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IEC 60488-2

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IEEE 488.2™

Standard digital interface for programmable instrumentation –

Part 2:
Codes, formats, protocols and common commands

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International Electrotechnical Commission, 3, rue de Varembé, PO Box 131, CH-1211 Geneva 20, Switzerland
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: inmail@iec.ch Web: www.iec.ch

The Institute of Electrical and Electronics Engineers, Inc, 3 Park Avenue, New York, NY 10016-5997, USA
Telephone: +1 732 562 3800 Telefax: +1 732 562 1571 E-mail: stds-info@ieee.org Web: www.standards.ieee.org

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STANDARD DIGITAL INTERFACE FOR PROGRAMMABLE INSTRUMENTATION –

Part 2: Codes, formats, protocols and common commands

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International Standard IEC/IEEE 60488-2 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 60625-2 (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 IEC/IEEE 60488-1:2004 is based. Where specific dated references were made to the 1987 edition, these references have been maintained.

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

IEEE Std	FDIS	Report on voting
488.2 (1992)	65C/320/FDIS	65C/326/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 Codes, Formats, Protocols, and Common Commands for use With IEEE Std 448.1-1987, IEEE Standard Digital Interface for Programmable Instrumentation

Sponsor
Automated Instrumentation Committee
of the
IEEE Instrumentation and Measurement Society

Approved June 18, 1992
IEEE Standards Board

Approved January 4, 1993
American National Standards Institute

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Abstract: A set of codes and formats to be used by devices connected via the IEEE 488.1 bus is specified. This standard also defines communication protocols that are necessary to effect application-independent and device-dependent message exchanges, and further defines common commands and characteristics useful in instrument system applications. It is intended to apply to small-scale to medium-scale instrument systems comprised mainly of measurement, stimulus, and interconnect devices outside the scope of the instrument system environment. IEEE 488.1 subsets, standard message-handling protocols including error handling, unambiguous program and response-message syntactic structures, common commands useful in a wide range of instrument system applications, standard status reporting structures, and system configuration and synchronization protocols are covered.
Keywords: controller, device, system, system bus, system interface

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IEEE Foreword

IEEE Std 488 has been in existence for seventeen years, during which time its power and versatility have been proven decisively. Probably its most important contribution to test system automation has been the standardization of system interconnection and communication. A large and growing base of design and application experience has allowed this further standardization of the IEEE Std 488 bus. The additional standardization sought by the original IEEE Std 488.2-1987 was founded on the premise that the existing investment in IEEE Std 488 resources must be protected. Thus, IEEE Std 488.2 describes functionality that complements and is based upon IEEE Std 488.1-1987. Every effort has been made to reap the benefits of standardization without limiting the freedom and creativity of the device designer.

Since the introduction of IEEE Std 488-1978, individual manufacturers of devices have developed internal standards that address the code, format, protocol, syntax, and semantic concepts. System integrators have identified requirements useful in configuring systems. All these sources have been used and refined in developing this standard.

This revision of the original 1987 document contains many minor changes, too numerous to list, plus a few major changes. The changes are intended to be optional additions and clarifications to the 1987 standard. The goal of the working group was to allow devices and controllers designed in compliance with IEEE Std 488.2-1978 to remain in compliance with IEEE Std 488.2-1992.

Major new features include the addition of an <EXPRESSION RESPONSE DATA> element; the expanded use of <SUFFIX PROGRAM DATA>; the addition of the *RMC, Remove Individual Macro Command; the addition of the *SDS, Save Default Device Settings Command; the modification of *DDT, *DMC, *PUD, and *RDT commands to accept block or string data; and a new appendix on Reset Guidelines. There are many clarifications including a macro expansion algorithm; the removal of ambiguity in the definition of suffixes; and the scope of *LRN?, *SAV, *RCL, and *RST, to name a few.

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The hope is that this new revision, incorporating five years of experience with IEEE Std 488.2-1987, will provide an even more solid foundation for the standardized communication of test and measurement systems.

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STANDARD DIGITAL INTERFACE FOR PROGRAMMABLE INSTRUMENTATION -

Part 2: Codes, formats, protocols and common commands

1. Introduction

1.1 Scope

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This standard specifies a set of codes and formats to be used by **devices** connected via the IEEE 488.1 bus. This standard also defines communication protocols necessary to effect application independent device-dependent message exchanges and further defines common commands and characteristics useful in instrument **system** applications.

