

# Embedded system paranoia: gcc 3.4.x, PowerPC and Intel desktop

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## 1 Output results

Data supplied by Robert Searle of Tait.

### 1.1 PowerPC 800 with ucLibc 0.9.28 and gcc 3.3.2.

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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: 1.9 $ $Date: 2004/04/13 14:21:53 $
COMMENT: This version will attempt divide by zero.
COMMENT: This version uses <stdio.h>
COMMENT: This version uses <signal.h>
COMMENT: This version uses <setjmp.h>
COMMENT: This version uses double precision. nbits=64
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 = 1.11022302462515650e-16
COMMENT: Recalculating radix and precision
COMMENT: confirms closest relative separation U1.
COMMENT: Checking U1 for sanity...
COMMENT: U1 is a sensible value
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
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COMMENT: Radix is 5.3000000000000000e+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.  
 FLAW : Multiplication neither chopped nor correctly rounded.  
 -----> 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: 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 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 exp(log).  
 COMMENT: random X, (exp(log(x)) - x) trials = 20  
 -----> Diagnosis resuming after Milestone 64, 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 65, Page 12  
 COMMENT: Running transcendental test 1.  
 COMMENT: random X, (sin(X)\*\*2+cos(X)\*\*2) - 1.0 trials = 20  
 -----> Diagnosis resuming after Milestone 66, Page 13  
 COMMENT: Running transcendental test 2.  
 COMMENT: random X, sin(4X) identity trials = 20  
 -----> Diagnosis resuming after Milestone 67, Page 14  
 COMMENT: Running hyperbolic test 1.  
 COMMENT: random X, (cosh(X)\*\*2-sinh(X)\*\*2) - 1.0 trials = 20  
 -----> Diagnosis resuming after Milestone 68, Page 15  
 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 16  
 -----> Diagnosis resuming after Milestone 80, Page 17  
 COMMENT: Testing whether sqrt is rounded or chopped.  
 PASSED : Square root appears to be correctly rounded.  
 -----> Diagnosis resuming after Milestone 85, Page 18  
 -----> Diagnosis resuming after Milestone 90, Page 19  
 COMMENT: Testing powers Z<sup>i</sup> for small Integers Z and i.  
 -----> Diagnosis resuming after Milestone 91, Page 20  
 PASSED : ... no discrepancies found.  
 -----> Diagnosis resuming after Milestone 100, Page 21  
 COMMENT: Seeking Underflow thresholds UfThold and E0.

FLAW : Underflow can stick at an allegedly positive

COMMENT: value PseudoZero that prints out as 4.94065645841246600e-324  
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 110, Page 22  
COMMENT: Smallest strictly positive number found  
COMMENT: is  $E0 = 4.94065645841246600e-324$   
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  $2.22507385850720190e-308$   
COMMENT: Below this, a calculation may suffer larger Relative  
COMMENT: error than merely roundoff.  
-----> Diagnosis resuming after Milestone 120, Page 23  
COMMENT: Since underflow occurs below the threshold  
COMMENT:  $UfThold = 2.0000000000000000e+00 \sim -1.0220000000000000e+03$   
COMMENT: only underflow could affect this expression.  
COMMENT: calculating yields:  $0.0000000000000000e+00$   
PASSED : This computed value is O.K.  
-----> Diagnosis resuming after Milestone 130, Page 24  
COMMENT: As  $X \rightarrow 1$ , Testing  $X^((X + 1) / (X - 1))$  against  $\exp(2)$ .  
COMMENT:  $\exp(2) = 7.38905609893065210e+00$   
PASSED : Accuracy seems adequate.  
-----> Diagnosis resuming after Milestone 140, Page 25  
COMMENT: Testing powers  $Z^Q$  at four nearly extreme values.  
PASSED : ... no discrepancies found.  
-----> Diagnosis resuming after Milestone 150, Page 26  
-----> Diagnosis resuming after Milestone 160, Page 27  
COMMENT: Searching for Overflow threshold:  
COMMENT: This may generate an error.  
COMMENT: Can 'Z = -Y' overflow?  
COMMENT: Trying it on  $Y = -inf$   
PASSED : Seems O.K.  
COMMENT: Overflow threshold is  $V = 1.79769313486231530e+308$   
COMMENT: Overflow saturates at  $V0 = inf$   
COMMENT: No overflow should be signalled for  $V*1 = 1.79769313486231530e+308$   
COMMENT: No overflow should be signalled for  $V/1 = 1.79769313486231530e+308$   
COMMENT: Any overflow separating  $V*1$  from  
COMMENT:  $V$  above is a DEFECT.  
-----> Diagnosis resuming after Milestone 161, Page 28  
-----> Diagnosis resuming after Milestone 170, Page 29  
-----> Diagnosis resuming after Milestone 175, Page 30  
-----> Diagnosis resuming after Milestone 180, Page 31  
-----> Diagnosis resuming after Milestone 190, Page 32  
-----> Diagnosis resuming after Milestone 191, Page 33

