CiA 103

CANopen®

Intrinsically safe capable physical layer

HISTORY

Date	Changes
2007-03-23	*Publication of Version 1.0* as draft standard proposal
2010-02-05	*Publication of Version 1.0* as draft standard

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CONTENTS

1 Scope

This specification describes an intrinsically safe capable physical layer application for CANopen. It may also be used for other CAN-based higher-layer protocols.

This specification addresses a recommended application for implementing an intrinsically safe capable communication and power system. This document does not attempt to list the requirements by which an item of equipment may be certified as intrinsically safe nor does it require equipment to be intrinsically safe. Rather, it seeks to exclude conditions or situations that would prevent IS certification. Many parameters are selected by the developers to provide a baseline for calculation. It does restrict other implementations from implementing their own selections.

NOTE   The wire medium specification provides the option of intrinsically safe power via the bus conductors.

2 References

/ISO7498-1/	ISO 7498, Information technology – Open Systems Interconnection – Part 1: Basic reference model: The basic model
/ISO11898-1/:	ISO 11898, Road vehicles – Controller area network (CAN) – Part 1: Data link layer and physical signaling
/ISO11898-2/	ISO 11898, Road vehicles – Controller area network (CAN) – Part 2: High-speed medium access unit
/IEC60079-11/	IEC 60079, Electrical apparatus for explosive gas atmospheres – Part 11: Intrinsic safety
/IEC61076-2/	IEC 61076, Connectors for electronic equipment – Part 2: Detailed specification for circular connectors M8 with screw- or snap-locking for low voltage applications
/EN50020/	EN 50020, Electrical apparatus for potentially explosive atmospheres. Intrinsic safety
/CiA301/	CiA 301, CANopen application layer and communication profile
/CiA303-1/	CiA 303, CANopen additional specification – Part 1: Cabling and connector pin assignment
/CSA/	CSA C22.2 No. 157, Intrinsically safe and Non-Incendive equipment for use in hazardous locations – Consumer and commercial products
/ANSI120201/	ANSI/ISA 12.02.01, Electrical apparatus for use in class I, zones 0, 1, &2 Hazardous (classified) locations – Intrinsic Safety
/UL913/FM3610/	ANSI/ UL913, Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II and III, Division 1 Hazardous (Classified) Locations
/UL60079-0/	UL 60079, Electrical apparatus for explosive gas atmospheres – Part 0:
/UL60079-11/	UL 60079, Electrical apparatus for explosive gas atmospheres – Part 11: Intrinsic Safety

3 Abbreviations and definitions

3.1 Abbreviations

AWG   American wire gauge

DC   Direct current

IEC   International electrotechnical commission

IS   Intrinsically safe

ISO   International organization for standardization

ECU   Electronic control unit

EIA   Electronic Industries Alliance

EMI   Electro magnetic interferences

GND   Ground

MAU   Medium Access Unit

NAMUR   Normenarbeitsgmeinschaft für Mess- und Regeltechnik

NeSSI^{TM} New Sampling/Sensor Initiative

PE   Polyethylene

PVC   Polyvinylchloride

TIA   Telecommunications Industry Association

Abbreviations given in /CiA301/ and /ISO11898-1/ apply for this specification as well.

3.2 Definitions

The definitions given in /ISO7498-1/, /ISO11898-1/, /ISO11898-2/, and /CiA301/ apply for this specification as well.

Barrier
Physical entity, which limits current and voltage into a hazardous area in order to satisfy intrinsic safety requirements

Circuit
Complete path for electric current including the generating apparatus, wires and load devices

Intrinsic Safety
Design methodology for a circuit or an assembly of circuits in which any spark or thermal effect produced under normal operating and specified fault conditions is not capable under prescribed test conditions of causing ignition of a given explosive atmosphere

NOTE   This definition is taken from EN 50020 (Intrinsically safe electrical apparatus).

Segment
Sum of nodes on a communication network

NOTE   Nodes on a common segment may be on a different circuit.

