Embedded system paranoia: IAR Compiler with MPS430, (low power mixed signal RISC)

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1 Output results

Data kindly supplied by Jurg Stierli.

1.1 Fast Math libraries

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COMMENT: ========================================
COMMENT: Welcome to ESP - Embedded System Paranoia
COMMENT: Please let me know your experiences
COMMENT: and suggestions at lesh@oakcomp.co.uk or
COMMENT: L.Hatton@kent.ac.uk
COMMENT:
COMMENT: $Revision: 1.5 $ $Date: 2003/09/26 13:23:47 $
COMMENT: This version will attempt divide by zero.
COMMENT: This version uses <stdio.h>
COMMENT: This version uses <setjmp.h>
COMMENT: This version uses double precision.
COMMENT: ========================================
FAILURE: Comparison says -0.0 is non-zero !
COMMENT: Since comparison denies Z = 0, evaluating
COMMENT: (Z + Z) / Z should be safe.
COMMENT: This is a VERY SERIOUS DEFECT !
DEFECT : Z != Z * 1
COMMENT: Z = .17e, Z * 1 = .17e
DEFECT : Z != 1 * Z
COMMENT: Z = .17e, 1 * Z = .17e
DEFECT : Z != Z / 1
COMMENT: Z = .17e, Z / 1 = .17e

-------> Diagnosis resuming after Milestone 0, Page 1

-------> Diagnosis resuming after Milestone 1, Page 2
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```
COMMENT: Searching for Radix and Precision.
COMMENT: Radix = .17e
COMMENT: Closest relative separation found is U1 = .17e
COMMENT: Recalculating radix and precision
COMMENT: confirms closest relative separation U1.
COMMENT: Radix confirmed.

-------> Diagnosis resuming after Milestone 10, Page 3

-------> Diagnosis resuming after Milestone 20, Page 4
COMMENT: The number of significant digits of the
COMMENT: Radix is .17e

-------> Diagnosis resuming after Milestone 25, Page 5

-------> Diagnosis resuming after Milestone 30, Page 6
COMMENT: Subtraction appears to be normalized, as it should be.
COMMENT: Checking for guard digit in *, / and -.
PASSED : *, /, and - appear to have guard digits, as they should.

-------> Diagnosis resuming after Milestone 35, Page 7
COMMENT: Checking rounding on multiply, divide and add/subtract.
PASSED : Multiplication appears to round correctly.

-------> Diagnosis resuming after Milestone 40, Page 8
FLAW   : Division neither chopped nor correctly rounded.

-------> Diagnosis resuming after Milestone 45, Page 9
COMMENT: Addition/Subtraction neither rounds  nor chops.
COMMENT: Sticky bit used incorrectly or not at all.
FLAW   : Flaws are present due to lack of guard digits or round/chop failures

-------> Diagnosis resuming after Milestone 50, Page 10
COMMENT: Testing multiplicative commutation
COMMENT: with random pairs, trials = 20
PASSED : No failures found during these trials.

-------> Diagnosis resuming after Milestone 60, Page 11
COMMENT: Running test of square root(x).
FAILURE: Square root of 0.0, -0.0 or 1.0 wrong
COMMENT: Testing integer X, sqrt(X * X) = X, trials = 20
COMMENT: Test for sqrt monotonicity.
PASSED : sqrt has passed a test for Monotonicity.

-------> Diagnosis resuming after Milestone 70, Page 12
COMMENT: Running test of difference of two squares).
COMMENT: integer X, (X**2-Y**2) - (X-Y)(X+Y) trials = 20

-------> Diagnosis resuming after Milestone 75, Page 13
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-------> Diagnosis resuming after Milestone 80, Page 14
COMMENT: Testing whether sqrt is rounded or chopped.
FLAW   : Square root is neither chopped nor correctly rounded.
COMMENT: Observed errors run from
COMMENT: .17e to .17e ulps.

