.1   Verification Test, Verification of a Gaseous Hydrogen Communications System

4.5.1.1 Verification Test Setup

To qualify a J2799 communications device, whether vehicle or station side, it shall be independently tested using a Verification test setup. The Verification test setup shall consist of electronics capable of testing the full range of receiver/transmitter locations, powers, and sensitivities as specified in sections *5.1.3.1.1* and *5.1.3.1.2*. The Verification test setup shall have the transmitter and receiver positioned around a simulated receptacle, consisting of a shaft of stainless steel with a diameter of 30 mm. Simulated light sources intensities and distance are specified by IrDA Physical Layer Measurement Guidelines (refer to sections 2.1.5, 2.1.6 and 2.1.7). The simulated light sources shall be directed toward and be positioned within line of sight of the receivers. The apparatus shall be located in an environment with no ambient light. The Verification test setup shall be capable of including a 38% transmittance filter in the 850 to 900 nm IR range placed 2 ± 0.5 mm in front of the transmitter. The setup shall not allow any transmitted or reflected IR light to pass around the filter.
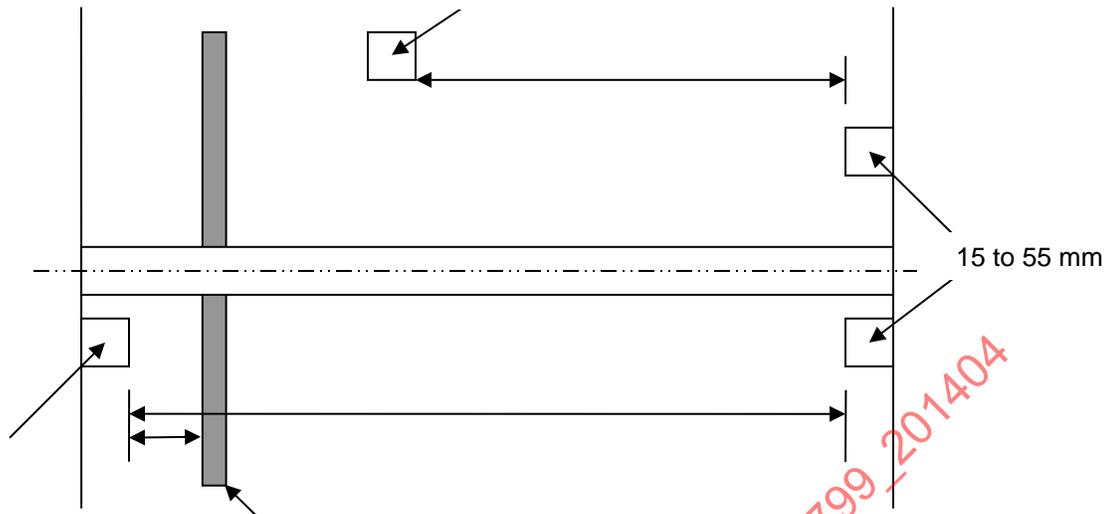
The test setup is shown in Figure 6.

15 to 55 mm

FIGURE 6 - VERIFICATION TEST SETUP

4.5.1.2 Test Scenario Definition

The scenarios listed in Table 5 shall be tested:

TABLE 5 - TEST SCENARIOS

Scenario	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
IR Filter	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	Y	Y	Y	Y
Simulated Sunlight	Y	N	N	Y	N	N	Y	N	N	Y	N	N	N	N	N	N
Simulated Florescent Light	N	Y	N	N	Y	N	N	Y	N	N	Y	N	N	N	N	N
Simulated Incandescent Light	N	N	Y	N	N	Y	N	N	Y	N	N	Y	N	N	N	N
Transmitter – Receiver Separation (mm)	55	55	55	55	55	55	15	15	15	15	15	15	55	55	15	15
Orientation (degrees)	30	30	30	30	30	30	0	0	0	0	0	0	30	30	30	30
Transmitter or receiver radial dimension (mm)	26	26	26	18	18	18	26	26	26	18	18	18	18	26	18	26

The orientation is determined by setting the 0 degree reference to be where the transmitter directly aligns with any receiver. Scenarios 1 to 6 test the low signal to noise condition; scenarios 7 to 12 test the highest received power scenarios; and scenarios 13 to 16 test a dark ambient light.

4.5.1.3 Transient Lighting Test

In addition to the above scenarios the transient effects of lighting shall be tested by repeating the poorest performing scenario in which a simulated light source is used. However, during transmission, the simulated light source is turned on for 10 ± 5 seconds and then off for 10 ± 5 seconds. This is repeated throughout the duration of the test.

