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Health informatics — Point-of-care medical device communication —
Part 30200: Transport profile — Cable connected

Informatique de santé — Communication entre dispositifs médicaux sur le site des soins —
Partie 30200: Profil de transport — Connection par câble

Reference number
ISO/IEEE 11073-30200:2004(E)

Health informatics — Point-of-care medical device communication —
Part 30200:
Transport profile — Cable connected

Sponsor

IEEE 1073™ Standard Committee

of the

IEEE Engineering in Medicine and Biology Society

Approved 30 January 2000

IEEE-SA Standards Board

Abstract: A connection-oriented transport profile and physical layer suitable for medical device communications in legacy devices is established. Communications services and protocols consistent with specifications of the Infrared Data Association are defined. These communication services and protocols are optimized for use in patient-connected bedside medical devices.
Keywords: bedside, Infrared Data Association, IrDA, legacy device, medical device, medical device communications, MIB, patient, SNTP

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ISO Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75% of the member bodies casting a vote.

A pilot project between ISO and the IEEE has been formed to develop and maintain a group of ISO/IEEE standards in the field of medical devices as approved by Council resolution 43/2000. Under this pilot project, IEEE is responsible for the development and maintenance of these standards with participation and input from ISO member bodies.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. Neither ISO nor the IEEE shall be held responsible for identifying any or all such patent rights.

ISO/IEEE 11073-30200:2004(E) was prepared by IEEE 1073 Committee of the IEEE Engineering in Medicine and Biology Society.

IEEE Introduction

This introduction is not part of ISO/IEEE 11073-30200:2004(E), Health informatics — Point-of-care medical device communication — Part 30200: Transport profile — Cable connected.

ISO/IEEE 11073 standards enable communication between medical devices and external computer systems. They provide automatic and detailed electronic data capture of patient vital signs information and device operational data. The primary goals are to:

— Provide real-time plug-and-play interoperability for patient-connected medical devices

— Facilitate the efficient exchange of vital signs and medical device data, acquired at the point-of-care, in all health care environments

"Real-time" means that data from multiple devices can be retrieved, time correlated, and displayed or processed in fractions of a second. "Plug-and-play" means that all the clinician has to do is make the connection — the systems automatically detect, configure, and communicate without any other human interaction.

"Efficient exchange of medical device data" means that information that is captured at the point-of-care (e.g., patient vital signs data) can be archived, retrieved, and processed by many different types of applications without extensive software and equipment support, and without needless loss of information. The standards are especially targeted at acute and continuing care devices, such as patient monitors, ventilators, infusion pumps, ECG devices, etc. They comprise a family of standards that can be layered together to provide connectivity optimized for the specific devices being interfaced.

ISO/IEEE 11073-30200:2004(E) defines a communications transport profile. This profile is for a cable-connected local area network (LAN) for the interconnection of computers and medical devices. This standard is suitable for new device designs, but is particularly targeted to modifications of legacy devices.

The term "legacy devices" refers to equipment that is

— Already in use in clinical facilities
— In active production at the facilities of medical device manufacturers, or
— Beyond the initial stages of engineering development

Specifically, this standard describes connection-oriented communications services and protocols consistent with standards of the Infrared Data Association (IrDA), adapted as appropriate for ISO/IEEE 11073 applications and optimized for use in patient-connected bedside medical devices.

ISO/IEEE 11073-30200:2004(E) is one part of the family of ISO/IEEE 11073 standards. It is compatible with the upper layer ISO/IEEE 11073 standards.

The primary users of this standard are technical personnel who are creating or interfacing with a medical device communications system. Familiarity with the ISO/IEEE 11073 family of standards is recommended. Familiarity with communications and networking technologies is also recommended.

This standard is intended to satisfy the following objectives:

a) Allow compatibility with existing medical device communications designs to minimize design risk, contain product costs, and simplify field upgrades
b) Specify hardware and software elements that are available from multiple vendors
c) Make use of other computer industry communication technology to allow for continuous cost decreases
d) Meet the requirements of IEEE Std 1073™-1996
e) Be compatible with the current published and draft ISO/IEEE standard upper layers

Notice to users

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Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken with respect to the existence or validity of any patent rights in connection therewith. The IEEE shall not be responsible for identifying patents or patent applications for which a license may be required by to implement an IEEE standard or for conducting inquiries into the legal validity or scope of those patents that are brought to its attention.

Errata

Errata, if any, for this and all other standards can be accessed at the following URL: http://standards.ieee.org/reading/ieee/updates/errata/index.html. Users are encouraged to check this URL for errata periodically.

Interpretations

Current interpretations can be accessed at the following URL: http://standards.ieee.org/reading/ieee/interp/index.html.

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1. Overview

This standard is divided into 11 clauses, as follows:

- Clause 1 provides an overview of this standard.
- Clause 2 lists references to other standards that are useful in applying this standard.
- Clause 3 provides definitions and abbreviations.
- Clause 4 provides goals for this standard.
- Clause 5 provides an overview of network topology and layering.
- Clause 6 provides a profile of the physical layer.
- Clause 7 provides a profile of the data link layer.
- Clause 8 provides a profile of the network layer.
- Clause 9 provides a profile of the transport layer.
- Clause 10 describes the optional time synchronization service.
- Clause 11 provides labeling and conformance requirements.

This standard also contains 15 annexes, as follows:

- Annex A describes the physical layer.
- Annex B provides information on the maximum cable length.
- Annex C provides examples of physical link media.
- Annex D provides example schematics for modular adapters.
- Annex E provides a detailed rationale for pin assignments.
- Annex F describes the use of 10BASE-T with this standard.
- Annex G provides a discussion of power delivery considerations.
- Annex H provides examples of simple bedside communications controller (BCC) and device communications controller (DCC) designs.
- Annex I provides an example of an isolated BCC design.
- Annex J provides an optical isolator design example.
- Annex K provides marking guidelines.
- Annex L provides protocol examples, particularly of connection establishment.

— Annex M defines the Infrared Data Association (IrDA) profile specifications adapted from the IrDA implementation guidelines.
— Annex N provides guidelines for using the SNTP time synchronization protocol.
— Annex O provides bibliographical references.

1.1 Scope

The scope of this standard is an IrDA-based, cable-connected local area network (LAN) for the interconnection of computers and medical devices. This standard is suitable for new device designs, but is particularly targeted to modifications of legacy devices.

The term “legacy devices” refers to equipment that is

— Already in use in clinical facilities
— In active production at the facilities of medical device manufacturers, or
— Beyond the initial stages of engineering development

In each of these cases, the degree of effort to add a standardized communications capability might normally be prohibitive, unless special care is taken in developing a suitable standard.

1.2 Purpose

The purpose of this standard is to provide connection-oriented communications services and protocols consistent with IrDA specifications and adapted as appropriate for ISO/IEEE 11073 applications.

1.3 Standards compatibility

This standard is one part of the family of ISO/IEEE 11073 standards. It is compatible with the ISO/IEEE upper layer standards.

1.4 Audience

The primary users of this standard are technical personnel who are creating or interfacing with a medical device communications system. Familiarity with the ISO/IEEE 11073 family of standards is recommended. Familiarity with communications and networking technologies is also recommended.

2. References

This standard shall be used in conjunction with the following publications. When the following standards are superseded by an approved revision, the revision shall apply.

ANSI/TIA/EIA-232-F-1997, Interface Between Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.[1]

ANSI/TIA/EIA-561-1990, Simple 8 Position Non-Synchronous Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.

[1]ANSI publications are available from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (http://www.ansi.org/).

ANSI/TIA/EIA-562-1989, Electrical Characteristics for an Unbalanced Digital Interface.

ANSI/TIA/EIA-568-A-1995, Commercial Building Telecommunications Cabling Standard.

IEC 60603-7: 1996, Connectors for Frequencies Below 3 MHz for Use with Printed Circuit Boards—Part 7: Detailed specification for connectors, 8-way, including fixed and free connectors with common mating features, with assessed quality.[2]

IEC 60417-1:1998, Graphical Symbols for Use on Equipment—Part 1: Overview and Application.

IEEE Std 802.3™, IEEE Standard for Local Area Networks—Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications.[3, 4]

IEEE Std 1073™-1996, IEEE Standard for Medical Device Communications—Transport Profiles—Overview and Framework.

IEEE Std 1073.3.1™-1994, IEEE Standard for Medical Device Communications—Transport Profile—Connection Mode.[5]

IEEE Std 1073.4.1™-1994, IEEE Standard for Medical Device Communications—Physical Layer Interface—Cable Connected.[6]

IrDA, Link Management Protocol, Version 1.1, Jan. 23, 1996.[7]

IrDA, Serial Infrared Link Access Protocol (IrLAP), Version 1.1, June 16, 1996.

IrDA, Tiny TP: A Flow-Control Mechanism for use with IrLMP, Version 1.1, Oct. 20, 1996.

ISO/IEC 8877:1992(E), Information technology—Telecommunications and information exchange between systems—Interface connector and contact assignments for ISDN Basic Access Interface located at reference points S and T.

RFC-1305, Internet Engineering Task Force, Network Working Group Report, Mar. 1992, "Network Time Protocol Specification, Implementation and Analysis," Mills, D., University of Delaware.[8, 9]

RFC-2030, Internet Engineering Task Force, Network Working Group Report, Oct. 1996, "Simple Network Time Protocol (SNTP) Version 4 for IPv4, IPv6 and OSI," Mills, D., University of Delaware.

[2]IEC publications are available from the Sales Department of the International Electrotechnical Commission, Case Postale 131, 3, rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse (http://www.iec.ch/). IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

[3]IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (http://www.standards.ieee.org/).

[4]The IEEE standards or products referred to in this clause are trademarks of the Institute of Electrical and Electronics Engineers, Inc.

[5]IEEE Std 1073.3.1-1994 has been withdrawn; however, copies can be obtained from Global Engineering, 15 Inverness Way East, Englewood, CO 80112-5704, USA, tel. (303) 792-2181 (http://global.ihs.com/).

[6]IEEE Std 1073.4.1-1994 has been withdrawn; however, copies can be obtained from Global Engineering, 15 Inverness Way East, Englewood, CO 80112-5704, USA, tel. (303) 792-2181 (http://global.ihs.com/).

[7]IrDA publications are available at http://www.irda.org.

[8]Internet Engineering Task Force publications are available at http://www.ietf.org/.

[9]Information on the Network Time Protocol is available at http://www.eecis.udel.edu/~ntp/.

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this standard, the following terms and definitions apply. *The Authoritative Dictionary of IEEE Standards Terms,* Seventh Edition, [B2] should be referenced for terms not defined in this clause.

3.1.1 10BASE-T: IEEE Std 802.3, 1998 Edition, physical layer specification for Ethernet over two pairs of unshielded twisted-pair (UTP) media at 10 Mb/s.

3.1.2 baud: A unit of signaling speed, expressed as the number of times per second the signal can change the electrical state of the transmission line or other medium.

NOTE—Depending on the encoding strategies, a signal event may represent a single bit, more, or less, than one bit.

3.1.3 bedside communications controller (BCC): A communications controller, typically located at a patient bedside, that serves to interface between one or more medical devices. The BCC may be embedded into local display, monitoring, or control equipment. Alternatively, it may be part of a communications router to a remote hospital host computer system.

3.1.4 beginning of frame (BOF): An octet specified by infrared link access protocol (IrLAP).

3.1.5 category 5 (CAT-5) balanced cable: The designation applied to 100 Ω unshielded twisted-pair (UTP) cables and associated connecting hardware whose transmission characteristics are specified up to 100 MHz. (ANSI/TIA/EIA-568-A-1995)

3.1.6 cyclic redundancy check (CRC): The result of a calculation carried out on the octets within an IrLAP frame; also called a frame check sequence. The CRC is appended to the transmitted frame. At the receiver, the calculation creating the CRC may be repeated, and the result compared to that encoded in the signal. *Syn:* **frame check sequence.**

3.1.7 device communications controller (DCC): A communications interface associated with a medical device. A DCC may support one or more physically distinct devices acting as a single network communications unit. Its purpose is to provide a point-to-point serial communication link to a BCC.

3.1.8 electromagnetic compatibility (EMC): The ability of a device, equipment, or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment.

3.1.9 electromagnetic interference (EMI): Signals emanating from external sources (e.g., power supplies, transmitters) or internal sources (e.g., adjacent electronic components, energy sources) that disrupt or prevent operation of electronic systems.

3.1.10 electrostatic discharge (ESD): The sudden transfer of charge between bodies of differing electrostatic potentials that may produce voltages or currents that could destroy or damage electrical components.

3.1.11 frame check sequence: *See:* **cyclic redundancy check.**

3.1.12 high-level data link control (HDLC): A standard protocol defined by ISO for bit-oriented, frame-delimited data communications.

3.1.13 information access service (IAS): A component of infrared link management protocol (IrLMP).

3.1.14 local area network (LAN): A communication network to interconnect a variety of intelligent devices (e.g., personal computers, workstations, printers, file storage devices) that can transmit data over a limited area, typically within a facility.

3.1.15 medical information bus (MIB): The informal name for the ISO/IEEE 11073 family of standards.

3.1.16 octet: A group of eight adjacent bits.

3.1.17 primary station: As defined by the infrared link access protocol (IrLAP), the station on the data link that assumes responsibility for the organization of data flow and for unrecoverable data link error conditions. It issues commands to the secondary stations and gives them permission to transmit.

3.1.18 protocol data unit (PDU): Information delivered as a unit between peer entities that contains control information and, optionally, data.

3.1.19 quality of service (QoS): The four negotiated parameters for a link: signaling speed, maximum turn-around time, data size, and disconnect threshold.

3.1.20 radio frequency (RF): (A) (Loosely) The frequency in the portion of the electromagnetic spectrum that is between the audio-frequency portion and the infrared portion. **(B)** A frequency useful for radio transmission.

NOTE—The present practicable limits of radio frequency are roughly 10 kHz to 100 000 MHz. Within this frequency range, electromagnetic radiation may be detected and amplified as an electric current at the wave frequency.[10]

3.1.21 radio frequency interference (RFI): *See:* **radio interference.**

3.1.22 radio interference: Degradation of the reception of a wanted signal caused by radio frequency (RF) disturbance.

NOTES

1—RF disturbance is an electromagnetic disturbance having components in the RF range.

2—The words “interference” and “disturbance” are often used indiscriminately. The expression “radio frequency interference” is also commonly applied to an RF disturbance or an unwanted signal.

3.1.23 RJ-45: (A) AT&T Registered Jack designation for the eight-pin modular connectors that meet the requirements of IEC 60603-7:1996 and ISO/IEC 8877:1992. **(B)** An eight-pin modular telephone plug.

NOTES

1—Also called a programmable connection, an RJ-45 plug is generally used on four-wire circuits, but can be used on eight-wire circuits.

2—Definition (B) reflects colloquial usage. Standards referencing this term should point to the precise standardized connector specification.

3.1.24 RS-232: The serial interface defined in ANSI/TIA/EIA-232-F-1997.

3.1.25 secondary station: As defined by the infrared link access protocol (IrLAP), any station on the data link that does not assume the role of the primary station. It will initiate transmission only as a result of receiving explicit permission to do so from the primary station.

3.1.26 service access point (SAP): An address that identifies a user of the services of a protocol entity.

[10]Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement the standard.

3.1.27 service data unit (SDU): Information that is delivered as a unit between peer service access points (SAPs). See: service access point.

3.1.28 set normal response mode (SNRM): A high-level data link control (HDLC) message sent by a bedside communications controller (BCC) to a device communications controller (DCC) when a successful connection to the network has occurred.

3.2 Acronyms and abbreviations

API	application program interface
AWG	American Wire Gage
BCC	bedside communications controller
BOF	beginning of frame
BPWR	bedside communications controller power
CAT-5	category 5
CRC	cyclic redundancy check
CS	connection sense
DCC	device communications controller
DPWR	device communications controller power
DTE	data terminal equipment
DTR	data terminal ready
EMC	electromagnetic compatibility
EMI	electromagnetic interference
EOF	end of frame
ESD	electrostatic discharge
EUI	extended unique identifier
GND	ground
HDLC	high-level data link control
IAS	information access service
IrDA	Infrared Data Association; the set of infrared data communications standards
IrLAP	IrDA link access protocol
IrLMP	IrDA link management protocol
IV	intravenous
LAN	local area network
LED	light-emitting diode
LI	leap indicator
LSAP	link service access point
LSB	least significant bit
MDDL	medical device data language
MIB	medical information bus
MSB	most significant bit
MTU	maximum transfer unit
NIBP	non-invasive blood pressure
NTP	network time protocol
PLL	phase-locked loop
PDU	protocol data unit
QoS	quality of service
RAC	IEEE Registration Authority Committee
RD	receive data
RF	radio frequency
RFI	radio frequency interference
RJ	registered jack
RR	receive ready
RTS	request to send

RxD	receive data
SAP	service access point
SAR	segmentation and reassembly
SDLC	synchronous data link control
SDU	service data unit
SNRM	set normal response mode
SNTP	simple network time protocol
TD	transmit data
TinyTP	tiny transport protocol
TTPSAP	TinyTP service access point
TxD	transmit data
UTC	coordinated universal time
UTP	unshielded twisted pair
XID	exchange station identification
XMIT	transmitting
VN	version number

4. Goals for this standard

The following are the main goals for this standard:

a) The standard shall allow the use of existing RS-232 port designs to minimize design risk, contain product costs, and simplify field upgrades.

b) The standard shall specify hardware and software elements that are available from multiple vendors.

c) The standard should make use of other computer industry communication technology to allow for continuous cost decreases.

d) The standard should meet the requirements of IEEE Std 1073-1996.

e) The standard should be compatible with the current published and draft IEEE/ANSI standard upper layers.

5. Architecture

This clause is intended to define ISO/IEEE 11073-30200 network topology and protocol layering.