4   System architecture

4.1   Introduction

The system architecture of this design incorporates "co-cabling". This means that both the power and communication lines are transmitted through a common gateway device to an intrinsically safe environment as shown in Figure 1. This gateway device shall provide the correct power and galvanic isolation requirements for an intrinsically safe system. The power supply availability has driven this design. Typically available power supplies provide four pairs of separate power lines. This allows the system to set up four separately IS powered co-cabled bus trunk circuits.
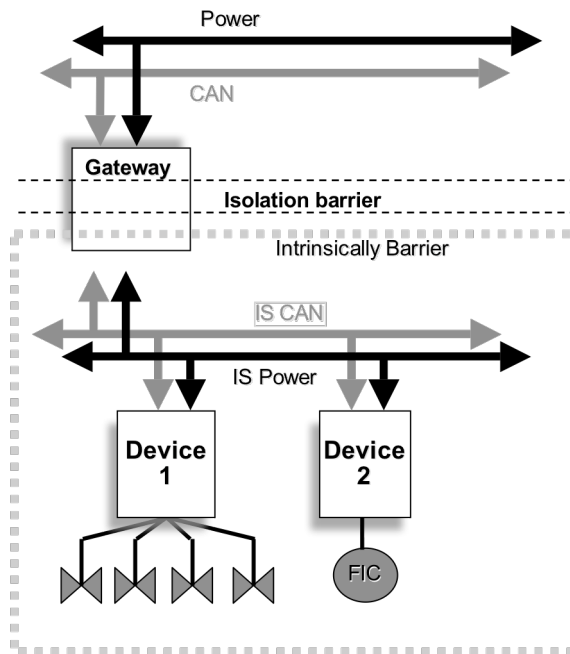
Figure 1 – System architecture

4.2   Communication physical layer

The communication model is described in /ISO11898-1/ and /CiA301/.

This specification is compliant with the CAN high-speed physical layer specifications as defined in /ISO11898-2/.

4.3   Power bus

The power bus specification is derived from commercially available power systems. The 10-m cable length is driven by this selection. In intrinsically safe applications, available power may limit the number of devices. Other power options may be considered in the future.

5 Intrinsically safe aspects

5.1 Introduction

In IS terminology, the gateway device is an associated apparatus, while the devices within the IS field are called IS apparatus. Figure 2 illustrates the generic IS architecture. The voltage, current, capacitance, and inductance delivered on the power bus by the apparatus are called entity parameters. These parameters are dictated by the IS Zone where the devices are placed. This system is designed to work within Zone 1 and Division 1 (see A.2).
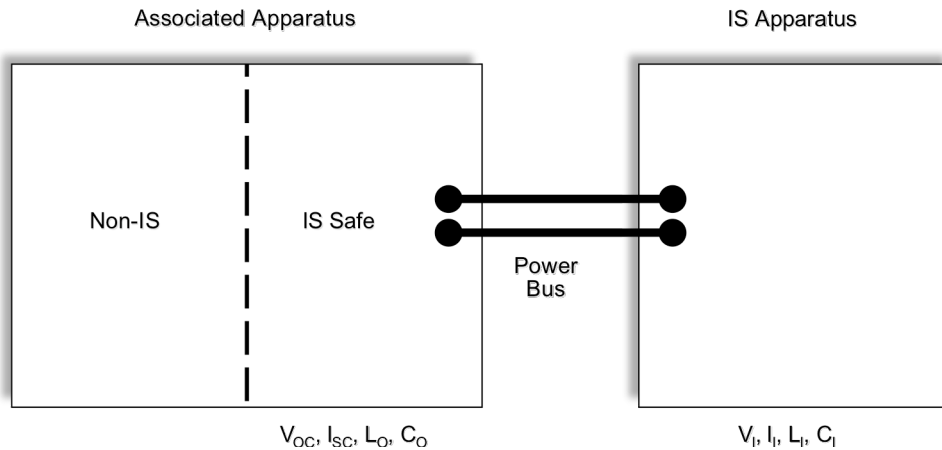
Associated Apparatus   IS Apparatus

V_{OC}, I_{SC}, L_O, C_O V_I, I_I, L_I, C_I

Figure 2 – IS architecture

5.2 Associated apparatus entity parameters

An associated apparatus in an intrinsically safe environment has component in both the IS and non-IS fields as illustrated in Figure 3. The system allows the usage of up to four channels. Table 1 specifies the entity parameters of one channel. The entity concept allows interconnection of intrinsically safe apparatus with associated apparatus to be combined as a system when the approved values of I_{sc} and V_{oc} are less than or equal to the V_{max} and I_{max} of the IS apparatus and the approved values of C_o and L_o of the associated apparatus are greater than $C_i + C_{cable}$ and $L_i + L_{cable}$ respectively for the IS apparatus and cable must be less than values of C_0 and L_0 of the associated.

