Automotive Math and Motor Control Library Set for NXP S32K3xx, MWCT2DxxS, and MWCT20xxS devices

Accuracy of Floating-Point Functions

Rev. 13 — 15 September 2023 User guide
S32K3XXMCFLTACC

Revision History

Revision	Date	Description
1.0	30-September-2020	Initial release.
2.0	31-December-2020	The Service Release v1.1.23. See release notes for list of changes.
3.0	31-March-2021	The Service Release v1.1.24. See release notes for list of changes.
4.0	30-June-2021	The Service Release v1.1.25. See release notes for list of changes.
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7.0	31-March-2022	The Service Release v1.1.28. See release notes for list of changes.
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12.0	30-June-2023	The Service Release v1.1.33. See release notes for list of changes.
13.0	30-September-2023	The Service Release v1.1.34. See release notes for list of changes.

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1 Introduction

Applications utilizing floating-point calculations tend to exhibit hard-to-predict behavior due to intricacies of finite-precision implementation of numerical algorithms. Such uncertainty cannot be ignored in critical systems. The risk of accidents resulting from numerical errors can be alleviated if the limitations of the algorithms are well understood.

Standard C libraries are typically designed to provide correctly rounded results for all functions (i.e. error less than ±0.5 ulp). Maintaining such accuracy is prohibitively slow for embedded applications. The Automotive Math and Motor Control Library Set for NXPS32K3xx (S32K311, S32K312, S32K314, S32K322, S32K324, S32K328, S32K338, S32K341, S32K342, S32K344, S32K348, S32K358, S32K374, S32K376, S32K394, S32K396), MWCT2DxxS, and MWCT20xxS devices (AMMCLib) is tailored for embedded automotive systems requiring maximum processing speed and useful accuracy of results.

The aim of this document is to specify the guaranteed accuracy of floating-point functions contained in the AMMCLib. The accuracy generally depends on specific numerical cases and hence is specified for all combinations of floating-point inputs, including all parameters and state variables accessed via input pointers. The guaranteed accuracy is expressed in terms of worst-case output error bounds for each specific case.

The accuracy criteria described in this document are also available in the form of Matlab® scripts suitable for automated verification systems.

1.1 About this Manual

This document employs the following typographical conventions:

Table 1. Typographical Conventions

Typographical Style	Example
Symbols in capital italic font represent sets.	*M*
Symbols in bold italic font represent vectors.	***fltTable***
symbols in italic font represent scalars.	*fltIn*
Subscript is used for indexing of vector elements.	$fltTable_n$

1.2 Acronyms and Definitions

Table 2. Acronyms and Definitions

Term	Definition
API	Application Programming Interface.
Inf	Floating-point special value "infinity".
NaN	Floating-point special value "not a number".
nmax	Maximum negative normalized single precision floating-point value.
pmax	Maximum positive normalized single precision floating-point value.
ulp	Unit in the last place. Used as a unit of measurement of floating-point calculation error.

1.3 Reference List

Table 3. Reference List

#	Title
1	IEEE 754-2008 IEEE Standard for Floating-Point Arithmetic, 2008
2	Power ISA , Version 2.06 Revision B, July 23, 2010

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Table 3. Reference List*...continued*

#	Title
3	ARMv7-M Architecture Reference Manual, Issue Derrata 2010_Q3, 2010
4	ISO/IEC 9899:1999 Programming Language – C, 1999
5	AMMCLib User's Guide, revision 13

1.4 Common Definitions

This document uses the following set builder notation for input values of library functions:

$\{(fltIn_1, fltIn_2) \in X \mid X \cap M = \emptyset \wedge X \cap D \neq \emptyset\}$ denotes a set X of one or more combinations of input values $fltIn_1$, $fltIn_2$, such that X does not contain elements of M and contains at least one element of D. $X \subset Z$ where Z is a set of all possible combinations of all floating-point values which can appear on the inputs.

The guaranteed accuracy of results is defined for each subset of input values. Whenever two subsets overlap, the one with higher allowed error takes precedence.

Unless otherwise stated, variables are to be taken as real numbers. Whenever a variable is compared to Inf, -Inf, or NaN, a single precision floating-point representation of such variable in round-to-nearest mode is considered.

Unless otherwise stated, inputs to library functions are considered exactly representable in single precision floating-point format.

Let $N = \langle -(2 - 2^{-23})\cdot 2^{127}, -2^{-126}\rangle \cup \langle 2^{-126}, (2 - 2^{-23})\cdot 2^{127}\rangle$, i.e. a set of real numbers which are represented by normalized numbers in single precision floating-point format.

Let $D = \langle -2^{-126}, -2^{-149}\rangle \cup \langle 2^{-149}, -2^{-126}\rangle$, i.e. a set of real numbers which are represented by denormalized numbers in single precision floating-point format, excluding zero.

Let M = {NaN, Inf, -Inf}, i.e. a set of non-numerical floating-point values.

Let $pmax = (2 - 2^{-23})\cdot 2^{127}$, i.e. the maximum positive normalized single precision floating-point value.

Let $nmax = -(2 - 2^{-23})\cdot 2^{127}$, i.e. the maximum negative normalized single precision floating-point value.

Function ceil(x) provides x rounded towards positive infinity.

Function fe(x) provides the unbiased exponent of a single precision floating-point representation of x.

Function fix(x) provides x rounded towards zero.

Function floor(x) provides x rounded towards negative infinity.

Function max(a,b,c,...) provides the maximum value of {a, b, c, …}.

Function min(a,b,c,...) provides the minimum value of {a, b, c, …}.

Function sign(x) provides 1 if $x > 0$, 0 if $x = 0$, and -1 if $x < 0$.

If x lies between two finite consecutive single precision floating-point numbers a and b without being equal to one of them, then ULP(x) = $|b - a|$, otherwise ULP(x) is the distance between two finite single precision floating-point numbers nearest x. ULP(NaN) = NaN.

The error of floating-point results is measured in units of ulp by comparing the actual *result* with theoretical exact *refResult* as follows:

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$$e = \frac{refResult\text{-}result}{\mathrm{ULP}(refResult)}\left[\mathrm{ulp}\right]$$

Equation 1

E.g. *e* = 10 ulp describes a result that deviates from exact result by ten times the absolute value of the least-significant mantissa bit of a single precision floating-point representation of the exact result.

All error measurements assume IEEE 754-2008 binary floating-point arithmetic with round-to-nearest rounding mode and default results mode in case of Power ISA implementation.

2 Library Functions

This sections provides error bounds for individual functions in the AMMCLib.

2.1 Function AMCLIB_BemfObsrvDQ_FLT

2.1.1 Declaration

```
tFloat AMCLIB_BemfObsrvDQ_FLT(const SWLIBS_2Syst_FLT *const pIAB,
const SWLIBS_2Syst_FLT *const pUAB, tFloat fltVelocity, tFloat
fltPhase, AMCLIB_BEMF_OBSRV_DQ_T_FLT *const pCtrl);
```

2.1.2 Arguments

Table 4. AMCLIB_BemfObsrvDQ_FLT arguments

Type	Name	Direction	Description
const SWLIBS_2Syst_FLT *const	pIAB	**input**	Pointer to the structure with Alpha/Beta current components [A].
const SWLIBS_2Syst_FLT *const	pUAB	**input**	Pointer to the structure with Alpha/Beta voltage components [V].
tFloat	fltVelocity	**input**	Estimated electrical angular velocity [rad/s].
tFloat	fltPhase	**input**	Estimated rotor flux angle [rad], must be in range [-π, π].
AMCLIB_BEMF_OBSRV_DQ_T_FLT *const	pCtrl	**input, output**	Pointer to the structure with BEMF observer parameters and state.

2.1.3 Worst-Case Error Bounds

Let (*pIABArg1*, *pIABArg2*, *pUABArg1*, *pUABArg2*, *fltVelocity*, *pPhaseErr*, *pIObsrvArg1*, *pIObsrvArg2*, *DfltCC1sc*, *DfltCC2sc*, *DfltAcc*, *DfltInErrK1*, *DfltUpperLimit*, *DfltLowerLimit*, *DfltCC1sc*, *DfltCC2sc*, *DfltAcc*, *DfltInErrK1*, *DfltUpperLimit*, *DfltLowerLimit*, *pIObsrvIn_1Arg1*, *pIObsrvIn_1Arg2*, *fltIGain*, *fltUGain*, *fltWIGain*, *fltEGain*) ∈ *X* be a set of inputs to AMCLIB_BemfObsrvDQ_FLT,

pIObsrvArg1, *pIObsrvArg2*, *DfltAcc*, *QfltAcc*, *DfltInErrK1*, *QfltInErrK1*, *pIObsrvIn_1Arg1*, *pIObsrvIn_1Arg2* inputs represent real numbers with an error of max. ±0.5 ulp,

$ir_1 = pUABArg1 \cdot \cos(pPhaseErr)$,

$me_1 = 84$,

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$ir_2 = pUABArg2 \cdot \sin(pPhaseErr)$,

$me_2 = 84$,

$ie_1 = \max(\mathrm{fe}(|ir_1| + me_1 \cdot \mathrm{ULP}(ir_1)), \mathrm{fe}(|ir_2| + me_2 \cdot \mathrm{ULP}(ir_2)))$,

$ir_3 = ir_1 + ir_2$,

$ie_2 = \mathrm{fe}(ir_3)$,

$$cb_1 = \begin{cases} 0, & ie_1 - ie_2 \le 0 \\ ie_1 - ie_2, & ie_1 - ie_2 > 0 \end{cases},$$

$me_3 = 1 + 168 \cdot 2^{cb_1}$,

$ir_4 = pUABArg2 \cdot \cos(pPhaseErr)$,

$me_4 = 84$,

$ir_5 = -pUABArg1 \cdot \sin(pPhaseErr)$,

$me_5 = 84$,

$ie_3 = \max(\mathrm{fe}(|ir_4| + 84 \cdot \mathrm{ULP}(ir_4)), \mathrm{fe}(|ir_5| + 84 \cdot \mathrm{ULP}(ir_5)))$,

$ir_6 = ir_4 + ir_5$,

$ie_4 = \mathrm{fe}(ir_6)$,

$$cb_2 = \begin{cases} 0, & ie_3 - ie_4 \le 0 \\ ie_3 - ie_4, & ie_3 - ie_4 > 0 \end{cases},$$

$me_6 = 1 + 168 \cdot 2^{cb_2}$,

$ir_7 = pIABArg1 \cdot \cos(pPhaseErr)$,

$me_7 = 84$,

$ir_8 = pIABArg2 \cdot \sin(pPhaseErr)$,

$me_8 = 84$,

$ie_5 = \max(\mathrm{fe}(|ir_7| + 84 \cdot \mathrm{ULP}(ir_7)), \mathrm{fe}(|ir_8| + 84 \cdot \mathrm{ULP}(ir_8)))$,

$ir_9 = ir_7 + ir_8$,

$ie_6 = \mathrm{fe}(ir_9)$,

$$cb_3 = \begin{cases} 0, & ie_5 - ie_6 \le 0 \\ ie_5 - ie_6, & ie_5 - ie_6 > 0 \end{cases},$$

$me_9 = 1 + 168 \cdot 2^{cb_3}$,

$ir_{10} = pIABArg2 \cdot \cos(pPhaseErr)$,

$me_{10} = 84$,

$ir_{11} = -pIABArg1 \cdot \sin(pPhaseErr)$,

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$me_{10} = 84$,

$ie_7 = \max(\mathrm{fe}(|ir_{10}| + 84 \cdot \mathrm{ULP}(ir_{10})), \mathrm{fe}(|ir_{11}| + 84 \cdot \mathrm{ULP}(ir_{11})))$,

$ir_{12} = ir_{10} + ir_{11}$,

$ie_8 = \mathrm{fe}(ir_{12})$,

$$cb_4 = \begin{cases} 0, & ie_7 - ie_8 \le 0 \\ ie_7 - ie_8, & ie_7 - ie_8 > 0 \end{cases},$$

$me_{12} = 1 + 168 \cdot 2^{cb_4}$,

$ie_9 = \max(\mathrm{fe}(|ir_9| + me_9 \cdot \mathrm{ULP}(ir_9)), \mathrm{fe}(|pIObsrvArg1| + 0.5 \cdot \mathrm{ULP}(pIObsrvArg1)))$,

$ir_{13} = ir_9 - pIObsrvArg1$,

$ie_{10} = \mathrm{fe}(ir_{13})$,

$$cb_5 = \begin{cases} 0, & ie_9 - ie_{10} \le 0 \\ ie_9 - ie_{10}, & ie_9 - ie_{10} > 0 \end{cases},$$

$me_{13} = 0.5 + (me_9 + 0.5) \cdot 2^{cb_5}$,

$ie_{11} = \max(\mathrm{fe}(|ir_{12}| + me_{12} \cdot \mathrm{ULP}(ir_{12})), \mathrm{fe}(|pIObsrvArg2| + 0.5 \cdot \mathrm{ULP}(pIObsrvArg2)))$,

$ir_{14} = ir_{12} - pIObsrvArg2$,

$ie_{12} = \mathrm{fe}(ir_{14})$,

$$cb_6 = \begin{cases} 0, & ie_{11} - ie_{12} \le 0 \\ ie_{11} - ie_{12}, & ie_{11} - ie_{12} > 0 \end{cases},$$

$me_{14} = 0.5 + (me_{12} + 0.5) \cdot 2^{cb_6}$,

$ir_{15} = ir_{13} \cdot DfltCC1sc$,

$me_{15} = 2 \cdot me_{13}$,

$ir_{16} = DfltInErrK1 \cdot DfltCC2sc$,

$me_{16} = 1$,

$ie_{13} = \max(\mathrm{fe}(|ir_{15}| + me_{15} \cdot \mathrm{ULP}(ir_{15})), \mathrm{fe}(|ir_{16}| + \mathrm{ULP}(ir_{16})))$,

$ir_{17} = ir_{15} + ir_{16}$,

$ie_{14} = \mathrm{fe}(ir_{17})$,

$$cb_7 = \begin{cases} 0, & ie_{13} - ie_{14} \le 0 \\ ie_{13} - ie_{14}, & ie_{13} - ie_{14} > 0 \end{cases},$$

$me_{17} = 1 + (me_{15} + 1) \cdot 2^{cb_7}$,

$ir_{18} = ir_{14} \cdot QfltCC1sc$,

$me_{18} = 2 \cdot me_{14}$,

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$$ir_{19} = QfltInErrK1 \cdot QfltCC2sc,$$

$$me_{19} = 1,$$

$$ie_{15} = \max(\mathrm{fe}(|ir_{18}| + me_{18} \cdot \mathrm{ULP}(ir_{18})), \mathrm{fe}(|ir_{19}| + \mathrm{ULP}(ir_{19}))),$$

$$ir_{20} = ir_{18} + ir_{19},$$

$$ie_{16} = \mathrm{fe}(ir_{20}),$$

$$cb_8 = \begin{cases} 0, & ie_{15} - ie_{16} \le 0 \\ ie_{15} - ie_{16}, & ie_{15} - ie_{16} > 0 \end{cases},$$

$$me_{20} = 1 + (me_{18} + 1) \cdot 2^{cb_8},$$

$$ie_{17} = \max(\mathrm{fe}(|ir_{17}| + me_{17} \cdot \mathrm{ULP}(ir_{17})), \mathrm{fe}(|DfltAcc| + 0.5 \cdot \mathrm{ULP}(DfltAcc))),$$

$$ir_{21} = ir_{17} + DfltAcc,$$

$$ie_{18} = \mathrm{fe}(ir_{21}),$$

$$cb_9 = \begin{cases} 0, & ie_{17} - ie_{18} \le 0 \\ ie_{17} - ie_{18}, & ie_{17} - ie_{18} > 0 \end{cases},$$

$$me_{21} = \begin{cases} 0, & ir_{21} + \left(0.5 + (me_{17} + 0.5) \cdot 2^{cb_9}\right) \cdot \mathrm{ULP}(ir_{21}) < DfltLowerLimit \\ 0, & ir_{21} - \left(0.5 + (me_{17} + 0.5) \cdot 2^{cb_9}\right) \cdot \mathrm{ULP}(ir_{21}) > DfltUpperLimit \\ 0.5 + (me_{17} + 0.5) \cdot 2^{cb_9}, & \text{otherwise} \end{cases},$$

$$ie_{19} = \max(\mathrm{fe}(|ir_{20}| + me_{20} \cdot \mathrm{ULP}(ir_{20})), \mathrm{fe}(|QfltAcc| + 0.5 \cdot \mathrm{ULP}(QfltAcc))),$$

$$ir_{22} = ir_{19} + QfltAcc,$$

$$ie_{20} = \mathrm{fe}(ir_{22}),$$

$$cb_{10} = \begin{cases} 0, & ie_{19} - ie_{20} \le 0 \\ ie_{19} - ie_{20}, & ie_{19} - ie_{20} > 0 \end{cases},$$

$$me_{22} = \begin{cases} 0, & ir_{22} + \left(0.5 + (me_{20} + 0.5) \cdot 2^{cb_{10}}\right) \cdot \mathrm{ULP}(ir_{22}) < QfltLowerLimit \\ 0, & ir_{22} - \left(0.5 + (me_{20} + 0.5) \cdot 2^{cb_{10}}\right) \cdot \mathrm{ULP}(ir_{22}) > QfltUpperLimit \\ 0.5 + (me_{20} + 0.5) \cdot 2^{cb_{10}}, & \text{otherwise} \end{cases},$$

$$ir_{23} = \begin{cases} DfltLowerLimit, & ir_{21} < DfltLowerLimit \\ DfltUpperLimit, & ir_{21} > DfltUpperLimit \\ ir_{21}, & \text{otherwise} \end{cases},$$

$$me_{23} = me_{21},$$

$$ir_{24} = \begin{cases} QfltLowerLimit, & ir_{22} < QfltLowerLimit \\ QfltUpperLimit, & ir_{22} > QfltUpperLimit \\ ir_{22}, & \text{otherwise} \end{cases},$$

$$me_{24} = me_{22},$$

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$ir_{25} = ir_{23} / ir_{24}$,

$me_{25} = 0.5 + 2 \cdot me_{23} + 2 \cdot me_{24}$,

$ir_{26} = fltVelocity \cdot fltWIGain$,

$me_{26} = 0.5$,

$ir_{27} = ir_{26} \cdot ir_{12}$,

$me_{27} = 0.5 + 2 \cdot me_{26} + 2 \cdot me_{12}$,

$ir_{28} = -ir_{26} \cdot ir_{9}$,

$me_{28} = 0.5 + 2 \cdot me_{26} + 2 \cdot me_{9}$,

$ir_{29} = ir_{23} \cdot fltEGain$,

$me_{29} = 2 \cdot me_{23}$,

$ir_{30} = ir_{24} \cdot fltEGain$,

$me_{30} = 2 \cdot me_{24}$,

$ie_{21} = \max(\mathrm{fe}(|ir_{27}| + me_{27} \cdot \mathrm{ULP}(ir_{27})), \mathrm{fe}(|ir_{29}| + me_{29} \cdot \mathrm{ULP}(ir_{29})))$,

$ir_{31} = ir_{27} + ir_{29}$,

$ie_{22} = \mathrm{fe}(ir_{31})$,

$$cb_{11} = \begin{cases} 0, & ie_{21} - ie_{22} \le 0 \\ ie_{21} - ie_{22}, & ie_{21} - ie_{22} > 0 \end{cases},$$

$me_{31} = 0.5 + (me_{27} + me_{29}) \cdot 2^{cb_{11}}$,

$ie_{23} = \max(\mathrm{fe}(|ir_{28}| + me_{28} \cdot \mathrm{ULP}(ir_{28})), \mathrm{fe}(|ir_{30}| + me_{30} \cdot \mathrm{ULP}(ir_{30})))$,

$ir_{32} = ir_{28} + ir_{30}$,

$ie_{24} = \mathrm{fe}(ir_{32})$,

$$cb_{12} = \begin{cases} 0, & ie_{23} - ie_{24} \le 0 \\ ie_{23} - ie_{24}, & ie_{23} - ie_{24} > 0 \end{cases},$$

$me_{32} = 0.5 + (me_{28} + me_{30}) \cdot 2^{cb_{12}}$,

$ir_{33} = ir_{3} \cdot fltUGain$,

$me_{33} = 2 \cdot me_{3}$,

$ir_{34} = ir_{6} \cdot fltUGain$,

$me_{34} = 2 \cdot me_{6}$,

$ie_{25} = \max(\mathrm{fe}(|ir_{31}| + me_{31} \cdot \mathrm{ULP}(ir_{31})), \mathrm{fe}(|ir_{33}| + me_{33} \cdot \mathrm{ULP}(ir_{33})))$,

$ir_{35} = ir_{31} + ir_{33}$,

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$$ie_{26} = \mathrm{fe}(ir_{35}),$$

$$cb_{13} = \begin{cases} 0, & ie_{25} - ie_{26} \le 0 \\ ie_{25} - ie_{26}, & ie_{25} - ie_{26} > 0 \end{cases},$$

$$me_{35} = 0.5 + (me_{31} + me_{33}) \cdot 2^{cb_{13}},$$

$$ie_{27} = \max(\mathrm{fe}(|ir_{32}| + me_{32} \cdot \mathrm{ULP}(ir_{32})), \mathrm{fe}(|ir_{34}| + me_{34} \cdot \mathrm{ULP}(ir_{34}))),$$

$$ir_{36} = ir_{32} + ir_{34},$$

$$ie_{28} = \mathrm{fe}(ir_{36}),$$

$$cb_{13} = \begin{cases} 0, & ie_{27} - ie_{28} \le 0 \\ ie_{27} - ie_{28}, & ie_{27} - ie_{28} > 0 \end{cases},$$

$$me_{36} = 0.5 + (me_{32} + me_{34}) \cdot 2^{cb_{13}},$$

$$ie_{29} = \max(\mathrm{fe}(|ir_{35}| + me_{35} \cdot \mathrm{ULP}(ir_{35})), \mathrm{fe}(|pIObsrvin_1Arg1| + 0.5 \cdot \mathrm{ULP}(pIObsrvin_1Arg1))),$$

$$ir_{37} = ir_{35} + pIObsrvin_1Arg1,$$

$$ie_{30} = \mathrm{fe}(ir_{37}),$$

$$cb_{14} = \begin{cases} 0, & ie_{29} - ie_{30} \le 0 \\ ie_{29} - ie_{30}, & ie_{29} - ie_{30} > 0 \end{cases},$$

$$me_{37} = 0.5 + (me_{35} + 0.5) \cdot 2^{cb_{14}},$$

$$ie_{31} = \max(\mathrm{fe}(|ir_{36}| + me_{36} \cdot \mathrm{ULP}(ir_{36})), \mathrm{fe}(|pIObsrvin_1Arg2| + 0.5 \cdot \mathrm{ULP}(pIObsrvin_1Arg2))),$$

$$ir_{38} = ir_{36} + pIObsrvin_1Arg2,$$

$$ie_{32} = \mathrm{fe}(ir_{38}),$$

$$cb_{15} = \begin{cases} 0, & ie_{31} - ie_{32} \le 0 \\ ie_{31} - ie_{32}, & ie_{31} - ie_{32} > 0 \end{cases},$$

$$me_{38} = 0.5 + (me_{36} + 0.5) \cdot 2^{cb_{15}},$$

$$ir_{39} = pIObsrvArg1 \cdot fltIGain,$$

$$me_{39} = 1,$$

$$ir_{40} = pIObsrvArg2 \cdot fltIGain,$$

$$me_{40} = 1,$$

$$ie_{33} = \max(\mathrm{fe}(|ir_{37}| + me_{37} \cdot \mathrm{ULP}(ir_{37})), \mathrm{fe}(|ir_{39}| + \mathrm{ULP}(ir_{39}))),$$

$$ir_{41} = ir_{37} + ir_{39},$$

$$ie_{34} = \mathrm{fe}(ir_{41}),$$

$$cb_{16} = \begin{cases} 0, & ie_{33} - ie_{34} \le 0 \\ ie_{33} - ie_{34}, & ie_{33} - ie_{34} > 0 \end{cases},$$

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$me_{41} = 0.5 + (me_{37} + 1) \cdot 2^{cb_{16}}$,

$ie_{35} = \max(\mathrm{fe}(|ir_{38}| + me_{38} \cdot \mathrm{ULP}(ir_{38})), \mathrm{fe}(|ir_{40}| + \mathrm{ULP}(ir_{40})))$,

$ir_{42} = ir_{38} + ir_{40}$,

$ie_{36} = \mathrm{fe}(ir_{42})$,

$cb_{17} = \begin{cases} 0, & ie_{35} - ie_{36} \le 0 \\ ie_{35} - ie_{36}, & ie_{35} - ie_{36} > 0 \end{cases}$,

$me_{42} = 0.5 + (me_{38} + 1) \cdot 2^{cb_{17}}$,

$me_{43} = 6 + me_{25}$,

then

Table 5. AMCLIB_BemfObsrvDQ_FLT Worst-Case Error Bounds - pParamD.fltInErrK1 output

Subset of input domain	Worst-case error bounds for pParamD.fltInErrK1 output [ulp]	Allowed specific values (regardless the error bounds) for pParamD.fltInErrK1 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \ne \varnothing \vee X \cap M \ne \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values with pPhaseErr beyond the allowed range, i.e. $\{X \mid X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert > \pi\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \\ \boldsymbol{ir} \in (N \cup \{-0, +0\})^{42} \end{array} \right\}$	$\langle -me_{13}, me_{13} \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \\ \exists n : ir_n \ne \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \\ \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 6. AMCLIB_BemfObsrvDQ_FLT Worst-Case Error Bounds - pParamQ.fltInErrK1 output

Subset of input domain	Worst-case error bounds for pParamQ.fltInErrK1 output [ulp]	Allowed specific values (regardless the error bounds) for pParamQ.fltInErrK1 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \neq \varnothing \vee X \cap M \neq \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values with pPhaseErr beyond the allowed range, i.e. $\{X \mid X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert > \pi\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \leq \pi, \\ \boldsymbol{ir} \in (N \cup \{-0, +0\})^{42} \end{array} \right\}$	$\langle -me_{14}, me_{14} \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \leq \pi, \\ \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \leq \pi, \\ \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 7. AMCLIB_BemfObsrvDQ_FLT Worst-Case Error Bounds - pParamD.fltAcc output

Subset of input domain	Worst-case error bounds for pParamD.fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for pParamD.fltAcc output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \neq \varnothing \vee X \cap M \neq \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 7. AMCLIB_BemfObsrvDQ_FLT Worst-Case Error Bounds - pParamD.fltAcc output...*continued*

Subset of input domain	Worst-case error bounds for pParamD.fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for pParamD.fltAcc output
Normalized or zero input values with pPhaseErr beyond the allowed range, i.e. $\{X \mid X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert > \pi\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ X \mid X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \; \boldsymbol{ir} \in (N \cup \{-0, +0\})^{42} \right\}$	$\langle -me_{21}, me_{21} \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ X \mid X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \; \exists n : ir_n \ne \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ X \mid X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \; \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 8. AMCLIB_BemfObsrvDQ_FLT Worst-Case Error Bounds - pParamQ.fltAcc output

Subset of input domain	Worst-case error bounds for pParamQ.fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for pParamQ.fltAcc output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \ne \varnothing \vee X \cap M \ne \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values with pPhaseErr beyond the allowed range, i.e. $\{X \mid X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert > \pi\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 8. AMCLIB_BemfObsrvDQ_FLT Worst-Case Error Bounds - pParamQ.fltAcc output...*continued*

Subset of input domain	Worst-case error bounds for pParamQ.fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for pParamQ.fltAcc output
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \boldsymbol{ir} \in (N \cup \{-0, +0\})^{42} \right\}$	$\langle -me_{22}, me_{22} \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \exists n : ir_n \ne \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 9. AMCLIB_BemfObsrvDQ_FLT Worst-Case Error Bounds - pPhaseErr output

Subset of input domain	Worst-case error bounds for pPhaseErr output [ulp]	Allowed specific values (regardless the error bounds) for pPhaseErr output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{ X \vert X \cap D \ne \varnothing \vee X \cap M \ne \varnothing \}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values with pPhaseErr beyond the allowed range, i.e. $\{ X \vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert > \pi \}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \boldsymbol{ir} \in (N \cup \{-0, +0\})^{42} \right\}$	$\langle -me_{22}, me_{22} \rangle$	N/A

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Table 9. AMCLIB_BemfObsrvDQ_FLT Worst-Case Error Bounds - pPhaseErr output*...continued*

Subset of input domain	Worst-case error bounds for pPhaseErr output [ulp]	Allowed specific values (regardless the error bounds) for pPhaseErr output
Normalized or zero input values which cause an underflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \exists n : ir_n \ne \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results with pEObsrv.fltArg2 close to zero, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \boldsymbol{ir} \in (N \cup \{-0, +0\})^{42}, \lvert ir_{22} \rvert \le me_{22} \cdot \mathrm{ULP}(ir_{22}) \right\}$	$(-Inf, Inf)$	N/A

Table 10. AMCLIB_BemfObsrvDQ_FLT Worst-Case Error Bounds - pIObsrvIn_1.fltArg1 output

Subset of input domain	Worst-case error bounds for pIObsrvIn_1.fltArg1 output [ulp]	Allowed specific values (regardless the error bounds) for pIObsrvIn_1.fltArg1 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{ X \vert X \cap D \ne \varnothing \vee X \cap M \ne \varnothing \}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values with pPhaseErr beyond the allowed range, i.e. $\{ X \vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert > \pi \}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \boldsymbol{ir} \in (N \cup \{-0, +0\})^{42} \right\}$	$\langle -me_{35}, me_{35} \rangle$	N/A

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Table 10. AMCLIB_BemfObsrvDQ_FLT Worst-Case Error Bounds - pIObsrvIn_1.fltArg1 output...*continued*

Subset of input domain	Worst-case error bounds for pIObsrvIn_1.fltArg1 output [ulp]	Allowed specific values (regardless the error bounds) for pIObsrvIn_1.fltArg1 output
Normalized or zero input values which cause an underflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \exists n : ir_n \ne \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 11. AMCLIB_BemfObsrvDQ_FLT Worst-Case Error Bounds - pIObsrvIn_1.fltArg2 output

Subset of input domain	Worst-case error bounds for pIObsrvIn_1.fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for pIObsrvIn_1.fltArg2 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{ X \vert X \cap D \ne \varnothing \vee X \cap M \ne \varnothing \}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values with pPhaseErr beyond the allowed range, i.e. $\{ X \vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert > \pi \}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \boldsymbol{ir} \in (N \cup \{-0, +0\})^{42} \right\}$	$\langle -me_{36}, me_{36} \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \exists n : ir_n \ne \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 11. AMCLIB_BemfObsrvDQ_FLT Worst-Case Error Bounds - plObsrvIn_1.fltArg2 output...*continued*

Subset of input domain	Worst-case error bounds for plObsrvIn_1.fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for plObsrvIn_1.fltArg2 output
Normalized or zero input values which cause an overflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 12. AMCLIB_BemfObsrvDQ_FLT Worst-Case Error Bounds - plObsrv.fltArg1 output

Subset of input domain	Worst-case error bounds for plObsrv.fltArg1 output [ulp]	Allowed specific values (regardless the error bounds) for plObsrv.fltArg1 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{ X \vert X \cap D \ne \varnothing \vee X \cap M \ne \varnothing \}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values with pPhaseErr beyond the allowed range, i.e. $\{ X \vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert > \pi \}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \boldsymbol{ir} \in (N \cup \{-0, +0\})^{42} \right\}$	$\langle -me_{41}, me_{41} \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \exists n : ir_n \ne \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 13. AMCLIB_BemfObsrvDQ_FLT Worst-Case Error Bounds - pIObsrv.fltArg2 output

Subset of input domain	Worst-case error bounds for pIObsrv.fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for pIObsrv.fltArg2 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \neq \varnothing \vee X \cap M \neq \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values with pPhaseErr beyond the allowed range, i.e. $\{X \mid X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert > \pi\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \leq \pi, \\ \boldsymbol{ir} \in (N \cup \{-0, +0\})^{42} \end{array} \right\}$	$\langle -me_{42}, me_{42} \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \leq \pi, \\ \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \leq \pi, \\ \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

2.2 Function AMCLIB_CurrentLoop_FLT

2.2.1 Declaration

```
void AMCLIB_CurrentLoop_FLT(tFloat fltUDcBus, SWLIBS_2Syst_FLT
*const pUDQReq, AMCLIB_CURRENT_LOOP_T_FLT *pCtrl);
```

2.2.2 Arguments

Table 14. AMCLIB_CurrentLoop_FLT arguments

Type	Name	Direction	Description
tFloat	fltUDcBus	**input**	DC bus voltage.
SWLIBS_2Syst_FLT *const	pUDQReq	**output**	Pointer to the structure with the required stator voltages in the two-phase rotational orthogonal system (d-q).

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Table 14. AMCLIB_CurrentLoop_FLT arguments...*continued*

Type	Name	Direction	Description
AMCLIB_ CURRENT_ LOOP_T_FLT *	pCtrl	**input, output**	Pointer to the structure with AMCLIB_ CurrentLoop state.

2.2.3 Worst-Case Error Bounds

Let (*fltUDcBus, pIDReq, pIQReq, pIDFbck, pIQFbck, fltCC1scD, fltCC2scD, fltAccD, fltInErrK1D, fltCC1scQ, fltCC2scQ, fltAccQ, fltInErrK1Q*) $\in X$ be a set of inputs to AMCLIB_CurrentLoop_FLT,

fltAccD, fltInErrK1D, fltAccQ, fltInErrK1Q inputs represent real numbers with an error of max. ±0.5 ulp,

$$ir_1 = pIQReq - pIDFbck,$$

$$me_1 = 0.5,$$

$$ir_2 = ir_1 \cdot fltCC1scD,$$

$$me_2 = 2 \cdot me_1,$$

$$ir_3 = fltInErrK1D \cdot fltCC2scD,$$

$$me_3 = 1,$$

$$ie_1 = \max(\mathrm{fe}(|ir_2| + me_2 \cdot \mathrm{ULP}(ir_2)), \mathrm{fe}(|ir_3| + me_3 \cdot \mathrm{ULP}(ir_3))),$$

$$ir_4 = ir_2 + ir_3,$$

$$ie_2 = \mathrm{fe}(ir_4),$$

$$cb_1 = \begin{cases} 0, & ie_1 - ie_2 \le 0 \\ ie_1 - ie_2, & ie_1 - ie_2 > 0 \end{cases},$$

$$me_4 = 1 + (me_2 + me_3) \cdot 2^{cb_1},$$

$$ie_3 = \max(\mathrm{fe}(|ir_4| + me_4 \cdot \mathrm{ULP}(ir_4)), \mathrm{fe}(|fltAccD| + 0.5 \cdot \mathrm{ULP}(fltAccD))),$$

$$ir_5 = ir_4 + fltAccD,$$

$$ie_4 = \mathrm{fe}(ir_5),$$

$$cb_2 = \begin{cases} 0, & ie_3 - ie_4 \le 0 \\ ie_3 - ie_4, & ie_3 - ie_4 > 0 \end{cases},$$

$$me_5 = 0.5 + (me_4 + 0.5) \cdot 2^{cb_2},$$

$$ir_{17} = fltUDcBus \cdot \frac{1}{\sqrt{3}},$$

$$me_{17} = 1.5,$$

$$me_6 = \begin{cases} \max(me_5, me_{17}), & ir_5 - me_5 \cdot \mathrm{ULP}(ir_5) > ir_{17} - me_{17} \cdot \mathrm{ULP}(ir_{17}) \\ \max(me_5, me_{17}), & ir_5 + me_5 \cdot \mathrm{ULP}(ir_5) < (-ir_{17} + me_{17} \cdot \mathrm{ULP}(ir_{17})) \\ me_5 & otherwise \end{cases},$$

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$$ir_6 = \begin{cases} ir_{17}, & ir_5 > ir_{17} \\ -ir_{17}, & ir_5 < (-ir_{17}) \\ ir_5 & otherwise \end{cases},$$

$$ir_7 = ir_6^2,$$

$$me_7 = 0.5 + 3 \cdot me_6,$$

$$ir_8 = ir_{17}^2,$$

$$me_8 = 0.5 + 3 \cdot me_{17},$$

$$ie_5 = \max(\mathrm{fe}(|ir_7| + me_7 \cdot \mathrm{ULP}(ir_7)), \mathrm{fe}(|ir_8| + me_8 \cdot \mathrm{ULP}(ir_8))),$$

$$ir_9 = ir_8 - ir_7,$$

$$ie_6 = \mathrm{fe}(ir_9),$$

$$cb_3 = \begin{cases} 0, & ie_5 - ie_6 \le 0 \\ ie_5 - ie_6, & ie_5 - ie_6 > 0 \end{cases},$$

$$me_9 = 0.5 + (me_7 + me_8) \cdot 2^{cb_3},$$

$$ir_{10} = \sqrt{ir_9},$$

$$me_8 = 0.5 + \frac{me_9}{\sqrt{2}},$$

$$ir_{11} = pIQReq - pIQFbck,$$

$$me_{11} = 0.5,$$

$$ir_{12} = ir_{11} \cdot fltCC1scQ,$$

$$me_{12} = 2 \cdot me_{11},$$

$$ir_{13} = fltInErrK1Q \cdot fltCC2scQ,$$

$$me_{13} = 1,$$

$$ie_7 = \max(\mathrm{fe}(|ir_{12}| + me_{12} \cdot \mathrm{ULP}(ir_{12})), \mathrm{fe}(|ir_{13}| + me_{13} \cdot \mathrm{ULP}(ir_{13}))),$$

$$ir_{14} = ir_{12} + ir_{13},$$

$$ie_8 = \mathrm{fe}(ir_{14}),$$

$$cb_4 = \begin{cases} 0, & ie_7 - ie_8 \le 0 \\ ie_7 - ie_8, & ie_7 - ie_8 > 0 \end{cases},$$

$$me_{14} = 1 + (me_{12} + me_{13}) \cdot 2^{cb_4},$$

$$ie_9 = \max(\mathrm{fe}(|ir_{14}| + me_{14} \cdot \mathrm{ULP}(ir_{14})), \mathrm{fe}(|fltAccQ| + 0.5 \cdot \mathrm{ULP}(fltAccQ))),$$

$$ir_{15} = ir_{14} + fltAccQ,$$

$$ie_{10} = \mathrm{fe}(ir_{15}),$$

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$$cb_5 = \begin{cases} 0, & ie_9 - ie_{10} \le 0 \\ ie_9 - ie_{10}, & ie_9 - ie_{10} > 0 \end{cases},$$

$$me_{15} = 0.5 + (me_{14} + 0.5) \cdot 2^{cb_5},$$

$$me_{16} = \begin{cases} \max(me_{15}, me_{10}), & ir_{15} - me_{15} \cdot \mathrm{ULP}(ir_{15}) > ir_{10} - me_{10} \cdot \mathrm{ULP}(ir_{10}) \\ \max(me_{15}, me_{10}), & ir_{15} + me_{15} \cdot \mathrm{ULP}(ir_{15}) < (-ir_{10} + me_{10} \cdot \mathrm{ULP}(ir_{10})) \\ me_{15} & otherwise \end{cases},$$

$$ir_{16} = \begin{cases} ir_{15}, & ir_{15} > ir_{10} \\ -ir_{10}, & ir_{15} < (-ir_{10}) \\ ir_{15} & otherwise \end{cases},$$

then

Table 15. AMCLIB_CurrentLoop_FLT Worst-Case Error Bounds - pPIrAWD.fltInErrK1 output

Subset of input domain	Worst-case error bounds for pPIrAWD.fltInErrK1 output [ulp]	Allowed specific values (regardless the error bounds) for pPIrAWD.fltInErrK1 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \ne \varnothing \vee X \cap M \ne \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values with fltUDPhMax or fltUQPhMax beyond the allowed range, i.e. $\left\{ X \mid X \subset N \cup \{-0, +0\} \wedge (\lvert fltUDPhMax \rvert < 0 \vee \lvert fltUQPhMax \rvert < 0) \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ X \mid X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \ge 0 \wedge \lvert fltUQPhMax \rvert \ge 0 \wedge ir \in (N \cup \{-0, +0\})^{17} \right\}$	$\langle -me_1, me_1 \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ X \mid X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \ge 0 \wedge \lvert fltUQPhMax \rvert \ge 0, \exists n : ir_n \ne \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 15. AMCLIB_CurrentLoop_FLT Worst-Case Error Bounds - pPIrAWD.fltInErrK1 output...*continued*

Subset of input domain	Worst-case error bounds for pPIrAWD.fltInErrK1 output [ulp]	Allowed specific values (regardless the error bounds) for pPIrAWD.fltInErrK1 output
Normalized or zero input values which cause an overflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \lvert fltUQPhMax \rvert \geq 0, \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 16. AMCLIB_CurrentLoop_FLT Worst-Case Error Bounds - pPIrAWD.fltAcc output

Subset of input domain	Worst-case error bounds for pPIrAWD.fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for pPIrAWD.fltAcc output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{ X \vert X \cap D \neq \varnothing \vee X \cap M \neq \varnothing \}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values with fltUDPhMax or fltUQPhMax beyond the allowed range, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge (\lvert fltUDPhMax \rvert < 0 \vee \lvert fltUQPhMax \rvert < 0) \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \lvert fltUQPhMax \rvert \geq 0 \wedge ir \in (N \cup \{-0, +0\})^{17} \right\}$	$\langle -me_6, me_6 \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \lvert fltUQPhMax \rvert \geq 0, \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 16. AMCLIB_CurrentLoop_FLT Worst-Case Error Bounds - pPIrAWD.fltAcc output...*continued*

Subset of input domain	Worst-case error bounds for pPIrAWD.fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for pPIrAWD.fltAcc output
Normalized or zero input values which cause an overflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \lvert fltUQPhMax \rvert \geq 0, \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 17. AMCLIB_CurrentLoop_FLT Worst-Case Error Bounds - pUDQReq.fltArg1 output

Subset of input domain	Worst-case error bounds for pUDQReq.fltArg1 output [ulp]	Allowed specific values (regardless the error bounds) for pUDQReq.fltArg1 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{ X \vert X \cap D \neq \varnothing \vee X \cap M \neq \varnothing \}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values with fltUDPhMax or fltUQPhMax beyond the allowed range, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge (\lvert fltUDPhMax \rvert < 0 \vee \lvert fltUQPhMax \rvert < 0) \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \lvert fltUQPhMax \rvert \geq 0 \wedge ir \in (N \cup \{-0, +0\})^{17} \right\}$	$\langle -me_6, me_6 \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \lvert fltUQPhMax \rvert \geq 0, \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 17. AMCLIB_CurrentLoop_FLT Worst-Case Error Bounds - pUDQReq.fltArg1 output...*continued*

Subset of input domain	Worst-case error bounds for pUDQReq.fltArg1 output [ulp]	Allowed specific values (regardless the error bounds) for pUDQReq.fltArg1 output
Normalized or zero input values which cause an overflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \lvert fltUQPhMax \rvert \geq 0, \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 18. AMCLIB_CurrentLoop_FLT Worst-Case Error Bounds - pPIrAWQ.fltInErrK1 output

Subset of input domain	Worst-case error bounds for pPIrAWQ.fltInErrK1 output [ulp]	Allowed specific values (regardless the error bounds) for pPIrAWQ.fltInErrK1 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{ X \vert X \cap D \neq \varnothing \vee X \cap M \neq \varnothing \}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values with fltUDPhMax or fltUQPhMax beyond the allowed range, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge (\lvert fltUDPhMax \rvert < 0 \vee \lvert fltUQPhMax \rvert < 0) \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \lvert fltUQPhMax \rvert \geq 0 \wedge ir \in (N \cup \{-0, +0\})^{17} \right\}$	$\langle -me_{11}, me_{11} \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \lvert fltUQPhMax \rvert \geq 0, \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 18. AMCLIB_CurrentLoop_FLT Worst-Case Error Bounds - pPIrAWQ.fltInErrK1 output...*continued*

Subset of input domain	Worst-case error bounds for pPIrAWQ.fltInErrK1 output [ulp]	Allowed specific values (regardless the error bounds) for pPIrAWQ.fltInErrK1 output
Normalized or zero input values which cause an overflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \lvert fltUQPhMax \rvert \geq 0, \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 19. AMCLIB_CurrentLoop_FLT Worst-Case Error Bounds - pPIrAWQ.fltAcc output

Subset of input domain	Worst-case error bounds for pPIrAWQ.fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for pPIrAWQ.fltAcc output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{ X \vert X \cap D \neq \varnothing \vee X \cap M \neq \varnothing \}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values with fltUDPhMax or fltUQPhMax beyond the allowed range, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge (\lvert fltUDPhMax \rvert < 0 \vee \lvert fltUQPhMax \rvert < 0) \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \lvert fltUQPhMax \rvert \geq 0 \wedge ir \in (N \cup \{-0, +0\})^{17} \right\}$	$\langle -me_{16}, me_{16} \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \lvert fltUQPhMax \rvert \geq 0, \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 19. AMCLIB_CurrentLoop_FLT Worst-Case Error Bounds - pPIrAWQ.fltAcc output...*continued*

Subset of input domain	Worst-case error bounds for pPIrAWQ.fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for pPIrAWQ.fltAcc output
Normalized or zero input values which cause an overflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \lvert fltUQPhMax \rvert \geq 0, \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 20. AMCLIB_CurrentLoop_FLT Worst-Case Error Bounds - pUDQReq.fltArg2 output

Subset of input domain	Worst-case error bounds for pUDQReq.fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for pUDQReq.fltArg2 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{ X \vert X \cap D \neq \varnothing \vee X \cap M \neq \varnothing \}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values with fltUDPhMax or fltUQPhMax beyond the allowed range, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge (\lvert fltUDPhMax \rvert < 0 \vee \lvert fltUQPhMax \rvert < 0) \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \lvert fltUQPhMax \rvert \geq 0 \wedge ir \in (N \cup \{-0, +0\})^{17} \right\}$	$\langle -me_{16}, me_{16} \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \lvert fltUQPhMax \rvert \geq 0, \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 20. AMCLIB_CurrentLoop_FLT Worst-Case Error Bounds - pUDQReq.fltArg2 output...*continued*

Subset of input domain	Worst-case error bounds for pUDQReq.fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for pUDQReq.fltArg2 output
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \\ \lvert fltUQPhMax \rvert \geq 0, \\ \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

2.3 Function AMCLIB_CurrentLoopPIp_FLT

2.3.1 Declaration

```
void AMCLIB_CurrentLoopPIp_FLT(tFloat fltUDcBus, SWLIBS_2Syst_FLT
*const pUDQReq, AMCLIB_CURRENT_LOOP_PIP_T_FLT *pCtrl);
```

2.3.2 Arguments

Table 21. AMCLIB_CurrentLoopPIp_FLT arguments

Type	Name	Direction	Description
tFloat	fltUDcBus	**input**	DC bus voltage.
SWLIBS_2Syst_FLT *const	pUDQReq	**output**	Pointer to the structure with the required stator voltages in the two-phase rotational orthogonal system (d-q).
AMCLIB_CURRENT_LOOP_PIP_T_FLT *	pCtrl	**input, output**	Pointer to the structure with AMCLIB_CurrentLoopPIp state.

2.3.3 Worst-Case Error Bounds

Let (*fltUDcBus, pIDReq, pIQReq, pIDFbck, pIQFbck, fltPropGainD, fltIntegGainD, fltIntegPartK1D, fltInErrK1D, fltPropGainQ, fltIntegGainQ, fltIntegPartK1Q, fltInErrK1Q*) ∈ *X* be a set of inputs to AMCLIB_CurrentLoopPIp_FLT,

fltIntegPartK1D, fltInErrK1D, fltIntegPartK1Q, fltInErrK1Q inputs represent real numbers with an error of max. ±0.5 ulp,

$ir_1 = pIDReq - pIDFbck$,

$ie_1 = \max(\mathrm{fe}(\lvert ir_1 \rvert + 0.5 \cdot \mathrm{ULP}(ir_1)), \mathrm{fe}(\lvert fltInErrK1D \rvert + 0.5 \cdot \mathrm{ULP}(fltInErrK1D)))$,

$ir_2 = ir_1 + fltInErrK1D$,

$ie_2 = \mathrm{fe}(ir_2)$,

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$$cb_1 = \begin{cases} 0, & ie_1 - ie_2 \le 0 \\ ie_1 - ie_2, & ie_1 - ie_2 > 0 \end{cases},$$

$$me_1 = 0.5 + (0.5 + 0.5) \cdot 2^{cb_1},$$

$$ir_3 = ir_2 \cdot fltIntegGainD,$$

$$me_2 = 2 \cdot me_1,$$

$$ie_3 = \max(\mathrm{fe}(|ir_3| + me_2 \cdot \mathrm{ULP}(ir_3)), \mathrm{fe}(|fltIntegPartK1D| + 0.5 \cdot \mathrm{ULP}(fltIntegPartK1D))),$$

$$ir_4 = ir_3 + fltIntegPartK1D,$$

$$ie_4 = \mathrm{fe}(ir_4),$$

$$cb_2 = \begin{cases} 0, & ie_3 - ie_4 \le 0 \\ ie_3 - ie_4, & ie_3 - ie_4 > 0 \end{cases},$$

$$me_3 = 0.5 + (me_2 + 0.5) \cdot 2^{cb_2},$$

$$ir_5 = ir_1 \cdot fltPropGainD,$$

$$ie_5 = \max(\mathrm{fe}(|ir_4| + me_3 \cdot \mathrm{ULP}(ir_4)), \mathrm{fe}(|ir_5| + 1 \cdot \mathrm{ULP}(ir_5))),$$

$$ir_6 = ir_4 + ir_5,$$

$$ie_6 = \mathrm{fe}(ir_6),$$

$$cb_3 = \begin{cases} 0, & ie_5 - ie_6 \le 0 \\ ie_5 - ie_6, & ie_5 - ie_6 > 0 \end{cases},$$

$$me_4 = 0.5 + (me_3 + 1) \cdot 2^{cb_3},$$

$$ir_7 = pIQReq - pIQFbck,$$

$$ie_7 = \max(\mathrm{fe}(|ir_7| + 0.5 \cdot \mathrm{ULP}(ir_7)), \mathrm{fe}(|fltInErrK1Q| + 0.5 \cdot \mathrm{ULP}(fltInErrK1Q))),$$

$$ir_8 = ir_7 + fltInErrK1Q,$$

$$ie_8 = \mathrm{fe}(ir_8),$$

$$cb_4 = \begin{cases} 0, & ie_7 - ie_8 \le 0 \\ ie_7 - ie_8, & ie_7 - ie_8 > 0 \end{cases},$$

$$me_5 = 0.5 + (0.5 + 0.5) \cdot 2^{cb_4},$$

$$ir_9 = ir_8 \cdot fltIntegGainQ,$$

$$me_6 = 2 \cdot me_5,$$

$$ie_9 = \max(\mathrm{fe}(|ir_9| + me_6 \cdot \mathrm{ULP}(ir_9)), \mathrm{fe}(|fltIntegPartK1Q| + 0.5 \cdot \mathrm{ULP}(fltIntegPartK1Q))),$$

$$ir_{10} = ir_9 + fltIntegPartK1Q,$$

$$ie_{10} = \mathrm{fe}(ir_{10}),$$

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$$cb_5 = \begin{cases} 0, & ie_9 - ie_{10} \le 0 \\ ie_9 - ie_{10}, & ie_9 - ie_{10} > 0 \end{cases},$$

$$me_7 = 0.5 + (me_6 + 0.5) \cdot 2^{cb_5},$$

$$ir_{11} = ir_7 \cdot fltPropGainQ,$$

$$ie_{11} = \max(\mathrm{fe}(|ir_{10}| + me_7 \cdot \mathrm{ULP}(ir_{10})), \mathrm{fe}(|ir_{11}| + 1 \cdot \mathrm{ULP}(ir_{11}))),$$

$$ir_{12} = ir_{10} + ir_{11},$$

$$ie_{12} = \mathrm{fe}(ir_{12}),$$

$$cb_6 = \begin{cases} 0, & ie_{11} - ie_{12} \le 0 \\ ie_{11} - ie_{12}, & ie_{11} - ie_{12} > 0 \end{cases},$$

$$me_8 = 0.5 + (me_7 + 1) \cdot 2^{cb_6},$$

then

Table 22. AMCLIB_CurrentLoopPIp_FLT Worst-Case Error Bounds - pPIpAWD.fltInErrK1 output

Subset of input domain	Worst-case error bounds for pPIrAWD.fltInErrK1 output [ulp]	Allowed specific values (regardless the error bounds) for pPIrAWD.fltInErrK1 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \neq \varnothing \vee X \cap M \neq \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values with fltUDPhMax or fltUQPhMax beyond the allowed range, i.e. $\left\{ X \mid X \subset N \cup \{-0, +0\} \wedge (\lvert fltUDPhMax \rvert < 0 \vee \lvert fltUQPhMax \rvert < 0) \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ X \mid X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \ge 0 \wedge \lvert fltUQPhMax \rvert \ge 0 \wedge ir \in (N \cup \{-0, +0\})^{17} \right\}$	$\langle -0.5, 0.5 \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ X \mid X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \ge 0 \wedge \lvert fltUQPhMax \rvert \ge 0, \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 22. AMCLIB_CurrentLoopPIp_FLT Worst-Case Error Bounds - pPIpAWD.fltInErrK1 output...*continued*

Subset of input domain	Worst-case error bounds for pPIrAWD.fltInErrK1 output [ulp]	Allowed specific values (regardless the error bounds) for pPIrAWD.fltInErrK1 output
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \\ \lvert fltUQPhMax \rvert \geq 0, \\ \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 23. AMCLIB_CurrentLoopPIp_FLT Worst-Case Error Bounds - pPIpAWD.fltIntegPartK1 output

Subset of input domain	Worst-case error bounds for pPIrAWD.fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for pPIrAWD.fltAcc output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \neq \varnothing \vee X \cap M \neq \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values with fltUDPhMax or fltUQPhMax beyond the allowed range, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ (\lvert fltUDPhMax \rvert < 0 \vee \lvert fltUQPhMax \rvert < 0) \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \\ \lvert fltUQPhMax \rvert \geq 0 \wedge ir \in (N \cup \{-0, +0\})^{17} \end{array} \right\}$	$\langle -me_3, me_3 \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \\ \lvert fltUQPhMax \rvert \geq 0, \\ \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 23. AMCLIB_CurrentLoopPIp_FLT Worst-Case Error Bounds - pPIpAWD.fltIntegPartK1 output...*continued*

Subset of input domain	Worst-case error bounds for pPIrAWD.fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for pPIrAWD.fltAcc output
Normalized or zero input values which cause an overflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \lvert fltUQPhMax \rvert \geq 0, \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 24. AMCLIB_CurrentLoopPIp_FLT Worst-Case Error Bounds - pUDQReq.fltArg1 output

Subset of input domain	Worst-case error bounds for pUDQReq.fltArg1 output [ulp]	Allowed specific values (regardless the error bounds) for pUDQReq.fltArg1 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{ X \vert X \cap D \neq \varnothing \vee X \cap M \neq \varnothing \}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values with fltUDPhMax or fltUQPhMax beyond the allowed range, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge (\lvert fltUDPhMax \rvert < 0 \vee \lvert fltUQPhMax \rvert < 0) \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \lvert fltUQPhMax \rvert \geq 0 \wedge ir \in (N \cup \{-0, +0\})^{17} \right\}$	$\langle -me_4, me_4 \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \lvert fltUQPhMax \rvert \geq 0, \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 24. AMCLIB_CurrentLoopPIp_FLT Worst-Case Error Bounds - pUDQReq.fltArg1 output...*continued*

Subset of input domain	Worst-case error bounds for pUDQReq.fltArg1 output [ulp]	Allowed specific values (regardless the error bounds) for pUDQReq.fltArg1 output
Normalized or zero input values which cause an overflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \lvert fltUQPhMax \rvert \geq 0, \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 25. AMCLIB_CurrentLoopPIp_FLT Worst-Case Error Bounds - pPIpAWQ.fltInErrK1 output

Subset of input domain	Worst-case error bounds for pPIrAWQ.fltInErrK1 output [ulp]	Allowed specific values (regardless the error bounds) for pPIrAWQ.fltInErrK1 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{ X \vert X \cap D \neq \varnothing \vee X \cap M \neq \varnothing \}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values with fltUDPhMax or fltUQPhMax beyond the allowed range, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge (\lvert fltUDPhMax \rvert < 0 \vee \lvert fltUQPhMax \rvert < 0) \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \lvert fltUQPhMax \rvert \geq 0 \wedge ir \in (N \cup \{-0, +0\})^{17} \right\}$	$\langle -0.5, 0.5 \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \lvert fltUQPhMax \rvert \geq 0, \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 25. AMCLIB_CurrentLoopPIp_FLT Worst-Case Error Bounds - pPIpAWQ.fltInErrK1 output...*continued*

Subset of input domain	Worst-case error bounds for pPIrAWQ.fltInErrK1 output [ulp]	Allowed specific values (regardless the error bounds) for pPIrAWQ.fltInErrK1 output
Normalized or zero input values which cause an overflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \lvert fltUQPhMax \rvert \geq 0, \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 26. AMCLIB_CurrentLoopPIp_FLT Worst-Case Error Bounds - pPIpAWQ.fltIntegPartK1 output

Subset of input domain	Worst-case error bounds for pPIrAWQ.fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for pPIrAWQ.fltAcc output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{ X \vert X \cap D \neq \varnothing \vee X \cap M \neq \varnothing \}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values with fltUDPhMax or fltUQPhMax beyond the allowed range, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge (\lvert fltUDPhMax \rvert < 0 \vee \lvert fltUQPhMax \rvert < 0) \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \lvert fltUQPhMax \rvert \geq 0 \wedge ir \in (N \cup \{-0, +0\})^{17} \right\}$	$\langle -me_7, me_7 \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \lvert fltUQPhMax \rvert \geq 0, \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 26. AMCLIB_CurrentLoopPIp_FLT Worst-Case Error Bounds - pPIpAWQ.fltIntegPartK1 output...*continued*

Subset of input domain	Worst-case error bounds for pPIrAWQ.fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for pPIrAWQ.fltAcc output
Normalized or zero input values which cause an overflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \lvert fltUQPhMax \rvert \geq 0, \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 27. AMCLIB_CurrentLoopPIp_FLT Worst-Case Error Bounds - pUDQReq.fltArg2 output

Subset of input domain	Worst-case error bounds for pUDQReq.fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for pUDQReq.fltArg2 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{ X \vert X \cap D \neq \varnothing \vee X \cap M \neq \varnothing \}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values with fltUDPhMax or fltUQPhMax beyond the allowed range, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge (\lvert fltUDPhMax \rvert < 0 \vee \lvert fltUQPhMax \rvert < 0) \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \lvert fltUQPhMax \rvert \geq 0 \wedge ir \in (N \cup \{-0, +0\})^{17} \right\}$	$\langle -me_8, me_8 \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \lvert fltUQPhMax \rvert \geq 0, \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 27. AMCLIB_CurrentLoopPIp_FLT Worst-Case Error Bounds - pUDQReq.fltArg2 output*...continued*

Subset of input domain	Worst-case error bounds for pUDQReq.fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for pUDQReq.fltArg2 output
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \lvert fltUDPhMax \rvert \geq 0 \wedge \\ \lvert fltUQPhMax \rvert \geq 0, \\ \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

2.4 Function AMCLIB_EstimBJ_FLT

2.4.1 Declaration

```
AMCLIB_ESTIMBJ_RET_T AMCLIB_EstimBJ_FLT(SWLIBS_2Syst_FLT *const
pUAlBeReq, const SWLIBS_2Syst_FLT *const pIAlBeFbck, tFloat
fltUDcBus, AMCLIB_ESTIMBJ_T_FLT *const pCtrl);
```

2.4.2 Arguments

Table 28. AMCLIB_EstimBJ_FLT arguments

Type	Name	Direction	Description
SWLIBS_2Syst_FLT *const	pUAlBeReq	**output**	Pointer to the structure containing calculated output voltages in the 2-phase stationary orthogonal system (α-β) [V].
const SWLIBS_2Syst_FLT *const	pIAlBeFbck	**input**	Pointer to the structure containing the measured phase currents in the 2-phase stationary orthogonal system (α-β) [A].
tFloat	fltUDcBus	**input**	Measured DC bus voltage [V].
AMCLIB_ESTIMBJ_T_FLT *const	pCtrl	**input, output**	Pointer to the structure with parameters and state variables.

2.4.3 Accuracy Specification

All estimated electrical parameters are calculated with a relative error of less than 5% if the signal-to-noise ratio (SNR) of the measured currents will not drop below 20 dB.

2.5 Function AMCLIB_EstimRL_FLT

2.5.1 Declaration

```
AMCLIB_ESTIMRL_RET_T AMCLIB_EstimRL_FLT(SWLIBS_2Syst_FLT
*const pUAlBeReq, const SWLIBS_2Syst_FLT *const pIAlBeFbck,
tFloat fltUDcBus, AMCLIB_ESTIMRL_T_FLT *const pCtrl,
AMCLIB_ESTIMRL_RUN_T_FLT pParam);
```


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2.5.2 Arguments

Table 29. AMCLIB_EstimRL_FLT arguments

Type	Name	Direction	Description
SWLIBS_2Syst_FLT *const	pUAlBeReq	**output**	Pointer to the structure containing calculated output voltages in the 2-phase stationary orthogonal system (α-β) [V].
const SWLIBS_2Syst_FLT *const	pIAlBeFbck	**input**	Pointer to the structure containing the measured phase currents in the 2-phase stationary orthogonal system (α-β) [A].
tFloat	fltUDcBus	**input**	Measured DC bus voltage [V].
AMCLIB_ESTIMRL_T_FLT *const	pCtrl	**input, output**	Pointer to the structure with parameters and state variables.
AMCLIB_ESTIMRL_RUN_T_FLT	pParam	**input**	Structure of configuration parameters. It is intended to be filled with one of the predefined macros: ESTIMRL_RUN_DEFAULT_FLT, ESTIMRL_RUN_CFG1_FLT, ESTIMRL_RUN_CFG2_FLT, or ESTIMRL_RUN_CFG3_FLT.

2.5.3 Accuracy Specification

All estimated electrical parameters are calculated with a relative error of less than 10% with the following assumptions:

- The DC bus voltage shall be sufficient to maintain the required DC and AC currents during the entire measurement. If the DC bus voltage is insufficient, the function will automatically limit the current and the estimated electrical parameters will correspond to the actual measured currents. If the DC bus voltage is lower than the required AC voltage amplitude, the function will return error.
- The motor temperature shall be kept constant. Note that prolonged measurements may heat up the motor and the results may be affected by thermal drift.
- The AC signal-to-noise ratio (SNR) of the measured currents shall not drop below 10 dB. The noise is assumed do be average white Gaussian. The function will attempt to compensate for any noise in the measured currents, however, excessively large noise power can lead to reduced accuracy of results.
- The measured currents shall be symmetrical, i.e., they shall sum to zero. Large assymetries (e.g. due to analog-to-digital converter offset) may lead to reduced accuracy of results.
- The actual inductances and resistances of the windings of the measured motor shall correspond to the usual range found in automotive applications. If the motor electrical parameters are beyond the expected range, the accuracy of results is not guaranteed. This assumption excludes all special floating-point values from the allowed range of inputs and parameters (infinity, not-a-number, denormalized values) as well as any inputs which do not reflect plausible physical values.
- The rotor shall be oriented in the correct position required by the algorithm. This means that the rotor is free to rotate and is not affected by any mechanical load (in case the DEFAULT or CFG1 presets are used) or it is mechanically fixed in the correct position (in case the CFG2 or CFG3 presets are used). If the rotor is not correctly oriented, the results are meaningless.
- The function shall be executed for as many iterations as needed until it returns RET_DONE. There is no guarantee of accuracy of results in case the CFG3 preset is used or if the function has not returned RET_DONE.

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2.6 Function AMCLIB_FluxEstimAB_FLT

2.6.1 Declaration

```
tFloat AMCLIB_FluxEstimAB_FLT(tFloat fltVelocity, const
SWLIBS_2Syst_FLT *const pIAB, const SWLIBS_2Syst_FLT *const pUAB,
const AMCLIB_FLUXESTIMAB_T_FLT *const pParam);
```

2.6.2 Arguments

Table 30. AMCLIB_FluxEstimAB_FLT arguments

Type	Name	Direction	Description
tFloat	fltVelocity	**input**	Electrical angular velocity.
const SWLIBS_2Syst_FLT *const	pIAB	**input**	Pointer to the structure with Alpha/Beta current components.
const SWLIBS_2Syst_FLT *const	pUAB	**input**	Pointer to the structure with Alpha/Beta voltage components.
const AMCLIB_FLUXESTIMAB_T_FLT *const	pParam	**input**	Pointer to the structure containing motor parameters.

2.6.3 Worst-Case Error Bounds

Let (*UfltArg1*, *UfltArg2*, *IfltArg1*, *IfltArg2*, *fltVelocity*, *fltRs*, *fltLs*) $\in X$ be a set of inputs to AMCLIB_FluxEstimAB_FLT,

$$ir_1 = fltVelocity \cdot fltLs,$$

$$me_1 = 0.5,$$

$$ir_2 = IfltArg2 \cdot fltRs,$$

$$ir_3 = UfltArg2 - ir_2,$$

$$me_2 = 0.5,$$

$$ir_4 = IfltArg1 \cdot ir_1,$$

$$me_3 = 1,$$

$$ie_1 = \max(fe(|ir_3| + me_2 \cdot ULP(ir_3)), fe(|ir_4| + me_3 \cdot ULP(ir_4))),$$

$$ir_5 = ir_3 - ir_4,$$

$$ie_2 = fe(ir_5),$$

$$cb_1 = \begin{cases} 0, & ie_1 - ie_2 \le 0 \\ ie_1 - ie_2, & ie_1 - ie_2 > 0 \end{cases},$$

$$me_4 = 0.5 + 2 \cdot (me_2 + me_3) \cdot 2^{cb_1},$$

$$ir_6 = IfltArg1 \cdot fltRs,$$

$$ir_7 = -UfltArg1 + ir_6,$$

$$me_5 = 0.5,$$

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$ir_8 = IfltArg2 \cdot ir_1$,

$me_6 = 1$,

$ie_3 = \max(fe(|ir_7| + me_5 \cdot ULP(ir_7)), fe(|ir_8| + me_6 \cdot ULP(ir_8)))$,

$ir_9 = ir_7 - ir_8$,

$ie_4 = fe(ir_9)$,

$cb_2 = \begin{cases} 0, & ie_3 - ie_4 \le 0 \\ ie_3 - ie_4, & ie_3 - ie_4 > 0 \end{cases}$,

$me_7 = 0.5 + 2 \cdot (me_5 + me_6) \cdot 2^{cb_2}$,

$ir_{10} = \frac{ir_9}{ir_5}$,

$me_8 = 0.5 + 2 \cdot (me_4 + me_7)$,

$me_9 = me_8 + 6$,

then

Table 31. AMCLIB_FluxEstimAB_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case error bounds for Return Value [ulp]	Allowed specific values (regardless the error bounds) for Return Value
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \neq \varnothing \vee X \cap M \neq \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltReturn \in (N \cup \{-0, +0\}) \wedge \\ \forall n \subset \{1..10\} : ir_n \in (N \cup \{-0, +0\}) \end{array} \right\}$	$\langle -me_9, me_9 \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ (fltReturn \in \mathrm{D} \vee \\ \exists n \subset \{1..10\} : ir_n \in D) \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 31. AMCLIB_FluxEstimAB_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case error bounds for Return Value [ulp]	Allowed specific values (regardless the error bounds) for Return Value
Normalized or zero input values which cause an overflow, i.e. $\left\{ X \middle\| X \subset N \cup \{-0, +0\} \wedge \left(fltReturn = Inf \vee \exists n \subset \{1..10\} : ir_n = Inf \right) \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

2.7 Function AMCLIB_FW_FLT

2.7.1 Declaration

```
void AMCLIB_FW_FLT(tFloat fltIDQReqAmp, tFloat fltVelocityFbck,
SWLIBS_2Syst_FLT *const pIDQReq, AMCLIB_FW_T_FLT *pCtrl);
```

2.7.2 Arguments

Table 32. AMCLIB_FW_FLT arguments

Type	Name	Direction	Description
tFloat	fltIDQReqAmp	**input**	Required amplitude of the currents Id and Iq in the two-phase rotational orthogonal system (d-q).
tFloat	fltVelocityFbck	**input**	Actual electrical angular velocity from the feedback.
SWLIBS_2Syst_FLT *const	pIDQReq	**input, output**	Pointer to the structure with the required stator currents in the two-phase rotational orthogonal system (d-q).
AMCLIB_FW_T_FLT *	pCtrl	**input, output**	Pointer to the structure with AMCLIB_FW state.

