ieee_arithmetic: IEEE Arithmetic Facilities Module

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1 Name

`ieee_arithmetic` — Intrinsic module providing IEEE arithmetic facilities

2 Usage

USE,INTRINSIC :: IEEE_ARITHMETIC

This module provides various facilities related to IEEE arithmetic.

The contents of this module conform to technical report ISO/IEC TR 15580:1998(E).

3 Synopsis

Derived Types

IEEE_CLASS_TYPE, IEEE_FLAG_TYPE (from IEEE_EXCEPTIONS), IEEE_ROUND_TYPE, IEEE_STATUS_TYPE (from IEEE_EXCEPTIONS).

Parameters

IEEE_ALL (from IEEE_EXCEPTIONS), IEEE_DIVIDE_BY_ZERO (from IEEE_EXCEPTIONS), IEEE_DOWN, IEEE_INEXACT (from IEEE_EXCEPTIONS), IEEE_INVALID (from IEEE_EXCEPTIONS), IEEE_NEAREST, IEEE_NEGATIVE_DENORMAL, IEEE_NEGATIVE_INF, IEEE_NEGATIVE_NORMAL, IEEE_NEGATIVE_ZERO, IEEE_OTHER, IEEE_OVERFLOW (from IEEE_EXCEPTIONS), IEEE_POSITIVE_DENORMAL, IEEE_POSITIVE_INF, IEEE_POSITIVE_NORMAL, IEEE_POSITIVE_ZERO, IEEE_QUIET_NAN, IEEE_SIGNALING_NAN, IEEE_TO_ZERO, IEEE_UNDERFLOW (from IEEE_EXCEPTIONS), IEEE_UP, IEEE_USUAL (from IEEE_EXCEPTIONS).

Operators

==, /=.

Procedures

IEEE_CLASS, IEEE_COPY_SIGN, IEEE_GET_FLAG (from IEEE_EXCEPTIONS), IEEE_GET_HALTING_MODE (from IEEE_EXCEPTIONS), IEEE_GET_ROUNDING_MODE, IEEE_GET_STATUS (from IEEE_EXCEPTIONS), IEEE_IS_FINITE, IEEE_IS_NAN, IEEE_IS_NEGATIVE, IEEE_IS_NORMAL, IEEE_LOGB, IEEE_NEXT_AFTER, IEEE_REM, IEEE_RINT, IEEE_SCALB, IEEE_SELECTED_REAL_KIND, IEEE_SET_FLAG (from IEEE_EXCEPTIONS), IEEE_SET_HALTING_MODE (from IEEE_EXCEPTIONS), IEEE_SET_ROUNDING_MODE, IEEE_SET_STATUS (from IEEE_EXCEPTIONS), IEEE_SUPPORT_DATATYPE, IEEE_SUPPORT_DENORMAL, IEEE_SUPPORT_DIVIDE, IEEE_SUPPORT_FLAG (from IEEE_EXCEPTIONS), IEEE_SUPPORT_HALTING (from IEEE_EXCEPTIONS), IEEE_SUPPORT_INF, IEEE_SUPPORT_NAN, IEEE_SUPPORT_ROUNDING, IEEE_SUPPORT_SQRT, IEEE_SUPPORT_STANDARD, IEEE_UNORDERED, IEEE_VALUE.

4 Derived-Type Description

```
TYPE IEEE_CLASS_TYPE
  PRIVATE
  ...
END TYPE
```

Type for specifying the class of a number. Its only possible values are those of the named constants exported by this module.

```
USE,INTRINSIC :: IEEE_EXCEPTIONS,ONLY:IEEE_FLAG_TYPE
```

See IEEE_EXCEPTIONS for a description of this type.

```
TYPE IEEE_ROUND_TYPE
  PRIVATE
  ...
END TYPE
```

Type for specifying the rounding mode. Its only possible values are those of the named constants exported by this module.

```
USE,INTRINSIC :: IEEE_EXCEPTIONS,ONLY:IEEE_STATUS_TYPE
```

See IEEE_EXCEPTIONS for a description of this type.