Table 1 - IS apparatus entity parameters

V_{max} [V]	I_{max} [A]	Groups	C_{in} [µF]	L_{in} [µH]
9,5	1,0	IIC	0,8	10
9,5	1,0	IIB	2,4	40
9,5	1,0	IIA	6,4	80

NOTE   The groups IIA, IIB, and IIC are references to different types of gases as defined in /EN50020/.

5.3 IS apparatus entity parameter

The total V_{max} and I_{max} shall be less that the parameters for the associated apparatus.

6 System aspects

6.1 Introduction

This clause provides physical layer definitions for the different components for an IS system topology as illustrated in Figure 3. All devices, which are indicated in Figure 3 as IS CAN

devices are IS apparatus. The power supply is an associated apparatus. The gateway is both, an associated apparatus and an IS apparatus.

All of the CAN devices are shown on the same segment and use a common bit rate. Devices that are co-cabled are on the same circuit. Devices that are not on the same co-cable are considered to be on separate circuits.
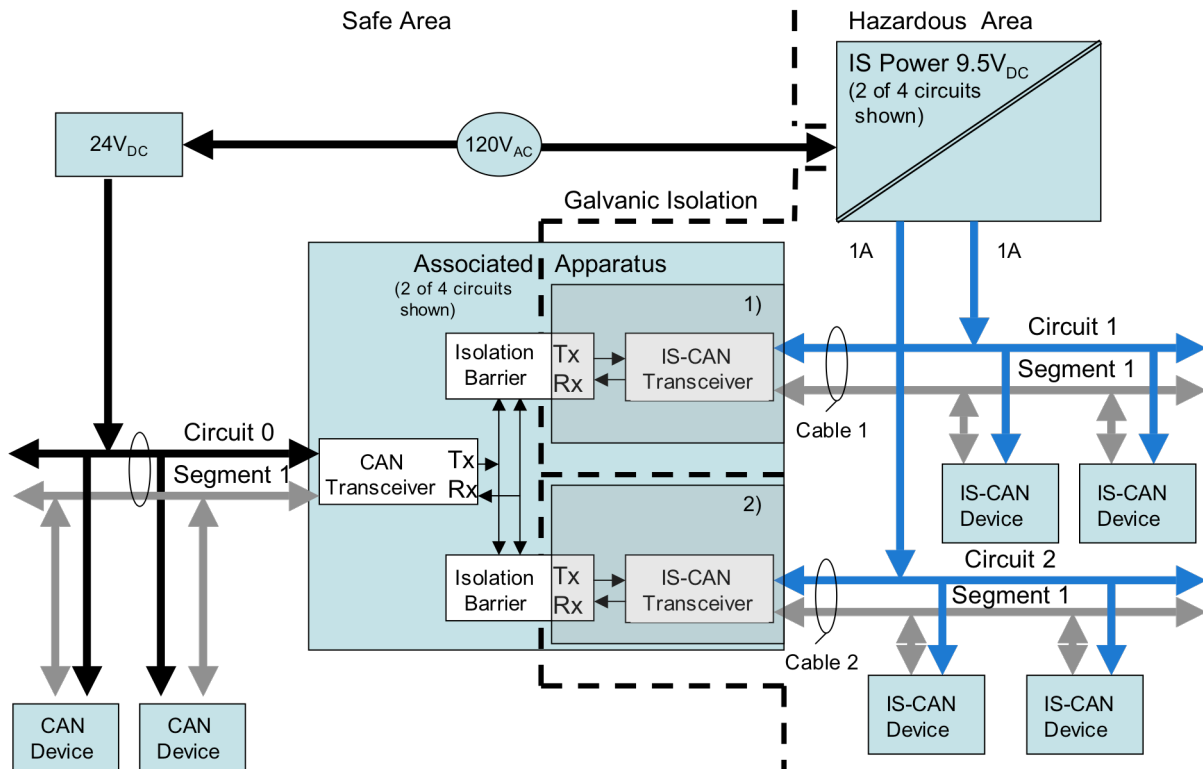
1) The only power source for this highlighted circuit shall be the 1A (circuit 1) provided by the power supply