2.7.3 Worst-Case Error Bounds

Let (*fltIDQReqAmp, fltVelocityFbck, pIQFbck, pIQreqK_1, pUQReq, pUQLim, fltUmaxDivImax, fltIntegPartK_1FW, fltInK_1FW, fltAccFW, fltLambdaFW, fltPropGainFW, fltIntegGainFW, fltLowerLimitFW, fltUpperLimitFW*) ∈ *X* be a set of inputs to AMCLIB_FW_FLT,

fltIntegPartK_1Q, fltInK_1Q, fltIntegPartK_1FW, fltInK_1FW, fltAccQ, fltAccFW inputs represent real numbers with an error of max. ±0.5 ulp,

$ir_{14} = (pIQreqK_1 - pIQFbck) \cdot \mathrm{sign}(fltVelocityFbck)$,

$me_{14} = 0.5$,

$ir_{15} = pUQLim - \mathrm{abs}(pUQReq)$,

$me_{15} = 0.5$,

$ir_{16} = fltUmaxDivImax \cdot ir_{14}$,

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$me_{16} = 2 \cdot me_{14}$,

$ie_{15} = \max(\mathrm{fe}(|ir_{16}| + me_{16} \cdot \mathrm{ULP}(ir_{16})), \mathrm{fe}(|ir_{15}| + me_{15} \cdot \mathrm{ULP}(ir_{15})))$,

$ir_{17} = ir_{15} - ir_{16}$,

$ie_{16} = \mathrm{fe}(ir_{17})$,

$$cb_8 = \begin{cases} 0, & ie_{15} - ie_{16} \le 0 \\ ie_{15} - ie_{16}, & ie_{15} - ie_{16} > 0 \end{cases},$$

$me_{17} = 0.5 + (me_{16} + me_{15}) \cdot 2^{cb_8}$,

$ir_{18} = fltLambdaFW \cdot ir_{17}$,

$me_{18} = me_{17}$,

$ie_{17} = \max(\mathrm{fe}(|ir_{18}| + me_{18} \cdot \mathrm{ULP}(ir_{18})), \mathrm{fe}(|fltAccFW| + 0.5 \cdot \mathrm{ULP}(fltAccFW)))$,

$ir_{19} = ir_{18} + fltAccFW$,

$ie_{18} = \mathrm{fe}(ir_{19})$,

$$cb_9 = \begin{cases} 0, & ie_{17} - ie_{18} \le 0 \\ ie_{17} - ie_{18}, & ie_{17} - ie_{18} > 0 \end{cases},$$

$me_{19} = 0.5 + (me_{18} + 0.5) \cdot 2^{cb_9}$,

$ir_{20} = fltLambdaFW \cdot ir_{19}$,

$me_{20} = 2 \cdot me_{19}$,

$ie_{19} = \max(\mathrm{fe}(|ir_{20}| + me_{20} \cdot \mathrm{ULP}(ir_{20})), \mathrm{fe}(|ir_{19}| + me_{19} \cdot \mathrm{ULP}(ir_{19})))$,

$ir_{21} = ir_{19} - ir_{20}$,

$ie_{20} = \mathrm{fe}(ir_{21})$,

$$cb_{10} = \begin{cases} 0, & ie_{19} - ie_{20} \le 0 \\ ie_{19} - ie_{20}, & ie_{19} - ie_{20} > 0 \end{cases},$$

$me_{21} = 0.5 + (me_{20} + me_{19}) \cdot 2^{cb_{10}}$,

$ie_{21} = \max(\mathrm{fe}(|ir_{19}| + me_{19} \cdot \mathrm{ULP}(ir_{19})), \mathrm{fe}(|fltInK_1FW| + 0.5 \cdot \mathrm{ULP}(fltInK_1FW)))$,

$ir_{22} = ir_{19} + fltInK_1FW$,

$ie_{22} = \mathrm{fe}(ir_{22})$,

$$cb_{11} = \begin{cases} 0, & ie_{21} - ie_{22} \le 0 \\ ie_{21} - ie_{22}, & ie_{21} - ie_{22} > 0 \end{cases},$$

$me_{22} = 0.5 + (me_{19} + 0.5) \cdot 2^{cb_{11}}$,

$ir_{23} = ir_{22} \cdot fltIntegGainFW$,

$me_{23} = 2 \cdot me_{22}$,

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$$ie_{23} = \max(\mathrm{fe}(|fltIntegPartK_1FW| + 0.5 \cdot \mathrm{ULP}(fltIntegPartK_1FW)), \mathrm{fe}(|ir_{23}| + me_{23} \cdot \mathrm{ULP}(ir_{23})))$$

$$ir_{24} = fltIntegPartK_1FW + ir_{23},$$

$$ie_{24} = \mathrm{fe}(ir_{24}),$$

$$cb_{12} = \begin{cases} 0, & ie_{23} - ie_{24} \le 0 \\ ie_{23} - ie_{24}, & ie_{23} - ie_{24} > 0 \end{cases},$$

$$me_{24} = 0.5 + (me_{23} + 0.5) \cdot 2^{cb_{12}},$$

$$me_{25} = \begin{cases} 0, & ir_{24} - me_{24} \cdot \mathrm{ULP}(ir_{24}) > fltUpperLimitFW \\ 0, & ir_{24} + me_{24} \cdot \mathrm{ULP}(ir_{24}) < fltLowerLimitFW \\ me_{24} & otherwise \end{cases},$$

$$ir_{25} = \begin{cases} fltUpperLimitFW, & ir_{24} > fltUpperLimitFW \\ fltLowerLimitFW, & ir_{24} < fltLowerLimitFW \\ ir_{24} & otherwise \end{cases},$$

$$ir_{26} = ir_{19} \cdot fltPropGainFW,$$

$$me_{26} = 2 \cdot me_{19},$$

$$ie_{25} = \max(\mathrm{fe}(|ir_{25}| + me_{25} \cdot \mathrm{ULP}(ir_{25})), \mathrm{fe}(|ir_{26}| + me_{26} \cdot \mathrm{ULP}(ir_{26})))$$

$$ir_{27} = ir_{25} + ir_{26},$$

$$ie_{26} = \mathrm{fe}(ir_{27}),$$

$$cb_{13} = \begin{cases} 0, & ie_{25} - ie_{26} \le 0 \\ ie_{25} - ie_{26}, & ie_{25} - ie_{26} > 0 \end{cases},$$

$$me_{27} = 0.5 + (me_{25} + me_{26}) \cdot 2^{cb_{13}},$$

$$me_{28} = \begin{cases} 0, & ir_{27} - me_{27} \cdot \mathrm{ULP}(ir_{24}) > fltUpperLimitFW \\ 0, & ir_{27} + me_{27} \cdot \mathrm{ULP}(ir_{24}) < fltLowerLimitFW \\ me_{27} & otherwise \end{cases},$$

$$ir_{28} = \begin{cases} fltUpperLimitFW, & ir_{27} > fltUpperLimitFW \\ fltLowerLimitFW, & ir_{27} < fltLowerLimitFW \\ ir_{27} & otherwise \end{cases},$$

$$ie_{27} = \max\left(\mathrm{fe}(|ir_{28}| + me_{28} \cdot \mathrm{ULP}(ir_{28})), \mathrm{fe}\left(\frac{\pi}{2} + 0.5 \cdot \mathrm{ULP}\left(\frac{\pi}{2}\right)\right)\right),$$

$$ir_{29} = \frac{\pi}{2} - ir_{28},$$

$$ie_{28} = \mathrm{fe}(ir_{29}),$$

$$cb_{14} = \begin{cases} 0, & ie_{27} - ie_{28} \le 0 \\ ie_{27} - ie_{28}, & ie_{27} - ie_{28} > 0 \end{cases},$$

$$me_{29} = 0.5 + (me_{28} + 0.5) \cdot 2^{cb_{14}},$$

$$ir_{30} = \sin(ir_{29}),$$

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$me_{30} = 42 + 8 \cdot me_{29}$,

$ir_{31} = \cos(ir_{29})$,

$me_{31} = 42 + 8 \cdot me_{29}$,

$ir_{32} = ir_{31} \cdot \mathrm{abs}(fltIDQReqAmp)$,

$me_{32} = 0.5 + 2 \cdot me_{31}$,

$ir_{33} = ir_{30} \cdot fltIDQReqAmp$,

$me_{33} = 0.5 + 2 \cdot me_{30}$,

then

Table 33. AMCLIB_FW_FLT Worst-Case Error Bounds - pPIpAWFW.fltInK_1 output

Subset of input domain	Worst-case error bounds for pPIpAWFW.fltInK_1 output [ulp]	Allowed specific values (regardless the error bounds) for pPIpAWFW.fltInK_1 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \neq \varnothing \vee X \cap M \neq \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values beyond the allowed range, i.e. $\left\{ X \mid X \subset N \cup \{-0, +0\} \wedge \left(\begin{array}{c} fltLowerLimitFW < -\frac{\pi}{2} \vee \\ fltUpperLimitFW > 0 \vee \\ fltLowerLimitFW > fltUpperLimitFW \vee \\ pUQLim < 0 \vee \\ ir_{29} \notin \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \end{array} \right) \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ ir \in (N \cup \{-0, +0\})^{33} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \end{array} \right\}$	$\langle -me_{19}, me_{19} \rangle$	N/A

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Table 33. AMCLIB_FW_FLT Worst-Case Error Bounds - pPIpAWFW.fltInK_1 output*...continued*

Subset of input domain	Worst-case error bounds for pPIpAWFW.fltInK_1 output [ulp]	Allowed specific values (regardless the error bounds) for pPIpAWFW.fltInK_1 output
Normalized or zero input values which cause an underflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle, \\ \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle, \\ \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 34. AMCLIB_FW_FLT Worst-Case Error Bounds - pFilterFW.fltAcc output

Subset of input domain	Worst-case error bounds for pFilterFW.fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for pFilterFW.fltAcc output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \neq \varnothing \vee X \cap M \neq \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 34. AMCLIB_FW_FLT Worst-Case Error Bounds - pFilterFW.fltAcc output*...continued*

Subset of input domain	Worst-case error bounds for pFilterFW.fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for pFilterFW.fltAcc output
Normalized or zero input values beyond the allowed range, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ \left(\begin{array}{c} fltLowerLimitFW < -\frac{\pi}{2} \vee \\ fltUpperLimitFW > 0 \vee \\ fltLowerLimitFW > fltUpperLimitFW \vee \\ pUQLim < 0 \vee \\ ir_{29} \notin \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \end{array} \right) \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ ir \in (N \cup \{-0, +0\})^{33} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \end{array} \right\}$	$\langle -me_{21}, me_{21} \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle, \\ \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 34. AMCLIB_FW_FLT Worst-Case Error Bounds - pFilterFW.fltAcc output*...continued*

Subset of input domain	Worst-case error bounds for pFilterFW.fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for pFilterFW.fltAcc output
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle, \\ \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 35. AMCLIB_FW_FLT Worst-Case Error Bounds - pPIpAWFW.fltIntegPartK_1 output

Subset of input domain	Worst-case error bounds for pPIpAWFW.fltIntegP 1 output [ulp]	Allowed specific values (regardless the error bounds) for pPIpAWFW.fltIntegPartK_ 1 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \neq \varnothing \vee X \cap M \neq \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values beyond the allowed range, i.e. $\left\{ \left(\begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW < -\frac{\pi}{2} \vee \\ fltUpperLimitFW > 0 \vee \\ fltLowerLimitFW > fltUpperLimitFW \vee \\ pUQLim < 0 \vee \\ ir_{29} \notin \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \end{array} \right) \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 35. AMCLIB_FW_FLT Worst-Case Error Bounds - pPIpAWFW.fltIntegPartK_1 output...*continued*

Subset of input domain	Worst-case error bounds for pPIpAWFW.fltIntegP 1 output [ulp]	Allowed specific values (regardless the error bounds) for pPIpAWFW.fltIntegPartK_ 1 output
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ ir \in (N \cup \{-0, +0\})^{33} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \end{array} \right\}$	$\langle -me_{25}, me_{25} \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle, \\ \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle, \\ \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 36. AMCLIB_FW_FLT Worst-Case Error Bounds - pIDQReq.fltArg1 output

Subset of input domain	Worst-case error bounds for pIDQReq.fltArg1 output [ulp]	Allowed specific values (regardless the error bounds) for pIDQReq.fltArg1 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \neq \varnothing \vee X \cap M \neq \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values beyond the allowed range, i.e. $\left\{ X \mid X \subset N \cup \{-0, +0\} \wedge \left(\begin{array}{c} fltLowerLimitFW < -\frac{\pi}{2} \vee \\ fltUpperLimitFW > 0 \vee \\ fltLowerLimitFW > fltUpperLimitFW \vee \\ pUQLim < 0 \vee \\ ir_{29} \notin \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \end{array} \right) \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ ir \in (N \cup \{-0, +0\})^{33} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \end{array} \right\}$	$\langle -me_{32}, me_{32} \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle, \\ \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 36. AMCLIB_FW_FLT Worst-Case Error Bounds - pIDQReq.fltArg1 output*...continued*

Subset of input domain	Worst-case error bounds for pIDQReq.fltArg1 output [ulp]	Allowed specific values (regardless the error bounds) for pIDQReq.fltArg1 output
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle, \\ \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 37. AMCLIB_FW_FLT Worst-Case Error Bounds - pIDQReq.fltArg2 output

Subset of input domain	Worst-case error bounds for pIDQReq.fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for pIDQReq.fltArg2 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \neq \varnothing \vee X \cap M \neq \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values beyond the allowed range, i.e. $\left\{ \left(\begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW < -\frac{\pi}{2} \vee \\ fltUpperLimitFW > 0 \vee \\ fltLowerLimitFW > fltUpperLimitFW \vee \\ pUQLim < 0 \vee \\ ir_{29} \notin \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \end{array} \right) \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 37. AMCLIB_FW_FLT Worst-Case Error Bounds - pIDQReq.fltArg2 output*...continued*

Subset of input domain	Worst-case error bounds for pIDQReq.fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for pIDQReq.fltArg2 output
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ ir \in (N \cup \{-0, +0\})^{33} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \end{array} \right\}$	$\langle -me_{33}, me_{33} \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle, \\ \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle, \\ \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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2.8 Function AMCLIB_FWSpeedLoop_FLT

2.8.1 Declaration

```
void AMCLIB_FWSpeedLoop_FLT(tFloat fltVelocityReq,
tFloat fltVelocityFbck, SWLIBS_2Syst_FLT *const pIDQReq,
AMCLIB_FW_SPEED_LOOP_T_FLT *pCtrl);
```

2.8.2 Arguments

Table 38. AMCLIB_FWSpeedLoop_FLT arguments

Type	Name	Direction	Description
tFloat	fltVelocityReq	**input**	Required electrical angular velocity (setpoint).
tFloat	fltVelocityFbck	**input**	Actual electrical angular velocity from the feedback.
SWLIBS_2Syst_FLT *const	pIDQReq	**input, output**	Pointer to the structure with the required stator currents in the two-phase rotational orthogonal system (d-q).
AMCLIB_FW_SPEED_LOOP_T_FLT *	pCtrl	**input, output**	Pointer to the structure with AMCLIB_FWSpeedLoop state.

2.8.3 Worst-Case Error Bounds

Let (*fltVelocityReq, fltVelocityFbck, fltState, pIQFbck, pIQreqK_1, pUQReq, pUQLim, fltUmaxDivImax, fltIntegPartK_1Q, fltInK_1Q, fltIntegPartK_1FW, fltInK_1FW, fltAccW, fltAccFW, fltRampUp, fltRampDown, fltLambdaW, fltLambdaFW, fltPropGainQ, fltIntegGainQ, fltLowerLimitQ, fltUpperLimitQ, fltPropGainFW, fltIntegGainFW, fltLowerLimitFW, fltUpperLimitFW*) $\in X$ be a set of inputs to AMCLIB_FWSpeedLoop_FLT,

fltIntegPartK_1Q, fltInK_1Q, fltIntegPartK_1FW, fltInK_1FW, fltAccQ, fltAccFW inputs represent real numbers with an error of max. ±0.5 ulp,

$$ie_1 = |fltState| + 0.5 \cdot \mathrm{ULP}(fltState),$$

$$ir_1 = \max(fltState - fltRampUp, \min(fltState + fltRampUp, fltVelocityReq)),$$

$$ie_2 = \mathrm{fe}(ir_1),$$

$$cb_1 = \begin{cases} 0, & ie_1 - ie_2 \le 0 \\ ie_1 - ie_2, & ie_1 - ie_2 > 0 \end{cases},$$

$$me_1 = 1 + 0.5 \cdot 2^{cb_1},$$

$$ir_2 = fltLambdaW \cdot fltVelocityFbck,$$

$$me_2 = 1,$$

$$ie_3 = \max(\mathrm{fe}(|ir_2| + me_2 \cdot \mathrm{ULP}(ir_2)), \mathrm{fe}(|fltAccW| + 0.5 \cdot \mathrm{ULP}(fltAccW))),$$

$$ir_3 = ir_2 + fltAccW,$$

$$ie_4 = \mathrm{fe}(ir_3),$$

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$$cb_2 = \begin{cases} 0, & ie_3 - ie_4 \le 0 \\ ie_3 - ie_4, & ie_3 - ie_4 > 0 \end{cases},$$

$$me_3 = 0.5 + (me_2 + 0.5) \cdot 2^{cb_2},$$

$$ir_4 = fltLambdaW \cdot ir_3,$$

$$me_4 = 2 \cdot me_3,$$

$$ie_5 = \max(\mathrm{fe}(|ir_4| + me_4 \cdot \mathrm{ULP}(ir_4)), \mathrm{fe}(|ir_3| + me_3 \cdot \mathrm{ULP}(ir_3))),$$

$$ir_5 = ir_3 - ir_4,$$

$$ie_6 = \mathrm{fe}(ir_5),$$

$$cb_3 = \begin{cases} 0, & ie_5 - ie_6 \le 0 \\ ie_5 - ie_6, & ie_5 - ie_6 > 0 \end{cases},$$

$$me_5 = 0.5 + (me_4 + me_3) \cdot 2^{cb_3},$$

$$ie_7 = \max(\mathrm{fe}(|ir_3| + me_3 \cdot \mathrm{ULP}(ir_3)), \mathrm{fe}(|ir_1| + me_1 \cdot \mathrm{ULP}(ir_1))),$$

$$ir_6 = ir_1 - ir_3,$$

$$ie_8 = \mathrm{fe}(ir_6),$$

$$cb_4 = \begin{cases} 0, & ie_7 - ie_8 \le 0 \\ ie_7 - ie_8, & ie_7 - ie_8 > 0 \end{cases},$$

$$me_6 = 0.5 + (me_3 + me_1) \cdot 2^{cb_4},$$

$$ie_9 = \max(\mathrm{fe}(|ir_6| + me_6 \cdot \mathrm{ULP}(ir_6)), \mathrm{fe}(|fltInK_1Q| + 0.5 \cdot \mathrm{ULP}(fltInK_1Q))),$$

$$ir_7 = ir_6 + fltInK_1Q,$$

$$ie_{10} = \mathrm{fe}(ir_7),$$

$$cb_5 = \begin{cases} 0, & ie_9 - ie_{10} \le 0 \\ ie_9 - ie_{10}, & ie_9 - ie_{10} > 0 \end{cases},$$

$$me_7 = 0.5 + (me_6 + 0.5) \cdot 2^{cb_5},$$

$$ir_8 = ir_7 \cdot fltIntegGainQ,$$

$$me_8 = 2 \cdot me_7,$$

$$ie_{11} = \max(\mathrm{fe}(|fltIntegPartK_1Q| + 0.5 \cdot \mathrm{ULP}(fltIntegPartK_1Q)), \mathrm{fe}(|ir_8| + me_8 \cdot \mathrm{ULP}(ir_8))),$$

$$ir_9 = fltIntegPartK_1Q + ir_8,$$

$$ie_{12} = \mathrm{fe}(ir_9),$$

$$cb_6 = \begin{cases} 0, & ie_{11} - ie_{12} \le 0 \\ ie_{11} - ie_{12}, & ie_{11} - ie_{12} > 0 \end{cases},$$

$$me_9 = 0.5 + (0.5 + me_8) \cdot 2^{cb_6},$$

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$$me_{10} = \begin{cases} 0, & ir_9 - me_9 \cdot \mathrm{ULP}(ir_9) > fltUpperLimitQ \\ 0, & ir_9 + me_9 \cdot \mathrm{ULP}(ir_9) < fltLowerLimitQ \\ me_9 & otherwise \end{cases},$$

$$ir_{10} = \begin{cases} fltUpperLimitQ, & ir_9 > fltUpperLimitQ \\ fltLowerLimitQ, & ir_9 < fltLowerLimitQ \\ ir_9 & otherwise \end{cases},$$

$$ir_{11} = ir_6 \cdot fltPropGainQ,$$

$$me_{11} = 2 \cdot me_6,$$

$$ie_{13} = \max(\mathrm{fe}(|ir_{10}| + me_{10} \cdot \mathrm{ULP}(ir_{10})), \mathrm{fe}(|ir_{11}| + me_{11} \cdot \mathrm{ULP}(ir_{11}))),$$

$$ir_{12} = ir_{10} + ir_{11},$$

$$ie_{14} = \mathrm{fe}(ir_{12}),$$

$$cb_7 = \begin{cases} 0, & ie_{13} - ie_{14} \le 0 \\ ie_{13} - ie_{14}, & ie_{13} - ie_{14} > 0 \end{cases},$$

$$me_{12} = 0.5 + (me_{10} + me_{11}) \cdot 2^{cb_7},$$

$$me_{13} = \begin{cases} 0, & ir_{12} - me_{12} \cdot \mathrm{ULP}(ir_{12}) > fltUpperLimitQ \\ 0, & ir_{12} + me_{12} \cdot \mathrm{ULP}(ir_{12}) < fltLowerLimitQ \\ me_{12} & otherwise \end{cases},$$

$$ir_{13} = \begin{cases} fltUpperLimitQ, & ir_{12} > fltUpperLimitQ \\ fltLowerLimitQ, & ir_{12} < fltLowerLimitQ \\ ir_{12} & otherwise \end{cases},$$

$$ir_{14} = (pIQreqK_1 - pIQFbck) \cdot \mathrm{sign}(fltVelocityFbck),$$

$$me_{14} = 0.5,$$

$$ir_{15} = pUQLim - \mathrm{abs}(pUQReq),$$

$$me_{15} = 0.5,$$

$$ir_{16} = fltUmaxDivImax \cdot ir_{14},$$

$$me_{16} = 2 \cdot me_{14},$$

$$ie_{15} = \max(\mathrm{fe}(|ir_{16}| + me_{16} \cdot \mathrm{ULP}(ir_{16})), \mathrm{fe}(|ir_{15}| + me_{15} \cdot \mathrm{ULP}(ir_{15}))),$$

$$ir_{17} = ir_{15} - ir_{16},$$

$$ie_{16} = \mathrm{fe}(ir_{17}),$$

$$cb_8 = \begin{cases} 0, & ie_{15} - ie_{16} \le 0 \\ ie_{15} - ie_{16}, & ie_{15} - ie_{16} > 0 \end{cases},$$

$$me_{17} = 0.5 + (me_{16} + me_{15}) \cdot 2^{cb_8},$$

$$ir_{18} = fltLambdaFW \cdot ir_{17},$$

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$me_{18} = me_{17},$

$ie_{17} = \max(\mathrm{fe}(|ir_{18}| + me_{18} \cdot \mathrm{ULP}(ir_{18})), \mathrm{fe}(|fltAccFW| + 0.5 \cdot \mathrm{ULP}(fltAccFW)))$,

$ir_{19} = ir_{18} + fltAccFW$,

$ie_{18} = \mathrm{fe}(ir_{19})$,

$$cb_9 = \begin{cases} 0, & ie_{17} - ie_{18} \le 0 \\ ie_{17} - ie_{18}, & ie_{17} - ie_{18} > 0 \end{cases},$$

$me_{19} = 0.5 + (me_{18} + 0.5) \cdot 2^{cb_9},$

$ir_{20} = fltLambdaFW \cdot ir_{19},$

$me_{20} = 2 \cdot me_{19},$

$ie_{19} = \max(\mathrm{fe}(|ir_{20}| + me_{20} \cdot \mathrm{ULP}(ir_{20})), \mathrm{fe}(|ir_{19}| + me_{19} \cdot \mathrm{ULP}(ir_{19})))$,

$ir_{21} = ir_{19} - ir_{20},$

$ie_{20} = \mathrm{fe}(ir_{21})$,

$$cb_{10} = \begin{cases} 0, & ie_{19} - ie_{20} \le 0 \\ ie_{19} - ie_{20}, & ie_{19} - ie_{20} > 0 \end{cases},$$

$me_{21} = 0.5 + (me_{20} + me_{19}) \cdot 2^{cb_{10}},$

$ie_{21} = \max(\mathrm{fe}(|ir_{19}| + me_{19} \cdot \mathrm{ULP}(ir_{19})), \mathrm{fe}(|fltInK_1FW| + 0.5 \cdot \mathrm{ULP}(fltInK_1FW)))$,

$ir_{22} = ir_{19} + fltInK_1FW$,

$ie_{22} = \mathrm{fe}(ir_{22})$,

$$cb_{11} = \begin{cases} 0, & ie_{21} - ie_{22} \le 0 \\ ie_{21} - ie_{22}, & ie_{21} - ie_{22} > 0 \end{cases},$$

$me_{22} = 0.5 + (me_{19} + 0.5) \cdot 2^{cb_{11}},$

$ir_{23} = ir_{22} \cdot fltIntegGainFW$,

$me_{23} = 2 \cdot me_{22},$

$ie_{23} = \max(\mathrm{fe}(|fltIntegPartK_1FW| + 0.5 \cdot \mathrm{ULP}(fltIntegPartK_1FW)), \mathrm{fe}(|ir_{23}| + me_{23} \cdot \mathrm{ULP}(ir_{23})))$,

$ir_{24} = fltIntegPartK_1FW + ir_{23},$

$ie_{24} = \mathrm{fe}(ir_{24})$,

$$cb_{12} = \begin{cases} 0, & ie_{23} - ie_{24} \le 0 \\ ie_{23} - ie_{24}, & ie_{23} - ie_{24} > 0 \end{cases},$$

$me_{24} = 0.5 + (me_{23} + 0.5) \cdot 2^{cb_{12}},$

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$$me_{25} = \begin{cases} 0, & ir_{24} - me_{24} \cdot \mathrm{ULP}(ir_{24}) > fltUpperLimitFW \\ 0, & ir_{24} + me_{24} \cdot \mathrm{ULP}(ir_{24}) < fltLowerLimitFW \\ me_{24} & otherwise \end{cases},$$

$$ir_{25} = \begin{cases} fltUpperLimitFW, & ir_{24} > fltUpperLimitFW \\ fltLowerLimitFW, & ir_{24} < fltLowerLimitFW \\ ir_{24} & otherwise \end{cases},$$

$$ir_{26} = ir_{19} \cdot fltPropGainFW,$$

$$me_{26} = 2 \cdot me_{19},$$

$$ie_{25} = \max(\mathrm{fe}(|ir_{25}| + me_{25} \cdot \mathrm{ULP}(ir_{25})), \mathrm{fe}(|ir_{26}| + me_{26} \cdot \mathrm{ULP}(ir_{26}))),$$

$$ir_{27} = ir_{25} + ir_{26},$$

$$ie_{26} = \mathrm{fe}(ir_{27}),$$

$$cb_{13} = \begin{cases} 0, & ie_{25} - ie_{26} \le 0 \\ ie_{25} - ie_{26}, & ie_{25} - ie_{26} > 0 \end{cases},$$

$$me_{27} = 0.5 + (me_{25} + me_{26}) \cdot 2^{cb_{13}},$$

$$me_{28} = \begin{cases} 0, & ir_{27} - me_{27} \cdot \mathrm{ULP}(ir_{24}) > fltUpperLimitFW \\ 0, & ir_{27} + me_{27} \cdot \mathrm{ULP}(ir_{24}) < fltLowerLimitFW \\ me_{27} & otherwise \end{cases},$$

$$ir_{28} = \begin{cases} fltUpperLimitFW, & ir_{27} > fltUpperLimitFW \\ fltLowerLimitFW, & ir_{27} < fltLowerLimitFW \\ ir_{27} & otherwise \end{cases},$$

$$ie_{27} = \max\left(\mathrm{fe}(|ir_{28}| + me_{28} \cdot \mathrm{ULP}(ir_{28})), \mathrm{fe}\left(\frac{\pi}{2} + 0.5 \cdot \mathrm{ULP}\left(\frac{\pi}{2}\right)\right)\right),$$

$$ir_{29} = \frac{\pi}{2} - ir_{28},$$

$$ie_{28} = \mathrm{fe}(ir_{29}),$$

$$cb_{14} = \begin{cases} 0, & ie_{27} - ie_{28} \le 0 \\ ie_{27} - ie_{28}, & ie_{27} - ie_{28} > 0 \end{cases},$$

$$me_{29} = 0.5 + (me_{28} + 0.5) \cdot 2^{cb_{14}},$$

$$ir_{30} = \sin(ir_{29}),$$

$$me_{30} = 42 + 8 \cdot me_{29},$$

$$ir_{31} = \cos(ir_{29}),$$

$$me_{31} = 42 + 8 \cdot me_{29},$$

$$ir_{32} = ir_{31} \cdot \mathrm{abs}(ir_{13}),$$

$$me_{32} = 0.5 + 2 \cdot me_{31} + 2 \cdot me_{13},$$

$$ir_{33} = ir_{30} \cdot ir_{13},$$

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$me_{33} = 0.5 + 2 \cdot me_{30} + 2 \cdot me_{13},$

then

Table 39. AMCLIB_FWSpeedLoop_FLT Worst-Case Error Bounds - pRamp.fltState output

Subset of input domain	Worst-case error bounds for pRamp.fltState output [ulp]	Allowed specific values (regardless the error bounds) for pRamp.fltState output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \neq \varnothing \vee X \cap M \neq \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values beyond the allowed range, i.e. $\left\{ X \mid X \subset N \cup \{-0, +0\} \wedge \left(\begin{array}{c} fltLowerLimitFW < -\frac{\pi}{2} \vee \\ fltUpperLimitFW > 0 \vee \\ fltLowerLimitFW > fltUpperLimitFW \vee \\ fltLowerLimitQ > fltUpperLimitQ \vee \\ fltRampUp < 0 \vee \\ fltRampDown < 0 \vee \\ pUQLim < 0 \vee \\ ir_{29} \notin \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \end{array} \right) \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ ir \in (N \cup \{-0, +0\})^{33} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \end{array} \right\}$	$\langle -me_1, me_1 \rangle$	N/A

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Table 39. AMCLIB_FWSpeedLoop_FLT Worst-Case Error Bounds - pRamp.fltState output...*continued*

Subset of input domain	Worst-case error bounds for pRamp.fltState output [ulp]	Allowed specific values (regardless the error bounds) for pRamp.fltState output
Normalized or zero input values which cause an underflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle, \\ \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle, \\ \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 40. AMCLIB_FWSpeedLoop_FLT Worst-Case Error Bounds - pFilterW.fltAcc output

Subset of input domain	Worst-case error bounds for pFilterW.fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for pFilterW.fltAcc output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \neq \varnothing \vee X \cap M \neq \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 40. AMCLIB_FWSpeedLoop_FLT Worst-Case Error Bounds - pFilterW.fltAcc output...*continued*

Subset of input domain	Worst-case error bounds for pFilterW.fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for pFilterW.fltAcc output
Normalized or zero input values beyond the allowed range, i.e. $\left\{ \left(\begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW < -\frac{\pi}{2} \vee \\ fltUpperLimitFW > 0 \vee \\ fltLowerLimitFW > fltUpperLimitFW \vee \\ fltLowerLimitQ > fltUpperLimitQ \vee \\ fltRampUp < 0 \vee \\ fltRampDown < 0 \vee \\ pUQLim < 0 \vee \\ ir_{29} \notin \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \end{array} \right) \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ ir \in (N \cup \{-0, +0\})^{33} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \end{array} \right\}$	$\langle -me_5, me_5 \rangle$	N/A

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Table 40. AMCLIB_FWSpeedLoop_FLT Worst-Case Error Bounds - pFilterW.fltAcc output...*continued*

Subset of input domain	Worst-case error bounds for pFilterW.fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for pFilterW.fltAcc output
Normalized or zero input values which cause an underflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle, \\ \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle, \\ \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 41. AMCLIB_FWSpeedLoop_FLT Worst-Case Error Bounds - pPIpAWQ.fltInK_1 output

Subset of input domain	Worst-case error bounds for pPIpAWQ.fltInK_1 output [ulp]	Allowed specific values (regardless the error bounds) for pPIpAWQ.fltInK_1 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \neq \varnothing \vee X \cap M \neq \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 41. AMCLIB_FWSpeedLoop_FLT Worst-Case Error Bounds - pPIpAWQ.fltInK_1 output...*continued*

Subset of input domain	Worst-case error bounds for pPIpAWQ.fltInK_1 output [ulp]	Allowed specific values (regardless the error bounds) for pPIpAWQ.fltInK_1 output
Normalized or zero input values beyond the allowed range, i.e. $\left\{ \left(\begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW < -\frac{\pi}{2} \vee \\ fltUpperLimitFW > 0 \vee \\ fltLowerLimitFW > fltUpperLimitFW \vee \\ fltLowerLimitQ > fltUpperLimitQ \vee \\ fltRampUp < 0 \vee \\ fltRampDown < 0 \vee \\ pUQLim < 0 \vee \\ ir_{29} \notin \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \end{array} \right) \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ ir \in (N \cup \{-0, +0\})^{33} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \end{array} \right\}$	$\langle -me_6, me_6 \rangle$	N/A

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Table 41. AMCLIB_FWSpeedLoop_FLT Worst-Case Error Bounds - pPIpAWQ.fltInK_1 output*...continued*

Subset of input domain	Worst-case error bounds for pPIpAWQ.fltInK_1 output [ulp]	Allowed specific values (regardless the error bounds) for pPIpAWQ.fltInK_1 output
Normalized or zero input values which cause an underflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle, \\ \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle, \\ \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 42. AMCLIB_FWSpeedLoop_FLT Worst-Case Error Bounds - pPIpAWQ.fltIntegPartK_1 output

Subset of input domain	Worst-case error bounds for pPIpAWQ.fltIntegPa 1 output [ulp]	Allowed specific values (regardless the error bounds) for pPIpAWQ.fltIntegPartK_ 1 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \neq \varnothing \vee X \cap M \neq \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values beyond the allowed range, i.e. $\left\{ \left(\begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW < -\frac{\pi}{2} \vee \\ fltUpperLimitFW > 0 \vee \\ fltLowerLimitFW > fltUpperLimitFW \vee \\ fltLowerLimitQ > fltUpperLimitQ \vee \\ fltRampUp < 0 \vee \\ fltRampDown < 0 \vee \\ pUQLim < 0 \vee \\ ir_{29} \notin \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \end{array} \right) \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ ir \in (N \cup \{-0, +0\})^{33} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \end{array} \right\}$	$\langle -me_{10}, me_{10} \rangle$	N/A

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Table 42. AMCLIB_FWSpeedLoop_FLT Worst-Case Error Bounds - pPIpAWQ.fltIntegPartK_1 output*...continued*

Subset of input domain	Worst-case error bounds for pPIpAWQ.fltIntegPa 1 output [ulp]	Allowed specific values (regardless the error bounds) for pPIpAWQ.fltIntegPartK_ 1 output
Normalized or zero input values which cause an underflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle, \\ \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle, \\ \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 43. AMCLIB_FWSpeedLoop_FLT Worst-Case Error Bounds - pPIpAWFW.fltInK_1 output

Subset of input domain	Worst-case error bounds for pPIpAWFW.fltInK_1 output [ulp]	Allowed specific values (regardless the error bounds) for pPIpAWFW.fltInK_1 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \neq \varnothing \vee X \cap M \neq \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values beyond the allowed range, i.e. $\left\{ X \mid X \subset N \cup \{-0, +0\} \wedge \left(\begin{array}{c} fltLowerLimitFW < -\frac{\pi}{2} \vee \\ fltUpperLimitFW > 0 \vee \\ fltLowerLimitFW > fltUpperLimitFW \vee \\ fltLowerLimitQ > fltUpperLimitQ \vee \\ fltRampUp < 0 \vee \\ fltRampDown < 0 \vee \\ pUQLim < 0 \vee \\ ir_{29} \notin \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \end{array} \right) \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ ir \in (N \cup \{-0, +0\})^{33} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \end{array} \right\}$	$\langle -me_{19}, me_{19} \rangle$	N/A

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Table 43. AMCLIB_FWSpeedLoop_FLT Worst-Case Error Bounds - pPIpAWFW.fltInK_1 output*...continued*

Subset of input domain	Worst-case error bounds for pPIpAWFW.fltInK_1 output [ulp]	Allowed specific values (regardless the error bounds) for pPIpAWFW.fltInK_1 output
Normalized or zero input values which cause an underflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle, \\ \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle, \\ \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 44. AMCLIB_FWSpeedLoop_FLT Worst-Case Error Bounds - pFilterFW.fltAcc output

Subset of input domain	Worst-case error bounds for pFilterFW.fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for pFilterFW.fltAcc output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \neq \varnothing \vee X \cap M \neq \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values beyond the allowed range, i.e. $\left\{ X \mid X \subset N \cup \{-0, +0\} \wedge \left(\begin{array}{c} fltLowerLimitFW < -\frac{\pi}{2} \vee \\ fltUpperLimitFW > 0 \vee \\ fltLowerLimitFW > fltUpperLimitFW \vee \\ fltLowerLimitQ > fltUpperLimitQ \vee \\ fltRampUp < 0 \vee \\ fltRampDown < 0 \vee \\ pUQLim < 0 \vee \\ ir_{29} \notin \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \end{array} \right) \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ ir \in (N \cup \{-0, +0\})^{33} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \end{array} \right\}$	$\langle -me_{21}, me_{21} \rangle$	N/A

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Table 44. AMCLIB_FWSpeedLoop_FLT Worst-Case Error Bounds - pFilterFW.fltAcc output...*continued*

Subset of input domain	Worst-case error bounds for pFilterFW.fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for pFilterFW.fltAcc output
Normalized or zero input values which cause an underflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle, \\ \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle, \\ \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 45. AMCLIB_FWSpeedLoop_FLT Worst-Case Error Bounds - pPIpAWFW.fltIntegPartK_1 output

Subset of input domain	Worst-case error bounds for pPIpAWFW.fltIntegP 1 output [ulp]	Allowed specific values (regardless the error bounds) for pPIpAWFW.fltIntegPartK_ 1 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \neq \varnothing \vee X \cap M \neq \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values beyond the allowed range, i.e. $\left\{ \left(\begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW < -\frac{\pi}{2} \vee \\ fltUpperLimitFW > 0 \vee \\ fltLowerLimitFW > fltUpperLimitFW \vee \\ fltLowerLimitQ > fltUpperLimitQ \vee \\ fltRampUp < 0 \vee \\ fltRampDown < 0 \vee \\ pUQLim < 0 \vee \\ ir_{29} \notin \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \end{array} \right) \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ ir \in (N \cup \{-0, +0\})^{33} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \end{array} \right\}$	$\langle -me_{25}, me_{25} \rangle$	N/A

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Table 45. AMCLIB_FWSpeedLoop_FLT Worst-Case Error Bounds - pPIpAWFW.fltIntegPartK_1 output*...continued*

Subset of input domain	Worst-case error bounds for pPIpAWFW.fltIntegP 1 output [ulp]	Allowed specific values (regardless the error bounds) for pPIpAWFW.fltIntegPartK_ 1 output
Normalized or zero input values which cause an underflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle, \\ \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle, \\ \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 46. AMCLIB_FWSpeedLoop_FLT Worst-Case Error Bounds - pIDQReq.fltArg1 output

Subset of input domain	Worst-case error bounds for pIDQReq.fltArg1 output [ulp]	Allowed specific values (regardless the error bounds) for pIDQReq.fltArg1 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \neq \varnothing \vee X \cap M \neq \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values beyond the allowed range, i.e. $\left\{ X \mid X \subset N \cup \{-0, +0\} \wedge \left(\begin{array}{c} fltLowerLimitFW < -\frac{\pi}{2} \vee \\ fltUpperLimitFW > 0 \vee \\ fltLowerLimitFW > fltUpperLimitFW \vee \\ fltLowerLimitQ > fltUpperLimitQ \vee \\ fltRampUp < 0 \vee \\ fltRampDown < 0 \vee \\ pUQLim < 0 \vee \\ ir_{29} \notin \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \end{array} \right) \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ ir \in (N \cup \{-0, +0\})^{33} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \end{array} \right\}$	$\langle -me_{32}, me_{32} \rangle$	N/A

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Table 46. AMCLIB_FWSpeedLoop_FLT Worst-Case Error Bounds - pIDQReq.fltArg1 output*...continued*

Subset of input domain	Worst-case error bounds for pIDQReq.fltArg1 output [ulp]	Allowed specific values (regardless the error bounds) for pIDQReq.fltArg1 output
Normalized or zero input values which cause an underflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle, \\ \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle, \\ \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 47. AMCLIB_FWSpeedLoop_FLT Worst-Case Error Bounds - pIDQReq.fltArg2 output

Subset of input domain	Worst-case error bounds for pIDQReq.fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for pIDQReq.fltArg2 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \neq \varnothing \vee X \cap M \neq \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values beyond the allowed range, i.e. $\left\{ X \mid X \subset N \cup \{-0, +0\} \wedge \left(\begin{array}{c} fltLowerLimitFW < -\frac{\pi}{2} \vee \\ fltUpperLimitFW > 0 \vee \\ fltLowerLimitFW > fltUpperLimitFW \vee \\ fltLowerLimitQ > fltUpperLimitQ \vee \\ fltRampUp < 0 \vee \\ fltRampDown < 0 \vee \\ pUQLim < 0 \vee \\ ir_{29} \notin \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \end{array} \right) \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ ir \in (N \cup \{-0, +0\})^{33} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \end{array} \right\}$	$\langle -me_{33}, me_{33} \rangle$	N/A

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Table 47. AMCLIB_FWSpeedLoop_FLT Worst-Case Error Bounds - pIDQReq.fltArg2 output*...continued*

Subset of input domain	Worst-case error bounds for pIDQReq.fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for pIDQReq.fltArg2 output
Normalized or zero input values which cause an underflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle, \\ \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitFW \geq -\frac{\pi}{2} \wedge \\ fltUpperLimitFW \leq 0 \wedge \\ fltLowerLimitFW \leq fltUpperLimitFW \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ pUQLim \geq 0 \wedge \\ ir_{29} \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle, \\ \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

2.9 Function AMCLIB_SpeedLoop_FLT

2.9.1 Declaration

```
void AMCLIB_SpeedLoop_FLT(tFloat fltVelocityReq, tFloat
fltVelocityFbck, SWLIBS_2Syst_FLT *const pIDQReq,
AMCLIB_SPEED_LOOP_T_FLT *pCtrl);
```


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2.9.2 Arguments

Table 48. AMCLIB_SpeedLoop_FLT arguments

Type	Name	Direction	Description
tFloat	fltVelocityReq	**input**	Required electrical angular velocity (setpoint).
tFloat	fltVelocityFbck	**input**	Actual electrical angular velocity from the feedback.
SWLIBS_2Syst_FLT *const	pIDQReq	**output**	Pointer to the structure with the required stator currents in the two-phase rotational orthogonal system (d-q). Only the q-axis component is written by the function.
AMCLIB_SPEED_LOOP_T_FLT *	pCtrl	**input, output**	Pointer to the structure with AMCLIB_SpeedLoop state.

2.9.3 Worst-Case Error Bounds

Let (*fltVelocityReq, fltVelocityFbck, fltState, fltIntegPartK_1Q, fltInK_1Q, fltAccW, fltRampUp, fltRampDown, fltLambdaW, fltPropGainQ, fltIntegGainQ, fltLowerLimitQ, fltUpperLimitQ*) $\in X$ be a set of inputs to AMCLIB_SpeedLoop_FLT,

fltIntegPartK_1Q, fltInK_1Q, fltAccQ inputs represent real numbers with an error of max. ±0.5 ulp,

$$ie_1 = |fltState| + 0.5 \cdot \mathrm{ULP}(fltState),$$

$$ir_1 = \max(fltState - fltRampUp, \min(fltState + fltRampUp, fltVelocityReq)),$$

$$ie_2 = \mathrm{fe}(ir_1),$$

$$cb_1 = \begin{cases} 0, & ie_1 - ie_2 \le 0 \\ ie_1 - ie_2, & ie_1 - ie_2 > 0 \end{cases},$$

$$me_1 = 1 + 0.5 \cdot 2^{cb_1},$$

$$ir_2 = fltLambdaW \cdot fltVelocityFbck,$$

$$me_2 = 1,$$

$$ie_3 = \max(\mathrm{fe}(|ir_2| + me_2 \cdot \mathrm{ULP}(ir_2)), \mathrm{fe}(|fltAccW| + 0.5 \cdot \mathrm{ULP}(fltAccW))),$$

$$ir_3 = ir_2 + fltAccW,$$

$$ie_4 = \mathrm{fe}(ir_3),$$

$$cb_2 = \begin{cases} 0, & ie_3 - ie_4 \le 0 \\ ie_3 - ie_4, & ie_3 - ie_4 > 0 \end{cases},$$

$$me_3 = 0.5 + (me_2 + 0.5) \cdot 2^{cb_2},$$

$$ir_4 = fltLambdaW \cdot ir_3,$$

$$me_4 = 2 \cdot me_3,$$

$$ie_5 = \max(\mathrm{fe}(|ir_4| + me_4 \cdot \mathrm{ULP}(ir_4)), \mathrm{fe}(|ir_3| + me_3 \cdot \mathrm{ULP}(ir_3))),$$

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$$ir_5 = ir_3 - ir_4,$$

$$ie_6 = \mathrm{fe}(ir_5),$$

$$cb_3 = \begin{cases} 0, & ie_5 - ie_6 \le 0 \\ ie_5 - ie_6, & ie_5 - ie_6 > 0 \end{cases},$$

$$me_5 = 0.5 + (me_4 + me_3) \cdot 2^{cb_3},$$

$$ie_7 = \max(\mathrm{fe}(|ir_3| + me_3 \cdot \mathrm{ULP}(ir_3)), \mathrm{fe}(|ir_1| + me_1 \cdot \mathrm{ULP}(ir_1))),$$

$$ir_6 = ir_1 - ir_3,$$

$$ie_8 = \mathrm{fe}(ir_6),$$

$$cb_4 = \begin{cases} 0, & ie_7 - ie_8 \le 0 \\ ie_7 - ie_8, & ie_7 - ie_8 > 0 \end{cases},$$

$$me_6 = 0.5 + (me_3 + me_1) \cdot 2^{cb_4},$$

$$ie_9 = \max(\mathrm{fe}(|ir_6| + me_6 \cdot \mathrm{ULP}(ir_6)), \mathrm{fe}(|fltInK_1Q| + 0.5 \cdot \mathrm{ULP}(fltInK_1Q))),$$

$$ir_7 = ir_6 + fltInK_1Q,$$

$$ie_{10} = \mathrm{fe}(ir_7),$$

$$cb_5 = \begin{cases} 0, & ie_9 - ie_{10} \le 0 \\ ie_9 - ie_{10}, & ie_9 - ie_{10} > 0 \end{cases},$$

$$me_7 = 0.5 + (me_6 + 0.5) \cdot 2^{cb_5},$$

$$ir_8 = ir_7 \cdot fltIntegGainQ,$$

$$me_8 = 2 \cdot me_7,$$

$$ie_{11} = \max(\mathrm{fe}(|fltIntegPartK_1Q| + 0.5 \cdot \mathrm{ULP}(fltIntegPartK_1Q)), \mathrm{fe}(|ir_8| + me_8 \cdot \mathrm{ULP}(ir_8))),$$

$$ir_9 = fltIntegPartK_1Q + ir_8,$$

$$ie_{12} = \mathrm{fe}(ir_9),$$

$$cb_6 = \begin{cases} 0, & ie_{11} - ie_{12} \le 0 \\ ie_{11} - ie_{12}, & ie_{11} - ie_{12} > 0 \end{cases},$$

$$me_9 = 0.5 + (0.5 + me_8) \cdot 2^{cb_6},$$

$$me_{10} = \begin{cases} 0, & ir_9 - me_9 \cdot \mathrm{ULP}(ir_9) > fltUpperLimitQ \\ 0, & ir_9 + me_9 \cdot \mathrm{ULP}(ir_9) < fltLowerLimitQ \\ me_9 & otherwise \end{cases},$$

$$ir_{10} = \begin{cases} fltUpperLimitQ, & ir_9 > fltUpperLimitQ \\ fltLowerLimitQ, & ir_9 < fltLowerLimitQ \\ ir_9 & otherwise \end{cases},$$

$$ir_{11} = ir_6 \cdot fltPropGainQ,$$

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$$me_{11} = 2 \cdot me_6,$$

$$ie_{13} = \max(\mathrm{fe}(|ir_{10}| + me_{10} \cdot \mathrm{ULP}(ir_{10})), \mathrm{fe}(|ir_{11}| + me_{11} \cdot \mathrm{ULP}(ir_{11}))),$$

$$ir_{12} = ir_{10} + ir_{11},$$

$$ie_{14} = \mathrm{fe}(ir_{12}),$$

$$cb_7 = \begin{cases} 0, & ie_{13} - ie_{14} \le 0 \\ ie_{13} - ie_{14}, & ie_{13} - ie_{14} > 0 \end{cases},$$

$$me_{12} = 0.5 + (me_{10} + me_{11}) \cdot 2^{cb_7},$$

$$me_{13} = \begin{cases} 0, & ir_{12} - me_{12} \cdot \mathrm{ULP}(ir_{12}) > fltUpperLimitQ \\ 0, & ir_{12} + me_{12} \cdot \mathrm{ULP}(ir_{12}) < fltLowerLimitQ \\ me_{12} & otherwise \end{cases},$$

$$ir_{13} = \begin{cases} fltUpperLimitQ, & ir_{12} > fltUpperLimitQ \\ fltLowerLimitQ, & ir_{12} < fltLowerLimitQ \\ ir_{12} & otherwise \end{cases},$$

then

Table 49. AMCLIB_SpeedLoop_FLT Worst-Case Error Bounds - pRamp.fltState output

Subset of input domain	Worst-case error bounds for pRamp.fltState output [ulp]	Allowed specific values (regardless the error bounds) for pRamp.fltState output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \ne \varnothing \vee X \cap M \ne \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values beyond the allowed range, i.e. $\left\{ X \mid X \subset N \cup \{-0, +0\} \wedge \left(\begin{array}{c} fltLowerLimitQ > fltUpperLimitQ \vee \\ fltRampUp < 0 \vee \\ fltRampDown < 0 \vee \end{array} \right) \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ ir \in (N \cup \{-0, +0\})^{13} \wedge \\ fltLowerLimitQ \le fltUpperLimitQ \wedge \\ fltRampUp \ge 0 \wedge \\ fltRampDown \ge 0 \wedge \end{array} \right\}$	$\langle -me_1, me_1 \rangle$	N/A

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Table 49. AMCLIB_SpeedLoop_FLT Worst-Case Error Bounds - pRamp.fltState output...*continued*

Subset of input domain	Worst-case error bounds for pRamp.fltState output [ulp]	Allowed specific values (regardless the error bounds) for pRamp.fltState output
Normalized or zero input values which cause an underflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitQ \le fltUpperLimitQ \wedge \\ fltRampUp \ge 0 \wedge \\ fltRampDown \ge 0 \wedge \\ \exists n : ir_n \ne \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitQ \le fltUpperLimitQ \wedge \\ fltRampUp \ge 0 \wedge \\ fltRampDown \ge 0 \wedge \\ \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 50. AMCLIB_SpeedLoop_FLT Worst-Case Error Bounds - pFilterW.fltAcc output

Subset of input domain	Worst-case error bounds for pFilterW.fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for pFilterW.fltAcc output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \ne \varnothing \vee X \cap M \ne \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values beyond the allowed range, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ \left(\begin{array}{c} fltLowerLimitQ > fltUpperLimitQ \vee \\ fltRampUp < 0 \vee \\ fltRampDown < 0 \vee \end{array} \right) \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 50. AMCLIB_SpeedLoop_FLT Worst-Case Error Bounds - pFilterW.fltAcc output...*continued*

Subset of input domain	Worst-case error bounds for pFilterW.fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for pFilterW.fltAcc output
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ ir \in (N \cup \{-0, +0\})^{13} \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \end{array} \right\}$	$\langle -me_5, me_5 \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 51. AMCLIB_SpeedLoop_FLT Worst-Case Error Bounds - pPIpAWQ.fltInK_1 output

Subset of input domain	Worst-case error bounds for pPIpAWQ.fltInK_1 output [ulp]	Allowed specific values (regardless the error bounds) for pPIpAWQ.fltInK_1 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \neq \varnothing \vee X \cap M \neq \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 51. AMCLIB_SpeedLoop_FLT Worst-Case Error Bounds - pPIpAWQ.fltInK_1 output...*continued*

Subset of input domain	Worst-case error bounds for pPIpAWQ.fltInK_1 output [ulp]	Allowed specific values (regardless the error bounds) for pPIpAWQ.fltInK_1 output
Normalized or zero input values beyond the allowed range, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \left(\begin{array}{c} fltLowerLimitQ > fltUpperLimitQ \vee \\ fltRampUp < 0 \vee \\ fltRampDown < 0 \vee \end{array} \right) \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} X \middle\vert X \subset N \cup \{-0, +0\} \wedge \\ ir \in (N \cup \{-0, +0\})^{13} \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \end{array} \right\}$	$\langle -me_6, me_6 \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ \begin{array}{c} X \middle\vert X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \middle\vert X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 52. AMCLIB_SpeedLoop_FLT Worst-Case Error Bounds - pPIpAWQ.fltIntegPartK_1 output

Subset of input domain	Worst-case error bounds for pPIpAWQ.fltIntegPa 1 output [ulp]	Allowed specific values (regardless the error bounds) for pPIpAWQ.fltIntegPartK_ 1 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \neq \varnothing \vee X \cap M \neq \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values beyond the allowed range, i.e. $\left\{ X \mid X \subset N \cup \{-0, +0\} \wedge \left(\begin{array}{c} fltLowerLimitQ > fltUpperLimitQ \vee \\ fltRampUp < 0 \vee \\ fltRampDown < 0 \vee \end{array} \right) \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ ir \in (N \cup \{-0, +0\})^{13} \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \end{array} \right\}$	$\langle -me_{10}, me_{10} \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 53. AMCLIB_SpeedLoop_FLT Worst-Case Error Bounds - pIDQReq.fltArg2 output

Subset of input domain	Worst-case error bounds for pIDQReq.fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for pIDQReq.fltArg2 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \neq \varnothing \vee X \cap M \neq \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values beyond the allowed range, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ \left(\begin{array}{c} fltLowerLimitQ > fltUpperLimitQ \vee \\ fltRampUp < 0 \vee \\ fltRampDown < 0 \vee \end{array} \right) \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ ir \in (N \cup \{-0, +0\})^{13} \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \end{array} \right\}$	$\langle -me_{13}, me_{13} \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \\ fltLowerLimitQ \leq fltUpperLimitQ \wedge \\ fltRampUp \geq 0 \wedge \\ fltRampDown \geq 0 \wedge \\ \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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2.10 Function AMCLIB_TrackObsrv_FLT

2.10.1 Declaration

```
void AMCLIB_TrackObsrv_FLT(tFloat fltPhaseErr, tFloat *pPosEst,
tFloat *pVelocityEst, AMCLIB_TRACK_OBSRV_T_FLT *pCtrl);
```

2.10.2 Arguments

Table 54. AMCLIB_TrackObsrv_FLT arguments

Type	Name	Direction	Description
tFloat	fltPhaseErr	**input**	Input signal representing phase error of system to be estimated.
tFloat *	pPosEst	**output**	Estimated output position.
tFloat *	pVelocityEst	**output**	Estimated output velocity.
AMCLIB_ TRACK_OBSRV_ T_FLT *	pCtrl	**input, output**	Pointer to a tracking observer structure AMCLIB_TRACK_OBSRV_T_FLT, which contains algorithm coefficients.

2.10.3 Worst-Case Error Bounds

Let (*fltPhaseErr*, *fltCC1sc*, *fltCC2sc*, *fltAcc*, *fltInErrK1*, *fltUpperLimit*, *fltLowerLimit*, *fltState*, *fltInK1*, *fltC1*) $\in X$ be a set of inputs to AMCLIB_TrackObsrv_FLT,

fltAcc, *fltState*, *fltInK1* inputs represent real numbers with an error of max. ±0.5 ulp,

$$ir_1 = fltPhaseErr \cdot fltCC1sc,$$

$$me_1 = 0,$$

$$ir_2 = fltInErrK1 \cdot fltCC2sc,$$

$$me_2 = 0,$$

$$ir_3 = ir_1 + ir_2,$$

$$me_3 = 1,$$

$$ie_1 = \max(\mathrm{fe}(|ir_3| + me_3 \cdot \mathrm{ULP}(ir_3)), \mathrm{fe}(|fltAcc| + 0.5 \cdot \mathrm{ULP}(fltAcc))),$$

$$ir_4 = \begin{cases} fltLowerLimit0, & ir_3 + fltAcc < fltLowerLimit \\ fltUpperLimit, & ir_3 + fltAcc > fltUpperLimit \\ ir_3 + fltAcc, & \text{otherwise} \end{cases},$$

$$ie_2 = \mathrm{fe}(ir_4),$$

$$cb_1 = \begin{cases} 0, & ie_1 - ie_2 \le 0 \\ ie_1 - ie_2, & ie_1 - ie_2 > 0 \end{cases},$$

$$me_4 = \begin{cases} 0, & ir_4 + \left(0.5 + 1.5 \cdot 2^{cb_1}\right) \cdot \mathrm{ULP}(ir_4) < fltLowerLimit \\ 0, & ir_4 - \left(0.5 + 1.5 \cdot 2^{cb_1}\right) \cdot \mathrm{ULP}(ir_4) > fltUpperLimit \\ 0.5 + 1.5 \cdot 2^{cb_1}, & \text{otherwise} \end{cases},$$

$$ie_3 = \max(\mathrm{fe}(|ir_4| + me_4 \cdot \mathrm{ULP}(ir_4)), \mathrm{fe}(|fltInK1| + 0.5 \cdot \mathrm{ULP}(fltInK1))),$$

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$ir_5 = ir_4 + fltInK1$,

$ie_4 = \mathrm{fe}(ir_5)$,

$cb_2 = \begin{cases} 0, & ie_3 - ie_4 \le 0 \\ ie_3 - ie_4, & ie_3 - ie_4 > 0 \end{cases}$,

$me_5 = 0.5 + (me_4 + 0.5) \cdot 2^{cb_2}$,

$ir_6 = ir_5 \cdot fltC1$,

$me_6 = 2 \cdot me_5$,

$ie_5 = \max(\mathrm{fe}(|ir_6| + me_6 \cdot \mathrm{ULP}(ir_6)), \mathrm{fe}(|fltState| + 0.5 \cdot \mathrm{ULP}(fltState)))$,

$ir_7 = ir_6 + fltState$,

$ie_6 = \mathrm{fe}(ir_7)$,

$cb_3 = \begin{cases} 0, & ie_5 - ie_6 \le 0 \\ ie_5 - ie_6, & ie_5 - ie_6 > 0 \end{cases}$,

$me_7 = 0.5 + (me_6 + 0.5) \cdot 2^{cb_3}$,

then

Table 55. AMCLIB_TrackObsrv_FLT Worst-Case Error Bounds - pVelocityEst output

Subset of input domain	Worst-case error bounds for pVelocityEst output [ulp]	Allowed specific values (regardless the error bounds) for pVelocityEst output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \ne \varnothing \vee X \cap M \ne \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values with pPhaseErr beyond the allowed range, i.e. $\{X \mid X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert > \pi\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \\ \boldsymbol{ir} \in (N \cup \{-0, +0\})^{42} \end{array} \right\}$	$\langle -me_4, me_4 \rangle$	N/A

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Table 55. AMCLIB_TrackObsrv_FLT Worst-Case Error Bounds - pVelocityEst output...*continued*

Subset of input domain	Worst-case error bounds for pVelocityEst output [ulp]	Allowed specific values (regardless the error bounds) for pVelocityEst output
Normalized or zero input values which cause an underflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \exists n : ir_n \ne \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 56. AMCLIB_TrackObsrv_FLT Worst-Case Error Bounds - pParamPI.fltAcc output

Subset of input domain	Worst-case error bounds for pParamPI.fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for pParamPI.fltAcc output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{ X \vert X \cap D \ne \varnothing \vee X \cap M \ne \varnothing \}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values with pPhaseErr beyond the allowed range, i.e. $\{ X \vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert > \pi \}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \boldsymbol{ir} \in (N \cup \{-0, +0\})^{42} \right\}$	$\langle -me_4, me_4 \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \exists n : ir_n \ne \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 56. AMCLIB_TrackObsrv_FLT Worst-Case Error Bounds - pParamPI.fltAcc output...*continued*

Subset of input domain	Worst-case error bounds for pParamPI.fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for pParamPI.fltAcc output
Normalized or zero input values which cause an overflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 57. AMCLIB_TrackObsrv_FLT Worst-Case Error Bounds - pParamPI.fltInErrK1 output

Subset of input domain	Worst-case error bounds for pParamPI.fltInErrK1 output [ulp]	Allowed specific values (regardless the error bounds) for pParamPI.fltInErrK1 output
Entire input domain	0	N/A

Table 58. AMCLIB_TrackObsrv_FLT Worst-Case Error Bounds - pPosEst output

Subset of input domain	Worst-case error bounds for pPosEst output [ulp]	Allowed specific values (regardless the error bounds) for pPosEst output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{ X \vert X \cap D \ne \varnothing \vee X \cap M \ne \varnothing \}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values with pPhaseErr beyond the allowed range, i.e. $\{ X \vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert > \pi \}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \boldsymbol{ir} \in (N \cup \{-0, +0\})^{42} \right\}$	$\langle -me_7, me_7 \rangle$	N/A

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Table 58. AMCLIB_TrackObsrv_FLT Worst-Case Error Bounds - pPosEst output*...continued*

Subset of input domain	Worst-case error bounds for pPosEst output [ulp]	Allowed specific values (regardless the error bounds) for pPosEst output
Normalized or zero input values which lead to normalized or zero results with output wrap-around, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \; ir \in (N \cup \{-0, +0\})^{42} \wedge \left(\begin{array}{l} \lvert ir_7 \rvert + me_7 \cdot \mathrm{ULP}(ir_7) > \pi \vee \\ \lvert ir_7 \rvert - me_7 \cdot \mathrm{ULP}(ir_7) < -\pi \end{array} \right) \right\}$	$(-Inf, Inf)$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \; \exists n : ir_n \ne \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \; \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 59. AMCLIB_TrackObsrv_FLT Worst-Case Error Bounds - pParamInteg.fltState output

Subset of input domain	Worst-case error bounds for pParamInteg.fltState output [ulp]	Allowed specific values (regardless the error bounds) for pParamInteg.fltState output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{ X \vert X \cap D \ne \varnothing \vee X \cap M \ne \varnothing \}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values with pPhaseErr beyond the allowed range, i.e. $\{ X \vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert > \pi \}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \; \boldsymbol{ir} \in (N \cup \{-0, +0\})^{42} \right\}$	$\langle -me_7, me_7 \rangle$	N/A

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Table 59. AMCLIB_TrackObsrv_FLT Worst-Case Error Bounds - pParamInteg.fltState output...*continued*

Subset of input domain	Worst-case error bounds for pParamInteg.fltState output [ulp]	Allowed specific values (regardless the error bounds) for pParamInteg.fltState output
Normalized or zero input values which cause an underflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \exists n : ir_n \ne \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 60. AMCLIB_TrackObsrv_FLT Worst-Case Error Bounds - pParamInteg.fltInK1 output

Subset of input domain	Worst-case error bounds for pParamInteg.fltInK1 output [ulp]	Allowed specific values (regardless the error bounds) for pParamInteg.fltInK1 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{ X \vert X \cap D \ne \varnothing \vee X \cap M \ne \varnothing \}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values with pPhaseErr beyond the allowed range, i.e. $\{ X \vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert > \pi \}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \boldsymbol{ir} \in (N \cup \{-0, +0\})^{42} \right\}$	$\langle -me_4, me_4 \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \exists n : ir_n \ne \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 60. AMCLIB_TrackObsrv_FLT Worst-Case Error Bounds - pParamInteg.fltInK1 output...*continued*

Subset of input domain	Worst-case error bounds for pParamInteg.fltInK1 output [ulp]	Allowed specific values (regardless the error bounds) for pParamInteg.fltInK1 output
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{l} X \mid X \subset N \cup \{-0, +0\} \wedge \lvert pPhaseErr \rvert \le \pi, \\ \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

2.11 Function AMCLIB_Windmilling_FLT

2.11.1 Declaration

```
AMCLIB_WINDMILLING_RET_T AMCLIB_Windmilling_FLT(const
SWLIBS_3Syst_FLT *pUabcIn, tFloat *pPosEst, tFloat *pVelocityEst,
AMCLIB_WINDMILLING_T_FLT *const pCtrl);
```

2.11.2 Arguments

Table 61. AMCLIB_Windmilling_FLT arguments

Type	Name	Direction	Description
const SWLIBS_3Syst_FLT *	pUabcIn	**input**	Pointer to the structure with the measured 3-phase A/B/C voltages.
tFloat *	pPosEst	**output**	Estimated rotor flux position in the interval <-π; π) radians.
tFloat *	pVelocityEst	**output**	Estimated electrical angular velocity of the rotor. The velocity estimates are noisy, especially for low speeds; therefore, it is recommended to use a GDFLIB_FilterMA_FLT to further filter the results. The filter should be engaged only after the AMCLIB_Windmilling has returned **SPIN NING**; use GDFLIB_FilterMASetState_FLT to initialize the filter state with the first estimated velocity value.
AMCLIB_WINDMILLING_T_FLT *const	pCtrl	**input, output**	Pointer to the structure with AMCLIB_Windmilling parameters and state variables.