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-----> Diagnosis resuming after Milestone 200, Page 34
COMMENT: Trying to compute 1/0 gives inf
COMMENT: Trying to compute 0/0 gives nan
-----> Diagnosis resuming after Milestone 210, Page 35
COMMENT: =====
COMMENT:      Embedded System Paranoia SUMMARY
COMMENT:      DOUBLE PRECISION 64 bits
COMMENT: Closest separation = 1.11022302462515650e-16
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          = 3
COMMENT:
PASSED : The arithmetic diagnosed seems satisfactory
COMMENT: though flawed.
COMMENT:
COMMENT: Rating ...
COMMENT:
COMMENT:      Excellent
COMMENT:      Very good
COMMENT:      =====> Good
COMMENT:      Acceptable
COMMENT:      Unacceptable
COMMENT:      Broken
COMMENT:
COMMENT: -----
COMMENT:      MATHS LIBRARY TESTS
COMMENT:      (should all give zero)
COMMENT:
COMMENT: Basic identities
COMMENT: ln(1.0) =
COMMENT:      0.000000000000000000e+00
COMMENT: exp(0.0) - 2.718281828459045235360287 =
COMMENT:      4.44089209850062600e-16
COMMENT: Basic tests (Random over range 0<=X<=1)
COMMENT: Test, exp(log(X)) - X =
COMMENT:      -2.7755756156289100e-17 -> 5.55111512312578200e-17
COMMENT:
COMMENT: Transcendental identities
COMMENT: Test, sin(1.0) - 0.84147098480789650665250 =
COMMENT:      0.000000000000000000e+00
COMMENT: Test, cos(1.0) - 0.54030230586813971740094 =
COMMENT:      0.000000000000000000e+00
COMMENT: Test, asin(1.0) - (pi/2) =
COMMENT:      0.000000000000000000e+00
COMMENT: Test, acos(0.0) - (pi/2) =
COMMENT:      0.000000000000000000e+00
COMMENT: Test, atan(1.0) - (pi/4) =
COMMENT:      0.000000000000000000e+00

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COMMENT: Transcendental tests (Random over range 0<=X<=1)
COMMENT: Test, sin**2(X)+cos**2(X)-1.0 =
COMMENT:      -1.11022302462515650e-16 -> 2.22044604925031300e-16
COMMENT: Test, sin(4X)-(8.0*cos**4(X)*tan(X))+(4.0*cos(X)*sin(X)) =
COMMENT:      -6.66133814775093910e-16 -> 6.66133814775093910e-16
COMMENT:
COMMENT: Hyperbolic identities
COMMENT: Test, sinh(0.0) =
COMMENT:      0.00000000000000000e+00
COMMENT: Test, cosh(0.0) - 1.0 =
COMMENT:      0.00000000000000000e+00
COMMENT: Hyperbolic tests (Random over range 0<=X<=1)
COMMENT: Test, cosh**2(X)-sinh**2(X)-1.0 =
COMMENT:      -6.66133814775093910e-16 -> 6.66133814775093910e-16
COMMENT:
COMMENT: END OF TEST.
COMMENT: =====

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## 1.2 Intel Pentium with Ubuntu Linux and gcc 3.4.6.

