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Higher performance protocol for the standard digital interface for programmable instrumentation –

Part 1: General

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

HIGHER PERFORMANCE PROTOCOLE FOR THE STANDARD DIGITAL INTERFACE FOR PROGRAMMABLE INSTRUMENTATION –

Part 1: General

FOREWORD

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International Standard IEC/IEEE 60488-1 has been processed through subcommittee 65C: Digital communications, of IEC technical committee 65: Industrial-process measurement and control.

This standard cancels and replaces the second edition of IEC 60625-1 (1993).

At times in this standard, specific reference is made to IEEE Std 488.1-1987, which constituted an earlier version of IEEE Std 488.1-2003, the IEEE edition upon which this standard is based. Where specific dated references were made to the 1987 edition, these references have been maintained.

Furthermore, it is to be noted that full compatibility of this standard with IEC/IEEE 60488-2:2004 requires implementation of all revisions indicated previously in the IEEE Introduction. Therefore, readers of this standard are encouraged to read also the companion standard IEEE Std 488.2-1987, which constitutes an earlier edition of IEC 60488-2:2004.

The text of this standard is based on the following documents:

IEEE Std	FDIS	Report on voting
488.1 (2003)	65C/319A/FDIS	65C/343/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives.

The committee has decided that the contents of this publication will remain unchanged until 2009.

IEC/IEEE 60488 consists of the following publications:

- Higher performance protocol for the standard digital interface for programmable instrumentation – Part 1: General (60488-1).
- Standard digital interface for programmable instrumentation – Part 2: Codes, formats, protocols and common commands (60488-2).

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IEEE Standard for Higher Performance Protocol for the Standard Digital Interface for Programmable Instrumentation

Sponsor

Technical Committee on Automated Test Systems and Instrumentation (TC-8)
of the
IEEE Instrumentation and Measurement Society

Approved 10 October 2003
American National Standard Institute

Approved 12 June 2003
IEEE-SA Standards Board

Abstract: This standard applies to interface systems used to interconnect both programmable and nonprogrammable electronic measuring apparatus with other apparatus and accessories necessary to assemble instrumentation systems. It applies to the interface of instrumentation systems, or portions of them, in which the

a) Data exchanged among the interconnected apparatus is digital (as distinct from analog)

b) Number of devices that may be interconnected by one contiguous bus does not exceed 15

c) Total transmission path lengths over the interconnecting cables does not exceed 20 m

d) Data rate among devices does not exceed 8 000 000 B/s

The basic functional specifications of this standard may be used in digital interface applications that require longer distances, more devices, increased noise immunity, or combinations of these. Different electrical and mechanical specifications may be required (for example, symmetrical circuit configurations, high threshold logic, special connectors, or cable configurations) for these extended applications.

Keywords: GPIB, HPIB, HS488, non-interlocked handshake, three-wire handshake

IEEE Introduction

IEEE Std 488™ has enjoyed continuous and widespread use since its initial publication in 1975. The first revision occurred in 1978 as a result of practical experience and recognition that certain clauses needed clarification to improve compatibility among independently designed products. No major changes were made in 1978; many changes were pure editorial; however, 20 clauses had textual changes with technical implications, although none contradicted the concepts as defined in the original publication. Supplement A was introduced in 1980 to correct one minor deficiency in the controller function related to "take control synchronously."

In 1987, a systematic review was undertaken as a result of both the normal 5-year review cycle and related work on IEEE 488 device-dependent message syntax structures. In addition, there was a strong desire on the part of both IEEE participants and our IEC colleagues to bring equivalent standards (IEC 625-1) into closer alignment. IEEE Std 488.1-1987 represents the culmination of this review cycle. Again, no major technical changes were made, and care was exercised to preserve compatibility with earlier versions of IEEE Std 488.

The IEEE Std 488.1-2003 specification adds new interface functions to allow designers the option of implementing noninterlocked handshake transfers.

