



# The GCC Quad-Precision Math Library

*Release 13.0.0 (experimental 20221108)*

**GCC Developer Community**

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## **INTRODUCTION**

This manual documents the usage of libquadmath, the GCC Quad-Precision Math Library Application Programming Interface (API).





## TYPEDEF AND CONSTANTS

The following data type has been defined via `typedef`.

- `__complex128`: `__float128`-based complex number

The following macros are defined, which give the numeric limits of the `__float128` data type.

- `FLT128_MAX`: largest finite number
- `FLT128_MIN`: smallest positive number with full precision
- `FLT128_EPSILON`: difference between 1 and the next larger representable number
- `FLT128_DENORM_MIN`: smallest positive denormalized number
- `FLT128_MANT_DIG`: number of digits in the mantissa (bit precision)
- `FLT128_MIN_EXP`: maximal negative exponent
- `FLT128_MAX_EXP`: maximal positive exponent
- `FLT128_DIG`: number of decimal digits in the mantissa
- `FLT128_MIN_10_EXP`: maximal negative decimal exponent
- `FLT128_MAX_10_EXP`: maximal positive decimal exponent

The following mathematical constants of type `__float128` are defined.

- `M_Eq`: the constant  $e$  (Euler's number)
- `M_LOG2Eq`: binary logarithm of 2
- `M_LOG10Eq`: common, decimal logarithm of 2
- `M_LN2q`: natural logarithm of 2
- `M_LN10q`: natural logarithm of 10
- `M_PIq`:  $\pi$
- `M_PI_2q`:  $\pi$  divided by two
- `M_PI_4q`:  $\pi$  divided by four
- `M_1_PIq`: one over  $\pi$
- `M_2_PIq`: one over two  $\pi$

- $M\_2\_SQRTPIq$ : two over square root of pi
- $M\_SQRT2q$ : square root of 2
- $M\_SQRT1\_2q$ : one over square root of 2

## MATH LIBRARY ROUTINES

The following mathematical functions are available:

- *acosq*: arc cosine function
- *acoshq*: inverse hyperbolic cosine function
- *asinq*: arc sine function
- *asinhq*: inverse hyperbolic sine function
- *atanq*: arc tangent function
- *atanhq*: inverse hyperbolic tangent function
- *atan2q*: arc tangent function
- *cbrtq*: cube root function
- *ceilq*: ceiling value function
- *copysignq*: copy sign of a number
- *coshq*: hyperbolic cosine function
- *cosq*: cosine function
- *erfq*: error function
- *erfcq*: complementary error function
- *exp2q*: base 2 exponential function
- *expq*: exponential function
- *expm1q*: exponential minus 1 function
- *fabsq*: absolute value function
- *fdimq*: positive difference function
- *finiteq*: check finiteness of value
- *floorq*: floor value function
- *fmaq*: fused multiply and add
- *fmaxq*: determine maximum of two values

- *fminq*: determine minimum of two values
- *fmodq*: remainder value function
- *frexpq*: extract mantissa and exponent
- *hypotq*: Euclidian distance function
- *ilogbq*: get exponent of the value
- *isinfq*: check for infinity
- *isnanq*: check for not a number
- *issignalingq*: check for signaling not a number
- *j0q*: Bessel function of the first kind, first order
- *j1q*: Bessel function of the first kind, second order
- *jnq*: Bessel function of the first kind, {n}-th order
- *ldexpq*: load exponent of the value
- *lgammaq*: logarithmic gamma function
- *llrintq*: round to nearest integer value
- *llroundq*: round to nearest integer value away from zero
- *logbq*: get exponent of the value
- *logq*: natural logarithm function
- *log10q*: base 10 logarithm function
- *log1pq*: compute natural logarithm of the value plus one
- *log2q*: base 2 logarithm function
- *lrinq*: round to nearest integer value
- *lroundq*: round to nearest integer value away from zero
- *modfq*: decompose the floating-point number
- *nanq*: return quiet NaN
- *nearbyintq*: round to nearest integer
- *nextafterq*: next representable floating-point number
- *powq*: power function
- *remainderq*: remainder function
- *remquoq*: remainder and part of quotient
- *rintq*: round-to-nearest integral value
- *roundq*: round-to-nearest integral value, return {\_\_float128}
- *scalblnq*: compute exponent using {FLT\_RADIX}