4.5.1.4 Transmission Definition

For each scenario specified above the transmitting side shall send 65,536 messages, each containing 9 unsigned word length numbers (1,179,648 bytes total). The algorithm to generate the data to be transmitted is included as follows.

For Message_Number = 0 to 65535 step 1
For Word = 0 to 8 step 1
Data(2*Word) = Low_Byte(Message_Number)
Data(2*Word+1) = High_Byte(Message_Number)
Next
Call Transmit_Data
Next

Each message shall contain the pre- and post-signal data as required for communications synchronization. The messages shall not contain a data length filed, as the messages for this test are of fixed length. The messages shall not contain error-checking fields. The transmit controller shall maintain a message frequency of 10 Hz.

4.5.1.5 Test Criteria

When the transmission is complete the data will be checked bit-for-bit. The number of incorrect bits will be recorded to determine the Bit Error Ratio (BER) for the test as shown in Table 6.

TABLE 6 - BIT ERROR RATIO

Incorrect Bits	BER
0	< 1.060E-07
1	1.060E-07
10	1.060E-06
100	1.060E-05
1000	1.060E-04
N	N / (1179648 * 8)

The J2799 system tested shall pass each defined test with a BER of less than 10 e -4.
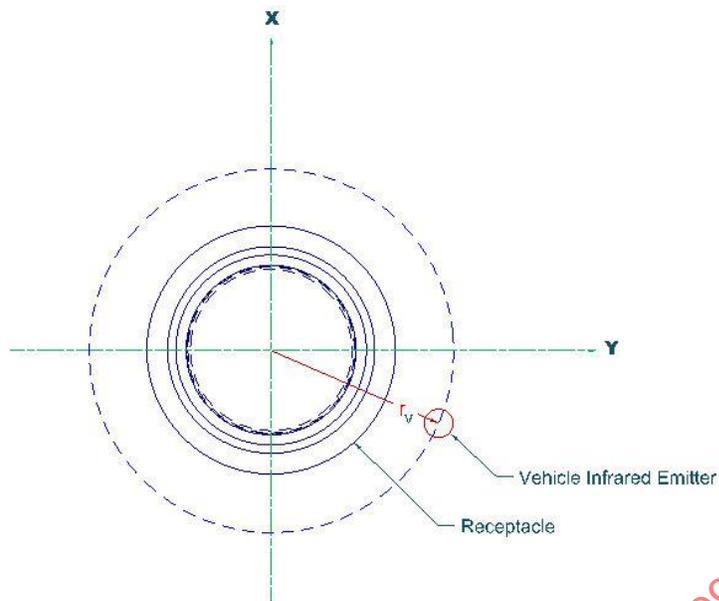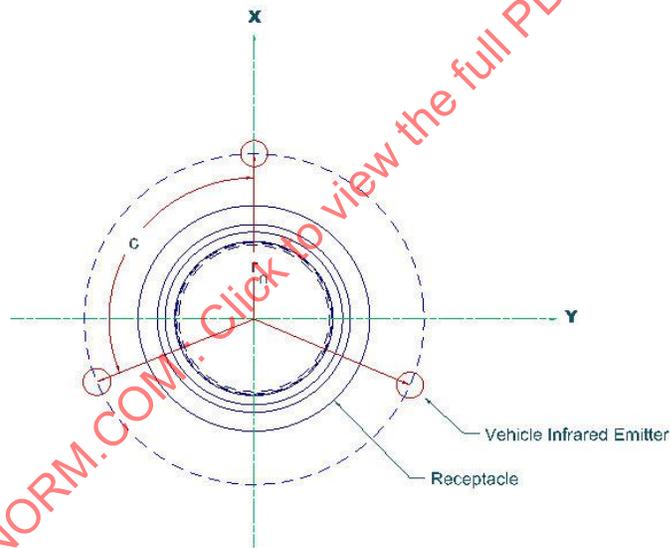
FIGURE 7 - VEHICLE TRANSMITTER (FRONT VIEW)