5.1 Topology

The ISO/IEEE 11073-30200 network defines a star topology, requiring each device to have its own connection directly into the network. On the communications network, two types of communications nodes are allowed:

a) The BCC is the primary node and functions as the network controller and the hub of the star.

b) DCCs are secondary nodes and limited in number to the loading capacity of the BCC and/or number of physical port sockets.

The devices connect to the network through the DCC. The BCC can interface directly to a local host computer, as in Figure 1, or to a remote host computer over a network, as in Figure 2. The portion of the BCC performing ISO/IEEE 11073-30200 operations would be the same in both configurations. However, the BCC would also include internet-working functions in the latter case.

Unless otherwise noted, all references to a BCC in this standard refer only to the components performing ISO/IEEE 11073-30200 functions, as indicated in Figure 1 and Figure 2.

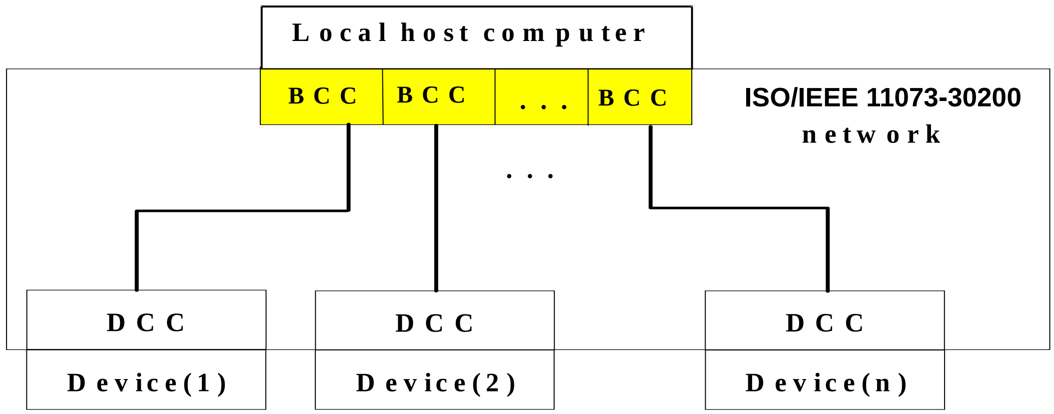


Figure 1—Connection topology with a local host

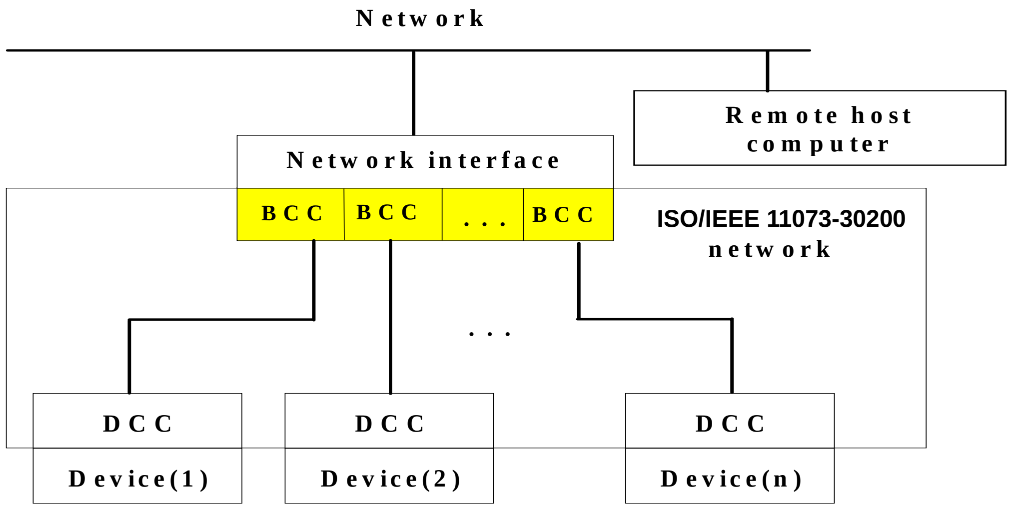


Figure 2—Connection topology with a remote host

The cable-connected network described by this standard consists of individual point-to-point connections between the BCC and each DCC: it is not a multidrop network. Only a single DCC is supported on each physical port connection.

5.2 Layering

Layering is consistent with the IrDA standards, as shown in Figure 3.

Briefly, the components of the stack are as follows.

a) Physical layer, defining a standard connector and electrical characteristics (see Clause 6)

b) Infrared link access protocol (IrLAP), providing a device-to-host connection for the reliable, ordered transfer of data, including device discovery procedures (see Clause 7)

c) Infrared link management protocol (IrLMP), providing multiplexing of the IrLAP layer (see Clause 8)

d) Tiny transport protocol (TinyTP), providing flow control on IrLMP connections (see Clause 9)

e) Simple network time protocol (SNTP) service access point (SAP), a SAP for an optional time synchronization service (see Clause 10)

f) Medical device data languages (MDDL) SAP, as described in other ISO/IEEE 11073 standards

Related ISO OSI layer	ISO/IEEE 11073-30200 layer	
	SNTP SAP	MDDL SAP
Transport	Tiny transport protocol – TinyTP	
Network	Link management protocol - IrLMP	
Data link	Link access protocol – IrLAP	
Physical link	Physical layer	

Figure 3—ISO/IEEE 11073-30200 layering

Service primitives are specified for some of the layers. This definition of service does not imply any specific interface implementation. These primitives do not constitute an application program interface (API). Conformance to this standard is judged by performance at the communications port only.

6. Physical layer

The physical layer provides point-to-point connection sensing, data transmission and power delivery between the BCC and DCC using an eight-pin RJ-45 modular connector. The physical layer requirements are defined in Annex A.

Refer to the following additional informative annexes for more information about the physical layer:

— Annex B provides information on the maximum cable length.
— Annex C provides examples of physical link media.
— Annex D provides example schematics for modular adapters.

— Annex E provides a detailed rationale for pin assignments.
— Annex F describes the use of 10BASE-T with this standard.
— Annex G provides a discussion of power delivery considerations.
— Annex H provides examples of simple BCC and DCC designs.
— Annex I provides an example of an isolated BCC design.
— Annex J provides an optical isolator design example.
— Annex K provides marking guidelines.

7. Data link layer

The data link layer is adopted from the IrLAP, which implements ISO/OSI layer 2, the data link layer. It is based on standard asynchronous high-level data link control (HDLC) and synchronous data link control (SDLC) half-duplex protocols.

IrLAP provides the following features:

a) Dynamic address and address conflict resolution
b) Error recovery mechanism
c) Station discovery and identification procedure
d) Connectionless and connection-oriented services
e) Negotiation of connection characteristics

This standard follows some of the recommendations of IrDA Lite [B4] for IrLAP. IrLAP capabilities not specified here are out of scope for an ISO/IEEE 11073-30200 interface. Examples of these capabilities are sniffing, connectionless data transfer, test frames, role exchange, and 2400 Bd operation.

IrLAP communication partners act in one of two roles: one primary station and one or more secondary stations. The primary station discovers all available secondary stations and establishes a connection to specific stations. The primary station is always the initiator of data transfer; the secondary station reacts to commands from the primary.

As shown in Figure 4, a BCC performs the functions of a primary station, and a DCC performs the functions of a secondary station. Although IrLAP supports multidrop communications in the infrared medium, this standard defines a single DCC at each cable-connected port on the BCC. Each port on a BCC represents a separate instance of the transport profile stack.

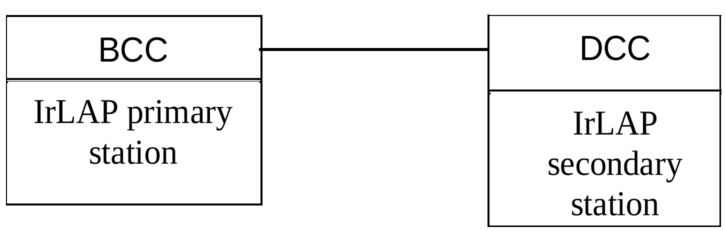


Figure 4—Logical network model

7.1 IrLAP frame

IrLAP defines a physical layer frame wrapper and a data link frame. The physical layer uses the ASYNC frame wrapper. The ASYNC frame wrapper has beginning frame (BOF), ending frame (EOF), and field check sequence fields. This frame encloses the data link frame, shown in Figure 5. IrLAP defines a transparency algorithm that allows the use of the framing characters (BOF and EOF) inside the data frame.

Address	Control	Information

Figure 5—IrLAP frame

7.2 Procedure model

The simplified procedure model in Figure 6 illustrates the different procedures within an IrDA communication.

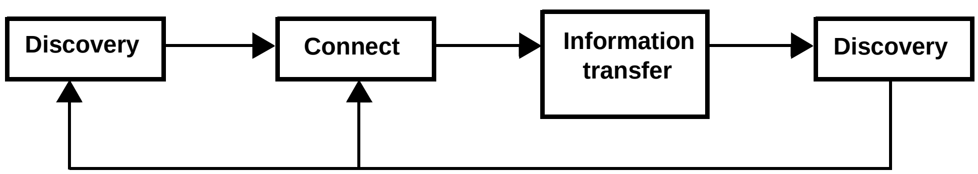


Figure 6— IrDA communication procedure model

7.2.1 Discovery

A primary station (the initiator) performs a discovery procedure to detect all available secondary devices. The secondary device (the responder) responds with address information and minimal device information (service hints and a device nickname). The discovery phase is done with a fixed set of communication parameters (e.g., 9600 Bd).

Discovery begins when the initiator broadcasts a discovery command frame. This command frame specifies the number of time slots for the discovery process—more time slots means more devices can be discovered and reduces the likelihood of collisions between responders during discovery.

Because this standard specifies a cable-connected topology, there is a maximum of one responder at each BCC port. In order to minimize the time spent during discovery, the BCC should provide only a single time slot for this procedure.

7.2.2 Negotiation and connection

The primary station establishes a connection by negotiating the maximum communication capabilities (e.g., signaling speed, data size, window size) supported by both devices. In the case of the BCC, this quality of service (QoS) may be constrained by available system bandwidth and the bandwidth requirements at other ports on the BCC.

After acknowledgement from the secondary station, both stations switch to the new communication parameters.

7.2.3 Information transfer

The primary station periodically polls the secondary station for data or status information. The stations communicate using a reliable data transport service. Stations may also use an unreliable expedited data transport service for time synchronization.

7.2.4 Disconnect

Both stations, primary or secondary, can normally disconnect the connection. In addition, timeout mechanisms on both sides detect a broken or aborted connection. All communication parameters are reset to negotiation values upon disconnect.

7.3 Minimum data link layer requirements

The minimum data link layer services support the capabilities of device discovery, connection, data transfer, and disconnection.

7.3.1 Minimum data link layer services

The status of the data link layer service primitives provided by a BCC or DCC is specified in Table 1 as follows:

M: Mandatory
C: Conditional

Table 1—Data link layer service requirements

Service primitives	**Status**	
	BCC	**DCC**
Device discovery		
IrLAP_Discovery.request(gen addr bit)	M	N/A
IrLAP_Discovery.confirm(list of discovery logs)	M	N/A
IrLAP_Discovery.indication(discovery log)	N/A	M
Connection		
IrLAP_Connect.request(target device address, requested QoS, sniff [a])	M	C[b]
IrLAP_Connect.confirm(connection handle, returned QoS)	M	C[b]

Table 1—Data link layer service requirements *(continued)*

IrLAP_Connect.indication(source device addr, connection handle, returned QoS)	C[b]	M
IrLAP_Connect.response(source device addr, connection handle, requested QoS)	C[b]	M
Data transfer		
IrLAP_Data.request(connection handle, user data, expedited unreliable flag = false)	M	M
IrLAP_Data.indication(connection handle, user data, expedited unreliable flag = false)	M	M
IrLAP_Data.request(connection handle, user data, expedited unreliable flag = true)	C[c]	C[c]
IrLAP_Data.indication(connection handle, user data, expedited unreliable flag = true)	C[c]	C[c]
Disconnection		
IrLAP_Disconnect.request(connection handle)	M	M
IrLAP_Disconnect.indication(connection handle, unacked data)	M	M

[a]Use of the sniffing feature is out of the scope of this standard.
[b]Indicated connect services are required in a BCC or DCC that supports SNTP.
[c]The expedited unreliable IrLAP_Data services are required for the LM_UData/TTP_UData service in a BCC or DCC that supports SNTP.

7.3.2 Wrapping layer

Asynchronous framing and transparency shall be used, as defined by IrLAP.

7.3.3 Negotiation

At a minimum, the IrLAP negotiation parameters in Table 2 shall be supported.

Table 2—IrLAP minimum negotiation parameters

Signaling speed	9600 Bd
Maximum turnaround time	500 ms
Data size[a]	64 octets
Window size	1 frame window
Additional BOFs	0 BOFs
Link disconnect time	3 s
Link threshold time	0 s

[a]The data size parameter is the maximum number of data octets allowed in any received frame. A data size parameter of 64 octets is required for negotiation. A larger data size may also be required to support the range of transfer protocol data unit (PDU) sizes provided by this profile.

7.3.4 Link disconnect time

IrLAP supports the negotiation of the link disconnect time, i.e., the time a station will wait without receiving valid frames before it disconnects the link. IrLAP stations may support a variety of link disconnect times, ranging from 3 s to 40 s. An ISO/IEEE 11073-30200 station should exclusively support the minimum value for the link disconnect time of 3 s. A longer disconnect timeout might be useful for devices using an infrared medium, but is not necessary for a cable-connected device. The minimum disconnect time is preferred, in order to permit rapid identification of the disconnected state.

7.3.5 Contention state

In the contention state, 11 BOFs shall be used on every frame. The first 10 BOFs shall be FFh. The eleventh BOF shall be C0h.

7.3.6 Signaling speed

A station shall operate at 9600 Bd. A station may operate at other signaling speeds supported by IrLAP that use asynchronous framing: 19 200 Bd, 38 400 Bd, 57 600 Bd, or 115 200 Bd.

7.3.7 Data size

The maximum size of a PDU is negotiated at the time of the connection. The IrLAP “data size” parameter is negotiated independently for each direction of the link; therefore, the primary and secondary stations may support different maximum PDU sizes.

The negotiated signaling speed and turnaround time may constrain the actual data size by limiting the amount of time available to transfer the frame. If the requested data size cannot be supported, the link shall be renegotiated.

7.3.8 Poll interval

When a BCC transmits an information frame, IrLAP permits the turnaround time to be as short as the negotiated minimum turnaround time.

When a BCC has no information frame to transmit, it shall wait for some interval before issuing a “receive ready” poll frame. The polling interval is not specified in IrLAP, but shall be bounded by the negotiated minimum and maximum turnaround times. Maximum turnaround time shall be negotiated as shown in Table 3. IrLAP does not provide a mechanism for negotiating the polling interval, represented by the P-Timer-Expired event in the XMIT state of the primary role state machine.

Many applications of medical information bus (MIB) may expect the DCC to consume the bulk of the available bandwidth at low signaling speeds. If the BCC were to frequently wait for 500 ms to issue a poll frame, a substantial proportion of the potential bandwidth would go unused. If the BCC were to simply issue a poll frame after the minimum turnaround time, it could drive the device to spend an inordinate amount of time servicing an inactive communications link. Therefore, it is reasonable to allow the negotiation of an intermediate polling interval that optimizes bandwidth usage without interfering with device performance.

A DCC may advertise the preference to be polled at a shorter interval than 500 ms. The available selections are shown in Table 4. The preferred polling interval is advertised through the information access service (IAS) (see Clause 8).

BCCs shall poll at the maximum turnaround time unless a shorter polling interval is advertised by the DCC. A BCC shall not poll faster than the advertised polling interval. A BCC shall not poll faster than the minimum turnaround time. A polling interval of 0 ms means that the DCC will accept polling as fast as the minimum turnaround time.

NOTE—Selecting a shorter poll interval should not interfere with the maximum turnaround time that determines the time allotted to the DCC to transmit.

Table 3—Maximum turnaround time

Signaling speed (Bd)	Timing
9600	Stations are restricted to a fixed maximum turnaround time of 500 ms.
19 200	
38 400	
57 600	
115 200	Stations select a maximum turnaround time during negotiation.

Table 4—Polling interval selections

0 ms
50 ms
100 ms
250 ms

8. Network layer

The network link layer is adopted from the IrLMP, which implements ISO/OSI layer 3.

IrLMP consists of the following components:

a) IAS maintains an information base with information about offered services and device information.

b) Link management multiplexer provides multiple connections over IrLAP.

This standard follows some of the recommendations of IrDA Lite [B4] for IrLMP. IrLMP capabilities not specified here are out of scope for an ISO/IEEE 11073-30200 interface. Examples of these capabilities are sniffing, connectionless data transfer, and exclusive mode.

8.1 Discovery information

IrLMP as service user for the IrLAP services provides the discovery information shown in Figure 7. This information is a maximum of 23 octets long.

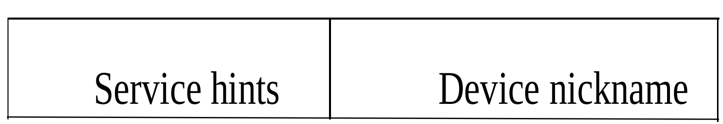


Figure 7—Discovery information field

Service hints are mandatory and contain at least 1 octet. They provide information about the general device class (e.g., computer, printer, modem). More hint octets can be appended to the first one. An ISO/IEEE 11073-30200 BCC or DCC shall assert the reserved service hint bit 12 and the extension bit 7, as shown in Table 5.

Table 5—Service hint bit assignment

Octet 1		Octet 2	
Bit	**Function**	**Bit**	**Function**
0		8	
1		9	
2		10	
3		11	
4		12	ISO/IEEE 11073 = 1
5		13	
6		14	
7	Extension = 1	15	

Not all IrDA devices that assert hint bit 12 are assured of supporting this standard. To be certain, the primary station should query the IAS of the secondary station for the IEEE:1073:3:2 object class (described in 8.2.6).