In preparing this specification, several stylistic changes to IEEE Std 488.1-1987 were necessary to bring the document up to IEEE standards. The following changes were made:

— Clause 1, which previously consisted of an overview, definitions, and references, was divided into three separate sections. Clause 1 now contains the overview, Clause 2 contains references, and Clause 3 contains definitions.
— The first level of ordered lists was previously numbered (1, 2, 3...). To comply with the IEEE standards, the first level of ordered lists is now lettered (a, b, c...), and the second level of ordered lists is numbered (1, 2, 3...).
— In the earlier version of this specification, tables had no grids. Grids have been added to the tables in this version.

The IEEE 488.1-2003, IEEE Standard for Digital Interface for Programmable Instrumentation, deals with systems that use a byte-serial, bit-parallel means to transfer digital data among a group of instruments and system components. The interface system described herein is optimized as an interdevice interface for system components in relatively close proximity able to communicate over a contiguous party-line bus system.

This document contains seven sections as follows:

— Clause 1 contains the scope, the object, and summary description of the interface.
— Clause 2 contains helpful references.
— Clause 3 contains basic definitions.
— Clause 4 deals with functional concepts and specifications of the interface system described in this standard. One or more interface functions contained within a device are each able to process messages and change states to maintain an orderly flow of information among a set of interconnected devices.
— Clause 5 deals with the electrical realization of the interface in order to transfer messages among a set of interconnected devices.
— Clause 6 deals with the mechanical realization of the interface in order to implement the electrical aspects of the interface system.
— Clause 7 deals with system considerations that must be given to the design of an individual device in order to make it compatible with other devices of a measurement system.

— Clause 8 deals with system considerations that must be recognized by the user of devices designed in accordance with this standard.
— Annexes deal with explanatory matter and examples.

In order to interconnect and program equipment designed in accordance with this standard, the user should have knowledge of Clause 1 and Clause 8. If the coding and transfer of messages is not done automatically by the apparatus to be programmed, it will be necessary that the user have knowledge of Clause 4. General familiarity with the other sections is recommended. The user must also be familiar with device-dependent characteristics of apparatus that may be used in a system, but that are beyond the scope of this standard.

This standard defines an interface with the objective to assure that messages may be accurately communicated between two or more devices in a system, but it does not guarantee that each device will interpret properly all possible messages sent to it or will properly generate all necessary messages. A wide latitude of interface capability is permitted within the scope of this standard, which may permit operational incompatibility among interconnected devices.

Device designers must have sufficient awareness of the characteristics of systems, which might include their devices, in order to select correctly among the options provided in this standard. Likewise, system configurators must have sufficient awareness of the options included in each of the devices in their systems in order to ensure that the correct communication techniques are used.

This standard does not specify the device-dependent or operational characteristics required for complete system compatibility. Therefore, following the rules and procedures of this standard alone will not guarantee unconditional compatibility.

The 1987 version of this standard was based on work initiated by the International Electrotechnical Commission (IEC) within Technical Committee 65, Subcommittee 65C, Working Group 3 (formerly TC66/WG3), and it follows the general concepts of a standard prepared by the IEC. In 1992, the IEEE technical working group enhanced the 1987 standard to improve performance over IEEE Std 488.1-1987.

The “helpful note” on metric threads found in previous editions has been deleted because metric thread use is common IEEE Std 488 practice. Consequently, the recommendation to coat such parts in black material to call attention to metric threads is also considered unnecessary. Electrical conductivity on the surface of these parts is, however, still considered essential.

Patents

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 for which a license may be required by an IEEE standard or for conducting inquiries into the legal validity or scope of those patents that are brought to its attention. A patent holder has filed a statement of assurance that it will grant licenses under these rights without compensation or under reasonable rates and nondiscriminatory, reasonable terms and conditions to all applicants desiring to obtain such licenses. The IEEE makes no representation as to the reasonableness of rates and/or terms and conditions of the license agreements offered by patent holders. Further information may be obtained from the IEEE Standards Department.