5 Parameter Description

```
USE,INTRINSIC :: IEEE_EXCEPTIONS,ONLY:IEEE_ALL
```

See IEEE_EXCEPTIONS for a description of this parameter.

```
USE,INTRINSIC :: IEEE_EXCEPTIONS,ONLY:IEEE_DIVIDE_BY_ZERO
```

See IEEE_EXCEPTIONS for a description of this parameter.

```
TYPE(IEEE_ROUND_TYPE),PARAMETER :: IEEE_DOWN
```

The rounding mode in which the results of a calculation are rounded to the nearest machine-representable number that is less than the true result.

```
USE,INTRINSIC :: IEEE_EXCEPTIONS,ONLY:IEEE_INEXACT
```

See IEEE_EXCEPTIONS for a description of this parameter.

```
USE,INTRINSIC :: IEEE_EXCEPTIONS,ONLY:IEEE_INVALID
```

See IEEE_EXCEPTIONS for a description of this parameter.

```
TYPE(IEEE_ROUND_TYPE),PARAMETER :: IEEE_NEAREST
```

The rounding mode in which the results of a calculation are rounded to the nearest machine-representable number.

```
TYPE(IEEE_CLASS_TYPE),PARAMETER :: IEEE_NEGATIVE_DENORMAL
```

A negative number whose precision is less than that of the normal numbers; the result of an IEEE gradual underflow.

```
TYPE(IEEE_CLASS_TYPE),PARAMETER :: IEEE_NEGATIVE_INF
```

Negative infinity.

```
TYPE(IEEE_CLASS_TYPE),PARAMETER :: IEEE_NEGATIVE_NORMAL
```

A normal negative number.

```
TYPE(IEEE_CLASS_TYPE),PARAMETER :: IEEE_NEGATIVE_ZERO
```

Negative zero.

```
TYPE(IEEE_ROUND_TYPE),PARAMETER :: IEEE_OTHER
```

Any processor-dependent rounding mode other than IEEE_DOWN, IEEE_NEAREST, IEEE_TO_ZERO and IEEE_UP.

```
USE,INTRINSIC :: IEEE_EXCEPTIONS,ONLY:IEEE_OVERFLOW
```

See IEEE_EXCEPTIONS for a description of this parameter.

```
TYPE(IEEE_CLASS_TYPE),PARAMETER :: IEEE_POSITIVE_DENORMAL
```

A positive number whose precision is less than that of the normal numbers; the result of an IEEE gradual underflow.

```
TYPE(IEEE_CLASS_TYPE),PARAMETER :: IEEE_POSITIVE_INF
```

Positive infinity.

```
TYPE(IEEE_CLASS_TYPE),PARAMETER :: IEEE_POSITIVE_NORMAL
```

A normal positive number.

```
TYPE(IEEE_CLASS_TYPE),PARAMETER :: IEEE_POSITIVE_ZERO
```

Positive zero.

```
TYPE(IEEE_CLASS_TYPE),PARAMETER :: IEEE_QUIET_NAN
```

A "Not-a-Number" value that propagates through arithmetic operations but which does not necessarily raise the IEEE_INVALID exception on use.

```
TYPE(IEEE_CLASS_TYPE),PARAMETER :: IEEE_SIGNALING_NAN
```

A "Not-a-Number" that raises the IEEE_INVALID exception on use.

```
TYPE(IEEE_ROUND_TYPE),PARAMETER :: IEEE_TO_ZERO
```

The rounding mode in which the results of a calculation are rounded to the nearest machine-representable number that lies between zero and the true result.

```
USE,INTRINSIC :: IEEE_EXCEPTIONS,ONLY:IEEE_UNDERFLOW
```

See IEEE_EXCEPTIONS for a description of this parameter.

```
TYPE(IEEE_ROUND_TYPE),PARAMETER :: IEEE_UP
```

The rounding mode in which the results of a calculation are rounded to the nearest machine-representable number that is greater than the true result.

```
USE,INTRINSIC :: IEEE_EXCEPTIONS,ONLY:IEEE_USUAL
```

See IEEE_EXCEPTIONS for a description of this parameter.

6 Operator Description

In addition to ISO/IEC TR 15580:1998(E), the module IEEE_ARITHMETIC defines the '==' and '/=' operators for the IEEE_CLASS_TYPE. These may be used to test the return value of the IEEE_CLASS function. E.g

```
USE,INTRINSIC :: IEEE_ARITHMETIC, ONLY: IEEE_CLASS, &
  IEEE_QUIET_NAN, OPERATOR(==)
  ...
  IF (IEEE_CLASS(X)==IEEE_QUIET_NAN) THEN
  ...
```

7 Procedure Description

```
ELEMENTAL TYPE(IEEE_CLASS_TYPE) FUNCTION IEEE_CLASS(X)
REAL(any kind),INTENT(IN) :: X
```

Returns the IEEE class that the value of X falls into.

```
ELEMENTAL REAL(kind) FUNCTION IEEE_COPY_SIGN(X,Y)
REAL(kind),INTENT(IN) :: X
REAL(kind),INTENT(IN) :: Y
```

Returns the value of X with the sign of Y. The result has the same kind as X.