A BCC or DCC shall report a device nickname with the discovery information. The device nickname should be a short, recognizable name for the device. That name shall begin with the acronym “MIB” followed by a space. The format of the device nickname encoding is shown in Figure 8. This encoding shall include a character set code, as described in IrLMP. Examples of device nicknames are shown in Table 6.

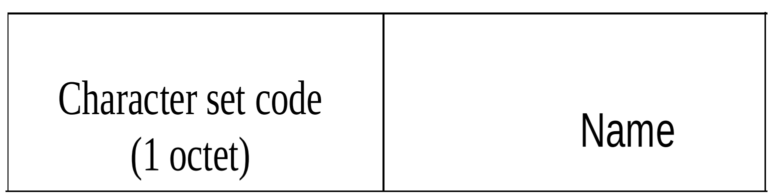


Figure 8—Device nickname format

Table 6—Sample device nicknames

Name	Encoding	Octets	Length
“MIB IV Pump”	ASCII	00 4D 49 42 20 49 56 20 50 75 6D 70	12 octets
“MIB Ventilator”	ASCII	00 4D 49 42 20 56 65 6E 74 69 6C 61 74 6F 72	15 octets
“MIB NIBP”	ASCII	00 4D 49 42 20 4E 49 42 50	9 octets
NOTE—IrLAP restricts the length of the discovery information (device nickname plus service hints) to 23 octets.			

8.2 Information access requirements

The information access requirements support the capabilities of a global identifier number, node type identification, and dynamic access point identification.

8.2.1 IAS

The IAS shall provide the service primitives described in Table 7. The status of an IAS primitives is specified as follows:

M: Service is mandatory
R: Service is recommended

Table 7—IAS requirements

IAS primitives	Status
LM_GetValueByClass.request(address, class name, attribute name)	M
LM_GetValueByClass.confirm(list of (object id, attribute value))	M
LM_GetValue.request(address, id, attribute name1, [attribute name2, ...])	R
LM_GetValue.confirm(list of attribute values)	R

8.2.2 Global identifier number

A BCC or DCC should report a global identifier number in the IAS object database, as shown in Table 8. The global identifier number is the 64 b global identifier [64 b extended unique identifier (EUI-64)] parameter for that BCC or DCC. This parameter consists of a 3-octet (24 b) company identifier (company_id) number followed by a 5-octet (40 b) extension identifier. The format, shown in Figure 9, follows the IrLMP conventions for an octet sequence.

type = 2 (octet sequence)	length = 8	company identifier	extension identifier
1 octet	2 octets	3 octets	5 octets

Figure 9—Global identifier format in IAS

The individual company_id number is assigned by the IEEE Registration Authority Committee (RAC) and represents a unique code for a particular manufacturing company or other organization.

The 40 b extension identifier number is assigned by the particular manufacturer or other organization. It is the responsibility of the individual manufacturer to assign a unique (nonduplicate) extension identifier number to each BCC or DCC.

No more than one 64 b global identifier value shall be contained within each component that is manufactured. For legacy devices that use a communications protocol adapter, the global identifier can reside in the adapter.

The use of the EUI-64 global identification number enables unique global identification of ISO/IEEE 11073 communication controllers. This identification allows for distinguishing between multiple devices of the same type that are connected to the same patient and facilitates device tracking and maintenance within an institution.

8.2.3 Interface type

A BCC or DCC shall report the type of interface supported (BCC or DCC) using the NodeType attribute as shown in Table 8 and Table 9.

8.2.4 Port identifier number

A BCC or DCC shall report a unique port number value for each port on the device, as described in Table 8 and Table 9.

8.2.5 Service access points

A BCC should specify a service connection endpoint for the SNTP upper layers to an IrDA TinyTP service, as shown in Table 8.

A DCC shall specify a service connection endpoint for the MDDL upper layers to an IrDA TinyTP service, as shown in Table 9.

8.2.6 Supported objects and attributes

The IAS in a BCC or DCC shall support the objects and attributes listed in Table 8 and Table 9, respectively. The status of an object-attribute pair is specified as follows:

M: IAS entry is mandatory
R: IAS entry is recommended
O: IAS entry is optional

Table 8—Objects and attributes in a BCC

Object class	Attribute name	Value type	Description	Status
Device	DeviceName	user string	This attribute is described in IrLMP.	M
	IrLMPSupport	octet sequence	This attribute is described in IrLMP.	M
IEEE :1073:3:2	GlobalID	octet sequence	Specifies the global identifier number for the BCC.	R[a]
	NodeType	integer	0 (= BCC)	M
	PortNumber	integer	Ascribes a specific number to each port on the BCC.	M
IEEE :1073:3:2 :SNTP	IrDA:TinyTP :LsapSel	integer	Specifies the service connection endpoint for the SNTP upper layers to an IrDA TinyTP service.	R[a]

[a]If the capability is not supported, the attribute shall be omitted from the IAS.

Table 9—Objects and attributes in a DCC

Object class	Attribute name	Value type	Description	Status
Device	DeviceName	user string	This attribute is described in IrLMP.	M
	IrLMPSupport	octet sequence	This attribute is described in IrLMP.	M
IEEE :1073:3:2	GlobalID	octet sequence	Specifies the global identifier number for the DCC.	R[a]
	NodeType	integer	1 (= DCC)	M
	PortNumber	integer	Ascribes a specific number to each MIB DCC port on the medical device.	M
	PollInterval	integer	Specifies the preferred polling interval, in milliseconds. May be 0, 50, 100, or 250.	O[a]
IEEE :1073:3:2 :MDDL	IrDA:TinyTP :LsapSel	integer	Specifies the service connection end-point for the ISO/IEEE 11073 MDDL upper layers to an IrDA TinyTP service.	M

[a]If the capability is not supported, the attribute shall be omitted from the IAS.

8.2.7 Extending the list of objects and attributes

The objects and attributes supported by the IAS may be extended by other ISO/IEEE 11073 family standards. A standard that provides IAS extensions shall specify the object class, the attribute name, and the value type. The object class name should incorporate the name of the standard, as in “IEEE:1073:3:2”.

Reasons for extending the IAS include the possibility of providing a link service access point (LSAP) that uses a protocol other than MDDL or SNTP. The use of other LSAPs to establish connections to other services is out of the scope of this standard.

NOTE—If sessions are established on other LSAPs concurrent with MDDL, it is important to understand the impact of this connection on the throughput and latency performance of the MDDL connection. It may be necessary to service the MDDL connection at a higher priority in order to guarantee the desired level of throughput and/or latency. If SNTP is implemented, that link should be serviced as high-priority, low-latency. The impact of SNTP on throughput is negligible.

8.3 Minimum IrLMP multiplexer requirements

The minimum multiplexer requirements provide support for device discovery, connection, status, data transfer, and disconnection.

The network layer shall provide the service primitives described in Table 10. The status of the network layer service primitives provided by a BCC or DCC is specified as follows:

O: Optional
M: Mandatory
C: Conditional

Table 10—Network layer service requirements

Service primitives	Status	
	BCC	DCC
Device discovery		
LM_DiscoverDevices.request(nr slots)	M	N/A
LM_DiscoverDevices.confirm(status, list of (device address, device info, method))	M	N/A
LM_DiscoverDevices.indication(device address, device info, method)	N/A	M
Connection		
LM_Connect.request(called LSAP, requested QoS, client data)	M	C[a]
LM_Connect.confirm(called LSAP, resultant QoS, client data)	M	C[a]
LM_Connect.indication(calling LSAP, resultant QoS, client data)	C[a]	M
LM_Connect.response(calling LSAP, client data)	C[a]	M
Status		
LM_Status.request()	M	M
LM_Status.indication(link status, lock status)	M	M
LM_Status.confirm(unacked data flag)	M	M
Data transfer		
LM_Data.request(data)	M	M
LM_Data.indication(data)	M	M
LM_UData.request(data)	C[a]	C[a]
LM_UData.indication(data)	C[a]	C[a]
Disconnection		
LM_Disconnect.request(reason, client data)	O[b]	O[b]
LM_Disconnect.indication(reason, client data)	M	M

[a]Indicated service is required in a BCC or DCC that supports SNTP.
[b]An IrLAP disconnect may be used in place of an IrLMP disconnect as described in IrDA Lite [B4].

9. Transport layer

The transport layer is adopted from TinyTP, which implements ISO/OSI layer 4, the transport layer. This layer supports multiple transport connections with independent flow control.

TinyTP also defines a capability for data stream segmentation and reassembly (SAR). SAR may be used to achieve a larger maximum transfer unit, if both ends of the link support SAR.

9.1 Maximum transfer unit

The transport profile provides a delivery service for user data. Any client service data unit (SDU) not larger than the maximum transfer unit (MTU) shall be delivered by the transport profile. The MTU is determined according to Table 11. “Data size” is the negotiated IrLAP data size parameter. The MTU is determined independently for each direction of transfer.

Table 11—MTU size

Data size	SAR supported	MTU
Any	Yes	1496
64	No	64
128	No	128
256	No	256
512	No	512
1024	No	1024
2048	No	1496

The selected MTU may constrain the use of the transport profile by the client. An MTU smaller than 1024 may be inadequate for some applications. IrLAP negotiates the most favorable link possible. If the negotiated link is inadequate for any client application, then the link fails.

9.2 Transport service requirements

The transport service requirements provide support for connection, flow control, data transfer, and disconnection. The transport layer shall provide the service primitives described in Table 12. The status of the transport layer service primitives provided by a BCC or DCC is specified as follows:

O: Optional
M: Mandatory
C: Conditional

Table 12—Transport layer service requirements

Service primitives	Status	
	BCC	DCC
Connection		
TTP_Connect.request(called TTPSAP, requested QoS, calling max SDU size, calling user data)	M	C[a]
TTP_Connect.confirm(called TTPSAP, resultant QoS, called max SDU size, called user data)	M	C[a]
TTP_Connect.indication(calling TTPSAP, resultant QoS, calling max SDU size, calling user data)	C[a]	M
TTP_Connect.response(calling TTPSAP, called max SDU size, called user data)	C[a]	M

Table 12—Transport layer service requirements *(continued)*

Flow control		
TTP_LocalFlow.request(flow)	M	M
Data transfer		
TTP_Data.request(user data)	M	M
TTP_Data.indication(user data, status)	M	M
TTP_UData.request(user data)	C[a]	C[a]
TTP_UData.indication(user data)	C[a]	C[a]
Disconnection		
TTP_Disconnect.request(user data)	O[b]	O[b]
TTP_Disconnect.indication(reason, user data)	M	M

[a]Indicated service is required in a BCC or DCC that supports SNTP.
[b]An IrLAP disconnect may be used in place of a TinyTP disconnect.

9.3 MDDL service

The MDDL SAP is provided by the DCC and used by the BCC to establish a connection for MDDL upper layer communications. This connection is established and confirmed using the connection service primitives identified in Table 12.

10. Time synchronization

Some applications of MIB may require precise synchronization of the DCC time-of-day clock with the BCC time-of-day clock. Synchronization shall be accomplished using the unicast communication mode of the SNTP Version 4. The use of this time-synchronization service by BCCs and DCCs is identified in Table 13.

Table 13—SNTP services

Service	BCC	DCC
SNTP server	Recommended	N/A
SNTP client	N/A	Optional

NOTE—The method by which a BCC obtains its time directly impacts the quality of the time service provided to a DCC. However, that method is out of the scope of this document.

The SNTP protocol described in RFC-2030 is a subset of the complete network time protocol (NTP) described in RFC-1305. RFC-2030 is the governing document regarding the SNTP protocol and message format.

For recommendations regarding the use of SNTP, see Annex N.

SNTP uses a 48-octet NTP message format. In client-server mode, the client (DCC) sends a 48-octet SNTP request to the server (BCC), and the server responds with a 48-octet SNTP reply. These messages are sent and received using the TinyTP service primitives

TTP_UData.request(user data)
TTP_UData.indication(user data)

The Udata service is an expedited, connection-oriented service. An expedited service is preferred over a reliable service in order to minimize communications latency.

NOTE—An implementation should strive to minimize delays that reduce the quality of the time synchronization. The IrDA TTP_Udata service primitives are mapped directly onto the IrLMP service primitives.

The SNTP service is connection-oriented and is assigned a separate SAP in order to prevent interference with the MDDL protocol. In order to support this capability, the IAS in a BCC shall support the SNTP object and attributes described in Clause 8.

11. Labeling and conformance requirements

This clause defines the labeling and conformance requirements for this standard.

11.1 Labeling requirements

The following specification information shall be provided with the documentation for a BCC or DCC:

a) Number of ports

b) Power supplied: zero-power, low-power, high-power

c) Power drawn (specify rating)

d) Connection sense supported (yes/no)

e) EUI-64 global identifier number supported (yes/no)

f) IrDA profile, as described in Annex M

g) SNTP supported (yes/no)

11.2 Conformance requirements

Conformance to the requirements described in this standard shall be ensured by means of conformance testing.

Conformance requirements for IrDA components can be found in Annex M.

Annex A

(normative)

Physical layer

This annex is intended to specify the physical link layer through relevant references or conformance specifications. The physical layer of ISO/IEEE 11073-30200 provides a full-duplex, short-haul, asynchronous serial binary data interchange.

A.1 Overview

The physical layer provides point-to-point data transmission between the BCC and DCC using an eight-pin RJ-45 modular connector. This layer also supports optional connection sensing and power delivery.

A.1.1 ANSI/TIA/EIA-232-F-1997 (RS-232)

The majority of today's medical devices communicate with ANSI/TIA/EIA-232-F-1997 (known as RS-232) due to its low hardware cost and ubiquitous nature. The RS-232 signals TxD and RxD are provided as a standard capability. Thus, it is possible to directly connect to the majority of RS-232 compatible medical devices without the need for adapter boxes.

A.1.2 DC power

Several power delivery profiles are specified to support a wide variety of devices and applications, ranging from the power that can be extracted from the RTS and DTR pins of a standard communications port to higher levels that can power small devices used in the clinical environment.

The BCC and DCC may also separately power their respective ends of a line accessory. Examples of such line accessories include fiber-optic, radio frequency (RF), and other short-haul serial line interfaces. The power profiles to support these features are

a) Zero-power. The communications controller provides no power.

b) Low-power. The power levels typically provided by the RTS and DTR pins of a standard communications port. This power can be provided for low-power serial line interfaces and converters.

c) High-power. +5 V ± 5% at 100 mA. This power can be provided to devices that have modest power requirements, such as remote controls, bar-code readers, sensors, and other signal and protocol converters.

A.1.3 Connection sensing

This standard provides support for either a BCC or DCC to sense a completed physical connection. Connection sensing does not require the sensed device to be powered. This capability can be used to provide informative messages to the user, such as "please turn on the device" or "communication error."

A.1.4 10BASE-T

This standard provides a measure of compatibility with high-speed data communication using 10BASE-T as defined in Clause 14 of IEEE Std 802.3, 1998 Edition.

A.1.5 Physical configurations

The standard supports a physical interface that can be used in a wide variety of configurations. The simplest medical device performs RS-232 communications and has no power requirements at the interface. This class of devices is illustrated in Figure A.1.

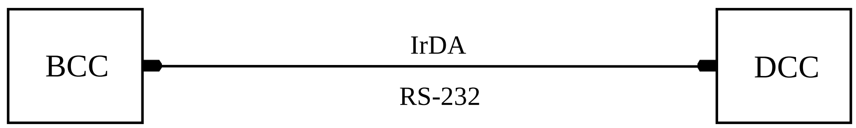


Figure A.1—Simplest physical configuration

Another type of medical device is a low-speed device that requires a modest amount of BCC power (BPWR) (i.e., +5 V) and RS-232 communication. Figure A.2 shows how an intravenous (IV) pump, urimeter, and other devices can be connected to a BCC without the need for an interface adapter or external power supply.

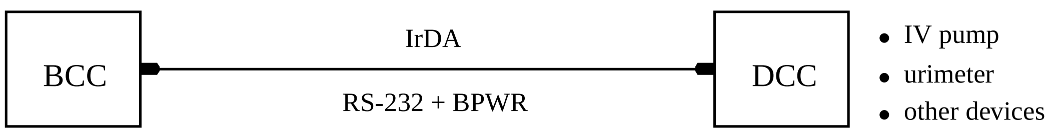


Figure A.2—Simple physical configuration for communications & power

Another important type of medical device is a legacy device that is not practical to modify. This device may use a proprietary interface, or it may support IEEE Std 1073.3.1-1994 and IEEE Std 1073.4.1-1994. The alternative approach is to use a protocol converter that converts the legacy interface to an ISO/IEEE 11073-30200 compliant interface, as shown in Figure A.3.

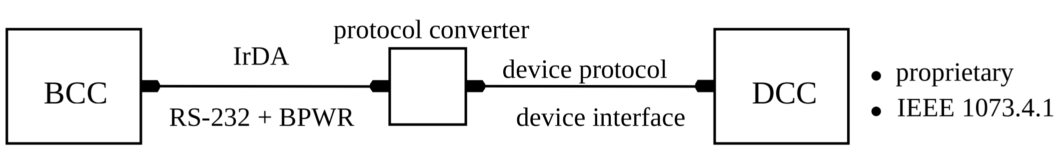


Figure A.3—Physical configuration with a protocol converter

The ability of the BCC and DCC to supply power (BPWR and DPWR) permits the use of many commercially available line-extender, line-isolator, and other adapters that require a small amount of power from the request to send (RTS) and data terminal ready (DTR) pins of the RS-232 port. This type of link can range from the simple optical isolator shown in Figure A.4 to a fiber-optic, infrared, or RF link as shown in Figure A.5.