2) The only power source for this highlighted circuit shall be the 1A (circuit 2) provided by the power supply

Figure 3 – IS CAN system topology

6.2 IS system parameters

The IS system parameters are defined in Table 2. The recommended DC voltage at the ECU shall be a nominal 8,63 V_{DC}. The ECU shall be able to operate with voltages as low as 7,71 V_{DC}. The maximum DC load current shall be obtained from Table 2.

Table 2 – IS system parameters

	Operating parameter	Min	Typ	Max	SI unit	Comments
V_{IN}	Input operating voltage	-	8,63	9,5	V	10% regulation
I_{IN}	Input operating current	-		1000	mA	@ 9,5V
P_{IN}	Power consumption	-	2,5	9	W	-
C_{IN}	Input capacitance to ground (any pin)	-	-	0,47	µF	-
L_{IN}	Input inductance to ground (any pin)	-	-	500	µH	-
t_{Bit}	Nominal bit time	1	-	8	µs	125 kbit/s default
n	Number of nodes	-	20	64	-	-

L	Cable length	-	-	10	m	-
L	Sub-length	-	1,67	-	m	-
	M8 connector	5	-	5	-	exactly 5 pins
	ISO 11898-2 high-speed CAN electrical specifications					compatibility

Note: The power consumption as well as the parameters passive minimum, active minimum, active maximum, in-rush/power-on and characteristics shall be manufacturer specific.

6.3 Transmission medium parameters

Table 3 specifies the physical medium parameters for CAN transceivers used in IS systems. The MAU of the IS CAN device shall be compliant to the definitions given in /ISO11898-2/.

Table 3 – Physical medium parameters for CAN transceivers

	Operating parameters	Min	Typ	Max	SI unit	Comments
I	Recessive state current	-	-	6	mA	-
I	Dominant state current	-	-	6	mA	No load
V_s	Supply voltage	3,0	3,3	3,6	V	-
	High bus input impedance with low Vcc	-	-	-	-	A high bus input impedance prevents an unpowered device from sinking all bus current and halting communication.
	Monotonic outputs during Power cycling	-	-	-	-	A device bus output shall not toggle during power up or power down to prevent false data entering the bus.