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HIGHER PERFORMANCE PROTOCOL FOR THE STANDARD DIGITAL INTERFACE FOR PROGRAMMABLE INSTRUMENTATION –

Part 1: General

1. Overview

1.1 Scope

This standard applies to interface systems used to interconnect both programmable and nonprogrammable electronic measuring apparatus with other apparatus and accessories necessary to assemble instrumentation systems. It applies to the interface of instrumentation systems, or portions of them, in which the

a) Data exchanged among the interconnected apparatus is digital (as distinct from analog)

b) Number of devices that may be interconnected by one contiguous bus does not exceed 15

c) Total transmission path lengths over the interconnecting cables does not exceed 20 m

d) Data rate among devices does not exceed 8 000 000 B/s

The basic functional specifications of this standard may be used in digital interface applications that require longer distances, more devices, increased noise immunity, or combinations of these. Different electrical and mechanical specifications may be required (for example, symmetrical circuit configurations, high threshold logic, special connectors, or cable configurations) for these extended applications.

This standard may also be applicable to other instrumentation system elements, such as processors, stimulus, display, or storage devices, and terminal units found useful in instrumentation systems. It applies generally to laboratory and production test environments that are both electrically quiet and restricted as to physical dimensions (distances between the system components).

This standard deals only with the interface characteristics of instrumentation systems to the exclusion of design specifications' consideration of radio-interface regulations, performance requirements, and safety requirements of apparatus.

NOTE—For the latter two items, reference is made to IEC 61010-1: 2001, and IEC 60359:2001.[1]

[1]For information on references, see Clause 2.

Throughout this standard, and insofar as further distinction is not necessary, the term “system” denotes the bit-parallel byte-serial interface system that, in general, includes all circuits, cables, connections, message repertoire, and control protocol to effect unambiguous data transfer between devices; and the term “device” or “apparatus” denotes any programmable measurement device or other product connected to the interface system that communicates information via, and conforms to, the interface system definition.

A primary focus of this standard is to set forth an interface system to interconnect self-contained apparatus to other apparatus by external means. This same standard may be applied to interconnecting the internal sub-sections within a self-contained equipment.

1.2 Object

This standard is intended

a) To define a general-purpose system for use in limited-distance applications
b) To specify the device-independent mechanical, electrical, and functional interface requirements that the apparatus shall meet in order to be interconnected and to communicate unambiguously via the system
c) To specify the terminology and definitions related to the system
d) To enable the interconnection of independently manufactured apparatus into a single functional system
e) To permit devices with a wide range of capability—from the simple to the complex—to be interconnected to the system simultaneously
f) To permit direct communication among the devices without requiring all messages to be routed to a control or intermediate unit
g) To define a system with a minimum of restrictions on the performance characteristics of the devices connected to the system
h) To define a system that permits asynchronous communication over a wide range of data rates
i) To define a system that, of itself, may be relatively low cost and permits the interconnection of low-cost devices
j) To define a system that is easy to use

1.3 Interface system overview

1.3.1 Interface system objective

The overall purpose of an interface system is to provide an effective communication link over which messages are carried in an unambiguous way among a group of interconnected devices.

Messages (quantities of information) carried by an interface system belong to either of two broad categories:

a) Messages used to manage the interface system itself, hereinafter called interface messages
b) Messages used by the devices interconnected via the interface system that are carried by, but not used or processed by, the interface system directly, hereinafter called device-dependent messages

NOTE—The detailed specification of device-dependent messages is beyond the scope of this standard.

1.3.2 Fundamental communication capabilities

An effective communication link requires three basic functional elements to organize and manage the flow of information to be exchanged among devices:

a) A device acting as a listener
b) A device acting as a talker
c) A device acting as a controller

In the context of the interface system described by this standard

a) A device with the capability to listen can be addressed by an interface message to receive device-dependent messages from another device connected to the interface system.
b) A device with the capability to talk can be addressed by an interface message to send device-dependent messages to another device connected to the interface system.
c) A device with the capability to control can address other devices to listen or to talk. In addition, this device can send interface messages to command specified actions within other devices. A device with only this capability neither sends nor receives device-dependent messages.