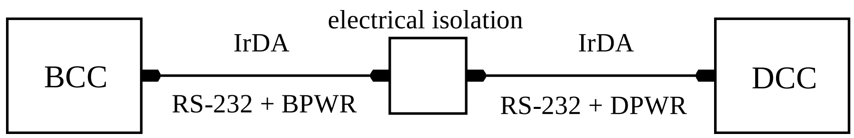


Figure A.4—Physical configuration with electrical isolation

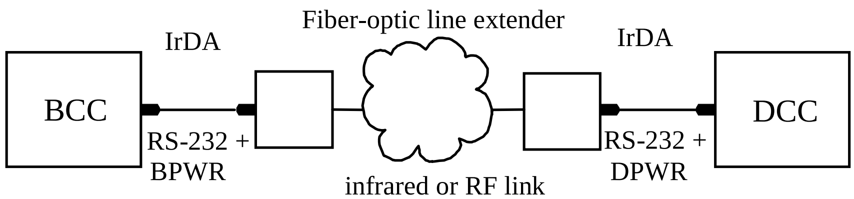


Figure A.5—Physical configuration with a line extender

A.2 Cable requirements

The cable-connected medium for this standard is specified in Table A.1. The status of each requirement is as follows:

M: Feature is mandatory
R: Feature is recommended

Refer to Annex B for additional cable characteristics and a discussion regarding cable length.

Table A.1—Cable requirements

Parameter	Requirement	Status
Cable	Eight conductor #24 American Wire Gage (AWG) unshielded twisted-pair (UTP) ANSI/TIA/EIA-568-A-1995 Category 5 (CAT-5)	M
Shielding	UTP	M
Conductor	Stranded	R
Crossover	None. Straight through pinning.	M
Length	≤ 20 m	M
Color	Yellow or neutral color	R
Connector	Eight-pin modular plug (RJ-45)	M

A.3 Connector requirements

Eight-pin modular connectors meeting the requirements of Clause 3 and Figure 1 through Figure 5 of ISO/IEC 8877:1992 shall be used as the mechanical interface (from section 14.5.1 of IEEE Std 802.3, 1998 Edition).

An eight-pin modular plug shall be used to physically terminate the cable. For a cable terminated at both ends, straight-through pinning is used, with twisted pairs 1-2, 4-5, 7-8, and 3-6. Because of their identical pair groupings, cables terminated per ANSI/TIA/EIA-568-A-1995 as T568A or T568B may be used interchangeably provided that both ends are terminated with the same pin/pair scheme.

In most cases, the cable has a connector on each end. In some cases, a permanently attached cable with a single connector may be appropriate.

Connecting hardware on the cable, BCC, or DCC shall meet or exceed the requirements of IEC 60603-7, performance level 1 (minimum 750 insertions).

NOTE—Connecting hardware on the cable, BCC, or DCC should meet the durability and reliability performance requirements suitable to the specific medical device application. IEC 60603-7 performance level 1 may be inadequate for some situations.

An eight-pin modular jack shall be used on the BCC, the DCC, and any communication or protocol adapters that directly connect to a cable conforming to this standard. The modular jack shall be rated according to the data transmission requirements of the BCC, DCC, and communication or protocol adapter in accordance with ANSI/TIA/EIA-568-A-1995.

Examples of the eight-pin modular jack and plug are shown in Annex C.

The electrical properties for the eight-pin modular connectors are summarized in Table A.2.

Table A.2—Selected RJ-45 connector electrical characteristics

Parameter (with mated contacts)	Value @ 20 °C
DC resistance R_c of mated connector[a]	< 50 mΩ
Maximum current capacity	≥ 1000 mA
Minimum current capacity	≥ 100 µA, with R_c < 50 mΩ
Insulation resistance	≥ 500 MΩ
DC or AC peak breakdown voltage[b]	≥ 1000 V

[a]Pin of jack to wire attached to plug; includes contact resistance.
[b]Contact-to-contact, mated connector.

This standard permits the use of communication interfaces and adapters that use other connector and pinout conventions. In these instances, adapters shall be used to convert to and from the standard eight-pin modular connector. Examples of these devices are shown in Annex C. Example adapter schematics are provided in Annex D.

Every ISO/IEEE 11073-30200 cable-connected communication link shall provide a demarcation point of an eight-pin modular jack serving as a BCC port.

For reasons of safety and convenience, devices (DCCs) and communication adapters may use permanently attached cables. For example, a hand-held bar-code scanner may have a permanently attached cable terminated at one end with an eight-pin modular plug that directly connects to the modular jack of a BCC. Unused lines do not need to be present in a cable that is permanently attached to a device (DCC).

A.4 Connector pin assignments and functions

ANSI/TIA/EIA-568-A-1995 Category 5 UTP cabling with straight-through pinning is used, with twisted pairs 1-2, 4-5, 7-8, and 3-6.

The eight-pin modular connector pin assignments are shown in Table A.3.

Table A.3—Modular connector pin assignments

BCC	Pin and signal direction	DCC
bRD+	1 ⇐	dDPWR/dTD+
bRD–	2 ⇐	dCS–/dTD–
bCS+/bTD+	3 ⇒	dRD+
bGND	4 ⇔	dGND
bRxD	5 ⇐	dTxD
bCS–/bTD–	6 ⇒	dRD–
bTxD	7 ⇒	dRxD
bBPWR	8 ⇒	dBPWR

A.4.1 Handshake signals

RS-232 handshake lines are not defined in this pin assignment and shall not be used for signaling. BCCs and DCCs may use inactive outgoing RS-232 handshake lines (i.e., RTS, DTR) to power signal converters and extenders. Handshake lines should be set to the asserted (i.e., positive output voltage) state if they are used to supply power. Incoming RS-232 handshake signals shall not be used.

A.4.2 Conventions for signal names and pin assignments

Signal names are preceded by “b” when they refer to the signal at the BCC end. They are preceded by “d” when they refer to the DCC end.

Where two signal names are given, separated by a slash, the first name is preferred and the second name is an alternative.

A.4.3 Signal names and functions

Signal names are summarized in Table A.4.

The RxD, TxD, and GND signals support the RS-232 serial data interface. BPWR and DPWR provide power for a line accessory or a DCC. Connection sense (CS) and DPWR provide connection sensing.

Table A.4—Signal names and functions

BCC connector	DCC connector	Function
bBPWR	dBPWR	Power from BCC
N/A	dDPWR	Power from DCC and sense BCC connection (+)
bGND	dGND	Signal ground
bRxD	dRxD	RS-232 data receive
bTxD	dTxD	RS-232 data transmit
bCS+	N/A	Sense DCC connection (+)
bCS–	dCS–	Connection sense (–)
bRD+	dRD+	10BASE-T receive data (+)
bRD–	dRD–	10BASE-T receive data (–)
bTD+	dTD+	10BASE-T transmit data (+)
bTD–	dTD–	10BASE-T transmit data (–)

This standard is compatible with a 10BASE-T interface, supported by the RD± and TD± signals (pins 1-2 and 3-6). A BCC port may be designed to support the ability to detect an ISO/IEEE 11073-30200 (RS-232) connection or a 10BASE-T connection and to communicate with either device. However, all 10BASE-T functions for BCCs and DCCs are out of the scope of this standard. Refer to Annex F for more information on the 10BASE-T interface.

A BCC can sense the connection of a DCC by testing the resistance across its bCS+ and bCS– pins. The alternative names bTD+ and bTD– indicate the 10BASE-T transmit data function.

A DCC may provide power on its dDPWR line to a line-extender or communications adapter. A DCC can sense its connection to a BCC by testing the resistance between its dDPWR and dCS– pins. The alternative names dTD+ and dTD– indicate the 10BASE-T transmit data function.

Pin assignments and functions are shown in schematic form in Figure A.6. BPWR, ground, and the RS-232 data signals are grouped together as four signals on two twisted-pairs.

A.4.4 BCC pin assignments and functions

The BCC shall transmit RS-232 data on bTxD and receive RS-232 data on bRxD; both signals shall be referenced to bGND.

The BCC may send power via a single bBPWR line using one of the three BCC power output options. This power can be used to power a DCC, serial line-extension adapter, or communications adapter.

The bRD± pins of the BCC shall be shorted together or terminated with $R < 110\ \Omega$ ($R = 100\ \Omega$ preferred) to allow a DCC to detect its connection to the BCC. A BCC port with 10BASE-T capability automatically satisfies this requirement due to the low dc resistance ($< 0.5\ \Omega$) of the bRD± input transformer windings.

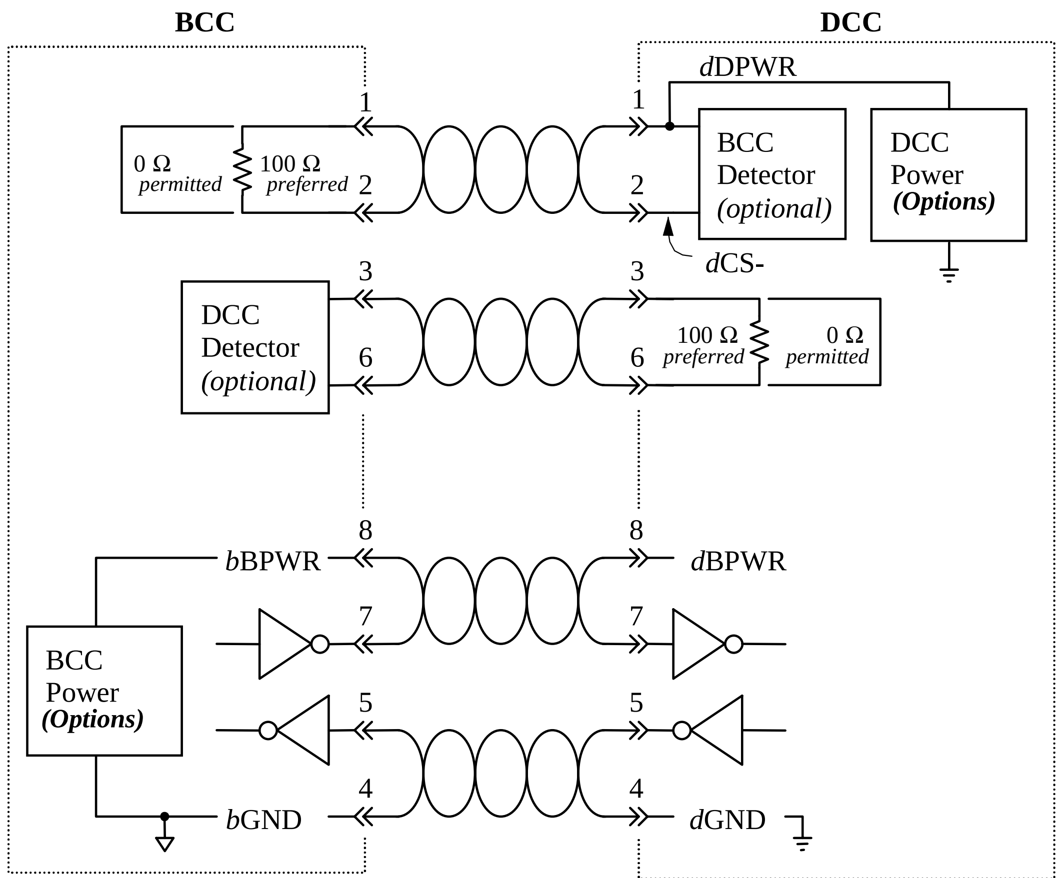


Figure A.6—Schematic of pin assignments and functions

A BCC may provide circuitry to sense the connection of a DCC by testing the dc resistance across its bCS+ and bCS– pins. The connection sense circuit in the BCC may assume that the termination or short provided by the dRD± pins of the DCC is not connected to any other internal DCC circuitry (i.e., there is no dc path to ground within the DCC).

A BCC that provides the zero-power option may tie bBPWR to bGND to provide an ac return for bTxD.

A.4.5 DCC pin assignments and functions

The DCC shall transmit RS-232 data on dTxD and receive RS-232 data on dRxD; both signals shall be referenced to dGND.

The DCC may send power via a single dDPWR line. This power can be used to power a serial line-extender or communications adapter.

The dRD± pins of the DCC shall be shorted together or terminated with R < 110 Ω (R = 100 Ω preferred) to allow a BCC to detect its connection to the DCC. The short or termination shall not be electrically connected to any other internal DCC circuitry (i.e., there is no dc path to ground). A DCC with 10BASE-T capability automatically satisfies this requirement due to the low dc resistance (< 0.5 Ω) of the dRD± input transformer windings.

A DCC may provide circuitry to sense its connection to a BCC by testing the dc resistance between its dDPWR and dCS– pins. For a DCC that provides power on its dDPWR pin, the connection sense circuit should tolerate or detect the reduced voltage on the dDPWR line due to a line extender or adapter that uses more current than dDPWR can provide. Alternatively, a DCC that provides the zero-power option (and does not have 10BASE-T capability) may tie dDPWR to dGND and apply a test current to its dCS– pin.

A.5 Driver/receiver electrical characteristics

The interface electrical characteristics for the RS-232 data transmit and data receive signals shall conform to the specifications in Table A.5.

Table A.5—Electrical characteristics for ANSI/TIA/EIA-232-F-1997

Parameter	Limit
Driver (bTxD and dTxD)	
Driver loaded output voltage (3 kΩ to 7 kΩ load)	$5\text{ V} \le \lvert V_{out} \rvert \le 15\text{ V}$
Driver open-circuit voltage	$\lvert V_{out} \rvert \le 25\text{ V}$
Driver short-circuit current (to ±15 V)	$\lvert I_{OSV} \rvert \le 100\text{ mA}$
Maximum driver slew rate	≤ 30 V/µs
Driver output resistance (power off)	≥ 300 Ω
Receiver (bRxD and dRxD)	
Receiver input resistance	3 kΩ to 7 kΩ
Maximum receiver input voltage	± 25 V
Receiver thresholds	± 3 V
Cable and receiver	
Maximum load capacitance C_L	2500 pF
NOTE—Specifications are from ANSI/TIA/EIA-232-F-1997.	

A.6 BCC and DCC power delivery

Three power delivery options exist:

a) *Zero-power.* The BCC or DCC does not provide power.

b) *Low-power.* The BCC or DCC offers power levels that are typically provided by the parallel connection of RTS || DTR or a single RTS or DTR pin of a standard RS-232 communications port. This option is defined in Table A.6.

c) *High-power.* The BCC or DCC offers dc power of +5 V ±5% at 100 mA, as defined in Table A.7. This power can be used for a wide range of devices that have modest power requirements.

The status of each parameter in Table A.6 and Table A.7 is specified as follows:

M: Mandatory
R: Recommended

Table A.6—Specifications for low-power dc power

Parameter	Limit	Status[a]	Vertex[b]
Minimum low-power output current[c]	3 mA @ 5 V	M	B
Minimum open-circuit output voltage[d]	8 V	R	A
Minimum short-circuit current (to ground)[d]	5 mA	R	C
Maximum short-circuit current (to ground)[e]	120 mA	R	D
Maximum open-circuit output voltage[f]	15 V	M	E, F

[a]The mandatory or recommended status applies only if the low-power option is implemented.
[b]The vertex labels listed in this column refer to Figure A.7 and are shown for information only. The vertex E current of 10 mA shown in Figure A.7 is derived from the ANSI/TIA/EIA-232-F-1997 maximum output voltage of 15 V across a 3 kΩ load (5 mA for a single driver or 10 mA for two drivers).
[c]This parameter specifies the guaranteed amount of current available from a low-power BCC or DCC at 5 V. This value can be achieved by using two drivers that strictly meet the 5 V/3 kΩ (1.7 mA) at 5 V minimum required by ANSI/TIA/EIA-232-F-1997 using a parallel RTS || DTR configuration or a single contemporary RS-232 driver that meets the 3 mA at 5 V specification.
[d]These values represent contemporary RS-232 driver performance.
[e]This defines the maximum short-circuit current (to ground) that could be delivered by two drivers in a parallel RTS || DTR configuration and is twice the 60 mA short-circuit current (to ground) specified in Section 3.1.4 of ANSI/TIA/EIA-562-1989 for a single RS-232 driver.
[f]The maximum open-circuit voltage of 15 V is less than the 25 V permitted by ANSI/TIA/EIA-232-F-1997.

Table A.7—Specifications for high-power dc power

Parameter	Limit	Status[a]	Vertex[b]
Minimum output voltage[c]	+4.75 V	M	X, Y
Maximum output voltage[c]	+5.25 V	M	Z
Minimum output current	100 mA	M	Y
Maximum output current	500 mA	M	Z

[a]The mandatory or recommended status applies only if the high-power dc option is implemented.
[b]The vertex labels listed in this column refer to Figure A.7 and are shown for information only.
[c]These voltage limits include any variation due to ripple or inadequate load regulation.

These specifications are shown for information only in Figure A.7. The low-power option is illustrated by the closed polygon ABCDEF using the limits specified in Table A.6 and shows the worst-case limits for contemporary RS-232 drivers operating with a ±15 V supply. Segments A-B-C delineate the guaranteed amount of power available from a low-power BCC or DCC using a single RTS or DTR pin as a power source. Currents and voltages in the shaded region are not guaranteed for all RS-232 drivers. Segments D-E-F delineate the maximum amount of power that could be delivered by a BCC or DCC that uses both RTS and DTR pins as a power source and may be used as a guide for determining worst-case power dissipation.

The polygon XYZ illustrates the lower and upper limits for a high-power +5 V ±5% supply that has a minimum output current of 100 mA and a maximum output current of 500 mA.