2.11.3 Worst-Case Error Bounds

The function internally normalizes the input voltages. If the inputs are near zero, the normalization causes significant amplification of intermediate rounding errors. Consequently, there is no practical upper bound for the possible output error. The function is implemented such that it achieves useful accuracy in all typical usage scenarios.

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If any of the inputs is NaN, infinity, or a denormalized number, or if any of the intermediate results overflows or underflows, the output values are undefined.

2.12 Function GDFLIB_FilterFIR_FLT

2.12.1 Declaration

```
tFloat GDFLIB_FilterFIR_FLT(tFloat fltIn, const
GDFLIB_FILTERFIR_PARAM_T_FLT *const pParam,
GDFLIB_FILTERFIR_STATE_T_FLT *const pState);
```

2.12.2 Arguments

Table 62. GDFLIB_FilterFIR_FLT arguments

Type	Name	Direction	Description
tFloat	fltIn	**input**	Input sample.
const GDFLIB_FILTERFIR_PARAM_T_FLT *const	pParam	**input**	Pointer to a parameter structure.
GDFLIB_FILTERFIR_STATE_T_FLT *const	pState	**input, output**	Pointer to a filter state structure.

2.12.3 Worst-Case Error Bounds

Let (*fltIn*, ***CoefBuf***, ***InBuf***) ∈ *X* be a set of inputs to GDFLIB_FilterFIR_FLT,

$\boldsymbol{CoefBuf} = \left(CoefBuf_0, CoefBuf_1, \ldots, CoefBuf_{u32Order}\right)$,

$\boldsymbol{InBuf} = \left(fltIn_t, fltIn_{t\text{-}1}, \ldots, fltIn_{t\text{-}u32Order}\right)$, where *t* is the current time,

refResult be the theoretical exact result,

$\boldsymbol{mr} = \boldsymbol{CoefBuf} \odot \boldsymbol{InBuf}$, i.e. a vector of element-wise multiplication results of vectors ***CoefBuf*** and ***InBuf***,

$\boldsymbol{sr} = \left(sr_1, sr_2, \ldots, sr_{u32Order\text{-}1}\right), sr_k = \sum_{n=0}^{k} CoefBuf_n \cdot InBuf_n$, i.e. a vector of partial sums of element-wise multiplication results of vectors ***CoefBuf*** and ***InBuf***,

$ie_1 = \max_n\left(\mathrm{fe}\left(mr_n\right)\right)$,

$ie_2 = \mathrm{fe}\left(refResult\right)$,

$$cb_1 = \begin{cases} 0, & ie_1 - ie_2 \le 0 \\ ie_1 - ie_2, & ie_1 - ie_2 > 0 \end{cases},$$

$$me = 0.5 \cdot \left(u32Order + 1\right) \cdot 2^{cb_1} + \sum_{n=1}^{\mathrm{ceil}\left(\frac{u32Order\text{-}2}{2}\right)} \mathrm{ceil}\left(\log_2\left(n+1\right)\right) + \sum_{n=1}^{\mathrm{floor}\left(\frac{u32Order\text{-}2}{2}\right)} \mathrm{ceil}\left(\log_2\left(n+1\right)\right),$$

then

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Table 63. GDFLIB_FilterFIR_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Input values which contain at least one denormalized number while other inputs are normalized or zero, i.e. $\left\{ \begin{matrix} (fltIn, \boldsymbol{CoefBuf}, \boldsymbol{InBuf}) \in X \\ X \cap M = \varnothing \wedge X \cap D \neq \varnothing \end{matrix} \right\}$	$(-Inf, Inf)$	N/A
Input values which contain at least one NaN, Inf, or -Inf, i.e. $\{ (fltIn, \boldsymbol{CoefBuf}, \boldsymbol{InBuf}) \in X \mid X \cap M \neq \varnothing \}$	N/A	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{matrix} (fltIn, \boldsymbol{CoefBuf}, \boldsymbol{InBuf}) \in X \mid \\ X \subset N \cup \{-0, +0\}, \\ mr \in (N \cup \{-0, +0\})^{u32Order+1}, \\ sr \in (N \cup \{-0, +0\})^{u32Order-1}, \\ refResult = 0 \vee \\ \left(\begin{matrix} \lvert refResult \rvert - me \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + me \cdot \mathrm{ULP}(refResult) \neq Inf \end{matrix} \right) \end{matrix} \right\}$	$\langle -me, me \rangle$	N/A
Normalized or zero input values which cause result overflow, i.e. $\left\{ \begin{matrix} (fltIn, \boldsymbol{CoefBuf}, \boldsymbol{InBuf}) \in X \mid \\ X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert + me \cdot \mathrm{ULP}(refResult) \in M \end{matrix} \right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}
Normalized or zero input values which cause result underflow, i.e. $\left\{ \begin{matrix} (fltIn, \boldsymbol{CoefBuf}, \boldsymbol{InBuf}) \in X \mid \\ X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert - me \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0 \end{matrix} \right\}$	$(-Inf, Inf)$	N/A

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Table 63. GDFLIB_FilterFIR_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Normalized or zero input values which cause intermediate result overflow, i.e. $\left\{ \begin{array}{c} (fltIn, \boldsymbol{CoefBuf}, \boldsymbol{InBuf}) \in X \mid \\ X \subset N \cup \{-0, +0\}, \\ \exists\, mr_n \in M \vee \\ \exists\, (\lvert sr_n \rvert + me \cdot \mathrm{ULP}(sr_n)) \in M \end{array} \right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}
Normalized or zero input values which cause intermediate result underflow, i.e. $\left\{ \begin{array}{c} (fltIn, \boldsymbol{CoefBuf}, \boldsymbol{InBuf}) \in X \mid \\ X \subset N \cup \{-0, +0\}, \\ \exists\, mr_n \in D \vee \\ \exists\, (\lvert sr_n \rvert - me \cdot \mathrm{ULP}(sr_n)) \in D, sr \neq 0 \end{array} \right\}$	$(-Inf, Inf)$	N/A

2.13 Function GDFLIB_FilterIIR1_FLT

2.13.1 Declaration

```
tFloat GDFLIB_FilterIIR1_FLT(tFloat fltIn,
GDFLIB_FILTER_IIR1_T_FLT *const pParam);
```

2.13.2 Arguments

Table 64. GDFLIB_FilterIIR1_FLT arguments

Type	Name	Direction	Description
tFloat	fltIn	**input**	Value of the input signal to be filtered in step (k). Input is a 32-bit number that contains a single precision floating point value.
GDFLIB_FILTER_IIR1_T_FLT *const	pParam	**input, output**	Pointer to a filter structure with a filter buffer and filter parameters. Arguments of the structure contain single precision floating point values.

2.13.3 Worst-Case Error Bounds

Let (*fltIn*, *fltB0*, *fltB1*, *flA1*, *fltFiltBufferX*, *fltFiltBufferY*) ∈ *X* be a set of inputs to GDFLIB_FilterIIR1_FLT,

refResult be the theoretical exact result,

$\boldsymbol{mr} = (fltIn, fltFiltBufferX, fltFiltBufferY) \odot (fltB0, fltB1, fltA1)$, i.e. a vector of element-wise multiplication results of vectors (*fltIn*, *fltFiltBufferX*, *fltFiltBufferY*) and (*fltB0*, *fltB1*, *fltA1*),

$sr = fltIn \cdot fltB0 + fltFiltBufferX \cdot fltB1$,

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$ie_1 = \max_n(\mathrm{fe}(mr_n))$,

$ie_2 = \mathrm{fe}(refResult)$,

$cb = \begin{cases} 0, & ie_1 - ie_2 \le 0 \\ ie_1 - ie_2, & ie_1 - ie_2 > 0 \end{cases}$,

$me = 0.5 + 2.5 \cdot 2^{cb}$,

the *fltFiltBufferY* input represents a real number with an error of max. ±0.5 ulp,

then

Table 65. GDFLIB_FilterIIR1_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Input values which contain at least one denormalized number while other inputs are normalized or zero, i.e. $\left\{ \begin{pmatrix} fltIn, fltB0, fltB1, fltA1, \\ fltFiltBufferX, fltFiltBufferY \end{pmatrix} \in X \middle\| X \cap M = \varnothing \wedge X \cap D \ne \varnothing \right\}$	$(-Inf, Inf)$	N/A
Input values which contain at least one NaN, Inf, or –Inf, i.e. $\left\{ \begin{pmatrix} fltIn, fltB0, fltB1, fltA1, \\ fltFiltBufferX, fltFiltBufferY \end{pmatrix} \in X \middle\| X \cap M \ne \varnothing \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{pmatrix} fltIn, fltB0, fltB1, fltA1, \\ fltFiltBufferX, fltFiltBufferY \end{pmatrix} \in X \middle\| \begin{matrix} X \subset N \cup \{-0, +0\}, \boldsymbol{mr} \in N^{u32Order+1}, \\ sr \in N \cup \{-0, +0\}, \\ refResult = 0 \vee \\ \begin{pmatrix} \lvert refResult \rvert - me \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + me \cdot \mathrm{ULP}(refResult) \ne Inf \end{pmatrix} \end{matrix} \right\}$	$\langle -me, me \rangle$	N/A
Normalized or zero input values which cause result overflow, i.e. $\left\{ \begin{pmatrix} fltIn, fltB0, fltB1, fltA1, \\ fltFiltBufferX, fltFiltBufferY \end{pmatrix} \in X \middle\| \begin{matrix} X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert + me \cdot \mathrm{ULP}(refResult) \in M \end{matrix} \right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}

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Table 65. GDFLIB_FilterIIR1_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Normalized or zero input values which cause result underflow, i.e. $\left\{\begin{matrix}\begin{pmatrix} fltIn, fltB0, fltB1, fltA1, \\ fltFiltBufferX, fltFiltBufferY \end{pmatrix} \in X \\ X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert - me \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0 \end{matrix}\right\}$	$(-Inf, Inf)$	N/A
Normalized or zero input values which cause intermediate result overflow with normalized or zero reference output, i.e. $\left\{\begin{matrix}\begin{pmatrix} fltIn, fltB0, fltB1, fltA1, \\ fltFiltBufferX, fltFiltBufferY \end{pmatrix} \in X \\ X \subset N \cup \{-0, +0\}, \\ \boldsymbol{mr} \in M^{u32Order+1} \vee \\ \lvert sr \rvert + me \cdot \mathrm{ULP}(sr) \in M \end{matrix}\right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}
Normalized or zero input values which cause intermediate result underflow with normalized or zero reference output, i.e. $\left\{\begin{matrix}\begin{pmatrix} fltIn, fltB0, fltB1, fltA1, \\ fltFiltBufferX, fltFiltBufferY \end{pmatrix} \in X \\ X \subset N \cup \{-0, +0\}, \\ \boldsymbol{mr} \in D^{u32Order+1} \vee \\ \lvert sr \rvert - me \cdot \mathrm{ULP}(sr) \in D, sr \neq 0 \end{matrix}\right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}

Table 66. GDFLIB_FilterIIR1_FLT Worst-Case Error Bounds - fltFiltBufferY Output

Subset of input domain	Worst-case error bounds for fltFiltBufferY output [ulp]	Allowed specific values (regardless the error bounds) for fltFiltBufferY output
Input values which contain at least one denormalized number while other inputs are normalized or zero, i.e. $\left\{\begin{matrix}\begin{pmatrix} fltIn, fltB0, fltB1, fltA1, \\ fltFiltBufferX, fltFiltBufferY \end{pmatrix} \in X \\ X \cap M = \varnothing \wedge X \cap D \neq \varnothing \end{matrix}\right\}$	$(-Inf, Inf)$	N/A

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Table 66. GDFLIB_FilterIIR1_FLT Worst-Case Error Bounds - fltFiltBufferY Output*...continued*

Subset of input domain	Worst-case error bounds for fltFiltBufferY output [ulp]	Allowed specific values (regardless the error bounds) for fltFiltBufferY output
Input values which contain at least one NaN, Inf, or –Inf, i.e. $\left\{ \begin{pmatrix} fltIn, fltB0, fltB1, fltA1, \\ fltFiltBufferX, fltFiltBufferY \end{pmatrix} \in X \middle\vert \begin{matrix} X \cap M \neq \varnothing \end{matrix} \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{matrix} \begin{pmatrix} fltIn, fltB0, fltB1, fltA1, \\ fltFiltBufferX, fltFiltBufferY \end{pmatrix} \in X \\ X \subset N \cup \{-0, +0\}, \boldsymbol{mr} \in N^{u32Order+1}, \\ sr \in N \cup \{-0, +0\}, \\ refResult = 0 \vee \\ \begin{pmatrix} \lvert refResult \rvert - me \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + me \cdot \mathrm{ULP}(refResult) \neq Inf \end{pmatrix} \end{matrix} \right\}$	$\langle -me, me \rangle$	N/A
Normalized or zero input values which cause result overflow, i.e. $\left\{ \begin{pmatrix} fltIn, fltB0, fltB1, fltA1, \\ fltFiltBufferX, fltFiltBufferY \end{pmatrix} \in X \middle\vert \begin{matrix} X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert + me \cdot \mathrm{ULP}(refResult) \in M \end{matrix} \right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}
Normalized or zero input values which cause result underflow, i.e. $\left\{ \begin{pmatrix} fltIn, fltB0, fltB1, fltA1, \\ fltFiltBufferX, fltFiltBufferY \end{pmatrix} \in X \middle\vert \begin{matrix} X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert - me \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0 \end{matrix} \right\}$	$(-Inf, Inf)$	N/A

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Table 66. GDFLIB_FilterIIR1_FLT Worst-Case Error Bounds - fltFiltBufferY Output*...continued*

Subset of input domain	Worst-case error bounds for fltFiltBufferY output [ulp]	Allowed specific values (regardless the error bounds) for fltFiltBufferY output
Normalized or zero input values which cause intermediate result overflow with normalized or zero reference output, i.e. $\left\{ \left(\begin{array}{c} fltIn, fltB0, fltB1, fltA1, \\ fltFiltBufferX, fltFiltBufferY \end{array} \right) \in X \middle\| \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \boldsymbol{mr} \in M^{u32Order+1} \vee \\ \lvert sr \rvert + me \cdot \mathrm{ULP}(sr) \in M \end{array} \right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}
Normalized or zero input values which cause intermediate result underflow with normalized or zero reference output, i.e. $\left\{ \left(\begin{array}{c} fltIn, fltB0, fltB1, fltA1, \\ fltFiltBufferX, fltFiltBufferY \end{array} \right) \in X \middle\| \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \boldsymbol{mr} \in D^{u32Order+1} \vee \\ \lvert sr \rvert - me \cdot \mathrm{ULP}(sr) \in D, sr \neq 0 \end{array} \right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}

Table 67. GDFLIB_FilterIIR1_FLT Worst-Case Error Bounds - fltFiltBufferX Output

Subset of input domain	Worst-case error bounds for fltFiltBufferX output [ulp]	Allowed specific values (regardless the error bounds) for fltFiltBufferX output
Entire input domain	0	*fltIn*

2.14 Function GDFLIB_FilterIIR2_FLT

2.14.1 Declaration

```
tFloat GDFLIB_FilterIIR2_FLT(tFloat fltIn,
GDFLIB_FILTER_IIR2_T_FLT *const pParam);
```

2.14.2 Arguments

Table 68. GDFLIB_FilterIIR2_FLT arguments

Type	Name	Direction	Description
tFloat	fltIn	**input**	Value of the input signal to be filtered in step (k). Input is a 32-bit number that contains a single precision floating point value.

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Table 68. GDFLIB_FilterIIR2_FLT arguments*...continued*

Type	Name	Direction	Description
GDFLIB_FILTER_IIR2_T_FLT *const	pParam	**input, output**	Pointer to a filter structure with a filter buffer and filter parameters. Arguments of the structure contain single precision floating point values.

2.14.3 Worst-Case Error Bounds

Let (*fltIn*, *fltB0*, *fltB1*, *fltB2*, *flA1*, *flA2*, ***fltFiltBufferX*** , ***fltFiltBufferY***) ∈ *X* be a set of inputs to GDFLIB_FilterIIR2_FLT,

$\boldsymbol{fltFiltBufferX} = \left(fltFiltBufferX_0, fltFiltBufferX_1 \right)$,

$\boldsymbol{fltFiltBufferY} = \left(fltFiltBufferY_0, fltFiltBufferY_1 \right)$,

refResult be the theoretical exact result,

$\boldsymbol{mr} = \left(fltIn, fltFiltBufferX, fltFiltBufferY \right) \odot \left(fltB0, fltB1, fltB2, fltA1, fltA2 \right)$,
i.e. a vector of element-wise multiplication results of vectors (*fltIn*, ***fltFiltBufferX*** , ***fltFiltBufferY***) and (*fltB0*, *fltB1*, *fltB2*, *flA1*, *flA2*),

$sr_1 = fltIn \cdot fltB_0 + fltFiltBufferX_0 \cdot fltB1$,

$sr_2 = sr_1 + fltFiltBufferX_1 \cdot fltB2$,

$sr_3 = sr_2 + fltFiltBufferY_0 \cdot fltA1$,

$\boldsymbol{sr} = \left(sr_1, sr_2, sr_3 \right)$,

$ie_1 = \max_n \left(\mathrm{fe}\left(mr_n \right) \right)$,

$ie_2 = \mathrm{fe}\left(refResult \right)$,

$cb = \begin{cases} 0, & ie_1 - ie_2 \le 0 \\ ie_1 - ie_2, & ie_1 - ie_2 > 0 \end{cases}$,

$me = 0.5 + 5 \cdot 2^{cb}$,

the *fltFiltBufferY* $_0$ input represents a real number with an error of max. ±0.5 ulp,

then

Table 69. GDFLIB_FilterIIR2_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Input values which contain at least one denormalized number while other inputs are normalized or zero, i.e. $\left\{ \left(\begin{matrix} fltIn, fltB0, fltB1, fltB2, fltA1, fltA2, \\ fltFiltBufferX, fltFiltBufferY \end{matrix} \right) \in X \middle\vert \begin{matrix} \\ X \cap M = \varnothing \wedge X \cap D \neq \varnothing \end{matrix} \right\}$	$\left(-Inf, Inf \right)$	N/A

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Table 69. GDFLIB_FilterIIR2_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Input values which contain at least one NaN, Inf, or –Inf, i.e. $\left\{ \begin{pmatrix} fltIn, fltB0, fltB1, fltB2, fltA1, fltA2, \\ fltFiltBufferX, fltFiltBufferY \end{pmatrix} \in X \middle\vert \begin{matrix} X \cap M \neq \varnothing \end{matrix} \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{pmatrix} fltIn, fltB0, fltB1, fltB2, fltA1, fltA2, \\ fltFiltBufferX, fltFiltBufferY \end{pmatrix} \in X \middle\vert \begin{matrix} X \subset N \cup \{-0, +0\}, \\ \boldsymbol{mr} \in (N \cup \{-0, +0\})^{u32Order+1}, \\ \boldsymbol{sr} \in (N \cup \{-0, +0\})^{u32Order-1}, \\ refResult = 0 \vee \\ \begin{pmatrix} \lvert refResult \rvert - me \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + me \cdot \mathrm{ULP}(refResult) \neq Inf \end{pmatrix} \end{matrix} \right\}$	$\langle -me, me \rangle$	N/A
Normalized or zero input values which cause result overflow, i.e. $\left\{ \begin{pmatrix} fltIn, fltB0, fltB1, fltB2, fltA1, fltA2, \\ fltFiltBufferX, fltFiltBufferY \end{pmatrix} \in X \middle\vert \begin{matrix} X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert + me \cdot \mathrm{ULP}(refResult) \in M \end{matrix} \right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}
Normalized or zero input values which cause result underflow, i.e. $\left\{ \begin{pmatrix} fltIn, fltB0, fltB1, fltB2, fltA1, fltA2, \\ fltFiltBufferX, fltFiltBufferY \end{pmatrix} \in X \middle\vert \begin{matrix} X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert - me \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0 \end{matrix} \right\}$	$(-Inf, Inf)$	N/A

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Table 69. GDFLIB_FilterIIR2_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Normalized or zero input values which cause intermediate result overflow, i.e. $\left\{ \left(\begin{matrix} fltIn, fltB0, fltB1, fltB2, fltA1, fltA2, \\ fltFiltBufferX, fltFiltBufferY \end{matrix} \right) \in X \middle\| \begin{matrix} X \subset N \cup \{-0, +0\}, \\ \exists\, mr_n \in M \vee \\ \exists\, (\lvert sr_n \rvert + me \cdot \mathrm{ULP}(sr_n)) \in M \end{matrix} \right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}
Normalized or zero input values which cause intermediate result underflow, i.e. $\left\{ \left(\begin{matrix} fltIn, fltB0, fltB1, fltB2, fltA1, fltA2, \\ fltFiltBufferX, fltFiltBufferY \end{matrix} \right) \in X \middle\| \begin{matrix} X \subset N \cup \{-0, +0\}, \\ \exists\, mr_n \in D \vee \\ \exists\, (\lvert sr_n \rvert - me \cdot \mathrm{ULP}(sr_n)) \in D, sr \neq 0 \end{matrix} \right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}

Table 70. GDFLIB_FilterIIR2_FLT Worst-Case Error Bounds - fltFiltBufferY$_0$ Output

Subset of input domain	Worst-case error bounds for fltFiltBufferY$_0$ output [ulp]	Allowed specific values (regardless the error bounds) for fltFiltBufferY$_0$ output
Input values which contain at least one denormalized number while other inputs are normalized or zero, i.e. $\left\{ \left(\begin{matrix} fltIn, fltB0, fltB1, fltB2, fltA1, fltA2, \\ fltFiltBufferX, fltFiltBufferY \end{matrix} \right) \in X \middle\| X \cap M = \varnothing \wedge X \cap D \neq \varnothing \right\}$	$(-Inf, Inf)$	N/A
Input values which contain at least one NaN, Inf, or –Inf, i.e. $\left\{ \left(\begin{matrix} fltIn, fltB0, fltB1, fltB2, fltA1, fltA2, \\ fltFiltBufferX, fltFiltBufferY \end{matrix} \right) \in X \middle\| X \cap M \neq \varnothing \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)

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Table 70. GDFLIB_FilterIIR2_FLT Worst-Case Error Bounds - fltFiltBufferY$_0$ Output*...continued*

Subset of input domain	Worst-case error bounds for fltFiltBufferY$_0$ output [ulp]	Allowed specific values (regardless the error bounds) for fltFiltBufferY$_0$ output
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} \left(\begin{array}{c} fltIn, fltB0, fltB1, fltB2, fltA1, fltA2, \\ fltFiltBufferX, fltFiltBufferY \end{array} \right) \in X \\ X \subset N \cup \{-0, +0\}, \\ \boldsymbol{mr} \in (N \cup \{-0, +0\})^{u32Order+1}, \\ \boldsymbol{sr} \in (N \cup \{-0, +0\})^{u32Order-1}, \\ refResult = 0 \vee \\ \left(\begin{array}{c} \lvert refResult \rvert - me \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + me \cdot \mathrm{ULP}(refResult) \neq Inf \end{array} \right) \end{array} \right\}$	$\langle -me, me \rangle$	N/A
Normalized or zero input values which cause result overflow, i.e. $\left\{ \begin{array}{c} \left(\begin{array}{c} fltIn, fltB0, fltB1, fltB2, fltA1, fltA2, \\ fltFiltBufferX, fltFiltBufferY \end{array} \right) \in X \\ X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert + me \cdot \mathrm{ULP}(refResult) \in M \end{array} \right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}
Normalized or zero input values which cause result underflow, i.e. $\left\{ \begin{array}{c} \left(\begin{array}{c} fltIn, fltB0, fltB1, fltB2, fltA1, fltA2, \\ fltFiltBufferX, fltFiltBufferY \end{array} \right) \in X \\ X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert - me \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0 \end{array} \right\}$	$(-Inf, Inf)$	N/A
Normalized or zero input values which cause intermediate result overflow, i.e. $\left\{ \begin{array}{c} \left(\begin{array}{c} fltIn, fltB0, fltB1, fltB2, fltA1, fltA2, \\ fltFiltBufferX, fltFiltBufferY \end{array} \right) \in X \\ X \subset N \cup \{-0, +0\}, \\ \exists\, mr_n \in M \vee \\ \exists\, (\lvert sr_n \rvert + me \cdot \mathrm{ULP}(sr_n)) \in M \end{array} \right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}

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Table 70. GDFLIB_FilterIIR2_FLT Worst-Case Error Bounds - fltFiltBufferY$_0$ Output*...continued*

Subset of input domain	Worst-case error bounds for fltFiltBufferY$_0$ output [ulp]	Allowed specific values (regardless the error bounds) for fltFiltBufferY$_0$ output
Normalized or zero input values which cause intermediate result underflow, i.e. $\left\{ \begin{pmatrix} fltIn, fltB0, fltB1, fltB2, fltA1, fltA2, \\ fltFiltBufferX, fltFiltBufferY \end{pmatrix} \in X \middle| \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \exists\, mr_n \in D \vee \\ \exists\, (\lvert sr_n \rvert - me \cdot \mathrm{ULP}(sr_n)) \in D, sr \neq 0 \end{array} \right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}

Table 71. GDFLIB_FilterIIR2_FLT Worst-Case Error Bounds - fltFiltBufferY$_1$ Output

Subset of input domain	Worst-case error bounds for fltFiltBufferY$_1$ output [ulp]	Allowed specific values (regardless the error bounds) for fltFiltBufferY$_1$ output
Entire input domain	0	*fltFiltBufferY* $_0$

Table 72. GDFLIB_FilterIIR2_FLT Worst-Case Error Bounds - fltFiltBufferX$_0$ Output

Subset of input domain	Worst-case error bounds for fltFiltBufferX$_0$ output [ulp]	Allowed specific values (regardless the error bounds) for fltFiltBufferX$_0$ output
Entire input domain	0	*fltIn*

Table 73. GDFLIB_FilterIIR2_FLT Worst-Case Error Bounds - fltFiltBufferX$_1$ Output

Subset of input domain	Worst-case error bounds for fltFiltBufferX$_1$ output [ulp]	Allowed specific values (regardless the error bounds) for fltFiltBufferX$_1$ output
Entire input domain	0	*fltFiltBufferX* $_0$

2.15 Function GDFLIB_FilterMA_FLT

2.15.1 Declaration

```
tFloat GDFLIB_FilterMA_FLT(tFloat fltIn, GDFLIB_FILTER_MA_T_FLT
*pParam);
```


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2.15.2 Arguments

Table 74. GDFLIB_FilterMA_FLT arguments

Type	Name	Direction	Description
tFloat	fltIn	**input**	Value of the input signal to be filtered in step (k). The value is a single precision floating point data type.
GDFLIB_FILTER_MA_T_FLT *	pParam	**input, output**	Pointer to the filter structure with a filter accumulator and a smoothing factor.

2.15.3 Worst-Case Error Bounds

Let (*fltIn*, *fltAcc*, *fltLambda*) $\in X$ be a set of inputs to GDFLIB_FilterMA_FLT,

refResult be the theoretical exact result,

$$mr_1 = fltIn \cdot fltLambda,$$

$$mr_2 = refResult \cdot fltLambda,$$

$$ie_1 = \max(\mathrm{fe}(mr_1), \mathrm{fe}(fltAcc)),$$

$$ie_2 = \mathrm{fe}(refResult),$$

$$cb_1 = \begin{cases} 0, & ie_1 - ie_2 \le 0 \\ ie_1 - ie_2, & ie_1 - ie_2 > 0 \end{cases},$$

$$me_1 = 0.5 + 0.5 \cdot 2^{cb_1},$$

$$refState = refResult - mr_2,$$

$$ie_3 = \max(\mathrm{fe}(|mr_2| + 2 \cdot me_1 \cdot \mathrm{ULP}(mr_2)), \mathrm{fe}(|refResult| + me_1 \cdot \mathrm{ULP}(refResult))),$$

$$ie_4 = \mathrm{fe}(refState),$$

$$cb_2 = \begin{cases} 0, & ie_3 - ie_4 \le 0 \\ ie_3 - ie_4, & ie_3 - ie_4 > 0 \end{cases},$$

$$me_2 = 0.5 + me_1 + (2 \cdot me_1) \cdot 2^{cb_2},$$

then

Table 75. GDFLIB_FilterMA_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Input values which contain at least one denormalized number while other inputs are normalized or zero, i.e. $\left\{ (fltIn, fltAcc, fltLambda) \in X \,\middle|\, X \cap M = \varnothing \wedge X \cap D \ne \varnothing \right\}$	$(-Inf, Inf)$	N/A

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Table 75. GDFLIB_FilterMA_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Input values which contain at least one NaN, Inf, or –Inf, i.e. $\{(fltIn, fltAcc, fltLambda) \in X \mid X \cap M \neq \varnothing\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)
Normalized or zero input values which lead to normalized or zero result, i.e. $\left\{ \begin{array}{c} (fltIn, fltAcc, fltLambda) \in X \mid \\ X \subset N \cup \{-0, +0\}, \\ mr_1 \in N \cup \{-0, +0\}, \\ refResult = 0 \vee \\ \left(\begin{array}{c} \lvert refResult \rvert - me_1 \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + me_1 \cdot \mathrm{ULP}(refResult) \neq Inf \end{array} \right), \end{array} \right\}$	$\langle -me_1, me_1 \rangle$	N/A
Normalized or zero input values which cause result overflow, i.e. $\left\{ \begin{array}{c} (fltIn, fltAcc, fltLambda) \in X \mid \\ X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert + me_1 \cdot \mathrm{ULP}(refResult) \in M \end{array} \right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}
Normalized or zero input values which cause result underflow, i.e. $\left\{ \begin{array}{c} (fltIn, fltAcc, fltLambda) \in X \mid \\ X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert - me_1 \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0 \end{array} \right\}$	$(-Inf, Inf)$	N/A
Normalized or zero input values which cause intermediate result overflow, i.e. $\left\{ \begin{array}{c} (fltIn, fltAcc, fltLambda) \in X \mid \\ X \subset N \cup \{-0, +0\}, \\ mr_1 \in \{Inf, -Inf\} \end{array} \right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}

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Table 75. GDFLIB_FilterMA_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Normalized or zero input values which cause intermediate result underflow, i.e. $\left\{ \begin{array}{c} (fltIn, fltAcc, fltLambda) \in X \mid \\ X \subset N \cup \{-0, +0\}, \\ mr_1 \in D \end{array} \right\}$	$(-Inf, Inf)$	N/A

Table 76. GDFLIB_FilterMA_FLT Worst-Case Error Bounds - fltAcc Output

Subset of input domain	Worst-case error bounds for fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for fltAcc output
Input values which contain at least one denormalized number while other inputs are normalized or zero, i.e. $\left\{ \begin{array}{c} (fltIn, fltAcc, fltLambda) \in X \mid \\ X \cap M = \varnothing \wedge X \cap D \neq \varnothing \end{array} \right\}$	$(-Inf, Inf)$	N/A
Input values which contain at least one NaN, Inf, or –Inf, i.e. $\{ (fltIn, fltAcc, fltLambda) \in X \mid X \cap M \neq \varnothing \}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)
Normalized or zero input values which lead to normalized or zero fltAcc output, i.e. $\left\{ \begin{array}{c} (fltIn, fltAcc, fltLambda) \in X \mid \\ X \subset N \cup \{-0, +0\}, \\ mr_1 \in N \cup \{-0, +0\}, mr_2 \in N \cup \{-0, +0\}, \\ refResult = 0 \vee \\ \left(\begin{array}{l} \lvert refResult \rvert - me_1 \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + me_1 \cdot \mathrm{ULP}(refResult) \neq Inf \end{array} \right), \\ refState = 0 \vee \\ \left(\begin{array}{l} \lvert refState \rvert - me_2 \cdot \mathrm{ULP}(refState) \notin D \wedge \\ \lvert refState \rvert + me_2 \cdot \mathrm{ULP}(refState) \neq Inf \end{array} \right) \end{array} \right\}$	$\langle -me_2, me_2 \rangle$	N/A
Normalized or zero input values which cause *fltAcc* output overflow, i.e. $\left\{ \begin{array}{c} (fltIn, fltAcc, fltLambda) \in X \mid \\ X \subset N \cup \{-0, +0\}, \\ \lvert refState \rvert + me_2 \cdot \mathrm{ULP}(refState) \in M \end{array} \right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}

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Table 76. GDFLIB_FilterMA_FLT Worst-Case Error Bounds - fltAcc Output*...continued*

Subset of input domain	Worst-case error bounds for fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for fltAcc output
Normalized or zero input values which cause *fltAcc* output underflow, i.e. $\left\{ \begin{array}{c} (fltIn, fltAcc, fltLambda) \in X \mid \\ X \subset N \cup \{-0, +0\}, \\ \lvert refState \rvert - me_2 \cdot \mathrm{ULP}(refState) \in D \wedge \\ refState \neq 0 \end{array} \right\}$	$(-Inf, Inf)$	N/A
Normalized or zero input values which cause intermediate results overflow, i.e. $\left\{ \begin{array}{c} (fltIn, fltAcc, fltLambda) \in X \mid \\ X \subset N \cup \{-0, +0\}, \\ mr_1 \in \{Inf, -Inf\}, \\ \lvert mr_2 \rvert + 2 \cdot me_1 \cdot \mathrm{ULP}(mr_2) = Inf \end{array} \right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}
Normalized or zero input values which cause intermediate results underflow, i.e. $\left\{ \begin{array}{c} (fltIn, fltAcc, fltLambda) \in X \mid \\ X \subset N \cup \{-0, +0\}, \\ mr_1 \in D \vee \\ \left(\begin{array}{c} refResult \neq 0 \wedge \\ \lvert refResult \rvert - me_1 \cdot \mathrm{ULP}(refResult) \in D \end{array} \right) \vee \\ (mr_2 \neq 0 \wedge \lvert mr_2 \rvert - 2 \cdot me_1 \cdot \mathrm{ULP}(mr_2) \in D) \end{array} \right\}$	$(-Inf, Inf)$	N/A

2.16 Function GFLIB_Acos_FLT

2.16.1 Declaration

```
tFloat GFLIB_Acos_FLT(tFloat fltIn, const GFLIB_ACOS_T_FLT *const
pParam);
```

2.16.2 Arguments

Table 77. GFLIB_Acos_FLT arguments

Type	Name	Direction	Description
tFloat	fltIn	**input**	Input argument is a 32-bit number that contains a single precision floating point value.
const GFLIB_ACOS_T_FLT *const	pParam	**input**	Pointer to an array of approximation coefficients. In case the default approximation coefficients are used, the &pParam must be replaced with GFLIB_ACOS_DEFAULT_FLT symbol.

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2.16.3 Worst-Case Error Bounds

Only the default approximation coefficients are considered.

Let *fltIn* ∈ *X* be an input to GFLIB_Acos_FLT,

then

Table 78. GFLIB_Acos_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Input NaN or infinity, i.e. $\{fltIn \in X \mid fltIn \in M\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)
Input denormalized, normalized or zero, and within the allowed input interval, i.e. $\left\{ \begin{matrix} fltIn \in X \mid X \cap M = \varnothing, \\ -1 \le fltIn \le 1 \end{matrix} \right\}$	$\langle -130, 130 \rangle$	N/A
Input normalized and beyond the allowed range, i.e. $\left\{ \begin{matrix} fltIn \in X \mid X \cap M = \varnothing, \\ fltIn < -1 \vee fltIn > 1 \end{matrix} \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)

2.17 Function GFLIB_Asin_FLT

2.17.1 Declaration

```
tFloat GFLIB_Asin_FLT(tFloat fltIn, const GFLIB_ASIN_T_FLT *const
pParam);
```

2.17.2 Arguments

Table 79. GFLIB_Asin_FLT arguments

Type	Name	Direction	Description
tFloat	fltIn	**input**	Input argument is a 32-bit number that contains a single precision floating point value.
const GFLIB_ASIN_T_FLT *const	pParam	**input**	Pointer to an array of approximation coefficients. In case the default approximation coefficients are used, the &pParam must be replaced with GFLIB_ASIN_DEFAULT_FLT symbol.

2.17.3 Worst-Case Error Bounds

Only the default approximation coefficients are considered.

Let *fltIn* ∈ *X* be an input to GFLIB_Asin_FLT,

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then

Table 80. GFLIB_Asin_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Input NaN or infinity, i.e. $\{fltIn \in X \mid fltIn \in M\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)
Input denormalized, normalized or zero, and within the allowed input interval, i.e. $\left\{ \begin{matrix} fltIn \in X \mid X \cap M = \varnothing, \\ -1 \le fltIn \le 1 \end{matrix} \right\}$	$\langle -155,155 \rangle$	N/A
Input normalized and beyond the allowed range, i.e. $\left\{ \begin{matrix} fltIn \in X \mid X \cap M = \varnothing, \\ fltIn < -1 \vee fltIn > 1 \end{matrix} \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)

2.18 Function GFLIB_Atan_FLT

2.18.1 Declaration

```
tFloat GFLIB_Atan_FLT(tFloat fltIn, const GFLIB_ATAN_T_FLT *const
pParam);
```

2.18.2 Arguments

Table 81. GFLIB_Atan_FLT arguments

Type	Name	Direction	Description
tFloat	fltIn	**input**	Input argument is a single precision floating point number between (- 2^{128}, 2^{128}).
const GFLIB_ATAN_T_FLT *const	pParam	**input**	Pointer to an array of rational polynomial coefficients. In case the default approximation coefficients are used, the &pParam must be replaced with GFLIB_ATAN_DEFAULT_FLT symbol.

2.18.3 Worst-Case Error Bounds

Only the default approximation coefficients are considered.

Let *fltIn* ∈ *X* be a an input to GFLIB_Atan_FLT,

then

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Table 82. GFLIB_Atan_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Input NaN, i.e. $\{ fltIn \in X \mid fltIn = NaN \}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)
Input not a NaN, i.e. $\{ fltIn \in X \mid fltIn \neq NaN, \}$	$\langle -3,3 \rangle$	N/A

2.19 Function GFLIB_AtanYX_FLT

2.19.1 Declaration

```
tFloat GFLIB_AtanYX_FLT(tFloat fltInY, tFloat fltInX);
```

2.19.2 Arguments

Table 83. GFLIB_AtanYX_FLT arguments

Type	Name	Direction	Description
tFloat	fltInY	**input**	The ordinate of the input vector (y coordinate).
tFloat	fltInX	**input**	The abscissa of the input vector (x coordinate).

2.19.3 Worst-Case Error Bounds

Let (*fltInX*, *fltInY*) $\in$ *X* be a set of inputs to GFLIB_AtanYX_FLT,

refResult be the theoretical exact result,

then

Table 84. GFLIB_AtanYX_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Any of the inputs is denormalized, NaN, or invinity, i.e. $\{ (fltInY, fltInX) \in X \mid X \cap M \neq \varnothing \vee X \cap D \neq \varnothing \}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)

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Table 84. GFLIB_AtanYX_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Both inputs are normalized or zero, results normalized or zero, i.e. $\left\{ \begin{array}{c} (fltInY, fltInX) \in X \mid X \subset N \cup \{-0, +0\}, \\ \frac{fltInY}{fltInX} \in N \cup \{-0, +0\}, \\ refResult = 0 \vee \\ \left(\begin{array}{c} \lvert refResult \rvert - 3.5 \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + 3.5 \cdot \mathrm{ULP}(refResult) \neq Inf \end{array} \right) \end{array} \right\}$	$\langle -3.5, 3.5 \rangle$	N/A
Both inputs are normalized or zero, result underflow, i.e. $\left\{ \begin{array}{c} (fltInY, fltInX) \in X \mid X \subset N \cup \{-0, +0\} \\ \lvert refResult \rvert - 3.5 \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0 \end{array} \right\}$	$(-Inf, Inf)$	N/A
Both inputs are normalized or zero, intermediate result overflow, i.e. $\left\{ \begin{array}{c} (fltInY, fltInX) \in X \mid X \subset N \cup \{-0, +0\} \\ \frac{fltInY}{fltInX} \in \{Inf, -Inf\} \end{array} \right\}$	$(-Inf, Inf)$	{NaN, -Inf, Inf}

2.20 Function GFLIB_AtanYXShifted_FLT

2.20.1 Declaration

```
tFloat GFLIB_AtanYXShifted_FLT(tFloat fltInY, tFloat fltInX,
const GFLIB_ATANYXSHIFTED_T_FLT *pParam);
```

2.20.2 Arguments

Table 85. GFLIB_AtanYXShifted_FLT arguments

Type	Name	Direction	Description
tFloat	fltInY	**input**	The value of the first signal, assumed to be sin (θ).
tFloat	fltInX	**input**	The value of the second signal, assumed to be sin(θ + Δθ).
const GFLIB_ATANYXSHIFTED_T_FLT *	pParam	**input**	The parameters for the function.

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2.20.3 Worst-Case Error Bounds

Let (*fltInX*, *fltInY*, *fltKx*, *fltKy*, *fltThetaAdj*) $\in X$ be a set of inputs to GFLIB_AtanYXShifted_FLT,

$ir_1 = fltInY + fltInX$,

$ir_2 = ir_1 \cdot fltKy$,

$ir_3 = fltInX - fltInY$,

$ir_4 = ir_3 \cdot fltKx$,

$ir_6 = \mathrm{atan2}(ir_2, ir_4)$, where ir_2 is the *y* coordinate and ir_4 is the *x* coordinate and atan2(*y*, *x*) is the four-quadrant arctangent function,

$ir_7 = ir_6 - fltThetaAdj$,

$ie_1 = \max(\mathrm{fe}(ir_6 - 10 \cdot \mathrm{ULP}(ir_6)), \mathrm{fe}(ir_6 + 13.5 \cdot \mathrm{ULP}(ir_6)), \mathrm{fe}(fltThetaAdj))$,

$ie_2 = \mathrm{fe}(ir_7)$,

$$cb_1 = \begin{cases} 0, & ie_1 - ie_2 \le 0 \\ ie_1 - ie_2, & ie_1 - ie_2 > 0 \end{cases},$$

$me_1 = 0.5 + 13.5 \cdot 2^{cb_1}$,

$ie_3 = \max(\mathrm{fe}(ir_7 - me_1 \cdot \mathrm{ULP}(ir_7)), \mathrm{fe}(ir_7 + me_1 \cdot \mathrm{ULP}(ir_7)), \mathrm{fe}(2\pi))$,

$ie_4 = \mathrm{fe}(refResult)$,

$$cb_2 = \begin{cases} 0, & ie_3 - ie_4 \le 0 \\ ie_3 - ie_4, & ie_3 - ie_4 > 0 \end{cases},$$

$me_2 = 0.5 + (me_1 + 0.5) \cdot 2^{cb_2}$,

$$me_3 = \begin{cases} me_2, & (ir_7 + me_1 \cdot \mathrm{ULP}(ir_7) > \pi) \text{ or } (ir_7 - me_1 \cdot \mathrm{ULP}(ir_7) < -\pi) \\ me_1, & otherwise \end{cases},$$

refResult be the theoretical exact result,

then

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Table 86. GFLIB_AtanYXShifted_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} (fltInX, fltInY, fltKx, fltKy, fltThetaAdj) \in X \\ X \subset N \cup \{-0, +0\}, \\ \{ir_1, ir_2, ir_3, ir_4, ir_5, ir_6, ir_7\} \subset N \cup \{-0, +0\}, \\ refResult = 0 \vee \\ \left(\begin{array}{c} \lvert refResult \rvert - me_3 \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + me_3 \cdot \mathrm{ULP}(refResult) \neq Inf \end{array} \right) \end{array} \right\}$	$\langle -me_3, me_3 \rangle$	N/A
Input values which contain at least one NaN, Inf, or -Inf, i.e. $\left\{ \begin{array}{c} (fltInX, fltInY, fltKx, fltKy, fltThetaAdj) \in X \\ X \cap M \neq \varnothing \end{array} \right\}$	N/A	Arbitrary floating-point value (including Inf, -Inf, NaN)
Input values which contain at least one denormalized number while other inputs are normalized or zero, i.e. $\left\{ \begin{array}{c} (fltInX, fltInY, fltKx, fltKy, fltThetaAdj) \in X \\ X \cap M = \varnothing \wedge X \cap D \neq \varnothing \end{array} \right\}$	N/A	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause result underflow, i.e. $\left\{ \begin{array}{c} (fltInX, fltInY, fltKx, fltKy, fltThetaAdj) \in X \\ X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert - me_3 \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0 \end{array} \right\}$	$(-Inf, Inf)$	N/A
Normalized or zero input values which cause intermediate result overflow, i.e. $\left\{ \begin{array}{c} (fltInX, fltInY, fltKx, fltKy, fltThetaAdj) \in X \\ X \subset N \cup \{-0, +0\}, \\ \left\{ \begin{array}{c} ir_1, \lvert ir_2 \rvert + 1.5 \cdot \mathrm{ULP}(ir_2), \\ ir_3, \lvert ir_4 \rvert + 1.5 \cdot \mathrm{ULP}(ir_4), \\ \frac{\lvert ir_2 \rvert + 1.5 \cdot \mathrm{ULP}(ir_2)}{\lvert ir_4 \rvert + 1.5 \cdot \mathrm{ULP}(ir_4)} \end{array} \right\} \cap M \neq \varnothing \end{array} \right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}

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Table 86. GFLIB_AtanYXShifted_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Normalized or zero input values which cause intermediate result underflow, i.e. $\left\{ \begin{array}{c} (fltInX, fltInY, fltKx, fltKy, fltThetaAdj) \in X \\ X \subset N \cup \{-0, +0\}, \\ \left\{ \begin{array}{c} ir_1, \lvert ir_2 \rvert - 1.5 \cdot \mathrm{ULP}(ir_2), \\ ir_3, \lvert ir_4 \rvert - 1.5 \cdot \mathrm{ULP}(ir_4), \\ \frac{\lvert ir_2 \rvert + 1.5 \cdot \mathrm{ULP}(ir_2)}{\lvert ir_4 \rvert + 1.5 \cdot \mathrm{ULP}(ir_4)}, \\ \lvert ir_6 \rvert - 13.5 \cdot \mathrm{ULP}(ir_6), \\ \lvert ir_7 \rvert - me_1 \cdot \mathrm{ULP}(ir_7), \end{array} \right\} \cap D \neq \emptyset, \\ ir_2 \neq 0, ir_4 \neq 0, ir_5 \neq 0, ir_6 \neq 0, ir_7 \neq 0 \end{array} \right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}

2.21 Function GFLIB_ControllerPIDpAW_FLT

2.21.1 Declaration

```
tFloat GFLIB_ControllerPIDpAW_FLT(tFloat fltInErr,
GFLIB_CONTROLLER_PID_P_AW_T_FLT *const pParam);
```

2.21.2 Arguments

Table 87. GFLIB_ControllerPIDpAW_FLT arguments

Type	Name	Direction	Description
tFloat	fltInErr	**input**	Input error signal to the controller in single precision floating format.
GFLIB_ CONTROLLER_ PID_P_AW_T_ FLT *const	pParam	**input, output**	Pointer to the controller parameters structure.

2.21.3 Worst-Case Error Bounds

Let (*fltInErr*, *fltPropGain*, *fltIntegGain*, *fltDerivGain*, *fltFiltCoef*, *fltLowerLimit*, *fltUpperLimit*, *fltIntegPartK_1*, *fltDerivPartK_1*, *fltInK_1*) ∈ *X* be a set of inputs to GFLIB_ControllerPIDpAW_FLT,

fltIntegPartK_1 input represents a real number with an error of max. ±0.5 ulp,

fltDerivPartK_1 input represents a real number with an error of max. ±0.5 ulp,

refResult be the theoretical exact result,

$ir_1 = (fltInErr + fltInK_1) \cdot fltIntegGain,$

$ie_1 = \max(\mathrm{fe}(\lvert ir_1 \rvert + \mathrm{ULP}(ir_1)), \mathrm{fe}(\lvert fltIntegPartK_1 \rvert + 0.5 \cdot \mathrm{ULP}(fltIntegPartK_1)))$,

$refInteg = fltIntegPartK_1 + ir_1,$

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$$ie_2 = fe(refInteg),$$

$$cb_1 = \begin{cases} 0, & ie_1 - ie_2 \le 0 \\ ie_1 - ie_2, & ie_1 - ie_2 > 0 \end{cases}$$

$$me_1 = \begin{cases} 0, & refInteg + \left(0.5 + 1.5 \cdot 2^{cb_1}\right) \cdot \mathrm{ULP}(refInteg) < fltLowerLimit \\ 0, & refInteg - \left(0.5 + 1.5 \cdot 2^{cb_1}\right) \cdot \mathrm{ULP}(refInteg) > fltUpperLimit \\ 0.5 + 1.5 \cdot 2^{cb_1}, & \text{otherwise} \end{cases}$$

$$ir_2 = fltInErr \cdot fltDerivGain,$$

$$ir_3 = fltInK_1 \cdot fltDerivGain,$$

$$ie_3 = \max(\mathrm{fe}(|ir_2| + 0.5 \cdot \mathrm{ULP}(ir_2)), \mathrm{fe}(|ir_3| + 1 \cdot \mathrm{ULP}(ir_3))),$$

$$ir_4 = ir_2 - ir_3,$$

$$ie_4 = fe(ir_4),$$

$$cb_2 = \begin{cases} 0, & ie_3 - ie_4 \le 0 \\ ie_3 - ie_4, & ie_3 - ie_4 > 0 \end{cases},$$

$$me_2 = 0.5 + 1.5 \cdot 2^{cb_2},$$

$$ir_5 = fltDerivPartK_1 \cdot fltFiltCoef,$$

$$ie_5 = \max(\mathrm{fe}(|ir_4| + me_2 \cdot \mathrm{ULP}(ir_4)), \mathrm{fe}(|ir_5| + 1 \cdot \mathrm{ULP}(ir_5))),$$

$$refDeriv = ir_4 + ir_5,$$

$$ie_6 = fe(refDeriv),$$

$$cb_3 = \begin{cases} 0, & ie_5 - ie_6 \le 0 \\ ie_5 - ie_6, & ie_5 - ie_6 > 0 \end{cases},$$

$$me_3 = 0.5 + \left(me_2 + 1\right) \cdot 2^{cb_3},$$

$$ir_6 = fltInErr \cdot fltPropGain,$$

$$ie_7 = \max(\mathrm{fe}(|refInteg| + me_1 \cdot \mathrm{ULP}(refInteg)), \mathrm{fe}(|ir_6| + 0.5 \cdot \mathrm{ULP}(ir_6))),$$

$$ir_7 = refInteg + ir_6,$$

$$ie_8 = fe(ir_7),$$

$$cb_4 = \begin{cases} 0, & ie_7 - ie_8 \le 0 \\ ie_7 - ie_8, & ie_7 - ie_8 > 0 \end{cases},$$

$$me_4 = 0.5 + \left(me_1 + 0.5\right) \cdot 2^{cb_4},$$

$$ie_8 = \max(\mathrm{fe}(|refDeriv| + me_3 \cdot \mathrm{ULP}(refDeriv)), \mathrm{fe}(|ir_7| + me_4 \cdot \mathrm{ULP}(ir_7))),$$

$$ie_9 = fe(refResult),$$

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$$cb_5 = \begin{cases} 0, & ie_8 - ie_9 \le 0 \\ ie_8 - ie_9, & ie_8 - ie_9 > 0 \end{cases},$$

$$me_5 = \begin{cases} 0, & refResult + \left(0.5 + \left(me_3 + me_4\right) \cdot 2^{cb_5}\right) \cdot \mathrm{ULP}(refResult) < fltLowerLimit \\ 0, & refResult - \left(0.5 + \left(me_3 + me_4\right) \cdot 2^{cb_5}\right) \cdot \mathrm{ULP}(refResult) > fltUpperLimit \\ 0.5 + \left(me_3 + me_4\right) \cdot 2^{cb_5}, & \text{otherwise} \end{cases}$$

then

Table 88. GFLIB_ControllerPIDpAW_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Any of the inputs is denormalized, others are normalized or zero, i.e. $\left\{ \begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltDerivGain, fltFiltCoef, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltDerivPartK_1 \end{pmatrix} \in X \;\middle|\; X \cap D \ne \varnothing \wedge X \cap M = \varnothing \right\}$	$(-Inf, Inf)$	N/A
Any of the inputs is NaN or infinity, i.e. $\left\{ \begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltDerivGain, fltFiltCoef, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltDerivPartK_1 \end{pmatrix} \in X \;\middle|\; X \cap M \ne \varnothing \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltDerivGain, fltFiltCoef, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltDerivPartK_1 \end{pmatrix} \in X \;\middle|\; \begin{matrix} X \subset N \cup \{-0, +0\}, \\ \{ir_1, ir_2, ir_3, ir_4, ir_5, ir_6, ir_7\} \subset N \cup \{-0, +0\}, \\ \{refInteg, refDeriv\} \subset N \cup \{-0, +0\}, \\ refResult = 0 \vee \\ \begin{pmatrix} \lvert refResult \rvert - me_5 \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + me_5 \cdot \mathrm{ULP}(refResult) \ne Inf \end{pmatrix} \end{matrix} \right\}$	$\langle -me_5, me_5 \rangle$	N/A

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Table 88. GFLIB_ControllerPIDpAW_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Normalized or zero input values which cause result underflow, i.e. $\left\{ \begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltDerivGain, fltFiltCoef, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltDerivPartK_1 \end{pmatrix} \in X \;\middle|\; \begin{matrix} X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert - me_5 \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ refResult \neq 0 \end{matrix} \right\}$	$(-Inf, Inf)$	N/A
Normalized or zero input values which cause result overflow, i.e. $\left\{ \begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltDerivGain, fltFiltCoef, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltDerivPartK_1 \end{pmatrix} \in X \;\middle|\; \begin{matrix} X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert + me_5 \cdot \mathrm{ULP}(refResult) = Inf \end{matrix} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}
Normalized or zero input values which cause intermediate result underflow, i.e. $\left\{ \begin{matrix} \begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltDerivGain, fltFiltCoef, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltDerivPartK_1 \end{pmatrix} \in X \\ X \subset N \cup \{-0, +0\}, \\ \left\{ \begin{matrix} \lvert ir_1 \rvert - 0.5 \cdot \mathrm{ULP}(ir_1), \\ \lvert ir_2 \rvert - 0.5 \cdot \mathrm{ULP}(ir_2), \\ \lvert ir_3 \rvert - 1 \cdot \mathrm{ULP}(ir_3), \\ \lvert refInteg \rvert - me_1 \cdot \mathrm{ULP}(refInteg), \\ \lvert ir_4 \rvert - me_2 \cdot \mathrm{ULP}(ir_4), \\ \lvert ir_5 \rvert - 1 \cdot \mathrm{ULP}(ir_5), \\ \lvert refDeriv \rvert - me_3 \cdot \mathrm{ULP}(refDeriv), \\ \lvert ir_6 \rvert - 0.5 \cdot \mathrm{ULP}(ir_6), \\ \lvert ir_7 \rvert - me_4 \cdot \mathrm{ULP}(ir_7), \end{matrix} \right\} \cap D \neq \varnothing \wedge \\ \{ir_1, ir_2, ir_3, ir_4, ir_5, ir_6, ir_7, refInteg, refDeriv\} \notin \{-0, +0\} \end{matrix} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

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Table 88. GFLIB_ControllerPIDpAW_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Normalized or zero input values which cause intermediate result overflow, i.e. $\left\{ \left(\begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltDerivGain, fltFiltCoef, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltDerivPartK_1 \end{pmatrix} \in X \middle| \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \left\{ \begin{array}{c} \lvert ir_1 \rvert + 0.5 \cdot \mathrm{ULP}(ir_1), \\ \lvert ir_2 \rvert + 0.5 \cdot \mathrm{ULP}(ir_2), \\ \lvert ir_3 \rvert + 1 \cdot \mathrm{ULP}(ir_3), \\ \lvert refInteg \rvert + me_1 \cdot \mathrm{ULP}(refInteg), \\ \lvert ir_4 \rvert + me_2 \cdot \mathrm{ULP}(ir_4), \\ \lvert ir_5 \rvert + 1 \cdot \mathrm{ULP}(ir_5), \\ \lvert refDeriv \rvert + me_3 \cdot \mathrm{ULP}(refDeriv), \\ \lvert ir_6 \rvert + 0.5 \cdot \mathrm{ULP}(ir_6), \\ \lvert ir_7 \rvert + me_4 \cdot \mathrm{ULP}(ir_7), \end{array} \right\} \cap M \neq \varnothing \end{array} \right) \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

Table 89. GFLIB_ControllerPIDpAW_FLT Worst-Case Error Bounds - fltIntegPartK_1 Output

Subset of input domain	Worst-case error bounds for fltIntegPartK_1 output [ulp]	Allowed specific values (regardless the error bounds) for fltIntegPartK_1 output
Any of the inputs is denormalized, others are normalized or zero, i.e. $\left\{ \left(\begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltDerivGain, fltFiltCoef, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltDerivPartK_1 \end{pmatrix} \in X \middle| X \cap D \neq \varnothing \wedge X \cap M = \varnothing \right) \right\}$	$(-Inf, Inf)$	N/A
Any of the inputs is NaN or infinity, i.e. $\left\{ \left(\begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltDerivGain, fltFiltCoef, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltDerivPartK_1 \end{pmatrix} \in X \middle| X \cap M \neq \varnothing \right) \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)

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Table 89. GFLIB_ControllerPIDpAW_FLT Worst-Case Error Bounds - fltIntegPartK_1 Output...*continued*

Subset of input domain	Worst-case error bounds for fltIntegPartK_1 output [ulp]	Allowed specific values (regardless the error bounds) for fltIntegPartK_1 output
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} \begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltDerivGain, fltFiltCoef, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltDerivPartK_1 \end{pmatrix} \in X \\ X \subset N \cup \{-0, +0\}, \\ ir_1 \in N \cup \{-0, +0\}, \\ refInteg = 0 \vee \\ \begin{pmatrix} \lvert refInteg \rvert - me_1 \cdot \mathrm{ULP}(refInteg) \notin D \wedge \\ \lvert refInteg \rvert + me_1 \cdot \mathrm{ULP}(refInteg) \neq Inf \end{pmatrix} \end{array} \right\}$	$\langle -me_1, me_1 \rangle$	N/A
Normalized or zero input values which cause *fltIntegPartK_1* output underflow, i.e. $\left\{ \begin{array}{c} \begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltDerivGain, fltFiltCoef, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltDerivPartK_1 \end{pmatrix} \in X \\ X \subset N \cup \{-0, +0\}, \\ \lvert refInteg \rvert - me_1 \cdot \mathrm{ULP}(refInteg) \notin D \wedge \\ refInteg \neq 0 \end{array} \right\}$	$(-Inf, Inf)$	N/A
Normalized or zero input values which cause *fltIntegPartK_1* output overflow, i.e. $\left\{ \begin{array}{c} \begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltDerivGain, fltFiltCoef, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltDerivPartK_1 \end{pmatrix} \in X \\ X \subset N \cup \{-0, +0\}, \\ \lvert refInteg \rvert + me_1 \cdot \mathrm{ULP}(refInteg) \neq Inf \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

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Table 89. GFLIB_ControllerPIDpAW_FLT Worst-Case Error Bounds - fltIntegPartK_1 Output...*continued*

Subset of input domain	Worst-case error bounds for fltIntegPartK_1 output [ulp]	Allowed specific values (regardless the error bounds) for fltIntegPartK_1 output
Normalized or zero input values which cause intermediate result underflow, i.e. $\left\{ \left(\begin{array}{c} fltInErr, fltPropGain, fltIntegGain, \\ fltDerivGain, fltFiltCoef, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltDerivPartK_1 \end{array} \right) \in X \middle| \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \{ \lvert ir_1 \rvert - 0.5 \cdot \mathrm{ULP}(ir_1) \} \cap D \neq \varnothing \wedge \\ ir_1 \notin \{-0, +0\} \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}
Normalized or zero input values which cause intermediate result overflow, i.e. $\left\{ \left(\begin{array}{c} fltInErr, fltPropGain, fltIntegGain, \\ fltDerivGain, fltFiltCoef, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltDerivPartK_1 \end{array} \right) \in X \middle| \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \{ \lvert ir_1 \rvert - 0.5 \cdot \mathrm{ULP}(ir_1) \} \cap M \neq \varnothing \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

Table 90. GFLIB_ControllerPIDpAW_FLT Worst-Case Error Bounds - fltDerivPartK_1 Output

Subset of input domain	Worst-case error bounds for fltDerivPartK_1 output [ulp]	Allowed specific values (regardless the error bounds) for fltDerivPartK_1 output
Any of the inputs is denormalized, others are normalized or zero, i.e. $\left\{ \left(\begin{array}{c} fltInErr, fltPropGain, fltIntegGain, \\ fltDerivGain, fltFiltCoef, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltDerivPartK_1 \end{array} \right) \in X \middle| X \cap D \neq \varnothing \wedge X \cap M = \varnothing \right\}$	$(-Inf, Inf)$	N/A

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Table 90. GFLIB_ControllerPIDpAW_FLT Worst-Case Error Bounds - fltDerivPartK_1 Output*...continued*

Subset of input domain	Worst-case error bounds for fltDerivPartK_1 output [ulp]	Allowed specific values (regardless the error bounds) for fltDerivPartK_1 output
Any of the inputs is NaN or infinity, i.e. $\left\{ \left(\begin{array}{c} fltInErr, fltPropGain, fltIntegGain, \\ fltDerivGain, fltFiltCoef, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltDerivPartK_1 \end{array} \right) \in X \middle| \begin{array}{c} X \cap M \neq \varnothing \end{array} \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \left(\begin{array}{c} fltInErr, fltPropGain, fltIntegGain, \\ fltDerivGain, fltFiltCoef, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltDerivPartK_1 \end{array} \right) \in X \middle| \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \{ir_2, ir_3, ir_4, ir_5\} \subset N \cup \{-0, +0\}, \\ refInteg = 0 \vee \\ \left(\begin{array}{c} \lvert refDeriv \rvert - me_3 \cdot \mathrm{ULP}(refDeriv) \notin D \wedge \\ \lvert refDeriv \rvert + me_3 \cdot \mathrm{ULP}(refDeriv) \neq Inf \end{array} \right) \end{array} \right\}$	$\langle -me_1, me_1 \rangle$	N/A
Normalized or zero input values which cause *fltDerivPartK_1* output underflow, i.e. $\left\{ \left(\begin{array}{c} fltInErr, fltPropGain, fltIntegGain, \\ fltDerivGain, fltFiltCoef, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltDerivPartK_1 \end{array} \right) \in X \middle| \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \lvert refDeriv \rvert - me_3 \cdot \mathrm{ULP}(refDeriv) \notin D \wedge \\ refDeriv \neq 0 \end{array} \right\}$	$(-Inf, Inf)$	N/A
Normalized or zero input values which cause *fltDerivPartK_1* output overflow, i.e. $\left\{ \left(\begin{array}{c} fltInErr, fltPropGain, fltIntegGain, \\ fltDerivGain, fltFiltCoef, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltDerivPartK_1 \end{array} \right) \in X \middle| \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \lvert refDeriv \rvert + me_3 \cdot \mathrm{ULP}(refDeriv) \neq Inf \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

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Table 90. GFLIB_ControllerPIDpAW_FLT Worst-Case Error Bounds - fltDerivPartK_1 Output...*continued*

Subset of input domain	Worst-case error bounds for fltDerivPartK_1 output [ulp]	Allowed specific values (regardless the error bounds) for fltDerivPartK_1 output
Normalized or zero input values which cause intermediate result underflow, i.e. $\left\{ \begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltDerivGain, fltFiltCoef, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltDerivPartK_1 \end{pmatrix} \in X \middle| \begin{matrix} X \subset N \cup \{-0, +0\}, \\ \begin{Bmatrix} \lvert ir_2 \rvert - 0.5 \cdot \mathrm{ULP}(ir_2), \\ \lvert ir_3 \rvert - 1 \cdot \mathrm{ULP}(ir_3), \\ \lvert ir_4 \rvert - me_2 \cdot \mathrm{ULP}(ir_4), \\ \lvert ir_5 \rvert - 1 \cdot \mathrm{ULP}(ir_5), \end{Bmatrix} \cap D \neq \varnothing \wedge \\ \{ir_2, ir_3, ir_4, ir_5\} \notin \{-0, +0\} \end{matrix} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}
Normalized or zero input values which cause intermediate result overflow, i.e. $\left\{ \begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltDerivGain, fltFiltCoef, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltDerivPartK_1 \end{pmatrix} \in X \middle| \begin{matrix} X \subset N \cup \{-0, +0\}, \\ \begin{Bmatrix} \lvert ir_2 \rvert - 0.5 \cdot \mathrm{ULP}(ir_2), \\ \lvert ir_3 \rvert - 1 \cdot \mathrm{ULP}(ir_3), \\ \lvert ir_4 \rvert - me_2 \cdot \mathrm{ULP}(ir_4), \\ \lvert ir_5 \rvert - 1 \cdot \mathrm{ULP}(ir_5), \end{Bmatrix} \cap M \neq \varnothing \end{matrix} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

Table 91. GFLIB_ControllerPIDpAW_FLT Worst-Case Error Bounds - fltInK_1 Output

Subset of input domain	Worst-case error bounds for fltInK_1 output [ulp]	Allowed specific values (regardless the error bounds) for fltInK_1 output
Entire input domain	0	*fltInErr*

2.22 Function GFLIB_ControllerPIp_FLT

2.22.1 Declaration

```
tFloat GFLIB_ControllerPIp_FLT(tFloat fltInErr,
GFLIB_CONTROLLER_PI_P_T_FLT *const pParam);
```


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2.22.2 Arguments

Table 92. GFLIB_ControllerPIp_FLT arguments

Type	Name	Direction	Description
tFloat	fltInErr	**input**	Input error signal to the controller in single precision floating format.
GFLIB_ CONTROLLER_ PI_P_T_FLT *const	pParam	**input, output**	Pointer to the controller parameters structure.

