Technical Specification

ISO/IEC TS 18661-4

# Programming languages, their environments, and system software interfaces — Floating-point extensions for C —

## Part 4: Supplementary functions

*Langages de programmation, leurs environnements et interfaces du logiciel système — Extensions à virgule flottante pour C —*

*Partie 4: Fonctions supplémentaires*

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# Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives or www.iec.ch/members_experts/refdocs).

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This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 22, *Programming languages, their environments and system software interfaces*.

This second edition cancels and replaces the first edition (ISO/IEC TS 18661-4:2015), which has been technically revised.

The main changes are as follows:

— The specification has been updated to extend ISO/IEC 9899:2024.

— The mathematical functions and constant rounding modes have been removed. These features are now incorporated into ISO/IEC 9899:2024.

— Functions to support the augmented arithmetic operations specified in IEEE 754-2019 have been added.

— New headers have been added, and all extensions to the `<math.h>` header have been removed.

A list of all parts in the ISO 18661 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html and www.iec.ch/national-committees.

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# Introduction

The IEEE 754-1985 standard for binary floating-point arithmetic was motivated by an expanding diversity in floating-point data representation and arithmetic, which made writing reliable programs, debugging and moving programs between systems exceedingly difficult. Now the great majority of systems provide data formats and arithmetic operations according to IEEE 754. Corresponding versions of IEEE 754 and ISO/IEC 60559 have equivalent content.

Support for IEEE 754-1985 was added in ISO/IEC 9899:1999 (also referred to as C99), and ISO/IEC 9899:2018 is still based on IEEE 754-1985. However, IEEE 754 underwent a major revision in 2008 and a minor revision in 2019, which added several new features.

The purpose of the ISO/IEC 18661 series (first published 2014 through 2016) has been to specify C language support for the new features introduced into IEEE 754 since 1985. Most of the ISO/IEC 18661 series has been incorporated into ISO/IEC 9899:2024 (also referred to as C23 because major work on this revision was completed in 2023), which supports all required and most recommended features in IEEE 754-2019.

To supplement the IEEE 754 support in C23, this document specifies two C headers with functions corresponding to the reduction and augmented arithmetic operations recommended by IEEE 754, but not included in C23.

The reduction operations perform widely used vector computations involving sums and products, including scaled products. These operations are allowed to associate in any order, and to evaluate in any wider format.

The augmented arithmetic operations, added in IEEE 754-2019, are versions of operations commonly called twoSum and twoProduct. These operations can be used to implement arithmetic with extra precision, for example, for double-double format. In theory, they can also be used to implement efficient reproducible dot products.

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# Programming languages, their environments, and system software interfaces — Floating-point extensions for C —

# Part 4: Supplementary functions

## 1 Scope

This document specifies extensions to programming language C to include functions corresponding to operations specified and recommended in ISO/IEC 60559, but not supported in ISO/IEC 9899:2024 (also referred to as C23).

## 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 9899:2024, *Information technology — Programming languages — C*

ISO/IEC 60559:2020, *Information technology — Microprocessor Systems — Floating-Point arithmetic*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 9899:2024 and ISO/IEC 60559:2020 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

## 4 Conformance

An implementation that meets the requirements for a conforming implementation of C23 may conform to one or both feature sets (reduction functions and augmented arithmetic) in this document. The implementation conforms to the reduction functions feature if:

a) it defines `__STDC_IEC_60559_BFP__` or `__STDC_IEC_60559_DFP__` or both, indicating support for ISO/IEC 60559 binary or decimal floating-point arithmetic, as specified in C23, Annex F;

b) it defines `__STDC_IEC_60559_FUNCS_REDUCTION__` to `202401L` and provides the `<reduc.h>` header specified in this document (Clause 6).

The implementation conforms to the augmented arithmetic feature if:

c) it defines `__STDC_IEC_60559_BFP__`, indicating support for ISO/IEC 60559 binary floating-point arithmetic, as specified in C23, Annex F;

d) it defines `__STDC_IEC_60559_FUNCS_AUGMENTED_ARITHMETIC__` to `202401L` and provides the `<augarith.h>` header specified in this document (Clause 7).

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