-------> Diagnosis resuming after Milestone 85, Page 15

-------> Diagnosis resuming after Milestone 90, Page 16
COMMENT: Testing powers Z^i for small Integers Z and i.
DEFECT : Power function
COMMENT: .17e ^ .17e = .17e
COMMENT: which differs from correct value by .17e
COMMENT: Number of similar discrepancies = 3
DEFECT : Power function
COMMENT: .17e ^ .17e = .17e
COMMENT: which differs from correct value by .17e
COMMENT: Number of similar discrepancies = 1
DEFECT : Power function
COMMENT: .17e ^ .17e = .17e
COMMENT: which differs from correct value by .17e

-------> Diagnosis resuming after Milestone 91, Page 17
COMMENT: Errors like this may invalidate financial calculations
COMMENT: involving interest rates.
COMMENT: Number of similar discrepancies = 72

-------> Diagnosis resuming after Milestone 100, Page 18
COMMENT: Seeking Underflow thresholds UfThold and E0.

-------> Diagnosis resuming after Milestone 110, Page 19
COMMENT: Smallest strictly positive number found
COMMENT: is E0 = .17e
COMMENT: Since comparison denies Z = 0, evaluating
COMMENT: (Z + Z) / Z should be safe.
COMMENT: (Z+Z)/Z is OK provided Over/Underflow
COMMENT: has NOT just been signaled.


-------> Diagnosis resuming after Milestone 120, Page 20
FLAW   :
COMMENT: X != Z but X - Z = Zero
COMMENT: X = .17e, Z  = .17e
COMMENT: This is OK only if underflow signalled.
COMMENT: X / Z = 1 + .17e
COMMENT: The Underflow threshold is .17e
COMMENT: Below this, a calculation may suffer larger Relative
COMMENT: error than merely roundoff.

-------> Diagnosis resuming after Milestone 121, Page 21
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```
COMMENT: Since underflow occurs below the threshold
COMMENT: UfThold = .17e ^ .17e
COMMENT: only underflow could affect this expression.
COMMENT: calculating yields: .17e
PASSED : This computed value is O.K.

-------> Diagnosis resuming after Milestone 130, Page 22
COMMENT: As X -> 1, Testing X^((X + 1) / (X - 1)) against exp(2).
COMMENT: exp(2) = .17e
DEFECT : Power function pow(x,z):
COMMENT: (1 + .17e) ^ .17e
COMMENT: differs from correct value by .17e
COMMENT: This may spoil financial calculations
COMMENT: involving tiny interest rates.

-------> Diagnosis resuming after Milestone 140, Page 23
COMMENT: Testing powers Z^Q at four nearly extreme values.

DEFECT : Power function
COMMENT: .17e ^ .17e = .17e
COMMENT: which differs from correct value by .17e
COMMENT: Number of similar discrepancies = 3

-------> Diagnosis resuming after Milestone 150, Page 24

-------> Diagnosis resuming after Milestone 160, Page 25
COMMENT: Searching for Overflow threshold:
COMMENT: This may generate an error.
COMMENT: Can 'Z = -Y' overflow?
COMMENT: Trying it on Y = .17e
PASSED : Seems O.K.
COMMENT: Overflow threshold is V = .17e
COMMENT: Overflow saturates at V0 = .17e
COMMENT: No overflow should be signalled for V*1 = .17e
COMMENT: No overflow should be signalled for V/1 = .17e
COMMENT: Any overflow separating V*1 from
COMMENT: V above is a DEFECT.

-------> Diagnosis resuming after Milestone 161, Page 26

-------> Diagnosis resuming after Milestone 170, Page 27

-------> Diagnosis resuming after Milestone 175, Page 28
DEFECT :
COMMENT: Comparison alleges that Z = .17e
COMMENT: is too far from sqrt(Z) ^ 2 =  .17e

-------> Diagnosis resuming after Milestone 180, Page 29

-------> Diagnosis resuming after Milestone 190, Page 30
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-------> Diagnosis resuming after Milestone 191, Page 31

-------> Diagnosis resuming after Milestone 200, Page 32
COMMENT: Trying to compute 1/0 gives .17e
COMMENT: Trying to compute 0/0 gives .17e