- *scalbnq*: compute exponent using  $\{\text{FLT\_RADIX}\}$
- *signbitq*: return sign bit
- *sincosq*: calculate sine and cosine simultaneously
- *sinhq*: hyperbolic sine function
- *sinq*: sine function
- *sqrtq*: square root function
- *tanq*: tangent function
- *tanhq*: hyperbolic tangent function
- *tgammq*: true gamma function
- *truncq*: round to integer, towards zero
- *y0q*: Bessel function of the second kind, first order
- *y1q*: Bessel function of the second kind, second order
- *ynq*: Bessel function of the second kind,  $\{n\}$ -th order
- *cabsq*: complex absolute value function
- *cargq*: calculate the argument
- *cimagq*: imaginary part of complex number
- *crealq*: real part of complex number
- *cacoshq*: complex arc hyperbolic cosine function
- *cacosq*: complex arc cosine function
- *casinhq*: complex arc hyperbolic sine function
- *casinq*: complex arc sine function
- *catanhq*: complex arc hyperbolic tangent function
- *catanq*: complex arc tangent function
- *ccosq*: complex cosine function
- *ccoshq*: complex hyperbolic cosine function
- *cexpq*: complex exponential function
- *cexpiq*: computes the exponential function of 'i' times a real value
- *clogq*: complex natural logarithm
- *clog10q*: complex base 10 logarithm
- *conjq*: complex conjugate function
- *cpowq*: complex power function
- *cprojq*: project into Riemann Sphere

- *csinq*: complex sine function
- *csinhq*: complex hyperbolic sine function
- *csqrtq*: complex square root
- *ctanq*: complex tangent function
- *ctanhq*: complex hyperbolic tangent function

## I/O LIBRARY ROUTINES

### 5.1 strtou128 — Convert from string

The function `strtou128` converts a string into a `__float128` number.

**Syntax:**

```
__float128 strtou128 (const char *s, char **sp)
```

**Arguments:**

<code>s</code>	input string
<code>sp</code>	the address of the next character in the string

The argument `sp` contains, if not `NULL`, the address of the next character following the parts of the string, which have been read.

**Example:**

```
#include <quadmath.h>

int main ()
{
    __float128 r;

    r = strtou128 ("1.2345678", NULL);

    return 0;
}
```

## 5.2 quadmath\_snprintf — Convert to string

The function `quadmath_snprintf` converts a `__float128` floating-point number into a string. It is a specialized alternative to `snprintf`, where the format string is restricted to a single conversion specifier with `Q` modifier and conversion specifier `e`, `E`, `f`, `F`, `g`, `G`, `a` or `A`, with no extra characters before or after the conversion specifier. The `%m$` or `*m$` style must not be used in the format.

### Syntax:

```
int quadmath_snprintf (char *s, size_t size, const char *format, ...)
```

### Arguments:

<i>s</i>	output string
<i>size</i>	byte size of the string, including trailing NUL
<i>format</i>	conversion specifier string

### Note:

On some targets when supported by the C library hooks are installed for `printf` family of functions, so that `printf ("%Qe", 1.2Q);` etc. works too.

### Example:

```
#include <quadmath.h>
#include <stdlib.h>
#include <stdio.h>

int main ()
{
    __float128 r;
    int prec = 20;
    int width = 46;
    char buf[128];

    r = 2.0q;
    r = sqrtq (r);
    int n = quadmath_snprintf (buf, sizeof buf, "%+-.#*.20Qe", width, r);
    if ((size_t) n < sizeof buf)
        printf ("%s\n", buf);
    /* Prints: +1.41421356237309504880e+00 */
    quadmath_snprintf (buf, sizeof buf, "%Qa", r);
    if ((size_t) n < sizeof buf)
        printf ("%s\n", buf);
    /* Prints: 0x1.6a09e667f3bcc908b2fb1366ea96p+0 */
    n = quadmath_snprintf (NULL, 0, "%+-.#46.*Qe", prec, r);
    if (n > -1)
    {
        char *str = malloc (n + 1);
        if (str)
        {
            quadmath_snprintf (str, n + 1, "%+-.#46.*Qe", prec, r);
            printf ("%s\n", str);
        }
    }
}
```

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```
        /* Prints: +1.41421356237309504880e+00 */
    }
    free (str);
}
return 0;
}
```



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If your document contains nontrivial examples of program code, we recommend releasing these examples in parallel under your choice of free software license, such as the GNU General Public License, to permit their use in free software.

## REPORTING BUGS

Bugs in the GCC Quad-Precision Math Library implementation should be reported via <https://gcc.gnu.org/bugs/>.



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