NOTE—The use of the word *controller* throughout this standard applies strictly to the management (control) of the interface system and does not imply the broad capabilities typically associated with the word in the data processing context. Further classification of the controller will be made in Clause 4 to distinguish between different types of controller capabilities related to the interface system.

Listener, talker, and controller capabilities occur individually or in any combination in devices interconnected via the interface system, as shown in Figure 1.

In addition to the basic listener, talker, and controller functions, the system provides interface messages to accomplish the following operations:

a) A serial poll sequence may be initiated when a device (with talker function) requires some action by the controller, by transmitting the service request message. The controller will then obtain the status byte of all possible devices in sequence to ascertain which required service.
b) The Parallel Poll function provides a device with the ability to transmit on the controller's demand one bit of status information (request service) simultaneously with several other devices. The assignment of a data line to a particular device for the response to a parallel poll may be accomplished through interface messages.
c) The Device Clear and Device Trigger functions provide a device with the ability to be initialized or triggered, respectively, on command from the controller. This may occur simultaneously with other selected or all devices in a system.
d) The remote/local function provides a device with the ability to accept program data from the bus, local data (for example, front panel controls), or both.

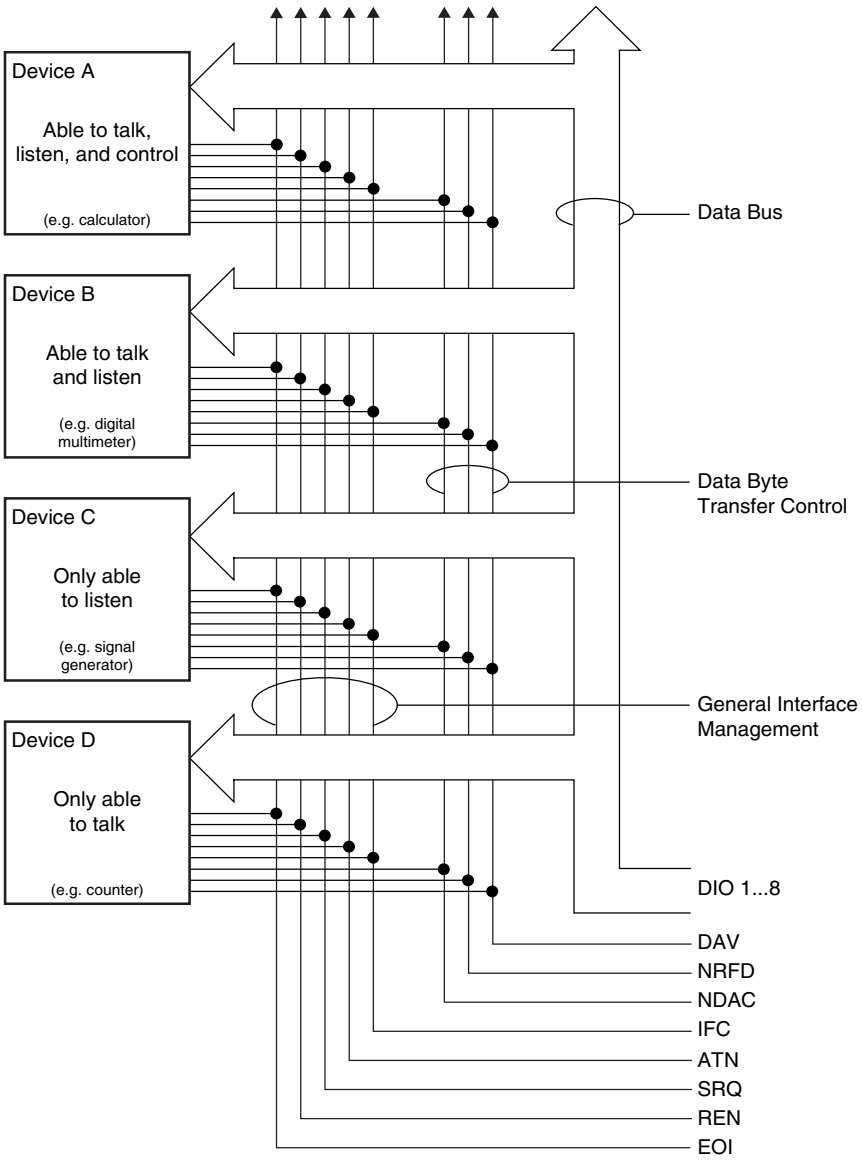

Figure 1—Interface capabilities and bus structure

1.3.3 Message paths and bus structure

The interface system contains a set of 16 signal lines used to carry all information, interface messages, and device-dependent messages among interconnected devices.

Messages may be coded on one or a set of signal lines as determined by the particular message content and its relationship to the interface system.

The bus structure is organized into three sets of signal lines:

a) Data bus, eight signal lines
b) Data byte transfer control bus, three signal lines
c) General interface management bus, five paths

Figure 1 illustrates the basic communication paths.

A set of eight interface signal lines carries all 7 bit interface messages and the device-dependent messages

DIO1 (data input output 1)
. .
. .
. .
DIO8 (data input output 8)

Message bytes are carried on the DIO signal lines in a bit-parallel byte-serial form, asynchronously, and generally in a bidirectional manner.

NOTE—A message may be carried on an individual DIO signal line when required.