-------> Diagnosis resuming after Milestone 210, Page 33
COMMENT: ========================================
COMMENT:     Embedded System Paranoia SUMMARY
COMMENT:
COMMENT: Number of FAILUREs encountered       = 2
COMMENT: Number of SERIOUS DEFECTs discovered = 1
COMMENT: Number of DEFECTs discovered         = 9
COMMENT: Number of FLAWs discovered           = 4
COMMENT:
FAILED : The arithmetic diagnosed has unacceptable
COMMENT: Serious DEFECT.
FAILED : Potentially fatal FAILURE has occurred
COMMENT:
COMMENT: Rating ...
COMMENT:
               Excellent
               Very good
               Good
               Acceptable
               Unacceptable
         =====> Broken
COMMENT:
COMMENT: END OF TEST.
COMMENT: ========================================
```

1.2 IEEElibrary

```
COMMENT: ========================================
COMMENT: Welcome to ESP - Embedded System Paranoia
COMMENT: Please let me know your experiences
COMMENT: and suggestions at lesh@oakcomp.co.uk or
COMMENT: L.Hatton@kent.ac.uk
COMMENT:
COMMENT: $Revision: 1.5 $ $Date: 2003/09/26 13:23:47 $
COMMENT: This version will attempt divide by zero.
COMMENT: This version uses <stdio.h>
COMMENT: This version uses <setjmp.h>
COMMENT: This version uses double precision.
COMMENT: ========================================

-------> Diagnosis resuming after Milestone 0, Page 1
COMMENT: -1, 0, 1/2, 1, 2, 3, 4, 5, 9, 27, 32 & 240
PASSED : small integer tests are all OK.
```

```
COMMENT: Searching for Radix and Precision.
COMMENT: Radix = .17e
COMMENT: Closest relative separation found is U1 = .17e
COMMENT: Recalculating radix and precision
COMMENT: confirms closest relative separation U1.
COMMENT: Radix confirmed.

-------> Diagnosis resuming after Milestone 10, Page 2

-------> Diagnosis resuming after Milestone 20, Page 3
COMMENT: The number of significant digits of the
COMMENT: Radix is .17e

-------> Diagnosis resuming after Milestone 25, Page 4

-------> Diagnosis resuming after Milestone 30, Page 5
COMMENT: Subtraction appears to be normalized, as it should be.
COMMENT: Checking for guard digit in *, / and -.
PASSED : *, /, and - appear to have guard digits, as they should.

-------> Diagnosis resuming after Milestone 35, Page 6
COMMENT: Checking rounding on multiply, divide and add/subtract.
PASSED : Multiplication appears to round correctly.

-------> Diagnosis resuming after Milestone 40, Page 7
PASSED : Division appears to round correctly.

-------> Diagnosis resuming after Milestone 45, Page 8
PASSED : Addition/Subtraction appears to round correctly.
COMMENT: Checking for sticky bit.

PASSED : Sticky bit apparently used correctly.

-------> Diagnosis resuming after Milestone 50, Page 9
COMMENT: Testing multiplicative commutation
COMMENT: with random pairs, trials = 20
PASSED : No failures found during these trials.

-------> Diagnosis resuming after Milestone 60, Page 10
COMMENT: Running test of square root(x).
COMMENT: Testing integer X, sqrt(X * X) = X, trials = 20
COMMENT: Test for sqrt monotonicity.
PASSED : sqrt has passed a test for Monotonicity.

-------> Diagnosis resuming after Milestone 70, Page 11
COMMENT: Running test of difference of two squares).
COMMENT: integer X, (X**2-Y**2) - (X-Y)(X+Y) trials = 20

-------> Diagnosis resuming after Milestone 75, Page 12
```

```
-------> Diagnosis resuming after Milestone 80, Page 13
COMMENT: Testing whether sqrt is rounded or chopped.
FLAW   : Square root is neither chopped nor correctly rounded.
COMMENT: Observed errors run from
COMMENT: .17e to .17e ulps.