6.4 Bus topologies

The physical medium shall be a differentially driven twisted pair cable. The ECUs shall be connected to the bus line by means of unterminated stub-lines. The bus line shall be terminated at both ends with the characteristic impedance of the line to prevent signal reflections. The location of a termination resistor shall not be within an ECU since the bus lines loose termination in case such an ECU is disconnected from the bus. Figure 4 illustrates a typical CAN bus topology.
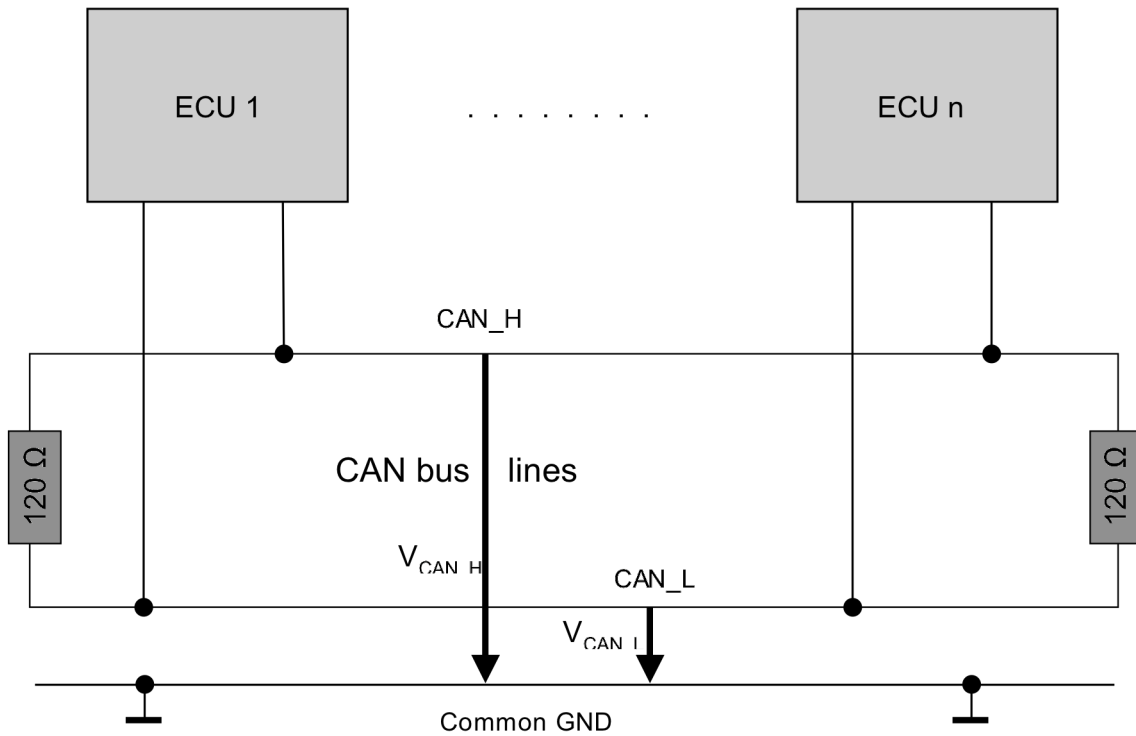
Figure 4 – CAN bus topology

6.5 Physical specification

6.5.1 Introduction

This section defines the recommended cable and connectors, the signal requirements, and isolation requirements.

6.5.2 Cable electrical specifications

6.5.2.1 Introduction

This section provides specifications for cabling to be considered in IS systems.

6.5.2.2 Cable type

For power and communication lines this specification recommends 24AWG cables with 26,5 Ω typically DC loss resistance and PVC jacket. Overall outer jacket shall be light blue in colour.

As long as the entity parameters are considered, a thicker cable may be used.

6.5.2.3 Characteristic impedance of the communication line

The characteristic impedance of the cable shall be 120 Ω; ±10% in the frequency range from DC up to 500 kHz.

6.5.2.4 Cable loss

The signal attenuation shall be 24dB/100m or less over the range of from 1 MHz up to 16 MHz for the AC property. The DC loss is typically 26,5 Ω (resp. 0,092 Ω/m).

6.5.2.5   Propagation delay

The maximum 5 ns/m propagation delay specification given in /ISO11898-2/ apply for this specification as well.

6.5.3   Dynamic attach and detach

6.5.3.1   Introduction

The act of plugging or unplugging an ECU to/from the system shall not affect the functionality of other devices connected to the system. Unplugging an ECU shall only stop any communication between the disconnected ECU and those remaining on the network.

6.5.3.2   Voltage spikes

A device shall not generate voltages exceeding 150% of the power supply voltage in case of being attached/detached to/from a powered IS system. A device shall not be damaged by input voltages up to 150% of the power supply voltage for periods up to 100 μs.

