Dr. Thomas Nicely's Pentium email

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TO: Whom it may concern

RE: Bug in the Pentium FPU

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It appears that there is a bug in the floating point unit (numeric coprocessor) of many, and perhaps all, Pentium processors.

In short, the Pentium FPU is returning erroneous values for certain division operations. For example,

0001/824633702441.0

is calculated incorrectly (all digits beyond the eighth significant digit are in error). This can be verified in compiled code, an ordinary spreadsheet such as Quattro Pro or Excel, or even the Windows calculator (use the scientific mode), by computing

00(824633702441.0)*(1/824633702441.0),

which should equal 1 exactly (within some extremely small rounding error; in general, coprocessor results should contain 19 significant decimal digits). However, the Pentiums tested return

0000.999999996274709702

for this calculation. A similar erroneous value is obtained for x*(1/x) for most values of x in the interval

00824633702418 <= x <= 824633702449,

and throughout any interval obtained by multiplying or dividing the above interval by an integer power of 2 (there are yet other intervals which also produce division errors).

The bug can also be observed by calculating 1/(1/x) for the above values of x. The Pentium FPU will fail to return the original x (in fact, it will often return a value exactly 3072 = 6*0x200 larger).

The bug has been observed on all Pentiums I have tested or had tested to date, including a Dell P90, a Gateway P90, a Micron P60, an Insight P60, and a Packard-Bell P60. It has not been observed on any 486 or earlier system, even those with a PCI bus. If the FPU is locked out (not always possible), the error disappears; but then the Pentium becomes a "586SX", and floating point must run in emulation, slowing down computations by a factor of roughly ten.

I encountered erroneous results which were related to this

bug as long ago as June, 1994, but it was not until 19 October 1994 that I felt I had eliminated all other likely sources of error (software logic, compiler, chipset, etc.). I contacted Intel Tech Support regarding this bug on Monday 24 October (call reference number 51270). The contact person later reported that the bug was observed on a 66-MHz system at Intel, but had no further information or explanation, other than the fact that no such bug had been previously reported or observed.

Further information can be obtained by contacting me directly, and by downloading files from the [anonymous.nicely.pentium_bug] directory of the acavax.lynchburg.edu machine via anonymous ftp on Internet (password ANONYMOUS, user ID = Internet ID). These files include a documentation file, a DOS executable image demonstrating the bug, and the source code for the demonstration. The zip file uses PKZIP version 2.04g.

I would be interested in hearing of test results from other Pentiums, and also from 486-DX4s and (if anybody has one yet) the AMD, Cyrix, and NexGen clones of the Pentium.

You may use this information freely as long as you give me attribution by name and employer.