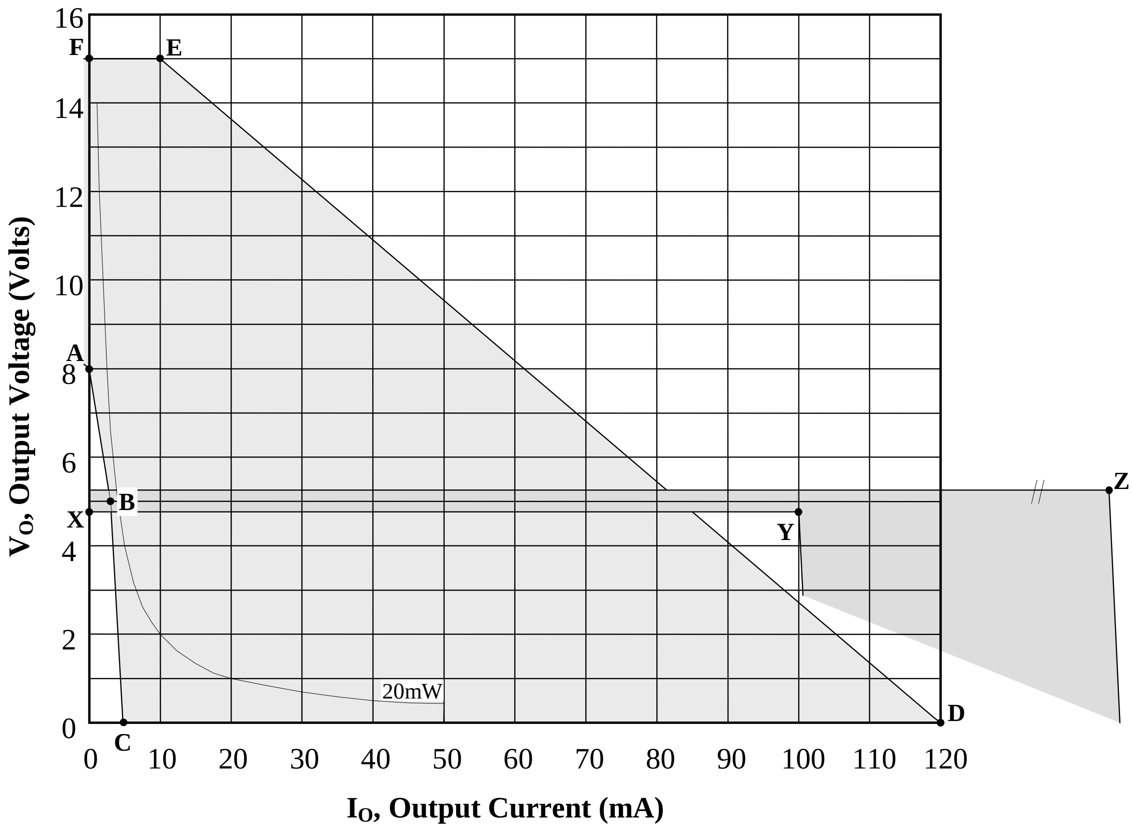


Figure A.7—Voltage and current limits for low-power and high-power (informative)

A.7 Electromagnetic compatibility (EMC)

The implementation of ISO/IEEE 11073-30200 shall not interfere with the equipment's ability to comply with applicable EMC standards.

A.8 Electrostatic discharge (ESD) immunity

The implementation of ISO/IEEE 11073-30200 shall not interfere with the equipment's ability to comply with applicable ESD standards.

A.9 Serial data communication

A.9.1 Signaling speed

A BCC or DCC may support one or more of the following signaling speeds: 9600 Bd, 19 200 Bd, 38 400 Bd, 57 600 Bd, or 115 200 Bd. At a minimum, BCCs and DCCs shall support 9600 Bd.

A.9.2 Transmission format

The transmission between BCCs and DCCs shall consist of contiguous octets. The octets are transmitted asynchronously.

A.9.3 Octet encoding

Octet encoding shall use start/stop encoding. Each octet shall be encoded to include a start bit (logic ‘0’, represented by a positive voltage), followed by eight data bits, followed by a stop bit (logic ‘1’, represented by a negative voltage). The bits of an octet are transmitted synchronously. The least significant bit (LSB) is transmitted first. The eight data bits may be logic ‘0’ or ‘1’.

Annex B

(informative)

Maximum cable length

The limitations imposed on cable lengths due to the principal MIB capabilities (RS-232 and dc power delivery) are shown in Table B.1.

Table B.1—MIB cable lengths using CAT-5 #24 AWG cable

Cable characteristics	Maximum length
ANSI/TIA/EIA-232-F-1997[a] CAT-5 UTP @ 84 pF/m, 2500-100 pF[b]	28 m
Dc power (100 mA from +4.75 V high-power BCC) to +4.50 V delivered to DCC to +4.35 V delivered to DCC	 12 m 20 m

[a]The capacitance per-unit length estimates are based on CAT-5 UTP cable with a mutual capacitance C_m = 56 pF/m. The capacitance for TxD and RxD with all other pins tied to GND is $C_s = 1.5 \times C_m$ = 84 pF/m. A terminating capacitance C_{st} = 100 pF is allocated for the receiver and connector capacitance on RxD.
[b]The capacitance for TxD and RxD for a shielded twisted pair cable with a foil shield with all other pins and shield tied to GND is $C_s = 1.8 \times C_m$ = 100 pF/m, resulting in a maximum cable length of about 24 m.

Based on the results shown in Table B.1, a 20 m CAT-5 cable will support any ISO/IEEE 11073-30200 capabilities for any off-the-shelf RS-232 transceiver that is operated at data rates specified with a load (shunt) capacitance of 2500 pF.

The maximum cable length can be calculated by using the fundamental electrical parameters shown in Table B.2.

Table B.2—Selected cable electrical specifications

Property	Value @ 20 °C
Characteristic impedance Z_0 of pair[a]	100 Ω ± 15%
Mutual capacitance C_m of pair[a]	≤ 5.6 nF per 100 m
Dc resistance R_w of #24 AWG wire[a]	≤ 9.38 Ω per 100 m
Dc resistance R_c of mated connector	≤ 50 mΩ[b]
Shunt capacitance C_s in CAT-5 UTP cable[c]	≤ 8.4 nF per 100 m ($1.5 \times C_m$)[d]
Terminating capacitance C_{st} for TxD or RxD	≤ 100 pF

[a]ANSI/TIA/EIA-568-A-1995 specification for a CAT-5 #24 AWG cable.
[b]This value is less than the ANSI/TIA/EIA-568-A-1995 specification.
[c]All other pins tied to GND; cable placed over ground plane.
[d]$1.5 \times C_m$ was obtained experimentally.

According to A.1.4 of ANSI/TIA/EIA-232-F-1997, the total load capacitance of the TxD or RxD lines is given by Equation (B.1).

$$C_L = C_s \times L + C_{st} \quad \text{(B.1)}$$

where

C_L is the total load capacitance for the cable,
C_s is the shunt capacitance as specified in Table B.2,
C_{st} is the terminating capacitance for the cable as specified in Table B.2,
L is the length of the cable.

For new designs, the RS-232 driver should be rated for 120 kBd for a load capacitance of 2500 pF.

According to A.1.4 of ANSI/TIA/EIA-232-F-1997, the total loop resistance R_{loop} for dc power delivery is given by Equation (B.2).

$$R_{loop} = 2 \times (R_w \times L + 2 \times R_c) \quad \text{(B.2)}$$

where

R_{loop} is the total loop resistance,
R_w is the dc resistance of the cable wire,
R_c is the dc resistance of the mated connector,
L is the length of the cable.

A 20 m cable and mated connectors would have a total loop resistance of 3.95 Ω, or less than 4.0 Ω. As a result, at least +4.35 V is delivered to a DCC that draws 100 mA over a 20 m cable from a high-power BCC supply at its minimum voltage of +4.75 V.

Annex C

(informative)

Modular connectors

C.1 RJ-45 plug and jack

Figure C.1 shows an example of the standard eight-pin modular plug. Figure C.2 shows an example of the standard eight-pin modular jack.

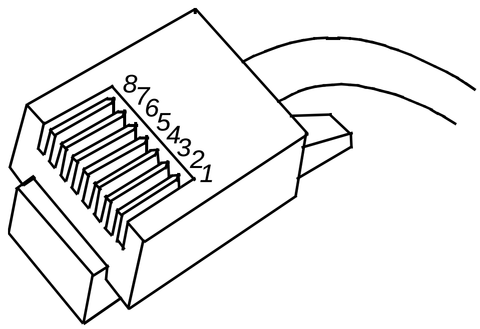


Figure C.1—Eight-pin modular plug used on cables

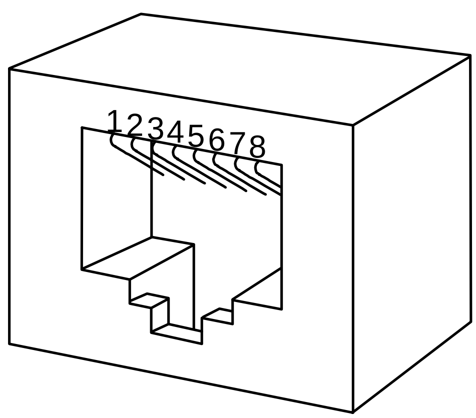


Figure C.2—Eight-pin modular jack

C.2 Connector adapters

Figure C.3 and Figure C.4 show examples of connectors commonly used in legacy medical devices. Modular adapters are commercially available to convert DB-9 and DB-25 connectors to the RJ-45 connector.

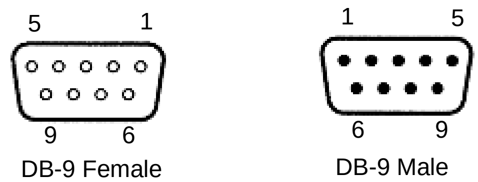


Figure C.3—DB-9 connectors, mating side

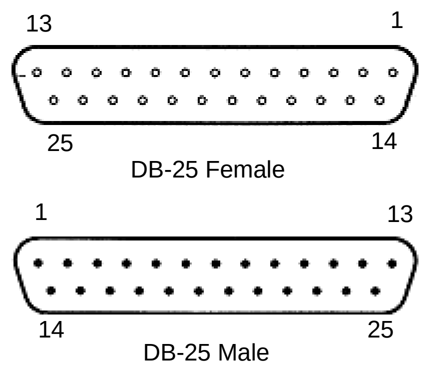


Figure C.4—DB-25 connector, mating side

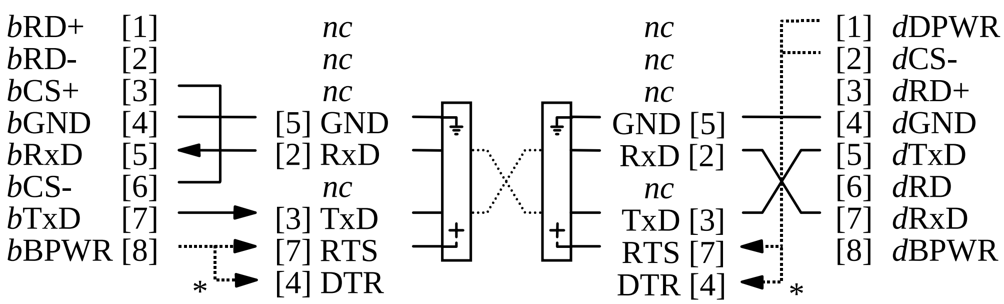
Annex D

(informative)

RJ-45 to DB-9 modular adapters

This annex provides several examples of how a RJ-45 modular adapter can be used to adapt legacy devices and components.

Figure D.1 shows an example of an adapter that may be used to convert an ISO/IEEE 11073-30200 port into a data terminal equipment (DTE) DB-9M for use with an off-the-shelf line interfaces or adapters.

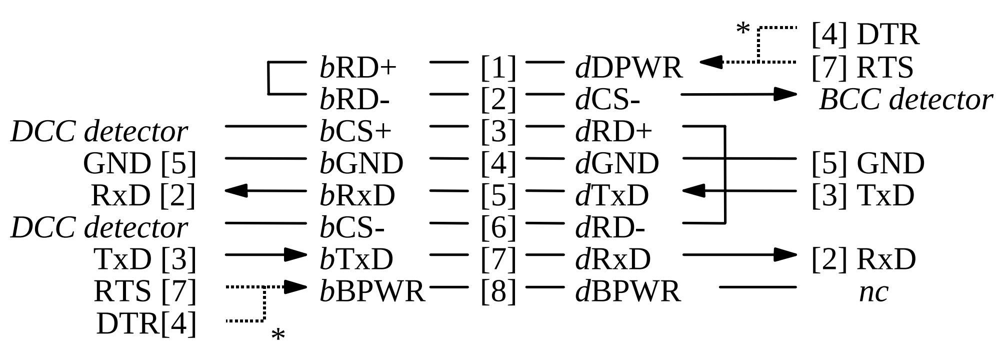


BCC to DTE DB-9M [fiber optic] DTE DB-9M to DCC
line-extender

* *connection to DTR is optional*

Figure D.1—Sample adapters for a line extension

Figure D.2 shows an example an adapter that may be used to convert a DTE DB-9M serial communications port into an ISO/IEEE 11073-30200 port.



DTE DB-9F to BCC [MIB Cable] DCC to DTE DB-9F

* *connection to DTR is optional*

Figure D.2—Sample adapters for a DCC or BCC port

Annex E

(informative)

Detailed rationale for pin assignments

This annex provides a detailed rationale for the pin assignments provided in Annex A.

Pins 1, 2, 3, and 6 conform to 10BASE-T pin assignments. These pin assignments allow for direct connection of 10BASE-T devices and other equipment in an architecturally consistent manner. A BCC could be designed to support either an ISO/IEEE 11073-30200 (RS-232) connection or a 10BASE-T connection.

Using a cross-pinned host/hub connector allows straight-through cables to be used. Straight-through cables are much easier to use in a clinical environment. The use of straight-through cables conforms to industry practice for off-the-shelf 10BASE-T hubs, which, incidentally, could be used with the proposed MIB connector pinout if only 10BASE-T functionality is required.

Pins 4 and 5 conform to ANSI/TIA/EIA-561-1990 pin assignments for Signal_Common and Received_Data. Assigning these signals to a twisted pair improves signal integrity favoring the data transfer direction that will be most frequently used (i.e., from DCC to BCC).

Assigning bTxD and bBPWR to pins 7 and 8, respectively, provides signal integrity benefits similar to pairing pins 4 and 5 (i.e., bBPWR serves as an ac return for bTxD).

Pairing bGND and bRxD to pins 4 and 5 and bTxD and bBPWR to pins 7 and 8 provides excellent device (DCC) survivability if a cross-connected cable is inadvertently used to connect the BCC and DCC. Also, locating dGND and dDPWR on pins 4 and 8, respectively, allows the DCC internal dGND and dDPWR circuit board traces to fully encircle the components (in the case of small single-layer board inside a modular adapter).

For a BCC capable of 10BASE-T and unpowered DCC detection, the bTD± 10BASE-T pair is used because any differential capacitance introduced by the detection circuit is tolerated better at the 10BASE-T transmitter than at the receiver. Any differential capacitance at the input windings of the receiver transformer would significantly reduce the overall common-mode rejection of the 10BASE-T receiver whereas it would have relatively little impact on the 10BASE-T transmitter.

Annex F

(informative)

10BASE-T

Figure F.1 shows an example use of a 10BASE-T interface, using the two line pairs 1-2 and 3-6. The 10BASE-T interface is specified in Clause 14 of IEEE Std 802.3, 1998 Edition.

High speed data communications is possible using a 10BASE-T interface. This standard does not prevent an ISO/IEEE 11073-30200 BCC port from also being used as a 10BASE-T interface. However, the 10BASE-T standard is out of scope for this standard.

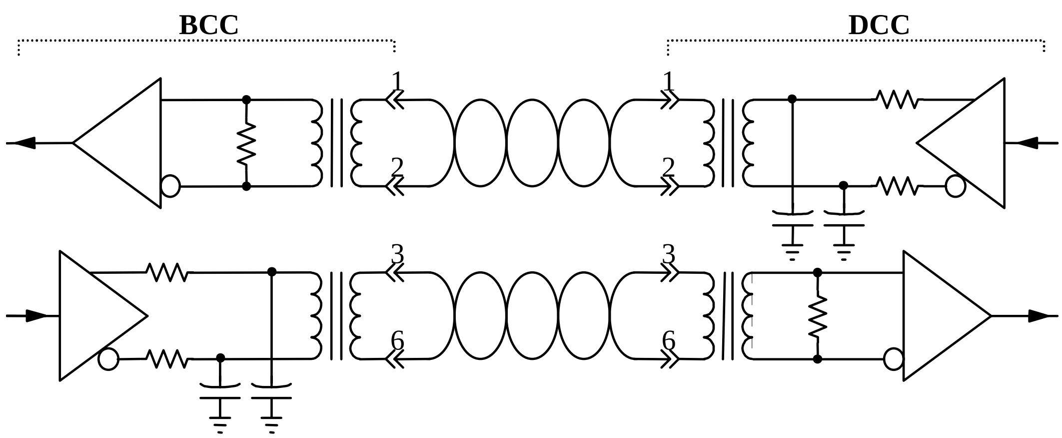


Figure F.1—10BASE-T Ethernet

NOTES

1—Detection of an unpowered DCC or BCC is still possible when 10BASE-T is used, but more complex circuitry is required.

2—This standard is not compatible with IEEE 802.3 standards that use all four twisted pairs, such as 100BASE-4.

Annex G

(informative)

Power delivery considerations

The low-power and high-power voltage and current requirements are specified relative to the output pins of the power source and not at the power input pins of the powered device or adapter. The maximum cable length of 20 m permitted by this standard has a dc loop resistance of 4 Ω (2 Ω each way, including mated connectors at both ends). See Annex B for a discussion regarding cable length.