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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: 1.9 $ $Date: 2004/04/13 14:21:53 $
COMMENT: This version will attempt divide by zero.
COMMENT: This version uses <stdio.h>
COMMENT: This version uses <signal.h>
COMMENT: This version uses <setjmp.h>
COMMENT: This version uses double precision. nbits=64
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 = 1.11022302462515654e-16
COMMENT: Recalculating radix and precision
COMMENT: confirms closest relative separation U1.
COMMENT: Checking U1 for sanity...
COMMENT: U1 is a sensible value
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 5.3000000000000000e+01
-----> Diagnosis resuming after Milestone 25, Page 4
COMMENT: Some subexpressions appear to be calculated extra precisely with

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COMMENT: about 3.31132995230379290e+00 extra significant decimals.  
 COMMENT: This is not tested further by this program.  
 -----> 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.  
 FLAW : Multiplication neither chopped nor correctly rounded.  
 -----> Diagnosis resuming after Milestone 40, Page 7  
 FLAW : Division neither chopped nor correctly rounded.  
 -----> Diagnosis resuming after Milestone 45, Page 8  
 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 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  $\exp(\log(x))$ .  
 COMMENT: random X,  $(\exp(\log(x)) - x)$  trials = 20  
 -----> Diagnosis resuming after Milestone 64, 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 65, Page 12  
 COMMENT: Running transcendental test 1.  
 COMMENT: random X,  $(\sin(X)**2+\cos(X)**2) - 1.0$  trials = 20  
 -----> Diagnosis resuming after Milestone 66, Page 13  
 COMMENT: Running transcendental test 2.  
 COMMENT: random X,  $\sin(4X)$  identity trials = 20  
 -----> Diagnosis resuming after Milestone 67, Page 14  
 COMMENT: Running hyperbolic test 1.  
 COMMENT: random X,  $(\cosh(X)**2-\sinh(X)**2) - 1.0$  trials = 20  
 -----> Diagnosis resuming after Milestone 68, Page 15  
 COMMENT: Running test of square root(x).  
 COMMENT: Testing integer X,  $\text{sqrt}(X * X) = X$ , trials = 20  
 COMMENT: Test for sqrt monotonicity.  
 PASSED : sqrt has passed a test for Monotonicity.  
 -----> Diagnosis resuming after Milestone 70, Page 16  
 -----> Diagnosis resuming after Milestone 80, Page 17  
 COMMENT: Testing whether sqrt is rounded or chopped.  
 FLAW : Square root is neither chopped nor correctly rounded.  
 COMMENT: Observed errors run from  
 COMMENT: -5.0000000000000111e-01 to 5.0000000000000000e-01 ulps.  
 -----> Diagnosis resuming after Milestone 85, Page 18  
 -----> Diagnosis resuming after Milestone 90, Page 19  
 COMMENT: Testing powers  $Z^i$  for small Integers Z and i.  
 -----> Diagnosis resuming after Milestone 91, Page 20  
 PASSED : ... no discrepancies found.

-----> Diagnosis resuming after Milestone 100, Page 21  
 COMMENT: Seeking Underflow thresholds UfThold and E0.  
 -----> Diagnosis resuming after Milestone 110, Page 22  
 COMMENT: Smallest strictly positive number found  
 COMMENT: is E0 = 4.94065645841246544e-324  
 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 2.22507385850720188e-308  
 COMMENT: Below this, a calculation may suffer larger Relative  
 COMMENT: error than merely roundoff.  
 -----> Diagnosis resuming after Milestone 120, Page 23  
 COMMENT: Since underflow occurs below the threshold  
 COMMENT: UfThold = 2.0000000000000000e+00 ^ -1.0220000000000000e+03  
 COMMENT: only underflow could affect this expression.  
 COMMENT: calculating yields: 0.0000000000000000e+00  
 PASSED : This computed value is O.K.  
 -----> Diagnosis resuming after Milestone 130, Page 24  
 COMMENT: As X -> 1, Testing X^((X + 1) / (X - 1)) against exp(2).  
 COMMENT: exp(2) = 7.38905609893065218e+00  
 DEFECT : Power function pow(x,z):  
 COMMENT: (1 + -1.11022302462515654e-16) ^ -1.80143985094819840e+16  
 COMMENT: differs from correct value by -3.44130679508225512e-09  
 COMMENT: This may spoil financial calculations  
 COMMENT: involving tiny interest rates.  
 -----> Diagnosis resuming after Milestone 140, Page 25  
 COMMENT: Testing powers Z^Q at four nearly extreme values.  
 PASSED : ... no discrepancies found.  
 -----> Diagnosis resuming after Milestone 150, Page 26  
 -----> Diagnosis resuming after Milestone 160, Page 27  
 COMMENT: Searching for Overflow threshold:  
 COMMENT: This may generate an error.  
 COMMENT: Can 'Z = -Y' overflow?  
 COMMENT: Trying it on Y = -inf  
 PASSED : Seems O.K.  
 COMMENT: Overflow threshold is V = 1.79769313486231571e+308  
 COMMENT: Overflow saturates at V0 = inf  
 COMMENT: No overflow should be signalled for V\*1 = 1.79769313486231571e+308  
 COMMENT: No overflow should be signalled for V/1 = 1.79769313486231571e+308  
 COMMENT: Any overflow separating V\*1 from  
 COMMENT: V above is a DEFECT.  
 -----> Diagnosis resuming after Milestone 161, Page 28  
 -----> Diagnosis resuming after Milestone 170, Page 29  
 -----> Diagnosis resuming after Milestone 175, Page 30  
 -----> Diagnosis resuming after Milestone 180, Page 31  
 -----> Diagnosis resuming after Milestone 190, Page 32  
 -----> Diagnosis resuming after Milestone 191, Page 33  
 -----> Diagnosis resuming after Milestone 200, Page 34