2.22.3 Worst-Case Error Bounds

Let (*fltInErr*, *fltPropGain*, *fltIntegGain*, *fltIntegPartK_1*, *fltInK_1*) ∈ *X* be a set of inputs to GFLIB_ControllerPIp_FLT,

fltIntegPartK_1 input represents a real number with an error of max. ±0.5 ulp,

refResult be the theoretical exact result,

$$ir_1 = fltInErr + fltInK_1,$$

$$ir_2 = ir_1 \cdot fltIntegGain,$$

$$ie_1 = \max(\mathrm{fe}(|ir_2| + \mathrm{ULP}(ir_2)), \mathrm{fe}(|fltIntegPartK_1| + 0.5 \cdot \mathrm{ULP}(fltIntegPartK_1))),$$

$$refInteg = fltIntegPartK_1 + ir_2,$$

$$ie_2 = \mathrm{fe}(refInteg),$$

$$cb_1 = \begin{cases} 0, & ie_1 - ie_2 \le 0 \\ ie_1 - ie_2, & ie_1 - ie_2 > 0 \end{cases},$$

$$me_1 = 0.5 + 1.5 \cdot 2^{cb_1},$$

$$ir_3 = fltInErr \cdot fltPropGain,$$

$$ie_3 = \max(\mathrm{fe}(ir_3), \mathrm{fe}(|refInteg| + me_1 \cdot \mathrm{ULP}(refInteg))),$$

$$ie_4 = \mathrm{fe}(refResult),$$

$$cb_2 = \begin{cases} 0, & ie_3 - ie_4 \le 0 \\ ie_3 - ie_4, & ie_3 - ie_4 > 0 \end{cases},$$

$$me_2 = 0.5 + me_1 \cdot 2^{cb_2},$$

then

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Table 93. GFLIB_ControllerPIp_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Any of the inputs is denormalized, others are normalized or zero, i.e. $\left\{ \left(\begin{matrix} fltInErr, fltPropGain, fltIntegGain, \\ fltIntegPartK_1, fltInK_1 \end{matrix} \right) \in X \middle\| \begin{matrix} X \cap D \neq \varnothing \wedge X \cap M = \varnothing \end{matrix} \right\}$	$(-Inf, Inf)$	N/A
Any of the inputs is NaN or infinity, i.e. $\left\{ \left(\begin{matrix} fltInErr, fltPropGain, fltIntegGain, \\ fltIntegPartK_1, fltInK_1 \end{matrix} \right) \in X \middle\| \begin{matrix} X \cap M \neq \varnothing \end{matrix} \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \left(\begin{matrix} fltInErr, fltPropGain, fltIntegGain, \\ fltIntegPartK_1, fltInK_1 \end{matrix} \right) \in X \middle\| \begin{matrix} X \subset N \cup \{-0, +0\}, \\ \{ir_1, ir_2, ir_3\} \subset N \cup \{-0, +0\}, \\ refInteg \in N \cup \{-0, +0\}, \\ refResult = 0 \vee \\ \left(\begin{matrix} \lvert refResult \rvert - me_2 \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + me_2 \cdot \mathrm{ULP}(refResult) \neq Inf \end{matrix} \right) \end{matrix} \right\}$	$\langle -me_2, me_2 \rangle$	N/A
Normalized or zero input values which cause result underflow, i.e. $\left\{ \left(\begin{matrix} fltInErr, fltPropGain, fltIntegGain, \\ fltIntegPartK_1, fltInK_1 \end{matrix} \right) \in X \middle\| \begin{matrix} X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert - me_2 \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0 \end{matrix} \right\}$	$(-Inf, Inf)$	N/A
Normalized or zero input values which cause result overflow, i.e. $\left\{ \left(\begin{matrix} fltInErr, fltPropGain, fltIntegGain, \\ fltIntegPartK_1, fltInK_1 \end{matrix} \right) \in X \middle\| \begin{matrix} X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert + me_2 \cdot \mathrm{ULP}(refResult) = Inf \end{matrix} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

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Table 93. GFLIB_ControllerPIp_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Normalized or zero input values which cause intermediate result underflow, i.e. $\left\{ \begin{array}{c} \left(\begin{array}{c} fltInErr, fltPropGain, fltIntegGain, \\ fltIntegPartK_1, fltInK_1 \end{array} \right) \in X \\ X \subset N \cup \{-0, +0\}, \\ \left\{ \begin{array}{c} \lvert ir_1 \rvert - 0.5 \cdot \mathrm{ULP}(ir_1), \\ \lvert ir_2 \rvert - \mathrm{ULP}(ir_2), \\ \lvert refInteg \rvert - me_1 \cdot \mathrm{ULP}(refInteg), \\ ir_3 \end{array} \right\} \cap D \neq \varnothing \wedge \\ \{ir_1, ir_2, ir_3, refInteg\} \notin \{-0, +0\} \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}
Normalized or zero input values which cause intermediate result overflow, i.e. $\left\{ \begin{array}{c} \left(\begin{array}{c} fltInErr, fltPropGain, fltIntegGain, \\ fltIntegPartK_1, fltInK_1 \end{array} \right) \in X \\ X \subset N \cup \{-0, +0\}, \\ \left\{ \begin{array}{c} \lvert ir_1 \rvert + 0.5 \cdot \mathrm{ULP}(ir_1), \\ \lvert ir_2 \rvert + \mathrm{ULP}(ir_2), \\ \lvert refInteg \rvert + me_1 \cdot \mathrm{ULP}(refInteg), \\ ir_3 \end{array} \right\} \cap M \neq \varnothing \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

Table 94. GFLIB_ControllerPIp_FLT Worst-Case Error Bounds - fltIntegPartK_1 Output

Subset of input domain	Worst-case error bounds for fltIntegPartK_1 output [ulp]	Allowed specific values (regardless the error bounds) for fltIntegPartK_1 output
Any of the inputs is denormalized, others are normalized or zero, i.e. $\left\{ \begin{array}{c} \left(\begin{array}{c} fltInErr, fltPropGain, fltIntegGain, \\ fltIntegPartK_1, fltInK_1 \end{array} \right) \in X \\ X \cap D \neq \varnothing \wedge X \cap M = \varnothing \end{array} \right\}$	$(-Inf, Inf)$	N/A
Any of the inputs is NaN or infinity, i.e. $\left\{ \begin{array}{c} \left(\begin{array}{c} fltInErr, fltPropGain, fltIntegGain, \\ fltIntegPartK_1, fltInK_1 \end{array} \right) \in X \\ X \cap M \neq \varnothing \end{array} \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)

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Table 94. GFLIB_ControllerPIp_FLT Worst-Case Error Bounds - fltIntegPartK_1 Output...*continued*

Subset of input domain	Worst-case error bounds for fltIntegPartK_1 output [ulp]	Allowed specific values (regardless the error bounds) for fltIntegPartK_1 output
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltIntegPartK_1, fltInK_1 \end{pmatrix} \in X \middle\| \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \{ir_1, ir_2\} \subset N \cup \{-0, +0\}, \\ refInteg = 0 \vee \\ \begin{pmatrix} \lvert refInteg \rvert - me_1 \cdot \mathrm{ULP}(refInteg) \notin D \wedge \\ \lvert refInteg \rvert + me_1 \cdot \mathrm{ULP}(refInteg) \neq Inf \end{pmatrix} \end{array} \right\}$	$\langle -me_1, me_1 \rangle$	N/A
Normalized or zero input values which cause *fltIntegPartK_1* output underflow, i.e. $\left\{ \begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltIntegPartK_1, fltInK_1 \end{pmatrix} \in X \middle\| \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \lvert refInteg \rvert - me_1 \cdot \mathrm{ULP}(refInteg) \in D \wedge \\ refInteg \neq 0 \end{array} \right\}$	$(-Inf, Inf)$	N/A
Normalized or zero input values which cause *fltIntegPartK_1* output overflow, i.e. $\left\{ \begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltIntegPartK_1, fltInK_1 \end{pmatrix} \in X \middle\| \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \lvert refInteg \rvert + me_1 \cdot \mathrm{ULP}(refInteg) = Inf \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}
Normalized or zero input values which cause intermediate result underflow, i.e. $\left\{ \begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltIntegPartK_1, fltInK_1 \end{pmatrix} \in X \middle\| \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \left\{ \begin{array}{l} \lvert ir_1 \rvert - 0.5 \cdot \mathrm{ULP}(ir_1), \\ \lvert ir_2 \rvert - \mathrm{ULP}(ir_2), \end{array} \right\} \cap D \neq \varnothing \wedge \\ \{ir_1, ir_2\} \notin \{-0, +0\} \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

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Table 94. GFLIB_ControllerPIp_FLT Worst-Case Error Bounds - fltIntegPartK_1 Output...*continued*

Subset of input domain	Worst-case error bounds for fltIntegPartK_1 output [ulp]	Allowed specific values (regardless the error bounds) for fltIntegPartK_1 output
Normalized or zero input values which cause intermediate result overflow, i.e. $\left\{ \begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltIntegPartK_1, fltInK_1 \end{pmatrix} \in X \middle| \begin{matrix} X \subset N \cup \{-0, +0\}, \\ \begin{Bmatrix} \lvert ir_1 \rvert + 0.5 \cdot \mathrm{ULP}(ir_1), \\ \lvert ir_2 \rvert + \mathrm{ULP}(ir_2), \end{Bmatrix} \cap M \neq \varnothing \end{matrix} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

Table 95. GFLIB_ControllerPIp_FLT Worst-Case Error Bounds - fltInK_1 Output

Subset of input domain	Worst-case error bounds for fltInK_1 output [ulp]	Allowed specific values (regardless the error bounds) for fltInK_1 output
Entire input domain	0	*fltInErr*

2.23 Function GFLIB_ControllerPIpAW_FLT

2.23.1 Declaration

```
tFloat GFLIB_ControllerPIpAW_FLT(tFloat fltInErr,
GFLIB_CONTROLLER_PIAW_P_T_FLT *const pParam);
```

2.23.2 Arguments

Table 96. GFLIB_ControllerPIpAW_FLT arguments

Type	Name	Direction	Description
tFloat	fltInErr	**input**	Input error signal to the controller is a single precision floating point data type.
GFLIB_ CONTROLLER_ PIAW_P_T_FLT *const	pParam	**input, output**	Pointer to the controller parameters structure.

2.23.3 Worst-Case Error Bounds

Let (*fltInErr*, *fltPropGain*, *fltIntegGain*, *fltLowerLimit*, *fltUpperLimit*, *fltIntegPartK_1*, *fltInK_1*) ∈ *X* be a set of inputs to GFLIB_ControllerPIpAW_FLT,

fltIntegPartK_1 input represents a real number with an error of max. ±0.5 ulp,

refResult be the theoretical exact result,

$ir_1 = fltInErr + fltInK_1$,

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$$ir_2 = ir_1 \cdot fltIntegGain,$$

$$ie_1 = \max(\mathrm{fe}(|ir_2| + \mathrm{ULP}(ir_2)), \mathrm{fe}(|fltIntegPartK_1| + 0.5 \cdot \mathrm{ULP}(fltIntegPartK_1))),$$

$$refInteg = fltIntegPartK_1 + ir_2,$$

$$ie_2 = \mathrm{fe}(refInteg),$$

$$cb_1 = \begin{cases} 0, & ie_1 - ie_2 \le 0 \\ ie_1 - ie_2, & ie_1 - ie_2 > 0 \end{cases},$$

$$me_1 = \begin{cases} 0, & refInteg + \left(0.5 + 1.5 \cdot 2^{cb_1}\right) \cdot \mathrm{ULP}(refInteg) < fltLowerLimit \\ 0, & refInteg - \left(0.5 + 1.5 \cdot 2^{cb_1}\right) \cdot \mathrm{ULP}(refInteg) > fltUpperLimit \\ 0.5 + 1.5 \cdot 2^{cb_1}, & \text{otherwise} \end{cases},$$

$$ir_3 = fltInErr \cdot fltPropGain,$$

$$ie_3 = \max(\mathrm{fe}(ir_3), \mathrm{fe}(|refInteg| + me_1 \cdot \mathrm{ULP}(refInteg))),$$

$$ie_4 = \mathrm{fe}(refResult),$$

$$cb_2 = \begin{cases} 0, & ie_3 - ie_4 \le 0 \\ ie_3 - ie_4, & ie_3 - ie_4 > 0 \end{cases},$$

$$me_2 = 0.5 + me_1 \cdot 2^{cb_2},$$

then

Table 97. GFLIB_ControllerPIpAW_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Any of the inputs is denormalized, others are normalized or zero, i.e. $\left\{ \left(\begin{array}{c} fltInErr, fltPropGain, fltIntegGain, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltInK_1 \end{array} \right) \in X \;\middle|\; X \cap D \neq \varnothing \wedge X \cap M = \varnothing \right\}$	$(-Inf, Inf)$	N/A
Any of the inputs is NaN or infinity, i.e. $\left\{ \left(\begin{array}{c} fltInErr, fltPropGain, fltIntegGain, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltInK_1 \end{array} \right) \in X \;\middle|\; X \cap M \neq \varnothing \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)

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Table 97. GFLIB_ControllerPIpAW_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltInK_1 \end{pmatrix} \in X \middle\| \begin{matrix} X \subset N \cup \{-0, +0\}, \\ \{ir_1, ir_2, ir_3\} \subset N \cup \{-0, +0\}, \\ refInteg \in N \cup \{-0, +0\}, \\ refResult = 0 \vee \\ \begin{pmatrix} \lvert refResult \rvert - me_2 \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + me_2 \cdot \mathrm{ULP}(refResult) \neq Inf \end{pmatrix} \end{matrix} \right\}$	$\langle -me_2, me_2 \rangle$	N/A
Normalized or zero input values which cause result underflow, i.e. $\left\{ \begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltInK_1 \end{pmatrix} \in X \middle\| \begin{matrix} X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert - me_2 \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0 \end{matrix} \right\}$	$(-Inf, Inf)$	N/A
Normalized or zero input values which cause result overflow, i.e. $\left\{ \begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltInK_1 \end{pmatrix} \in X \middle\| \begin{matrix} X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert + me_2 \cdot \mathrm{ULP}(refResult) = Inf \end{matrix} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

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Table 97. GFLIB_ControllerPIpAW_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Normalized or zero input values which cause intermediate result underflow, i.e. $\left\{ \begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltInK_1 \end{pmatrix} \in X \middle\vert \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \left\{ \begin{array}{c} \lvert ir_1 \rvert - 0.5 \cdot \mathrm{ULP}(ir_1), \\ \lvert ir_2 \rvert - \mathrm{ULP}(ir_2), \\ \lvert refInteg \rvert - me_1 \cdot \mathrm{ULP}(refInteg), \\ ir_3 \end{array} \right\} \cap D \neq \varnothing \wedge \\ \{ir_1, ir_2, ir_3, refInteg\} \notin \{-0, +0\} \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}
Normalized or zero input values which cause intermediate result overflow, i.e. $\left\{ \begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltInK_1 \end{pmatrix} \in X \middle\vert \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \left\{ \begin{array}{c} \lvert ir_1 \rvert + 0.5 \cdot \mathrm{ULP}(ir_1), \\ \lvert ir_2 \rvert + \mathrm{ULP}(ir_2), \\ \lvert refInteg \rvert + me_1 \cdot \mathrm{ULP}(refInteg), \\ ir_3 \end{array} \right\} \cap M \neq \varnothing \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

Table 98. GFLIB_ControllerPIpAW_FLT Worst-Case Error Bounds - fltIntegPartK_1 Output

Subset of input domain	Worst-case error bounds for fltIntegPartK_1 output [ulp]	Allowed specific values (regardless the error bounds) for fltIntegPartK_1 output
Any of the inputs is denormalized, others are normalized or zero, i.e. $\left\{ \begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltInK_1 \end{pmatrix} \in X \middle\vert X \cap D \neq \varnothing \wedge X \cap M = \varnothing \right\}$	$(-Inf, Inf)$	N/A

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Table 98. GFLIB_ControllerPIpAW_FLT Worst-Case Error Bounds - fltIntegPartK_1 Output*...continued*

Subset of input domain	Worst-case error bounds for fltIntegPartK_1 output [ulp]	Allowed specific values (regardless the error bounds) for fltIntegPartK_1 output
Any of the inputs is NaN or infinity, i.e. $\left\{ \left(\begin{array}{c} fltInErr, fltPropGain, fltIntegGain, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltInK_1 \end{array} \right) \in X \;\middle|\; X \cap M \neq \varnothing \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \left(\begin{array}{c} fltInErr, fltPropGain, fltIntegGain, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltInK_1 \end{array} \right) \in X \;\middle|\; \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \{ir_1, ir_2\} \subset N \cup \{-0, +0\}, \\ refInteg = 0 \vee \\ \left(\begin{array}{l} \lvert refInteg \rvert - me_1 \cdot \mathrm{ULP}(refInteg) \notin D \wedge \\ \lvert refInteg \rvert + me_1 \cdot \mathrm{ULP}(refInteg) \neq Inf \end{array} \right) \end{array} \right\}$	$\langle -me_1, me_1 \rangle$	N/A
Normalized or zero input values which cause *fltIntegPartK_1* output underflow, i.e. $\left\{ \left(\begin{array}{c} fltInErr, fltPropGain, fltIntegGain, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltInK_1 \end{array} \right) \in X \;\middle|\; \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \lvert refInteg \rvert - me_1 \cdot \mathrm{ULP}(refInteg) \in D \wedge \\ refInteg \neq 0 \end{array} \right\}$	$(-Inf, Inf)$	N/A
Normalized or zero input values which cause *fltIntegPartK_1* output overflow, i.e. $\left\{ \left(\begin{array}{c} fltInErr, fltPropGain, fltIntegGain, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltInK_1 \end{array} \right) \in X \;\middle|\; \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \lvert refInteg \rvert + me_1 \cdot \mathrm{ULP}(refInteg) = Inf \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

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Table 98. GFLIB_ControllerPIpAW_FLT Worst-Case Error Bounds - fltIntegPartK_1 Output...*continued*

Subset of input domain	Worst-case error bounds for fltIntegPartK_1 output [ulp]	Allowed specific values (regardless the error bounds) for fltIntegPartK_1 output
Normalized or zero input values which cause intermediate result underflow, i.e. $\left\{ \left(\begin{array}{c} fltInErr, fltPropGain, fltIntegGain, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltInK_1 \end{array} \right) \in X \middle| \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \left\{ \begin{array}{c} \lvert ir_1 \rvert - 0.5 \cdot \mathrm{ULP}(ir_1), \\ \lvert ir_2 \rvert - \mathrm{ULP}(ir_2), \end{array} \right\} \cap D \neq \varnothing \wedge \\ \{ir_1, ir_2\} \notin \{-0, +0\} \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}
Normalized or zero input values which cause intermediate result overflow, i.e. $\left\{ \left(\begin{array}{c} fltInErr, fltPropGain, fltIntegGain, \\ fltLowerLimit, fltUpperLimit, \\ fltIntegPartK_1, fltInK_1 \end{array} \right) \in X \middle| \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \left\{ \begin{array}{c} \lvert ir_1 \rvert + 0.5 \cdot \mathrm{ULP}(ir_1), \\ \lvert ir_2 \rvert + \mathrm{ULP}(ir_2), \end{array} \right\} \cap M \neq \varnothing \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

Table 99. GFLIB_ControllerPIpAW_FLT Worst-Case Error Bounds - fltInK_1 Output

Subset of input domain	Worst-case error bounds for fltInK_1 output [ulp]	Allowed specific values (regardless the error bounds) for fltInK_1 output
Entire input domain	0	*fltInErr*

2.24 Function GFLIB_ControllerPIr_FLT

2.24.1 Declaration

```
tFloat GFLIB_ControllerPIr_FLT(tFloat fltInErr,
GFLIB_CONTROLLER_PI_R_T_FLT *const pParam);
```

2.24.2 Arguments

Table 100. GFLIB_ControllerPIr_FLT arguments

Type	Name	Direction	Description
tFloat	fltInErr	**input**	Input error signal to the controller as a single precision floating point value.

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Table 100. GFLIB_ControllerPIr_FLT arguments*...continued*

Type	Name	Direction	Description
GFLIB_ CONTROLLER_ PI_R_T_FLT *const	pParam	**input, output**	Pointer to the controller parameters structure.

2.24.3 Worst-Case Error Bounds

Let (*fltInErr*, *fltCC1sc*, *fltCC2sc*, *fltAcc*, *fltInErrK1*) $\in X$ be a set of inputs to GFLIB_ControllerPIr_FLT,

fltAcc input represents a real number with an error of max. ±0.5 ulp,

refResult be the theoretical exact result,

$ir_1 = fltInErr \cdot fltCC1sc$,

$ir_2 = fltInErrK1 \cdot fltCC2sc$,

$ir_3 = ir_1 + ir_2$,

$ie_1 = \max(\mathrm{fe}(|ir_3| + \mathrm{ULP}(ir_3)), \mathrm{fe}(|fltAcc| + 0.5 \cdot \mathrm{ULP}(fltAcc)))$,

$ie_2 = \mathrm{fe}(refResult)$,

$$cb = \begin{cases} 0, & ie_1 - ie_2 \le 0 \\ ie_1 - ie_2, & ie_1 - ie_2 > 0 \end{cases},$$

$me = 0.5 + 1.5 \cdot 2^{cb}$,

then

Table 101. GFLIB_ControllerPIr_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Any of the inputs is denormalized, others are normalized or zero, i.e. $\left\{ \begin{pmatrix} fltInErr, fltCC1sc, fltCC2sc, \\ fltAcc, fltInErrK1 \end{pmatrix} \in X \middle\vert \begin{matrix} \\ X \cap D \neq \varnothing \wedge X \cap M = \varnothing \end{matrix} \right\}$	$(-Inf, Inf)$	N/A
Any of the inputs is NaN or infinity, i.e. $\left\{ \begin{pmatrix} fltInErr, fltCC1sc, fltCC2sc, \\ fltAcc, fltInErrK1 \end{pmatrix} \in X \middle\vert \begin{matrix} \\ X \cap M \neq \varnothing \end{matrix} \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)

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Table 101. GFLIB_ControllerPIr_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} \left(\begin{array}{c} fltInErr, fltCC1sc, fltCC2sc, \\ fltAcc, fltInErrK1 \end{array} \right) \in X \Big| \\ X \subset N \cup \{-0, +0\}, \\ \{ir_1, ir_2, ir_3\} \subset N \cup \{-0, +0\}, \\ refResult = 0 \vee \\ \left(\begin{array}{l} \lvert refResult \rvert - me \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + me \cdot \mathrm{ULP}(refResult) \neq Inf \end{array} \right) \end{array} \right\}$	$\langle -me, me \rangle$	N/A
Normalized or zero input values which cause result underflow, i.e. $\left\{ \begin{array}{c} \left(\begin{array}{c} fltInErr, fltCC1sc, fltCC2sc, \\ fltAcc, fltInErrK1 \end{array} \right) \in X \Big| \\ X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert - me \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0 \end{array} \right\}$	$(-Inf, Inf)$	N/A
Normalized or zero input values which cause result overflow, i.e. $\left\{ \begin{array}{c} \left(\begin{array}{c} fltInErr, fltCC1sc, fltCC2sc, \\ fltAcc, fltInErrK1 \end{array} \right) \in X \Big| \\ X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert + me \cdot \mathrm{ULP}(refResult) = Inf \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}
Normalized or zero input values which cause intermediate result underflow, i.e. $\left\{ \begin{array}{c} \left(\begin{array}{c} fltInErr, fltCC1sc, fltCC2sc, \\ fltAcc, fltInErrK1 \end{array} \right) \in X \Big| \\ X \subset N \cup \{-0, +0\}, \\ \{ir_1, ir_2\} \cap D \neq \varnothing \vee \\ (\lvert ir_3 \rvert - \mathrm{ULP}(ir_3) \in D \wedge ir_3 \neq 0) \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

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Table 101. GFLIB_ControllerPIr_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Normalized or zero input values which cause intermediate result overflow, i.e. $\left\{ \begin{pmatrix} fltInErr, fltCC1sc, fltCC2sc, \\ fltAcc, fltInErrK1 \end{pmatrix} \in X \middle\vert \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \{ir_1, ir_2, \lvert ir_3 \rvert + \mathrm{ULP}(ir_3)\} \cap M \neq \varnothing \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

Table 102. GFLIB_ControllerPIr_FLT Worst-Case Error Bounds - fltAcc Output

Subset of input domain	Worst-case error bounds for fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for fltAcc output
Any of the inputs is denormalized, others are normalized or zero, i.e. $\left\{ \begin{pmatrix} fltInErr, fltCC1sc, fltCC2sc, \\ fltAcc, fltInErrK1 \end{pmatrix} \in X \middle\vert \begin{array}{c} X \cap D \neq \varnothing \wedge X \cap M = \varnothing \end{array} \right\}$	$(-Inf, Inf)$	N/A
Any of the inputs is NaN or infinity, i.e. $\left\{ \begin{pmatrix} fltInErr, fltCC1sc, fltCC2sc, \\ fltAcc, fltInErrK1 \end{pmatrix} \in X \middle\vert \begin{array}{c} X \cap M \neq \varnothing \end{array} \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} \begin{pmatrix} fltInErr, fltCC1sc, fltCC2sc, \\ fltAcc, fltInErrK1 \end{pmatrix} \in X \\ X \subset N \cup \{-0, +0\}, \\ \{ir_1, ir_2, ir_3\} \subset N \cup \{-0, +0\}, \\ refResult = 0 \vee \\ \begin{pmatrix} \lvert refResult \rvert - me \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + me \cdot \mathrm{ULP}(refResult) \neq Inf \end{pmatrix} \end{array} \right\}$	$\langle -me, me \rangle$	N/A

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Table 102. GFLIB_ControllerPIr_FLT Worst-Case Error Bounds - fltAcc Output*...continued*

Subset of input domain	Worst-case error bounds for fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for fltAcc output
Normalized or zero input values which cause *fltAcc* output underflow, i.e. $\left\{ \begin{array}{c} \left(\begin{array}{c} fltInErr, fltCC1sc, fltCC2sc, \\ fltAcc, fltInErrK1 \end{array} \right) \in X \\ X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert - me \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0 \end{array} \right\}$	$(-Inf, Inf)$	N/A
Normalized or zero input values which cause *fltAcc* output overflow, i.e. $\left\{ \begin{array}{c} \left(\begin{array}{c} fltInErr, fltCC1sc, fltCC2sc, \\ fltAcc, fltInErrK1 \end{array} \right) \in X \\ X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert + me \cdot \mathrm{ULP}(refResult) = Inf \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}
Normalized or zero input values which cause intermediate result underflow, i.e. $\left\{ \begin{array}{c} \left(\begin{array}{c} fltInErr, fltCC1sc, fltCC2sc, \\ fltAcc, fltInErrK1 \end{array} \right) \in X \\ X \subset N \cup \{-0, +0\}, \\ \{ir_1, ir_2\} \cap D \neq \varnothing \vee \\ (\lvert ir_3 \rvert - \mathrm{ULP}(ir_3) \in D \wedge ir_3 \neq 0) \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}
Normalized or zero input values which cause intermediate result overflow, i.e. $\left\{ \begin{array}{c} \left(\begin{array}{c} fltInErr, fltCC1sc, fltCC2sc, \\ fltAcc, fltInErrK1 \end{array} \right) \in X \\ X \subset N \cup \{-0, +0\}, \\ \{ir_1, ir_2, \lvert ir_3 \rvert + \mathrm{ULP}(ir_3)\} \cap M \neq \varnothing \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

Table 103. GFLIB_ControllerPIr_FLT Worst-Case Error Bounds - fltInErrK1 Output

Subset of input domain	Worst-case error bounds for fltInErrK1 output [ulp]	Allowed specific values (regardless the error bounds) for fltInErrK1 output
Entire input domain	0	*fltInErr*

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2.25 Function GFLIB_ControllerPIrAW_FLT

2.25.1 Declaration

```
tFloat GFLIB_ControllerPIrAW_FLT(tFloat fltInErr,
GFLIB_CONTROLLER_PIAW_R_T_FLT *const pParam);
```

2.25.2 Arguments

Table 104. GFLIB_ControllerPIrAW_FLT arguments

Type	Name	Direction	Description
tFloat	fltInErr	**input**	Input error signal to the controller in single precision floating point data format.
GFLIB_ CONTROLLER_ PIAW_R_T_FLT *const	pParam	**input, output**	Pointer to the controller parameters structure.

2.25.3 Worst-Case Error Bounds

Let (*fltInErr*, *fltCC1sc*, *fltCC2sc*, *fltAcc*, *fltInErrK1*, *fltUpperLimit*, *fltLowerLimit*) $\in X$ be a set of inputs to GFLIB_ControllerPIrAW_FLT,

fltAcc input represents a real number with an error of max. ±0.5 ulp,

refResult be the theoretical exact result,

$ir_1 = fltInErr \cdot fltCC1s$,

$ir_2 = fltInErrK1 \cdot fltCC2sc$,

$ir_3 = ir_1 + ir_2$,

$ie_1 = \max(\mathrm{fe}(|ir_3| + \mathrm{ULP}(ir_3)), \mathrm{fe}(|fltAcc| + 0.5 \cdot \mathrm{ULP}(fltAcc)))$,

$ie_2 = \mathrm{fe}(refResult)$,

$$cb = \begin{cases} 0, & ie_1 - ie_2 \le 0 \\ ie_1 - ie_2, & ie_1 - ie_2 > 0 \end{cases},$$

$me = 0.5 + 1.5 \cdot 2^{cb}$,

then

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Table 105. GFLIB_ControllerPIrAW_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Any of the inputs is denormalized, others are normalized or zero, i.e. $\left\{ \begin{pmatrix} fltInErr, fltCC1sc, fltCC2sc, \\ fltAccfltInErrK1, \\ fltUpperLimit, fltLowerLimit \end{pmatrix} \in X \middle\vert \begin{matrix} X \cap D \neq \varnothing \wedge X \cap M = \varnothing \end{matrix} \right\}$	$(-Inf, Inf)$	N/A
Any of the inputs is NaN or infinity, i.e. $\left\{ \begin{pmatrix} fltInErr, fltCC1sc, fltCC2sc, \\ fltAccfltInErrK1, \\ fltUpperLimit, fltLowerLimit \end{pmatrix} \in X \middle\vert \begin{matrix} X \cap M \neq \varnothing \end{matrix} \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{matrix} \begin{pmatrix} fltInErr, fltCC1sc, fltCC2sc, \\ fltAccfltInErrK1, \\ fltUpperLimit, fltLowerLimit \end{pmatrix} \in X \\ X \subset N \cup \{-0, +0\}, \\ \{ir_1, ir_2, ir_3\} \subset N \cup \{-0, +0\}, \\ refResult = 0 \vee \\ \begin{pmatrix} \lvert refResult \rvert - me \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + me \cdot \mathrm{ULP}(refResult) \neq Inf \end{pmatrix} \end{matrix} \right\}$	$\langle -me, me \rangle$	N/A
Normalized or zero input values which cause result underflow, i.e. $\left\{ \begin{matrix} \begin{pmatrix} fltInErr, fltCC1sc, fltCC2sc, \\ fltAccfltInErrK1, \\ fltUpperLimit, fltLowerLimit \end{pmatrix} \in X \\ X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert - me \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0 \end{matrix} \right\}$	$(-Inf, Inf)$	N/A

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Table 105. GFLIB_ControllerPIrAW_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Normalized or zero input values which cause result overflow, i.e. $\left\{ \begin{pmatrix} fltInErr, fltCC1sc, fltCC2sc, \\ fltAccfltInErrK1, \\ fltUpperLimit, fltLowerLimit \end{pmatrix} \in X \middle\vert \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert + me \cdot \mathrm{ULP}(refResult) = Inf \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}
Normalized or zero input values which cause intermediate result underflow, i.e. $\left\{ \begin{pmatrix} fltInErr, fltCC1sc, fltCC2sc, \\ fltAccfltInErrK1, \\ fltUpperLimit, fltLowerLimit \end{pmatrix} \in X \middle\vert \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \{ir_1, ir_2\} \cap D \neq \varnothing \vee \\ (\lvert ir_3 \rvert - \mathrm{ULP}(ir_3) \in D \wedge ir_3 \neq 0) \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}
Normalized or zero input values which cause intermediate result overflow, i.e. $\left\{ \begin{pmatrix} fltInErr, fltCC1sc, fltCC2sc, \\ fltAccfltInErrK1, \\ fltUpperLimit, fltLowerLimit \end{pmatrix} \in X \middle\vert \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \{ir_1, ir_2, \lvert ir_3 \rvert + \mathrm{ULP}(ir_3)\} \cap M \neq \varnothing \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

Table 106. GFLIB_ControllerPIrAW_FLT Worst-Case Error Bounds - fltAcc Output

Subset of input domain	Worst-case error bounds for fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for fltAcc output
Any of the inputs is denormalized, others are normalized or zero, i.e. $\left\{ \begin{pmatrix} fltInErr, fltCC1sc, fltCC2sc, \\ fltAccfltInErrK1, \\ fltUpperLimit, fltLowerLimit \end{pmatrix} \in X \middle\vert X \cap D \neq \varnothing \wedge X \cap M = \varnothing \right\}$	$(-Inf, Inf)$	N/A

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Table 106. GFLIB_ControllerPIrAW_FLT Worst-Case Error Bounds - fltAcc Output*...continued*

Subset of input domain	Worst-case error bounds for fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for fltAcc output
Any of the inputs is NaN or infinity, i.e. $\left\{ \begin{pmatrix} fltInErr, fltCC1sc, fltCC2sc, \\ fltAccfltInErrK1, \\ fltUpperLimit, fltLowerLimit \end{pmatrix} \in X \middle\vert \begin{matrix} X \cap M \neq \varnothing \end{matrix} \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{matrix} \begin{pmatrix} fltInErr, fltCC1sc, fltCC2sc, \\ fltAccfltInErrK1, \\ fltUpperLimit, fltLowerLimit \end{pmatrix} \in X \\ X \subset N \cup \{-0, +0\}, \\ \{ir_1, ir_2, ir_3\} \subset N \cup \{-0, +0\}, \\ refResult = 0 \vee \\ \begin{pmatrix} \lvert refResult \rvert - me \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + me \cdot \mathrm{ULP}(refResult) \neq Inf \end{pmatrix} \end{matrix} \right\}$	$\langle -me, me \rangle$	N/A
Normalized or zero input values which cause *fltAcc* output underflow, i.e. $\left\{ \begin{matrix} \begin{pmatrix} fltInErr, fltCC1sc, fltCC2sc, \\ fltAccfltInErrK1, \\ fltUpperLimit, fltLowerLimit \end{pmatrix} \in X \\ X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert - me \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0 \end{matrix} \right\}$	$(-Inf, Inf)$	N/A
Normalized or zero input values which cause *fltAcc* output overflow, i.e. $\left\{ \begin{matrix} \begin{pmatrix} fltInErr, fltCC1sc, fltCC2sc, \\ fltAccfltInErrK1, \\ fltUpperLimit, fltLowerLimit \end{pmatrix} \in X \\ X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert + me \cdot \mathrm{ULP}(refResult) = Inf \end{matrix} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

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Table 106. GFLIB_ControllerPIrAW_FLT Worst-Case Error Bounds - fltAcc Output*...continued*

Subset of input domain	Worst-case error bounds for fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for fltAcc output
Normalized or zero input values which cause intermediate result underflow, i.e. $\left\{ \begin{pmatrix} fltInErr, fltCC1sc, fltCC2sc, \\ fltAcc fltInErrK1, \\ fltUpperLimit, fltLowerLimit \end{pmatrix} \in X \middle\vert \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \{ir_1, ir_2\} \cap D \neq \varnothing \vee \\ (\lvert ir_3 \rvert - \mathrm{ULP}(ir_3) \in D \wedge ir_3 \neq 0) \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}
Normalized or zero input values which cause intermediate result overflow, i.e. $\left\{ \begin{pmatrix} fltInErr, fltCC1sc, fltCC2sc, \\ fltAcc fltInErrK1, \\ fltUpperLimit, fltLowerLimit \end{pmatrix} \in X \middle\vert \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \{ir_1, ir_2, \lvert ir_3 \rvert + \mathrm{ULP}(ir_3)\} \cap M \neq \varnothing \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

Table 107. GFLIB_ControllerPIrAW_FLT Worst-Case Error Bounds - fltInErrK1 Output

Subset of input domain	Worst-case error bounds for fltAcc output [ulp]	Allowed specific values (regardless the error bounds) for fltAcc output
Entire input domain	0	*fltInErr*

2.26 Function GFLIB_Cos_FLT

2.26.1 Declaration

```
tFloat GFLIB_Cos_FLT(tFloat fltIn, const GFLIB_COS_T_FLT *const
pParam);
```

2.26.2 Arguments

Table 108. GFLIB_Cos_FLT arguments

Type	Name	Direction	Description
tFloat	fltIn	**input**	Input argument is a single precision floating point number that contains an angle in radians from interval [- π, π].

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Table 108. GFLIB_Cos_FLT arguments*...continued*

Type	Name	Direction	Description
const GFLIB_COS_T_FLT *const	pParam	**input**	Pointer to an array of approximation coefficients. In case the default approximation coefficients are used, the &pParam must be replaced with GFLIB_COS_DEFAULT_FLT symbol.

2.26.3 Worst-Case Error Bounds

Only the default approximation coefficients are considered.

Let *fltIn* ∈ *X* be an input to GFLIB_Cos_FLT,

then

Table 109. GFLIB_Cos_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Input NaN or infinity, i.e. $\{ fltIn \in X \mid fltIn \in M \}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)
Input denormalized, normalized or zero, and within the allowed input interval, i.e. $\left\{ \begin{matrix} fltIn \in X \mid X \cap M = \varnothing, \\ -\pi \le fltIn \le \pi \end{matrix} \right\}$	$\langle -42,42 \rangle$	N/A
Input normalized and beyond the allowed range, i.e. $\left\{ \begin{matrix} fltIn \in X \mid X \cap M = \varnothing, \\ fltIn < -\pi \vee fltIn > \pi \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, -Inf, Inf}

2.27 Function GFLIB_Hyst_FLT

2.27.1 Declaration

```
tFloat GFLIB_Hyst_FLT(tFloat fltIn, GFLIB_HYST_T_FLT *const
pParam);
```

2.27.2 Arguments

Table 110. GFLIB_Hyst_FLT arguments

Type	Name	Direction	Description
tFloat	fltIn	**input**	Input value, in single precision floating point data format.

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Table 110. GFLIB_Hyst_FLT arguments*...continued*

Type	Name	Direction	Description
GFLIB_HYST_T_FLT *const	pParam	**input, output**	Pointer to the structure with parameters and states of the hysteresis function. Arguments of the structure contain a single precision floating point values.

2.27.3 Worst-Case Error Bounds

Let (*fltIn*, *fltHystOn*, *fltHystOff*, *fltOutValOn*, *fltOutValOff*) ∈ *X* be a set of inputs to GFLIB_Hyst_FLT,

then

Table 111. GFLIB_Hyst_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
All inputs are normalized, denormalized, or zero, and *fltHystOn* is greater than *fltHystOff*, i.e. $\left\{ \begin{pmatrix} fltIn, fltHystOn, fltHystOff, \\ fltOutValOn, fltOutValOff \end{pmatrix} \in X \middle\vert \begin{matrix} X \cap M = \varnothing \wedge \\ fltHystOff < fltHystOn \end{matrix} \right\}$	0	N/A
At least one of the inputs is NaN or infinite, or *fltHyst On* is not greater than *fltHystOff*, i.e. $\left\{ \begin{pmatrix} fltIn, fltHystOn, fltHystOff, \\ fltOutValOn, fltOutValOff \end{pmatrix} \in X \middle\vert \begin{matrix} X \cap M \neq \varnothing \vee \\ fltHystOff \geq fltHystOn \end{matrix} \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)

2.28 Function GFLIB_IntegratorTR_FLT

2.28.1 Declaration

```
tFloat GFLIB_IntegratorTR_FLT(tFloat fltIn,
GFLIB_INTEGRATOR_TR_T_FLT *const pParam);
```

2.28.2 Arguments

Table 112. GFLIB_IntegratorTR_FLT arguments

Type	Name	Direction	Description
tFloat	fltIn	**input**	Input argument to be integrated.
GFLIB_INTEGRATOR_TR_T_FLT *const	pParam	**input, output**	Pointer to the integrator parameters structure.

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2.28.3 Worst-Case Error Bounds

Let (*fltIn*, *fltState*, *fltInK1*, *fltC1*) $\in X$ be a set of inputs to GFLIB_IntegratorTR_FLT,

fltState input represents a real number with an error of max. ±0.5 ulp,

refResult be the theoretical exact result,

$ir_1 = fltIn + fltInK1$,

$ir_2 = ir_1 \cdot fltC1$,

$ie_1 = \max(\mathrm{fe}(|ir_2| + \mathrm{ULP}(ir_2)), \mathrm{fe}(|fltState| + 0.5 \cdot \mathrm{ULP}(fltState)))$,

$ie_2 = \mathrm{fe}(refResult)$,

$$cb = \begin{cases} 0, & ie_1 - ie_2 \le 0 \\ ie_1 - ie_2, & ie_1 - ie_2 > 0 \end{cases},$$

$me = 0.5 + 1.5 \cdot 2^{cb}$,

then

Table 113. GFLIB_IntegratorTR_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Any of the inputs is denormalized, others are normalized or zero, i.e. $\left\{ (fltIn, fltState, fltInK1, fltC1) \in X \,\middle\vert\, X \cap D \ne \varnothing \wedge X \cap M = \varnothing \right\}$	$(-Inf, Inf)$	N/A
Any of the inputs is NaN or infinity, i.e. $\left\{ (fltIn, fltState, fltInK1, fltC1) \in X \,\middle\vert\, X \cap M \ne \varnothing \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} (fltIn, fltState, fltInK1, fltC1) \in X \,\middle\vert \\ X \subset N \cup \{-0, +0\}, \\ \{ir_1, ir_2\} \subset N \cup \{-0, +0\}, \\ refResult = 0 \vee \\ \left(\begin{array}{c} \lvert refResult \rvert - me \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + me \cdot \mathrm{ULP}(refResult) \ne Inf \end{array} \right) \end{array} \right\}$	$\langle -me, me \rangle$	N/A

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Table 113. GFLIB_IntegratorTR_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Normalized or zero input values which cause result underflow, i.e. $\left\{ \begin{array}{c} (fltIn, fltState, fltInK1, fltC1) \in X \mid \\ X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert - me \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0 \end{array} \right\}$	$(-Inf, Inf)$	N/A
Normalized or zero input values which cause result overflow, i.e. $\left\{ \begin{array}{c} (fltIn, fltState, fltInK1, fltC1) \in X \mid \\ X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert + me \cdot \mathrm{ULP}(refResult) = Inf \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}
Normalized or zero input values which cause intermediate result underflow, i.e. $\left\{ \begin{array}{c} (fltIn, fltState, fltInK1, fltC1) \in X \mid \\ X \subset N \cup \{-0, +0\}, \\ \left\{ \begin{array}{c} (\lvert ir_1 \rvert - 0.5 \cdot \mathrm{ULP}(ir_1)), \\ (\lvert ir_2 \rvert - \mathrm{ULP}(ir_2)) \end{array} \right\} \cap D \neq \varnothing \vee \\ ir_1 \neq 0 \vee ir_2 \neq 0 \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}
Normalized or zero input values which cause intermediate result overflow, i.e. $\left\{ \begin{array}{c} (fltIn, fltState, fltInK1, fltC1) \in X \mid \\ X \subset N \cup \{-0, +0\}, \\ \left\{ \begin{array}{c} (\lvert ir_1 \rvert + 0.5 \cdot \mathrm{ULP}(ir_1)), \\ (\lvert ir_2 \rvert + \mathrm{ULP}(ir_2)) \end{array} \right\} \cap M \neq \varnothing \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

Table 114. GFLIB_IntegratorTR_FLT Worst-Case Error Bounds - fltState Output

Subset of input domain	Worst-case error bounds for fltState output [ulp]	Allowed specific values (regardless the error bounds) for fltState output
Any of the inputs is denormalized, others are normalized or zero, i.e. $\left\{ \begin{array}{c} (fltIn, fltState, fltInK1, fltC1) \in X \mid \\ X \cap D \neq \varnothing \wedge X \cap M = \varnothing \end{array} \right\}$	$(-Inf, Inf)$	N/A

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Table 114. GFLIB_IntegratorTR_FLT Worst-Case Error Bounds - fltState Output*...continued*

Subset of input domain	Worst-case error bounds for fltState output [ulp]	Allowed specific values (regardless the error bounds) for fltState output
Any of the inputs is NaN or infinity, i.e. $\left\{ \begin{matrix} (fltIn, fltState, fltInK1, fltC1) \in X \\ X \cap M \neq \varnothing \end{matrix} \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{matrix} (fltIn, fltState, fltInK1, fltC1) \in X \\ X \subset N \cup \{-0, +0\}, \\ \{ir_1, ir_2\} \subset N \cup \{-0, +0\}, \\ refResult = 0 \vee \\ \left(\begin{matrix} \lvert refResult \rvert - me \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + me \cdot \mathrm{ULP}(refResult) \neq Inf \end{matrix} \right) \end{matrix} \right\}$	$\langle -me, me \rangle$	N/A
Normalized or zero input values which cause *fltState* output underflow, i.e. $\left\{ \begin{matrix} (fltIn, fltState, fltInK1, fltC1) \in X \\ X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert - me \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0 \end{matrix} \right\}$	$(-Inf, Inf)$	N/A
Normalized or zero input values which cause *fltState* output overflow, i.e. $\left\{ \begin{matrix} (fltIn, fltState, fltInK1, fltC1) \in X \\ X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert + me \cdot \mathrm{ULP}(refResult) = Inf \end{matrix} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}
Normalized or zero input values which cause intermediate result underflow, i.e. $\left\{ \begin{matrix} (fltIn, fltState, fltInK1, fltC1) \in X \\ X \subset N \cup \{-0, +0\}, \\ \left\{ \begin{matrix} (\lvert ir_1 \rvert - 0.5 \cdot \mathrm{ULP}(ir_1)), \\ (\lvert ir_2 \rvert - \mathrm{ULP}(ir_2)) \end{matrix} \right\} \cap D \neq \varnothing \vee \\ ir_1 \neq 0 \vee ir_2 \neq 0 \end{matrix} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

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Table 114. GFLIB_IntegratorTR_FLT Worst-Case Error Bounds - fltState Output*...continued*

Subset of input domain	Worst-case error bounds for fltState output [ulp]	Allowed specific values (regardless the error bounds) for fltState output
Normalized or zero input values which cause intermediate result overflow, i.e. $\left\{ \begin{array}{c} (fltIn, fltState, fltInK1, fltC1) \in X \\ X \subset N \cup \{-0, +0\}, \\ \left\{ \begin{array}{c} (\lvert ir_1 \rvert + 0.5 \cdot \mathrm{ULP}(ir_1)), \\ (\lvert ir_2 \rvert + \mathrm{ULP}(ir_2)) \end{array} \right\} \cap M \neq \varnothing \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

Table 115. GFLIB_IntegratorTR_FLT Worst-Case Error Bounds - fltInK1 Output

Subset of input domain	Worst-case error bounds for fltInK1 output [ulp]	Allowed specific values (regardless the error bounds) for fltInK1 output
Entire input domain	0	*fltIn*

2.29 Function GFLIB_Limit_FLT

2.29.1 Declaration

```
tFloat GFLIB_Limit_FLT(tFloat fltIn, const GFLIB_LIMIT_T_FLT
*const pParam);
```

2.29.2 Arguments

Table 116. GFLIB_Limit_FLT arguments

Type	Name	Direction	Description
tFloat	fltIn	**input**	Input value.
const GFLIB_LIMIT_T_FLT *const	pParam	**input**	Pointer to the limits structure.

2.29.3 Worst-Case Error Bounds

Let (*fltIn*, *fltLowerLimit*, *fltUpperLimit*) ∈ *X* be a set of inputs to GFLIB_Limit_FLT, then

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Table 117. GFLIB_Limit_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
All inputs are normalized, denormalized, or zero, and *fltUpperLimit* is greater than *fltLowerLimit*, i.e. $\left\{ (fltIn, fltLowerLimit, fltUpperLimit) \in X \middle\vert \begin{array}{c} X \cap M = \varnothing \wedge \\ fltLowerLimit < fltUpperLimit \end{array} \right\}$	0	N/A
At least one of the inputs is NaN or infinite, or *fltUpperLimit* is not greater than *fltLowerLimit*, i.e. $\left\{ (fltIn, fltLowerLimit, fltUpperLimit) \in X \middle\vert \begin{array}{c} X \cap M \neq \varnothing \vee \\ fltLowerLimit \geq fltUpperLimit \end{array} \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)

2.30 Function GFLIB_Log10_FLT

2.30.1 Declaration

```
tFloat GFLIB_Log10_FLT(tFloat fltIn, const GFLIB_LOG10_T_FLT
*const pParam);
```

2.30.2 Arguments

Table 118. GFLIB_Log10_FLT arguments

Type	Name	Direction	Description
tFloat	fltIn	**input**	Input argument is a 32-bit number that contains a single precision floating point value.
const GFLIB_LOG10_T_FLT *const	pParam	**input**	Pointer to an array of approximation coefficients.

2.30.3 Worst-Case Error Bounds

Only the default approximation coefficients are considered.

Let *fltIn* $\in$ *X* be an input to GFLIB_Log10_FLT,

then

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Table 119. GFLIB_Log10_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Input not normalized, i.e. $\{fltIn \in X \mid fltIn \notin N\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, –Inf, NaN)
Input normalized, i.e. $\{fltIn \in X \mid fltIn \in N\}$	$\langle -760, 760 \rangle$	N/A

2.31 Function GFLIB_LowerLimit_FLT

2.31.1 Declaration

```
tFloat GFLIB_LowerLimit_FLT(tFloat fltIn, const
GFLIB_LOWERLIMIT_T_FLT *const pParam);
```

2.31.2 Arguments

Table 120. GFLIB_LowerLimit_FLT arguments

Type	Name	Direction	Description
tFloat	fltIn	**input**	Input value.
const GFLIB_LOWERLIMIT_T_FLT *const	pParam	**input**	Pointer to the limits structure.

2.31.3 Worst-Case Error Bounds

Let (*fltIn*, *fltLowerLimit*) ∈ *X* be a set of inputs to GFLIB_LowerLimit_FLT,

then

Table 121. GFLIB_LowerLimit_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
All inputs are normalized, denormalized, or zero, i.e. $\left\{ (fltIn, fltLowerLimit) \in X \mid X \cap M = \varnothing \right\}$	0	N/A
At least one of the inputs is NaN or infinite, i.e. $\left\{ (fltIn, fltLowerLimit) \in X \mid X \cap M \neq \varnothing \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)

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2.32 Function GFLIB_Lut1D_FLT

2.32.1 Declaration

```
tFloat GFLIB_Lut1D_FLT(tFloat fltIn, const GFLIB_LUT1D_T_FLT
*const pParam);
```

2.32.2 Arguments

Table 122. GFLIB_Lut1D_FLT arguments

Type	Name	Direction	Description
tFloat	fltIn	**input**	The abscissa for which 1D interpolation is performed.
const GFLIB_LUT1D_T_FLT *const	pParam	**input**	Pointer to the parameters structure with parameters of the look-up table function.

2.32.3 Worst-Case Error Bounds

Let (*fltIn*, *u32ShamOffset*, ***fltTable***) ∈ *X* be a set of inputs to GFLIB_Lut1D_FLT,

refResult be the theoretical exact result,

$$k = \begin{cases} fltIn \cdot 2^{u32ShamOffset} - \mathrm{fix}\left(fltIn \cdot 2^{u32ShamOffset}\right), & fltIn \geq 0 \\ fltIn \cdot 2^{u32ShamOffset} - \mathrm{fix}\left(fltIn \cdot 2^{u32ShamOffset}\right) + 1, & fltIn < 0 \end{cases},$$

$$mr_n = k \cdot \left(fltTable_{n+1} - fltTable_n\right),$$

$$ie = \max_n\left(\max\left(\mathrm{fe}\left(|mr_n| + 2.5 \cdot \mathrm{ULP}(mr_n)\right), \mathrm{fe}\left(fltTable_n\right)\right) - \mathrm{fe}\left(mr_n + fltTable_n\right)\right),$$

$$cb = \begin{cases} 0, & ie \leq 0 \\ ie, & ie > 0 \end{cases},$$

$$me = 0.5 + 2.5 \cdot 2^{cb},$$

then

Table 123. GFLIB_Lut1D_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Any of the inputs is denormalized, others are normalized or zero, i.e. $\left\{ (fltIn, u32ShamOffset, \boldsymbol{fltTable}) \in X \,\middle|\, X \cap D \neq \varnothing \wedge X \cap M = \varnothing \right\}$	$(-Inf, Inf)$	N/A

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Table 123. GFLIB_Lut1D_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Any of the inputs is NaN or infinity, or the input is beyond allowed range, i.e. $\left\{ \begin{matrix} (fltIn, u32ShamOffset, \boldsymbol{fltTable}) \in X \mid \\ X \cap M \neq \varnothing \vee \lvert fltIn \rvert \geq 1 \end{matrix} \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, input within allowed range, i.e. $\left\{ \begin{matrix} (fltIn, u32ShamOffset, \boldsymbol{fltTable}) \in X \mid \\ X \subset N \cup \{-0, +0\}, \\ fltTable \subset N \cup \{-0, +0\} \\ \lvert fltIn \rvert < 1, \\ \max_n(\lvert mr_n \rvert) + 2.5 \cdot \mathrm{ULP}(\max_n(mr_n)) \neq Inf, \\ \bigvee mr_n = 0 \vee \lvert mr_n \rvert - 2.5 \cdot \mathrm{ULP}(mr_n) \notin D, \\ refResult = 0 \vee \\ \left(\begin{matrix} \lvert refResult \rvert - me_2 \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + me_2 \cdot \mathrm{ULP}(refResult) \neq Inf \end{matrix} \right) \end{matrix} \right\}$	$\langle -me, me \rangle$	N/A
Normalized or zero input values which cause result underflow, i.e. $\left\{ \begin{matrix} (fltIn, u32ShamOffset, \boldsymbol{fltTable}) \in X \mid \\ X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert - me \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0 \end{matrix} \right\}$	$(-Inf, Inf)$	N/A
Normalized or zero input values which cause intermediate result underflow, i.e. $\left\{ \begin{matrix} (fltIn, u32ShamOffset, \boldsymbol{fltTable}) \in X \mid \\ X \subset N \cup \{-0, +0\}, \\ \exists \lvert mr_n \rvert - 2.5 \cdot \mathrm{ULP}(mr_n) \in D \wedge mr_n \neq 0 \end{matrix} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

2.33 Function GFLIB_Lut2D_FLT

2.33.1 Declaration

```
tFloat GFLIB_Lut2D_FLT(tFloat fltIn1, tFloat fltIn2, const
GFLIB_LUT2D_T_FLT *const pParam);
```


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2.33.2 Arguments

Table 124. GFLIB_Lut2D_FLT arguments

Type	Name	Direction	Description
tFloat	fltIn1	**input**	X-coordinate (across columns of the table) of the point for which the 2D interpolation is performed. Input value is in single precision floating data format.
tFloat	fltIn2	**input**	Y-coordinate (across rows of the table) of the point for which the 2D interpolation is performed. Input value is in single precision floating data format.
const GFLIB_LUT2D_T_FLT *const	pParam	**input**	Pointer to the parameters structure with parameters of the two dimensional look-up table function.

2.33.3 Worst-Case Error Bounds

Let (*fltIn1*, *fltIn2*, *u32ShamOffset1*, *u32ShamOffset2*, ***fltTable***) ∈ *X* be a set of inputs to GFLIB_Lut2D_FLT,

refResult be the theoretical exact result,

$$kx = \begin{cases} fltIn1 \cdot 2^{u32ShamOffset1} - \mathrm{fix}\left(fltIn1 \cdot 2^{u32ShamOffset1}\right), & fltIn1 \geq 0 \\ fltIn1 \cdot 2^{u32ShamOffset1} - \mathrm{fix}\left(fltIn1 \cdot 2^{u32ShamOffset1}\right) + 1, & fltIn1 < 0 \end{cases},$$

$$ky = \begin{cases} fltIn2 \cdot 2^{u32ShamOffset2} - \mathrm{fix}\left(fltIn2 \cdot 2^{u32ShamOffset2}\right), & fltIn2 \geq 0 \\ fltIn2 \cdot 2^{u32ShamOffset2} - \mathrm{fix}\left(fltIn2 \cdot 2^{u32ShamOffset2}\right) + 1, & fltIn2 < 0 \end{cases},$$

$$yr = 2^{u32ShamOffset2} + 1,$$

$$z11_n = fltTable_n,$$

$$z21_n = fltTable_{n+yr},$$

$$z12_n = fltTable_{n+1},$$

$$z22_n = fltTable_{n+1+yr},$$

$$mra_n = kx \cdot (z21_n - z11_n),$$

$$sra = \max_n\left(\max\left(\mathrm{fe}\left(|mra_n| + 2.5 \cdot \mathrm{ULP}(mra_n)\right), \mathrm{fe}(z11_n)\right) - \mathrm{fe}\left(mra_n + z11_n\right)\right),$$

$$cb_1 = \begin{cases} 0, & sra \leq 0 \\ sra, & sra > 0 \end{cases},$$

$$me_1 = 0.5 + 2.5 \cdot 2^{cb_1},$$

$$mrb_n = kx \cdot (z22_n - z12_n),$$

$$srb = \max_n\left(\max\left(\mathrm{fe}\left(|mrb_n| + 2.5 \cdot \mathrm{ULP}(mrb_n)\right), \mathrm{fe}(z12_n)\right) - \mathrm{fe}\left(mrb_n + z12_n\right)\right),$$

$$cb_2 = \begin{cases} 0, & srb \leq 0 \\ srb, & srb > 0 \end{cases},$$

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$$me_2 = 0.5 + 2.5 \cdot 2^{cb_2},$$

$$mrc_n = ky \cdot \left(\left(mrb_n + z12_n \right) - \left(mra_n + z11_n \right) \right),$$

$$mec = \left(2 \cdot \left(me_1 + me_2 + 0.5 \right) + 0.5 \right) \cdot \mathrm{ULP}\left(mrc_n \right),$$

$$src = \max_n \left(\max\left(\mathrm{fe}\left(\left| mrc_n \right| + mec \right), \mathrm{fe}\left(mra_n + z11_n \right) \right) - \mathrm{fe}\left(mrc_n + \left(mra_n + z11_n \right) \right) \right),$$

$$cb_3 = \begin{cases} 0, & src \le 0 \\ src, & src > 0 \end{cases},$$

$$me_3 = 0.5 + \left(2 \cdot \left(me_1 + me_2 + 0.5 \right) + 0.5 \right) \cdot 2^{cb_3},$$

then

Table 125. GFLIB_Lut2D_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Any of the inputs is denormalized, others are normalized or zero, i.e. $\left\{ \left(\begin{matrix} fltIn1, fltIn2, u32ShamOffset1, \\ u32ShamOffset2, \boldsymbol{fltTable} \end{matrix} \right) \in X \middle\| \begin{matrix} X \cap D \neq \varnothing \wedge X \cap M = \varnothing \end{matrix} \right\}$	$\left(-Inf, Inf \right)$	N/A
Any of the inputs is NaN or infinity, or an input is beyond allowed range, i.e. $\left\{ \left(\begin{matrix} fltIn1, fltIn2, u32ShamOffset1, \\ u32ShamOffset2, \boldsymbol{fltTable} \end{matrix} \right) \in X \middle\| \begin{matrix} X \cap M \neq \varnothing \vee \left\| fltIn \right\| \ge 1 \vee \left\| fltIn \right\| \ge 1 \end{matrix} \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)

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Table 125. GFLIB_Lut2D_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Normalized or zero input values which lead to normalized or zero results, inputs within allowed range, i.e. $\left\{ \begin{array}{c} \begin{pmatrix} fltIn1, fltIn2, u32ShamOffset1, \\ u32ShamOffset2, \boldsymbol{fltTable} \end{pmatrix} \in X \Big| \\ X \subset N \cup \{-0, +0\}, \\ \boldsymbol{fltTable} \subset N \cup \{-0, +0\} \\ \lvert fltIn1 \rvert < 1, \\ \lvert fltIn2 \rvert < 1, \\ \max_n(\lvert mra_n \rvert) + 2.5 \cdot \mathrm{ULP}\left(\max_n(mra_n)\right) \neq Inf, \\ \bigvee mra_n = 0 \vee \lvert mra_n \rvert - 2.5 \cdot \mathrm{ULP}(mra_n) \notin D, \\ \max_n(\lvert sra_n \rvert) + 2.5 \cdot \mathrm{ULP}\left(\max_n(sra_n)\right) \neq Inf, \\ \bigvee sra_n = 0 \vee \lvert sra_n \rvert - 2.5 \cdot \mathrm{ULP}(sra_n) \notin D, \\ \max_n(\lvert mrb_n \rvert) + 2.5 \cdot \mathrm{ULP}\left(\max_n(mrb_n)\right) \neq Inf, \\ \bigvee mrb_n = 0 \vee \lvert mrb_n \rvert - 2.5 \cdot \mathrm{ULP}(mrb_n) \notin D, \\ \max_n(\lvert srb_n \rvert) + 2.5 \cdot \mathrm{ULP}\left(\max_n(srb_n)\right) \neq Inf, \\ \bigvee srb_n = 0 \vee \lvert srb_n \rvert - 2.5 \cdot \mathrm{ULP}(srb_n) \notin D, \\ \max_n(\lvert mrc_n \rvert) + 2.5 \cdot \mathrm{ULP}\left(\max_n(mrc_n)\right) \neq Inf, \\ \bigvee mrc_n = 0 \vee \lvert mrc_n \rvert - 2.5 \cdot \mathrm{ULP}(mrc_n) \notin D, \\ refResult = 0 \vee \\ \begin{pmatrix} \lvert refResult \rvert - me_3 \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + me_3 \cdot \mathrm{ULP}(refResult) \neq Inf \end{pmatrix} \end{array} \right\}$	$\langle -me_3, me_3 \rangle$	N/A
Normalized or zero input values which cause result underflow, i.e. $\left\{ \begin{array}{c} \begin{pmatrix} fltIn1, fltIn2, u32ShamOffset1, \\ u32ShamOffset2, \boldsymbol{fltTable} \end{pmatrix} \in X \Big| \\ X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert - me_3 \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0 \end{array} \right\}$	$(-Inf, Inf)$	N/A

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Table 125. GFLIB_Lut2D_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Normalized or zero input values which cause intermediate result underflow, i.e. $\left\{ \begin{array}{c} \left(\begin{array}{c} fltIn1, fltIn2, u32ShamOffset1, \\ u32ShamOffset2, \boldsymbol{fltTable} \end{array} \right) \in X \Big| \\ X \subset N \cup \{-0, +0\}, \\ \exists \lvert mra_n \rvert - 2.5 \cdot \mathrm{ULP}(mra_n) \in D \wedge mra_n \neq 0 \vee \\ \exists \lvert sra_n \rvert - 2.5 \cdot \mathrm{ULP}(sra_n) \in D \wedge sra_n \neq 0 \vee \\ \exists \lvert mrb_n \rvert - 2.5 \cdot \mathrm{ULP}(mrb_n) \in D \wedge mrb_n \neq 0 \vee \\ \exists \lvert srb_n \rvert - 2.5 \cdot \mathrm{ULP}(srb_n) \in D \wedge srb_n \neq 0 \vee \\ \exists \lvert mrc_n \rvert - 2.5 \cdot \mathrm{ULP}(mrc_n) \in D \wedge mrc_n \neq 0 \vee \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

2.34 Function GFLIB_Ramp_FLT

2.34.1 Declaration

```
tFloat GFLIB_Ramp_FLT(tFloat fltIn, GFLIB_RAMP_T_FLT *const
pParam);
```

2.34.2 Arguments

Table 126. GFLIB_Ramp_FLT arguments

Type	Name	Direction	Description
tFloat	fltIn	**input**	Input argument representing the desired output value. Input value is in single precision floating data format.
GFLIB_RAMP_T_FLT *const	pParam	**input, output**	Pointer to the ramp parameters structure. Arguments of the structure contain single precision floating point values.

2.34.3 Worst-Case Error Bounds

Let (*fltIn*, *fltState*, *fltRampUp*, *fltRampDown*) ∈ *X* be a set of inputs to GFLIB_Ramp_FLT,

fltState input represents a real number with an error of max. ±0.5 ulp,

refResult be the theoretical exact result,

$ie_1 = \mathrm{fe}(\lvert fltState \rvert + 0.5 \cdot \mathrm{ULP}(fltState))$,

$ie_2 = \mathrm{fe}(refResult)$,

$cb = \begin{cases} 0, & ie_1 - ie_2 \leq 0 \\ ie_1 - ie_2, & ie_1 - ie_2 > 0 \end{cases}$,

$me = 0.5 + 0.5 \cdot 2^{cb}$,

then

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Table 127. GFLIB_Ramp_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Any of the inputs is denormalized, others are normalized or zero, i.e. $\left\{ \left(\begin{matrix} fltIn, fltState, \\ fltRampUp, fltRampDown \end{matrix} \right) \in X \middle\vert \begin{matrix} X \cap D \neq \varnothing \wedge X \cap M = \varnothing \end{matrix} \right\}$	$(-Inf, Inf)$	N/A
Any of the inputs is NaN or infinity, i.e. $\left\{ \left(\begin{matrix} fltIn, fltState, \\ fltRampUp, fltRampDown \end{matrix} \right) \in X \middle\vert \begin{matrix} X \cap M \neq \varnothing \end{matrix} \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{matrix} \left(\begin{matrix} fltIn, fltState, \\ fltRampUp, fltRampDown \end{matrix} \right) \in X \middle\vert \\ X \subset N \cup \{-0, +0\}, \\ refResult = 0 \vee \\ \left(\begin{matrix} \lvert refResult \rvert - me \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + me \cdot \mathrm{ULP}(refResult) \neq Inf \end{matrix} \right) \end{matrix} \right\}$	$\langle -me, me \rangle$	N/A
Normalized or zero input values which cause result underflow, i.e. $\left\{ \begin{matrix} \left(\begin{matrix} fltIn, fltState, \\ fltRampUp, fltRampDown \end{matrix} \right) \in X \middle\vert \\ X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert - me \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0 \end{matrix} \right\}$	$(-Inf, Inf)$	N/A

Table 128. GFLIB_Ramp_FLT Worst-Case Error Bounds - fltState Output

Subset of input domain	Worst-case error bounds for fltState output [ulp]	Allowed specific values (regardless the error bounds) for fltState output
Any of the inputs is denormalized, others are normalized or zero, i.e. $\left\{ \left(\begin{matrix} fltIn, fltState, \\ fltRampUp, fltRampDown \end{matrix} \right) \in X \middle\vert \begin{matrix} X \cap D \neq \varnothing \wedge X \cap M = \varnothing \end{matrix} \right\}$	$(-Inf, Inf)$	N/A

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Table 128. GFLIB_Ramp_FLT Worst-Case Error Bounds - fltState Output*...continued*

Subset of input domain	Worst-case error bounds for fltState output [ulp]	Allowed specific values (regardless the error bounds) for fltState output
Any of the inputs is NaN or infinity, i.e. $\left\{ \left(\begin{matrix} fltIn, fltState, \\ fltRampUp, fltRampDown \end{matrix} \right) \in X \middle\vert \begin{matrix} X \cap M \neq \varnothing \end{matrix} \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \left(\begin{matrix} fltIn, fltState, \\ fltRampUp, fltRampDown \end{matrix} \right) \in X \middle\vert \begin{matrix} X \subset N \cup \{-0, +0\}, \\ refResult = 0 \vee \\ \left(\begin{matrix} \lvert refResult \rvert - me \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + me \cdot \mathrm{ULP}(refResult) \neq Inf \end{matrix} \right) \end{matrix} \right\}$	$\langle -me, me \rangle$	N/A
Normalized or zero input values which cause result underflow, i.e. $\left\{ \left(\begin{matrix} fltIn, fltState, \\ fltRampUp, fltRampDown \end{matrix} \right) \in X \middle\vert \begin{matrix} X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert - me \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0 \end{matrix} \right\}$	$(-Inf, Inf)$	N/A

Table 129. GFLIB_Ramp_FLT Worst-Case Error Bounds - fltInK1 Output

Subset of input domain	Worst-case error bounds for fltInK1 output [ulp]	Allowed specific values (regardless the error bounds) for fltInK1 output
Entire input domain	0	*fltIn*

2.35 Function GFLIB_Sign_FLT

2.35.1 Declaration

```
tFloat GFLIB_Sign_FLT(tFloat fltIn);
```

2.35.2 Arguments

Table 130. GFLIB_Sign_FLT arguments

Type	Name	Direction	Description
tFloat	fltIn	**input**	Input argument.