A set of three interface signal lines is used to effect the transfer of each byte of data on the DIO signal lines from a talker or controller to one or more listeners:

a) Data Valid (DAV) is used to indicate the condition (availability and validity) of information on the DIO signal lines.
b) Not Ready For Data (NRFD) is used to indicate the condition of readiness of device(s) to accept data or (by a source) to indicate to all acceptors that it is capable of supporting noninterlocked handshake cycles.
c) Not Data Accepted (NDAC) is used to indicate the condition of acceptance of data by device(s).

The DAV, NRFD, and NDAC signal lines operate in what is called a three-wire (interlocked) handshake or a noninterlocked handshake process to transfer each data byte across the interface.

Five interface signal lines are used to manage an orderly flow of information across the interface:

a) Attention (ATN) is used (by a controller) to specify how data on the DIO signal lines are to be interpreted and which devices must respond to the data.
b) Interface Clear (IFC) is used (by a controller) to place the interface system, portions of which are contained in all interconnected devices, in a known quiescent state.
c) Service Request (SRQ) is used by a device to indicate the need for attention and to request an interruption of the current sequence of events.
d) Remote Enable (REN) is used (by a controller), in conjunction with other messages, to enable or disable one or more local controls that have corresponding remote controls.
e) End or Identify (EOI) is used (by a talker) to indicate the end of a multiple byte transfer sequence or, in conjunction with ATN (by a controller), to execute a polling sequence.

1.3.4 Interface system elements

The primary elements of this interface system are as follows:

a) Functional elements
b) Electrical elements
c) Mechanical elements

Each is described in a following clause.

2. References

This standard shall be used in conjunction with the following standards. For this standard, all references have been updated to reflect the most recent editions. When these references have been superseded by an approved revision, the revision shall apply. For undated references, the latest edition of the referenced document (including any amendments) applies.

ANSI X3.4-1986, American National Standard Code for Information Interchange Coded Character Set—7-Bit.[2]

IEC 60068-2 (all parts) Environmental Testing – Part 2: Tests.[3]

IEC 61010-1:2001, Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 1: General requirements.

IEC 60359:2001: Electrical and Electronic Measuring Equipment — Expression of Performance.

MIL STD 202F (1986), Test Method for Electronic and Electrical Component Parts.[4]

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