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COMMENT: Trying to compute 1/0 gives inf
COMMENT: Trying to compute 0/0 gives nan
-----> Diagnosis resuming after Milestone 210, Page 35
COMMENT: =====
COMMENT:      Embedded System Paranoia SUMMARY
COMMENT:      DOUBLE PRECISION 64 bits
COMMENT: Closest separation = 1.11022302462515654e-16
COMMENT:
COMMENT: Number of FAILURES encountered      = 0
COMMENT: Number of SERIOUS DEFECTs discovered = 0
COMMENT: Number of DEFECTs discovered        = 1
COMMENT: Number of FLAWs discovered         = 4
COMMENT:
COMMENT: The arithmetic diagnosed may be Acceptable
COMMENT: despite inconvenient DEFECT.
COMMENT:
COMMENT: Rating ...
COMMENT:
COMMENT:           Excellent
COMMENT:           Very good
COMMENT:           Good
COMMENT:      =====> Acceptable
COMMENT:           Unacceptable
COMMENT:           Broken
COMMENT:
COMMENT: -----
COMMENT:           MATHS LIBRARY TESTS
COMMENT:           (should all give zero)
COMMENT:
COMMENT: Basic identities
COMMENT: ln(1.0) =
COMMENT:      0.000000000000000000e+00
COMMENT: exp(0.0) - 2.718281828459045235360287 =
COMMENT:      0.000000000000000000e+00
COMMENT: Basic tests (Random over range 0<=X<=1)
COMMENT: Test, exp(log(X)) - X =
COMMENT:      -5.55111512312578270e-17 -> 3.46944695195361419e-18
COMMENT:
COMMENT: Transcendental identities
COMMENT: Test, sin(1.0) - 0.84147098480789650665250 =
COMMENT:      1.78893358460108232e-18
COMMENT: Test, cos(1.0) - 0.54030230586813971740094 =
COMMENT:      -4.75964753721136447e-17
COMMENT: Test, asin(1.0) - (pi/2) =
COMMENT:      0.000000000000000000e+00
COMMENT: Test, acos(0.0) - (pi/2) =
COMMENT:      0.000000000000000000e+00
COMMENT: Test, atan(1.0) - (pi/4) =
COMMENT:      3.06287113727155003e-17
COMMENT: Transcendental tests (Random over range 0<=X<=1)

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COMMENT: Test, sin**2(X)+cos**2(X)-1.0 =
COMMENT:      -1.02999206386122921e-16 -> 1.27610595701543872e-16
COMMENT: Test, sin(4X)-(8.0*cos**4(X)*tan(X))+(4.0*cos(X)*sin(X)) =
COMMENT:      -4.44197630067311167e-16 -> 7.03321949291346726e-16
COMMENT:
COMMENT: Hyperbolic identities
COMMENT: Test, sinh(0.0) =
COMMENT:      0.00000000000000000e+00
COMMENT: Test, cosh(0.0) - 1.0 =
COMMENT:      0.00000000000000000e+00
COMMENT: Hyperbolic tests (Random over range 0<=X<=1)
COMMENT: Test, cosh**2(X)-sinh**2(X)-1.0 =
COMMENT:      -3.31874284997812907e-16 -> 1.83989108670790102e-16
COMMENT:
COMMENT: END OF TEST.
COMMENT: =====

```