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2.35.3 Worst-Case Error Bounds

Let *fltIn* ∈ *X* be an input to GFLIB_Sign_FLT,

then

Table 131. GFLIB_Sign_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Input NaN, i.e. $\{fltIn \in X \mid fltIn = NaN\}$	N/A	{NaN, *pmax*, *nmax*, 0, -0}
Normalized, denormalized, infinite, or zero input, i.e. $\{fltIn \in X \mid fltIn \neq NaN\}$	0	N/A

2.36 Function GFLIB_Sin_FLT

2.36.1 Declaration

```
tFloat GFLIB_Sin_FLT(tFloat fltIn, const GFLIB_SIN_T_FLT *const
pParam);
```

2.36.2 Arguments

Table 132. GFLIB_Sin_FLT arguments

Type	Name	Direction	Description
tFloat	fltIn	**input**	Input argument is a single precision floating point number that contains an angle in radians from interval [- π, π].
const GFLIB_SIN_T_FLT *const	pParam	**input**	Pointer to an array of approximation coefficients. In case the default approximation coefficients are used, the &pParam must be replaced with GFLIB_SIN_DEFAULT_FLT symbol.

2.36.3 Worst-Case Error Bounds

Only the default approximation coefficients are considered.

Let (*fltIn*) ∈ *X* be an input to GFLIB_Sin_FLT,

π_{SP} be the single-precision representation of π,

then

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Table 133. GFLIB_Sin_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Input infinite, i.e. $\{fltIn \in X \mid fltIn \in \{Inf, -Inf\}\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}
Input NaN, i.e. $\{fltIn \in X \mid fltIn = NaN\}$	$(-Inf, Inf)$	{NaN, pmax}
Normalized, denormalized, or zero input within guaranteed range, i.e. $\{fltIn \in X \mid fltIn \notin M, \lvert fltIn \rvert \le \pi_{SP}\}$	$\langle -42, 42 \rangle$	N/A
Normalized input beyond the guaranteed range, i.e. $\{fltIn \in X \mid fltIn \notin M, \lvert fltIn \rvert > \pi_{SP}\}$	$(-Inf, Inf)$	N/A

2.37 Function GFLIB_SinCos_FLT

2.37.1 Declaration

```
void GFLIB_SinCos_FLT(tFloat fltIn, SWLIBS_2Syst_FLT *pOut, const
GFLIB_SINCOS_T_FLT *const pParam);
```

2.37.2 Arguments

Table 134. GFLIB_SinCos_FLT arguments

Type	Name	Direction	Description
tFloat	fltIn	**input**	Input argument is a single precision floating point number that contains an angle in radians from interval [- π, π].
SWLIBS_2Syst_FLT *	pOut	**output**	Pointer to the structure where the values of the sine and cosine of the input angle are stored. The function returns the sine and cosine of the input argument as a single precision floating point number. The *sine* of input angle is returned in first item of the structure and the *cosine* of input angle is returned in second item of the structure.
const GFLIB_SINCOS_T_FLT *const	pParam	**input**	Pointer to an array of approximation coefficients. In case the default approximation coefficients are used, the &pParam must be replaced with GFLIB_SINCOS_DEFAULT_FLT symbol.

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2.37.3 Worst-Case Error Bounds

Only the default approximation coefficients are considered.

Let (*fltIn*) $\in X$ be an input to GFLIB_SinCos_FLT,

π_{SP} be the single-precision representation of π,

then

Table 135. GFLIB_SinCos_FLT Worst-Case Error Bounds - fltArg1 Output

Subset of input domain	Worst-case error bounds for fltArg1 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg1 output
Input infinite, i.e. $\{ fltIn \in X \mid fltIn \in \{ Inf, -Inf \} \}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}
Input NaN, i.e. $\{ fltIn \in X \mid fltIn = NaN \}$	$(-Inf, Inf)$	{NaN, pmax}
Normalized, denormalized, or zero input within guaranteed range, i.e. $\{ fltIn \in X \mid fltIn \notin M, \lvert fltIn \rvert \le \pi_{SP} \}$	$\langle -42, 42 \rangle$	N/A
Normalized input beyond the guaranteed range, i.e. $\{ fltIn \in X \mid fltIn \notin M, \lvert fltIn \rvert > \pi_{SP} \}$	$(-Inf, Inf)$	N/A

Table 136. GFLIB_SinCos_FLT Worst-Case Error Bounds - fltArg2 Output

Subset of input domain	Worst-case error bounds for fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg2 output
Input NaN or infinity, i.e. $\{ fltIn \in X \mid fltIn \in M \}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)
Input denormalized, normalized or zero, and within the allowed input interval, i.e. $\left\{ \begin{array}{c} fltIn \in X \mid X \cap M = \varnothing, \\ -\pi \le fltIn \le \pi \end{array} \right\}$	$\langle -42, 42 \rangle$	N/A

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Table 136. GFLIB_SinCos_FLT Worst-Case Error Bounds - fltArg2 Output*...continued*

Subset of input domain	Worst-case error bounds for fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg2 output
Input normalized and beyond the allowed range, i.e. $\left\{ \begin{matrix} fltIn \in X \mid X \cap M = \varnothing, \\ fltIn < -\pi \vee fltIn > \pi \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, -Inf, Inf}

2.38 Function GFLIB_Sqrt_FLT

2.38.1 Declaration

```
tFloat GFLIB_Sqrt_FLT(tFloat fltIn);
```

2.38.2 Arguments

Table 137. GFLIB_Sqrt_FLT arguments

Type	Name	Direction	Description
tFloat	fltIn	**input**	The input value.

2.38.3 Worst-Case Error Bounds

Let *fltIn* $\in$ *X* be an input to GFLIB_Sqrt_FLT,

then

Table 138. GFLIB_Sqrt_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Input positive infinity, i.e. $\{ fltIn \in X \mid fltIn = Inf \}$	$(-Inf, Inf)$	{NaN, Inf, -Inf, *pmax*, 0}
Input NaN, i.e. $\{ fltIn \in X \mid fltIn = NaN \}$	$(-Inf, Inf)$	{0, -0, NaN}
Negative input, i.e. $\{ fltIn \in X \mid fltIn < 0 \}$	N/A	{-0, NaN}
Positive denormalized input, i.e. $\{ fltIn \in X \mid fltIn \in D \wedge fltIn > 0 \}$	$(-Inf, Inf)$	N/A

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Table 138. GFLIB_Sqrt_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Positive normalized input, i.e. $\{fltIn \in X \mid fltIn \in N \wedge fltIn > 0\}$	$\langle -0.5, 0.5 \rangle$	N/A
Positive zero input, i.e. $\{fltIn \in X \mid fltIn = 0\}$	N/A	0
Negative zero input, i.e. $\{fltIn \in X \mid fltIn = -0\}$	N/A	-0

2.39 Function GFLIB_Tan_FLT

2.39.1 Declaration

```
tFloat GFLIB_Tan_FLT(tFloat fltIn, const GFLIB_TAN_T_FLT *const
pParam);
```

2.39.2 Arguments

Table 139. GFLIB_Tan_FLT arguments

Type	Name	Direction	Description
tFloat	fltIn	**input**	Input argument is a single precision floating point number that contains an angle in radians from interval (- π, π).
const GFLIB_TAN_T_FLT *const	pParam	**input**	Pointer to an array of approximation coefficients. In case the default approximation coefficients are used, the &pParam must be replaced with GFLIB_TAN_DEFAULT_FLT symbol.

2.39.3 Worst-Case Error Bounds

Only the default approximation coefficients are considered.

Let *fltIn* ∈ *X* be an input to GFLIB_Tan_FLT,

π_{SP} be the single-precision representation of π,

then

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Table 140. GFLIB_Tan_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Input infinite, i.e. $\{fltIn \in X \mid fltIn \in \{Inf, -Inf\}\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}
Input NaN, i.e. $\{fltIn \in X \mid fltIn = NaN\}$	$(-Inf, Inf)$	NaN
Normalized, denormalized, or zero input within guaranteed range, i.e. $\{fltIn \in X \mid fltIn \notin M, \lvert fltIn \rvert \le \pi_{SP}\}$	$\langle -13, 13 \rangle$	N/A
Normalized input beyond the guaranteed range, i.e. $\{fltIn \in X \mid fltIn \notin M, \lvert fltIn \rvert > \pi_{SP}\}$	$(-Inf, Inf)$	N/A

2.40 Function GFLIB_UpperLimit_FLT

2.40.1 Declaration

```
tFloat GFLIB_UpperLimit_FLT(tFloat fltIn, const
GFLIB_UPPERLIMIT_T_FLT *const pParam);
```

2.40.2 Arguments

Table 141. GFLIB_UpperLimit_FLT arguments

Type	Name	Direction	Description
tFloat	fltIn	**input**	Input value.
const GFLIB_ UPPERLIMIT_T_ FLT *const	pParam	**input**	Pointer to the limits structure.

2.40.3 Worst-Case Error Bounds

Let (*fltIn*, *fltUpperLimit*) ∈ *X* be a set of inputs to GFLIB_UpperLimit_FLT,

then

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Table 142. GFLIB_UpperLimit_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
All inputs are normalized, denormalized, i.e. $\left\{ \begin{matrix} (fltIn, fltUpperLimit) \in X \\ X \cap M = \varnothing \end{matrix} \right\}$	0	N/A
At least one of the inputs is NaN or infinite, i.e. $\left\{ \begin{matrix} (fltIn, fltUpperLimit) \in X \\ X \cap M \neq \varnothing \vee \end{matrix} \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)

2.41 Function GFLIB_VectorLimit_FLT

2.41.1 Declaration

```
tBool GFLIB_VectorLimit_FLT(SWLIBS_2Syst_FLT *const pOut, const
SWLIBS_2Syst_FLT *const pIn, const GFLIB_VECTORLIMIT_T_FLT *const
pParam);
```

2.41.2 Arguments

Table 143. GFLIB_VectorLimit_FLT arguments

Type	Name	Direction	Description
SWLIBS_2Syst_FLT *const	pOut	**output**	Pointer to the structure of the limited output vector.
const SWLIBS_2Syst_FLT *const	pIn	**input**	Pointer to the structure of the input vector.
const GFLIB_VECTORLIMIT_T_FLT *const	pParam	**input**	Pointer to the parameters structure.

2.41.3 Worst-Case Error Bounds

Let (*fltArg1*, *fltArg2*, *fltLimit*) $\in X$ be a set of inputs to GFLIB_VectorLimit_FLT,

reffltArg1, *reffltArg2* be the theoretical exact results for outputs *fltArg1* and *fltArg2*, respectively,

$ir_1 = fltArg1 \cdot fltArg1$,

$ir_2 = fltArg2 \cdot fltArg2$,

$ir_3 = ir_1 + ir_2$,

$ir_4 = \sqrt{ir_3}$,

$ir_5 = \frac{fltLimit}{ir_4}$,

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$ir_6 = fltArg1 \cdot ir_5,$

$ir_7 = fltArg2 \cdot ir_5,$

then

Table 144. GFLIB_VectorLimit_FLT Return Value

Subset of input domain	Meaningful Return Value
Any of the inputs is denormalized, others are normalized or zero, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltLimit) \in X \\ X \cap D \neq \varnothing \wedge X \cap M = \varnothing \end{matrix} \right\}$	No
Any of the inputs is NaN or infinity, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltLimit) \in X \\ X \cap M \neq \varnothing \end{matrix} \right\}$	No
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltLimit) \in X \\ X \subset N \cup \{-0, +0\}, \\ \left\{ \begin{matrix} refFltArg1, refFltArg2, \\ ir_1, ir_2, ir_3, ir_4, ir_5, ir_6, ir_7 \end{matrix} \right\} \subset N \cup \{-0, +0\} \end{matrix} \right\}$	Yes
Normalized or zero input values which cause an output underflow, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltLimit) \in X \\ X \subset N \cup \{-0, +0\}, \\ \{refFltArg1, refFltArg2\} \cap M \neq \varnothing \\ \left(\begin{matrix} \lvert refFltArg1 \rvert - 276 \cdot \mathrm{ULP}(refFltArg1) \in D \wedge \\ refFltArg1 \neq 0 \end{matrix} \right) \vee \\ \left(\begin{matrix} \lvert refFltArg2 \rvert - 276 \cdot \mathrm{ULP}(refFltArg2) \in D \wedge \\ refFltArg2 \neq 0 \end{matrix} \right) \end{matrix} \right\}$	No
Normalized or zero input values which cause an output overflow, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltLimit) \in X \\ X \subset N \cup \{-0, +0\}, \\ (\lvert refFltArg1 \rvert + 276 \cdot \mathrm{ULP}(refFltArg1) \in M \wedge) \vee \\ (\lvert refFltArg2 \rvert + 276 \cdot \mathrm{ULP}(refFltArg2) \in M \wedge) \end{matrix} \right\}$	No

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Table 144. GFLIB_VectorLimit_FLT Return Value*...continued*

Subset of input domain	Meaningful Return Value
Normalized or zero input values which cause intermediate results underflow, i.e. $\left\{ \begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltIntegPartK_1, fltInK_1 \end{pmatrix} \in X \middle\vert \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ (\lvert ir_1 \rvert - 0.5 \cdot \mathrm{ULP}(ir_1) \in D \wedge ir_1 \neq 0) \vee \\ (\lvert ir_2 \rvert - 0.5 \cdot \mathrm{ULP}(ir_2) \in D \wedge ir_2 \neq 0) \vee \\ (\lvert ir_3 \rvert - \mathrm{ULP}(ir_3) \in D \wedge ir_3 \neq 0) \vee \\ (\lvert ir_4 \rvert - 276 \cdot \mathrm{ULP}(ir_4) \in D \wedge ir_4 \neq 0) \vee \\ (\lvert ir_5 \rvert - 276 \cdot \mathrm{ULP}(ir_5) \in D \wedge ir_5 \neq 0) \vee \\ (\lvert ir_6 \rvert - 276 \cdot \mathrm{ULP}(ir_6) \in D \wedge ir_6 \neq 0) \vee \\ (\lvert ir_7 \rvert - 276 \cdot \mathrm{ULP}(ir_7) \in D \wedge ir_7 \neq 0), \\ \{ir_1, ir_2, ir_3, ir_4, ir_5, ir_6, ir_7\} \cap M \neq \varnothing \end{array} \right\}$	No
Normalized or zero input values which cause intermediate results overflow, i.e. $\left\{ \begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltIntegPartK_1, fltInK_1 \end{pmatrix} \in X \middle\vert \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ (\lvert ir_1 \rvert + 0.5 \cdot \mathrm{ULP}(ir_1) \in M) \vee \\ (\lvert ir_2 \rvert + 0.5 \cdot \mathrm{ULP}(ir_2) \in M) \vee \\ (\lvert ir_3 \rvert + \mathrm{ULP}(ir_3) \in M) \vee \\ (\lvert ir_4 \rvert + 276 \cdot \mathrm{ULP}(ir_4) \in M) \vee \\ (\lvert ir_5 \rvert + 276 \cdot \mathrm{ULP}(ir_5) \in M) \vee \\ (\lvert ir_6 \rvert + 276 \cdot \mathrm{ULP}(ir_6) \in M) \vee \\ (\lvert ir_7 \rvert + 276 \cdot \mathrm{ULP}(ir_7) \in M) \end{array} \right\}$	No

Table 145. GFLIB_VectorLimit_FLT Worst-Case Error Bounds - fltArg1 Output

Subset of input domain	Worst-case error bounds for fltArg1 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg1 output
Any of the inputs is denormalized, others are normalized or zero, i.e. $\left\{ (fltArg1, fltArg2, fltLimit) \in X \middle\vert \begin{array}{c} X \cap D \neq \varnothing \wedge X \cap M = \varnothing \end{array} \right\}$	$(-Inf, Inf)$	N/A

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Table 145. GFLIB_VectorLimit_FLT Worst-Case Error Bounds - fltArg1 Output*...continued*

Subset of input domain	Worst-case error bounds for fltArg1 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg1 output
Any of the inputs is NaN or infinity, i.e. $\left\{ (fltArg1, fltArg2, fltLimit) \in X \middle\vert \begin{matrix} X \cap M \neq \varnothing \end{matrix} \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltLimit) \in X \vert \\ X \subset N \cup \{-0, +0\}, \\ \left\{ \begin{matrix} refFltArg1, refFltArg2, \\ ir_1, ir_2, ir_3, ir_4, ir_5, ir_6, ir_7 \end{matrix} \right\} \subset N \cup \{-0, +0\} \end{matrix} \right\}$	$\langle -276, 276 \rangle$	N/A
Normalized or zero input values which cause an output underflow, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltLimit) \in X \vert \\ X \subset N \cup \{-0, +0\}, \\ \{refFltArg1, refFltArg2\} \cap M \neq \varnothing \\ \left(\begin{matrix} \lvert refFltArg1 \rvert - 276 \cdot \mathrm{ULP}(refFltArg1) \in D \wedge \\ refFltArg1 \neq 0 \end{matrix} \right) \vee \\ \left(\begin{matrix} \lvert refFltArg2 \rvert - 276 \cdot \mathrm{ULP}(refFltArg2) \in D \wedge \\ refFltArg2 \neq 0 \end{matrix} \right) \end{matrix} \right\}$	$(-Inf, Inf)$	N/A
Normalized or zero input values which cause an output overflow, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltLimit) \in X \vert \\ X \subset N \cup \{-0, +0\}, \\ (\lvert refFltArg1 \rvert + 276 \cdot \mathrm{ULP}(refFltArg1) \in M \wedge) \vee \\ (\lvert refFltArg2 \rvert + 276 \cdot \mathrm{ULP}(refFltArg2) \in M \wedge) \end{matrix} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

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Table 145. GFLIB_VectorLimit_FLT Worst-Case Error Bounds - fltArg1 Output*...continued*

Subset of input domain	Worst-case error bounds for fltArg1 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg1 output
Normalized or zero input values which cause intermediate results underflow, i.e. $\left\{ \begin{array}{c} \begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltIntegPartK_1, fltInK_1 \end{pmatrix} \in X \\ X \subset N \cup \{-0, +0\}, \\ (\lvert ir_1 \rvert - 0.5 \cdot \mathrm{ULP}(ir_1) \in D \wedge ir_1 \neq 0) \vee \\ (\lvert ir_2 \rvert - 0.5 \cdot \mathrm{ULP}(ir_2) \in D \wedge ir_2 \neq 0) \vee \\ (\lvert ir_3 \rvert - \mathrm{ULP}(ir_3) \in D \wedge ir_3 \neq 0) \vee \\ (\lvert ir_4 \rvert - 276 \cdot \mathrm{ULP}(ir_4) \in D \wedge ir_4 \neq 0) \vee \\ (\lvert ir_5 \rvert - 276 \cdot \mathrm{ULP}(ir_5) \in D \wedge ir_5 \neq 0) \vee \\ (\lvert ir_6 \rvert - 276 \cdot \mathrm{ULP}(ir_6) \in D \wedge ir_6 \neq 0) \vee \\ (\lvert ir_7 \rvert - 276 \cdot \mathrm{ULP}(ir_7) \in D \wedge ir_7 \neq 0), \\ \{ir_1, ir_2, ir_3, ir_4, ir_5, ir_6, ir_7\} \cap M \neq \varnothing \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}
Normalized or zero input values which cause intermediate results overflow, i.e. $\left\{ \begin{array}{c} \begin{pmatrix} fltInErr, fltPropGain, fltIntegGain, \\ fltIntegPartK_1, fltInK_1 \end{pmatrix} \in X \\ X \subset N \cup \{-0, +0\}, \\ (\lvert ir_1 \rvert + 0.5 \cdot \mathrm{ULP}(ir_1) \in M) \vee \\ (\lvert ir_2 \rvert + 0.5 \cdot \mathrm{ULP}(ir_2) \in M) \vee \\ (\lvert ir_3 \rvert + \mathrm{ULP}(ir_3) \in M) \vee \\ (\lvert ir_4 \rvert + 276 \cdot \mathrm{ULP}(ir_4) \in M) \vee \\ (\lvert ir_5 \rvert + 276 \cdot \mathrm{ULP}(ir_5) \in M) \vee \\ (\lvert ir_6 \rvert + 276 \cdot \mathrm{ULP}(ir_6) \in M) \vee \\ (\lvert ir_7 \rvert + 276 \cdot \mathrm{ULP}(ir_7) \in M) \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

Table 146. GFLIB_VectorLimit_FLT Worst-Case Error Bounds - fltArg2 Output

Subset of input domain	Worst-case error bounds for fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg2 output
Any of the inputs is denormalized, others are normalized or zero, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2, fltLimit) \in X \\ X \cap D \neq \varnothing \wedge X \cap M = \varnothing \end{array} \right\}$	$(-Inf, Inf)$	N/A

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Table 146. GFLIB_VectorLimit_FLT Worst-Case Error Bounds - fltArg2 Output*...continued*

Subset of input domain	Worst-case error bounds for fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg2 output
Any of the inputs is NaN or infinity, i.e. $\left\{ (fltArg1, fltArg2, fltLimit) \in X \middle\vert \begin{matrix} X \cap M \neq \varnothing \end{matrix} \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltLimit) \in X \vert \\ X \subset N \cup \{-0, +0\}, \\ \left\{ \begin{matrix} refFltArg1, refFltArg2, \\ ir_1, ir_2, ir_3, ir_4, ir_5, ir_6, ir_7 \end{matrix} \right\} \subset N \cup \{-0, +0\} \end{matrix} \right\}$	$\langle -276, 276 \rangle$	N/A
Normalized or zero input values which cause an output underflow, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltLimit) \in X \vert \\ X \subset N \cup \{-0, +0\}, \\ \{refFltArg1, refFltArg2\} \cap M \neq \varnothing \\ \left(\begin{matrix} \lvert refFltArg1 \rvert - 276 \cdot \mathrm{ULP}(refFltArg1) \in D \wedge \\ refFltArg1 \neq 0 \end{matrix} \right) \vee \\ \left(\begin{matrix} \lvert refFltArg2 \rvert - 276 \cdot \mathrm{ULP}(refFltArg2) \in D \wedge \\ refFltArg2 \neq 0 \end{matrix} \right) \end{matrix} \right\}$	$(-Inf, Inf)$	N/A
Normalized or zero input values which cause an output overflow, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltLimit) \in X \vert \\ X \subset N \cup \{-0, +0\}, \\ (\lvert refFltArg1 \rvert + 276 \cdot \mathrm{ULP}(refFltArg1) \in M \wedge) \vee \\ (\lvert refFltArg2 \rvert + 276 \cdot \mathrm{ULP}(refFltArg2) \in M \wedge) \end{matrix} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

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Table 146. GFLIB_VectorLimit_FLT Worst-Case Error Bounds - fltArg2 Output*...continued*

Subset of input domain	Worst-case error bounds for fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg2 output
Normalized or zero input values which cause intermediate results underflow, i.e. $\left\{ \begin{array}{c} \left(\begin{array}{c} fltInErr, fltPropGain, fltIntegGain, \\ fltIntegPartK_1, fltInK_1 \end{array} \right) \in X \\ X \subset N \cup \{-0, +0\}, \\ (\lvert ir_1 \rvert - 0.5 \cdot \mathrm{ULP}(ir_1) \in D \wedge ir_1 \neq 0) \vee \\ (\lvert ir_2 \rvert - 0.5 \cdot \mathrm{ULP}(ir_2) \in D \wedge ir_2 \neq 0) \vee \\ (\lvert ir_3 \rvert - \mathrm{ULP}(ir_3) \in D \wedge ir_3 \neq 0) \vee \\ (\lvert ir_4 \rvert - 276 \cdot \mathrm{ULP}(ir_4) \in D \wedge ir_4 \neq 0) \vee \\ (\lvert ir_5 \rvert - 276 \cdot \mathrm{ULP}(ir_5) \in D \wedge ir_5 \neq 0) \vee \\ (\lvert ir_6 \rvert - 276 \cdot \mathrm{ULP}(ir_6) \in D \wedge ir_6 \neq 0) \vee \\ (\lvert ir_7 \rvert - 276 \cdot \mathrm{ULP}(ir_7) \in D \wedge ir_7 \neq 0), \\ \{ir_1, ir_2, ir_3, ir_4, ir_5, ir_6, ir_7\} \cap M \neq \varnothing \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}
Normalized or zero input values which cause intermediate results overflow, i.e. $\left\{ \begin{array}{c} \left(\begin{array}{c} fltInErr, fltPropGain, fltIntegGain, \\ fltIntegPartK_1, fltInK_1 \end{array} \right) \in X \\ X \subset N \cup \{-0, +0\}, \\ (\lvert ir_1 \rvert + 0.5 \cdot \mathrm{ULP}(ir_1) \in M) \vee \\ (\lvert ir_2 \rvert + 0.5 \cdot \mathrm{ULP}(ir_2) \in M) \vee \\ (\lvert ir_3 \rvert + \mathrm{ULP}(ir_3) \in M) \vee \\ (\lvert ir_4 \rvert + 276 \cdot \mathrm{ULP}(ir_4) \in M) \vee \\ (\lvert ir_5 \rvert + 276 \cdot \mathrm{ULP}(ir_5) \in M) \vee \\ (\lvert ir_6 \rvert + 276 \cdot \mathrm{ULP}(ir_6) \in M) \vee \\ (\lvert ir_7 \rvert + 276 \cdot \mathrm{ULP}(ir_7) \in M) \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

2.42 Function GFLIB_VLog10_FLT

2.42.1 Declaration

```
void GFLIB_VLog10_FLT(tFloat *pInOut, tU32 u32N, const
GFLIB_VLOG10_T_FLT *const pParam);
```

2.42.2 Arguments

Table 147. GFLIB_VLog10_FLT arguments

Type	Name	Direction	Description
tFloat *	pInOut	**input, output**	Pointer to the floating-point input/output data array. Must be aligned to a double-word boundary.

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Table 147. GFLIB_VLog10_FLT arguments*...continued*

Type	Name	Direction	Description
tU32	u32N	**input**	Array length. Must be divisible by 8 (i.e. 8, 16, 24, ...).
const GFLIB_VLOG10_T_FLT *const	pParam	**input**	Pointer to an array of approximation coefficients.

2.42.3 Worst-Case Error Bounds

Only the default approximation coefficients are considered.

Let *fltIn* ∈ *X* be an input to GFLIB_VLog10_FLT,

then

Table 148. GFLIB_VLog10_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case output value error bounds [ulp]	Allowed specific output values (regardless the error bounds)
Input not normalized, i.e. $\{fltIn \in X \mid fltIn \notin N\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, –Inf, NaN)
Input normalized, i.e. $\{fltIn \in X \mid fltIn \in N\}$	$\langle -760, 760 \rangle$	N/A

2.43 Function GFLIB_VMin_FLT

2.43.1 Declaration

```
tU32 GFLIB_VMin_FLT(const tFloat *pIn, tU32 u32N);
```

2.43.2 Arguments

Table 149. GFLIB_VMin_FLT arguments

Type	Name	Direction	Description
const tFloat *	pIn	**input**	Pointer to an array of single precision floating-point input values.
tU32	u32N	**input**	Length of the input array.

2.43.3 Worst-Case Error Bounds

The return value is exact if all inputs are normalized or zero. The return value is undefined if any of the inputs are denormalized, infinite, or not a number.

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2.44 Function GMCLIB_BetaProjection_FLT

2.44.1 Declaration

```
void GMCLIB_BetaProjection_FLT(SWLIBS_2Syst_FLT *const pOut,
const SWLIBS_3Syst_FLT *const pIn);
```

2.44.2 Arguments

Table 150. GMCLIB_BetaProjection_FLT arguments

Type	Name	Direction	Description
const SWLIBS_3Syst_FLT *const	pIn	**input**	Pointer to the structure containing data of the three-phase stationary system (fltA-fltB-fltC). Arguments of the structure contain single precision floating point values.
SWLIBS_2Syst_FLT *const	pOut	**output**	Pointer to the structure containing data of the two-phase stationary orthogonal system (α-β). Arguments of the structure contain single precision floating point values.

2.44.3 Worst-Case Error Bounds

Let (*fltArg1*, *fltArg2*, *fltArg3*) ∈ *X* be a set of inputs to GMCLIB_BetaProjection_FLT,

$$ir_1 = fltArg2 + fltArg3,$$

$$ir_2 = 2 \cdot fltArg1,$$

$$ir_3 = ir_1 + ir_2,$$

$$ie_1 = \max(\mathrm{fe}(|ir_1| + 0.5 \cdot \mathrm{ULP}(ir_1)), \mathrm{fe}(|ir_2|)),$$

$$ie_2 = \mathrm{fe}(ir_3),$$

$$cb = \begin{cases} 0, & ie_1 - ie_2 \le 0 \\ ie_1 - ie_2, & ie_1 - ie_2 > 0 \end{cases},$$

$$me_1 = 0.5 + 0.5 \cdot 2^{cb},$$

$$ir_4 = \frac{ir_3}{3},$$

$$me_2 = 1.5 + 2 \cdot me_1,$$

$$ir_5 = fltArg2 - fltArg3,$$

$$ir_6 = \frac{ir_5}{\sqrt{3}},$$

then

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Table 151. GMCLIB_BetaProjection_FLT Worst-Case Error Bounds - fltArg1 Output

Subset of input domain	Worst-case error bounds for fltArg1 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg1 output
Any of the inputs is NaN or infinity, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltArg3) \in X \\ X \cap M \neq \varnothing \end{matrix} \right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}
Any of the inputs is denormalized, others are normalized or zero, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltArg3) \in X \\ X \cap D \neq \varnothing \wedge X \cap M = \varnothing \end{matrix} \right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltArg3) \in X \\ X \subset N \cup \{-0, +0\}, \\ \{ir_1, ir_2, ir_3, ir_4, ir_5, ir_6\} \subset N \cup \{-0, +0\}, \end{matrix} \right\}$	$\langle -me_2, me_2 \rangle$	N/A
Normalized or zero input values which cause result overflow, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltArg3) \in X \\ X \subset N \cup \{-0, +0\}, \\ \exists n : ir_n \cap M \neq \varnothing \end{matrix} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}
Normalized or zero input values which cause result underflow, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltArg3) \in X \\ X \subset N \cup \{-0, +0\}, \\ \exists n : ir_n \cap D \neq \varnothing \end{matrix} \right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}

Table 152. GMCLIB_BetaProjection_FLT Worst-Case Error Bounds - fltArg2 Output

Subset of input domain	Worst-case error bounds for fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg2 output
Any of the inputs is NaN or infinity, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltArg3) \in X \\ X \cap M \neq \varnothing \end{matrix} \right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}

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Table 152. GMCLIB_BetaProjection_FLT Worst-Case Error Bounds - fltArg2 Output*...continued*

Subset of input domain	Worst-case error bounds for fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg2 output
Any of the inputs is denormalized, others are normalized or zero, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2, fltArg3) \in X \\ X \cap D \neq \varnothing \wedge X \cap M = \varnothing \end{array} \right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2, fltArg3) \in X \\ X \subset N \cup \{-0, +0\}, \\ \{ir_1, ir_2, ir_3, ir_4, ir_5, ir_6\} \subset N \cup \{-0, +0\}, \end{array} \right\}$	(-2.5, 2.5)	N/A
Normalized or zero input values which cause result overflow, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2, fltArg3) \in X \\ X \subset N \cup \{-0, +0\}, \\ \exists n : ir_n \cap M \neq \varnothing \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}
Normalized or zero input values which cause result underflow, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2, fltArg3) \in X \\ X \subset N \cup \{-0, +0\}, \\ \exists n : ir_n \cap D \neq \varnothing \end{array} \right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}

2.45 Function GMCLIB_BetaProjection3Ph_FLT

2.45.1 Declaration

```
void GMCLIB_BetaProjection3Ph_FLT(SWLIBS_3Syst_FLT *const pOut,
const SWLIBS_3Syst_FLT *const pIn);
```

2.45.2 Arguments

Table 153. GMCLIB_BetaProjection3Ph_FLT arguments

Type	Name	Direction	Description
const SWLIBS_3Syst_FLT *const	pIn	**input**	Pointer to the structure containing data of the input three-phase stationary system (fltA-fltB-fltC). Arguments of the structure contain single precision floating point values.

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Table 153. GMCLIB_BetaProjection3Ph_FLT arguments*...continued*

Type	Name	Direction	Description
SWLIBS_3Syst_FLT *const	pOut	**output**	Pointer to the structure containing data of the output three-phase stationary orthogonal system (fltAout-fltBout-fltCout). Arguments of the structure contain single precision floating point values.

2.45.3 Worst-Case Error Bounds

Let (*fltArg1*, *fltArg2*, *fltArg3*) ∈ *X* be a set of inputs to GMCLIB_BetaProjection3Ph_FLT,

$$ir_1 = fltArg2 + fltArg3,$$

$$ir_2 = 2 \cdot fltArg1,$$

$$ir_3 = ir_1 + ir_2,$$

$$ie_1 = \max(\mathrm{fe}(|ir_1| + 0.5 \cdot \mathrm{ULP}(ir_1)), \mathrm{fe}(|ir_2|)),$$

$$ie_2 = \mathrm{fe}(ir_3),$$

$$cb_1 = \begin{cases} 0, & ie_1 - ie_2 \le 0 \\ ie_1 - ie_2, & ie_1 - ie_2 > 0 \end{cases},$$

$$me_1 = 0.5 + 0.5 \cdot 2^{cb_1},$$

$$ir_4 = \frac{ir_3}{3},$$

$$me_2 = 1.5 + 2 \cdot me_1,$$

$$ir_5 = fltArg1 + fltArg3,$$

$$ir_6 = 2 \cdot fltArg2,$$

$$ir_7 = ir_5 + ir_6,$$

$$ie_3 = \max(\mathrm{fe}(|ir_5| + 0.5 \cdot \mathrm{ULP}(ir_5)), \mathrm{fe}(|ir_6|)),$$

$$ie_4 = \mathrm{fe}(ir_7),$$

$$cb_2 = \begin{cases} 0, & ie_3 - ie_4 \le 0 \\ ie_3 - ie_4, & ie_3 - ie_4 > 0 \end{cases},$$

$$me_3 = 0.5 + 0.5 \cdot 2^{cb_2},$$

$$ir_8 = \frac{ir_7}{3},$$

$$me_4 = 1.5 + 2 \cdot me_3,$$

$$ir_9 = fltArg1 + fltArg2,$$

$$ir_{10} = 2 \cdot fltArg3,$$

$$ir_{11} = ir_9 + ir_{10},$$

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$ie_5 = \max(\mathrm{fe}(|ir_9| + 0.5 \cdot \mathrm{ULP}(ir_9)), \mathrm{fe}(|ir_{10}|))$,

$ie_6 = \mathrm{fe}(ir_{11})$,

$cb_3 = \begin{cases} 0, & ie_5 - ie_6 \le 0 \\ ie_5 - ie_6, & ie_5 - ie_6 > 0 \end{cases}$,

$me_5 = 0.5 + 0.5 \cdot 2^{cb_3}$,

$ir_{12} = \frac{ir_{11}}{3}$,

$me_6 = 1.5 + 2 \cdot me_5$,

then

Table 154. GMCLIB_BetaProjection3Ph_FLT Worst-Case Error Bounds - fltArg1 Output

Subset of input domain	Worst-case error bounds for fltArg1 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg1 output
Any of the inputs is NaN or infinity, i.e. $\left\{ (fltArg1, fltArg2, fltArg3) \in X \middle\vert X \cap M \neq \varnothing \right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}
Any of the inputs is denormalized, others are normalized or zero, i.e. $\left\{ (fltArg1, fltArg2, fltArg3) \in X \middle\vert X \cap D \neq \varnothing \wedge X \cap M = \varnothing \right\}$	$(-Inf, Inf)$	N/A
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ (fltArg1, fltArg2, fltArg3) \in X \middle\vert X \subset N \cup \{-0, +0\}, ir_n \subset N \cup \{-0, +0\}\ for\ \forall\, n \right\}$	$\langle -me_2, me_2 \rangle$	N/A
Normalized or zero input values which cause result overflow, i.e. $\left\{ (fltArg1, fltArg2, fltArg3) \in X \middle\vert X \subset N \cup \{-0, +0\}, \exists\, n : ir_n \cap M \neq \varnothing \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

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Table 154. GMCLIB_BetaProjection3Ph_FLT Worst-Case Error Bounds - fltArg1 Output...*continued*

Subset of input domain	Worst-case error bounds for fltArg1 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg1 output
Normalized or zero input values which cause result underflow, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2, fltArg3) \in X \\ X \subset N \cup \{-0, +0\}, \\ \exists n: ir_n \cap D \neq \varnothing \end{array} \right\}$	$(-Inf, Inf)$	N/A

Table 155. GMCLIB_BetaProjection3Ph_FLT Worst-Case Error Bounds - fltArg2 Output

Subset of input domain	Worst-case error bounds for fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg2 output
Any of the inputs is NaN or infinity, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2, fltArg3) \in X \\ X \cap M \neq \varnothing \end{array} \right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}
Any of the inputs is denormalized, others are normalized or zero, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2, fltArg3) \in X \\ X \cap D \neq \varnothing \wedge X \cap M = \varnothing \end{array} \right\}$	$(-Inf, Inf)$	N/A
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2, fltArg3) \in X \\ X \subset N \cup \{-0, +0\}, \\ ir_n \subset N \cup \{-0, +0\} \ for \ \forall n \end{array} \right\}$	$\langle -me_4, me_4 \rangle$	N/A
Normalized or zero input values which cause result overflow, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2, fltArg3) \in X \\ X \subset N \cup \{-0, +0\}, \\ \exists n: ir_n \cap M \neq \varnothing \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

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Table 155. GMCLIB_BetaProjection3Ph_FLT Worst-Case Error Bounds - fltArg2 Output...*continued*

Subset of input domain	Worst-case error bounds for fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg2 output
Normalized or zero input values which cause result underflow, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2, fltArg3) \in X \\ X \subset N \cup \{-0, +0\}, \\ \exists n: ir_n \cap D \neq \varnothing \end{array} \right\}$	$(-Inf, Inf)$	N/A

Table 156. GMCLIB_BetaProjection3Ph_FLT Worst-Case Error Bounds - fltArg3 Output

Subset of input domain	Worst-case error bounds for fltArg3 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg3 output
Any of the inputs is NaN or infinity, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2, fltArg3) \in X \\ X \cap M \neq \varnothing \end{array} \right\}$	$(-Inf, Inf)$	{Inf, -Inf, NaN}
Any of the inputs is denormalized, others are normalized or zero, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2, fltArg3) \in X \\ X \cap D \neq \varnothing \wedge X \cap M = \varnothing \end{array} \right\}$	$(-Inf, Inf)$	N/A
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2, fltArg3) \in X \\ X \subset N \cup \{-0, +0\}, \\ ir_n \subset N \cup \{-0, +0\} \ for \ \forall n \end{array} \right\}$	$\langle -me_6, me_6 \rangle$	N/A
Normalized or zero input values which cause result overflow, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2, fltArg3) \in X \\ X \subset N \cup \{-0, +0\}, \\ \exists n: ir_n \cap M \neq \varnothing \end{array} \right\}$	$(-Inf, Inf)$	{Inf, –Inf, NaN}

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Table 156. GMCLIB_BetaProjection3Ph_FLT Worst-Case Error Bounds - fltArg3 Output*...continued*

Subset of input domain	Worst-case error bounds for fltArg3 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg3 output
Normalized or zero input values which cause result underflow, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2, fltArg3) \in X \\ X \subset N \cup \{-0, +0\}, \\ \exists n : ir_n \cap D \neq \varnothing \end{array} \right\}$	$(-Inf, Inf)$	N/A

2.46 Function GMCLIB_Clark_FLT

2.46.1 Declaration

```
void GMCLIB_Clark_FLT(SWLIBS_2Syst_FLT *const pOut, const
SWLIBS_3Syst_FLT *const pIn);
```

2.46.2 Arguments

Table 157. GMCLIB_Clark_FLT arguments

Type	Name	Direction	Description
const SWLIBS_3Syst_FLT *const	pIn	**input**	Pointer to the structure containing data of the three-phase stationary system (fltA-fltB-fltC). Arguments of the structure contain single precision floating point values.
SWLIBS_2Syst_FLT *const	pOut	**output**	Pointer to the structure containing data of the two-phase stationary orthogonal system (α-β). Arguments of the structure contain single precision floating point values.

2.46.3 Worst-Case Error Bounds

Let (*fltArg1*, *fltArg2*, *fltArg3*) ∈ *X* be a set of inputs to GMCLIB_Clark_FLT,

reffltArg1, *reffltArg2* be the theoretical exact results for outputs *fltArg1* and *fltArg2*, respectively,

$ir = fltArg2 - fltArg3$,

then

Table 158. GMCLIB_Clark_FLT Worst-Case Error Bounds - fltArg1 Output

Subset of input domain	Worst-case error bounds for fltArg1 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg1 output
Entire input domain	0	*fltArg1*

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Table 159. GMCLIB_Clark_FLT Worst-Case Error Bounds - fltArg2 Output

Subset of input domain	Worst-case error bounds for fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg2 output
Inputs fltArg2 and fltArg3 infinity, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltArg3) \in X \mid \\ fltArg2 \in \{Inf, -Inf\}, \\ fltArg3 \in \{Inf, -Inf\} \end{matrix} \right\}$	N/A	{Inf, -Inf, NaN, *pmax*, *nmax*}
fltArg2 arbitrary value, *fltArg3* NaN, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltArg3) \in X \mid \\ fltArg3 = NaN \end{matrix} \right\}$	N/A	{NaN, *pmax*, *nmax*}
fltArg2 infinity, *fltArg3* normalized, denormalized, or zero, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltArg3) \in X \mid \\ fltArg2 \in \{Inf, -Inf\}, \\ fltArg3 \in N \cup D \cup \{-0, +0\} \end{matrix} \right\}$	N/A	{sign(*fltArg2*)•Inf, sign(*fltArg2*)•pmax}
fltArg2 NaN, *fltArg3* arbitrary value, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltArg3) \in X \mid \\ fltArg2 = NaN \end{matrix} \right\}$	N/A	{NaN, *pmax*, *nmax*}
fltArg2 normalized, denormalized, or zero, *fltArg3* infinity, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltArg3) \in X \mid \\ fltArg2 \in N \cup D \cup \{-0, +0\}, \\ fltArg3 \in \{Inf, -Inf\} \end{matrix} \right\}$	N/A	{-sign(*fltArg3*)•Inf, -sign(*fltArg3*)•pmax}
Inputs fltArg2 and fltArg3 denormalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltArg3) \in X \mid \\ X \subset D \end{matrix} \right\}$	$(-Inf, Inf)$	{-0, +0}
fltArg2 denormalized, *fltArg3* zero, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltArg3) \in X \mid \\ fltArg2 \in D, fltIn_2 = 0 \end{matrix} \right\}$	$(-Inf, Inf)$	{-0, +0}

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Table 159. GMCLIB_Clark_FLT Worst-Case Error Bounds - fltArg2 Output*...continued*

Subset of input domain	Worst-case error bounds for fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg2 output
fltArg2 denormalized, *fltArg3* normalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltArg3) \in X \mid \\ fltArg2 \in D, \\ fltArg3 \in N \end{matrix} \right\}$	$(-Inf, Inf)$	N/A
fltArg2 zero, *fltArg3* denormalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltArg3) \in X \mid \\ fltArg2 = 0, fltArg3 \in D \end{matrix} \right\}$	$(-Inf, Inf)$	{-0, +0}
Inputs fltArg2 and fltArg3 zero, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltArg3) \in X \mid \\ fltArg2 = 0, fltArg3 = 0 \end{matrix} \right\}$	0	N/A
fltArg2 zero, *fltArg3* normalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltArg3) \in X \mid \\ fltArg2 = 0, \\ fltArg3 \in N \end{matrix} \right\}$	$\langle -2.5, 2.5 \rangle$	N/A
fltArg2 normalized, *fltArg3* denormalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltArg3) \in X \mid \\ fltArg2 \in N, fltArg3 \in D \end{matrix} \right\}$	$(-Inf, Inf)$	N/A
fltArg2 normalized, *fltArg3* zero, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltArg3) \in X \mid \\ fltArg2 \in N, fltArg3 = 0 \end{matrix} \right\}$	$\langle -2.5, 2.5 \rangle$	N/A
Inputs fltArg2 and fltArg3 normalized, results normalized or zero, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2, fltArg3) \in X \mid \\ X \subset N, \\ refFltArg2 = 0 \vee \\ \left(\begin{matrix} \lvert refFltArg2 \rvert - 0.5 \cdot \mathrm{ULP}(refFltArg2) \notin D \wedge \\ \lvert refFltArg2 \rvert + 0.5 \cdot \mathrm{ULP}(refFltArg2) \neq Inf \end{matrix} \right) \end{matrix} \right\}$	$\langle -2.5, 2.5 \rangle$	N/A

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Table 159. GMCLIB_Clark_FLT Worst-Case Error Bounds - fltArg2 Output*...continued*

Subset of input domain	Worst-case error bounds for fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg2 output
Inputs fltArg2 and fltArg3 normalized, result overflow, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2, fltArg3) \in X \mid \\ X \subset N, \\ \lvert refffltArg2 \rvert + 0.5 \cdot \mathrm{ULP}(refffltArg2) = Inf \end{array} \right\}$	$(-Inf, Inf)$	{sign(reffltArg2)•Inf, sign(reffltArg2)•pmax, NaN}
Inputs fltArg2 and fltArg3 normalized, intermediate result overflow, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2, fltArg3) \in X \mid \\ X \subset N, \\ \lvert ir \rvert + 0.5 \cdot \mathrm{ULP}(ir) = Inf \end{array} \right\}$	$(-Inf, Inf)$	{sign(reffltArg2)•Inf, sign(reffltArg2)•pmax, NaN}
Inputs fltArg2 and fltArg3 normalized, intermediate result underflow, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2, fltArg3) \in X \mid \\ X \subset N, \\ \lvert ir \rvert - 0.5 \cdot \mathrm{ULP}(ir) \in D \wedge \\ ir \neq 0 \end{array} \right\}$	$\langle -2.5, 2.5 \rangle$	{-0, +0}

2.47 Function GMCLIB_Clark6Ph_FLT

2.47.1 Declaration

```
void GMCLIB_Clark6Ph_FLT(SWLIBS_2Syst_FLT *const pOut, const
SWLIBS_6Syst_FLT *const pIn, const GMCLIB_CLARK_6PH_T_FLT *const
pParam);
```

2.47.2 Arguments

Table 160. GMCLIB_Clark6Ph_FLT arguments

Type	Name	Direction	Description
const SWLIBS_6Syst_FLT *const	pIn	**input**	Pointer to the structure containing data of the six-phase machine consisting of two sets of starconnected three-phase stator windings fltA-fltB-fltC and fltD-fltE-fltF. Arguments of the structure contain single precision floating point values.
SWLIBS_2Syst_FLT *const	pOut	**output**	Pointer to the structure containing data of the two-phase stationary orthogonal system (α-β). Arguments of the structure contain single precision floating point values.

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Table 160. GMCLIB_Clark6Ph_FLT arguments...*continued*

Type	Name	Direction	Description
const GMCLIB_CLARK_6PH_T_FLT *const	pParam	**input**	Pointer to the structure containing the transformation coefficient calculated by GMCLIB_Clark6PhInit function. Arguments of the structure contain single precision floating point values.

2.47.3 Worst-Case Error Bounds

Let (*fltArg1*, *fltArg2*, *fltArg3*, *fltArg4*, *fltArg5*, *fltArg6*, *fltAlphaD*, *fltAlphaE*, *fltAlphaF*, *fltBetaD*, *fltBetaE*, *fltBetaF*) $\in X$ be a set of inputs to GMCLIB_Clark6Ph_FLT,

reffltArg1, *reffltArg2* be the theoretical exact results for outputs *fltArg1* and *fltArg2*, respectively,

$$ir_1 = \frac{fltArg1}{2} + fltArg4 \cdot fltAlphaD,$$

$$me_1 = 0.5,$$

$$ir_2 = fltArg5 \cdot fltAlphaE,$$

$$ie_1 = max(fe(|ir_1| + me_1 \cdot ULP(ir_1)), fe(ir_2)),$$

$$ir_3 = ir_1 + ir_2,$$

$$ie_2 = fe(ir_3),$$

$$cb_1 = \begin{cases} 0, & ie_1 - ie_2 \le 0 \\ ie_1 - ie_2, & ie_1 - ie_2 > 0 \end{cases},$$

$$me_2 = 0.5 + me_1 \cdot 2^{cb_1},$$

$$ir_4 = fltArg6 \cdot fltAlphaF,$$

$$ie_3 = max(fe(|ir_3| + me_2 \cdot ULP(ir_3)), fe(ir_4)),$$

$$ie_4 = fe(refffltArg1),$$

$$cb_2 = \begin{cases} 0, & ie_3 - ie_4 \le 0 \\ ie_3 - ie_4, & ie_3 - ie_4 > 0 \end{cases},$$

$$me_3 = 0.5 + me_2 \cdot 2^{cb_2},$$

$$ir_5 = (fltArg2 - fltArg3) \cdot \frac{\sqrt{3}}{6},$$

$$me_4 = 2.5,$$

$$ir_6 = fltArg4 \cdot fltBetaD,$$

$$ie_5 = max(fe(|ir_5| + me_4 \cdot ULP(ir_5)), fe(ir_6)),$$

$$ir_7 = ir_5 + ir_6,$$

$$ie_6 = fe(ir_7),$$

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$$cb_3 = \begin{cases} 0, & ie_5 - ie_6 \le 0 \\ ie_5 - ie_6, & ie_5 - ie_6 > 0 \end{cases},$$

$$me_5 = 0.5 + me_4 \cdot 2^{cb_3},$$

$$ir_8 = fltArg5 \cdot fltBetaD,$$

$$ie_7 = max(fe(|ir_7| + me_5 \cdot ULP(ir_7)), fe(ir_8)),$$

$$ir_9 = ir_7 + ir_8,$$

$$ie_8 = fe(ir_9),$$

$$cb_4 = \begin{cases} 0, & ie_7 - ie_8 \le 0 \\ ie_7 - ie_8, & ie_7 - ie_8 > 0 \end{cases},$$

$$me_6 = 0.5 + me_5 \cdot 2^{cb_4},$$

$$ir_{10} = fltArg6 \cdot fltBetaF,$$

$$ie_9 = max(fe(|ir_9| + me_6 \cdot ULP(ir_9)), fe(ir_{10})),$$

$$ie_{10} = fe(refFltArg2),$$

$$cb_5 = \begin{cases} 0, & ie_9 - ie_{10} \le 0 \\ ie_9 - ie_{10}, & ie_9 - ie_{10} > 0 \end{cases},$$

$$me_7 = 0.5 + me_6 \cdot 2^{cb_5},$$

then

Table 161. GMCLIB_Clark6Ph_FLT Worst-Case Error Bounds - fltArg1 Output

Subset of input domain	Worst-case error bounds for fltArg1 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg1 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \neq \varnothing \vee X \cap M \neq \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 161. GMCLIB_Clark6Ph_FLT Worst-Case Error Bounds - fltArg1 Output*...continued*

Subset of input domain	Worst-case error bounds for fltArg1 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg1 output
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\}, \\ refFltArg1 \subset N \cup \{-0, +0\} \wedge \\ \lvert refFltArg1 \rvert - me_3 \cdot ULP(refFltArg1) \notin D \wedge \\ \lvert refFltArg1 \rvert + me_3 \cdot ULP(refFltArg1) \neq Inf, \\ \{ir_1, ir_2, ir_3, ir_4\} \subset N \cup \{-0, +0\} \wedge \\ \lvert ir_1 \rvert - me_1 \cdot ULP(ir_1) \notin D \wedge \\ \lvert ir_1 \rvert + me_1 \cdot ULP(ir_1) \neq Inf \wedge \\ \lvert ir_3 \rvert - me_2 \cdot ULP(ir_3) \notin D \wedge \\ \lvert ir_3 \rvert + me_2 \cdot ULP(ir_3) \neq Inf \end{array} \right\}$	$\langle -me_7, me_7 \rangle$	N/A
Normalized or zero input values which cause an underflow or an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\}, \\ refFltArg1 \notin \{-0, +0\} \wedge \\ \big(\lvert refFltArg1 \rvert - me_3 \cdot ULP(refFltArg1) \cap D \neq \varnothing \vee \\ \lvert refFltArg1 \rvert + me_3 \cdot ULP(refFltArg1) = Inf \big), \\ \{ir_1, ir_2, ir_3, ir_4\} \notin \{-0, +0\} \wedge \\ \big(\lvert ir_1 \rvert - me_1 \cdot ULP(ir_1) \cap D \neq \varnothing \vee \\ \lvert ir_1 \rvert + me_1 \cdot ULP(ir_1) = Inf \vee \\ \lvert ir_3 \rvert - me_2 \cdot ULP(ir_3) \cap D \neq \varnothing \vee \\ \lvert ir_3 \rvert + me_2 \cdot ULP(ir_3) = Inf \big) \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 162. GMCLIB_Clark6Ph_FLT Worst-Case Error Bounds - fltArg2 Output

Subset of input domain	Worst-case error bounds for fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg2 output
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \neq \varnothing \vee X \cap M \neq \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 162. GMCLIB_Clark6Ph_FLT Worst-Case Error Bounds - fltArg2 Output*...continued*

Subset of input domain	Worst-case error bounds for fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg2 output
Normalized or zero input values which lead to normalized or zero results, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\}, \\ refFltArg2 \subset N \cup \{-0, +0\} \wedge \\ \lvert refFltArg2 \rvert - me_7 \cdot ULP(refFltArg2) \notin D \wedge \\ \lvert refFltArg2 \rvert + me_7 \cdot ULP(refFltArg2) \neq Inf, \\ \{ir_5, ir_6, ir_7, ir_8, ir_9, ir_{10}\} \subset N \cup \{-0, +0\} \wedge \\ \lvert ir_5 \rvert - me_4 \cdot ULP(ir_5) \notin D \wedge \\ \lvert ir_5 \rvert + me_4 \cdot ULP(ir_5) \neq Inf \wedge \\ \lvert ir_7 \rvert - me_5 \cdot ULP(ir_7) \notin D \wedge \\ \lvert ir_7 \rvert + me_5 \cdot ULP(ir_7) \neq Inf \wedge \\ \lvert ir_9 \rvert - me_6 \cdot ULP(ir_9) \notin D \wedge \\ \lvert ir_9 \rvert + me_6 \cdot ULP(ir_9) \neq Inf \end{array} \right\}$	$\langle -me_3, me_3 \rangle$	N/A
Normalized or zero input values which cause an underflow or an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\}, \\ refFltArg2 \notin \{-0, +0\} \wedge \\ \big(\lvert refFltArg2 \rvert - me_7 \cdot ULP(refFltArg2) \cap D \neq \varnothing \vee \\ \lvert refFltArg2 \rvert + me_7 \cdot ULP(refFltArg2) = Inf\big), \\ \{ir_5, ir_6, ir_7, ir_8, ir_9, ir_{10}\} \notin \{-0, +0\} \wedge \\ \big(\lvert ir_5 \rvert - me_4 \cdot ULP(ir_5) \cap D \neq \varnothing \vee \\ \lvert ir_5 \rvert + me_4 \cdot ULP(ir_5) = Inf \vee \\ \lvert ir_7 \rvert - me_5 \cdot ULP(ir_7) \cap D \neq \varnothing \vee \\ \lvert ir_7 \rvert + me_5 \cdot ULP(ir_7) = Inf \vee \\ \lvert ir_9 \rvert - me_6 \cdot ULP(ir_9) \cap D \neq \varnothing \vee \\ \lvert ir_9 \rvert + me_6 \cdot ULP(ir_9) = Inf\big) \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

2.48 Function GMCLIB_ClarkInv_FLT

2.48.1 Declaration

```
void GMCLIB_ClarkInv_FLT(SWLIBS_3Syst_FLT *const pOut, const
SWLIBS_2Syst_FLT *const pIn);
```


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2.48.2 Arguments

Table 163. GMCLIB_ClarkInv_FLT arguments

Type	Name	Direction	Description
const SWLIBS_2Syst_FLT *const	pIn	**input**	Pointer to the structure containing data of the two-phase stationary orthogonal system (α-β). Arguments of the structure contain single precision floating point values.
SWLIBS_3Syst_FLT *const	pOut	**output**	Pointer to the structure containing data of the three-phase stationary system (fltA-fltB-fltC). Arguments of the structure contain single precision floating point values.

2.48.3 Worst-Case Error Bounds

Let (*fltArg1*, *fltArg2*) ∈ *X* be a set of inputs to GMCLIB_ClarkInv_FLT,

reffltArg2, *reffltArg3* be the theoretical exact results for outputs *fltArg2* and *fltArg3*, respectively,

$$ir_1 = 0.5 \cdot fltArg1,$$

$$ir_2 = \frac{\sqrt{3}}{2} \cdot fltArg2,$$

$$ie_1 = \max(\mathrm{fe}(|ir_1|), \mathrm{fe}(|ir_2| + 1.5 \cdot \mathrm{ULP}(ir_2))),$$

$$refInteg = fltIntegPartK_1 + ir_2,$$

$$ix = \mathrm{fe}(refFltArg2),$$

$$iy = \mathrm{fe}(refFltArg3),$$

$$cb_1 = \begin{cases} 0, & ie_1 - ix \le 0 \\ ie_1 - ix, & ie_1 - ix > 0 \end{cases},$$

$$cb_2 = \begin{cases} 0, & ie_1 - iy \le 0 \\ ie_1 - iy, & ie_1 - iy > 0 \end{cases},$$

$$me_1 = 0.5 + 1.5 \cdot 2^{cb_1},$$

$$me_2 = 0.5 + 1.5 \cdot 2^{cb_2},$$

then

Table 164. GMCLIB_ClarkInv_FLT Worst-Case Error Bounds - Output *fltArg1*

Subset of input domain	Worst-case error bounds for *fltArg1* output [ulp]	Allowed specific values (regardless the error bounds) for *fltArg1* output
Entire input domain	0	N/A

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Table 165. GMCLIB_ClarkInv_FLT Worst-Case Error Bounds - Output *fltArg2*

Subset of input domain	Worst-case error bounds for *fltArg2* output [ulp]	Allowed specific values (regardless the error bounds) for *fltArg2* output
Both inputs infinity, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \\ X \subset \{Inf, -Inf\} \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, 0, -0} if sign(*fltArg1*) = sign(*fltArg2*), {sign(*fltArg2*)•Inf, sign(*fltArg2*)•pmax} otherwise
fltArg1 infinity, *fltArg2* NaN, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 = NaN \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, 0, -0, *pmax*, *nmax*}
fltArg1 infinity, *fltArg2* denormalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in D \end{matrix} \right\}$	$(-Inf, Inf)$	{-sign(*fltArg1*)•Inf, sign(*fltArg1*)•pmax}
fltArg1 infinity, *fltArg2* zero, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 = 0 \end{matrix} \right\}$	$(-Inf, Inf)$	{-sign(*fltArg1*)•Inf, sign(*fltArg1*)•pmax}
fltArg1 infinity, *fltArg2* normalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in N \end{matrix} \right\}$	$(-Inf, Inf)$	{-sign(*fltArg1*)•Inf, sign(*fltArg1*)•pmax}
fltArg1 NaN, *fltArg2* infinity, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \\ fltIn_1 = NaN, \\ fltIn_2 \in \{Inf, -Inf\} \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*}

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Table 165. GMCLIB_ClarkInv_FLT Worst-Case Error Bounds - Output *fltArg2* ...continued

Subset of input domain	Worst-case error bounds for *fltArg2* output [ulp]	Allowed specific values (regardless the error bounds) for *fltArg2* output
Both inputs NaN, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 = NaN, \\ fltIn_2 = NaN \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*}
fltArg1 NaN, *fltArg2* denormalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 = NaN, \\ fltIn_2 \in D \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*}
fltArg1 NaN, *fltArg2* zero, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 = NaN, \\ fltIn_2 \in D \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*}
fltArg1 NaN, *fltArg2* normalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 = NaN, \\ fltIn_2 \in N \end{matrix} \right\}$	$(-Inf, Inf)$	NaN
fltArg1 denormalized, *fltArg2* infinite, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 \in \{Inf, -Inf\} \end{matrix} \right\}$	$(-Inf, Inf)$	{sign(*fltArg2*)•Inf, sign(*fltArg2*)•pmax}
fltArg1 denormalized, *fltArg2* NaN, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 = NaN \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*}

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Table 165. GMCLIB_ClarkInv_FLT Worst-Case Error Bounds - Output *fltArg2* ...continued

Subset of input domain	Worst-case error bounds for *fltArg2* output [ulp]	Allowed specific values (regardless the error bounds) for *fltArg2* output
Both inputs denormalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 \in D \end{matrix} \right\}$	$\langle -2^{23}, 2^{23} \rangle$	{0, -0}
fltArg1 zero, *fltArg2* infinite, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 = 0, \\ fltIn_2 \in \{Inf, -Inf\} \end{matrix} \right\}$	$(-Inf, Inf)$	{sign(*fltArg2*)•Inf, sign(*fltArg2*)•pmax}
fltArg1 zero, *fltArg2* NaN, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 = 0, \\ fltIn_2 = NaN \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*}
fltArg1 denormalized, *fltArg2* zero, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 = 0 \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	{0, -0}
fltArg1 zero, *fltArg2* denormalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 = 0, \\ fltIn_2 \in D \end{matrix} \right\}$	$\langle -1.5, 1.5 \rangle$	{0, -0}
fltArg1 normalized, *fltArg2* infinite, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in N, \\ fltIn_2 \in \{Inf, -Inf\} \end{matrix} \right\}$	$(-Inf, Inf)$	sign(*fltArg2*)•Inf

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Table 165. GMCLIB_ClarkInv_FLT Worst-Case Error Bounds - Output *fltArg2* ...continued

Subset of input domain	Worst-case error bounds for *fltArg2* output [ulp]	Allowed specific values (regardless the error bounds) for *fltArg2* output
fltArg1 normalized, *fltArg2* NaN, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in N, \\ fltIn_2 = NaN \end{matrix} \right\}$	$(-Inf, Inf)$	NaN
fltArg1 denormalized, *fltArg2* normalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 \in N \end{matrix} \right\}$	$\langle -2^{23}, 2^{23} \rangle$	N/A
fltArg1 normalized, *fltArg2* denormalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 \in N \end{matrix} \right\}$	$\langle -2^{23}, 2^{23} \rangle$	N/A
Both inputs normalized or zero, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ X \in N \cup \{-0, +0\} \end{matrix} \right\}$	$\langle -me_1, me_1 \rangle$	N/A
Both inputs normalized or zero, *fltArg2* output underflow i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ X \in N \cup \{-0, +0\}, \\ \left(\begin{matrix} \lvert ref fltArg2 \rvert - me_1 \cdot \mathrm{ULP}(ref fltArg2) \in D \wedge \\ ref fltArg2 \neq 0, \end{matrix} \right) \end{matrix} \right\}$	$(-Inf, Inf)$	{-0, +0}
Both inputs normalized or zero, intermediate result underflow i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ X \in N \cup \{-0, +0\}, \\ ir_1 \in D \vee \\ \left(\begin{matrix} \lvert ir_2 \rvert - 1.5 \cdot \mathrm{ULP}(ir_2) \in D \wedge \\ ir_2 \neq 0, \end{matrix} \right) \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, -Inf, Inf}

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Table 165. GMCLIB_ClarkInv_FLT Worst-Case Error Bounds - Output *fltArg2* ...continued

Subset of input domain	Worst-case error bounds for *fltArg2* output [ulp]	Allowed specific values (regardless the error bounds) for *fltArg2* output
Both inputs normalized or zero, *fltArg2* output overflow i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \in N \cup \{-0, +0\}, \\ \lvert reffltArg2 \rvert + me_1 \cdot \mathrm{ULP}(reffltArg2) \in M \end{array} \right\}$	$(-Inf, Inf)$	{NaN, -Inf, Inf}

Table 166. GMCLIB_ClarkInv_FLT Worst-Case Error Bounds - Output *fltArg3*

Subset of input domain	Worst-case error bounds for fltArg3 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg3 output
Both inputs infinity, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset \{Inf, -Inf\} \end{array} \right\}$	$(-Inf, Inf)$	{-sign(*fltArg2*)•Inf, sign(*fltArg2*)•pmax} if sign(*fltArg1*) = sign(*fltArg2*), {NaN, 0, -0} otherwise
fltArg1 infinity, *fltArg2* NaN, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 = NaN \end{array} \right\}$	$(-Inf, Inf)$	{NaN, 0, -0, *pmax*, *nmax*}
fltArg1 infinity, *fltArg2* denormalized, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in D \end{array} \right\}$	$(-Inf, Inf)$	{-sign(*fltArg1*)•Inf, sign(*fltArg1*)•pmax}
fltArg1 infinity, *fltArg2* zero, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 = 0 \end{array} \right\}$	$(-Inf, Inf)$	{-sign(*fltArg1*)•Inf, sign(*fltArg1*)•pmax}
fltArg1 infinity, *fltArg2* normalized, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in N \end{array} \right\}$	$(-Inf, Inf)$	{-sign(*fltArg1*)•Inf, sign(*fltArg1*)•pmax}

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Table 166. GMCLIB_ClarkInv_FLT Worst-Case Error Bounds - Output *fltArg3* ...continued

Subset of input domain	Worst-case error bounds for fltArg3 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg3 output
fltArg1 NaN, *fltArg2* infinity, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 = NaN, \\ fltIn_2 \in \{Inf, -Inf\} \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*}
Both inputs NaN, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 = NaN, \\ fltIn_2 = NaN \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*}
fltArg1 NaN, *fltArg2* denormalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 = NaN, \\ fltIn_2 \in D \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*}
fltArg1 NaN, *fltArg2* zero, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 = NaN, \\ fltIn_2 \in D \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*}
fltArg1 NaN, *fltArg2* normalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 = NaN, \\ fltIn_2 \in N \end{matrix} \right\}$	$(-Inf, Inf)$	NaN
fltArg1 denormalized, *fltArg2* infinite, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 \in \{Inf, -Inf\} \end{matrix} \right\}$	$(-Inf, Inf)$	{-sign(*fltArg2*)•Inf, sign(*fltArg2*)•pmax}

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Table 166. GMCLIB_ClarkInv_FLT Worst-Case Error Bounds - Output *fltArg3* ...continued

Subset of input domain	Worst-case error bounds for fltArg3 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg3 output
fltArg1 denormalized, *fltArg2* NaN, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 = NaN \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*}
Both inputs denormalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 \in D \end{matrix} \right\}$	$\langle -2^{23}, 2^{23} \rangle$	{0, -0}
fltArg1 zero, *fltArg2* infinite, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 = 0, \\ fltIn_2 \in \{Inf, -Inf\} \end{matrix} \right\}$	$(-Inf, Inf)$	{-sign(*fltArg2*)•Inf, sign(*fltArg2*)•pmax}
fltArg1 zero, *fltArg2* NaN, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 = 0, \\ fltIn_2 = NaN \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*}
fltArg1 denormalized, *fltArg2* zero, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 = 0 \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	{0, -0}
fltArg1 zero, *fltArg2* denormalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 = 0, \\ fltIn_2 \in D \end{matrix} \right\}$	$\langle -1.5, 1.5 \rangle$	{0, -0}

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Table 166. GMCLIB_ClarkInv_FLT Worst-Case Error Bounds - Output *fltArg3* ...continued

Subset of input domain	Worst-case error bounds for fltArg3 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg3 output
fltArg1 normalized, *fltArg2* infinite, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in N, \\ fltIn_2 \in \{Inf, -Inf\} \end{matrix} \right\}$	$(-Inf, Inf)$	{-sign(*fltArg2*)•Inf}
fltArg1 normalized, *fltArg2* NaN, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in N, \\ fltIn_2 = NaN \end{matrix} \right\}$	$(-Inf, Inf)$	NaN
fltArg1 denormalized, *fltArg2* normalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 \in N \end{matrix} \right\}$	$\langle -2^{23}, 2^{23} \rangle$	N/A
fltArg1 normalized, *fltArg2* denormalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 \in N \end{matrix} \right\}$	$\langle -2^{23}, 2^{23} \rangle$	N/A
Both inputs normalized or zero, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ X \in N \cup \{-0, +0\} \end{matrix} \right\}$	$\langle -me_1, me_1 \rangle$	N/A
Both inputs normalized or zero, *fltArg3* output underflow i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ X \in N \cup \{-0, +0\}, \\ \left(\begin{matrix} \lvert refFltArg2 \rvert - me_1 \cdot \mathrm{ULP}(refFltArg2) \in D \wedge \\ refFltArg2 \neq 0, \end{matrix} \right) \end{matrix} \right\}$	$(-Inf, Inf)$	{-0, +0}

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Table 166. GMCLIB_ClarkInv_FLT Worst-Case Error Bounds - Output *fltArg3* ...continued

Subset of input domain	Worst-case error bounds for fltArg3 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg3 output
Both inputs normalized or zero, intermediate result underflow i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \in N \cup \{-0, +0\}, \\ ir_1 \in D \vee \\ \left(\begin{array}{c} \lvert ir_2 \rvert - 1.5 \cdot \mathrm{ULP}(ir_2) \in D \wedge \\ ir_2 \neq 0, \end{array} \right) \end{array} \right\}$	$(-Inf, Inf)$	{NaN, -Inf, Inf}
Both inputs normalized or zero, *fltArg3* output overflow i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \in N \cup \{-0, +0\}, \\ \lvert refffltArg2 \rvert + me_1 \cdot \mathrm{ULP}(refffltArg2) \in M \end{array} \right\}$	$(-Inf, Inf)$	{NaN, -Inf, Inf}

2.49 Function GMCLIB_ClarkInv6Ph_FLT

2.49.1 Declaration

```
void GMCLIB_ClarkInv6Ph_FLT(SWLIBS_6Syst_FLT *const pOut, const
SWLIBS_2Syst_FLT *const pIn, const GMCLIB_CLARKINV_6PH_T_FLT
*const pParam);
```

2.49.2 Arguments

Table 167. GMCLIB_ClarkInv6Ph_FLT arguments

Type	Name	Direction	Description
const SWLIBS_2Syst_FLT *const	pIn	**input**	Pointer to the structure containing direct U_α and quadrature U_β components of the stator voltage vector. Arguments of the structure contain single precision floating-point values.
const GMCLIB_CLARKINV_6PH_T_FLT *const	pParam	**output**	Pointer to the structure containing the transformation coefficient calculated by GMCLIB_ClarkInv6PhInit function. Arguments of the structure contain single precision floating-point values.