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This standard is intended to apply directly to small-scale to medium-scale instrument **systems**. It applies to **systems** comprised mainly of measurement, stimulus, and interconnect **devices** with an instrumentation **controller**. The standard may also apply to certain **devices** outside the scope of the instrument **system** environment.

As well as defining a variety of device-dependent messages, this standard extends and further interprets certain interface functions contained in IEEE Std 488.1-1987 [4][1] while remaining compatible with that standard.

This standard covers the following topics:

1) IEEE 488.1 subsets
2) Standard message handling protocols including error handling
3) Unambiguous program and response message syntactic structures
4) Common commands useful in a wide range of instrument **system** applications
5) Standard status reporting structures
6) **System** configuration and synchronization protocols

Use of this standard does not relieve the user from the burden of responsibility for **system** compatibility at the application level. The user must be familiar with the characteristics of all the **system** components in order to configure an optimum **system**.

The intended readers of this standard include both **controller** and **device** designers.

[1]The numbers in brackets correspond to those of the references in Section 2.

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1.2 Objectives

The objectives of this standard are

1) To provide a well-defined and unambiguous structure of codes, formats, protocols, and common commands
2) To retain generality to accommodate the needs of a wide variety of applications within the scope of the standard
3) To promote the degree to which **devices** from different manufacturers may be interconnected and used, without modification
4) To enable the interconnection of instrumentation and related **devices** with both limited and extensive capability to generate, process, and interpret a variety of different message types
5) To define codes, formats, protocols, and common commands that will reduce the costs of generating application software and the costs of **system** integration
6) To permit direct communication among instrument **system devices** without extraordinary translation and conversion of special codes and formats

1.3 Notation

This standard defines several common English words that have special meaning in the context of this standard. These words have different connotations in IEEE Std 488.1-1987 [4], but are, for reasons of readability and conciseness of text, the preferred words for use in this standard. To avoid confusion, these words always appear in bold type when referenced in this document. Words that appear in bold type are: **system, device, controller, system bus,** and **system interface**. Local messages peculiar to IEEE 488.2 will also appear in lowercase bold type.

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This standard also defines syntactic elements that are used to describe messages transferred on the bus. Syntactic elements are enclosed by angle brackets, for example, <syntactic element>, to set them off from local messages, remote messages, and normal text.

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2. References

This standard shall be used in conjunction with the following publications:

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

[2] ANSI X3.42-1990, American National Standard Representation of Numeric Values in Character Strings for Information Interchange.

[3] IEEE Std 260-1978, (Reaff 1985). IEEE Standard Letter Symbols for Units of Measurement (SI Units, Customary Inch-Pound Units, and Certain Other Units) (ANSI, DoD).[3]

[4] IEEE Std 488.1-1987, IEEE Standard Digital Interface for Programmable Instrumentation (ANSI)*.

[2]ANSI publications are available 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, Service Center, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

* Reference is made in this standard to IEEE Std 488.1:1987, an earlier edition of the IEEE document upon which IEC/IEEE 60488-1:2004 is based.

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[5] IEEE Std 754-1985 (Reaff 1991), IEEE Standard for Binary Floating-Point Arithmetic.

[6] ISO 31-1: 1992, Quantities and units — Part 1: Space and time.[4]
[7] ISO 31-2: 1992, Quanities and units — Part 2: Periodic and related phenomena.

[8] ISO 31-3: 1992, Quantities and units — Part 3: Mechanics.

[9] ISO 31-4: 1992, Quanitites and units — Part 4: Heat.

[10] ISO 31-5: 1992, Quanitites and units — Part 5: Electricity and magnetism.

[11] ISO 31-6: 1992, Quantities and units — Part 6: Light and related electromagnetic radiations.

[12] ISO 31-7: 1992, Quantities and units — Part 7: Acoustics.

[13] ISO 31-8 : 1992, Quantities and units — Part 8: Physical chemistry and molecular physics.

[14] ISO 31-9: 1992, Quantities and units — Part 9: Atomic and nuclear physics.

[15] ISO 31-10: 1992, Quantities and units — Part 10: Nuclear reactions and ionizing radiations.