This function is only available if IEEE_SUPPORT_DATATYPE(X) and IEEE_SUPPORT_DATATYPE(Y) are both true.

```
USE,INTRINSIC :: IEEE_EXCEPTIONS,ONLY:IEEE_GET_FLAG
```

See IEEE_EXCEPTIONS for a description of this procedure.

```
USE,INTRINSIC :: IEEE_EXCEPTIONS,ONLY:IEEE_GET_HALTING_MODE
```

See IEEE_EXCEPTIONS for a description of this procedure.

```
SUBROUTINE IEEE_GET_ROUNDING_MODE(ROUND_VALUE)
TYPE(IEEE_ROUND_TYPE),INTENT(OUT) :: ROUND_VALUE
```

Sets ROUND_VALUE to the current rounding mode, one of IEEE_DOWN, IEEE_NEAREST, IEEE_OTHER, IEEE_TO_ZERO or IEEE_UP.

```
USE,INTRINSIC :: IEEE_EXCEPTIONS,ONLY:IEEE_GET_STATUS
```

See IEEE_EXCEPTIONS for a description of this procedure.

```
ELEMENTAL LOGICAL FUNCTION IEEE_IS_FINITE(X)
REAL(any kind),INTENT(IN) :: X
```

Returns true if X is a finite number, i.e. neither an infinity nor a NaN.

```
ELEMENTAL LOGICAL FUNCTION IEEE_IS_NAN(X)
REAL(any kind),INTENT(IN) :: X
```

Returns true if X is a NaN (either quiet or signalling).

```
ELEMENTAL LOGICAL FUNCTION IEEE_IS_NEGATIVE(X)
REAL(any kind),INTENT(IN) :: X
```

Returns true if X is negative, even for negative zero.

```
ELEMENTAL LOGICAL FUNCTION IEEE_IS_NORMAL(X)
REAL(any kind),INTENT(IN) :: X
```

Returns if X is normal, i.e. not an infinity, a NaN, or denormal.

```
ELEMENTAL REAL(kind) FUNCTION IEEE_LOGB(X)
REAL(kind),INTENT(IN) :: X
```

Returns the unbiased exponent of X. For normal, non-zero numbers this is the same as the EXPONENT(X)-1; for zero, IEEE_DIVIDE_BY_ZERO is signalled and the result is negative infinity (or -HUGE(X) if negative infinity is not available); for an infinity the result is positive infinity; for a NaN the result is a quiet NaN.

```
ELEMENTAL REAL(kind) FUNCTION IEEE_NEXT_AFTER(X,Y)
REAL(kind),INTENT(IN) :: X
REAL(kind),INTENT(IN) :: Y
```

Returns the closest machine-representable number to X (of the same kind as X) that is either greater than X (if X<Y) or less than X (if X>Y). If X and Y are equal, X is returned.

```
ELEMENTAL REAL(kind) FUNCTION IEEE_REM(X,Y)
REAL(kind),INTENT(IN) :: X
REAL(kind),INTENT(IN) :: Y
```

The result value is the exact remainder from the division X/Y, viz X-Y*N where N is the nearest integer to the true result of X/Y.

```
ELEMENTAL REAL(kind) FUNCTION IEEE_RINT(X)
REAL(kind),INTENT(IN) :: X
```

X rounded to the nearest integer using the current rounding mode.

```
ELEMENTAL REAL(kind) FUNCTION IEEE_SCALB(X,I)
REAL(kind),INTENT(IN) :: X
INTEGER(any kind),INTENT(IN) :: I
```

The result is X*2**I without computing 2**I, with overflow or underflow exceptions signalled only if the end result overflows or underflows.

```
INTEGER FUNCTION IEEE_SELECTED_REAL_KIND(P,R,RADIX)
INTEGER(any kind),INTENT(IN),OPTIONAL :: P
INTEGER(any kind),INTENT(IN),OPTIONAL :: R
INTEGER(any kind),INTENT(IN),OPTIONAL :: RADIX
```

The same as the intrinsic function SELECTED_REAL_KIND(P,R,RADIX), but only returns numbers of kinds for which IEEE_SUPPORT_DATATYPE returns true.

```
USE,INTRINSIC :: IEEE_EXCEPTIONS,ONLY:IEEE_SET_FLAG
```

See IEEE_EXCEPTIONS for a description of this procedure.

```
USE,INTRINSIC :: IEEE_EXCEPTIONS,ONLY:IEEE_SET_HALTING_MODE
```