6.5.3.3   Recommended connectors

According to Table 2 the connector used on the ECUs is the 5-pin M8 ("Pico" style) connector as illustrated in Figure 5. The connector shall use the pinning as shown in Table 4. The device shall provide the plug connector.
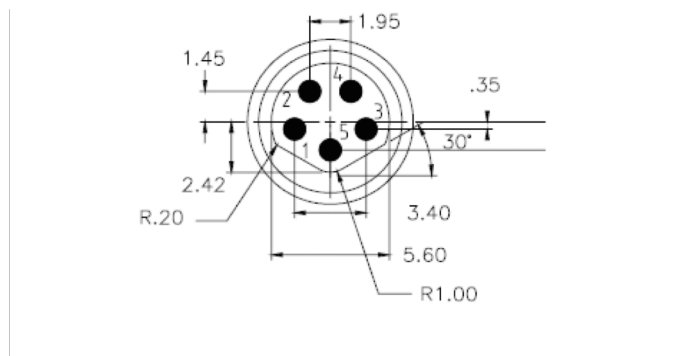

Figure 5 – Pinning for the M8 connector plug connector

Table 4 – Definition of the pinning for the M8 Pico style connector

Pin	Signal	Description
1	(CAN_V+)	Optional CAN external positive supply (dedicated for supply of transceivers and optocoupler, if galvanic isolation of the bus node applies)
2	(CAN_SHLD)	Optional CAN shield
3	CAN_H	CAN_H bus line (dominant high)
4	CAN_L	CAN_L bus line (dominant low)
5	CAN_GND	Ground / 0V / V-

For this application other connectors may be selected, but they shall be keyed to insure against reverse polarity. The ground connection shall provide a "make-first/break-last" function.

6.5.4   Electrical characteristics of data signals

The definitions provided in /ISO11898-2/ apply for this specification as well.

6.5.5   Bit timing

The bit timing defined in /CiA301/ shall apply for this specification as well. An ECU shall support the bit rate 125 kbit/s. Optionally further bit rates, which are specified in /CiA301/, may be supported.

6.5.6   Isolation requirements

The isolation requirements of the IS standards referenced in Annex A.2, shall apply for this document as well.

Annex A Appendix
(Informative only)

A.1   Calculations

In calculating the viability of this implementation, calculations were made regarding the worst-case power supply with the selected cable length. They are as follows:

I_{Omax} = 1 A

V_{Omax} = 9,5 V

If 5% variation is probable, then:

V_{Otyp} = 9,0 V, V_{Omin} = 8,6 V

For a 10 m @ 24 AWG, resistance 0,87 Ω

1 A * 0,87 Ω = 0,9 V

Therefore, actual voltage delivered to the device could be:

$VDEV_{min}$ = 8,6 V – 0,9 V = 7,7 V

Since this system is expected to work with NAMUR spec valves, this voltage level is acceptable.

A.2   International standards

A.2.1.1   General

This clause provides the international standards that define zones resp. divisions and the related entity parameters. In addition specifications for wiring and general requirements are listed, which have to be considered in the given countries or regions.

A.2.1.2   Zone method

Table 5 provides references to the relevant standards for zone method.

Table 5 – Standards for zone method

Protection method	Zone	Relevant standard in certain country/area		
		Europe	Canada	USA
Ex ia, (Dual Fault)	0, 1, & 2	EN 50020	IEC 60079-11	UL 60079-11 & -0
Ex ib, (Single Fault)	1 & 2			

A.2.1.3   Division method

Table 6 provides references to the relevant standards for division method.

Table 6 – Standards for division method

Protection method	Division	Relevant standard in certain country/area	
		Canada	**USA**
Intrinsic safety (Dual Fault only)	1, & 2	CSA C22.2 No. 157	UL913/ FM3610

NOTE   IS devices certified under UL 913 edition 6 remain effective until July 31, 2012. New devices should comply with UL 913 edition 7.

A.2.1.4   General requirements for devices in hazardous areas

Table 7 provides specifications, which provide general requirements for devices in hazardous areas to be considered in the given country or region.

Table 7 – General requirements for devices in hazardous areas

Document	Country or region
CAN/CSA-E60079-0-02 (R2006):	Canada
IEC 60079-0	International
ANSI/ISA-12.00.01-2002 (IEC 60079-0 Mod)	USA

A.2.1.5   Wiring practice specifications

Table 8 provides wiring practice specifications, to be considered in the given country or region.

Table 8 – Wiring practice specifications

Document	Country or region
CSA C22.1	Canada
IEC 60364	International
NEC 2005, ANSI/NFPA 70, articles 504 and 505	USA
ANSI/ISA RP12.06.01-1995 (R2002)	USA