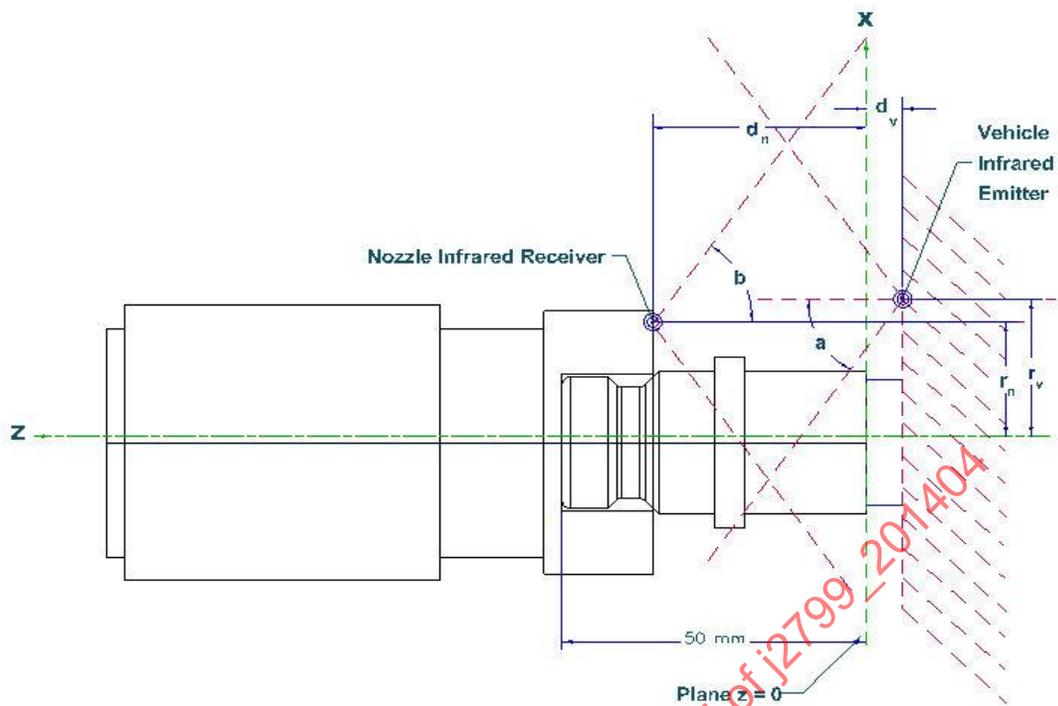FIGURE 8 - NOZZLE RECEIVER (FRONT VIEW)

FIGURE 9 - VEHICLE RECEPTACLE (SIDE VIEW)

4.6   Verification of a Gaseous Hydrogen Communications System in a Dispenser

CSA 4.3 or equivalent dispenser specification shall define additional testing to confirm that the station dispenser hardware may receive the signals as per SAE J2799.

4.6.1   Examples of Verifications Testing on Dispenser side for CSA 4.3

4.6.1.1 Demonstration of Fueling with Communications Data from both V.1.1 and V.1.0 communications versions

4.6.1.2 Response due to an incorrect CRC or incorrect of CRCs

4.6.1.3 Response to data which is delayed

4.6.1.4 Response to data which is out of order.

5. NOTES

5.1   Marginal Indicia

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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APPENDIX A - FAST FRAME CHECK SEQUENCE (FCS)

A.1 FAST FRAME CHECK SEQUENCE IMPLEMENTATION

The following reference implementation of the CRC-CCITT FCS algorithm is an example for the correct calulation method which also take care of the transparency character(s) (see also section 6.1.2.4).

In general the CRC calculation steps are:

  1. Use IrDA-Data-Block for calculation

  2. Invert data bytes before each xor operation

  3. reverse CRC result before Final XOR

  4. Finally check transparancy

A.1.1 FCS Computation Method

The following C code provides a CCITT-Tester for calculating the Frame Check Sequence
Parts of the program one example which may be used for online CCITT calculation at station side with the received IR-Data as well as a Table based method.

```
// -------------------------------------------------------------------------

// CCITT-Tester for SAE J2799 VN=01.00

// -------------------------------------------------------------------------



// includes:

#include "stdafx.h"

#include <string.h>

#include <stdio.h>

#include <conio.h>



// CRC parameters (default values are for CCITT 16 Bit):

const int order = 16;

const unsigned long polynom = 0x1021;

const int direct = 1;

const unsigned long crcinit = 0x0000;

const unsigned long crcxor = 0x00;
```

```c
const int refin = 1;

const int refout = 1;


// 'order' [1..32] is the CRC polynom order, counted without the leading '1' bit

// 'polynom' is the CRC polynom without leading '1' bit

// 'direct' [0,1] specifies the kind of algorithm: 1=direct, no augmented zero bits

// 'crcinit' is the initial CRC value belonging to that algorithm

// 'crcxor' is the final XOR value

// 'refin' [0,1] specifies if a data byte is reflected before processing (UART) or not

// 'refout' [0,1] specifies if the CRC will be reflected before XOR


// SAE J2799 msg control codes

#define XBOF_sym 0xFF // Extra Begin of Frame

#define BOF_sym 0xC0  // Begin of Frame

#define EOF_sym 0xC1 // End of Frame

#define CE_sym 0x7D   // Control Escape


// Data character string

// no transparency

unsigned char msgdata[] = "|ID=SAE␣J2799|VN=01.00|TV=0119.0|RT=H70|FC=Halt|MP=050.0|MT=273.0|";

// with transparency

unsigned char msgdata_2[] = "|ID=SAE␣J2799|VN=01.00|TV=0119.0|RT=H70|FC=Dyna|MP=025.1|MT=234.0|";


// internal global values:

unsigned long crcmask;

unsigned long crchighbit;

unsigned long crcinit_direct;

unsigned long crcinit_nondirect;

unsigned long crctab[256];
```

```
// subroutines

unsigned long reflect (unsigned long crc, int bitnum) {

// reflects the lower 'bitnum' bits of 'crc'

unsigned long i, j=1, crcout=0;

for (i=(unsigned long)1<<(bitnum-1); i; i>>=1) {

if (crc & i) crcout|=j;

j<<= 1;

}

return (crcout);

}


void generate_crc_table() {

// make CRC lookup table used by table algorithms

int i, j;

unsigned long bit, crc;

for (i=0; i<256; i++) {

crc=(unsigned long)i;

if (refin) crc=reflect(crc, 8);

crc<<= order-8;

for (j=0; j<8; j++) {

bit = crc & crchighbit;

crc<<= 1;

if (bit) crc^= polynom;

}


if (refin) crc = reflect(crc, order);

crc&= crcmask;

crctab[i]= crc;

}

}
```

```
unsigned long crctablefast (unsigned char* p, unsigned long len) {

// fast lookup table algorithm without augmented zero bytes, e.g., used in pkzip.

// only usable with polynom orders of 8, 16, 24 or 32.

unsigned long crc = crcinit_direct;

if (refin) crc = reflect(crc, order);

if (!refin) while (len--) crc = (crc << 8) ^ crctab[ ((crc >> (order-8)) & 0xff) ^ *p++];

else while (len--) crc = (crc >> 8) ^ crctab[ (crc & 0xff) ^ *p++];

if (refout^refin) crc = reflect(crc, order);

crc^= crcxor;

crc&= crcmask;

return(crc);

}


unsigned long crcbitbybitfast(unsigned char* p, unsigned long len) {

// fast bit by bit algorithm without augmented zero bytes.

// does not use lookup table, suited for polynom orders between 1...32.

unsigned long i, j, c, bit;

unsigned long crc = crcinit_direct;

for (i=0; i<len; i++) {

c = (unsigned long)*p++;

if (refin) c = reflect(c, 8);

for (j=0x80; j; j>>=1) {

bit = crc & crchighbit;

crc<<= 1;

if (c & j) bit^= crchighbit;

if (bit) crc^= polynom;

}

}
```

```
if (refout) crc=reflect(crc, order);

crc^= crcxor;

crc&= crcmask;

return(crc);

}


int msglen(unsigned char * str)

{

int i = 0;

while(*(str++))

   i++;

   return i;

}


unsigned long chk_transparency(unsigned int crc_in){

   // transparency check

   unsigned char crc_part1,crc_part2;

union{

unsigned long crc_value;

unsigned char crc_bytes[4];

}crc;

   bool Transparency=false;

crc.crc_value=0;


   crc_part1= (unsigned char)((crc_in>>8) & 0xff);

   switch (crc_part1)

   {

   case XBOF_sym:

   case BOF_sym:

   case EOF_sym:
```

```
    case CE_sym:

    crc.crc_bytes[3]= CE_sym;

    crc.crc_bytes[2]= (crc_part1^0x20);

    Transparency=true;

    break;

    default:

    crc.crc_bytes[2]= crc_part1;

crc.crc_bytes[3]= 0;


    }


    crc_part2= (unsigned char)(crc_in & 0xff);

    switch (crc_part2)

    {

    case XBOF_sym:

    case BOF_sym:

    case EOF_sym:

    case CE_sym:

    crc.crc_bytes[1]= CE_sym;

    crc.crc_bytes[0]= (crc_part2^0x20);

    Transparency=true;

    break;

    default:

    crc.crc_bytes[0]= crc_part2;

crc.crc_bytes[1]= 0;


    }


if (Transparency)

return crc.crc_value;
```