See IEEE_EXCEPTIONS for a description of this procedure.

```
SUBROUTINE IEEE_SET_ROUNDING_MODE(ROUND_VALUE)
TYPE(IEEE_ROUND_TYPE),INTENT(IN) :: ROUND_VALUE
```

Sets the current rounding mode to ROUND_VALUE. This is only allowed when IEEE_SUPPORT_ROUNDING(ROUND_VALUE,X) is true for all X such that IEEE_SUPPORT_DATATYPE(X) is true.

```
USE,INTRINSIC :: IEEE_EXCEPTIONS,ONLY:IEEE_SET_STATUS
```

See IEEE_EXCEPTIONS for a description of this procedure.

```
LOGICAL FUNCTION IEEE_SUPPORT_DATATYPE(X)
REAL(any kind),INTENT(IN),OPTIONAL :: X
```

Returns true if and only if all reals (if X is absent), or reals of the same kind as X conform to the IEEE standard for representation, addition, subtraction and multiplication when the operands and results have normal values.

```
LOGICAL FUNCTION IEEE_SUPPORT_DENORMAL(X)
REAL(any kind),INTENT(IN),OPTIONAL :: X
```

Returns true if and only if IEEE denormalised values are supported for all real kinds (if X is absent) or for reals of the same kind as X.

```
LOGICAL FUNCTION IEEE_SUPPORT_DIVIDE(X)
REAL(any kind),INTENT(IN),OPTIONAL :: X
```

Returns true if and only if division on all reals (if X is absent) or on reals of the same kind as X is performed to the accuracy required by the IEEE standard.

```
USE,INTRINSIC :: IEEE_EXCEPTIONS,ONLY:IEEE_SUPPORT_FLAG
```

See IEEE_EXCEPTIONS for a description of this procedure.

```
USE,INTRINSIC :: IEEE_EXCEPTIONS,ONLY:IEEE_SUPPORT_HALTING
```

See IEEE_EXCEPTIONS for a description of this procedure.

```
LOGICAL FUNCTION IEEE_SUPPORT_INF(X)
REAL(any kind),INTENT(IN),OPTIONAL :: X
```

Returns true if and only if IEEE infinities are supported for all reals (if X is absent) or for reals of the same kind as X.

```
LOGICAL FUNCTION IEEE_SUPPORT_NAN(X)
REAL(any kind),INTENT(IN),OPTIONAL :: X
```

Returns true if and only if IEEE NaNs are supported for all reals (if X is absent) or for reals of the same kind as X.

```
LOGICAL FUNCTION IEEE_SUPPORT_ROUNDING(ROUND_VALUE,X)
TYPE(IEEE_ROUND_TYPE) :: ROUND_VALUE
REAL(any kind),OPTIONAL :: X
```

Returns true if and only if the rounding mode for all reals (if X is absent) or reals of the same kind as X, can be changed to the specified rounding mode by the IEEE_SET_ROUNDING procedure.

```
LOGICAL FUNCTION IEEE_SUPPORT_SQRT(X)
REAL(any kind),INTENT(IN),OPTIONAL :: X
```

Returns true if and only if the SQRT intrinsic conforms to the IEEE standard for all reals (if X is absent) or for reals of the same kind as X.

```
LOGICAL FUNCTION IEEE_SUPPORT_STANDARD(X)
REAL(any kind),INTENT(IN),OPTIONAL :: X
```

Returns true if and only if all the other IEEE_SUPPORT inquiry functions return the value true for all reals (if X is absent) or for reals of the same kind as X.

```
ELEMENTAL LOGICAL FUNCTION IEEE_UNORDERED(X,Y)
REAL(any kind),INTENT(IN) :: X
REAL(any kind),INTENT(IN) :: Y
```

Returns IEEE_IS_NAN(X).OR.IEEE_IS_NAN(Y).

```
ELEMENTAL REAL(kind) FUNCTION IEEE_VALUE(X,CLASS)
REAL(kind),INTENT(IN) :: X
TYPE(IEEE_CLASS_TYPE),INTENT(IN) :: CLASS
```

Returns a sample value of the same kind as X that falls into the specified IEEE number class. For a given kind of X and class, the same value is always returned.

8 See Also

nagfor(1), **ieee_exceptions**(3), **ieee_features**(3), **intro**(3), **nag_modules**(3).

9 Bugs

Please report any bugs found to 'support@nag.co.uk' or 'support@nag.com', along with any suggestions for improvements.