Inadequate power supplied at the communications interface may result in undesired behavior. It is suggested that the powered device or adapter

a) Operate normally if voltage and current are sufficient to function correctly

b) Shut down if power is insufficient to function correctly

c) Simply not function at all if there is little or no power

A BCC that can detect the connection of a DCC may be able to identify situations where the device has insufficient power to function properly.

A powered device or adapter could incorporate a power-supply voltage-monitoring circuit to verify that the power delivered to it is within tolerance.

It is suggested that a powered device or adapter that is designed to run on a low-power supply also be designed for the possibly lower voltage available from a high-power supply.

A low-power supply may use a single RTS or DTR line (RTS is preferred) or it may use both RTS and DTR in a parallel configuration (RTS || DTR) to provide more current. In the latter case, a Schottky diode-OR connection of RTS and DTR should be used as it provides protection against polarity reversal.

Because the state of the RTS or DTR pins may be indeterminate on power-up, a powered device or communications adapter should also be able to tolerate a temporary reverse polarity condition on its power input pin(s). A protective Schottky diode may be connected across the powered device or adapter power input pins, and the BCC or DCC that is powering it should be able to tolerate this near short-circuit condition until it is initialized to the correct (positive) polarity. If necessary, a Schottky diode can be connected in series with the output of a low power BCC or DCC power source to protect it from the short circuit created by the protective diode in the powered device or adapter.

Annex H

(informative)

Nonisolated BCC and DCC design examples

Design examples for simple, non isolated BCC and DCC ports are shown in Figure H.1. RS-232 communication and DCC and BCC detection and power delivery are supported.

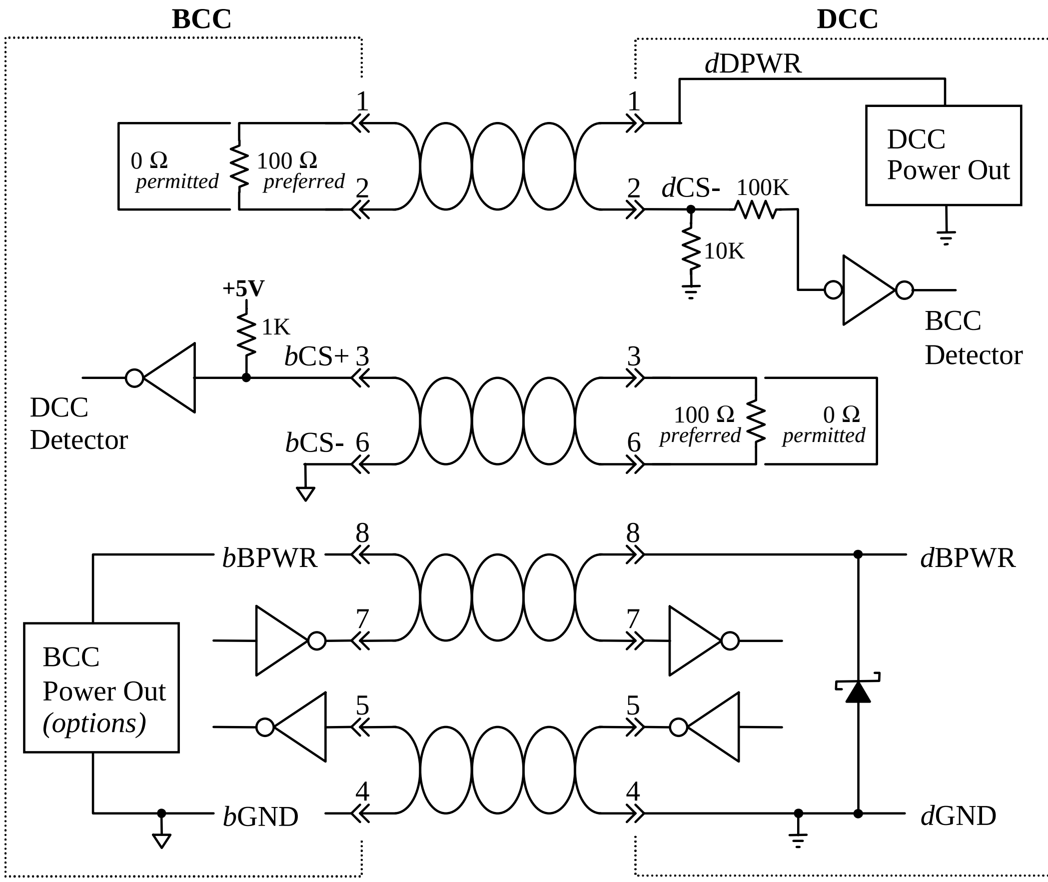


Figure H.1—Nonisolated BCC and DCC port implementation

NOTE—ESD, electromagnetic interference (EMI), and radio frequency interference (RFI) suppression circuitry for signal pins is not shown.

H.1 Nonisolated BCC design example

Although implementing the BCC circuitry to detect the connection of a DCC is not mandatory, it is relatively easy to implement by connecting a 1 kΩ pullup to the bCS+ pin and connecting the bCS– pin to bGND. When a DCC with a dRD± impedance less than 110 Ω is connected across the bCS± pins of the BCC port, bCS+ is asserted low and the output of the inverting "DCC detector" is asserted high. When the DCC is disconnected, the output of the inverting "DCC detector" is low.

A 100 Ω resistor terminates the bRD± lines to allow a DCC to detect its connection to the BCC. Although bRD± can be shorted, a 100 Ω terminating resistor provides damping for differential transients induced in that line pair.

H.2 Nonisolated DCC design example

Although implementing the DCC circuitry to detect its connection to a BCC is not mandatory, it is also relatively easy to implement. Because the dDPWR (dCS+) line may be used for delivering power to an external adapter or line interface, a 10 kΩ pull-down resistor is tied to the dCS– line. When a BCC with a bRD± impedance less than 110 Ω is connected across the dCS± pins of the DCC port, the dCS– line is pulled high and the output of the noninverting “BCC detector” is asserted high. When the DCC is disconnected from the BCC, the 10 kΩ resistor pulls the dCS+ low and the output of the noninverting “BCC detector” is low. The buffer used for the “BCC detector” should have high input impedance and input protection diodes; the 100 kΩ resistor provides protection against excessively high positive and negative input voltages if the DCC uses the low-power option to provide dDPWR.

The connection sense circuit should be able to tolerate or detect the reduced voltage on the dDPWR line due to a line extender or adapter that uses more current than dDPWR can provide. Although not shown in Figure H.1, the voltage on the dDPWR line can be monitored. The following statements would apply if dDPWR were too low:

a) A line interface or adapter is connected to the DCC.

b) It uses more current than dDPWR can provide.

c) The connection sense circuit output should be ignored because the voltage on dDPWR may be too low for it to function correctly.

A 100 Ω resistor terminates the dRD± lines to allow a BCC to detect the connection of the DCC. Although dRD± can be shorted, a 100 Ω terminating resistor provides damping for differential transients induced in that line pair.

Since it is possible for a BCC with a low-power supply to initially provide a negative voltage on the bBPWR line, a DCC may incorporate a Schottky diode to protect its circuitry. A BCC should be able to tolerate this “short-circuit” condition during the time that its output polarity is reversed.

H.3 Electrical isolation

For the sake of simplicity, a nonisolated connection between the BCC and DCC host circuitry is shown in Figure H.1. Although a nonisolated connection is not prohibited by this standard, it is highly recommended that at least one component (i.e., the BCC, the DCC, or a cable adapter) provide electrical isolation

a) If connection to the patient is anticipated, or

b) Where “ground-loops” between the BCC and DCC would compromise communications reliability.

Annex I

(informative)

Isolated BCC design example

An example circuit for an isolated BCC port is shown in Figure I.1. It supports RS-232 communication, DCC detection, and power delivery. Although not specifically required by this standard, the design is electrically isolated from the main host or hub circuit board and from other BCC ports.

An isolated dc-to-dc converter provides dc power to the isolated circuitry and to the bPWR line. Current limiting can be incorporated in the dc-to-dc converter, or a discrete 500 mA current-limiting device can be used. The data lines for the bTxD transmitter and bRxD receiver are also isolated. A spark gap and a 100 MΩ resistor provide ESD protection.

Although the circuitry to detect a DCC connection is not mandatory, it is relatively easy to implement. When a DCC with a dRD± impedance less than 110 Ω is connected across the bCS± pins of the BCC port, current flows through the 1 kΩ resistor and the photoemitter inside the bCS± optical isolator. In this case the optoisolator output is asserted (i.e., low), indicating connection of the DCC. The output is unasserted (i.e., high) if a DCC is not connected to the BCC port.

A 100 Ω resistor terminates the bRD± lines to allow a DCC to detect its connection to the BCC. Although dCS± can be shorted, a 100 Ω terminating resistor provides damping for differential transients induced in that line pair.

There are two important details regarding this design. First, the Schottky diode across the inputs of the bCS± optical isolator protects the photoemitter from reverse-bias damage due to ESD transients. Second, the 4.7 kΩ resistor biases the bCS+ line to the isolated power supply voltage to reduce the probability of false detection of a device.

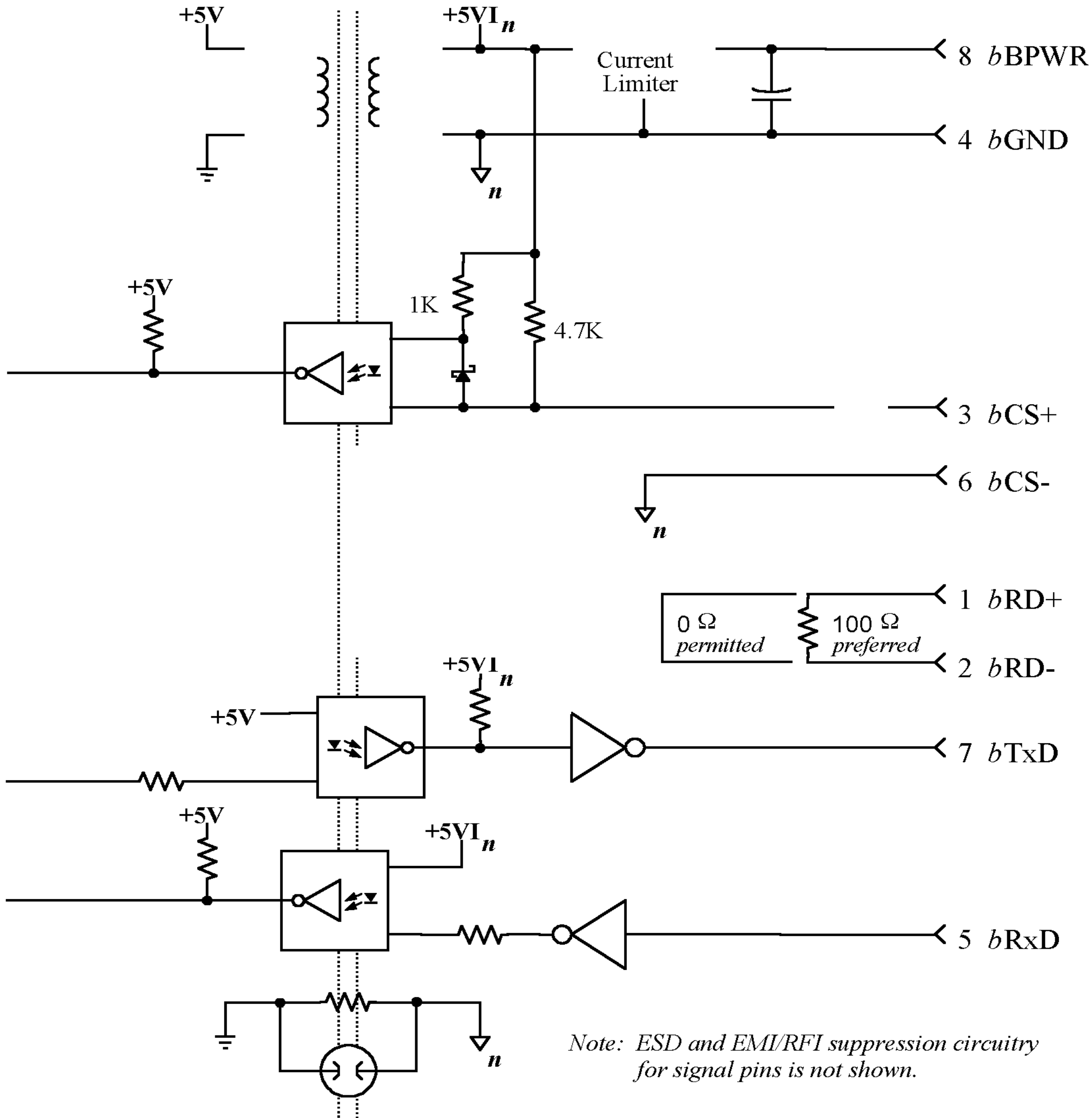


Figure I.1—An isolated BCC port implementation with data transmission, connection sensing, and supplied power

Annex J

(informative)

Optical isolator design example

One of the principal uses for BPWR and DPWR is to power an optical isolator. An example design for an optical isolator installed on the MIB cable between the BCC and DCC is shown in Figure J.1. This design could also be used for an isolator that directly attached to the DB-9F connector of a serial communications port. This design uses little power and can be powered by the modest current available from the RTS and/or DTR pins of a communications port.

The basic design was described in an article by Bolton [B1]. The circuit uses a push-pull configuration that supports high data rates without the need for power-consuming pullup resistors. The light-emitting diodes (LEDs) are driven directly by the bTxD and dTxD transmit signals, and the push-pull output stage consumes no quiescent current other than what is needed to drive the input resistance of the receivers dRxD and bRxD. The power supply current is low because the power supply drives only the output and not the LEDs, photo-detector, or any output buffers. When the incoming RS-232 signal is inactive, the LEDs and output transistors are off. An optocoupler with a minimum current transfer ratio of 100% at 1 mA should be used for this design.

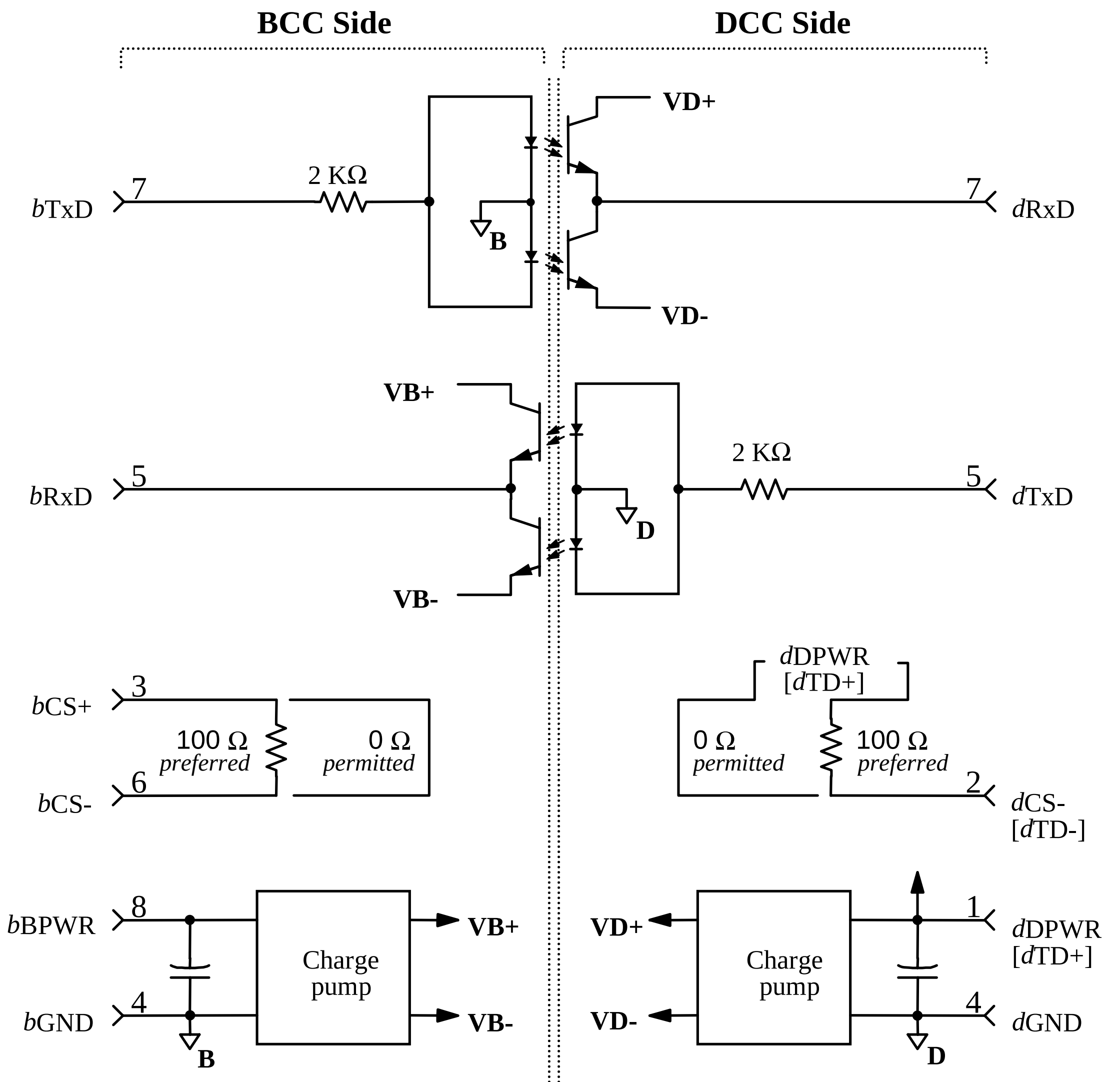


Figure J.1—Example design of an optical isolator

Annex K

(informative)

Marking guidelines

This annex describes physical media marking guidelines.

K.1 Labeling for ports, cables, and connectors

ISO/IEEE 11073-30200 ports, cables, and connectors should be labeled as shown in Figure K.1, Figure K.2, and Figure K.3. The shaded areas of these figures represent the color yellow.