-------> Diagnosis resuming after Milestone 85, Page 14

-------> Diagnosis resuming after Milestone 90, Page 15
COMMENT: Testing powers Z^i for small Integers Z and i.
DEFECT : Power function
COMMENT: .17e ^ .17e = .17e
COMMENT: which differs from correct value by .17e
COMMENT: Number of similar discrepancies = 1
DEFECT : Power function
COMMENT: .17e ^ .17e = .17e
COMMENT: which differs from correct value by .17e

-------> Diagnosis resuming after Milestone 91, Page 16
COMMENT: Errors like this may invalidate financial calculations
COMMENT: involving interest rates.
COMMENT: Number of similar discrepancies = 81

-------> Diagnosis resuming after Milestone 100, Page 17
COMMENT: Seeking Underflow thresholds UfThold and E0.

-------> Diagnosis resuming after Milestone 110, Page 18
COMMENT: Smallest strictly positive number found
COMMENT: is E0 = .17e
COMMENT: Since comparison denies Z = 0, evaluating
COMMENT: (Z + Z) / Z should be safe.
COMMENT: (Z+Z)/Z is OK provided Over/Underflow
COMMENT: has NOT just been signaled.

COMMENT: Underflow is gradual; Absolute roundoff error in UfThold < E0.
COMMENT: The Underflow threshold is .17e
COMMENT: Below this, a calculation may suffer larger Relative
COMMENT: error than merely roundoff.

-------> Diagnosis resuming after Milestone 120, Page 19
COMMENT: Since underflow occurs below the threshold
COMMENT: UfThold = .17e ^ .17e
COMMENT: only underflow could affect this expression.
COMMENT: calculating yields: .17e
PASSED : This computed value is O.K.

-------> Diagnosis resuming after Milestone 130, Page 20
COMMENT: As X -> 1, Testing X^((X + 1) / (X - 1)) against exp(2).
COMMENT: exp(2) = .17e
DEFECT : Power function pow(x,z):
```

```
COMMENT: (1 + .17e) ^ .17e
COMMENT: differs from correct value by .17e
COMMENT: This may spoil financial calculations
COMMENT: involving tiny interest rates.

-------> Diagnosis resuming after Milestone 140, Page 21
COMMENT: Testing powers Z^Q at four nearly extreme values.

DEFECT : Power function
COMMENT: .17e ^ .17e = .17e
COMMENT: which differs from correct value by .17e
COMMENT: Number of similar discrepancies = 4

-------> Diagnosis resuming after Milestone 150, Page 22

-------> Diagnosis resuming after Milestone 160, Page 23
COMMENT: Searching for Overflow threshold:
COMMENT: This may generate an error.
COMMENT: Can 'Z = -Y' overflow?
COMMENT: Trying it on Y = .17e
PASSED : Seems O.K.
COMMENT: Overflow threshold is V = .17e
COMMENT: Overflow saturates at V0 = .17e
COMMENT: No overflow should be signalled for V*1 = .17e
COMMENT: No overflow should be signalled for V/1 = .17e
COMMENT: Any overflow separating V*1 from
COMMENT: V above is a DEFECT.

-------> Diagnosis resuming after Milestone 161, Page 24

-------> Diagnosis resuming after Milestone 170, Page 25
DEFECT :
COMMENT: Comparison alleges that what prints as Z =.17e
COMMENT: is too far from .17e

-------> Diagnosis resuming after Milestone 175, Page 26
DEFECT :
COMMENT: Comparison alleges that Z = .17e
COMMENT: is too far from sqrt(Z) ^ 2 =  .17e

-------> Diagnosis resuming after Milestone 180, Page 27

-------> Diagnosis resuming after Milestone 190, Page 28

-------> Diagnosis resuming after Milestone 191, Page 29

-------> Diagnosis resuming after Milestone 200, Page 30
COMMENT: Trying to compute 1/0 gives .17e
COMMENT: Trying to compute 0/0 gives .17e
```