2.49.3 Worst-Case Error Bounds

Let (*fltArg1*, *fltArg2*) $\in$ *X* be a set of inputs to GMCLIB_ClarkInv_FLT,

reffltArg2, *reffltArg3* be the theoretical exact results for outputs *fltArg2* and *fltArg3*, respectively,

$ir_1 = 0.5 \cdot fltArg1$,

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$$ir_2 = \frac{\sqrt{3}}{2} \cdot fltArg2,$$

$$ie_1 = \max(\mathrm{fe}(|ir_1|), \mathrm{fe}(|ir_2| + 1.5 \cdot \mathrm{ULP}(ir_2))),$$

$$refInteg = fltIntegPartK_1 + ir_2,$$

$$ix = \mathrm{fe}(refFltArg2),$$

$$iy = \mathrm{fe}(refFltArg3),$$

$$cb_1 = \begin{cases} 0, & ie_1 - ix \le 0 \\ ie_1 - ix, & ie_1 - ix > 0 \end{cases},$$

$$cb_2 = \begin{cases} 0, & ie_1 - iy \le 0 \\ ie_1 - iy, & ie_1 - iy > 0 \end{cases},$$

$$me_1 = 0.5 + 1.5 \cdot 2^{cb_1},$$

$$me_2 = 0.5 + 1.5 \cdot 2^{cb_2},$$

then

Table 168. GMCLIB_ClarkInv_FLT Worst-Case Error Bounds - Output *fltArg1*

Subset of input domain	Worst-case error bounds for *fltArg1* output [ulp]	Allowed specific values (regardless the error bounds) for *fltArg1* output
Entire input domain	0	N/A

Table 169. GMCLIB_ClarkInv_FLT Worst-Case Error Bounds - Output *fltArg2*

Subset of input domain	Worst-case error bounds for *fltArg2* output [ulp]	Allowed specific values (regardless the error bounds) for *fltArg2* output
Both inputs infinity, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \\ X \subset \{Inf, -Inf\} \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, 0, -0} if sign(*fltArg1*) = sign(*fltArg2*), {sign(*fltArg2*)•Inf, sign(*fltArg2*)•pmax} otherwise
fltArg1 infinity, *fltArg2* NaN, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 = NaN \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, 0, -0, *pmax*, *nmax*}

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Table 169. GMCLIB_ClarkInv_FLT Worst-Case Error Bounds - Output *fltArg2* ...continued

Subset of input domain	Worst-case error bounds for *fltArg2* output [ulp]	Allowed specific values (regardless the error bounds) for *fltArg2* output
fltArg1 infinity, *fltArg2* denormalized, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in D \end{array} \right\}$	$(-Inf, Inf)$	{-sign(*fltArg1*)•Inf, sign(*fltArg1*)•pmax}
fltArg1 infinity, *fltArg2* zero, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 = 0 \end{array} \right\}$	$(-Inf, Inf)$	{-sign(*fltArg1*)•Inf, sign(*fltArg1*)•pmax}
fltArg1 infinity, *fltArg2* normalized, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in N \end{array} \right\}$	$(-Inf, Inf)$	{-sign(*fltArg1*)•Inf, sign(*fltArg1*)•pmax}
fltArg1 NaN, *fltArg2* infinity, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 = NaN, \\ fltIn_2 \in \{Inf, -Inf\} \end{array} \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*}
Both inputs NaN, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 = NaN, \\ fltIn_2 = NaN \end{array} \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*}
fltArg1 NaN, *fltArg2* denormalized, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 = NaN, \\ fltIn_2 \in D \end{array} \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*}

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Table 169. GMCLIB_ClarkInv_FLT Worst-Case Error Bounds - Output *fltArg2* ...continued

Subset of input domain	Worst-case error bounds for *fltArg2* output [ulp]	Allowed specific values (regardless the error bounds) for *fltArg2* output
fltArg1 NaN, *fltArg2* zero, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 = NaN, \\ fltIn_2 \in D \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*}
fltArg1 NaN, *fltArg2* normalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 = NaN, \\ fltIn_2 \in N \end{matrix} \right\}$	$(-Inf, Inf)$	NaN
fltArg1 denormalized, *fltArg2* infinite, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 \in \{Inf, -Inf\} \end{matrix} \right\}$	$(-Inf, Inf)$	{sign(*fltArg2*)•Inf, sign(*fltArg2*)•pmax}
fltArg1 denormalized, *fltArg2* NaN, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 = NaN \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*}
Both inputs denormalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 \in D \end{matrix} \right\}$	$\langle -2^{23}, 2^{23} \rangle$	{0, -0}
fltArg1 zero, *fltArg2* infinite, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 = 0, \\ fltIn_2 \in \{Inf, -Inf\} \end{matrix} \right\}$	$(-Inf, Inf)$	{sign(*fltArg2*)•Inf, sign(*fltArg2*)•pmax}

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Table 169. GMCLIB_ClarkInv_FLT Worst-Case Error Bounds - Output *fltArg2* ...continued

Subset of input domain	Worst-case error bounds for *fltArg2* output [ulp]	Allowed specific values (regardless the error bounds) for *fltArg2* output
fltArg1 zero, *fltArg2* NaN, i.e. $\left\{ (fltArg1, fltArg2) \in X \middle\vert \begin{array}{c} fltIn_1 = 0, \\ fltIn_2 = NaN \end{array} \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*}
fltArg1 denormalized, *fltArg2* zero, i.e. $\left\{ (fltArg1, fltArg2) \in X \middle\vert \begin{array}{c} fltIn_1 \in D, \\ fltIn_2 = 0 \end{array} \right\}$	$\langle -0.5, 0.5 \rangle$	{0, -0}
fltArg1 zero, *fltArg2* denormalized, i.e. $\left\{ (fltArg1, fltArg2) \in X \middle\vert \begin{array}{c} fltIn_1 = 0, \\ fltIn_2 \in D \end{array} \right\}$	$\langle -1.5, 1.5 \rangle$	{0, -0}
fltArg1 normalized, *fltArg2* infinite, i.e. $\left\{ (fltArg1, fltArg2) \in X \middle\vert \begin{array}{c} fltIn_1 \in N, \\ fltIn_2 \in \{Inf, -Inf\} \end{array} \right\}$	$(-Inf, Inf)$	sign(*fltArg2*)•Inf
fltArg1 normalized, *fltArg2* NaN, i.e. $\left\{ (fltArg1, fltArg2) \in X \middle\vert \begin{array}{c} fltIn_1 \in N, \\ fltIn_2 = NaN \end{array} \right\}$	$(-Inf, Inf)$	NaN
fltArg1 denormalized, *fltArg2* normalized, i.e. $\left\{ (fltArg1, fltArg2) \in X \middle\vert \begin{array}{c} fltIn_1 \in D, \\ fltIn_2 \in N \end{array} \right\}$	$\langle -2^{23}, 2^{23} \rangle$	N/A

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Table 169. GMCLIB_ClarkInv_FLT Worst-Case Error Bounds - Output *fltArg2* ...continued

Subset of input domain	Worst-case error bounds for *fltArg2* output [ulp]	Allowed specific values (regardless the error bounds) for *fltArg2* output
fltArg1 normalized, *fltArg2* denormalized, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 \in N \end{array} \right\}$	$\langle -2^{23}, 2^{23} \rangle$	N/A
Both inputs normalized or zero, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \in N \cup \{-0, +0\} \end{array} \right\}$	$\langle -me_1, me_1 \rangle$	N/A
Both inputs normalized or zero, *fltArg2* output underflow i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \in N \cup \{-0, +0\}, \\ \left(\begin{array}{c} \lvert refFltArg2 \rvert - me_1 \cdot \mathrm{ULP}(refFltArg2) \in D \wedge \\ refFltArg2 \neq 0, \end{array} \right) \end{array} \right\}$	$(-Inf, Inf)$	{-0, +0}
Both inputs normalized or zero, intermediate result underflow i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \in N \cup \{-0, +0\}, \\ ir_1 \in D \vee \\ \left(\begin{array}{c} \lvert ir_2 \rvert - 1.5 \cdot \mathrm{ULP}(ir_2) \in D \wedge \\ ir_2 \neq 0, \end{array} \right) \end{array} \right\}$	$(-Inf, Inf)$	{NaN, -Inf, Inf}
Both inputs normalized or zero, *fltArg2* output overflow i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \in N \cup \{-0, +0\}, \\ \lvert refFltArg2 \rvert + me_1 \cdot \mathrm{ULP}(refFltArg2) \in M \end{array} \right\}$	$(-Inf, Inf)$	{NaN, -Inf, Inf}

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Table 170. GMCLIB_ClarkInv_FLT Worst-Case Error Bounds - Output *fltArg3*

Subset of input domain	Worst-case error bounds for fltArg3 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg3 output
Both inputs infinity, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \\ X \subset \{Inf, -Inf\} \end{matrix} \right\}$	$(-Inf, Inf)$	{-sign(*fltArg2*)•Inf, sign(*fltArg2*)•pmax} if sign(*fltArg1*) = sign(*fltArg2*), {NaN, 0, -0} otherwise
fltArg1 infinity, *fltArg2* NaN, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 = NaN \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, 0, -0, *pmax*, *nmax*}
fltArg1 infinity, *fltArg2* denormalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in D \end{matrix} \right\}$	$(-Inf, Inf)$	{-sign(*fltArg1*)•Inf, sign(*fltArg1*)•pmax}
fltArg1 infinity, *fltArg2* zero, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 = 0 \end{matrix} \right\}$	$(-Inf, Inf)$	{-sign(*fltArg1*)•Inf, sign(*fltArg1*)•pmax}
fltArg1 infinity, *fltArg2* normalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in N \end{matrix} \right\}$	$(-Inf, Inf)$	{-sign(*fltArg1*)•Inf, sign(*fltArg1*)•pmax}
fltArg1 NaN, *fltArg2* infinity, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \\ fltIn_1 = NaN, \\ fltIn_2 \in \{Inf, -Inf\} \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*}

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Table 170. GMCLIB_ClarkInv_FLT Worst-Case Error Bounds - Output *fltArg3* ...continued

Subset of input domain	Worst-case error bounds for fltArg3 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg3 output
Both inputs NaN, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 = NaN, \\ fltIn_2 = NaN \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*}
fltArg1 NaN, *fltArg2* denormalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 = NaN, \\ fltIn_2 \in D \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*}
fltArg1 NaN, *fltArg2* zero, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 = NaN, \\ fltIn_2 \in D \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*}
fltArg1 NaN, *fltArg2* normalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 = NaN, \\ fltIn_2 \in N \end{matrix} \right\}$	$(-Inf, Inf)$	NaN
fltArg1 denormalized, *fltArg2* infinite, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 \in \{Inf, -Inf\} \end{matrix} \right\}$	$(-Inf, Inf)$	{-sign(*fltArg2*)•Inf, sign(*fltArg2*)•pmax}
fltArg1 denormalized, *fltArg2* NaN, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 = NaN \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*}

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Table 170. GMCLIB_ClarkInv_FLT Worst-Case Error Bounds - Output *fltArg3* ...continued

Subset of input domain	Worst-case error bounds for fltArg3 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg3 output
Both inputs denormalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 \in D \end{matrix} \right\}$	$\langle -2^{23}, 2^{23} \rangle$	{0, -0}
fltArg1 zero, *fltArg2* infinite, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 = 0, \\ fltIn_2 \in \{Inf, -Inf\} \end{matrix} \right\}$	$(-Inf, Inf)$	{-sign(*fltArg2*)•Inf, sign(*fltArg2*)•pmax}
fltArg1 zero, *fltArg2* NaN, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 = 0, \\ fltIn_2 = NaN \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*}
fltArg1 denormalized, *fltArg2* zero, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 = 0 \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	{0, -0}
fltArg1 zero, *fltArg2* denormalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 = 0, \\ fltIn_2 \in D \end{matrix} \right\}$	$\langle -1.5, 1.5 \rangle$	{0, -0}
fltArg1 normalized, *fltArg2* infinite, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in N, \\ fltIn_2 \in \{Inf, -Inf\} \end{matrix} \right\}$	$(-Inf, Inf)$	{-sign(*fltArg2*)•Inf}

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Table 170. GMCLIB_ClarkInv_FLT Worst-Case Error Bounds - Output *fltArg3* ...continued

Subset of input domain	Worst-case error bounds for fltArg3 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg3 output
fltArg1 normalized, *fltArg2* NaN, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in N, \\ fltIn_2 = NaN \end{matrix} \right\}$	$(-Inf, Inf)$	NaN
fltArg1 denormalized, *fltArg2* normalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 \in N \end{matrix} \right\}$	$\langle -2^{23}, 2^{23} \rangle$	N/A
fltArg1 normalized, *fltArg2* denormalized, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 \in N \end{matrix} \right\}$	$\langle -2^{23}, 2^{23} \rangle$	N/A
Both inputs normalized or zero, i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ X \in N \cup \{-0, +0\} \end{matrix} \right\}$	$\langle -me_1, me_1 \rangle$	N/A
Both inputs normalized or zero, *fltArg3* output underflow i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ X \in N \cup \{-0, +0\}, \\ \left(\begin{matrix} \lvert ref fltArg2 \rvert - me_1 \cdot \mathrm{ULP}(ref fltArg2) \in D \wedge \\ ref fltArg2 \neq 0, \end{matrix} \right) \end{matrix} \right\}$	$(-Inf, Inf)$	{-0, +0}
Both inputs normalized or zero, intermediate result underflow i.e. $\left\{ \begin{matrix} (fltArg1, fltArg2) \in X \mid \\ X \in N \cup \{-0, +0\}, \\ ir_1 \in D \vee \\ \left(\begin{matrix} \lvert ir_2 \rvert - 1.5 \cdot \mathrm{ULP}(ir_2) \in D \wedge \\ ir_2 \neq 0, \end{matrix} \right) \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, -Inf, Inf}

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Table 170. GMCLIB_ClarkInv_FLT Worst-Case Error Bounds - Output *fltArg3* ...continued

Subset of input domain	Worst-case error bounds for fltArg3 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg3 output
Both inputs normalized or zero, *fltArg3* output overflow i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \\ X \in N \cup \{-0, +0\}, \\ \lvert reffltArg2 \rvert + me_1 \cdot \mathrm{ULP}(reffltArg2) \in M \end{array} \right\}$	$(-Inf, Inf)$	{NaN, -Inf, Inf}

2.50 Function GMCLIB_DecouplingPMSM_FLT

2.50.1 Declaration

```
void GMCLIB_DecouplingPMSM_FLT(SWLIBS_2Syst_FLT *const pUdqDec,
const SWLIBS_2Syst_FLT *const pUdq, const SWLIBS_2Syst_FLT *const
pIdq, tFloat fltAngularVel, const GMCLIB_DECOUPLINGPMSM_T_FLT
*const pParam);
```

2.50.2 Arguments

Table 171. GMCLIB_DecouplingPMSM_FLT arguments

Type	Name	Direction	Description
SWLIBS_2Syst_FLT *const	pUdqDec	**output**	Pointer to the structure containing direct (u_{df_dec}) and quadrature (u_{qf_dec}) components of the decoupled stator voltage vector to be applied on the motor terminals.
const SWLIBS_2Syst_FLT *const	pUdq	**input**	Pointer to the structure containing direct (u_{df}) and quadrature (u_{qf}) components of the stator voltage vector generated by the current controllers.
const SWLIBS_2Syst_FLT *const	pIdq	**input**	Pointer to the structure containing direct (i_{df}) and quadrature (i_{qf}) components of the stator current vector measured on the motor terminals.
tFloat	fltAngularVel	**input**	Rotor angular velocity in rad/sec, referred to as ($omega_{ef}$) in the detailed section of the documentation.
const GMCLIB_DECOUPLINGPMSM_T_FLT *const	pParam	**input**	Pointer to the structure containing L_D and L_Q coefficients (see the detailed section of the documentation).

2.50.3 Worst-Case Error Bounds

Let (*UfltArg1*, *UfltArg2*, *IfltArg1*, *IfltArg2*, *fltAngularVel*, *fltLD*, *fltLQ*) $\in$ *X* be a set of inputs to GMCLIB_DecouplingPMSM_FLT,

reffltArg1, *reffltArg2* be the theoretical exact results for outputs *fltArg1* and *fltArg2*, respectively,

$ira_1 = fltAngularVel \cdot IfltArg2$,

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$ira_2 = ira_1 \cdot fltLQ$,

$irb_1 = fltAngularVel \cdot IfltArg1$,

$irb_2 = irb_1 \cdot fltLD$,

then

Table 172. GMCLIB_DecouplingPMSM_FLT Worst-Case Error Bounds - fltArg1 Output

Subset of input domain	Worst-case error bounds for fltArg1 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg1 output
Any of {*UfltArg1*, *IfltArg2*, *fltLQ*, *fltAngularVel*} is NaN, i.e. $\left\{ \begin{pmatrix} UfltArg1, UfltArg2, \\ IfltArg1, IfltArg2, \\ fltAngularVel, fltLD, fltLQ \end{pmatrix} \in X \middle\vert \begin{Bmatrix} UfltArg1, IfltArg2, \\ fltLQ, fltAngularVel \end{Bmatrix} \cap NaN \neq \varnothing \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*}
Any of {*UfltArg1*, *IfltArg2*, *fltLQ*, *fltAngularVel*} is infinity, i.e. $\left\{ \begin{pmatrix} UfltArg1, UfltArg2, \\ IfltArg1, IfltArg2, \\ fltAngularVel, fltLD, fltLQ \end{pmatrix} \in X \middle\vert \begin{Bmatrix} UfltArg1, IfltArg2, \\ fltLQ, fltAngularVel \end{Bmatrix} \cap \{Inf, -Inf\} \neq \varnothing \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*, Inf, -Inf, 0, -0}
At least one of {*UfltArg1*, *IfltArg2*, *fltLQ*, *fltAngularVel*} is denormalized, others are normalized, denormalized, or zero, i.e. $\left\{ \begin{pmatrix} UfltArg1, UfltArg2, \\ IfltArg1, IfltArg2, \\ fltAngularVel, fltLD, fltLQ \end{pmatrix} \in X \middle\vert \begin{Bmatrix} UfltArg1, IfltArg2, \\ fltLQ, fltAngularVel \end{Bmatrix} \cap D \neq \varnothing, \begin{Bmatrix} UfltArg1, IfltArg2, \\ fltLQ, fltAngularVel \end{Bmatrix} \cap M = \varnothing \right\}$	$(-Inf, Inf)$	{0, -0}

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Table 172. GMCLIB_DecouplingPMSM_FLT Worst-Case Error Bounds - fltArg1 Output*...continued*

Subset of input domain	Worst-case error bounds for fltArg1 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg1 output
All of {*UfltArg1*, *IfltArg2*, *fltLQ*, *fltAngularVel*} are zero, i.e. $\left\{ \begin{pmatrix} UfltArg1, UfltArg2, \\ IfltArg1, IfltArg2, \\ fltAngularVel, fltLD, fltLQ \end{pmatrix} \in X \middle\vert \begin{matrix} UfltArg1 = 0, \\ IfltArg2 = 0, \\ fltLQ = 0, \\ fltAngularVel = 0 \end{matrix} \right\}$	0	N/A
All of {*UfltArg1*, *IfltArg2*, *fltLQ*, *fltAngularVel*} are normalized or zero, inputs lead to normalized or zero results, i.e. $\left\{ \begin{pmatrix} UfltArg1, UfltArg2, \\ IfltArg1, IfltArg2, \\ fltAngularVel, fltLD, fltLQ \end{pmatrix} \in X \middle\vert \begin{matrix} \left\{ \begin{matrix} UfltArg1, IfltArg2, \\ fltLQ, fltAngularVel \end{matrix} \right\} \subset N \cup \{-0, +0\}, \\ \{ira_1, ira_2\} \subset N \cup \{-0, +0\}, \\ refefltArg1 = 0 \vee \\ \begin{pmatrix} 0.5 \cdot (\lvert refefltArg1 \rvert - \mathrm{ULP}(refefltArg1)) \notin D \wedge \\ \lvert refefltArg1 \rvert + \mathrm{ULP}(refefltArg1) \neq Inf \end{pmatrix} \end{matrix} \right\}$	$\langle -1, 1 \rangle$	N/A
All of {*UfltArg1*, *IfltArg2*, *fltLQ*, *fltAngularVel*} are normalized or zero, *fltArg1* output overflow, i.e. $\left\{ \begin{pmatrix} UfltArg1, UfltArg2, \\ IfltArg1, IfltArg2, \\ fltAngularVel, fltLD, fltLQ \end{pmatrix} \in X \middle\vert \begin{matrix} \left\{ \begin{matrix} UfltArg1, IfltArg2, \\ fltLQ, fltAngularVel \end{matrix} \right\} \subset N \cup \{-0, +0\}, \\ \lvert refefltArg1 \rvert + \mathrm{ULP}(refefltArg1) = Inf \end{matrix} \right\}$	$(-Inf, Inf)$	{sign(*reffltArg1*)•Inf, sign(*reffltArg1*)•pmax, NaN}

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Table 172. GMCLIB_DecouplingPMSM_FLT Worst-Case Error Bounds - fltArg1 Output...*continued*

Subset of input domain	Worst-case error bounds for fltArg1 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg1 output
All of {*UfltArg1*, *IfltArg2*, *fltLQ*, *fltAngularVel*} are normalized or zero, *fltArg1* output underflow or uncompensated calculation, i.e. $\left\{ \begin{pmatrix} UfltArg1, UfltArg2, \\ IfltArg1, IfltArg2, \\ fltAngularVel, fltLD, fltLQ \end{pmatrix} \in X \middle| \begin{pmatrix} \begin{Bmatrix} UfltArg1, IfltArg2, \\ fltLQ, fltAngularVel \end{Bmatrix} \subset N \cup \{-0, +0\}, \\ refFltArg1 \neq 0 \wedge \\ 0.5 \cdot (\lvert refFltArg1 \rvert - \mathrm{ULP}(refFltArg1)) \in D \end{pmatrix} \right\}$	$\langle -2^{24}, 2^{24} \rangle$	{0, -0}
All of {*UfltArg1*, *IfltArg2*, *fltLQ*, *fltAngularVel*} are normalized or zero, intermediate result overflow, i.e. $\left\{ \begin{pmatrix} UfltArg1, UfltArg2, \\ IfltArg1, IfltArg2, \\ fltAngularVel, fltLD, fltLQ \end{pmatrix} \in X \middle| \begin{pmatrix} \begin{Bmatrix} UfltArg1, IfltArg2, \\ fltLQ, fltAngularVel \end{Bmatrix} \subset N \cup \{-0, +0\}, \\ \begin{pmatrix} \lvert ira_1 \rvert + 0.5 \cdot \mathrm{ULP}(ira_1), \\ \lvert ira_2 \rvert + \mathrm{ULP}(ira_2) \end{pmatrix} \cap \{Inf, -Inf\} \neq \varnothing \end{pmatrix} \right\}$	$(-Inf, Inf)$	{*pmax*, *nmax*, Inf, -Inf}
All of {*UfltArg1*, *IfltArg2*, *fltLQ*, *fltAngularVel*} are normalized or zero, intermediate result underflow, i.e. $\left\{ \begin{pmatrix} UfltArg1, UfltArg2, \\ IfltArg1, IfltArg2, \\ fltAngularVel, fltLD, fltLQ \end{pmatrix} \in X \middle| \begin{pmatrix} \begin{Bmatrix} UfltArg1, IfltArg2, \\ fltLQ, fltAngularVel \end{Bmatrix} \subset N \cup \{-0, +0\}, \\ \begin{pmatrix} 0.5 \cdot (\lvert ira_1 \rvert - 0.5 \cdot \mathrm{ULP}(ira_1)) \in D \wedge \\ ira_1 \neq 0, \end{pmatrix} \vee \\ \begin{pmatrix} 0.5 \cdot (\lvert ira_2 \rvert - \mathrm{ULP}(ira_2)) \in D \wedge \\ ira_2 \neq 0, \end{pmatrix} \end{pmatrix} \right\}$	$\langle -2^{24}, 2^{24} \rangle$	{0, -0}

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Table 173. GMCLIB_DecouplingPMSM_FLT Worst-Case Error Bounds - fltArg2 Output

Subset of input domain	Worst-case error bounds for fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg2 output
Any of {*UfltArg2*, *IfltArg1*, *fltLD*, *fltAngularVel*} is NaN, i.e. $\left\{ \begin{pmatrix} UfltArg1, UfltArg2, \\ IfltArg1, IfltArg2, \\ fltAngularVel, fltLD, fltLQ \end{pmatrix} \in X \middle\vert \begin{Bmatrix} UfltArg2, IfltArg1, \\ fltLD, fltAngularVel \end{Bmatrix} \cap NaN \neq \varnothing \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*}
Any of {*UfltArg2*, *IfltArg1*, *fltLD*, *fltAngularVel*} is infinity, i.e. $\left\{ \begin{pmatrix} UfltArg1, UfltArg2, \\ IfltArg1, IfltArg2, \\ fltAngularVel, fltLD, fltLQ \end{pmatrix} \in X \middle\vert \begin{Bmatrix} UfltArg2, IfltArg1, \\ fltLD, fltAngularVel \end{Bmatrix} \cap \{Inf, -Inf\} \neq \varnothing \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*, Inf, -Inf, 0, -0}
At least one of {*UfltArg2*, *IfltArg1*, *fltLD*, *fltAngularVel*} is denormalized, others are normalized, denormalized, or zero, i.e. $\left\{ \begin{pmatrix} UfltArg1, UfltArg2, \\ IfltArg1, IfltArg2, \\ fltAngularVel, fltLD, fltLQ \end{pmatrix} \in X \middle\vert \begin{Bmatrix} UfltArg2, IfltArg1, \\ fltLD, fltAngularVel \end{Bmatrix} \cap D \neq \varnothing, \begin{Bmatrix} UfltArg2, IfltArg1, \\ fltLD, fltAngularVel \end{Bmatrix} \cap M = \varnothing \right\}$	$(-Inf, Inf)$	{0, -0}
All of {*UfltArg2*, *IfltArg1*, *fltLD*, *fltAngularVel*} are zero, i.e. $\left\{ \begin{pmatrix} UfltArg1, UfltArg2, \\ IfltArg1, IfltArg2, \\ fltAngularVel, fltLD, fltLQ \end{pmatrix} \in X \middle\vert \begin{matrix} UfltArg2 = 0, \\ IfltArg1 = 0, \\ fltLD = 0, \\ fltAngularVel = 0 \end{matrix} \right\}$	0	N/A

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Table 173. GMCLIB_DecouplingPMSM_FLT Worst-Case Error Bounds - fltArg2 Output...*continued*

Subset of input domain	Worst-case error bounds for fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg2 output
All of {*UfltArg2*, *IfltArg1*, *fltLD*, *fltAngularVel*} are normalized or zero, inputs lead to normalized or zero results, i.e. $\left\{ \begin{pmatrix} UfltArg1, UfltArg2, \\ IfltArg1, IfltArg2, \\ fltAngularVel, fltLD, fltLQ \end{pmatrix} \in X \middle\vert \begin{pmatrix} \begin{Bmatrix} UfltArg2, IfltArg1, \\ fltLD, fltAngularVel \end{Bmatrix} \subset N \cup \{-0, +0\}, \\ \{irb_1, irb_2\} \subset N \cup \{-0, +0\}, \\ refffltArg2 = 0 \vee \\ \begin{pmatrix} 0.5 \cdot (\lvert refffltArg2 \rvert - \mathrm{ULP}(refffltArg2)) \notin D \wedge \\ \lvert refffltArg2 \rvert + \mathrm{ULP}(refffltArg2) \neq Inf \end{pmatrix} \end{pmatrix} \right\}$	$\langle -1, 1 \rangle$	N/A
All of {*UfltArg2*, *IfltArg1*, *fltLD*, *fltAngularVel*} are normalized or zero, *fltArg2* output overflow, i.e. $\left\{ \begin{pmatrix} UfltArg1, UfltArg2, \\ IfltArg1, IfltArg2, \\ fltAngularVel, fltLD, fltLQ \end{pmatrix} \in X \middle\vert \begin{pmatrix} \begin{Bmatrix} UfltArg2, IfltArg1, \\ fltLD, fltAngularVel \end{Bmatrix} \subset N \cup \{-0, +0\}, \\ \lvert refffltArg2 \rvert + \mathrm{ULP}(refffltArg2) = Inf \end{pmatrix} \right\}$	$(-Inf, Inf)$	{sign(*reffltArg2*)•Inf, sign(*reffltArg2*)•pmax, NaN}
All of {*UfltArg2*, *IfltArg1*, *fltLD*, *fltAngularVel*} are normalized or zero, *fltArg2* output underflow or uncompensated calculation, i.e. $\left\{ \begin{pmatrix} UfltArg1, UfltArg2, \\ IfltArg1, IfltArg2, \\ fltAngularVel, fltLD, fltLQ \end{pmatrix} \in X \middle\vert \begin{pmatrix} \begin{Bmatrix} UfltArg2, IfltArg1, \\ fltLD, fltAngularVel \end{Bmatrix} \subset N \cup \{-0, +0\}, \\ refffltArg2 \neq 0 \wedge \\ 0.5 \cdot (\lvert refffltArg2 \rvert - \mathrm{ULP}(refffltArg2)) \in D \end{pmatrix} \right\}$	$\langle -2^{24}, 2^{24} \rangle$	{0, -0}

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Table 173. GMCLIB_DecouplingPMSM_FLT Worst-Case Error Bounds - fltArg2 Output...*continued*

Subset of input domain	Worst-case error bounds for fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg2 output
All of {*UfltArg2*, *IfltArg1*, *fltLD*, *fltAngularVel*} are normalized or zero, intermediate result overflow, i.e. $\left\{ \begin{pmatrix} UfltArg1, UfltArg2, \\ IfltArg1, IfltArg2, \\ fltAngularVel, fltLD, fltLQ \end{pmatrix} \in X \middle| \begin{pmatrix} \begin{Bmatrix} UfltArg2, IfltArg1, \\ fltLD, fltAngularVel \end{Bmatrix} \subset N \cup \{-0, +0\}, \\ \begin{pmatrix} \lvert irb_1 \rvert + 0.5 \cdot \mathrm{ULP}(irb_1), \\ \lvert irb_2 \rvert + \mathrm{ULP}(irb_2) \end{pmatrix} \cap \{Inf, -Inf\} \neq \varnothing \end{pmatrix} \right\}$	$(-Inf, Inf)$	{*pmax*, *nmax*, Inf, -Inf}
All of {*UfltArg2*, *IfltArg1*, *fltLD*, *fltAngularVel*} are normalized or zero, intermediate result underflow, i.e. $\left\{ \begin{pmatrix} UfltArg1, UfltArg2, \\ IfltArg1, IfltArg2, \\ fltAngularVel, fltLD, fltLQ \end{pmatrix} \in X \middle| \begin{pmatrix} \begin{Bmatrix} UfltArg2, IfltArg1, \\ fltLD, fltAngularVel \end{Bmatrix} \subset N \cup \{-0, +0\}, \\ \begin{pmatrix} 0.5 \cdot (\lvert irb_1 \rvert - 0.5 \cdot \mathrm{ULP}(irb_1)) \in D \wedge \\ ira_1 \neq 0, \end{pmatrix} \vee \\ \begin{pmatrix} 0.5 \cdot (\lvert irb_2 \rvert - \mathrm{ULP}(irb_2)) \in D \wedge \\ irb_2 \neq 0, \end{pmatrix} \end{pmatrix} \right\}$	$\langle -2^{24}, 2^{24} \rangle$	{0, -0}

2.51 Function GMCLIB_ElimDcBusRip_FLT

2.51.1 Declaration

```
void GMCLIB_ElimDcBusRip_FLT(SWLIBS_2Syst_FLT *const pOut, const
SWLIBS_2Syst_FLT *const pIn, const GMCLIB_ELIMDCBUSRIP_T_FLT
*const pParam);
```

2.51.2 Arguments

Table 174. GMCLIB_ElimDcBusRip_FLT arguments

Type	Name	Direction	Description
SWLIBS_2Syst_FLT *const	pOut	**output**	Pointer to the structure with direct (α) and quadrature (β) components of the required stator voltage vector re-calculated so as to compensate for voltage ripples on the DC bus. Outputs are normalized to the range [-1; 1].

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Table 174. GMCLIB_ElimDcBusRip_FLT arguments*...continued*

Type	Name	Direction	Description
const SWLIBS_2Syst_FLT *const	pIn	**input**	Pointer to the structure with direct (α) and quadrature (β) components of the required stator voltage vector before compensation of voltage ripples on the DC bus.
const GMCLIB_ELIMDCBUSRIP_T_FLT *const	pParam	**input**	Pointer to the parameters structure.

2.51.3 Worst-Case Error Bounds

Let (*fltArg1*, *fltArg2*, *fltModIndex*, *fltArgDcBusMsr*) ∈ *X* be a set of inputs to GMCLIB_ElimDcBusRip_FLT,

reffltArg1, *reffltArg2* be the theoretical exact results for outputs *fltArg1* and *fltArg2*, respectively,

$ir_1 = fltArg1 \cdot fltModIndex$,

$ir_2 = fltArg2 \cdot fltModIndex$,

then

Table 175. GMCLIB_ElimDcBusRip_FLT Worst-Case Error Bounds - *fltArg1* Output

Subset of input domain	Worst-case error bounds for *fltArg1* output [ulp]	Allowed specific values (regardless the error bounds) for *fltArg1* output
Any of {*fltArg1*, *fltModIndex*, *fltArgDcBusMsr*} is NaN, i.e. $\left\{ \left(\begin{matrix} fltArg1, fltArg2, \\ fltModIndex, fltArgDcBusMsr \end{matrix} \right) \in X \middle| \left\{ \begin{matrix} fltArg1, \\ fltModIndex, \\ fltArgDcBusMsr \end{matrix} \right\} \cap NaN \neq \varnothing \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*}
Any of {*fltArg1*, *fltModIndex*, *fltArgDcBusMsr*} is infinity, i.e. $\left\{ \left(\begin{matrix} fltArg1, fltArg2, \\ fltModIndex, fltArgDcBusMsr \end{matrix} \right) \in X \middle| \left\{ \begin{matrix} fltArg1, \\ fltModIndex, \\ fltArgDcBusMsr \end{matrix} \right\} \cap \{Inf, -Inf\} \neq \varnothing \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*, Inf, -Inf}

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Table 175. GMCLIB_ElimDcBusRip_FLT Worst-Case Error Bounds - *fltArg1* Output*...continued***

Subset of input domain	Worst-case error bounds for *fltArg1* output [ulp]	Allowed specific values (regardless the error bounds) for *fltArg1* output
At least one of {*fltArg1*, *fltModIndex*, *fltArgDcBusMsr*} is denormalized, others are normalized, denormalized, or zero, i.e. $\left\{ \begin{pmatrix} fltArg1, fltArg2, \\ fltModIndex, fltArgDcBusMsr \end{pmatrix} \in X \middle\vert \begin{Bmatrix} fltArg1, \\ fltModIndex, \\ fltArgDcBusMsr \end{Bmatrix} \cap D \neq \varnothing, \begin{Bmatrix} fltArg1, \\ fltModIndex, \\ fltArgDcBusMsr \end{Bmatrix} \cap M = \varnothing \right\}$	$(-Inf, Inf)$	{*pmax*, *nmax*, Inf, -Inf, 0, -0}
All of {*fltArg1*, *fltModIndex*} are normalized or zero, *fltArgDcBusMsr* is normalized, inputs lead to normalized or zero results, i.e. $\left\{ \begin{pmatrix} fltArg1, fltArg2, \\ fltModIndex, fltArgDcBusMsr \end{pmatrix} \in X \middle\vert \begin{Bmatrix} fltArg1, \\ fltModIndex \end{Bmatrix} \subset N \cup \{-0, +0\}, fltArgDcBusMsr \in N, ir_1 \in N \cup \{-0, +0\}, refFltArg1 = 0 \vee \begin{pmatrix} \lvert refFltArg1 \rvert - 1.5 \cdot \mathrm{ULP}(refFltArg1) \notin D \wedge \\ \lvert refFltArg1 \rvert + 1.5 \cdot \mathrm{ULP}(refFltArg1) \neq Inf \end{pmatrix} \right\}$	$\langle -1.5, 1.5 \rangle$	N/A
All of {*fltArg1*, *fltModIndex*} are normalized or zero, *flt ArgDcBusMsr* is zero, i.e. $\left\{ \begin{pmatrix} fltArg1, fltArg2, \\ fltModIndex, fltArgDcBusMsr \end{pmatrix} \in X \middle\vert \begin{Bmatrix} fltArg1, \\ fltModIndex \end{Bmatrix} \subset N \cup \{-0, +0\}, fltArgDcBusMsr = 0 \right\}$	0	{0, -0}

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Table 175. GMCLIB_ElimDcBusRip_FLT Worst-Case Error Bounds - *fltArg1* Output*...continued*

Subset of input domain	Worst-case error bounds for *fltArg1* output [ulp]	Allowed specific values (regardless the error bounds) for *fltArg1* output
All of {*fltArg1*, *fltModIndex*} are normalized or zero, *fltArgDcBusMsr* is normalized, *fltArg1* output overflow, i.e. $\left\{ \begin{array}{c} \left(\begin{array}{c} fltArg1,\ fltArg2, \\ fltModIndex,\ fltArgDcBusMsr \end{array} \right) \in X \\ \left\{ \begin{array}{c} fltArg1, \\ fltModIndex \end{array} \right\} \subset N \cup \{-0,\ +0\}, \\ fltArgDcBusMsr \in N, \\ \lvert refFltArg1 \rvert + 1.5 \cdot \mathrm{ULP}(refFltArg1) = Inf \end{array} \right\}$	$(-Inf, Inf)$	{sign(*reffltArg1*)•Inf, sign(*reffltArg1*)•pmax, NaN}
All of {*fltArg1*, *fltModIndex*} are normalized or zero, *fltArgDcBusMsr* is normalized, *fltArg1* output underflow, i.e. $\left\{ \begin{array}{c} \left(\begin{array}{c} fltArg1,\ fltArg2, \\ fltModIndex,\ fltArgDcBusMsr \end{array} \right) \in X \\ \left\{ \begin{array}{c} fltArg1, \\ fltModIndex \end{array} \right\} \subset N \cup \{-0,\ +0\}, \\ fltArgDcBusMsr \in N, \\ refFltArg1 \neq 0 \wedge \\ \lvert refFltArg1 \rvert - 1.5 \cdot \mathrm{ULP}(refFltArg1) \in D \end{array} \right\}$	$\langle -1.5, 1.5 \rangle$	{0, -0}
All of {*fltArg1*, *fltModIndex*} are normalized or zero, *fltArgDcBusMsr* is normalized, intermediate result overflow, i.e. $\left\{ \begin{array}{c} \left(\begin{array}{c} fltArg1,\ fltArg2, \\ fltModIndex,\ fltArgDcBusMsr \end{array} \right) \in X \\ \left\{ \begin{array}{c} fltArg1, \\ fltModIndex \end{array} \right\} \subset N \cup \{-0,\ +0\}, \\ fltArgDcBusMsr \in N, \\ \lvert ir_1 \rvert + 0.5 \cdot \mathrm{ULP}(ir_1) \in \{Inf,\ -Inf\} \end{array} \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*, Inf, -Inf, 0, -0}

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Table 175. GMCLIB_ElimDcBusRip_FLT Worst-Case Error Bounds - *fltArg1* Output*...continued***

Subset of input domain	Worst-case error bounds for *fltArg1* output [ulp]	Allowed specific values (regardless the error bounds) for *fltArg1* output
All of {*fltArg1*, *fltModIndex*} are normalized or zero, *fltArgDcBusMsr* is normalized, intermediate result underflow, i.e. $\left\{ \left(\begin{matrix} fltArg1, fltArg2, \\ fltModIndex, fltArgDcBusMsr \end{matrix} \right) \in X \middle\vert \begin{matrix} \left\{ \begin{matrix} fltArg1, \\ fltModIndex \end{matrix} \right\} \subset N \cup \{-0, +0\}, \\ fltArgDcBusMsr \in N, \\ \lvert ir_1 \rvert - 0.5 \cdot \mathrm{ULP}(ir_1) \in D \wedge \\ ir_1 \neq 0 \end{matrix} \right. \right\}$	$\langle -1.5, 1.5 \rangle$	{NaN, *pmax*, *nmax*, Inf, -Inf, 0, -0}

Table 176. GMCLIB_ElimDcBusRip_FLT Worst-Case Error Bounds - *fltArg2* Output

Subset of input domain	Worst-case error bounds for *fltArg2* output [ulp]	Allowed specific values (regardless the error bounds) for *fltArg2* output
Any of {*fltArg2*, *fltModIndex*, *fltArgDcBusMsr*} is NaN, i.e. $\left\{ \left(\begin{matrix} fltArg1, fltArg2, \\ fltModIndex, fltArgDcBusMsr \end{matrix} \right) \in X \middle\vert \left\{ \begin{matrix} fltArg2, \\ fltModIndex, \\ fltArgDcBusMsr \end{matrix} \right\} \cap NaN \neq \varnothing \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*}
Any of {*fltArg2*, *fltModIndex*, *fltArgDcBusMsr*} is infinity, i.e. $\left\{ \left(\begin{matrix} fltArg1, fltArg2, \\ fltModIndex, fltArgDcBusMsr \end{matrix} \right) \in X \middle\vert \left\{ \begin{matrix} fltArg2, \\ fltModIndex, \\ fltArgDcBusMsr \end{matrix} \right\} \cap \{Inf, -Inf\} \neq \varnothing \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*, Inf, -Inf}

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Table 176. GMCLIB_ElimDcBusRip_FLT Worst-Case Error Bounds - *fltArg2* Output*...continued*

Subset of input domain	Worst-case error bounds for *fltArg2* output [ulp]	Allowed specific values (regardless the error bounds) for *fltArg2* output
At least one of {*fltArg2*, *fltModIndex*, *fltArgDcBusMsr*} is denormalized, others are normalized, denormalized, or zero, i.e. $\left\{ \left(\begin{matrix} fltArg1, fltArg2, \\ fltModIndex, fltArgDcBusMsr \end{matrix} \right) \in X \middle| \begin{matrix} \left\{ \begin{matrix} fltArg2, \\ fltModIndex, \\ fltArgDcBusMsr \end{matrix} \right\} \cap D \neq \varnothing, \\ \left\{ \begin{matrix} fltArg2, \\ fltModIndex, \\ fltArgDcBusMsr \end{matrix} \right\} \cap M = \varnothing \end{matrix} \right\}$	$(-Inf, Inf)$	{*pmax*, *nmax*, Inf, -Inf, 0, -0}
All of {*fltArg2*, *fltModIndex*} are normalized or zero, *fltArgDcBusMsr* is normalized, inputs lead to normalized or zero results, i.e. $\left\{ \begin{matrix} \left(\begin{matrix} fltArg1, fltArg2, \\ fltModIndex, fltArgDcBusMsr \end{matrix} \right) \in X \Big| \\ \left\{ \begin{matrix} fltArg2, \\ fltModIndex \end{matrix} \right\} \subset N \cup \{-0, +0\}, \\ fltArgDcBusMsr \in N, \\ ir_2 \in N \cup \{-0, +0\}, \\ refFltArg2 = 0 \vee \\ \left(\begin{matrix} \lvert refFltArg2 \rvert - 1.5 \cdot \mathrm{ULP}(refFltArg2) \notin D \wedge \\ \lvert refFltArg2 \rvert + 1.5 \cdot \mathrm{ULP}(refFltArg2) \neq Inf \end{matrix} \right) \end{matrix} \right\}$	$\langle -1.5, 1.5 \rangle$	N/A
All of {*fltArg1*, *fltModIndex*} are normalized or zero, *fltArgDcBusMsr* is zero, i.e. $\left\{ \left(\begin{matrix} fltArg1, fltArg2, \\ fltModIndex, fltArgDcBusMsr \end{matrix} \right) \in X \middle| \begin{matrix} \left\{ \begin{matrix} fltArg2, \\ fltModIndex \end{matrix} \right\} \subset N \cup \{-0, +0\}, \\ fltArgDcBusMsr = 0 \end{matrix} \right\}$	0	{0, -0}

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Table 176. GMCLIB_ElimDcBusRip_FLT Worst-Case Error Bounds - *fltArg2* Output*...continued*

Subset of input domain	Worst-case error bounds for *fltArg2* output [ulp]	Allowed specific values (regardless the error bounds) for *fltArg2* output
All of {*fltArg2*, *fltModIndex*} are normalized or zero, *fltArgDcBusMsr* is normalized, *fltArg2* output overflow, i.e. $\left\{ \begin{array}{c} \left(\begin{array}{c} fltArg1,\ fltArg2, \\ fltModIndex,\ fltArgDcBusMsr \end{array} \right) \in X \\ \left\{ \begin{array}{c} fltArg2, \\ fltModIndex \end{array} \right\} \subset N \cup \{-0,\ +0\}, \\ fltArgDcBusMsr \in N, \\ \lvert refFltArg2 \rvert + 1.5 \cdot \mathrm{ULP}(refFltArg2) = Inf \end{array} \right\}$	$(-Inf, Inf)$	{sign(*reffltArg2*)•Inf, sign(*reffltArg2*)•pmax, NaN}
All of {*fltArg2*, *fltModIndex*} are normalized or zero, *fltArgDcBusMsr* is normalized, *fltArg2* output underflow, i.e. $\left\{ \begin{array}{c} \left(\begin{array}{c} fltArg1,\ fltArg2, \\ fltModIndex,\ fltArgDcBusMsr \end{array} \right) \in X \\ \left\{ \begin{array}{c} fltArg2, \\ fltModIndex \end{array} \right\} \subset N \cup \{-0,\ +0\}, \\ fltArgDcBusMsr \in N, \\ refFltArg2 \neq 0 \wedge \\ \lvert refFltArg2 \rvert - 1.5 \cdot \mathrm{ULP}(refFltArg2) \in D \end{array} \right\}$	$\langle -1.5, 1.5 \rangle$	{0, -0}
All of {*fltArg2*, *fltModIndex*} are normalized or zero, *fltArgDcBusMsr* is normalized, intermediate result overflow, i.e. $\left\{ \begin{array}{c} \left(\begin{array}{c} fltArg1,\ fltArg2, \\ fltModIndex,\ fltArgDcBusMsr \end{array} \right) \in X \\ \left\{ \begin{array}{c} fltArg2, \\ fltModIndex \end{array} \right\} \subset N \cup \{-0,\ +0\}, \\ fltArgDcBusMsr \in N, \\ \lvert ir_2 \rvert + 0.5 \cdot \mathrm{ULP}(ir_2) \in \{Inf,\ -Inf\} \end{array} \right\}$	$(-Inf, Inf)$	{NaN, *pmax*, *nmax*, Inf, -Inf, 0, -0}

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Table 176. GMCLIB_ElimDcBusRip_FLT Worst-Case Error Bounds - *fltArg2* Output...*continued*

Subset of input domain	Worst-case error bounds for *fltArg2* output [ulp]	Allowed specific values (regardless the error bounds) for *fltArg2* output
All of {*fltArg2*, *fltModIndex*} are normalized or zero, *fltArgDcBusMsr* is normalized, intermediate result underflow, i.e. $\left\{ \begin{array}{c} \left(\begin{array}{c} fltArg1,\ fltArg2, \\ fltModIndex,\ fltArgDcBusMsr \end{array} \right) \in X \\ \left\{ \begin{array}{c} fltArg2, \\ fltModIndex \end{array} \right\} \subset N \cup \{-0,\ +0\}, \\ fltArgDcBusMsr \in N, \\ \lvert ir_2 \rvert - 0.5 \cdot \mathrm{ULP}(ir_2) \in D \wedge \\ ir_2 \neq 0 \end{array} \right\}$	$\langle -1.5, 1.5 \rangle$	{NaN, *pmax*, *nmax*, Inf, -Inf, 0, -0}

2.52 Function GMCLIB_Park_FLT

2.52.1 Declaration

```
void GMCLIB_Park_FLT(SWLIBS_2Syst_FLT *pOut, const
SWLIBS_2Syst_FLT *const pInAngle, const SWLIBS_2Syst_FLT *const
pIn);
```

2.52.2 Arguments

Table 177. GMCLIB_Park_FLT arguments

Type	Name	Direction	Description
SWLIBS_2Syst_FLT *	pOut	**input, output**	Pointer to the structure containing data of the two-phase rotational orthogonal system (d-q).
const SWLIBS_2Syst_FLT *const	pInAngle	**input**	Pointer to the structure where the values of the sine and cosine of the rotor position are stored.
const SWLIBS_2Syst_FLT *const	pIn	**input**	Pointer to the structure containing data of the two-phase stationary orthogonal system (α-β).

2.52.3 Worst-Case Error Bounds

Let (*AnglefltArg1*, *AnglefltArg2*, *InfltArg1*, *InfltArg2*) ∈ *X* be a set of inputs to GMCLIB_Park_FLT,

reffltArg1, *reffltArg2* be the theoretical exact results for outputs *fltArg1* and *fltArg2*, respectively,

$ir_1 = InfltArg1 \cdot AnglefltArg2$,

$ir_2 = InfltArg2 \cdot AnglefltArg1$,

$ir_3 = InfltArg2 \cdot AnglefltArg2$,

$ir_4 = -InfltArg1 \cdot AnglefltArg1$,

then

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Table 178. GMCLIB_Park_FLT Worst-Case Error Bounds - fltArg1 Output

Subset of input domain	Worst-case error bounds for fltArg1 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg1 output
Any of the inputs is NaN or infinity, i.e. $\left\{ \begin{pmatrix} AngleffltArg1, AngleffltArg2, \\ InfltArg1, InfltArg2 \end{pmatrix} \in X \middle\vert \begin{matrix} X \cap M \neq \varnothing \end{matrix} \right\}$	N/A	{Inf, -Inf, NaN, *pmax*, *nmax*, -0, +0}
Any of the inputs is denormalized, neither is NaN or infinity, i.e. $\left\{ \begin{pmatrix} AngleffltArg1, AngleffltArg2, \\ InfltArg1, InfltArg2 \end{pmatrix} \in X \middle\vert \begin{matrix} X \cap D \neq \varnothing, X \cap M = \varnothing \end{matrix} \right\}$	$(-Inf, Inf)$	N/A
All inputs normalized or zero, results normalized or zero, i.e. $\left\{ \begin{matrix} \begin{pmatrix} AngleffltArg1, AngleffltArg2, \\ InfltArg1, InfltArg2 \end{pmatrix} \in X \\ X \subset N \cup \{-0, +0\}, \\ \{ir_1, ir_2\} \subset N \cup \{-0, +0\}, \\ reffltArg1 = 0 \vee \\ \begin{pmatrix} \lvert reffltArg1 \rvert - \mathrm{ULP}(reffltArg1) \notin D \wedge \\ \lvert reffltArg1 \rvert + \mathrm{ULP}(reffltArg1) \neq Inf \end{pmatrix} \end{matrix} \right\}$	$\langle -1, 1 \rangle$	N/A
All inputs zero, i.e. $\left\{ \begin{pmatrix} AngleffltArg1, AngleffltArg2, \\ InfltArg1, InfltArg2 \end{pmatrix} \in X \middle\vert \begin{matrix} X \subset \{-0, +0\} \end{matrix} \right\}$	0	N/A
All inputs normalized or zero, *fltArg1* output overflow, i.e. $\left\{ \begin{matrix} \begin{pmatrix} AngleffltArg1, AngleffltArg2, \\ InfltArg1, InfltArg2 \end{pmatrix} \in X \\ X \subset N \cup \{-0, +0\}, \\ \lvert reffltArg1 \rvert + \mathrm{ULP}(reffltArg1) = Inf \end{matrix} \right\}$	$\langle -1, 1 \rangle$	{sign(*reffltArg1*)•Inf, sign(*reffltArg1*)•pmax, NaN}

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Table 178. GMCLIB_Park_FLT Worst-Case Error Bounds - fltArg1 Output*...continued*

Subset of input domain	Worst-case error bounds for fltArg1 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg1 output
All inputs normalized or zero, *fltArg1* output underflow or underflow in internal compensation calculation, i.e. $\left\{ \begin{pmatrix} AngleffltArg1, AngleffltArg2, \\ InfltArg1, InfltArg2 \end{pmatrix} \in X \middle\vert \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ 0.5 \cdot (\lvert refffltArg1 \rvert - \mathrm{ULP}(refffltArg1) \in D) \wedge \\ refffltArg1 \neq 0 \end{array} \right\}$	$\langle -2^{24}, 2^{24} \rangle$	{-0, +0}
All inputs normalized or zero, intermediate result overflow, i.e. $\left\{ \begin{pmatrix} AngleffltArg1, AngleffltArg2, \\ InfltArg1, InfltArg2 \end{pmatrix} \in X \middle\vert \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \lvert ir_1 \rvert \in \{Inf, -Inf\} \vee \lvert ir_2 \rvert \in \{Inf, -Inf\} \end{array} \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)
All inputs normalized or zero, intermediate result underflow, i.e. $\left\{ \begin{pmatrix} AngleffltArg1, AngleffltArg2, \\ InfltArg1, InfltArg2 \end{pmatrix} \in X \middle\vert \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ ir_1 \in D \vee ir_2 \in D \end{array} \right\}$	$(-Inf, Inf)$	N/A

Table 179. GMCLIB_Park_FLT Worst-Case Error Bounds - fltArg2 Output

Subset of input domain	Worst-case error bounds for fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg2 output
Any of the inputs is NaN or infinity, i.e. $\left\{ \begin{pmatrix} AngleffltArg1, AngleffltArg2, \\ InfltArg1, InfltArg2 \end{pmatrix} \in X \middle\vert X \cap M \neq \varnothing \right\}$	N/A	{Inf, -Inf, NaN, *pmax*, *nmax*, -0, +0}
Any of the inputs is denormalized, neither is NaN or infinity, i.e. $\left\{ \begin{pmatrix} AngleffltArg1, AngleffltArg2, \\ InfltArg1, InfltArg2 \end{pmatrix} \in X \middle\vert X \cap D \neq \varnothing, X \cap M = \varnothing \right\}$	$(-Inf, Inf)$	N/A

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Table 179. GMCLIB_Park_FLT Worst-Case Error Bounds - fltArg2 Output*...continued*

Subset of input domain	Worst-case error bounds for fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg2 output
All inputs normalized or zero, results normalized or zero, i.e. $\left\{ \begin{pmatrix} AngleflitArg1, AngleflitArg2, \\ InfltArg1, InfltArg2 \end{pmatrix} \in X \middle\vert \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \{ir_3, ir_4\} \subset N \cup \{-0, +0\}, \\ refflitArg2 = 0 \vee \\ \begin{pmatrix} \lvert refflitArg2 \rvert - \mathrm{ULP}(refflitArg2) \notin D \wedge \\ \lvert refflitArg2 \rvert + \mathrm{ULP}(refflitArg2) \neq Inf \end{pmatrix} \end{array} \right\}$	$\langle -1, 1 \rangle$	N/A
All inputs zero, i.e. $\left\{ \begin{pmatrix} AngleflitArg1, AngleflitArg2, \\ InfltArg1, InfltArg2 \end{pmatrix} \in X \middle\vert \begin{array}{c} X \subset \{-0, +0\} \end{array} \right\}$	0	N/A
All inputs normalized or zero, *fltArg2* output overflow, i.e. $\left\{ \begin{pmatrix} AngleflitArg1, AngleflitArg2, \\ InfltArg1, InfltArg2 \end{pmatrix} \in X \middle\vert \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \lvert refflitArg2 \rvert + \mathrm{ULP}(refflitArg2) = Inf \end{array} \right\}$	$\langle -1, 1 \rangle$	{sign(*reffltArg2*)•Inf, sign(*reffltArg2*)•pmax, NaN}
All inputs normalized or zero, *fltArg2* output underflow or underflow in internal compensation calculation, i.e. $\left\{ \begin{pmatrix} AngleflitArg1, AngleflitArg2, \\ InfltArg1, InfltArg2 \end{pmatrix} \in X \middle\vert \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ 0.5 \cdot (\lvert refflitArg2 \rvert - \mathrm{ULP}(refflitArg2) \in D) \wedge \\ refflitArg2 \neq 0 \end{array} \right\}$	$\langle -2^{24}, 2^{24} \rangle$	{-0, +0}
All inputs normalized or zero, intermediate result overflow, i.e. $\left\{ \begin{pmatrix} AngleflitArg1, AngleflitArg2, \\ InfltArg1, InfltArg2 \end{pmatrix} \in X \middle\vert \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \lvert ir_3 \rvert \in \{Inf, -Inf\} \vee \lvert ir_4 \rvert \in \{Inf, -Inf\} \end{array} \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)

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Table 179. GMCLIB_Park_FLT Worst-Case Error Bounds - fltArg2 Output*...continued*

Subset of input domain	Worst-case error bounds for fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg2 output
All inputs normalized or zero, intermediate result underflow, i.e. $\left\{ \begin{array}{c} \left(\begin{array}{c} AnglefltArg1, AnglefltArg2, \\ InfltArg1, InfltArg2 \end{array} \right) \in X \\ X \subset N \cup \{-0, +0\}, \\ ir_3 \in D \vee ir_4 \in D \end{array} \right\}$	$(-Inf, Inf)$	N/A

2.53 Function GMCLIB_ParkInv_FLT

2.53.1 Declaration

```
void GMCLIB_ParkInv_FLT(SWLIBS_2Syst_FLT *const pOut, const
SWLIBS_2Syst_FLT *const pInAngle, const SWLIBS_2Syst_FLT *const
pIn);
```

2.53.2 Arguments

Table 180. GMCLIB_ParkInv_FLT arguments

Type	Name	Direction	Description
SWLIBS_2Syst_FLT *const	pOut	**input, output**	Pointer to the structure containing data of the two-phase stationary orthogonal system (α-β).
const SWLIBS_2Syst_FLT *const	pInAngle	**input**	Pointer to the structure where the values of the sine and cosine of the rotor position are stored.
const SWLIBS_2Syst_FLT *const	pIn	**input**	Pointer to the structure containing data of the two-phase rotational orthogonal system (d-q).

2.53.3 Worst-Case Error Bounds

Let (*AnglefltArg1*, *AnglefltArg2*, *InfltArg1*, *InfltArg2*) ∈ *X* be a set of inputs to GMCLIB_ParkInv_FLT,

reffltArg1, *reffltArg2* be the theoretical exact results for outputs *fltArg1* and *fltArg2*, respectively,

$ir_1 = InfltArg1 \cdot AnglefltArg2$,

$ir_2 = -InfltArg2 \cdot AnglefltArg1$,

$ir_3 = InfltArg1 \cdot AnglefltArg1$,

$ir_4 = InfltArg2 \cdot AnglefltArg2$,

then

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Table 181. GMCLIB_ParkInv_FLT Worst-Case Error Bounds - fltArg1 Output

Subset of input domain	Worst-case error bounds for fltArg1 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg1 output
Any of the inputs is NaN or infinity, i.e. $\left\{ \left(\begin{matrix} AnglefltArg1, AnglefltArg2, \\ InfltArg1, InfltArg2 \end{matrix} \right) \in X \middle\vert \begin{matrix} \\ X \cap M \neq \varnothing \end{matrix} \right\}$	N/A	{Inf, -Inf, NaN, *pmax*, *nmax*, -0, +0}
Any of the inputs is denormalized, neither is NaN or infinity, i.e. $\left\{ \left(\begin{matrix} AnglefltArg1, AnglefltArg2, \\ InfltArg1, InfltArg2 \end{matrix} \right) \in X \middle\vert \begin{matrix} \\ X \cap D \neq \varnothing, X \cap M = \varnothing \end{matrix} \right\}$	$(-Inf, Inf)$	N/A
All inputs normalized or zero, results normalized or zero, i.e. $\left\{ \begin{matrix} \left(\begin{matrix} AnglefltArg1, AnglefltArg2, \\ InfltArg1, InfltArg2 \end{matrix} \right) \in X \\ X \subset N \cup \{-0, +0\}, \\ \{ir_1, ir_2\} \subset N \cup \{-0, +0\}, \\ refefltArg1 = 0 \vee \\ \left(\begin{matrix} \lvert refefltArg1 \rvert - \mathrm{ULP}(refefltArg1) \notin D \wedge \\ \lvert refefltArg1 \rvert + \mathrm{ULP}(refefltArg1) \neq Inf \end{matrix} \right) \end{matrix} \right\}$	$\langle -1, 1 \rangle$	N/A
All inputs zero, i.e. $\left\{ \left(\begin{matrix} AnglefltArg1, AnglefltArg2, \\ InfltArg1, InfltArg2 \end{matrix} \right) \in X \middle\vert \begin{matrix} \\ X \subset \{-0, +0\} \end{matrix} \right\}$	0	N/A
All inputs normalized or zero, *fltArg1* output overflow, i.e. $\left\{ \begin{matrix} \left(\begin{matrix} AnglefltArg1, AnglefltArg2, \\ InfltArg1, InfltArg2 \end{matrix} \right) \in X \\ X \subset N \cup \{-0, +0\}, \\ \lvert refefltArg1 \rvert + \mathrm{ULP}(refefltArg1) = Inf \end{matrix} \right\}$	$\langle -1, 1 \rangle$	{sign(*reffltArg1*)•Inf, sign(*reffltArg1*)•pmax, NaN}

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Table 181. GMCLIB_ParkInv_FLT Worst-Case Error Bounds - fltArg1 Output*...continued*

Subset of input domain	Worst-case error bounds for fltArg1 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg1 output
All inputs normalized or zero, *fltArg1* output underflow or underflow in internal compensation calculation, i.e. $\left\{ \begin{pmatrix} AngleflrtArg1, AngleflrtArg2, \\ InfltArg1, InfltArg2 \end{pmatrix} \in X \middle\vert \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ 0.5 \cdot (\lvert refflrtArg1 \rvert - \mathrm{ULP}(refflrtArg1) \in D) \wedge \\ refflrtArg1 \neq 0 \end{array} \right\}$	$\langle -2^{24}, 2^{24} \rangle$	{-0, +0}
All inputs normalized or zero, intermediate result overflow, i.e. $\left\{ \begin{pmatrix} AngleflrtArg1, AngleflrtArg2, \\ InfltArg1, InfltArg2 \end{pmatrix} \in X \middle\vert \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \lvert ir_1 \rvert \in \{Inf, -Inf\} \vee \lvert ir_2 \rvert \in \{Inf, -Inf\} \end{array} \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)
All inputs normalized or zero, intermediate result underflow, i.e. $\left\{ \begin{pmatrix} AngleflrtArg1, AngleflrtArg2, \\ InfltArg1, InfltArg2 \end{pmatrix} \in X \middle\vert \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ ir_1 \in D \vee ir_2 \in D \end{array} \right\}$	$(-Inf, Inf)$	N/A

Table 182. GMCLIB_ParkInv_FLT Worst-Case Error Bounds - fltArg2 Output

Subset of input domain	Worst-case error bounds for fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg2 output
Any of the inputs is NaN or infinity, i.e. $\left\{ \begin{pmatrix} AngleflrtArg1, AngleflrtArg2, \\ InfltArg1, InfltArg2 \end{pmatrix} \in X \middle\vert X \cap M \neq \varnothing \right\}$	N/A	{Inf, -Inf, NaN, *pmax*, *nmax*, -0, +0}
Any of the inputs is denormalized, neither is NaN or infinity, i.e. $\left\{ \begin{pmatrix} AngleflrtArg1, AngleflrtArg2, \\ InfltArg1, InfltArg2 \end{pmatrix} \in X \middle\vert X \cap D \neq \varnothing, X \cap M = \varnothing \right\}$	$(-Inf, Inf)$	N/A

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Table 182. GMCLIB_ParkInv_FLT Worst-Case Error Bounds - fltArg2 Output*...continued*

Subset of input domain	Worst-case error bounds for fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg2 output
All inputs normalized or zero, results normalized or zero, i.e. $\left\{ \begin{pmatrix} AngleflfltArg1, AngleflfltArg2, \\ InfltArg1, InfltArg2 \end{pmatrix} \in X \middle\vert \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \{ir_3, ir_4\} \subset N \cup \{-0, +0\}, \\ refffltArg2 = 0 \vee \\ \left(\begin{array}{l} \lvert refffltArg2 \rvert - \mathrm{ULP}(refffltArg2) \notin D \wedge \\ \lvert refffltArg2 \rvert + \mathrm{ULP}(refffltArg2) \neq Inf \end{array} \right) \end{array} \right\}$	$\langle -1, 1 \rangle$	N/A
All inputs zero, i.e. $\left\{ \begin{pmatrix} AngleflfltArg1, AngleflfltArg2, \\ InfltArg1, InfltArg2 \end{pmatrix} \in X \middle\vert \begin{array}{c} X \subset \{-0, +0\} \end{array} \right\}$	0	N/A
All inputs normalized or zero, *fltArg2* output overflow, i.e. $\left\{ \begin{pmatrix} AngleflfltArg1, AngleflfltArg2, \\ InfltArg1, InfltArg2 \end{pmatrix} \in X \middle\vert \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \lvert refffltArg2 \rvert + \mathrm{ULP}(refffltArg2) = Inf \end{array} \right\}$	$\langle -1, 1 \rangle$	{sign(*reffltArg2*)•Inf, sign(*reffltArg2*)•pmax, NaN}
All inputs normalized or zero, *fltArg2* output underflow or underflow in internal compensation calculation, i.e. $\left\{ \begin{pmatrix} AngleflfltArg1, AngleflfltArg2, \\ InfltArg1, InfltArg2 \end{pmatrix} \in X \middle\vert \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ 0.5 \cdot (\lvert refffltArg2 \rvert - \mathrm{ULP}(refffltArg2) \in D) \wedge \\ refffltArg2 \neq 0 \end{array} \right\}$	$\langle -2^{24}, 2^{24} \rangle$	{-0, +0}
All inputs normalized or zero, intermediate result overflow, i.e. $\left\{ \begin{pmatrix} AngleflfltArg1, AngleflfltArg2, \\ InfltArg1, InfltArg2 \end{pmatrix} \in X \middle\vert \begin{array}{c} X \subset N \cup \{-0, +0\}, \\ \lvert ir_3 \rvert \in \{Inf, -Inf\} \vee \lvert ir_4 \rvert \in \{Inf, -Inf\} \end{array} \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)

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Table 182. GMCLIB_ParkInv_FLT Worst-Case Error Bounds - fltArg2 Output*...continued*

Subset of input domain	Worst-case error bounds for fltArg2 output [ulp]	Allowed specific values (regardless the error bounds) for fltArg2 output
All inputs normalized or zero, intermediate result underflow, i.e. $\left\{ \begin{pmatrix} AngleFltArg1, AngleFltArg2, \\ InfltArg1, InfltArg2 \end{pmatrix} \in X \middle\vert \begin{matrix} X \subset N \cup \{-0, +0\}, \\ ir_3 \in D \vee ir_4 \in D \end{matrix} \right\}$	$(-Inf, Inf)$	N/A

2.54 Function GMCLIB_PwmIct_FLT

2.54.1 Declaration

```
tU32 GMCLIB_PwmIct_FLT(SWLIBS_3Syst_FLT *pOut, const
SWLIBS_2Syst_FLT *const pIn);
```

2.54.2 Arguments

Table 183. GMCLIB_PwmIct_FLT arguments

Type	Name	Direction	Description
SWLIBS_3Syst_FLT *	pOut	**input, output**	Pointer to the structure containing calculated duty-cycle ratios of the 3-Phase system.
const SWLIBS_2Syst_FLT *const	pIn	**input**	Pointer to the structure containing direct U_α and quadrature U_β components of the stator voltage vector.

