TS 18661-3 AS ANNEX FOR C2X

N2374
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C FP group

TS 18661-3

n2117

Types and functions to support
IEC 60559 interchange and extended formats

IEC 60559 interchange formats

- IEC 60559:2011 specifies a "tower" of *interchange* formats
- Arbitrarily large wdiths (32x)
- For binary and decimal
- Balanced precision and range determined by width
- For exchange of FP data
- binary16, for GPU data, etc.
- Formats may be supported as
  - Arithmetic – with all standard operations
  - Non-arithmetic – with conversion operations

IEC 60559 extended formats

- IEEE specifies *extended* formats that extend its basic formats: binary32|64|128 and decimal64|128
- Have at least a specified precision and range
- For explicit wide evaluation
- Not for data exchange

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- Three features
  - Interchange floating types
  - Extended floating types
  - Support for non-arithmetic interchange formats
- Full language and library support for interchange and extended floating types
- Conversion operations for non-arithmetic interchange formats represented in unsigned char arrays

TS 18661-3 – type structure extensions

interchange floating types: _Float*N,* _Decimal*N*
extended floating types: _Float*N*x, _Decimal*N*x

real floating types
      standard floating types: float, double, long double
      binary floating types: _Float*N*, _Float*N*x
      decimal floating types: _Decimal*N*, _Decimal*N*x

complex types
      float _Complex, double _Complex, long double _Complex
      _Float*N* _Complex, _Float*N*x _Complex

Imaginary types
      float _Imaginary, double _Imaginary, long double _Imaginary
      _Float*N* _Imaginary, _Float*N*x _Imaginary

TS 18661-3 – type structure unchanged

floating types

    real floating types

    complex types

    imaginary types

real types

    integer types

    real floating types

arithmetic types

    integer types

    floating types

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- Standard binding for extension floating types with IEC 60559 formats, which are common extensions (e.g., float16, float128, float80)
- Facilitates exchange of FP data, without full support type
- Enables explicit wide evaluation, for robustness

Publication

- [ISO/IEC TS 18661-3:2015, Information technology — Programming languages, their environments and system software interfaces — Floating-point extensions for C — Part 3: Interchange and extended types](#)

TS 18661-3 as annex

- TS 18661-3 written as changes to C, on top of the changes in TS parts 1 and 2
- Recast as annex for C2X: **N2342**
- Per WG14 direction
- Original skepticism because TS 18661-3 affects so many parts of C, but …

Advantages of annex

- Shorter specification: 38 vs 73 pages
- More comprehensible: direct specification vs changes to changes to changes
- Avoids extensive changes to C, just

In 6.10.8.3#1, add:

__STDC_IEC_60559_TYPES__ The integer constant **20yymmL**, intended to indicate conformance to the specification in Annex X (IEC 60559 interchange and extended types).

Changing to annex

- Requirement: achieve equivalent specification
- Some direct specification, e.g.,

  Types designated **_Float32x**, **_Float64x**, **_Float128x**, **_Decimal64x**, and **_Decimal128x** support the corresponding IEC 60559 extended formats and are collectively called the *extended floating types*. …

- Some broadening of definitions, e.g.,

  The *real floating types* are broadened to include all interchange floating types and extended floating types, as well as standard floating types.

- Some additions to C, e.g.,

  This subclause expands floating-suffix (6.4.4.2) to also include:

  fN FN fNx FNx dN DN dNx DNx

- Reorganized to better match C organization and for general order

Annex outline - language

- X.1 Introduction
- X.2 Types
  - X.2.1 Interchange floating types
  - X.2.2 Non-arithmetic interchange formats
  - X.2.3 Extended floating types
  - X.2.4 Classification of real floating types
  - X.2.5 Complex types
  - X.2.6 Imaginary types
- X.3 Characteristics in <float.h>
- X.4 Conversions
  - X.4.1 Real floating and integer
  - X.4.2 Usual arithmetic conversions
  - X.4.3 Arithmetic and non-arithmetic formats
- X.5 Lexical elements
  - X.5.1 Keywords
  - X.5.2 Constants
- X.6 Expressions
- X.7 Declarations

Annex outline - library

- X.8 Identifiers in standard headers
  - X.8.1 <float.h>
  - X.8.2 <complex.h>
  - X.8.3 <math.h>
  - X.8.4 <stdlib.h>
- X.9 Complex arithmetic <complex.h>
- X.10 Floating-point environment <fenv.h>
- X.11 Mathematics <math.h>
  - X.11.1 Macros
  - X.11.2 Function prototypes
  - X.11.3 Encoding conversion functions
    - X.11.3.1 Encode and decode functions
    - X.11.3.2 Encoding-to-encoding conversion functions
- X.12 Numeric conversion functions in <stdlib.h>
  - X.12.1 String from floating
  - X.12.2 String to floating
  - X.12.3 String from encoding
  - X.12.4 String to encoding
- X.13 Type-generic macros <tgmath.h>

Implementation

- GCC supports _FloatN and _FloatNx types (including with _Complex) on multiple systems.

- Several C implementations have provided additional floating-point types as extensions. For examples, HPUX C/C++ has a fourth type with the IEC 60559 double64-extended format, and LCC supports float128_t and qfloat.