The acronym “MIB” should be treated as part of the symbol; it should not be translated. It should appear in a sans serif typeface.

The color yellow should be used in addition to the symbol where feasible, e.g., as background for labels with the symbols or as the color of the cable, connectors, or adapters. The foreground (i.e., symbol, including text) color is black.

The alternate color scheme is a yellow symbol on a dark background.

The input symbol used with the BCC port is symbol number 5034, from IEC 60417-1:1998. The output symbol used with the DCC port is symbol number 5035.

NOTE—Labeling should not involve a variant of these guidelines. Variations are reserved for future ISO/IEEE 11073 standards.

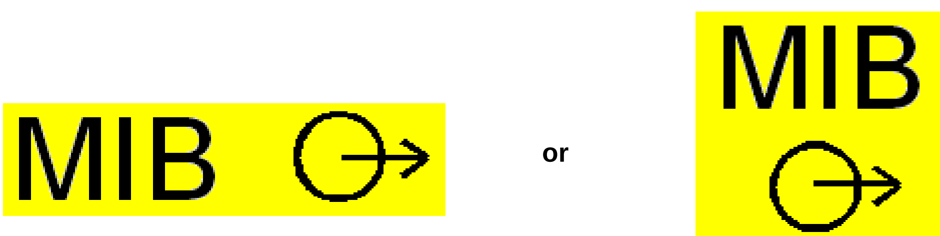


Figure K.1—MIB labeling on a DCC port

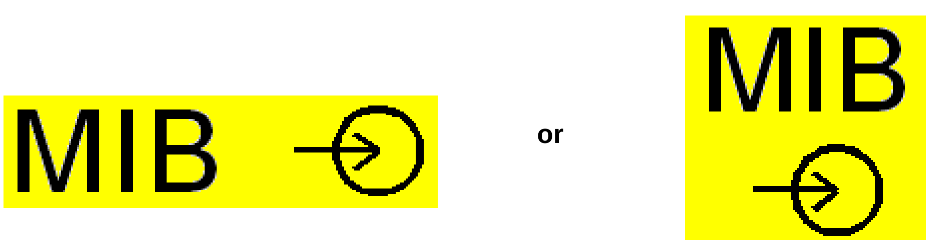


Figure K.2—MIB labeling on a BCC port

Figure K.3—MIB labeling on a cable or connector (both ends)

K.2 Labeling examples

Figure K.4, Figure K.5, Figure K.6, and Figure K.7 show examples of labeling for adapters, cables, and ports.

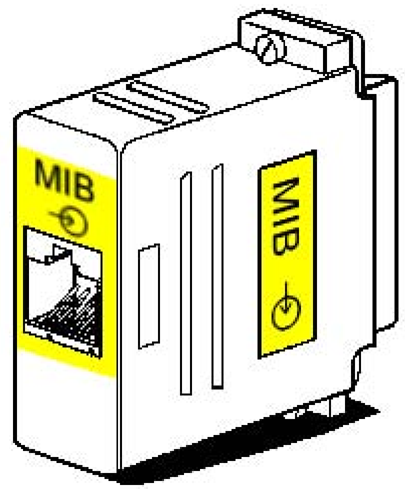


Figure K.4—Modular adapter (for BCC) with MIB labels

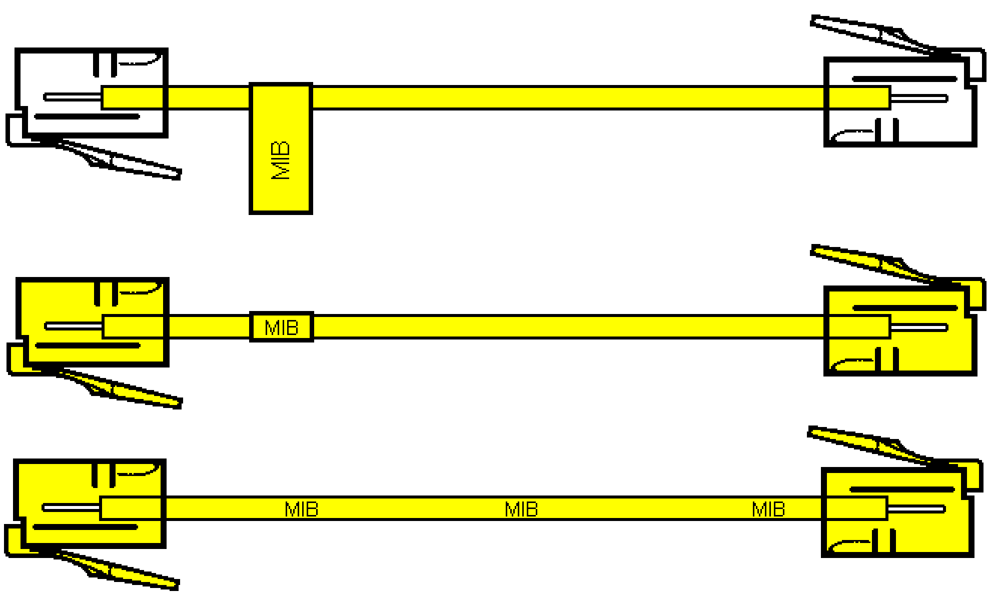


Figure K.5—Cables with MIB labeling

Figure K.6—DCC port with MIB marking

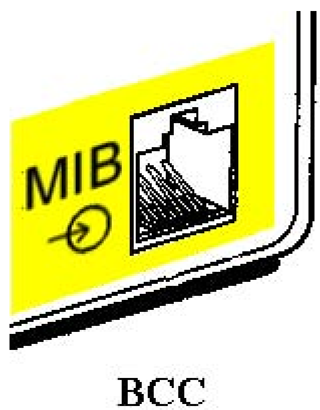


Figure K.7—BCC port with MIB marking

Annex L

(informative)

IrDA message examples

This annex includes message dumps for a typical connection establishment procedure between DCC and BCC. The message dumps are from the point of view of an IrLAP frame and include elements for that layer and the higher layers. The dumps do not include elements of the wrapping layer, namely the frame check sequence, framing characters, nor frame transparency.

L.1 Discovery

Discovery is done at a fixed signaling speed of 9600 Bd. The primary station (BCC) polls on slot 0 and receives a response from the secondary station (DCC).

— BCC: Poll for slot 0

```
ff              address: IrLAP broadcast addr. (0x7F << 1) + command bit
3f              control field: XID req
01              format field
28 62 00 00     source address
ff ff ff ff     destination address = any
00              flags: polling 1 slot
00              slot number
00              version
```

— DCC: Respond to slot 0

```
fe              address: IrLAP broadcast addr. (0x7F)
bf              control field: XID resp
01              format field
c4 69 00 00     source address
28 62 00 00     destination address
00              flags: polling 1 slot
00              slot number
00              version
80 10           service hints
00              character set = ASCII
4D 49 42 20 44  device nick name ("MIB DCC")
43 43
```

NOTE—This standard recommends the use of one slot as shown. IrLAP generally allows primary stations to perform discovery on 6, 8, or 16 slots as well.

— BCC: End discovery and send own discovery information

```
ff 3f 01 28 62 00 00 ff ff ff ff 00 ff 00
80 10           service hints
00              character set
4D 49 42 20 42  device nick name ("MIB BCC")
43 43
```

L.2 BCC opening an IrLAP connection

— BCC: SNRM (= Set Normal Response Mode)

```
ff              address: IrLAP broadcast addr. (0x7F << 1) + command bit
93              control field: SNRM req

28 62 00 00     source address
c4 69 00 00     destination address
a6              connect address
                negotiation parameters (format: id, len, value)
01 01 26        - signaling speed 9600, 19200, 115200
82 01 01        - max turnaround time
83 01 09        - data size = 64 or 512 Octets
84 01 00        - window size = 1
85 01 80        - additional BOFs
86 01 02        - min turnaround time = 5 ms
87 01 01        - (obsolete)
08 01 01        - link disconnect threshold = 3 s
```

— DCC: Response to SNRM

```
a6              address (0x53)
73              control field: SNRM resp
c4 69 00 00     source address
28 62 00 00     destination address
                negotiation parameters
01 01 26        - same as above
82 01 01
83 01 09
84 01 00
85 01 80
86 01 02
87 01 01
08 01 01
```

— Both BCC and DCC: set to a signaling speed of 115 200 Bd

L.3 BCC opening an IAS port

— BCC: Connect Request to Port 0 (IAS Port)

```
a7              address + command bit
10              control = I-frame
80              destination LSAP = 0 + control bit
60              source LSAP = 60
01 00           connect request
```

— DCC: IrLMP Connect Response

```
a6              address
30              control = I-frame
e0              destination LSAP + control bit
00              source LSAP
81 00           connect confirm
```

L.4 BCC performing an IAS query

The BCC queries IAS to determine the MDDL LSAP.

— BCC: IrLMP IAS GetValueByClass

```
a7              address + command bit
32              control = I-frame
00              destination LSAP
60              source LSAP
84              Lst=1, Ack=0, LM_GetValueByClass(ClassName, AttributeName)
12              length = 18
49 45 45 45 3a  "IEEE:1073:3:2:MDDL"
31 30 37 33 3a
33 3a 32 3a 4d
44 44 4c
13              length = 19
49 72 44 41 3a  "IrDA:TinyTP:LsapSel"
54 69 6e 79 54
50 3a 4c 73 61
70 53 65 6c
```

— DCC: IrLMP IAS GetValueByClass Response

```
a6              address
52              control = I-frame
60              destination LSAP
00              source LSAP
84 00           LM_GetValueByClass returns success
00 01           return list length
00 01           object identifier
01              return type = integer
00 00 00 04     return value = 4
```

L.5 BCC closing the IAS port

In this example, the BCC closes the IAS port after use because it will not be needed further.

— BCC: IrLMP Close Request (to port #0)

```
a7              address + command bit
54              control = I-frame
80              destination LSAP + control bit
60              source LSAP
02              disconnect request
01              reason = user request
```

— DCC: Returns receive ready

```
a6              address
71              control = RR (receive ready)
```

— BCC: Holds the connection active (no upper level data to transmit)

— BCC: Polls with receive ready

```
a7              address + command bit
11              control field: RR (receive ready)
```

— DCC: Returns receive ready

```
a6             address
11             control field: RR (receive ready)
```

— BCC polling is repeated every polling interval [11]

L.6 BCC opening a TinyTP connection

— BCC: I frame with TinyTP/IrLMP Connect request

```
a7             IrLAP address + command bit
10             IrLAP control = I frame
91             IrLMP Dest LSAP   (0x11 plus C bit)
60             IrLMP Source LSAP
01             IrLMP CONNECT PDU
03             TinyTP Parameterless connect PDU, credit=3
00             client data (unused)
```

— DCC: I frame with TinyTP/IrLMP Connect response

```
a6             address
30             control = I frame
e0             IrLMP Dest LSAP   (0x60 plus C bit)
11             IrLMP Source LSAP
81             IrLMP CONNECT PDU confirm
02             TinyTP Parameterless connect response, credit=2
00             client data (unused)
```

L.7 BCC begins with MDDL communication

— BCC: TinyTP/IrLMP data frame in IrLAP I frame

```
a7             IrLAP address + command bit
32             IrLAP control = I frame
11             IrLMP Dest LSAP
60             IrLMP Source LSAP
00             TinyTP Data PDU, delta credit=0
0d b6 05 08 13 application data (MDDL Association Request)
01 00 16 01 02
80 00 14 02 00
02 c1 a6 31 80
a0 80 80 01 01
00 00 a2 80 a0
03 00 00 01 a4
80 30 80 02 01
01 06 04 52 01
00 01 30 80 06
02 51 01 00 00
00 00 30 80 02
01 02 30 80 02
01 02 06 0c 2a
86 48 ce 14 02
01 00 00 00 01
01 30 80 06 0c
2a 86 48 ce 14
```

[11] If the client does not receive this message within the maximum turnaround time, then it starts the 3 s link disconnect timer.

```
02 01 00 00 00
02 01 00 00 00
00 00 00 61 80
30 80 02 01 01
a0 80 60 80 60
80 a1 80 06 0c
2a 86 48 ce 14
02 01 00 00 00
03 01 00 00 be
80 28 80 06 0c
2a 86 48 ce 14
02 01 00 00 00
01 01 02 01 02
80 00 00 00 40
00 00 00 00 00
00 00 80 00 00
00 00 00 00 00
```

— DCC: Returns receive ready

```
a6             address
11             control field: RR (receive ready)
```

— BCC: Holds the connection active (waiting for MDDL response)

— BCC: Polls with receive ready

```
a7             address + command bit
12             control field: RR (receive ready)
```

— DCC: TinyTP/IrLMP data frame in IrLAP I frame

```
a6             IrLAP address
52             IrLAP control = I frame
60             IrLMP Dest LSAP
11             IrLMP Source LSAP
00             TinyTP Data PDU, delta credit=0
0e 98 05 08 13 application data (MDDL Association Response)
01 00 16 01 02
80 00 14 02 00
02 c1 88 31 80
a0 80 80 01 01
00 00 a2 80 a0
03 00 00 01 a5
80 30 80 80 01
00 81 02 51 01
00 00 30 80 80
01 00 81 02 51
01 00 00 30 80
80 01 00 81 0c
2a 86 48 ce 14
02 01 00 00 00
02 01 00 00 00
00 61 80 30 80
02 01 01 a0 80
61 80 a1 80 06
0c 2a 86 48 ce
14 02 01 00 00
00 03 01 00 00
a2 03 02 01 00
a3 05 a1 03 02
```



```
01 00 be 80 28
80 02 01 02 80
00 00 00 40 00
00 00 00 00 00
00 80 00 00 00
00 00 00 00
```

L.8 BCC closes IrLAP connection

— BCC: IrLAP DISC

```
a7              address + command bit
53              control = DISC req
28 62 00 00     source address
c4 69 00 00     destination address
```

— DCC: Response to IrLAP DISC

```
a6              address
73              control = DISC resp
c4 69 00 00     source address
28 62 00 00     destination address
```

— Upper level connection aborted automatically

Annex M

(normative)

IrDA profile

This annex is adapted from the Implementation Guide for IrDA Standards [B3]. It is intended to include specifications pertaining to the ISO/IEEE 11073-30200 IrDA profile and to be used as a statement of conformance for ISO/IEEE 11073-30200 implementers.

The status of each IrDA function (see Table M.1, Table M.2, and Table M.3) is specified as follows:

O: Optional
M: Mandatory
R: Recommended
C: Conditional

M.1 IrLAP implementation

Please document results by circling the appropriate response(s):

Specification version: ____________________________

Table M.1—IrLAP conformance requirements

Function	BCC	DCC	Supported
Secondary station	N/A	M	Yes/no
Primary station	M	N/A	Yes/no
9600 Bd supported	M	M	Yes/no
Other signaling speeds supported (Bd)	O	O	19 200, 38 400, 57 600, 115 200
500 ms maximum turnaround supported	M	M	Yes/no
Other maximum turnaround supported (ms)	O	O	250, 100, 50
64 octets data size supported	M	M	Yes/no
Other data sizes supported (octets)	O	O	128, 256, 512, 1024, 2048
1 transmit frame window supported	M	M	Yes/no
Other transmit window sizes supported	O	O	2, 3, 4, 5, 6, 7
1 receive frame window supported	M	M	Yes/no
Other receive window sizes supported	O	O	2, 3, 4, 5, 6, 7
Number of BOF required @ 115 kb/s	Specify		48, 24, 12, 5, 3, 2, 1, 0
Minimum turnaround time (ms)	Specify		0, 0.01, 0.05, 0.1, 0.5, 1, 5, 10
3 s link disconnect time supported	M	M	Yes/no

M.2 IrLMP implementation

Please document results by checking the appropriate response(s):

Specification version: ________________

Table M.2—IrLMP conformance requirements

Function	BCC	DCC	Supported
Link management multiplexer	M	M	Yes/no
Device nickname	M	M	Yes/no (specify name)
Hint bit 12	M	M	Yes/no
IAS objects and attributes:			
Device			
DeviceName	M	M	Yes/no
IrLMPSupport	M	M	Yes/no
IEEE:1073:3:2			
GlobalID	R	R	Yes/no
NodeType	M	M	Yes/no
PortNumber	M	M	Yes/no
PollInterval	N/A	O	Yes/no
IEEE:1073:3:2:SNTP			
LsapSel	R	N/A	Yes/no
IEEE:1073:3:2:MDDL			
LsapSel	N/A	M	Yes/no
IAS services			
GetValue	R	R	Yes/no
GetValueByClass	M	M	Yes/no

M.3 TinyTP implementation

Specification version: ___________

Table M.3—TinyTP conformance requirements

Function	BCC	DCC	Supported
SAR	O	O	Yes/no
Flow control			
Connect	M	M	Yes/no
Disconnect	M	M	Yes/no
Data	M	M	Yes/no
LocalFlow	M	M	Yes/no
UData (required for SNTP)	C	C	Yes/no

M.4 Interoperability

List other IrDA devices with which the applicant device has been demonstrated to interoperate.

List other IrDA devices with which the applicant device has failed to be interoperable. Where possible document diagnosis of the failure.

M.5 Testing and quality assurance

Briefly describe why this device is compatible with the IrDA standard. What methods have been used to ensure IrDA compliance?

Has an independent test suite been used to validate this implementation? If yes, state which suite and attach sample results.

Describe any plans for regression testing for subsequent releases.

Annex N

(informative)

Time synchronization using SNTP

N.1 Introduction

Precision time synchronization is an important capability for the MIB to support. As MIB devices begin to proliferate, especially the devices with real-time waveform capability, it will be desirable to be able to acquire, analyze, and store waveforms and related events with a high degree of confidence that the data are accurately time-aligned.