2.54.3 Worst-Case Error Bounds

Note: The allowed error bounds for the floating-point outputs of this function are expressed in terms of allowed absolute error.

Let (*fltArg1*, *fltArg2*) ∈ *X* be a set of inputs to GMCLIB_PwmIct_FLT,

then

Table 184. GMCLIB_PwmIct_FLT Return Value

Subset of input domain	Meaningful Return Value
Any of the inputs is NaN, i.e. $\left\{ (fltArg1, fltArg2) \in X \middle\vert \begin{matrix} fltArg1 = NaN \vee \\ fltArg2 = NaN \end{matrix} \right\}$	No

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Table 184. GMCLIB_PwmIct_FLT Return Value*...continued*

Subset of input domain	Meaningful Return Value
Normalized, denormalized, or zero inputs, at least one input is outside the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert > 1 \vee \lvert fltArg2 \rvert > 1 \end{array} \right\}$	No
All inputs within the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert \leq 1, \lvert fltArg2 \rvert \leq 1 \end{array} \right\}$	Yes

Table 185. GMCLIB_PwmIct_FLT Worst-Case Error Bounds - Output fltArg1

Subset of input domain	Worst-case absolute error for fltArg1 output	Allowed specific values (regardless the error bounds) for fltArg1 output
Any of the inputs is NaN, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ fltArg1 = NaN \vee \\ fltArg2 = NaN \end{array} \right\}$	Inf	NaN
Normalized, denormalized, or zero inputs, at least one input is outside the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert > 1 \vee \lvert fltArg2 \rvert > 1 \end{array} \right\}$	Inf	{NaN, Inf, -Inf}
All inputs within the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert \leq 1, \lvert fltArg2 \rvert \leq 1 \end{array} \right\}$	2^{-19}	N/A

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Table 186. GMCLIB_PwmIct_FLT Worst-Case Error Bounds - Output fltArg2

Subset of input domain	Worst-case absolute error for fltArg2 output	Allowed specific values (regardless the error bounds) for fltArg2 output
Any of the inputs is NaN, i.e. $\left\{ (fltArg1, fltArg2) \in X \middle\vert \begin{array}{c} fltArg1 = NaN \vee \\ fltArg2 = NaN \end{array} \right\}$	Inf	NaN
Normalized, denormalized, or zero inputs, at least one input is outside the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \middle\vert \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert > 1 \vee \lvert fltArg2 \rvert > 1 \end{array} \right\}$	Inf	{NaN, Inf, -Inf}
All inputs within the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \middle\vert \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert \le 1, \lvert fltArg2 \rvert \le 1 \end{array} \right\}$	2^{-19}	N/A

Table 187. GMCLIB_PwmIct_FLT Worst-Case Error Bounds - Output fltArg3

Subset of input domain	Worst-case absolute error for fltArg3 output	Allowed specific values (regardless the error bounds) for fltArg3 output
Any of the inputs is NaN, i.e. $\left\{ (fltArg1, fltArg2) \in X \middle\vert \begin{array}{c} fltArg1 = NaN \vee \\ fltArg2 = NaN \end{array} \right\}$	Inf	NaN
Normalized, denormalized, or zero inputs, at least one input is outside the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \middle\vert \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert > 1 \vee \lvert fltArg2 \rvert > 1 \end{array} \right\}$	Inf	{NaN, Inf, -Inf}
All inputs within the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \middle\vert \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert \le 1, \lvert fltArg2 \rvert \le 1 \end{array} \right\}$	2^{-19}	N/A

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2.55 Function GMCLIB_SvmSci_FLT

2.55.1 Declaration

```
tU32 GMCLIB_SvmSci_FLT(SWLIBS_3Syst_FLT *pOut, const
SWLIBS_2Syst_FLT *const pIn);
```

2.55.2 Arguments

Table 188. GMCLIB_SvmSci_FLT arguments

Type	Name	Direction	Description
SWLIBS_3Syst_FLT *	pOut	**input, output**	Pointer to the structure containing calculated duty-cycle ratios of the 3-Phase system.
const SWLIBS_2Syst_FLT *const	pIn	**input**	Pointer to the structure containing direct U_α and quadrature U_β components of the stator voltage vector.

2.55.3 Worst-Case Error Bounds

Let (*fltArg1*, *fltArg2*) ∈ *X* be a set of inputs to GMCLIB_SvmSci_FLT,

$$ir_1 = \frac{fltArg2}{\sqrt{3}},$$

$$me_1 = 1.5,$$

$$ir_2 = -\frac{fltArg1}{2\cdot\sqrt{3}},$$

$$me_2 = 1.0,$$

$$ie_1 = \max(fe(|fltArg2\cdot 0.5|), fe(|ir_2| + me_2\cdot ULP(ir_2))),$$

$$ir_3 = fltArg2\cdot 0.5 + ir_2,$$

$$ie_2 = fe(ir_3),$$

$$cb_1 = \begin{cases} 0, & ie_1 - ie_2 \le 0 \\ ie_1 - ie_2, & ie_1 - ie_2 > 0 \end{cases},$$

$$me_3 = 0.5 + 1.0\cdot 2^{cb_1},$$

$$ir_4 = -fltArg2\cdot 0.5 + ir_2,$$

$$ie_3 = fe(ir_4),$$

$$cb_2 = \begin{cases} 0, & ie_1 - ie_3 \le 0 \\ ie_1 - ie_3, & ie_1 - ie_3 > 0 \end{cases},$$

$$me_4 = 0.5 + 1.0\cdot 2^{cb_2},$$

$$ir_5 = 1 - ir_1,$$

$$ie_4 = fe(ir_5),$$

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$$cb_3 = \begin{cases} 0, & 1 - ie_4 \le 0 \\ 1 - ie_4, & 1 - ie_4 > 0 \end{cases},$$

$$me_5 = 0.5 + me_1 \cdot 2^{cb_3},$$

$$ir_6 = 1 - ir_3,$$

$$ie_5 = fe(ir_6),$$

$$cb_4 = \begin{cases} 0, & 1 - ie_5 \le 0 \\ 1 - ie_5, & 1 - ie_5 > 0 \end{cases},$$

$$me_6 = 0.5 + me_3 \cdot 2^{cb_4},$$

$$ir_7 = 1 - ir_4,$$

$$ie_6 = fe(ir_7),$$

$$cb_5 = \begin{cases} 0, & 1 - ie_6 \le 0 \\ 1 - ie_6, & 1 - ie_6 > 0 \end{cases},$$

$$me_7 = 0.5 + me_4 \cdot 2^{cb_5},$$

$$ir_8 = \begin{cases} ir_5, & if\left(ir_1 > 0.5\right) \vee \left(ir_1 < -0.5\right) \\ ir_6, & if\left(ir_3 > 0.5\right) \vee \left(ir_3 < -0.5\right) \\ ir_7, & if\left(ir_4 > 0.5\right) \vee \left(ir_4 < -0.5\right) \\ 0.5, & otherwise \end{cases},$$

$$me_8 = \begin{cases} me_5, & if\left(ir_1 > 0.5\right) \vee \left(ir_1 < -0.5\right) \\ me_6, & if\left(ir_3 > 0.5\right) \vee \left(ir_3 < -0.5\right) \\ me_7, & if\left(ir_4 > 0.5\right) \vee \left(ir_4 < -0.5\right) \\ 0, & otherwise \end{cases},$$

$$ie_7 = \max(fe(|ir_8| + me_8 \cdot ULP(ir_8)), fe(|ir_1| + me_1 \cdot ULP(ir_1))),$$

$$ir_9 = ir_1 + ir_8,$$

$$ie_8 = fe(ir_9),$$

$$cb_6 = \begin{cases} 0, & ie_7 - ie_8 \le 0 \\ ie_7 - ie_8, & ie_7 - ie_8 > 0 \end{cases},$$

$$me_9 = 0.5 + \left(me_1 + me_8\right) \cdot 2^{cb_6},$$

$$ie_9 = \max(fe(|ir_8| + me_8 \cdot ULP(ir_8)), fe(|ir_3| + me_3 \cdot ULP(ir_3))),$$

$$ir_{10} = ir_3 + ir_8,$$

$$ie_{10} = fe(ir_{10}),$$

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$$cb_7 = \begin{cases} 0, & ie_9 - ie_{10} \le 0 \\ ie_9 - ie_{10}, & ie_9 - ie_{10} > 0 \end{cases},$$

$$me_{10} = 0.5 + \left(me_3 + me_8\right) \cdot 2^{cb_7},$$

$$ie_{11} = \max\left(fe\left(|ir_8| + me_8 \cdot ULP\left(ir_8 \right) \right), fe\left(|ir_4| + me_4 \cdot ULP\left(ir_4 \right) \right) \right),$$

$$ir_{11} = ir_4 + ir_8,$$

$$ie_{12} = fe\left(ir_{11} \right),$$

$$cb_8 = \begin{cases} 0, & ie_{11} - ie_{12} \le 0 \\ ie_{11} - ie_{12}, & ie_{11} - ie_{12} > 0 \end{cases},$$

$$me_{11} = 0.5 + \left(me_4 + me_8\right) \cdot 2^{cb_8},$$

then

Table 189. GMCLIB_SvmSci_FLT Return Value

Subset of input domain	Meaningful Return Value
Any of the inputs is NaN, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ fltArg1 = NaN \vee \\ fltArg2 = NaN \end{array} \right\}$	No
Normalized, denormalized, or zero inputs, at least one input is outside the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert > 1 \vee \lvert fltArg2 \rvert > 1 \end{array} \right\}$	No
All inputs within the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert \le 1, \lvert fltArg2 \rvert \le 1 \end{array} \right\}$	Yes

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Table 190. GMCLIB_SvmSci_FLT Worst-Case Error Bounds - Output fltArg1

Subset of input domain	Worst-case absolute error for fltArg1 output	Allowed specific values (regardless the error bounds) for fltArg1 output
Any of the inputs is NaN, i.e. $\left\{ (fltArg1, fltArg2) \in X \middle\vert \begin{array}{c} fltArg1 = NaN \vee \\ fltArg2 = NaN \end{array} \right\}$	$(-Inf, Inf)$	NaN
Normalized, denormalized, or zero inputs, at least one input is outside the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \middle\vert \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert > 1 \vee \lvert fltArg2 \rvert > 1 \end{array} \right\}$	$(-Inf, Inf)$	{NaN, Inf, -Inf}
All inputs within the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \middle\vert \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert \le 1, \lvert fltArg2 \rvert \le 1 \end{array} \right\}$	$\langle -me_9, me_9 \rangle$	N/A

Table 191. GMCLIB_SvmSci_FLT Worst-Case Error Bounds - Output fltArg2

Subset of input domain	Worst-case absolute error for fltArg2 output	Allowed specific values (regardless the error bounds) for fltArg2 output
Any of the inputs is NaN, i.e. $\left\{ (fltArg1, fltArg2) \in X \middle\vert \begin{array}{c} fltArg1 = NaN \vee \\ fltArg2 = NaN \end{array} \right\}$	$(-Inf, Inf)$	NaN
Normalized, denormalized, or zero inputs, at least one input is outside the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \middle\vert \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert > 1 \vee \lvert fltArg2 \rvert > 1 \end{array} \right\}$	$(-Inf, Inf)$	{NaN, Inf, -Inf}
All inputs within the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \middle\vert \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert \le 1, \lvert fltArg2 \rvert \le 1 \end{array} \right\}$	$\langle -me_{10}, me_{10} \rangle$	N/A

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Table 192. GMCLIB_SvmSci_FLT Worst-Case Error Bounds - Output fltArg3

Subset of input domain	Worst-case absolute error for fltArg3 output	Allowed specific values (regardless the error bounds) for fltArg3 output
Any of the inputs is NaN, i.e. $\left\{ (fltArg1, fltArg2) \in X \middle\vert \begin{array}{c} fltArg1 = NaN \vee \\ fltArg2 = NaN \end{array} \right\}$	$(-Inf, Inf)$	NaN
Normalized, denormalized, or zero inputs, at least one input is outside the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \middle\vert \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert > 1 \vee \lvert fltArg2 \rvert > 1 \end{array} \right\}$	$(-Inf, Inf)$	{NaN, Inf, -Inf}
All inputs within the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \middle\vert \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert \le 1, \lvert fltArg2 \rvert \le 1 \end{array} \right\}$	$\langle -me_{11}, me_{11} \rangle$	N/A

2.56 Function GMCLIB_SvmStd_FLT

2.56.1 Declaration

```
tU32 GMCLIB_SvmStd_FLT(SWLIBS_3Syst_FLT *pOut, const
SWLIBS_2Syst_FLT *const pIn);
```

2.56.2 Arguments

Table 193. GMCLIB_SvmStd_FLT arguments

Type	Name	Direction	Description
SWLIBS_3Syst_FLT *	pOut	**input, output**	Pointer to the structure containing calculated duty-cycle ratios of the 3-Phase system.
const SWLIBS_2Syst_FLT *const	pIn	**input**	Pointer to the structure containing direct U_α and quadrature U_β components of the stator voltage vector.

2.56.3 Worst-Case Error Bounds

Note: The allowed error bounds for the floating-point outputs of this function are expressed in terms of allowed absolute error.

Let (*fltArg1*, *fltArg2*) ∈ *X* be a set of inputs to GMCLIB_SvmStd_FLT,

then

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Table 194. GMCLIB_SvmStd_FLT Return Value

Subset of input domain	Meaningful Return Value
Any of the inputs is NaN, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ fltArg1 = NaN \vee \\ fltArg2 = NaN \end{array} \right\}$	No
Normalized, denormalized, or zero inputs, at least one input is outside the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert > 1 \vee \lvert fltArg2 \rvert > 1 \end{array} \right\}$	No
All inputs within the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert \le 1, \lvert fltArg2 \rvert \le 1 \end{array} \right\}$	Yes

Table 195. GMCLIB_SvmStd_FLT Worst-Case Error Bounds - Output fltArg1

Subset of input domain	Worst-case absolute error for fltArg1 output	Allowed specific values (regardless the error bounds) for fltArg1 output
Any of the inputs is NaN, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ fltArg1 = NaN \vee \\ fltArg2 = NaN \end{array} \right\}$	Inf	NaN
Normalized, denormalized, or zero inputs, at least one input is outside the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert > 1 \vee \lvert fltArg2 \rvert > 1 \end{array} \right\}$	Inf	{NaN, Inf, -Inf}
All inputs within the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert \le 1, \lvert fltArg2 \rvert \le 1 \end{array} \right\}$	2^{-19}	N/A

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Table 196. GMCLIB_SvmStd_FLT Worst-Case Error Bounds - Output fltArg2

Subset of input domain	Worst-case absolute error for fltArg2 output	Allowed specific values (regardless the error bounds) for fltArg2 output
Any of the inputs is NaN, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ fltArg1 = NaN \vee \\ fltArg2 = NaN \end{array} \right\}$	Inf	NaN
Normalized, denormalized, or zero inputs, at least one input is outside the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert > 1 \vee \lvert fltArg2 \rvert > 1 \end{array} \right\}$	Inf	{NaN, Inf, -Inf}
All inputs within the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert \le 1, \lvert fltArg2 \rvert \le 1 \end{array} \right\}$	2^{-19}	N/A

Table 197. GMCLIB_SvmStd_FLT Worst-Case Error Bounds - Output fltArg3

Subset of input domain	Worst-case absolute error for fltArg3 output	Allowed specific values (regardless the error bounds) for fltArg3 output
Any of the inputs is NaN, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ fltArg1 = NaN \vee \\ fltArg2 = NaN \end{array} \right\}$	Inf	NaN
Normalized, denormalized, or zero inputs, at least one input is outside the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert > 1 \vee \lvert fltArg2 \rvert > 1 \end{array} \right\}$	Inf	{NaN, Inf, -Inf}
All inputs within the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert \le 1, \lvert fltArg2 \rvert \le 1 \end{array} \right\}$	2^{-19}	N/A

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2.57 Function GMCLIB_SvmStd6Ph_FLT

2.57.1 Declaration

```
void GMCLIB_SvmStd6Ph_FLT(SWLIBS_6Syst_FLT *const pOutPwm,
SWLIBS_2Syst_U32 *const pOutSector, const SWLIBS_2Syst_FLT *const
pIn, const GMCLIB_SVMSTD_6PH_T_FLT *const pParam);
```

2.57.2 Arguments

Table 198. GMCLIB_SvmStd6Ph_FLT arguments

Type	Name	Direction	Description
SWLIBS_2Syst_U32 *const	pOutSector	**output**	Pointer to the structure containing calculated space sectors for each three-phase stator windings of the six-phase system. Arguments of the structure contain 32-bit unsigned integer values.
const SWLIBS_2Syst_FLT *const	pIn	**input**	Pointer to the structure containing direct U_α and quadrature U_β components of the stator voltage vector. Arguments of the structure contain single precision floating-point values.
const GMCLIB_SVMSTD_6PH_T_FLT *const	pParam	**output**	Pointer to the structure containing the transformation coefficient calculated by GMCLIB_SvmStd6PhInit function. Arguments of the structure contain single precision floating-point values.

2.57.3 Worst-Case Error Bounds

Note: The allowed error bounds for the floating-point outputs of this function are expressed in terms of allowed absolute error.

Let (*fltArg1*, *fltArg2*) ∈ *X* be a set of inputs to GMCLIB_SvmStd6Ph_FLT,

then

Table 199. GMCLIB_SvmStd6Ph_FLT Worst-Case Error Bounds - Output fltPwmA

Subset of input domain	Worst-case absolute error for fltPwmA output	Allowed specific values (regardless the error bounds) for fltPwmA output
Any of the inputs is NaN, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ fltArg1 = NaN \vee \\ fltArg2 = NaN \end{array} \right\}$	Inf	NaN
Normalized, denormalized, or zero inputs, at least one input is outside the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert > 1 \vee \lvert fltArg2 \rvert > 1 \end{array} \right\}$	Inf	{NaN, Inf, -Inf}

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Table 199. GMCLIB_SvmStd6Ph_FLT Worst-Case Error Bounds - Output fltPwmA*...continued*

Subset of input domain	Worst-case absolute error for fltPwmA output	Allowed specific values (regardless the error bounds) for fltPwmA output
All inputs within the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert \le 1, \lvert fltArg2 \rvert \le 1 \end{array} \right\}$	2^{-19}	N/A

Table 200. GMCLIB_SvmStd6Ph_FLT Worst-Case Error Bounds - Output fltPwmB

Subset of input domain	Worst-case absolute error for fltPwmB output	Allowed specific values (regardless the error bounds) for fltPwmB output
Any of the inputs is NaN, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ fltArg1 = NaN \vee \\ fltArg2 = NaN \end{array} \right\}$	Inf	NaN
Normalized, denormalized, or zero inputs, at least one input is outside the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert > 1 \vee \lvert fltArg2 \rvert > 1 \end{array} \right\}$	Inf	{NaN, Inf, -Inf}
All inputs within the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert \le 1, \lvert fltArg2 \rvert \le 1 \end{array} \right\}$	2^{-19}	N/A

Table 201. GMCLIB_SvmStd6Ph_FLT Worst-Case Error Bounds - Output fltPwmC

Subset of input domain	Worst-case absolute error for fltPwmC output	Allowed specific values (regardless the error bounds) for fltPwmC output
Any of the inputs is NaN, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ fltArg1 = NaN \vee \\ fltArg2 = NaN \end{array} \right\}$	Inf	NaN

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Table 201. GMCLIB_SvmStd6Ph_FLT Worst-Case Error Bounds - Output fltPwmC*...continued*

Subset of input domain	Worst-case absolute error for fltPwmC output	Allowed specific values (regardless the error bounds) for fltPwmC output
Normalized, denormalized, or zero inputs, at least one input is outside the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert > 1 \vee \lvert fltArg2 \rvert > 1 \end{array} \right\}$	Inf	{NaN, Inf, -Inf}
All inputs within the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert \leq 1, \lvert fltArg2 \rvert \leq 1 \end{array} \right\}$	2^{-19}	N/A

Table 202. GMCLIB_SvmStd6Ph_FLT Worst-Case Error Bounds - Output fltPwmD

Subset of input domain	Worst-case absolute error for fltPwmD output	Allowed specific values (regardless the error bounds) for fltPwmD output
Any of the inputs is NaN, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ fltArg1 = NaN \vee \\ fltArg2 = NaN \end{array} \right\}$	Inf	NaN
Normalized, denormalized, or zero inputs, at least one input is outside the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert > 1 \vee \lvert fltArg2 \rvert > 1 \end{array} \right\}$	Inf	{NaN, Inf, -Inf}
All inputs within the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert \leq 1, \lvert fltArg2 \rvert \leq 1 \end{array} \right\}$	2^{-19}	N/A

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Table 203. GMCLIB_SvmStd6Ph_FLT Worst-Case Error Bounds - Output fltPwmE

Subset of input domain	Worst-case absolute error for fltPwmE output	Allowed specific values (regardless the error bounds) for fltPwmE output
Any of the inputs is NaN, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ fltArg1 = NaN \vee \\ fltArg2 = NaN \end{array} \right\}$	Inf	NaN
Normalized, denormalized, or zero inputs, at least one input is outside the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert > 1 \vee \lvert fltArg2 \rvert > 1 \end{array} \right\}$	Inf	{NaN, Inf, -Inf}
All inputs within the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert \le 1, \lvert fltArg2 \rvert \le 1 \end{array} \right\}$	2^{-19}	N/A

Table 204. GMCLIB_SvmStd6Ph_FLT Worst-Case Error Bounds - Output fltPwmF

Subset of input domain	Worst-case absolute error for fltPwmF output	Allowed specific values (regardless the error bounds) for fltPwmF output
Any of the inputs is NaN, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ fltArg1 = NaN \vee \\ fltArg2 = NaN \end{array} \right\}$	Inf	NaN
Normalized, denormalized, or zero inputs, at least one input is outside the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert > 1 \vee \lvert fltArg2 \rvert > 1 \end{array} \right\}$	Inf	{NaN, Inf, -Inf}
All inputs within the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert \le 1, \lvert fltArg2 \rvert \le 1 \end{array} \right\}$	2^{-19}	N/A

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Table 205. GMCLIB_SvmStd6Ph_FLT - Output Sector1

Subset of input domain	Meaningful Return Value
Any of the inputs is NaN, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ fltArg1 = NaN \vee \\ fltArg2 = NaN \end{array} \right\}$	No
Normalized, denormalized, or zero inputs, at least one input is outside the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert > 1 \vee \lvert fltArg2 \rvert > 1 \end{array} \right\}$	No
All inputs within the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert \leq 1, \lvert fltArg2 \rvert \leq 1 \end{array} \right\}$	Yes

Table 206. GMCLIB_SvmStd6Ph_FLT - Output Sector2

Subset of input domain	Meaningful Return Value
Any of the inputs is NaN, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ fltArg1 = NaN \vee \\ fltArg2 = NaN \end{array} \right\}$	No
Normalized, denormalized, or zero inputs, at least one input is outside the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert > 1 \vee \lvert fltArg2 \rvert > 1 \end{array} \right\}$	No
All inputs within the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert \leq 1, \lvert fltArg2 \rvert \leq 1 \end{array} \right\}$	Yes

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2.58 Function GMCLIB_SvmU0n_FLT

2.58.1 Declaration

```
tU32 GMCLIB_SvmU0n_FLT(SWLIBS_3Syst_FLT *pOut, const
SWLIBS_2Syst_FLT *const pIn);
```

2.58.2 Arguments

Table 207. GMCLIB_SvmU0n_FLT arguments

Type	Name	Direction	Description
SWLIBS_3Syst_FLT *	pOut	**input, output**	Pointer to the structure containing calculated duty-cycle ratios of the 3-Phase system.
const SWLIBS_2Syst_FLT *const	pIn	**input**	Pointer to the structure containing direct U_α and quadrature U_β components of the stator voltage vector.

2.58.3 Worst-Case Error Bounds

Note: The allowed error bounds for the floating-point outputs of this function are expressed in terms of allowed absolute error.

Let (*fltArg1*, *fltArg2*) $\in X$ be a set of inputs to GMCLIB_SvmU0n_FLT,

then

Table 208. GMCLIB_SvmU0n_FLT Return Value

Subset of input domain	Meaningful Return Value
Any of the inputs is NaN, i.e. $\left\{ (fltArg1, fltArg2) \in X \middle\vert \begin{array}{c} fltArg1 = NaN \vee \\ fltArg2 = NaN \end{array} \right\}$	No
Normalized, denormalized, or zero inputs, at least one input is outside the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \middle\vert \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert > 1 \vee \lvert fltArg2 \rvert > 1 \end{array} \right\}$	No
All inputs within the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \middle\vert \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert \le 1, \lvert fltArg2 \rvert \le 1 \end{array} \right\}$	Yes

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Table 209. GMCLIB_SvmU0n_FLT Worst-Case Error Bounds - Output fltArg1

Subset of input domain	Worst-case absolute error for fltArg1 output	Allowed specific values (regardless the error bounds) for fltArg1 output
Any of the inputs is NaN, i.e. $\left\{ (fltArg1, fltArg2) \in X \middle\vert \begin{array}{c} fltArg1 = NaN \vee \\ fltArg2 = NaN \end{array} \right\}$	Inf	NaN
Normalized, denormalized, or zero inputs, at least one input is outside the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \middle\vert \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert > 1 \vee \lvert fltArg2 \rvert > 1 \end{array} \right\}$	Inf	{NaN, Inf, -Inf}
All inputs within the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \middle\vert \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert \le 1, \lvert fltArg2 \rvert \le 1 \end{array} \right\}$	2^{-19}	N/A

Table 210. GMCLIB_SvmU0n_FLT Worst-Case Error Bounds - Output fltArg2

Subset of input domain	Worst-case absolute error for fltArg2 output	Allowed specific values (regardless the error bounds) for fltArg2 output
Any of the inputs is NaN, i.e. $\left\{ (fltArg1, fltArg2) \in X \middle\vert \begin{array}{c} fltArg1 = NaN \vee \\ fltArg2 = NaN \end{array} \right\}$	Inf	NaN
Normalized, denormalized, or zero inputs, at least one input is outside the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \middle\vert \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert > 1 \vee \lvert fltArg2 \rvert > 1 \end{array} \right\}$	Inf	{NaN, Inf, -Inf}
All inputs within the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \middle\vert \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert \le 1, \lvert fltArg2 \rvert \le 1 \end{array} \right\}$	2^{-19}	N/A

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Table 211. GMCLIB_SvmU0n_FLT Worst-Case Error Bounds - Output fltArg3

Subset of input domain	Worst-case absolute error for fltArg3 output	Allowed specific values (regardless the error bounds) for fltArg3 output
Any of the inputs is NaN, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ fltArg1 = NaN \vee \\ fltArg2 = NaN \end{array} \right\}$	Inf	NaN
Normalized, denormalized, or zero inputs, at least one input is outside the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert > 1 \vee \lvert fltArg2 \rvert > 1 \end{array} \right\}$	Inf	{NaN, Inf, -Inf}
All inputs within the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert \le 1, \lvert fltArg2 \rvert \le 1 \end{array} \right\}$	2^{-19}	N/A

2.59 Function GMCLIB_SvmU7n_FLT

2.59.1 Declaration

```
tU32 GMCLIB_SvmU7n_FLT(SWLIBS_3Syst_FLT *pOut, const
SWLIBS_2Syst_FLT *const pIn);
```

2.59.2 Arguments

Table 212. GMCLIB_SvmU7n_FLT arguments

Type	Name	Direction	Description
SWLIBS_3Syst_FLT *	pOut	**input, output**	Pointer to the structure containing calculated duty-cycle ratios of the 3-Phase system.
const SWLIBS_2Syst_FLT *const	pIn	**input**	Pointer to the structure containing direct U_α and quadrature U_β components of the stator voltage vector.

2.59.3 Worst-Case Error Bounds

Note: The allowed error bounds for the floating-point outputs of this function are expressed in terms of allowed absolute error.

Let (*fltArg1*, *fltArg2*) ∈ *X* be a set of inputs to GMCLIB_SvmU7n_FLT,

then

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Table 213. GMCLIB_SvmU7n_FLT Return Value

Subset of input domain	Meaningful Return Value
Any of the inputs is NaN, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ fltArg1 = NaN \vee \\ fltArg2 = NaN \end{array} \right\}$	No
Normalized, denormalized, or zero inputs, at least one input is outside the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert > 1 \vee \lvert fltArg2 \rvert > 1 \end{array} \right\}$	No
All inputs within the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert \le 1, \lvert fltArg2 \rvert \le 1 \end{array} \right\}$	Yes

Table 214. GMCLIB_SvmU7n_FLT Worst-Case Error Bounds - Output fltArg1

Subset of input domain	Worst-case absolute error for fltArg1 output	Allowed specific values (regardless the error bounds) for fltArg1 output
Any of the inputs is NaN, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ fltArg1 = NaN \vee \\ fltArg2 = NaN \end{array} \right\}$	Inf	NaN
Normalized, denormalized, or zero inputs, at least one input is outside the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert > 1 \vee \lvert fltArg2 \rvert > 1 \end{array} \right\}$	Inf	{NaN, Inf, -Inf}
All inputs within the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \mid \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert \le 1, \lvert fltArg2 \rvert \le 1 \end{array} \right\}$	2^{-19}	N/A

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Table 215. GMCLIB_SvmU7n_FLT Worst-Case Error Bounds - Output fltArg2

Subset of input domain	Worst-case absolute error for fltArg2 output	Allowed specific values (regardless the error bounds) for fltArg2 output
Any of the inputs is NaN, i.e. $\left\{ (fltArg1, fltArg2) \in X \middle\vert \begin{array}{c} fltArg1 = NaN \vee \\ fltArg2 = NaN \end{array} \right\}$	Inf	NaN
Normalized, denormalized, or zero inputs, at least one input is outside the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \middle\vert \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert > 1 \vee \lvert fltArg2 \rvert > 1 \end{array} \right\}$	Inf	{NaN, Inf, -Inf}
All inputs within the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \middle\vert \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert \le 1, \lvert fltArg2 \rvert \le 1 \end{array} \right\}$	2^{-19}	N/A

Table 216. GMCLIB_SvmU7n_FLT Worst-Case Error Bounds - Output fltArg3

Subset of input domain	Worst-case absolute error for fltArg3 output	Allowed specific values (regardless the error bounds) for fltArg3 output
Any of the inputs is NaN, i.e. $\left\{ (fltArg1, fltArg2) \in X \middle\vert \begin{array}{c} fltArg1 = NaN \vee \\ fltArg2 = NaN \end{array} \right\}$	Inf	NaN
Normalized, denormalized, or zero inputs, at least one input is outside the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \middle\vert \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert > 1 \vee \lvert fltArg2 \rvert > 1 \end{array} \right\}$	Inf	{NaN, Inf, -Inf}
All inputs within the [-1, 1] interval, i.e. $\left\{ \begin{array}{c} (fltArg1, fltArg2) \in X \middle\vert \\ X \subset N \cup D \cup \{-0, +0\}, \\ \lvert fltArg1 \rvert \le 1, \lvert fltArg2 \rvert \le 1 \end{array} \right\}$	2^{-19}	N/A

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2.60 Function GMCLIB_Vmag2coord_FLT

2.60.1 Declaration

```
tFloat GMCLIB_Vmag2coord_FLT(tFloat fltInMag, tFloat fltInCoord);
```

2.60.2 Arguments

Table 217. GMCLIB_Vmag2coord_FLT arguments

Type	Name	Direction	Description
Commented parameter f32InMag does not exist in function GMCLIB_Vmag2coord_FLT.	f32InMag	**input**	Input magnitude of the vector.
Commented parameter f32InCoord does not exist in function GMCLIB_Vmag2coord_FLT.	f32InCoord	**input**	Input coordinate of the vector.

2.60.3 Worst-Case Error Bounds

Let (*fltInMag*, *fltInCoord*) ∈ *X* be a set of inputs to GMCLIB_Vmag2coord_FLT,

refResult be the theoretical exact result,

$ir_1 = fltInMag^2$,

$ir_2 = fltInCoord^2$,

$ir_3 = ir_1 + ir_2$,

then

Table 218. GMCLIB_Vmag2coord_FLT Worst-Case Error Bounds - refMagnitude output

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \neq \varnothing \vee X \cap M \neq \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values, i.e. $\left\{ \begin{matrix} X \mid X \subset N \cup \{-0, +0\}, \\ refResult \subset N \cup \{-0, +0\} \end{matrix} \right\}$	$\langle -3.5, 3.5 \rangle$	N/A

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Table 218. GMCLIB_Vmag2coord_FLT Worst-Case Error Bounds - refMagnitude output...*continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Normalized or zero input values which cause an underflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\}, \\ refResult \subset D, \\ \exists n : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\}, \\ refResult = Inf, \\ \exists n : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

2.61 Function GMCLIB_VRot_FLT

2.61.1 Declaration

```
void GMCLIB_VRot_FLT(SWLIBS_2Syst_FLT *const fltOutVec, const
SWLIBS_2Syst_FLT *const fltInVec, tFloat fltAngle);
```

2.61.2 Arguments

Table 219. GMCLIB_VRot_FLT arguments

Type	Name	Direction	Description
SWLIBS_2Syst_FLT *const	fltOutVec	**output**	Rotated vector.
const SWLIBS_2Syst_FLT *const	fltInVec	**input**	Input vector to be rotated.
tFloat	fltAngle	**input**	Angle the input vector shall be rotated by.

2.61.3 Worst-Case Error Bounds

Let {*fltInVec = (fltInVec1, flotInVec2)*, *fltAngle*} ∈ *X* be a set of inputs to GMCLIB_VRot_FLT,

refResult = (refResult1, refResult2) be the theoretical exact result,

$ir_1 = fltInVec_1 \cdot \cos(fltAngle)$,

$me_1 = 84$,

$ir_2 = fltInVec_2 \cdot \sin(fltAngle)$,

$me_2 = 84$,

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$ie_1 = \max(\mathrm{fe}(|ir_1| + me_1 \cdot \mathrm{ULP}(ir_1)), \mathrm{fe}(|ir_2| + me_2 \cdot \mathrm{ULP}(ir_2)))$,

$ir_3 = ir_1 - ir_2$,

$ie_2 = \mathrm{fe}(ir_3)$,

$cb_1 = \begin{cases} 0, & ie_1 - ie_2 \le 0 \\ ie_1 - ie_2, & ie_1 - ie_2 > 0 \end{cases}$,

$me_3 = 1 + 168 \cdot 2^{cb_1}$,

$ir_4 = fltInVec_1 \cdot \sin(fltAngle)$,

$me_4 = 84$,

$ir_5 = fltInVec_2 \cdot \cos(fltAngle)$,

$me_5 = 84$,

$ie_3 = \max(\mathrm{fe}(|ir_4| + me_4 \cdot \mathrm{ULP}(ir_4)), \mathrm{fe}(|ir_5| + me_5 \cdot \mathrm{ULP}(ir_5)))$,

$ir_6 = ir_4 + ir_5$,

$ie_4 = \mathrm{fe}(ir_6)$,

$cb_2 = \begin{cases} 0, & ie_3 - ie_4 \le 0 \\ ie_3 - ie_4, & ie_3 - ie_4 > 0 \end{cases}$,

$me_6 = 1 + 168 \cdot 2^{cb_2}$,

then

Table 220. GMCLIB_VRot_FLT Worst-Case Error Bounds - refResult1 output

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \ne \varnothing \vee X \cap M \ne \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
All inputs normalized, i.e. $\left\{\begin{matrix} fltInVec_1 \in N \\ fltInVec_2 \in N \\ fltAngle \in N \end{matrix}\right\}$	$\langle -me_3, me_3 \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{\begin{matrix} X \mid X \subset N \cup \{-0, +0\}, \\ \exists n \subset \{1,2,3\} : ir_n \ne \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \end{matrix}\right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 220. GMCLIB_VRot_FLT Worst-Case Error Bounds - refResult1 output*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\}, \\ \exists n \subset \{1,2,3\} : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 221. GMCLIB_VRot_FLT Worst-Case Error Bounds - refResult2 output

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \neq \varnothing \vee X \cap M \neq \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
All inputs normalized, i.e. $\left\{ \begin{array}{c} fltInVec_1 \in N \\ fltInVec_2 \in N \\ fltAngle \in N \end{array} \right\}$	$\langle -me_6, me_6 \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\}, \\ \exists n \subset \{4,5,6\} : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\}, \\ \exists n \subset \{4,5,6\} : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

2.62 Function GMCLIB_VUnit_FLT

2.62.1 Declaration

```
void GMCLIB_VUnit_FLT(SWLIBS_2Syst_FLT *const fltOutVec, const
SWLIBS_2Syst_FLT *const fltInVec);
```


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2.62.2 Arguments

Table 222. GMCLIB_VUnit_FLT arguments

Type	Name	Direction	Description
SWLIBS_2Syst_FLT *const	fltOutVec	**output**	Output unit vector.
const SWLIBS_2Syst_FLT *const	fltInVec	**input**	Input vector to be scaled to unit vector.

2.62.3 Worst-Case Error Bounds

Let *fltInVec* = *(fltInVec1, flotInVec2)* $\in X$ be a set of inputs to GMCLIB_VUnit_FLT,

refResult = *(refResult1, refResult2)* be the theoretical exact result,

$ir_1 = \tan^{-1}\left(\frac{fltInVec_2}{fltInVec_1}\right)$,

$me_1 = 3.5$,

$ir_2 = \cos(ir_1)$,

$me_2 = 42 + 8 \cdot me_1$,

$ir_3 = \sin(ir_1)$,

$me_3 = 42 + 8 \cdot me_1$,

then

Table 223. GMCLIB_VUnit_FLT Worst-Case Error Bounds - refResult1 output

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{X \mid X \cap D \neq \varnothing \vee X \cap M \neq \varnothing\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values, intermediate results beyond the allowed range, i.e. $\left\{ X \mid X \subset N \cup \{-0, +0\}, \; ir_1 \notin \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values, intermediate results in the allowed range, i.e. $\left\{ X \mid X \subset N \cup \{-0, +0\}, \; ir_1 \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \right\}$	$\langle -me_2, me_2 \rangle$	N/A

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Table 223. GMCLIB_VUnit_FLT Worst-Case Error Bounds - refResult1 output*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Normalized or zero input values which cause an underflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\}, \exists n \subset \{1,2\} : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values which cause an overflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\}, \exists n \subset \{1,2\} : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

Table 224. GMCLIB_VUnit_FLT Worst-Case Error Bounds - refResult2 output

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Any of the inputs is denormalized, NaN, or infinity, i.e. $\{ X \vert X \cap D \neq \varnothing \vee X \cap M \neq \varnothing \}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values, intermediate results beyond the allowed range, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\}, ir_1 \notin \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)
Normalized or zero input values, intermediate results in the allowed range, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\}, ir_1 \in \left\langle \frac{\pi}{2} \cdot 1.1, \pi \cdot 0.9 \right\rangle \right\}$	$\langle -me_3, me_3 \rangle$	N/A
Normalized or zero input values which cause an underflow, i.e. $\left\{ X \middle\vert X \subset N \cup \{-0, +0\}, \exists n \subset \{1,3\} : ir_n \neq \varnothing \wedge \lvert ir_n \rvert - me_n \cdot \mathrm{ULP}(ir_n) \in D \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

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Table 224. GMCLIB_VUnit_FLT Worst-Case Error Bounds - refResult2 output*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Normalized or zero input values which cause an overflow, i.e. $\left\{ \begin{array}{c} X \mid X \subset N \cup \{-0, +0\}, \\ \exists n \subset \{1,3\} : ir_n \in M \vee \lvert ir_n \rvert + me_n \cdot \mathrm{ULP}(ir_n) = Inf \end{array} \right\}$	$(-Inf, Inf)$	Arbitrary floating-point value (including Inf, -Inf, NaN)

2.63 Function MLIB_Abs_FLT

2.63.1 Declaration

```
INLINEtFloat MLIB_Abs_FLT(register tFloat fltIn);
```

2.63.2 Arguments

Table 225. MLIB_Abs_FLT arguments

Type	Name	Direction	Description
register tFloat	fltIn	**input**	Input value.

2.63.3 Worst-Case Error Bounds

Let *fltIn* ∈ *X* be an input to MLIB_Abs_FLT,

then

Table 226. MLIB_Abs_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Input infinity, i.e. $\{ fltIn \in X \mid fltIn \in \{Inf, -Inf\} \}$	N/A	{Inf, *pmax*}
Input NaN, i.e. $\{ fltIn \in X \mid fltIn = NaN \}$	N/A	{NaN, *pmax*}
Denormalized input, i.e. $\{ fltIn \in X \mid X \subset D \}$	0	0
Normalized input, i.e. $\{ fltIn \in X \mid X \subset N \}$	0	N/A

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Table 226. MLIB_Abs_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Zero input, i.e. $\{fltIn \in X \mid fltIn = 0\}$	0	{-0, +0}

2.64 Function MLIB_Add_FLT

2.64.1 Declaration

```
INLINEtFloat MLIB_Add_FLT(register tFloat fltIn1, register tFloat
fltIn2);
```

2.64.2 Arguments

Table 227. MLIB_Add_FLT arguments

Type	Name	Direction	Description
register tFloat	fltIn1	**input**	First value to be add.
register tFloat	fltIn2	**input**	Second value to be add.

2.64.3 Worst-Case Error Bounds

Let (*fltIn1*, *fltIn2*) $\in$ *X* be a set of inputs to MLIB_Add_FLT,

refResult be the theoretical exact result,

then

Table 228. MLIB_Add_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Both inputs infinity, i.e. $\left\{ fltIn_1, fltIn_2 \in X \mid fltIn_1 \in \{Inf, -Inf\}, \; fltIn_2 \in \{Inf, -Inf\} \right\}$	N/A	{Inf, -Inf, NaN, *pmax*, *nmax*}
fltIn1 arbitrary value, *fltIn2* NaN, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_2 = NaN\}$	N/A	{NaN, *pmax*, *nmax*}

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Table 228. MLIB_Add_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 infinity, *fltIn2* normalized, denormalized, or zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in N \cup D \cup \{-0, +0\} \end{matrix} \right\}$	N/A	{sign(*fltIn1*)•Inf, sign(*fltIn1*)•*pmax*}
fltIn1 NaN, *fltIn2* arbitrary value, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 = NaN\}$	N/A	{NaN, *pmax*, *nmax*}
fltIn1 normalized, denormalized, or zero, *fltIn2* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid \\ fltIn_1 \in N \cup D \cup \{-0, +0\}, \\ fltIn_2 \in \{Inf, -Inf\} \end{matrix} \right\}$	N/A	{sign(*fltIn2*)•Inf, sign(*fltIn2*)•*pmax*}
Both inputs denormalized, i.e. $\{fltIn_1, fltIn_2 \in X \mid X \subset D\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
fltIn1 denormalized, *fltIn2* zero, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 \in D, fltIn_2 = 0\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
fltIn1 denormalized, *fltIn2* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid fltIn_1 \in D, \\ fltIn_2 \in N \end{matrix} \right\}$	$\langle -(2^{24}-1), 2^{24}-1 \rangle$	N/A
fltIn1 zero, *fltIn2* denormalized, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 = 0, fltIn_2 \in D\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
Both inputs zero, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 = 0, fltIn_2 = 0\}$	0	N/A

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Table 228. MLIB_Add_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 zero, *fltIn2* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid fltIn_1 = 0, \\ fltIn_2 \in N \end{matrix} \right\}$	0	N/A
fltIn1 normalized, *fltIn2* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid \\ fltIn_1 \in N, fltIn_2 \in D \end{matrix} \right\}$	$\langle -(2^{24}-1), 2^{24}-1 \rangle$	N/A
fltIn1 normalized, *fltIn2* zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid \\ fltIn_1 \in N, fltIn_2 = 0 \end{matrix} \right\}$	0	N/A
Both inputs normalized, result normalized or zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid X \subset N, \\ refResult = 0 \vee \\ \left(\begin{matrix} \lvert refResult \rvert - 0.5 \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + 0.5 \cdot \mathrm{ULP}(refResult) \neq Inf \end{matrix} \right) \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	N/A
Both inputs normalized, result overflow, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid X \subset N, \\ \lvert refResult \rvert + 0.5 \cdot \mathrm{ULP}(refResult) = Inf \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	{sign(*refResult*)•Inf, sign(*refResult*)•*pmax*}
Both inputs normalized, result underflow, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid X \subset N, \\ \lvert refResult \rvert - 0.5 \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0 \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}

2.65 Function MLIB_Convert_F32FLT

2.65.1 Declaration

```
INLINEtFrac32 MLIB_Convert_F32FLT(register tFloat fltIn1,
register tFloat fltIn2);
```


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2.65.2 Arguments

Table 229. MLIB_Convert_F32FLT arguments

Type	Name	Direction	Description
register tFloat	fltIn1	**input**	Input value in single precision floating point format to be converted.
register tFloat	fltIn2	**input**	Scale factor in single precision floating point format.

2.65.3 Worst-Case Error Bounds

This function returns a fixed-point result as specified in the AMMCLib User's Guide. If any of the inputs is a NaN or infinity, then the function returns an arbitrary value.

2.66 Function MLIB_Convert_F16FLT

2.66.1 Declaration

```
INLINEtFrac16 MLIB_Convert_F16FLT(register tFloat fltIn1,
register tFloat fltIn2);
```

2.66.2 Arguments

Table 230. MLIB_Convert_F16FLT arguments

Type	Name	Direction	Description
register tFloat	fltIn1	**input**	Input value in single precision floating point format to be converted.
register tFloat	fltIn2	**input**	Scale factor in single precision floating point format.

2.66.3 Worst-Case Error Bounds

This function returns a fixed-point result as specified in the AMMCLib User's Guide. If any of the inputs is a NaN or infinity, then the function returns an arbitrary value.

2.67 Function MLIB_Convert_FLTF16

2.67.1 Declaration

```
INLINEtFloat MLIB_Convert_FLTF16(register tFrac16 f16In1,
register tFrac16 f16In2);
```

2.67.2 Arguments

Table 231. MLIB_Convert_FLTF16 arguments

Type	Name	Direction	Description
register tFrac16	f16In1	**input**	Input value in 16-bit fractional format to be converted.
register tFrac16	f16In2	**input**	Scale factor in 16-bit fractional format.

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2.67.3 Worst-Case Error Bounds

This function returns a result with worst-case error bounds of $\langle -1536, 1536 \rangle$ ulp. The result is always a normalized value or zero.

2.68 Function MLIB_Convert_FLTF32

2.68.1 Declaration

```
INLINEtFloat MLIB_Convert_FLTF32(register tFrac32 f32In1,
register tFrac32 f32In2);
```

2.68.2 Arguments

Table 232. MLIB_Convert_FLTF32 arguments

Type	Name	Direction	Description
register tFrac32	f32In1	**input**	Input value in 32-bit fractional format to be converted.
register tFrac32	f32In2	**input**	Scale factor in 32-bit fractional format.

2.68.3 Worst-Case Error Bounds

This function returns a result with worst-case error bounds of $\langle -1536, 1536 \rangle$ ulp. The result is always a normalized value or zero.

2.69 Function MLIB_ConvertPU_F32FLT

2.69.1 Declaration

```
INLINEtFrac32 MLIB_ConvertPU_F32FLT(register tFloat fltIn);
```

2.69.2 Arguments

Table 233. MLIB_ConvertPU_F32FLT arguments

Type	Name	Direction	Description
register tFloat	fltIn	**input**	Input value in single precision floating point format to be converted.

2.69.3 Worst-Case Error Bounds

This function returns a fixed-point result as specified in the AMMCLib User's Guide. If any of the inputs is a NaN or infinity, then the function returns an arbitrary value.

2.70 Function MLIB_ConvertPU_F16FLT

2.70.1 Declaration

```
INLINEtFrac16 MLIB_ConvertPU_F16FLT(register tFloat fltIn);
```


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2.70.2 Arguments

Table 234. MLIB_ConvertPU_F16FLT arguments

Type	Name	Direction	Description
register tFloat	fltIn	**input**	Input value in single precision floating point format to be converted.

2.70.3 Worst-Case Error Bounds

This function returns a fixed-point result as specified in the AMMCLib User's Guide. If any of the inputs is a NaN or infinity, then the function returns an arbitrary value.

2.71 Function MLIB_ConvertPU_FLTF16

2.71.1 Declaration

```
INLINEtFloat MLIB_ConvertPU_FLTF16(register tFrac16 f16In);
```

2.71.2 Arguments

Table 235. MLIB_ConvertPU_FLTF16 arguments

Type	Name	Direction	Description
register tFrac16	f16In	**input**	Input value in 16-bit fractional format to be converted.

2.71.3 Worst-Case Error Bounds

This function returns a result with worst-case error bounds of $\langle -1536, 1536 \rangle$ ulp. The result is always a normalized value or zero.

2.72 Function MLIB_ConvertPU_FLTF32

2.72.1 Declaration

```
INLINEtFloat MLIB_ConvertPU_FLTF32(register tFrac32 f32In);
```

2.72.2 Arguments

Table 236. MLIB_ConvertPU_FLTF32 arguments

Type	Name	Direction	Description
register tFrac32	f32In	**input**	Input value in 32-bit fractional format to be converted.

2.72.3 Worst-Case Error Bounds

This function returns a result with worst-case error bounds of $\langle -1536, 1536 \rangle$ ulp. The result is always a normalized value or zero.

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2.73 Function MLIB_Div_FLT

2.73.1 Declaration

```
INLINEtFloat MLIB_Div_FLT(register tFloat fltIn1, register tFloat
fltIn2);
```

2.73.2 Arguments

Table 237. MLIB_Div_FLT arguments

Type	Name	Direction	Description
register tFloat	fltIn1	**input**	Numerator of division.
register tFloat	fltIn2	**input**	Denominator of division.

2.73.3 Worst-Case Error Bounds

Let (*fltIn1*, *fltIn2*) ∈ *X* be a set of inputs to MLIB_Div_FLT,

refResult be the theoretical exact result,

then

Table 238. MLIB_Div_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Both inputs infinity, i.e. $\left\{ fltIn_1, fltIn_2 \in X \middle\vert fltIn_1 \in \{Inf, -Inf\}, fltIn_2 \in \{Inf, -Inf\} \right\}$	N/A	{NaN, 0, -0}
fltIn1 infinity, *fltIn2* NaN, i.e. $\left\{ fltIn_1, fltIn_2 \in X \middle\vert fltIn_1 \in \{Inf, -Inf\}, fltIn_2 = NaN \right\}$	N/A	{NaN, 0, -0}
fltIn1 infinity, *fltIn2* NaN, i.e. $\left\{ fltIn_1, fltIn_2 \in X \middle\vert fltIn_1 \in \{Inf, -Inf\}, fltIn_2 \in D \right\}$	N/A	{Inf, *pmax*} if sign(*fltIn1*) = sign(*fltIn2*), {-Inf, *nmax*} if sign(*fltIn1*) ≠ sign(*fltIn2*)
fltIn1 infinity, *fltIn2* zero, i.e. $\left\{ fltIn_1, fltIn_2 \in X \middle\vert fltIn_1 \in \{Inf, -Inf\}, fltIn_2 = 0 \right\}$	N/A	{Inf, *pmax*} if sign(*fltIn1*) = sign(*fltIn2*), {-Inf, *nmax*} if sign(*fltIn1*) ≠ sign(*fltIn2*)

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Table 238. MLIB_Div_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 infinity, *fltIn2* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in N \end{matrix} \right\}$	N/A	{Inf, *pmax*} if sign(*fltIn1*) = sign(*fltIn2*), {-Inf, *nmax*} if sign(*fltIn1*) ≠ sign(*fltIn2*)
fltIn1 NaN, *fltIn2* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid fltIn_1 = NaN, \\ fltIn_2 \in \{Inf, -Inf\} \end{matrix} \right\}$	N/A	{NaN, 0, -0}
Both inputs NaN, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 = NaN, fltIn_2 = NaN\}$	N/A	{NaN, 0, -0}
fltIn1 NaN, *fltIn2* denormalized, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 = NaN, fltIn_2 \in D\}$	N/A	{NaN, *pmax*, *nmax*}
fltIn1 NaN, *fltIn2* zero, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 = NaN, fltIn_2 = 0\}$	N/A	{NaN, *pmax*, *nmax*}
fltIn1 NaN, *fltIn2* normalized, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 = NaN, fltIn_2 \in N\}$	N/A	{NaN, *pmax*, *nmax*}
fltIn1 denormalized, *fltIn2* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid fltIn_1 \in D, \\ fltIn_2 \in \{Inf, -Inf\} \end{matrix} \right\}$	0	N/A
fltIn1 denormalized, *fltIn2* NaN, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid fltIn_1 \in D, \\ fltIn_2 = NaN \end{matrix} \right\}$	N/A	{NaN, 0, -0}
Both inputs denormalized, i.e. $\{fltIn_1, fltIn_2 \in X \mid X \subset D\}$	$\langle -0.5, 0.5 \rangle$	NaN or (*pmax* if sign(*fltIn1*) = sign(*fltIn2*), *nmax* if sign(*fltIn1*) ≠ sign(*fltIn2*))

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Table 238. MLIB_Div_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 denormalized, *fltIn2* zero, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 \in D, fltIn_2 = 0\}$	N/A	{Inf, *pmax*} if sign(*fltIn1*) = sign(*fltIn2*), {-Inf, *nmax*} if sign(*fltIn1*) ≠ sign(*fltIn2*)
fltIn1 denormalized, *fltIn2* normalized, i.e. $\left\{\begin{matrix} fltIn_1, fltIn_2 \in X \mid fltIn_1 \in D, \\ fltIn_2 \in N \end{matrix}\right\}$	$\langle -0.5, 0.5 \rangle$	+0 if sign(*fltIn1*) = sign(*fltIn2*), -0 if sign(*fltIn1*) ≠ sign(*fltIn2*)
fltIn1 zero, *fltIn2* infinity, i.e. $\left\{\begin{matrix} fltIn_1, fltIn_2 \in X \mid fltIn_1 = 0, \\ fltIn_2 \in \{Inf, -Inf\} \end{matrix}\right\}$	0	N/A
fltIn1 zero, *fltIn2* NaN, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 = 0, fltIn_2 = NaN\}$	N/A	{NaN, 0, -0}
fltIn1 zero, *fltIn2* denormalized, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 = 0, fltIn_2 \in D\}$	0	*pmax* if sign(*fltIn1*) = sign(*fltIn2*), *nmax* if sign(*fltIn1*) ≠ sign(*fltIn2*)
Both inputs zero, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 = 0, fltIn_2 = 0\}$	N/A	{NaN, *pmax*, *nmax*}
fltIn1 zero, *fltIn2* normalized, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 = 0, fltIn_2 \in N\}$	0	N/A
fltIn1 normalized, *fltIn2* infinity, i.e. $\left\{\begin{matrix} fltIn_1, fltIn_2 \in X \mid fltIn_1 \in N, \\ fltIn_2 \in \{Inf, -Inf\} \end{matrix}\right\}$	0	N/A
fltIn1 normalized, *fltIn2* NaN, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 \in N, fltIn_2 = NaN\}$	N/A	{NaN, 0, -0}

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Table 238. MLIB_Div_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 normalized, *fltIn2* denormalized, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 \in N, fltIn_2 \in D\}$	$\langle -0.5, 0.5 \rangle$	{Inf, *pmax*} if sign(*fltIn1*) = sign(*fltIn2*), {-Inf, *nmax*} if sign(*fltIn1*) ≠ sign(*fltIn2*)
fltIn1 normalized, *fltIn2* zero, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 \in N, fltIn_2 = 0\}$	N/A	{Inf, *pmax*} if sign(*fltIn1*) = sign(*fltIn2*), {-Inf, *nmax*} if sign(*fltIn1*) ≠ sign(*fltIn2*)
Both inputs normalized, normalized result, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2 \in X \mid X \subset N, \\ \left(\begin{array}{c} \lvert refResult \rvert - 0.5 \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + 0.5 \cdot \mathrm{ULP}(refResult) \neq Inf \end{array} \right) \end{array} \right\}$	$\langle -0.5, 0.5 \rangle$	N/A
Both inputs normalized, result overflow, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2 \in X \mid X \subset N, \\ \lvert refResult \rvert + 0.5 \cdot \mathrm{ULP}(refResult) = Inf \end{array} \right\}$	$\langle -0.5, 0.5 \rangle$	{Inf, *pmax*} if sign(*fltIn1*) = sign(*fltIn2*), {-Inf, *nmax*} if sign(*fltIn1*) ≠ sign(*fltIn2*)
Both inputs normalized, result underflow, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2 \in X \mid X \subset N, \\ \lvert refResult \rvert - 0.5 \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0 \end{array} \right\}$	$\langle -0.5, 0.5 \rangle$	+0 if sign(*fltIn1*) = sign(*fltIn2*), -0 if sign(*fltIn1*) ≠ sign(*fltIn2*)

2.74 Function MLIB_Mac_FLT

2.74.1 Declaration

```
INLINEtFloat MLIB_Mac_FLT(register tFloat fltIn1, register tFloat
fltIn2, register tFloat fltIn3);
```

2.74.2 Arguments

Table 239. MLIB_Mac_FLT arguments

Type	Name	Direction	Description
register tFloat	fltIn1	**input**	Input value to be add.
register tFloat	fltIn2	**input**	First value to be multiplied.
register tFloat	fltIn3	**input**	Second value to be multiplied.