```
-------> Diagnosis resuming after Milestone 210, Page 31
COMMENT: ========================================
COMMENT:     Embedded System Paranoia SUMMARY
COMMENT:
COMMENT: Number of FAILUREs encountered       = 0
COMMENT: Number of SERIOUS DEFECTs discovered = 0
COMMENT: Number of DEFECTs discovered         = 6
COMMENT: Number of FLAWs discovered           = 1
COMMENT:
COMMENT: The arithmetic diagnosed may be Acceptable
COMMENT: despite inconvenient DEFECT.
COMMENT:
COMMENT: Rating ...
COMMENT:
               Excellent
               Very good
               Good
         =====> Acceptable
               Unacceptable
               Broken
COMMENT:
COMMENT: END OF TEST.
COMMENT: ========================================
```

1.3 EC++ library

```
COMMENT: ========================================
COMMENT: Welcome to ESP - Embedded System Paranoia
COMMENT: Please let me know your experiences
COMMENT: and suggestions at lesh@oakcomp.co.uk or
COMMENT: L.Hatton@kent.ac.uk
COMMENT:
COMMENT: $Revision: 1.5 $ $Date: 2003/09/26 13:23:47 $
COMMENT: This version will attempt divide by zero.
COMMENT: This version uses <stdio.h>
COMMENT: This version uses <setjmp.h>
COMMENT: This version uses double precision.
COMMENT: ========================================

-------> Diagnosis resuming after Milestone 0, Page 1
COMMENT: -1, 0, 1/2, 1, 2, 3, 4, 5, 9, 27, 32 & 240
PASSED : small integer tests are all OK.
COMMENT: Searching for Radix and Precision.
COMMENT: Radix = 2.0000000000000000e+00
COMMENT: Closest relative separation found is U1 = 5.96040000000000000e-08
COMMENT: Recalculating radix and precision
COMMENT: confirms closest relative separation U1.
COMMENT: Radix confirmed.

-------> Diagnosis resuming after Milestone 10, Page 2
```

```
-------> Diagnosis resuming after Milestone 20, Page 3
COMMENT: The number of significant digits of the
COMMENT: Radix is 2.40000000000000000e+01

-------> Diagnosis resuming after Milestone 25, Page 4

-------> Diagnosis resuming after Milestone 30, Page 5
COMMENT: Subtraction appears to be normalized, as it should be.
COMMENT: Checking for guard digit in *, / and -.
PASSED : *, /, and - appear to have guard digits, as they should.

-------> Diagnosis resuming after Milestone 35, Page 6
COMMENT: Checking rounding on multiply, divide and add/subtract.
PASSED : Multiplication appears to round correctly.

-------> Diagnosis resuming after Milestone 40, Page 7
PASSED : Division appears to round correctly.

-------> Diagnosis resuming after Milestone 45, Page 8
PASSED : Addition/Subtraction appears to round correctly.
COMMENT: Checking for sticky bit.

PASSED : Sticky bit apparently used correctly.

-------> Diagnosis resuming after Milestone 50, Page 9
COMMENT: Testing multiplicative commutation
COMMENT: with random pairs, trials = 20
PASSED : No failures found during these trials.

-------> Diagnosis resuming after Milestone 60, Page 10
COMMENT: Running test of square root(x).
COMMENT: Testing integer X, sqrt(X * X) = X, trials = 20
COMMENT: Test for sqrt monotonicity.
PASSED : sqrt has passed a test for Monotonicity.

-------> Diagnosis resuming after Milestone 70, Page 11
COMMENT: Running test of difference of two squares).
COMMENT: integer X, (X**2-Y**2) - (X-Y)(X+Y) trials = 20

-------> Diagnosis resuming after Milestone 75, Page 12

-------> Diagnosis resuming after Milestone 80, Page 13
COMMENT: Testing whether sqrt is rounded or chopped.
FLAW   : Square root is neither chopped nor correctly rounded.
COMMENT: Observed errors run from
COMMENT: -5.00000000000000000e-01 to 5.00000000000000000e-01 ulps.