[16] ISO 31-11: 1992, Quantities and units — Part 11: Mathematical signs and symbols for use in the physical sciences and technology.

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[17] ISO 31-12: 1992, Quantities and units — Part 12: Characteristic numbers.

[18] ISO 1000: 1992, SI units and recommendations for the use of their multiples and of certain other units.

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[19] ISO 2955: 1983, Information processing — Representation of SI and other units in systems with limited character sets.

[20] Mueller, J. E., "Efficient Instrument Design Using IEEE 488.2," *IEEE Transactions on Instrumentation and Measurement*, vol. IM-39, pp. 146–150, Feb. 1990.

3. System Considerations

3.1 Definitions

The following definitions apply for the purpose of this standard. This section contains only general definitions. Detailed definitions are given in further sections, as appropriate. For definitions relating specifically to IEEE Std 488.1-1987 [4], see 1.3 of that standard.

controller: . The component of a **system**that functions as the **system controller**. A **controller**typically sends program messages to and receives response messages from **devices**. A controller may pass and receive control per the protocols in this standard. A controller meets all the requirements stated in Section 14. of this standard.

default: . The choice used when no specification is given.

[4]ISO publications are available from ISO, Case Postale 56, 1 rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse. ISO 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.

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device: A component of a **system** that does not function as the **system controller** but typically receives program messages from and sends response messages to the **controller**. A **device** may optionally have the capability to receive control from the **controller** and become the controller-in-charge of the **system.** A **device**meets all the requirements stated in Section 4. of this standard.

system: . A group of **devices** and a **controller** interconnected with a **system interface**.

system bus: The IEEE 488.1 bus and protocols that interconnect the **devices** and **controllers** in a **system.** The content of this standard applies to device-dependent traffic over this bus.

system interface: An interface that connects a **device** or **controller** to the **system bus**. A "non-IEEE 488.2 system interface" is any interface other than the **system interface** that may happen to be connected to a **device** or **controller**

3.2 System Message Traffic

This standard is optimized for a **system** in which the **devices** do not become controller-in-charge. The usual message traffic is assumed to be from "controller-to-device" or from "device-to-controller" (see Fig 3-1).

The flexibility of the program message syntax, see Section 7., also may allow the use of an IEEE 488.2 component in a **system** that contains non-IEEE 488.2 components.

In a **system** with a **device** and a noncompliant **controller**, the flexible listening formats allow the achievement of a higher degree of compatibility. This compatibility is realized by requiring minor variations in syntax to be accepted by the **device.** These variations are designed to be syntactically easy to generate on a variety of **controllers.** They may even be the noncompliant **controller's** default syntax. Such **systems** are beyond the scope of this standard and may not perform their intended functions.

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3.2.1 Program and Response Message Relationships

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Subsequent sections of this standard will describe, in detail, the allowed syntax and semantics for **system** message traffic. The philosophy of this standard is that **devices** receive in a more flexible manner than they send.

Thus, a range of variations of syntax defined by this standard must be accepted when **devices** listen. Likewise, a precise syntax also identified by this standard is required when **devices** talk.

These controller-to-device (program) and device-to-controller (response) messages are composed of syntactic elements that are described in Sections 7. and 8., respectively.

The following example demonstrates this relationship among program and response messages for a **device** that has a range that may be programmed and queried. The **device** has discrete ranges of 1.2, 12, and 120.

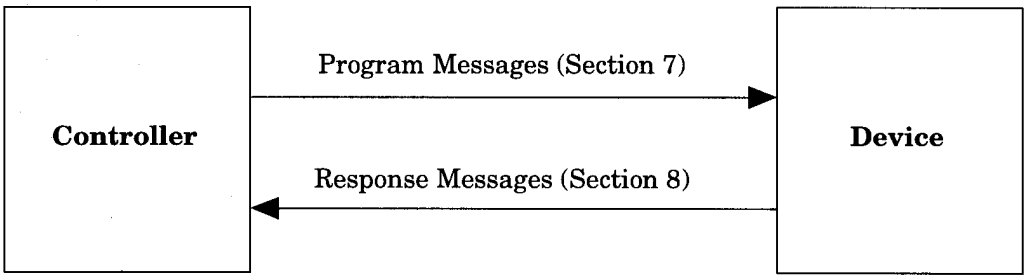

Figure 3-1—Usual Message Traffic

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