Another use for a time-synchronization protocol is that it would allow a DCC to automatically verify, set, and periodically update its local clock using the clock in the BCC, which in turn could ultimately obtain its time from a highly reliable and accurate reference clock on the network. Time synchronization would be a major convenience for clinicians and would promote accurate and consistent time-stamps on medical records.

This annex describes the use of the Internet SNTP for time synchronization between MIB DCCs and BCCs. The SNTP described in RFC-2030 is a subset of the complete NTP described in RFC-1305. RFC-2030 is the governing document regarding SNTP and its message format; the purpose of this annex is to provide specific guidance and recommendations regarding the use of SNTP on the IEEE P1073.3.2 MIB.

N.2 SNTP and NTP

SNTP and NTP use a 48-octet NTP message format. In client-server mode, the client (DCC) sends a 48-octet NTP request to the server (BCC); and the server responds with a 48-octet reply, allowing timestamps to be recorded. These timestamps can be used to compute a local clock offset and roundtrip delay.

The offset measures the time difference between the client and server clocks. A small fraction of an individual offset measurement is used to update the time offset and drift of the client (DCC) local clock relative to the server (BCC) and ultimately to an NTP time server on the network. The update process (described in RFC-1305 and related publications) is robust and tends to assign the greatest weight to offset measurements with the shortest roundtrip delay because they would be the most accurate. In addition to the timestamps, the message includes warning flags about “leap seconds” and other information regarding the status and accuracy of the time server.

Although the preferred method for a BCC to obtain its time from the network would be to use SNTP or NTP, it is not required. A BCC can obtain its time using a different network protocol or even by using an unsynchronized local clock (as in the case of a transport monitor). Recommendations regarding the use BCC clocks that are not synchronized to a primary or secondary SNTP or NTP time server are provided in this annex.

N.3 Timestamp format

SNTP (and NTP) timestamps are represented by a 64 b unsigned fixed-point integer, in seconds relative to 0 h : 0 min : 0 s on 1 January 1900. The upper 32 b represent the integer number of seconds (secs) and the lower 32 b represent the fraction (frac). In the fraction part, the nonsignificant low order bits can be set to 0 or they can be filled with a random, unbiased bitstring to avoid systematic roundoff errors. The timestamp format is shown in Figure N.1.

msb lsb

Seconds integer
Seconds fraction

Figure N.1—SNTP timestamp format

This format can be easily processed using multiple-precision integer arithmetic. The maximum number that can be represented is 4 294 967 295 seconds with a precision of about 200 ps. After some time in 1968 (second number 2 147 483 648), the most significant bit (MSB) has been set, and the 64 b field will overflow some time in 2036 (second number 4 294 967 296). There will exist a 200 ps interval every 136 y when the 64 b field will be 0. A 64 b field of 0 shall by convention be interpreted as an invalid or unavailable timestamp.

Since the ISO/IEEE 11073 MIB standard did not exist until after 1968, an alternative convention (originally proposed in RFC-2030) shall be adopted to extend the useful life of the timestamp. If the MSB of the seconds integer is set, the coordinated universal time (UTC) is in the range of 1968 through 2036; and UTC time is reckoned from 0 h : 0 min : 0 s UTC on 1 January 1900. If the MSB is not set, the time is in the range of 2036 through 2104; and UTC time is reckoned from 6 h : 28 min : 16 s UTC on 7 February 2036. When calculating the correspondence, 2000 is not a leap year.

N.4 SNTP and NTP message format

Although SNTP and NTP both use the same message format, many of the fields are initialized with prespecified data when used with SNTP. The function of each field is briefly summarized in Figure N.2. RFC-2030 for SNTP and RFC-1305 for NTP should be consulted for a complete description of the SNTP and NTP message format. Following network and IrDA conventions, the most significant octet of each 32-bit integer is transmitted first.

N.5 DCC SNTP client operations

After the DCC establishes a connection for SNTP service from the BCC, the DCC sends an SNTP client request (mode 3) and expects an SNTP reply (mode 4). Requests are normally sent at intervals from 64 s to 1024 s, depending on the frequency tolerance of the DCC clock and the required accuracy.

N.5.1 DCC sends SNTP client request

The DCC can set all of the SNTP message fields to 0, except the octet containing the leap indicator (LI), version number (VN), and mode bits and (optional) Transmit Timestamp fields. The LI field is set to 0 (no warning) and the Mode field is set to 3 (client). The VN field should agree with the version number of the SNTP server; however, Version 4 servers will accept all previous versions and are required to reply in the same version as the request so the VN field of the request is preserved in the reply. SNTP Version 4 clients can interoperate with all previous version NTP and SNTP servers because the header fields used by SNTP clients are unchanged.

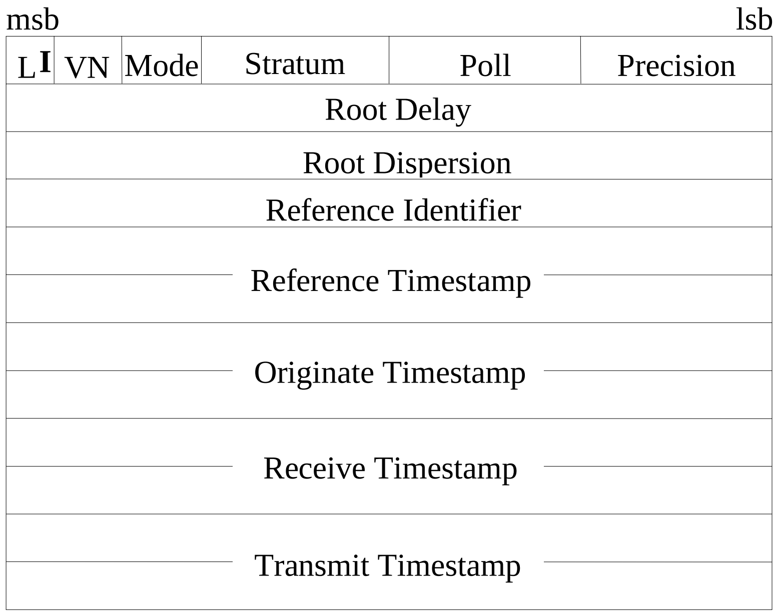


Figure N.2—SNTP message format (see Table N.1)

Table N.1—SNTP message format definitions

Name	Type_Width	Description
LI	b_2	Leap indicator and “clock not synchronized” warning: 00: no warning; 01: last minute has 61 secs; 10: last minute has 59 secs; 11: clock not synchronized
VN	u_3	SNTP and NTP version number { 3-4 }
Mode	u_3	Mode { use 3 for DCC client request; 4 for BCC server reply }
Stratum	u_8	Stratum level of local clock {1 primary; 2-15 secondary; 0 unspecified}
Poll	s_8	Poll interval, log2 seconds { typical range: 6 (64 s) to 10 (1024 s) }
Precision	s_8	Precision of local clock, log2 seconds {e.g., –6 (ac-mains) –20 (1 µs)}
Root Delay		Total roundtrip delay to primary reference signed secs<16>.frac<16>
Root Dispersion		Nominal error relative to primary reference unsigned secs<16>.frac<16>
Reference Identifier		Reference identifier {value depends on version number and stratum; see RFC-2030}
Reference Timestamp		Reference timestamp unsigned secs<32>.frac<32>
Originate Timestamp		Originate timestamp
Receive Timestamp		Receive timestamp
Transmit Timestamp		Transmit timestamp
NOTE—b_n bit field, u_n unsigned integer, s_n signed integer n bits wide.		

Immediately after noting the transmit timestamp (T1) of the request according to the client clock in NTP timestamp format, the DCC sends the SNTP client request to the BCC using TTP_UData.request(user data). While not necessary in a conforming client implementation, it is highly recommended that the transmit timestamp in the request be set to time T1. It is then a simple matter for the client to verify that the server reply is in fact a legitimate response to the specific client request.

N.5.2 DCC receives SNTP server reply

After the SNTP server receives the request, the server copies the transmit timestamp in the request to the Originate Timestamp (T1) field in the reply and sets the receive timestamp (T2) and transmit timestamp (T3) to the time of day according to the server clock in NTP timestamp format. The reply containing the timestamps and other information is then sent to the DCC.

The DCC receives the reply using TTP_UData.indication(user data) and notes the destination timestamp (T4) according to its clock in NTP timestamp format. At this point, four timestamps have been accumulated; they are summarized in Table N.2.

Table N.2—Timestamp definitions

Timestamp name	ID	When generated
Originate Timestamp	T1	Time request sent by client
Receive Timestamp	T2	Time request received by server
Transmit Timestamp	T3	Time reply sent by server
Destination Timestamp	T4	Time reply received by client

N.5.3 Updating the local DCC clock

The error checks summarized in the Client Tests column in Table N.4 should be performed. The local DCC clock can be updated if all of the following are true:

a) The LI indicates synchronized operation (LI = 0, 1, or 2).

b) The VN matches or can be processed by the version if the SNTP client used by the DCC.

c) The mode indicates that the received message is a server reply (4).

d) The stratum of the BCC server clock is within the range of 1 through 14.

e) The Originate Timestamp (T1) field of the reply matches the Transmit Timestamp (T1) field of the request.

The local clock update process depends primarily on the two measurements defined in Equation (N.1) and Equation (N.2).

$$t = [(T2 - T1) + (T3 - T4)]/2 \qquad (N.1)$$

$$d = (T4 - T1) - (T3 - T2) \qquad (N.2)$$

where

t	is the local clock offset,
d	is the roundtrip delay,
T1, T2, T3, and T4	are timestamps defined in Table N.2.

These measurements, plus the root dispersion reported by the server (if available), can be used to update the local DCC clock using the clock update algorithms described in RFC-1305. A small fraction of the offset can be used to update a Type-II phase-locked loop (PLL) that estimates the time offset and drift of the client (DCC) local oscillator relative to the server (BCC) clock and ultimately the SNTP primary reference clock on the network. The update process is robust and weights the measurements with the shortest roundtrip delay the most because they are likely to be the most accurate. All calculations are performed using integer arithmetic. Simpler calculations using only the raw offset measurements can be used if an accuracy of only a few tens of milliseconds is required.

The leap bits are interpreted only in the last two seconds of the leap day and are used only by the operating system kernel if it indeed supports the leap as specified. The kernel uses the leap bits to update a seconds offset that is added to the seconds counter of the local NTP clock in order to compute or update the civil time and date. The seconds counter of the local NTP clock itself is not modified by the leap bits. The bits can be set anytime in the last day and normally are propagated from the reference clocks up by stratum to higher stratum (leaf) devices.

N.5.4 Reply from an unsynchronized SNTP server

Normally the LI field should indicate synchronized operation (LI = 0, 1, or 2) for the other fields and timestamps T2 and T3 of the server reply to be considered valid. A BCC clock source that has not been synchronized to a valid timing source over a prolonged time (e.g., several days) or was manually set by the eyeball-and-wristwatch method would send the following reply to the DCC:

a) LI indicates the “clock not synchronized” warning state (LI = 3).

b) VN matches the version used by the DCC.

c) Mode indicates that the received message is a server reply (4).

d) Stratum of the BCC server clock is 0.

e) One of the two four-character ASCII strings is stored in the reference identifier, shown in Table N.3.

Table N.3—Reference identifier strings

String	Definition
“LOCL”	The BCC clock has been unsynchronized over a long period of time.
“EBWW”	The BCC clock has been set manually by the eyeball-and-wristwatch method.

In this case, the DCC may elect whether to use the unsynchronized timestamps.

N.5.5 Summary of SNTP client request and server reply

Table N.4 summarizes the DCC SNTP client request and BCC SNTP server reply in client-server mode. The recommended error checks are shown in the Server Tests and Client Tests columns. The message should be considered valid only if all the fields shown contain values in the respective ranges. Whether to believe the message if one or more of the fields marked “ignore” or “use/ignore” may contain invalid values is at the discretion of the implementation. The status regarding the use of each field is indicated as follows:

S: Required by SNTP
N: Specified in NTP and optional for SNTP

Table N.4— SNTP client request and server reply

Field name	Client request	Server tests	Server reply	Status	Client tests
LI	0	Ignore	0–3	S	0, 1, 2, 3 √
VN	3 or 4	3 or 4 √	3 or 4 (copied from request)	S	3 or 4 √
Mode	3 (client)	3 √	4 (server)	S	4 √
Stratum	0	Ignore	Server stratum { 0, 1–14 }	S	0, 1–14 √
Poll	0	Ignore	Copied from request	N	Ignore
Precision	0	Ignore	–log2 server fraction bits	N	Use/ignore
Root Delay	0	Ignore	Root delay to reference	N	Ignore
Root Dispersion	0	Ignore	Root dispersion relative to reference	N	Use/ignore
Reference Identifier	0	Ignore	Reference identifier	N	Use/ignore
Reference Timestamp	0	Ignore	Time last updated by reference	N	Use/ignore
Originate Timestamp	0	Ignore	T1 (copied from request)	S	T1 √
Receive Timestamp	0	Ignore	T2 (time server received request)	S	T2
Transmit Timestamp	T1	T1	T3 (time server sent reply)	S	T3
—	—	—	T4 (time client received reply)	N/A	T4
NOTE —√ indicates tested field(s).					

N.6 BCC SNTP server operations

A BCC functions as an SNTP server relative to DCC client requests. The server receives an SNTP request from the DCC (mode 3), modifies certain fields in the message, and sends an SNTP reply (mode 4) back to the DCC.

A BCC may use SNTP, NTP, or other protocols to obtain or update its local clock from a network. SNTP would suffice in cases where there is only a single reference clock. NTP is more suitable for larger and more complex networks with multiple reference clock sources and secondary NTP servers because it supports redundant peers and diverse network paths. The BCC (or its host monitor or data concentrator) may use any of the NTP or SNTP communication modes (e.g., client-server, symmetric, multicast or anycast reception) described in RFC-1305 or RFC-2030 to obtain time from the network. Authentication may or may not be used. The key issue is that the BCC may use whatever means possible to accurately update and characterize its local clock so that the BCC can function as a SNTP time server for the DCCs attached to it.

N.6.1 BCC server operations

The BCC receives the SNTP client request from the DCC using TTP_UData.indication(user data) and updates the Receive Timestamp T2 field of the server reply (which could be in the buffer that contains the client request). The error checks in the Server Tests column in Table N.4 should be performed, and the BCC SNTP server should reply to the DCC client request if

a) The VN matches or can be processed by the version of the SNTP server used by the BCC, and

b) The mode indicates that the received message is a client request (3).

The VN and Poll fields of the request are copied intact to the reply. The Transmit Timestamp field containing T1 is copied intact to the Originate Timestamp field of the reply. The Precision field is set to reflect the maximum reading error of the local clock. For all practical cases it is computed as the negative of the number of significant bits to the right of the decimal point in the NTP timestamp format. The remaining fields of the server reply are updated according to the synchronization status of the server's clock, described below and summarized in Table N.5.

N.6.2 Synchronization status of BCC clock and SNTP reply

If the BCC uses NTP or SNTP to obtain or update its local clock from the network, all fields of the Synchronized column in Table N.5 should be updated for a "secondary server" as described in RFC-2030.

If the BCC uses a network time protocol other than SNTP or NTP to obtain its time, then LI ← 0, Mode ← 4, Stratum ← 0 fields should be updated. If possible, some attempt should be made to accurately characterize the root dispersion and update it and other recommended fields.

Although the original intent of the NTP Version 3 specification was to declare an unsynchronized state after a suitable period when no external synchronization source is available, NTP Version 4 compliant daemons can run well over a day without significant loss of accuracy. Accordingly, the intent is never to declare unsynchronized after once declaring synchronized. In this case, the dispersion increases without limit; however, the clients of such a server will typically drop off after their root dispersion exceeds 1 s.

If a BCC clock source has not been synchronized to a valid timing source for a prolonged period of time or was manually set by the eyeball-and-wristwatch method, then LI ← 3, Mode ← 4, Stratum ← 0 fields should be updated. The Reference Identifier field should be updated with the proper string from Table N.3. If possible, the Root Dispersion field should reflect the maximum expected error of the unsynchronized BCC clock source (e.g., a 100 ppm crystal oscillator would exhibit a worst-case dispersion of 8.5 s for every 24 h interval that it was not synchronized). The Reference Timestamp field should be set to the last time the clock was updated or set. If the BCC time has never been set or is just starting up, then all the Transmit Timestamp fields of the reply except for T1 should be set to zero.

The BCC SNTP server may or may not respond if not synchronized, but the preferred option is to respond. This response allows reachability to be determined regardless of synchronization state.

N.6.3 BCC SNTP reply

Immediately after updating the Transmit Timestamp (T3) field according to the server clock in NTP timestamp format, the BCC sends the SNTP server reply to the DCC using TTP_UData.request(user data).

N.6.4 Summary of SNTP server replies

Table N.5 summarizes the BCC SNTP server replies in client-server mode for various conditions of the server's clock. The status regarding the use of each field is indicated as follows:

S: Required by SNTP
N: Specified in NTP and optional for SNTP

Table N.5—SNTP server replies

Field name	Synchronized	Unsynchronized/ manually set	Not-set or start-up	Status
LI	0, 1, or 2	3	3	S
VN	3 or 4 (copied)	3 or 4	3 or 4	S
Mode	4 (server)	4	4	S
Stratum	1–14	0	0	S
Poll	Copied from request	Copied from request	Copied from request	N
Precision	–log2 server	–log2 server	–log2 server	N
Root Delay	Root delay	0	0	N
Root Dispersion	Root dispersion	Root dispersion	0	N
Reference Identifier	Reference identifier	"LOCL"/"EBWW"	0	N
Reference Timestamp	Time last updated	Time last updated/set	0	N
Originate Timestamp	T1	T1	T1	S
Receive Timestamp	T2	T2	0	S
Transmit Timestamp	T3	T3	0	S

Annex O

(informative)

Bibliography

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