-------> Diagnosis resuming after Milestone 85, Page 14
```

```
-------> Diagnosis resuming after Milestone 90, Page 15
COMMENT: Testing powers Z^i for small Integers Z and i.
COMMENT: Power function
COMMENT: -0.00000000000000000e+00 ^ 0.00000000000000000e+00 = -NaN
COMMENT: which differs from correct value by -NaN
COMMENT: Number of similar discrepancies = 1

-------> Diagnosis resuming after Milestone 91, Page 16
PASSED : ... no discrepancies found.

-------> Diagnosis resuming after Milestone 100, Page 17
COMMENT: Seeking Underflow thresholds UfThold and E0.

-------> Diagnosis resuming after Milestone 110, Page 18
COMMENT: Smallest strictly positive number found
COMMENT: is E0 = 1.40129000000000000e-45
COMMENT: Since comparison denies Z = 0, evaluating
COMMENT: (Z + Z) / Z should be safe.
COMMENT: (Z+Z)/Z is OK provided Over/Underflow
COMMENT: has NOT just been signaled.

COMMENT: Underflow is gradual; Absolute roundoff error in UfThold < E0.
COMMENT: The Underflow threshold is 1.17549400000000000e-38
COMMENT: Below this, a calculation may suffer larger Relative
COMMENT: error than merely roundoff.

-------> Diagnosis resuming after Milestone 120, Page 19
COMMENT: Since underflow occurs below the threshold
COMMENT: UfThold = 2.00000000000000000e+00 ^ -1.26000000000000000e+02
COMMENT: only underflow could affect this expression.
COMMENT: calculating yields: 0.00000000000000000e+00
PASSED : This computed value is O.K.

-------> Diagnosis resuming after Milestone 130, Page 20
COMMENT: As X -> 1, Testing X^((X + 1) / (X - 1)) against exp(2).
COMMENT: exp(2) = 7.38905500000000000e+00
PASSED : Accuracy seems adequate.

-------> Diagnosis resuming after Milestone 140, Page 21
COMMENT: Testing powers Z^Q at four nearly extreme values.

PASSED : ... no discrepancies found.

-------> Diagnosis resuming after Milestone 150, Page 22

-------> Diagnosis resuming after Milestone 160, Page 23
COMMENT: Searching for Overflow threshold:
COMMENT: This may generate an error.
COMMENT: Can 'Z = -Y' overflow?
COMMENT: Trying it on Y = -Inf
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PASSED : Seems O.K.
COMMENT: Overflow threshold is V = 3.40282300000000000e+38
COMMENT: Overflow saturates at V0 = Inf
COMMENT: No overflow should be signalled for V*1 = 3.40282300000000000e+38
COMMENT: No overflow should be signalled for V/1 = 3.40282300000000000e+38
COMMENT: Any overflow separating V*1 from
COMMENT: V above is a DEFECT.

-------> Diagnosis resuming after Milestone 161, Page 24

-------> Diagnosis resuming after Milestone 170, Page 25

-------> Diagnosis resuming after Milestone 175, Page 26

-------> Diagnosis resuming after Milestone 180, Page 27

-------> Diagnosis resuming after Milestone 190, Page 28

-------> Diagnosis resuming after Milestone 191, Page 29

-------> Diagnosis resuming after Milestone 200, Page 30
COMMENT: Trying to compute 1/0 gives Inf
COMMENT: Trying to compute 0/0 gives NaN

-------> Diagnosis resuming after Milestone 210, Page 31
COMMENT: ========================================
COMMENT:     Embedded System Paranoia SUMMARY
COMMENT:
COMMENT: Number of FAILUREs encountered       = 0
COMMENT: Number of SERIOUS DEFECTs discovered = 0
COMMENT: Number of DEFECTs discovered         = 0
COMMENT: Number of FLAWs discovered           = 1
COMMENT:
PASSED : The arithmetic diagnosed seems satisfactory
COMMENT: though flawed.
COMMENT:
COMMENT: Rating ...
COMMENT:
               Excellent
               Very good
         =====> Good
               Acceptable
               Unacceptable
               Broken
COMMENT:
COMMENT: END OF TEST.
COMMENT: ========================================
```