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2.74.3 Worst-Case Error Bounds

Let (*fltIn1*, *fltIn2*, *fltIn3*) ∈ *X* be a set of inputs to MLIB_Mac_FLT,

$mr = fltIn_2 \cdot fltIn_3$,

refResult be the theoretical exact result,

then

Table 240. MLIB_Mac_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
All inputs infinity, i.e. $\{fltIn_1, fltIn_2, fltIn_3 \in X \mid X \subset \{Inf, -Inf\}\}$	N/A	{Inf, *pmax*} if (sign(*fltIn2*) = sign(*fltIn3*) and *fltIn1* > 0) or (sign(*fltIn2*)≠sign(*fltIn3*) and *fltIn1* < 0), {-Inf, *nmax*} otherwise
fltIn1 zero or denormalized, *fltIn2* and *fltIn3* infinity, i.e. $\left\{\begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in D \bigvee fltIn_1 = 0, \\ fltIn_2 \in \{Inf, -Inf\}, fltIn_3 \in \{Inf, -Inf\} \end{array}\right\}$	N/A	{Inf, *pmax*} if sign(*fltIn2*) = sign(*fltIn3*), {-Inf, *nmax*} otherwise
fltIn1 normalized, *fltIn2* and *fltIn3* infinity, i.e. $\left\{\begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in N, \\ fltIn_2 \in \{Inf, -Inf\}, fltIn_3 \in \{Inf, -Inf\} \end{array}\right\}$	$(-Inf, Inf)$	Inf if sign(*fltIn2*) = sign(*fltIn3*), -Inf otherwise
fltIn1 NaN, i.e. $\{fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 = NaN\}$	$(-Inf, Inf)$	NaN
fltIn2 NaN, i.e. $\{fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_2 = NaN\}$	$(-Inf, Inf)$	NaN
fltIn3 NaN, i.e. $\{fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_3 = NaN\}$	$(-Inf, Inf)$	NaN

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Table 240. MLIB_Mac_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn2 zero, *fltIn3* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_2 = 0, fltIn_3 \in \{Inf, -Inf\} \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, 0, -0}
fltIn2 infinity, *fltIn3* zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_2 \in \{Inf, -Inf\}, fltIn_3 = 0 \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, 0, -0}
fltIn1 infinity, *fltIn2* denormalized, *fltIn3* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in D, fltIn_3 \in \{Inf, -Inf\} \end{matrix} \right\}$	N/A	{NaN, Inf, -Inf, 0, -0, *pmax*, *nmax*}
fltIn1 zero, *fltIn2* denormalized, *fltIn3* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 = 0, fltIn_2 \in D, \\ fltIn_3 \in \{Inf, -Inf\} \end{matrix} \right\}$	N/A	{NaN, Inf, -Inf, 0, -0}
fltIn1 denormalized, *fltIn2* denormalized, *fltIn3* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in D, fltIn_2 \in D, \\ fltIn_3 \in \{Inf, -Inf\} \end{matrix} \right\}$	N/A	{NaN, Inf, -Inf, 0, -0}
fltIn1 normalized, *fltIn2* denormalized, *fltIn3* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in N, \\ fltIn_2 \in D, fltIn_3 \in \{Inf, -Inf\} \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, Inf, -Inf}

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Table 240. MLIB_Mac_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 infinity, *fltIn2* normalized, *fltIn3* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in N, \\ fltIn_3 \in \{Inf, -Inf\} \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, Inf, -Inf}
fltIn1 zero, *fltIn2* normalized, *fltIn3* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 = 0, \\ fltIn_2 \in N, \\ fltIn_3 \in \{Inf, -Inf\} \end{matrix} \right\}$	N/A	{Inf, *pmax*} if sign(*fltIn2*) = sign(*fltIn3*), {-Inf, *nmax*} otherwise
fltIn1 denormalized, *fltIn2* normalized, *fltIn3* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 \in N, \\ fltIn_3 \in \{Inf, -Inf\} \end{matrix} \right\}$	N/A	{Inf, *pmax*} if sign(*fltIn2*) = sign(*fltIn3*), {-Inf, *nmax*} otherwise
fltIn1 normalized, *fltIn2* normalized, *fltIn3* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in N, fltIn_2 \in N, \\ fltIn_3 \in \{Inf, -Inf\} \end{matrix} \right\}$	$(-Inf, Inf)$	Inf if sign(*fltIn2*) = sign(*fltIn3*), -Inf otherwise
fltIn1 infinity, *fltIn2* zero, *fltIn3* zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 = 0, fltIn_3 = 0 \end{matrix} \right\}$	N/A	{sign(*fltIn1*)•Inf, sign(*fltIn1*)•*pmax*}
All inputs zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 = 0, fltIn_2 = 0, fltIn_3 = 0 \end{matrix} \right\}$	0	{-0, +0}

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Table 240. MLIB_Mac_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 denormalized, *fltIn2* zero, *fltIn3* zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 = 0, fltIn_3 = 0 \end{matrix} \right\}$	0	{-0, +0}
fltIn1 normalized, *fltIn2* zero, *fltIn3* zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in N, \\ fltIn_2 = 0, fltIn_3 = 0 \end{matrix} \right\}$	0	N/A
fltIn1 infinity, *fltIn2* denormalized, *fltIn3* zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in D, fltIn_3 = 0 \end{matrix} \right\}$	N/A	{sign(*fltIn1*)•Inf, sign(*fltIn1*)•*pmax*}
fltIn1 zero, *fltIn2* denormalized, *fltIn3* zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 = 0, \\ fltIn_2 \in D, fltIn_3 = 0 \end{matrix} \right\}$	0	{-0, +0}
fltIn1 denormalized, *fltIn2* denormalized, *fltIn3* zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 \in D, fltIn_3 = 0 \end{matrix} \right\}$	0	{-0, +0}
fltIn1 normalized, *fltIn2* denormalized, *fltIn3* zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in N, \\ fltIn_2 \in D, fltIn_3 = 0 \end{matrix} \right\}$	0	N/A

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Table 240. MLIB_Mac_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 infinity, *fltIn2* normalized, *fltIn3* zero, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in N, \\ fltIn_3 = 0 \end{array} \right\}$	0	{sign(*fltIn1*)•Inf, sign(*fltIn1*)•*pmax*}
fltIn1 zero, *fltIn2* normalized, *fltIn3* zero, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \\ fltIn_1 = 0, \\ fltIn_2 \in N, \\ fltIn_3 = 0 \end{array} \right\}$	0	N/A
fltIn1 denormalized, *fltIn2* normalized, *fltIn3* zero, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \\ fltIn_1 \in D, \\ fltIn_2 \in N, \\ fltIn_3 = 0 \end{array} \right\}$	0	{-0, +0}
fltIn1 normalized, *fltIn2* normalized, *fltIn3* zero, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \\ fltIn_1 \in N, \\ fltIn_2 \in N, \\ fltIn_3 = 0 \end{array} \right\}$	0	N/A
fltIn1 infinity, *fltIn2* infinity, *fltIn3* denormalized, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in \{Inf, -Inf\}, \\ fltIn_3 \in D \end{array} \right\}$	N/A	{NaN, Inf, -Inf, *pmax*, *nmax*}

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Table 240. MLIB_Mac_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 zero, *fltIn2* infinity, *fltIn3* denormalized, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \\ fltIn_1 = 0, \\ fltIn_2 \in \{Inf, -Inf\}, \\ fltIn_3 \in D \end{array} \right\}$	N/A	{NaN, Inf, -Inf, 0, -0}
fltIn1 denormalized, *fltIn2* infinity, *fltIn3* denormalized, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \\ fltIn_1 \in D, \\ fltIn_2 \in \{Inf, -Inf\}, \\ fltIn_3 \in D \end{array} \right\}$	N/A	{NaN, Inf, -Inf, 0, -0}
fltIn1 normalized, *fltIn2* infinity, *fltIn3* denormalized, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \\ fltIn_1 \in N, \\ fltIn_2 \in \{Inf, -Inf\}, \\ fltIn_3 \in D \end{array} \right\}$	$(-Inf, Inf)$	{NaN, Inf, -Inf, 0, -0}
fltIn1 infinity, *fltIn2* zero, *fltIn3* denormalized, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 = 0, fltIn_3 \in D \end{array} \right\}$	N/A	{sign(*fltIn1*)•Inf, sign(*fltIn1*)•*pmax*}
fltIn1 zero, *fltIn2* zero, *fltIn3* denormalized, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \\ fltIn_1 = 0, \\ fltIn_2 = 0, fltIn_3 \in D \end{array} \right\}$	0	N/A

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Table 240. MLIB_Mac_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 denormalized, *fltIn2* zero, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in D, \\ fltIn_2 = 0, fltIn_3 \in D \end{matrix} \right\}$	0	{-0, +0}
fltIn1 normalized, *fltIn2* zero, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in N, \\ fltIn_2 = 0, fltIn_3 \in D \end{matrix} \right\}$	0	N/A
fltIn1 infinity, *fltIn2* denormalized, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 = \in D, fltIn_3 \in D \end{matrix} \right\}$	N/A	{sign(*fltIn1*)•Inf, sign(*fltIn1*)•*pmax*}
fltIn1 zero, *fltIn2* denormalized, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 = 0, \\ fltIn_2 \in D, fltIn_3 \in D \end{matrix} \right\}$	0	N/A
All inputs denormalized, i.e. $\{ fltIn_1, fltIn_2, fltIn_3 \in X \mid X \subset D, \}$	0	{-0, +0}
fltIn1 normalized, *fltIn2* and *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in N, \\ fltIn_2 \in D, fltIn_3 \in D \end{matrix} \right\}$	0	N/A
fltIn1 infinity, *fltIn2* normalized, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in N, fltIn_3 \in D \end{matrix} \right\}$	N/A	{sign(*fltIn1*)•Inf, sign(*fltIn1*)•*pmax*}

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Table 240. MLIB_Mac_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 zero, *fltIn2* normalized, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 = 0, \\ fltIn_2 \in N, fltIn_3 \in D \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
fltIn1 denormalized, *fltIn2* normalized, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in D, \\ fltIn_2 \in N, fltIn_3 \in D \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
fltIn1 normalized, *fltIn2* normalized, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in N, \\ fltIn_2 \in N, fltIn_3 \in D \end{matrix} \right\}$	$(-Inf, Inf)$	N/A
fltIn1 infinity, *fltIn2* infinity, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in \{Inf, -Inf\}, fltIn_3 \in N \end{matrix} \right\}$	N/A	{NaN, Inf, -Inf, 0, -0, *pmax*, *nmax*}
fltIn1 zero, *fltIn2* infinity, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 = 0, \\ fltIn_2 \in \{Inf, -Inf\}, fltIn_3 \in N \end{matrix} \right\}$	N/A	{Inf, -Inf, *pmax*, *nmax*}
fltIn1 denormalized, *fltIn2* infinity, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in D, \\ fltIn_2 \in \{Inf, -Inf\}, fltIn_3 \in N \end{matrix} \right\}$	N/A	{Inf, -Inf, *pmax*, *nmax*}
fltIn1 normalized, *fltIn2* infinity, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in N, \\ fltIn_2 \in \{Inf, -Inf\}, fltIn_3 \in N \end{matrix} \right\}$	$(-Inf, Inf)$	{Inf, -Inf}

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Table 240. MLIB_Mac_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 infinity, *fltIn2* zero, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 = 0, fltIn_3 \in N \end{matrix} \right\}$	N/A	{sign(*fltIn1*)•Inf, sign(*fltIn1*)•*pmax*}
fltIn1 zero, *fltIn2* zero, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 = 0, \\ fltIn_2 = 0, fltIn_3 \in N \end{matrix} \right\}$	0	N/A
fltIn1 denormalized, *fltIn2* zero, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in D, \\ fltIn_2 = 0, fltIn_3 \in N \end{matrix} \right\}$	0	{-0, +0}
fltIn1 normalized, *fltIn2* zero, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in N, \\ fltIn_2 = 0, fltIn_3 \in N \end{matrix} \right\}$	0	N/A
fltIn1 infinity, *fltIn2* denormalized, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in N, \\ fltIn_2 \in D, fltIn_3 \in N \end{matrix} \right\}$	$(-Inf, Inf)$	{sign(*fltIn1*)•Inf, sign(*fltIn1*)•*pmax*}
fltIn1 zero, *fltIn2* denormalized, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 = 0, \\ fltIn_2 \in D, fltIn_3 \in N \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
fltIn1 denormalized, *fltIn2* denormalized, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in D, \\ fltIn_2 \in D, fltIn_3 \in N \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}

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Table 240. MLIB_Mac_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 normalized, *fltIn2* denormalized, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in N, \\ fltIn_2 \in D, fltIn_3 \in N \end{matrix} \right\}$	$(-Inf, Inf)$	N/A
fltIn1 infinity, *fltIn2* normalized, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in N, fltIn_3 \in N \end{matrix} \right\}$	N/A	{sign(*fltIn1*)•Inf, sign(*fltIn1*)•*pmax*}
fltIn1 zero, *fltIn2* normalized, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 = 0, \\ fltIn_2 \in N, fltIn_3 \in N \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	N/A
fltIn1 denormalized, *fltIn2* normalized, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 \in N, fltIn_3 \in N \end{matrix} \right\}$	$\langle -(2^{24}-1), 2^{24}-1 \rangle$	N/A
fltIn1 finite, *fltIn2* and *fltIn3* normalized or denormalized, normalized or zero result and intermediate result i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \notin M, \\ fltIn_2 \in N \cup D, fltIn_3 \in N \cup D \\ refResult = 0 \vee \\ \left(\begin{matrix} \lvert refResult \rvert - 0.5 \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + 0.5 \cdot \mathrm{ULP}(refResult) \neq Inf \end{matrix} \right), \\ mr \subset N \cup \{-0, +0\} \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	N/A

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Table 240. MLIB_Mac_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 finite, *fltIn2* and *fltIn3* normalized or denormalized, result underflow i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \notin M \\ fltIn_2 \in N \cup D, fltIn_3 \in N \cup D, \\ \lvert refResult \rvert - 0.5 \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0, \end{array} \right\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
fltIn1 finite, *fltIn2* and *fltIn3* normalized or denormalized, result overflow i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \notin M \\ fltIn_2 \in N \cup D, fltIn_3 \in N \cup D, \\ \lvert refResult \rvert + 0.5 \cdot \mathrm{ULP}(refResult) \in M \end{array} \right\}$	$\langle -0.5, 0.5 \rangle$	{sign(refResult)•Inf, sign(refResult)•*pmax*}
fltIn1 finite, *fltIn2* and *fltIn3* normalized or denormalized, intermediate result underflow i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \notin M \\ fltIn_2 \in N \cup D, fltIn_3 \in N \cup D, \\ mr \in D \end{array} \right\}$	$(-Inf, Inf)$	N/A
fltIn1 finite, *fltIn2* and *fltIn3* normalized or denormalized, intermediate result overflow i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \notin M \\ fltIn_2 \in N \cup D, fltIn_3 \in N \cup D, \\ mr \in M \end{array} \right\}$	$(-Inf, Inf)$	{Inf, -Inf}

2.75 Function MLIB_Mnac_FLT

2.75.1 Declaration

```
INLINEtFloat MLIB_Mnac_FLT(register tFloat fltIn1, register
tFloat fltIn2, register tFloat fltIn3);
```

2.75.2 Arguments

Table 241. MLIB_Mnac_FLT arguments

Type	Name	Direction	Description
register tFloat	fltIn1	**input**	Input value to be subtracted.
register tFloat	fltIn2	**input**	First value to be multiplied.

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Table 241. MLIB_Mnac_FLT arguments*...continued*

Type	Name	Direction	Description
register tFloat	fltIn3	**input**	Second value to be multiplied.

2.75.3 Worst-Case Error Bounds

Let (*fltIn1*, *fltIn2*, *fltIn3*) $\in X$ be a set of inputs to MLIB_Mnac_FLT,

$mr = fltIn_2 \cdot fltIn_3$,

refResult be the theoretical exact result,

then

Table 242. MLIB_Mnac_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
All inputs infinity, i.e. $\{fltIn_1, fltIn_2, fltIn_3 \in X \mid X \subset \{Inf, -Inf\}\}$	N/A	{Inf, *pmax*, -Inf, *nmax* }
fltIn1 zero or denormalized, *fltIn2* and *fltIn3* infinity, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in D \bigvee fltIn_1 = 0, \\ fltIn_2 \in \{Inf, -Inf\}, fltIn_3 \in \{Inf, -Inf\} \end{array} \right\}$	N/A	{Inf, *pmax*} if sign(*fltIn2*) = sign(*fltIn3*), {-Inf, *nmax*} otherwise
fltIn1 normalized, *fltIn2* and *fltIn3* infinity, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in N, \\ fltIn_2 \in \{Inf, -Inf\}, fltIn_3 \in \{Inf, -Inf\} \end{array} \right\}$	$(-Inf, Inf)$	Inf if sign(*fltIn2*) = sign(*fltIn3*), -Inf otherwise
fltIn1 NaN, i.e. $\{fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 = NaN\}$	$(-Inf, Inf)$	NaN
fltIn2 NaN, i.e. $\{fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_2 = NaN\}$	$(-Inf, Inf)$	NaN
fltIn3 NaN, i.e. $\{fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_3 = NaN\}$	$(-Inf, Inf)$	NaN

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Table 242. MLIB_Mnac_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn2 zero, *fltIn3* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_2 = 0, fltIn_3 \in \{Inf, -Inf\} \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, 0, -0}
fltIn2 infinity, *fltIn3* zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_2 \in \{Inf, -Inf\}, fltIn_3 = 0 \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, 0, -0}
fltIn1 infinity, *fltIn2* denormalized, *fltIn3* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in D, fltIn_3 \in \{Inf, -Inf\} \end{matrix} \right\}$	N/A	{NaN, Inf, -Inf, 0, -0, *pmax*, *nmax*}
fltIn1 zero, *fltIn2* denormalized, *fltIn3* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 = 0, fltIn_2 \in D, \\ fltIn_3 \in \{Inf, -Inf\} \end{matrix} \right\}$	N/A	{NaN, Inf, -Inf, 0, -0}
fltIn1 denormalized, *fltIn2* denormalized, *fltIn3* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in D, fltIn_2 \in D, \\ fltIn_3 \in \{Inf, -Inf\} \end{matrix} \right\}$	N/A	{NaN, Inf, -Inf, 0, -0}
fltIn1 normalized, *fltIn2* denormalized, *fltIn3* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in N, \\ fltIn_2 \in D, fltIn_3 \in \{Inf, -Inf\} \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, Inf, -Inf}

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Table 242. MLIB_Mnac_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 infinity, *fltIn2* normalized, *fltIn3* infinity, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in N, \\ fltIn_3 \in \{Inf, -Inf\} \end{array} \right\}$	$(-Inf, Inf)$	{NaN, Inf, -Inf}
fltIn1 zero, *fltIn2* normalized, *fltIn3* infinity, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 = 0, \\ fltIn_2 \in N, \\ fltIn_3 \in \{Inf, -Inf\} \end{array} \right\}$	N/A	{Inf, *pmax*} if sign(*fltIn2*) = sign(*fltIn3*), {-Inf, *nmax*} otherwise
fltIn1 denormalized, *fltIn2* normalized, *fltIn3* infinity, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 \in N, \\ fltIn_3 \in \{Inf, -Inf\} \end{array} \right\}$	N/A	{Inf, *pmax*} if sign(*fltIn2*) = sign(*fltIn3*), {-Inf, *nmax*} otherwise
fltIn1 normalized, *fltIn2* normalized, *fltIn3* infinity, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in N, fltIn_2 \in N, \\ fltIn_3 \in \{Inf, -Inf\} \end{array} \right\}$	$(-Inf, Inf)$	Inf if sign(*fltIn2*) = sign(*fltIn3*), -Inf otherwise
fltIn1 infinity, *fltIn2* zero, *fltIn3* zero, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 = 0, fltIn_3 = 0 \end{array} \right\}$	N/A	{-sign(*fltIn1*)•Inf, -sign(*fltIn1*)•*pmax*}
All inputs zero, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 = 0, fltIn_2 = 0, fltIn_3 = 0 \end{array} \right\}$	0	{-0, +0}

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Table 242. MLIB_Mnac_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 denormalized, *fltIn2* zero, *fltIn3* zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 = 0, fltIn_3 = 0 \end{matrix} \right\}$	0	{-0, +0}
fltIn1 normalized, *fltIn2* zero, *fltIn3* zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in N, \\ fltIn_2 = 0, fltIn_3 = 0 \end{matrix} \right\}$	0	N/A
fltIn1 infinity, *fltIn2* denormalized, *fltIn3* zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in D, fltIn_3 = 0 \end{matrix} \right\}$	N/A	{-sign(*fltIn1*)•Inf, -sign(*fltIn1*)•*pmax*}
fltIn1 zero, *fltIn2* denormalized, *fltIn3* zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 = 0, \\ fltIn_2 \in D, fltIn_3 = 0 \end{matrix} \right\}$	0	{-0, +0}
fltIn1 denormalized, *fltIn2* denormalized, *fltIn3* zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 \in D, fltIn_3 = 0 \end{matrix} \right\}$	0	{-0, +0}
fltIn1 normalized, *fltIn2* denormalized, *fltIn3* zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in N, \\ fltIn_2 \in D, fltIn_3 = 0 \end{matrix} \right\}$	0	N/A

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Table 242. MLIB_Mnac_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 infinity, *fltIn2* normalized, *fltIn3* zero, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in N, \\ fltIn_3 = 0 \end{array} \right\}$	0	{-sign(*fltIn1*)•Inf, -sign(*fltIn1*)•*pmax*}
fltIn1 zero, *fltIn2* normalized, *fltIn3* zero, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \\ fltIn_1 = 0, \\ fltIn_2 \in N, \\ fltIn_3 = 0 \end{array} \right\}$	0	N/A
fltIn1 denormalized, *fltIn2* normalized, *fltIn3* zero, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \\ fltIn_1 \in D, \\ fltIn_2 \in N, \\ fltIn_3 = 0 \end{array} \right\}$	0	{-0, +0}
fltIn1 normalized, *fltIn2* normalized, *fltIn3* zero, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \\ fltIn_1 \in N, \\ fltIn_2 \in N, \\ fltIn_3 = 0 \end{array} \right\}$	0	N/A
fltIn1 infinity, *fltIn2* infinity, *fltIn3* denormalized, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in \{Inf, -Inf\}, \\ fltIn_3 \in D \end{array} \right\}$	N/A	{NaN, Inf, -Inf, *pmax*, *nmax*}

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Table 242. MLIB_Mnac_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 zero, *fltIn2* infinity, *fltIn3* denormalized, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \\ fltIn_1 = 0, \\ fltIn_2 \in \{Inf, -Inf\}, \\ fltIn_3 \in D \end{array} \right\}$	N/A	{NaN, Inf, -Inf, 0, -0}
fltIn1 denormalized, *fltIn2* infinity, *fltIn3* denormalized, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \\ fltIn_1 \in D, \\ fltIn_2 \in \{Inf, -Inf\}, \\ fltIn_3 \in D \end{array} \right\}$	N/A	{NaN, Inf, -Inf, 0, -0}
fltIn1 normalized, *fltIn2* infinity, *fltIn3* denormalized, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \\ fltIn_1 \in N, \\ fltIn_2 \in \{Inf, -Inf\}, \\ fltIn_3 \in D \end{array} \right\}$	$(-Inf, Inf)$	{NaN, Inf, -Inf, 0, -0}
fltIn1 infinity, *fltIn2* zero, *fltIn3* denormalized, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 = 0, fltIn_3 \in D \end{array} \right\}$	N/A	{-sign(*fltIn1*)•Inf, -sign(*fltIn1*)•*pmax*}
fltIn1 zero, *fltIn2* zero, *fltIn3* denormalized, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \\ fltIn_1 = 0, \\ fltIn_2 = 0, fltIn_3 \in D \end{array} \right\}$	0	N/A

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Table 242. MLIB_Mnac_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 denormalized, *fltIn2* zero, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in D, \\ fltIn_2 = 0, fltIn_3 \in D \end{matrix} \right\}$	0	{-0, +0}
fltIn1 normalized, *fltIn2* zero, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in N, \\ fltIn_2 = 0, fltIn_3 \in D \end{matrix} \right\}$	0	N/A
fltIn1 infinity, *fltIn2* denormalized, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 = \in D, fltIn_3 \in D \end{matrix} \right\}$	N/A	{-sign(*fltIn1*)•Inf, -sign(*fltIn1*)•*pmax*}
fltIn1 zero, *fltIn2* denormalized, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 = 0, \\ fltIn_2 \in D, fltIn_3 \in D \end{matrix} \right\}$	0	N/A
All inputs denormalized, i.e. $\{ fltIn_1, fltIn_2, fltIn_3 \in X \mid X \subset D, \}$	0	{-0, +0}
fltIn1 normalized, *fltIn2* and *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in N, \\ fltIn_2 \in D, fltIn_3 \in D \end{matrix} \right\}$	0	N/A
fltIn1 infinity, *fltIn2* normalized, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in N, fltIn_3 \in D \end{matrix} \right\}$	N/A	{-sign(*fltIn1*)•Inf, -sign(*fltIn1*)•*pmax*}

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Table 242. MLIB_Mnac_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 zero, *fltIn2* normalized, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 = 0, \\ fltIn_2 \in N, fltIn_3 \in D \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
fltIn1 denormalized, *fltIn2* normalized, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in D, \\ fltIn_2 \in N, fltIn_3 \in D \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
fltIn1 normalized, *fltIn2* normalized, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in N, \\ fltIn_2 \in N, fltIn_3 \in D \end{matrix} \right\}$	$(-Inf, Inf)$	N/A
fltIn1 infinity, *fltIn2* infinity, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in \{Inf, -Inf\}, fltIn_3 \in N \end{matrix} \right\}$	N/A	{NaN, Inf, -Inf, 0, -0, *pmax*, *nmax*}
fltIn1 zero, *fltIn2* infinity, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 = 0, \\ fltIn_2 \in \{Inf, -Inf\}, fltIn_3 \in N \end{matrix} \right\}$	N/A	{Inf, -Inf, *pmax*, *nmax*}
fltIn1 denormalized, *fltIn2* infinity, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in D, \\ fltIn_2 \in \{Inf, -Inf\}, fltIn_3 \in N \end{matrix} \right\}$	N/A	{Inf, -Inf, *pmax*, *nmax*}
fltIn1 normalized, *fltIn2* infinity, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in N, \\ fltIn_2 \in \{Inf, -Inf\}, fltIn_3 \in N \end{matrix} \right\}$	$(-Inf, Inf)$	{Inf, -Inf}

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Table 242. MLIB_Mnac_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 infinity, *fltIn2* zero, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 = 0, fltIn_3 \in N \end{matrix} \right\}$	N/A	{-sign(*fltIn1*)•Inf, -sign(*fltIn1*)•*pmax*}
fltIn1 zero, *fltIn2* zero, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 = 0, \\ fltIn_2 = 0, fltIn_3 \in N \end{matrix} \right\}$	0	N/A
fltIn1 denormalized, *fltIn2* zero, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in D, \\ fltIn_2 = 0, fltIn_3 \in N \end{matrix} \right\}$	0	{-0, +0}
fltIn1 normalized, *fltIn2* zero, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in N, \\ fltIn_2 = 0, fltIn_3 \in N \end{matrix} \right\}$	0	N/A
fltIn1 infinity, *fltIn2* denormalized, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in N, \\ fltIn_2 \in D, fltIn_3 \in N \end{matrix} \right\}$	$(-Inf, Inf)$	{-sign(*fltIn1*)•Inf, -sign(*fltIn1*)•*pmax*}
fltIn1 zero, *fltIn2* denormalized, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 = 0, \\ fltIn_2 \in D, fltIn_3 \in N \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
fltIn1 denormalized, *fltIn2* denormalized, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in D, \\ fltIn_2 \in D, fltIn_3 \in N \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}

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Table 242. MLIB_Mnac_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 normalized, *fltIn2* denormalized, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in N, \\ fltIn_2 \in D, fltIn_3 \in N \end{matrix} \right\}$	$(-Inf, Inf)$	N/A
fltIn1 infinity, *fltIn2* normalized, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in N, fltIn_3 \in N \end{matrix} \right\}$	N/A	{-sign(*fltIn1*)•Inf, -sign(*fltIn1*)•*pmax*}
fltIn1 zero, *fltIn2* normalized, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 = 0, \\ fltIn_2 \in N, fltIn_3 \in N \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	N/A
fltIn1 denormalized, *fltIn2* normalized, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 \in N, fltIn_3 \in N \end{matrix} \right\}$	$\langle -(2^{24}-1), 2^{24}-1 \rangle$	N/A
fltIn1 finite, *fltIn2* and *fltIn3* normalized or denormalized, normalized or zero result and intermediate result i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \notin M, \\ fltIn_2 \in N \cup D, fltIn_3 \in N \cup D \\ refResult = 0 \vee \\ \left(\begin{matrix} \lvert refResult \rvert - 0.5 \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + 0.5 \cdot \mathrm{ULP}(refResult) \neq Inf \end{matrix} \right), \\ mr \subset N \cup \{-0, +0\} \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	N/A

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Table 242. MLIB_Mnac_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 finite, *fltIn2* and *fltIn3* normalized or denormalized, result underflow i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \notin M \\ fltIn_2 \in N \cup D, fltIn_3 \in N \cup D, \\ \lvert refResult \rvert - 0.5 \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0, \end{array} \right\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
fltIn1 finite, *fltIn2* and *fltIn3* normalized or denormalized, result overflow i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \notin M \\ fltIn_2 \in N \cup D, fltIn_3 \in N \cup D, \\ \lvert refResult \rvert + 0.5 \cdot \mathrm{ULP}(refResult) \in M \end{array} \right\}$	$\langle -0.5, 0.5 \rangle$	{sign(refResult)•Inf, sign(refResult)•*pmax*}
fltIn1 finite, *fltIn2* and *fltIn3* normalized or denormalized, intermediate result underflow i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \notin M \\ fltIn_2 \in N \cup D, fltIn_3 \in N \cup D, \\ mr \in D \end{array} \right\}$	$(-Inf, Inf)$	N/A
fltIn1 finite, *fltIn2* and *fltIn3* normalized or denormalized, intermediate result overflow i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \notin M \\ fltIn_2 \in N \cup D, fltIn_3 \in N \cup D, \\ mr \in M \end{array} \right\}$	$(-Inf, Inf)$	{Inf, -Inf}

2.76 Function MLIB_Msu_FLT

2.76.1 Declaration

```
INLINEtFloat MLIB_Msu_FLT(register tFloat fltIn1, register tFloat
fltIn2, register tFloat fltIn3);
```

2.76.2 Arguments

Table 243. MLIB_Msu_FLT arguments

Type	Name	Direction	Description
register tFloat	fltIn1	**input**	Input value from which to subtract.
register tFloat	fltIn2	**input**	First value to be multiplied.

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Table 243. MLIB_Msu_FLT arguments*...continued*

Type	Name	Direction	Description
register tFloat	fltIn3	**input**	Second value to be multiplied.

2.76.3 Worst-Case Error Bounds

Let (*fltIn1*, *fltIn2*, *fltIn3*) $\in X$ be a set of inputs to MLIB_Msu_FLT,

$mr = fltIn_2 \cdot fltIn_3$,

refResult be the theoretical exact result,

then

Table 244. MLIB_Msu_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
All inputs infinity, i.e. $\{fltIn_1, fltIn_2, fltIn_3 \in X \mid X \subset \{Inf, -Inf\}\}$	N/A	{Inf, *pmax*, -Inf, *nmax*, NaN}
fltIn1 zero or denormalized, *fltIn2* and *fltIn3* infinity, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in D \bigvee fltIn_1 = 0, \\ fltIn_2 \in \{Inf, -Inf\}, fltIn_3 \in \{Inf, -Inf\} \end{array} \right\}$	N/A	{-Inf, *nmax*} if sign(*fltIn2*) = sign(*fltIn3*), {Inf, *pmax*} otherwise
fltIn1 normalized, *fltIn2* and *fltIn3* infinity, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in N, \\ fltIn_2 \in \{Inf, -Inf\}, fltIn_3 \in \{Inf, -Inf\} \end{array} \right\}$	$(-Inf, Inf)$	-Inf if sign(*fltIn2*) = sign(*fltIn3*), Inf otherwise
fltIn1 NaN, i.e. $\{fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 = NaN\}$	$(-Inf, Inf)$	NaN
fltIn2 NaN, i.e. $\{fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_2 = NaN\}$	$(-Inf, Inf)$	NaN
fltIn3 NaN, i.e. $\{fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_3 = NaN\}$	$(-Inf, Inf)$	NaN

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Table 244. MLIB_Msu_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn2 zero, *fltIn3* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_2 = 0, fltIn_3 \in \{Inf, -Inf\} \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, 0, -0}
fltIn2 infinity, *fltIn3* zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_2 \in \{Inf, -Inf\}, fltIn_3 = 0 \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, 0, -0}
fltIn1 infinity, *fltIn2* denormalized, *fltIn3* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in D, fltIn_3 \in \{Inf, -Inf\} \end{matrix} \right\}$	N/A	{NaN, Inf, -Inf, 0, -0, *pmax*, *nmax*}
fltIn1 zero, *fltIn2* denormalized, *fltIn3* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 = 0, fltIn_2 \in D, \\ fltIn_3 \in \{Inf, -Inf\} \end{matrix} \right\}$	N/A	{NaN, Inf, -Inf, 0, -0}
fltIn1 denormalized, *fltIn2* denormalized, *fltIn3* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in D, fltIn_2 \in D, \\ fltIn_3 \in \{Inf, -Inf\} \end{matrix} \right\}$	N/A	{NaN, Inf, -Inf, 0, -0}
fltIn1 normalized, *fltIn2* denormalized, *fltIn3* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in N, \\ fltIn_2 \in D, fltIn_3 \in \{Inf, -Inf\} \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, Inf, -Inf}

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Table 244. MLIB_Msu_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 infinity, *fltIn2* normalized, *fltIn3* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in N, \\ fltIn_3 \in \{Inf, -Inf\} \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, Inf, -Inf}
fltIn1 zero, *fltIn2* normalized, *fltIn3* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 = 0, \\ fltIn_2 \in N, \\ fltIn_3 \in \{Inf, -Inf\} \end{matrix} \right\}$	N/A	{-Inf, *nmax*} if sign(*fltIn2*) = sign(*fltIn3*), {Inf, *pmax*} otherwise
fltIn1 denormalized, *fltIn2* normalized, *fltIn3* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 \in N, \\ fltIn_3 \in \{Inf, -Inf\} \end{matrix} \right\}$	N/A	{-Inf, *nmax*} if sign(*fltIn2*) = sign(*fltIn3*), {Inf, *pmax*} otherwise
fltIn1 normalized, *fltIn2* normalized, *fltIn3* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in N, fltIn_2 \in N, \\ fltIn_3 \in \{Inf, -Inf\} \end{matrix} \right\}$	$(-Inf, Inf)$	-Inf if sign(*fltIn2*) = sign(*fltIn3*), Inf otherwise
fltIn1 infinity, *fltIn2* zero, *fltIn3* zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 = 0, fltIn_3 = 0 \end{matrix} \right\}$	N/A	{sign(*fltIn1*)•Inf, sign(*fltIn1*)•*pmax*}
All inputs zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 = 0, fltIn_2 = 0, fltIn_3 = 0 \end{matrix} \right\}$	0	{-0, +0}

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Table 244. MLIB_Msu_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 denormalized, *fltIn2* zero, *fltIn3* zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 = 0, fltIn_3 = 0 \end{matrix} \right\}$	0	{-0, +0}
fltIn1 normalized, *fltIn2* zero, *fltIn3* zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in N, \\ fltIn_2 = 0, fltIn_3 = 0 \end{matrix} \right\}$	0	N/A
fltIn1 infinity, *fltIn2* denormalized, *fltIn3* zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in D, fltIn_3 = 0 \end{matrix} \right\}$	N/A	{sign(*fltIn1*)•Inf, sign(*fltIn1*)•*pmax*}
fltIn1 zero, *fltIn2* denormalized, *fltIn3* zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 = 0, \\ fltIn_2 \in D, fltIn_3 = 0 \end{matrix} \right\}$	0	{-0, +0}
fltIn1 denormalized, *fltIn2* denormalized, *fltIn3* zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 \in D, fltIn_3 = 0 \end{matrix} \right\}$	0	{-0, +0}
fltIn1 normalized, *fltIn2* denormalized, *fltIn3* zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in N, \\ fltIn_2 \in D, fltIn_3 = 0 \end{matrix} \right\}$	0	N/A

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Table 244. MLIB_Msu_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 infinity, *fltIn2* normalized, *fltIn3* zero, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in N, \\ fltIn_3 = 0 \end{array} \right\}$	0	{sign(*fltIn1*)•Inf, sign(*fltIn1*)•*pmax*}
fltIn1 zero, *fltIn2* normalized, *fltIn3* zero, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \\ fltIn_1 = 0, \\ fltIn_2 \in N, \\ fltIn_3 = 0 \end{array} \right\}$	0	N/A
fltIn1 denormalized, *fltIn2* normalized, *fltIn3* zero, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \\ fltIn_1 \in D, \\ fltIn_2 \in N, \\ fltIn_3 = 0 \end{array} \right\}$	0	{-0, +0}
fltIn1 normalized, *fltIn2* normalized, *fltIn3* zero, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \\ fltIn_1 \in N, \\ fltIn_2 \in N, \\ fltIn_3 = 0 \end{array} \right\}$	0	N/A
fltIn1 infinity, *fltIn2* infinity, *fltIn3* denormalized, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in \{Inf, -Inf\}, \\ fltIn_3 \in D \end{array} \right\}$	N/A	{NaN, Inf, -Inf, *pmax*, *nmax*}

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Table 244. MLIB_Msu_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 zero, *fltIn2* infinity, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 = 0, \\ fltIn_2 \in \{Inf, -Inf\}, \\ fltIn_3 \in D \end{matrix} \right\}$	N/A	{NaN, Inf, -Inf, 0, -0}
fltIn1 denormalized, *fltIn2* infinity, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 \in \{Inf, -Inf\}, \\ fltIn_3 \in D \end{matrix} \right\}$	N/A	{NaN, Inf, -Inf, 0, -0}
fltIn1 normalized, *fltIn2* infinity, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in N, \\ fltIn_2 \in \{Inf, -Inf\}, \\ fltIn_3 \in D \end{matrix} \right\}$	$(-Inf, Inf)$	{NaN, Inf, -Inf, 0, -0}
fltIn1 infinity, *fltIn2* zero, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 = 0, fltIn_3 \in D \end{matrix} \right\}$	N/A	{sign(*fltIn1*)•Inf, sign(*fltIn1*)•*pmax*}
fltIn1 zero, *fltIn2* zero, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 = 0, \\ fltIn_2 = 0, fltIn_3 \in D \end{matrix} \right\}$	0	N/A

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Table 244. MLIB_Msu_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 denormalized, *fltIn2* zero, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in D, \\ fltIn_2 = 0, fltIn_3 \in D \end{matrix} \right\}$	0	{-0, +0}
fltIn1 normalized, *fltIn2* zero, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in N, \\ fltIn_2 = 0, fltIn_3 \in D \end{matrix} \right\}$	0	N/A
fltIn1 infinity, *fltIn2* denormalized, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 = \in D, fltIn_3 \in D \end{matrix} \right\}$	N/A	{sign(*fltIn1*)•Inf, sign(*fltIn1*)•*pmax*}
fltIn1 zero, *fltIn2* denormalized, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 = 0, \\ fltIn_2 \in D, fltIn_3 \in D \end{matrix} \right\}$	0	N/A
All inputs denormalized, i.e. $\{ fltIn_1, fltIn_2, fltIn_3 \in X \mid X \subset D, \}$	0	{-0, +0}
fltIn1 normalized, *fltIn2* and *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in N, \\ fltIn_2 \in D, fltIn_3 \in D \end{matrix} \right\}$	0	N/A
fltIn1 infinity, *fltIn2* normalized, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in N, fltIn_3 \in D \end{matrix} \right\}$	N/A	{sign(*fltIn1*)•Inf, sign(*fltIn1*)•*pmax*}

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Table 244. MLIB_Msu_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 zero, *fltIn2* normalized, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 = 0, \\ fltIn_2 \in N, fltIn_3 \in D \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
fltIn1 denormalized, *fltIn2* normalized, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in D, \\ fltIn_2 \in N, fltIn_3 \in D \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
fltIn1 normalized, *fltIn2* normalized, *fltIn3* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in N, \\ fltIn_2 \in N, fltIn_3 \in D \end{matrix} \right\}$	$(-Inf, Inf)$	N/A
fltIn1 infinity, *fltIn2* infinity, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in \{Inf, -Inf\}, fltIn_3 \in N \end{matrix} \right\}$	N/A	{NaN, Inf, -Inf, 0, -0, *pmax*, *nmax*}
fltIn1 zero, *fltIn2* infinity, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 = 0, \\ fltIn_2 \in \{Inf, -Inf\}, fltIn_3 \in N \end{matrix} \right\}$	N/A	{Inf, -Inf, *pmax*, *nmax*}
fltIn1 denormalized, *fltIn2* infinity, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in D, \\ fltIn_2 \in \{Inf, -Inf\}, fltIn_3 \in N \end{matrix} \right\}$	N/A	{Inf, -Inf, *pmax*, *nmax*}
fltIn1 normalized, *fltIn2* infinity, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in N, \\ fltIn_2 \in \{Inf, -Inf\}, fltIn_3 \in N \end{matrix} \right\}$	$(-Inf, Inf)$	{Inf, -Inf}

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Table 244. MLIB_Msu_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 infinity, *fltIn2* zero, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 = 0, fltIn_3 \in N \end{matrix} \right\}$	N/A	{sign(*fltIn1*)•Inf, sign(*fltIn1*)•*pmax*}
fltIn1 zero, *fltIn2* zero, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 = 0, \\ fltIn_2 = 0, fltIn_3 \in N \end{matrix} \right\}$	0	N/A
fltIn1 denormalized, *fltIn2* zero, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in D, \\ fltIn_2 = 0, fltIn_3 \in N \end{matrix} \right\}$	0	{-0, +0}
fltIn1 normalized, *fltIn2* zero, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in N, \\ fltIn_2 = 0, fltIn_3 \in N \end{matrix} \right\}$	0	N/A
fltIn1 infinity, *fltIn2* denormalized, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in N, \\ fltIn_2 \in D, fltIn_3 \in N \end{matrix} \right\}$	$(-Inf, Inf)$	{sign(*fltIn1*)•Inf, sign(*fltIn1*)•*pmax*}
fltIn1 zero, *fltIn2* denormalized, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 = 0, \\ fltIn_2 \in D, fltIn_3 \in N \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
fltIn1 denormalized, *fltIn2* denormalized, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in D, \\ fltIn_2 \in D, fltIn_3 \in N \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}

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Table 244. MLIB_Msu_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 normalized, *fltIn2* denormalized, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \in N, \\ fltIn_2 \in D, fltIn_3 \in N \end{matrix} \right\}$	$(-Inf, Inf)$	N/A
fltIn1 infinity, *fltIn2* normalized, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in N, fltIn_3 \in N \end{matrix} \right\}$	N/A	{sign(*fltIn1*)•Inf, sign(*fltIn1*)•*pmax*}
fltIn1 zero, *fltIn2* normalized, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 = 0, \\ fltIn_2 \in N, fltIn_3 \in N \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	N/A
fltIn1 denormalized, *fltIn2* normalized, *fltIn3* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid \\ fltIn_1 \in D, \\ fltIn_2 \in N, fltIn_3 \in N \end{matrix} \right\}$	$\langle -(2^{24}-1), 2^{24}-1 \rangle$	N/A
fltIn1 finite, *fltIn2* and *fltIn3* normalized or denormalized, normalized or zero result and intermediate result i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \notin M, \\ fltIn_2 \in N \cup D, fltIn_3 \in N \cup D \\ refResult = 0 \vee \\ \left(\begin{matrix} \lvert refResult \rvert - 0.5 \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + 0.5 \cdot \mathrm{ULP}(refResult) \neq Inf \end{matrix} \right), \\ mr \subset N \cup \{-0, +0\} \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	N/A

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Table 244. MLIB_Msu_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 finite, *fltIn2* and *fltIn3* normalized or denormalized, result underflow i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \notin M \\ fltIn_2 \in N \cup D, fltIn_3 \in N \cup D, \\ \lvert refResult \rvert - 0.5 \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0, \end{array} \right\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
fltIn1 finite, *fltIn2* and *fltIn3* normalized or denormalized, result overflow i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \notin M \\ fltIn_2 \in N \cup D, fltIn_3 \in N \cup D, \\ \lvert refResult \rvert + 0.5 \cdot \mathrm{ULP}(refResult) \in M \end{array} \right\}$	$\langle -0.5, 0.5 \rangle$	{sign(refResult)•Inf, sign(refResult)•*pmax*}
fltIn1 finite, *fltIn2* and *fltIn3* normalized or denormalized, intermediate result underflow i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \notin M \\ fltIn_2 \in N \cup D, fltIn_3 \in N \cup D, \\ mr \in D \end{array} \right\}$	$(-Inf, Inf)$	N/A
fltIn1 finite, *fltIn2* and *fltIn3* normalized or denormalized, intermediate result overflow i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3 \in X \mid fltIn_1 \notin M \\ fltIn_2 \in N \cup D, fltIn_3 \in N \cup D, \\ mr \in M \end{array} \right\}$	$(-Inf, Inf)$	{Inf, -Inf}

2.77 Function MLIB_Mul_FLT

2.77.1 Declaration

```
INLINEtFloat MLIB_Mul_FLT(register tFloat fltIn1, register tFloat
fltIn2);
```

2.77.2 Arguments

Table 245. MLIB_Mul_FLT arguments

Type	Name	Direction	Description
register tFloat	fltIn1	**input**	Operand is a single precision floating point number.

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Table 245. MLIB_Mul_FLT arguments*...continued*

Type	Name	Direction	Description
register tFloat	fltIn2	**input**	Operand is a single precision floating point number.

2.77.3 Worst-Case Error Bounds

Let (*fltIn1*, *fltIn2*) ∈ *X* be a set of inputs to MLIB_Mul_FLT,

refResult be the theoretical exact result,

then

Table 246. MLIB_Mul_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Both inputs infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in \{Inf, -Inf\} \end{matrix} \right\}$	N/A	{Inf, -Inf, *pmax*, *nmax*}
fltIn1 normalized number, NaN, or infinity, *fltIn2* NaN, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid \\ fltIn_1 \in N \cup NaN \cup \{Inf, -Inf\}, \\ fltIn_2 = NaN \end{matrix} \right\}$	N/A	{NaN, *pmax*, *nmax*}
fltIn1 denormalized or zero, *fltIn2* NaN, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid fltIn_1 \in D \cup \{-0, +0\}, \\ fltIn_2 = NaN \end{matrix} \right\}$	N/A	{NaN, -0, +0}
fltIn1 infinity, *fltIn2* denormalized or zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid fltIn_1 \in \{Inf, -Inf\} \\ fltIn_1 \in D \cup \{-0, +0\} \end{matrix} \right\}$	N/A	{NaN, Inf, -Inf, -0, +0}
fltIn1 infinity, *fltIn2* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid fltIn_1 \in \{Inf, -Inf\} \\ fltIn_1 \in N \end{matrix} \right\}$	N/A	{Inf, -Inf, *pmax*, *nmax*}

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Table 246. MLIB_Mul_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 NaN, *fltIn2* infinity or normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid fltIn_1 = NaN, \\ fltIn_2 \in N \cup \{Inf, -Inf\} \end{matrix} \right\}$	N/A	{NaN, *pmax*, *nmax*}
fltIn1 NaN, *fltIn2* denormalized or zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid fltIn_1 = NaN, \\ fltIn_2 \in D \cup \{-0, +0\} \end{matrix} \right\}$	N/A	{NaN, -0, +0}
fltIn1 denormalized or zero, *fltIn2* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid \\ fltIn_1 \in D \cup \{-0, +0\}, \\ fltIn_2 \in \{Inf, -Inf\} \end{matrix} \right\}$	N/A	{NaN, Inf, -Inf, -0, +0}
fltIn1 normalized, *fltIn2* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid fltIn_1 \in N, \\ fltIn_2 \in \{Inf, -Inf\} \end{matrix} \right\}$	N/A	{Inf, -Inf, *pmax*, *nmax*}
Both inputs denormalized, i.e. $\{fltIn_1, fltIn_2 \in X \mid X \subset D\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
fltIn1 denormalized, *fltIn2* zero, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 \in D, fltIn_2 = 0\}$	0	N/A
fltIn1 denormalized, *fltIn2* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid fltIn_1 \in D, \\ fltIn_2 \in N \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
fltIn1 zero, *fltIn2* denormalized, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 = 0, fltIn_2 \in D\}$	0	N/A

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Table 246. MLIB_Mul_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Both inputs zero, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 = 0, fltIn_2 = 0\}$	0	N/A
fltIn1 zero, *fltIn2* normalized, i.e. $\left\{\begin{matrix} fltIn_1, fltIn_2 \in X \mid fltIn_1 = 0, \\ fltIn_2 \in N \end{matrix}\right\}$	0	N/A
fltIn1 normalized, *fltIn2* denormalized, i.e. $\left\{\begin{matrix} fltIn_1, fltIn_2 \in X \mid \\ fltIn_1 \in N, fltIn_2 \in D \end{matrix}\right\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
fltIn1 normalized, *fltIn2* zero, i.e. $\left\{\begin{matrix} fltIn_1, fltIn_2 \in X \mid \\ fltIn_1 \in N, fltIn_2 = 0 \end{matrix}\right\}$	0	N/A
Both inputs normalized, result normalized, i.e. $\left\{\begin{matrix} fltIn_1, fltIn_2 \in X \mid X \subset N, \\ \lvert refResult \rvert - 0.5 \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + 0.5 \cdot \mathrm{ULP}(refResult) \neq Inf \end{matrix}\right\}$	$\langle -0.5, 0.5 \rangle$	N/A
Both inputs normalized, result overflow, i.e. $\left\{\begin{matrix} fltIn_1, fltIn_2 \in X \mid X \subset N, \\ \lvert refResult \rvert + 0.5 \cdot \mathrm{ULP}(refResult) = Inf \end{matrix}\right\}$	$\langle -0.5, 0.5 \rangle$	{Inf, -Inf, *pmax*, *nmax*}
Both inputs normalized, result underflow, i.e. $\left\{\begin{matrix} fltIn_1, fltIn_2 \in X \mid X \subset N, \\ \lvert refResult \rvert - 0.5 \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0 \end{matrix}\right\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}

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2.78 Function MLIB_Neg_FLT

2.78.1 Declaration

```
INLINEtFloat MLIB_Neg_FLT(register tFloat fltIn);
```

2.78.2 Arguments

Table 247. MLIB_Neg_FLT arguments

Type	Name	Direction	Description
register tFloat	fltIn	**input**	Input value which negative value should be returned.

2.78.3 Worst-Case Error Bounds

Let (*fltIn*) ∈ *X* be an input to MLIB_Neg_FLT,

then

Table 248. MLIB_Neg_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Input infinity, i.e. $\{fltIn \in X \mid fltIn \in \{Inf, -Inf\}\}$	N/A	{-sign(*fltIn*)•Inf, -sign(*fltIn*)•*pmax*}
Input NaN, i.e. $\{fltIn \in X \mid fltIn = NaN\}$	N/A	{NaN, *pmax*, *nmax*}
Denormalized input, i.e. $\{fltIn \in X \mid X \subset D\}$	0	{-0, +0}
Normalized input, i.e. $\{fltIn \in X \mid X \subset N\}$	0	N/A
Zero input, i.e. $\{fltIn \in X \mid fltIn = 0\}$	0	N/A

2.79 Function MLIB_Sub_FLT

2.79.1 Declaration

```
INLINEtFloat MLIB_Sub_FLT(register tFloat fltIn1, register tFloat
fltIn2);
```


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2.79.2 Arguments

Table 249. MLIB_Sub_FLT arguments

Type	Name	Direction	Description
register tFloat	fltIn1	**input**	Operand is a single precision floating point number.
register tFloat	fltIn2	**input**	Operand is a single precision floating point number.

2.79.3 Worst-Case Error Bounds

Let (*fltIn1*, *fltIn2*) ∈ *X* be a set of inputs to MLIB_Sub_FLT,

then

Table 250. MLIB_Sub_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Both inputs infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in \{Inf, -Inf\} \end{matrix} \right\}$	N/A	{Inf, -Inf, NaN, *pmax*, *nmax*}
fltIn1 arbitrary value, *fltIn2* NaN, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_2 = NaN\}$	N/A	{NaN, *pmax*, *nmax*}
fltIn1 infinity, *fltIn2* normalized, denormalized, or zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in N \cup D \cup \{-0, +0\} \end{matrix} \right\}$	N/A	{sign(*fltIn1*)•Inf, sign(*fltIn1*)•*pmax*}
fltIn1 NaN, *fltIn2* arbitrary value, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 = NaN\}$	N/A	{NaN, *pmax*, *nmax*}
fltIn1 normalized, denormalized, or zero, *fltIn2* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid \\ fltIn_1 \in N \cup D \cup \{-0, +0\}, \\ fltIn_2 \in \{Inf, -Inf\} \end{matrix} \right\}$	N/A	{-sign(*fltIn2*)•Inf, -sign(*fltIn2*)•*pmax*}

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Table 250. MLIB_Sub_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Both inputs denormalized, i.e. $\{fltIn_1, fltIn_2 \in X \mid X \subset D\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
fltIn1 denormalized, *fltIn2* zero, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 \in D, fltIn_2 = 0\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
fltIn1 denormalized, *fltIn2* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid fltIn_1 \in D, \\ fltIn_2 \in N \end{matrix} \right\}$	$\langle -(2^{24}-1), 2^{24}-1 \rangle$	N/A
fltIn1 zero, *fltIn2* denormalized, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 = 0, fltIn_2 \in D\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
Both inputs zero, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 = 0, fltIn_2 = 0\}$	0	N/A
fltIn1 zero, *fltIn2* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid fltIn_1 = 0, \\ fltIn_2 \in N \end{matrix} \right\}$	0	N/A
fltIn1 normalized, *fltIn2* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid \\ fltIn_1 \in N, fltIn_2 \in D \end{matrix} \right\}$	$\langle -(2^{24}-1), 2^{24}-1 \rangle$	N/A
fltIn1 normalized, *fltIn2* zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid \\ fltIn_1 \in N, fltIn_2 = 0 \end{matrix} \right\}$	0	N/A

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Table 250. MLIB_Sub_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Both inputs normalized, result normalized or zero, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2 \in X \mid X \subset N, \\ refResult = 0 \vee \\ \left(\begin{array}{l} \lvert refResult \rvert - 0.5 \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + 0.5 \cdot \mathrm{ULP}(refResult) \neq Inf \end{array} \right) \end{array} \right\}$	$\langle -0.5, 0.5 \rangle$	N/A
Both inputs normalized, result overflow, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2 \in X \mid X \subset N, \\ \lvert refResult \rvert + 0.5 \cdot \mathrm{ULP}(refResult) = Inf \end{array} \right\}$	$\langle -0.5, 0.5 \rangle$	{sign(refResult)•Inf, sign(refResult)•*pmax*}
Both inputs normalized, result underflow, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2 \in X \mid X \subset N, \\ \lvert refResult \rvert - 0.5 \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0 \end{array} \right\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}

2.80 Function MLIB_VAdd_FLT

2.80.1 Declaration

```
INLINE void MLIB_VAdd_FLT(SWLIBS_2Syst_FLT *const fltOut, const
SWLIBS_2Syst_FLT *const fltIn1, const SWLIBS_2Syst_FLT *const
fltIn2);
```

2.80.2 Arguments

Table 251. MLIB_VAdd_FLT arguments

Type	Name	Direction	Description
SWLIBS_2Syst_FLT *const	fltOut	**output**	Sum of two input vectors.
const SWLIBS_2Syst_FLT *const	fltIn1	**input**	First vector to be added.
const SWLIBS_2Syst_FLT *const	fltIn2	**input**	Second vector to be added.

2.80.3 Worst-Case Error Bounds

Let (*fltIn1*, *fltIn2*) $\in$ *X* be a set of inputs to MLIB_VAdd_FLT,

refResult be the theoretical exact result,

then

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Table 252. MLIB_VAdd_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Both inputs infinity, i.e. $\left\{ fltIn_1, fltIn_2 \in X \middle\vert fltIn_1 \in \{Inf, -Inf\}, fltIn_2 \in \{Inf, -Inf\} \right\}$	N/A	{Inf, -Inf, NaN, *pmax*, *nmax*}
fltIn1 arbitrary value, *fltIn2* NaN, i.e. $\left\{ fltIn_1, fltIn_2 \in X \middle\vert fltIn_2 = NaN \right\}$	N/A	{NaN, *pmax*, *nmax*}
fltIn1 infinity, *fltIn2* normalized, denormalized, or zero, i.e. $\left\{ fltIn_1, fltIn_2 \in X \middle\vert fltIn_1 \in \{Inf, -Inf\}, fltIn_2 \in N \cup D \cup \{-0, +0\} \right\}$	N/A	{sign(*fltIn1*)•Inf, sign(*fltIn1*)•*pmax*}
fltIn1 NaN, *fltIn2* arbitrary value, i.e. $\left\{ fltIn_1, fltIn_2 \in X \middle\vert fltIn_1 = NaN \right\}$	N/A	{NaN, *pmax*, *nmax*}
fltIn1 normalized, denormalized, or zero, *fltIn2* infinity, i.e. $\left\{ fltIn_1, fltIn_2 \in X \middle\vert fltIn_1 \in N \cup D \cup \{-0, +0\}, fltIn_2 \in \{Inf, -Inf\} \right\}$	N/A	{sign(*fltIn2*)•Inf, sign(*fltIn2*)•*pmax*}
Both inputs denormalized, i.e. $\left\{ fltIn_1, fltIn_2 \in X \middle\vert X \subset D \right\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
fltIn1 denormalized, *fltIn2* zero, i.e. $\left\{ fltIn_1, fltIn_2 \in X \middle\vert fltIn_1 \in D, fltIn_2 = 0 \right\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
fltIn1 denormalized, *fltIn2* normalized, i.e. $\left\{ fltIn_1, fltIn_2 \in X \middle\vert fltIn_1 \in D, fltIn_2 \in N \right\}$	$\langle -(2^{24}-1), 2^{24}-1 \rangle$	N/A

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Table 252. MLIB_VAdd_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 zero, *fltIn2* denormalized, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 = 0, fltIn_2 \in D\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
Both inputs zero, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 = 0, fltIn_2 = 0\}$	0	N/A
fltIn1 zero, *fltIn2* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid fltIn_1 = 0, \\ fltIn_2 \in N \end{matrix} \right\}$	0	N/A
fltIn1 normalized, *fltIn2* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid \\ fltIn_1 \in N, fltIn_2 \in D \end{matrix} \right\}$	$\langle -(2^{24}-1), 2^{24}-1 \rangle$	N/A
fltIn1 normalized, *fltIn2* zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid \\ fltIn_1 \in N, fltIn_2 = 0 \end{matrix} \right\}$	0	N/A
Both inputs normalized, result normalized or zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid X \subset N, \\ refResult = 0 \vee \\ \left(\begin{matrix} \lvert refResult \rvert - 0.5 \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + 0.5 \cdot \mathrm{ULP}(refResult) \neq Inf \end{matrix} \right) \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	N/A
Both inputs normalized, result overflow, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid X \subset N, \\ \lvert refResult \rvert + 0.5 \cdot \mathrm{ULP}(refResult) = Inf \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	{sign(*refResult*)•Inf, sign(*refResult*)•*pmax*}
Both inputs normalized, result underflow, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid X \subset N, \\ \lvert refResult \rvert - 0.5 \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0 \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}

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2.81 Function MLIB_VMac_FLT

2.81.1 Declaration

```
INLINEtFloat MLIB_VMac_FLT(register tFloat fltIn1, register
tFloat fltIn2, register tFloat fltIn3, register tFloat fltIn4);
```

2.81.2 Arguments

Table 253. MLIB_VMac_FLT arguments

Type	Name	Direction	Description
register tFloat	fltIn1	**input**	First input value to first multiplication.
register tFloat	fltIn2	**input**	Second input value to first multiplication.
register tFloat	fltIn3	**input**	First input value to second multiplication.
register tFloat	fltIn4	**input**	Second input value to second multiplication.

2.81.3 Worst-Case Error Bounds

Let (*fltIn1*, *fltIn2*, *fltIn3*, *fltIn4*) $\in X$ be a set of inputs to MLIB_VMac_FLT,

$ir_1 = fltIn_1 \cdot fltIn_2,$

$ir_2 = fltIn_3 \cdot fltIn_4,$

refResult be the theoretical exact result,

then

Table 254. MLIB_VMac_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Any of the inputs is NaN or infinity, i.e. $\{fltIn_1, fltIn_2, fltIn_3, fltIn_4 \in X \mid X \cap M \neq \varnothing\}$	N/A	{Inf, -Inf, NaN, *pmax*, *nmax*, -0, +0}
Any of the inputs is denormalized, neither is NaN or infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2, fltIn_3, fltIn_4 \in X \mid \\ X \cap D \neq \varnothing, X \cap M = \varnothing \end{matrix} \right\}$	$(-Inf, Inf)$	N/A

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Table 254. MLIB_VMac_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
All inputs normalized or zero, results normalized or zero, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3, fltIn_4 \in X \mid \\ X \subset N \cup \{-0, +0\}, \\ ir_1 \in N \cup \{-0, +0\}, ir_2 \in N \cup \{-0, +0\}, \\ refResult = 0 \vee \\ \left(\begin{array}{l} \lvert refResult \rvert - \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + \mathrm{ULP}(refResult) \neq Inf \end{array} \right) \end{array} \right\}$	$\langle -1, 1 \rangle$	N/A
All inputs zero, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3, fltIn_4 \in X \mid \\ X \subset \{-0, +0\} \end{array} \right\}$	0	N/A
All inputs normalized or zero, result overflow, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3, fltIn_4 \in X \mid \\ X \subset N \cup \{-0, +0\}, \\ \lvert refResult \rvert + \mathrm{ULP}(refResult) = Inf \end{array} \right\}$	$\langle -1, 1 \rangle$	{sign(refResult)•Inf, sign(refResult)•*pmax*, NaN}
All inputs normalized or zero, result underflow or underflow in internal compensation calculation, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3, fltIn_4 \in X \mid \\ X \subset N \cup \{-0, +0\}, \\ 0.5 \cdot (\lvert refResult \rvert - \mathrm{ULP}(refResult) \in D) \wedge \\ refResult \neq 0 \end{array} \right\}$	$\langle -2^{24}, 2^{24} \rangle$	{-0, +0}
All inputs normalized or zero, intermediate result overflow, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3, fltIn_4 \in X \mid \\ X \subset N \cup \{-0, +0\}, \\ \lvert ir_1 \rvert \in \{Inf, -Inf\} \vee \lvert ir_2 \rvert \in \{Inf, -Inf\} \end{array} \right\}$	N/A	Arbitrary floating-point value (including Inf, –Inf, NaN)

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Table 254. MLIB_VMac_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
All inputs normalized or zero, intermediate result underflow, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2, fltIn_3, fltIn_4 \in X \mid \\ X \subset N \cup \{-0, +0\}, \\ ir_1 \in D \vee ir_2 \in D \end{array} \right\}$	$(-Inf, Inf)$	N/A

2.82 Function MLIB_VScale_FLT

2.82.1 Declaration

```
INLINE void MLIB_VScale_FLT(SWLIBS_2Syst_FLT *const fltOutVec,
const SWLIBS_2Syst_FLT *const fltInVec, tFloat fltInScale);
```

2.82.2 Arguments

Table 255. MLIB_VScale_FLT arguments

Type	Name	Direction	Description
SWLIBS_2Syst_FLT *const	fltOutVec	**output**	Scaled vector.
const SWLIBS_2Syst_FLT *const	fltInVec	**input**	Input vector to be scaled.
tFloat	fltInScale	**input**	Scaling coefficient.

2.82.3 Worst-Case Error Bounds

Let (*fltIn1*, *fltInScale*) ∈ *X* be a set of inputs to MLIB_VScale_FLT,

refResult be the theoretical exact result,

then

Table 256. MLIB_VScale_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Both inputs infinity, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2 \in X \mid fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in \{Inf, -Inf\} \end{array} \right\}$	N/A	{Inf, -Inf, *pmax*, *nmax*}

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Table 256. MLIB_VScale_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 normalized number, NaN, or infinity, *fltIn2* NaN, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2 \in X \mid \\ fltIn_1 \in N \cup NaN \cup \{Inf, -Inf\}, \\ fltIn_2 = NaN \end{array} \right\}$	N/A	{NaN, *pmax*, *nmax*}
fltIn1 denormalized or zero, *fltIn2* NaN, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2 \in X \mid fltIn_1 \in D \cup \{-0, +0\}, \\ fltIn_2 = NaN \end{array} \right\}$	N/A	{NaN, -0, +0}
fltIn1 infinity, *fltIn2* denormalized or zero, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2 \in X \mid fltIn_1 \in \{Inf, -Inf\} \\ fltIn_1 \in D \cup \{-0, +0\} \end{array} \right\}$	N/A	{NaN, Inf, -Inf, -0, +0}
fltIn1 infinity, *fltIn2* normalized, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2 \in X \mid fltIn_1 \in \{Inf, -Inf\} \\ fltIn_1 \in N \end{array} \right\}$	N/A	{Inf, -Inf, *pmax*, *nmax*}
fltIn1 NaN, *fltIn2* infinity or normalized, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2 \in X \mid fltIn_1 = NaN, \\ fltIn_2 \in N \cup \{Inf, -Inf\} \end{array} \right\}$	N/A	{NaN, *pmax*, *nmax*}
fltIn1 NaN, *fltIn2* denormalized or zero, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2 \in X \mid fltIn_1 = NaN, \\ fltIn_2 \in D \cup \{-0, +0\} \end{array} \right\}$	N/A	{NaN, -0, +0}
fltIn1 denormalized or zero, *fltIn2* infinity, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2 \in X \mid \\ fltIn_1 \in D \cup \{-0, +0\}, \\ fltIn_2 \in \{Inf, -Inf\} \end{array} \right\}$	N/A	{NaN, Inf, -Inf, -0, +0}

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Table 256. MLIB_VScale_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 normalized, *fltIn2* infinity, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid fltIn_1 \in N, \\ fltIn_2 \in \{Inf, -Inf\} \end{matrix} \right\}$	N/A	{Inf, -Inf, *pmax*, *nmax*}
Both inputs denormalized, i.e. $\{fltIn_1, fltIn_2 \in X \mid X \subset D\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
fltIn1 denormalized, *fltIn2* zero, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 \in D, fltIn_2 = 0\}$	0	N/A
fltIn1 denormalized, *fltIn2* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid fltIn_1 \in D, \\ fltIn_2 \in N \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
fltIn1 zero, *fltIn2* denormalized, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 = 0, fltIn_2 \in D\}$	0	N/A
Both inputs zero, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 = 0, fltIn_2 = 0\}$	0	N/A
fltIn1 zero, *fltIn2* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid fltIn_1 = 0, \\ fltIn_2 \in N \end{matrix} \right\}$	0	N/A
fltIn1 normalized, *fltIn2* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid \\ fltIn_1 \in N, fltIn_2 \in D \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
fltIn1 normalized, *fltIn2* zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid \\ fltIn_1 \in N, fltIn_2 = 0 \end{matrix} \right\}$	0	N/A

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Table 256. MLIB_VScale_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Both inputs normalized, result normalized, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2 \in X \mid X \subset N, \\ \lvert refResult \rvert - 0.5 \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + 0.5 \cdot \mathrm{ULP}(refResult) \neq Inf \end{array} \right\}$	$\langle -0.5, 0.5 \rangle$	N/A
Both inputs normalized, result overflow, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2 \in X \mid X \subset N, \\ \lvert refResult \rvert + 0.5 \cdot \mathrm{ULP}(refResult) = Inf \end{array} \right\}$	$\langle -0.5, 0.5 \rangle$	{Inf, -Inf, *pmax*, *nmax*}
Both inputs normalized, result underflow, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2 \in X \mid X \subset N, \\ \lvert refResult \rvert - 0.5 \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0 \end{array} \right\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}

2.83 Function MLIB_VSub_FLT

2.83.1 Declaration

```
INLINE void MLIB_VSub_FLT(SWLIBS_2Syst_FLT *const fltOut, const
SWLIBS_2Syst_FLT *const fltIn1, const SWLIBS_2Syst_FLT *const
fltIn2);
```

2.83.2 Arguments

Table 257. MLIB_VSub_FLT arguments

Type	Name	Direction	Description
SWLIBS_2Syst_FLT *const	fltOut	**output**	Subtraction of two input vectors.
const SWLIBS_2Syst_FLT *const	fltIn1	**input**	Vector representing first operand.
const SWLIBS_2Syst_FLT *const	fltIn2	**input**	Vector representing second operand.

2.83.3 Worst-Case Error Bounds

Let (*fltIn1*, *fltIn2*) $\in X$ be a set of inputs to MLIB_VSub_FLT,

then

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Table 258. MLIB_VSub_FLT Worst-Case Error Bounds - Return Value

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
Both inputs infinity, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2 \in X \mid fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in \{Inf, -Inf\} \end{array} \right\}$	N/A	{Inf, -Inf, NaN, *pmax*, *nmax*}
fltIn1 arbitrary value, *fltIn2* NaN, i.e. $\{ fltIn_1, fltIn_2 \in X \mid fltIn_2 = NaN \}$	N/A	{NaN, *pmax*, *nmax*}
fltIn1 infinity, *fltIn2* normalized, denormalized, or zero, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2 \in X \mid fltIn_1 \in \{Inf, -Inf\}, \\ fltIn_2 \in N \cup D \cup \{-0, +0\} \end{array} \right\}$	N/A	{sign(*fltIn1*)•Inf, sign(*fltIn1*)•*pmax*}
fltIn1 NaN, *fltIn2* arbitrary value, i.e. $\{ fltIn_1, fltIn_2 \in X \mid fltIn_1 = NaN \}$	N/A	{NaN, *pmax*, *nmax*}
fltIn1 normalized, denormalized, or zero, *fltIn2* infinity, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2 \in X \mid \\ fltIn_1 \in N \cup D \cup \{-0, +0\}, \\ fltIn_2 \in \{Inf, -Inf\} \end{array} \right\}$	N/A	{-sign(*fltIn2*)•Inf, -sign(*fltIn2*)•*pmax*}
Both inputs denormalized, i.e. $\{ fltIn_1, fltIn_2 \in X \mid X \subset D \}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
fltIn1 denormalized, *fltIn2* zero, i.e. $\{ fltIn_1, fltIn_2 \in X \mid fltIn_1 \in D, fltIn_2 = 0 \}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
fltIn1 denormalized, *fltIn2* normalized, i.e. $\left\{ \begin{array}{c} fltIn_1, fltIn_2 \in X \mid fltIn_1 \in D, \\ fltIn_2 \in N \end{array} \right\}$	$\langle -(2^{24}-1), 2^{24}-1 \rangle$	N/A

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Table 258. MLIB_VSub_FLT Worst-Case Error Bounds - Return Value*...continued*

Subset of input domain	Worst-case return value error bounds [ulp]	Allowed specific return values (regardless the error bounds)
fltIn1 zero, *fltIn2* denormalized, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 = 0, fltIn_2 \in D\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}
Both inputs zero, i.e. $\{fltIn_1, fltIn_2 \in X \mid fltIn_1 = 0, fltIn_2 = 0\}$	0	N/A
fltIn1 zero, *fltIn2* normalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid fltIn_1 = 0, \\ fltIn_2 \in N \end{matrix} \right\}$	0	N/A
fltIn1 normalized, *fltIn2* denormalized, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid \\ fltIn_1 \in N, fltIn_2 \in D \end{matrix} \right\}$	$\langle -(2^{24}-1), 2^{24}-1 \rangle$	N/A
fltIn1 normalized, *fltIn2* zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid \\ fltIn_1 \in N, fltIn_2 = 0 \end{matrix} \right\}$	0	N/A
Both inputs normalized, result normalized or zero, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid X \subset N, \\ refResult = 0 \vee \\ \left(\begin{matrix} \lvert refResult \rvert - 0.5 \cdot \mathrm{ULP}(refResult) \notin D \wedge \\ \lvert refResult \rvert + 0.5 \cdot \mathrm{ULP}(refResult) \neq Inf \end{matrix} \right) \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	N/A
Both inputs normalized, result overflow, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid X \subset N, \\ \lvert refResult \rvert + 0.5 \cdot \mathrm{ULP}(refResult) = Inf \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	{sign(refResult)•Inf, sign(refResult)•*pmax*}
Both inputs normalized, result underflow, i.e. $\left\{ \begin{matrix} fltIn_1, fltIn_2 \in X \mid X \subset N, \\ \lvert refResult \rvert - 0.5 \cdot \mathrm{ULP}(refResult) \in D \wedge \\ refResult \neq 0 \end{matrix} \right\}$	$\langle -0.5, 0.5 \rangle$	{-0, +0}

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