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Technical Note PT25

MPW's -mc68881 Option

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This Technical Note discusses MPW's `-mc68881` option, which represents `Extended` values in 96 bits (instead of 80, as with software SANE), and compatibility issues when using non-SANE system calls that expect 80-bit `Extended` values.

[Jul 01 1990]

MPW Compilers and Extended Values

The MPW 2.0 and later compilers provide a command-line option, `-mc68881`, to generate in-line code to use the Motorola 68881/68882 floating-point units (FPU). (Note that MPW compilers currently do not include a `-mc68882` option, as they treat the two chips the same. If you want to optimize code for the 68882, then you need to write your own assembly-language code.) This option allows applications to sacrifice compatibility with other Macintosh models (those not equipped with an FPU) in exchange for much increased numeric performance.

Warning:

Applications should not make assumptions about the presence of an FPU based upon the microprocessor of a Macintosh. If an application makes a conditional branch to execute floating-point instructions directly, then it should first explicitly check for the presence of the FPU with `_Gestalt` or `_SysEnviron`s. Furthermore, you should not assume that the presence of an MC68040 processor guarantees access to floating-point instructions. Motorola has announced a reduced-cost MC68040 CPU that lacks an integral floating-point unit. Possible inclusion of such a CPU in future Macintosh products means FPU-less 68040 products may someday exist.

When using the `-mc68881` option, the compiler stores all `Extended` values in the 96-bit format used by the 68881 instead of the 80-bit software SANE (Standard Apple Numerics Environment), both of which are illustrated in Figures 1 and 2.

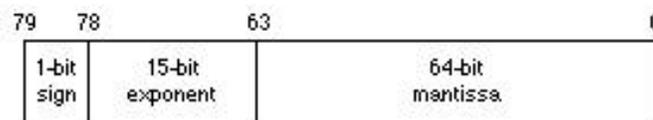


Figure 1. Software SANE Format (80-Bit)

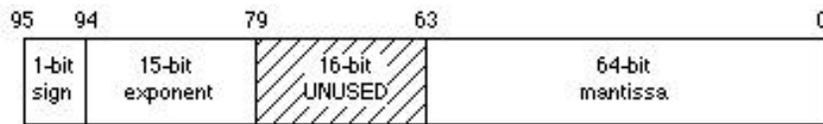


Figure 2. MC68881 Format (96-Bit)

This difference in format affects all procedures that accept floating-point values as arguments, since all floating-point arguments are converted to `Extended` before being passed, no matter how they are declared (for example, `Real`, `Single`, `Double`, or `Comp`).

When compiling with this option, you must link with a special `SANELib` library file, `SANE881Lib.o`; the interface source file `SANE.p` contains conditional-compilation statements to make sure that the correct library's interface is compiled. In this situation, `SANE` procedures are used for certain transcendental functions only (see the last section of this Technote), and these functions, which are in `SANE881Lib.o`, expect their `Extended` parameters in 96-bit format.

However, numeric routines that are not compiled by Pascal (such as any assembly-language routines) have no way of finding out that their parameters are in 96-bit format. If it is not possible to rewrite these routines for 96-bit values, you can use the `SANELib` routines `X96ToX80` and `X80ToX96` to convert between formats. It might be simplest to define a new interface routine that automatically converts the formats:

Pascal

```
{FPFunc is a generic floating-point, assembly-language function that accepts}
{an 80-bit Extended parameter and returns an 80-bit result.}
{We've changed the types to reflect that these are not 96-bit values.}

FUNCTION FPFunc(x: Extended80): Extended80; EXTERNAL;

{Given that we're compiling in -mc68881 mode, the compiler}
{thinks that Extended values are 96-bits long, but FPFunc wants an}
{80-bit parameter and produces an 80-bit result; we convert.}

FUNCTION FPFunc96(x: Extended): Extended; {x is a 96-bit extended!}
BEGIN
  {convert our argument, call the function, then convert the result}
  MyFPFunc := X80ToX96(FPFunc(X96ToX80(x))); {call the real FPFunc}
```

C

```
extern Extended80 FPFunc (Extended80 x);

Extended FPFunc96 (Extended x); //x is a 96-bit extended!
{
  //convert our argument, call the function, then convert the result
  MyFPFunc = X80ToX96(FPFunc(X96ToX80(x))); //call the real FPFunc
```

It's best to avoid compiling some parts of an application with the `-mc68881` option on and other parts with it off; very strange bugs can occur if you try this. Note that 80-bit code and 96-bit code cannot reference the same `Extended` variables. There is no way to tell whether a given stored value is in 80-bit format or 96-bit format.

Size of Data Structures

Compile time differences in the size of extended variables also cause problems for variables embedded in data structures. The size of data structures and offsets within the structure can change depending on the compile-time options. This could be particularly troublesome if you write the data to a file and then attempt to read the file with a version of the program which was compiled differently.

An example of this can be found in some of the Sound Manager interfaces. For example, prior to MPW 3.2.1, the `ExtSoundHeader` record contained an extended field which could cause the problem described above. In MPW 3.2.1, the extended field was changed to the uniform type `extended80` to avoid the problem.

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SANE on the Macintosh II

The version of SANE provided in the Macintosh II ROM recognizes the presence of the 68881 and uses it for most calculations automatically. SANE still expects (and produces) 80-bit-format `Extended` values; it converts to and from 96-bit format internally when using the 68881.

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A Note About 68881 Accuracy and Numeric Compatibility

SANE is more accurate than the 68881 when calculating results of certain functions (`Sin`, `Cos`, `Arctan`, `Exp`, `Ln`, `Tan`, `Exp1`, `Exp2`, `Ln1`, and `Log2`). To maintain this accuracy, SANE does not use 68881 instructions to directly perform these functions; thus the results you get from SANE calculations are still identical on all Macintosh systems.

To preserve this numeric compatibility with other SANE implementations, MPW compilers normally do not generate in-line 68881 calls to the above functions, even when the `-mc68881` option is used; instead, they generate SANE calls to accomplish them. If you are willing to sacrifice numeric compatibility to gain extra speed, you can override this compiler feature with the compile-time variable, `ElEmS881`; include the option `-d ElEmS881 = TRUE` on the Pascal compiler and `-ElEmS881` on the C compiler command line to cause the compiler to generate direct 68881 instructions.

For certain other transcendental functions provided by the 68881 that are not provided by SANE, MPW compilers generate direct 68881 calls if the `-mc68881` option is on, independent of the setting of the `ElEmS881` variable. These operations are `Arctanh`, `Cosh`, `Sinh`, `Tanh`, `Log10`, `Exp10`, `Arccos`, `Arcsin`, and `Sincos`.

For Pascal programmers, it is important to note that if you want an application to check for an FPU and exit gracefully if it does not exist, then you need to check for the FPU with code that does not have the `-mc68881` option turned on. You need to do this because the `-mc68881` option inserts code to initialize the 68881/68882 at the beginning of your code, and this initialization code causes an exception error if no FPU is present. For example, if you check for the existence of an FPU in your main Pascal procedure, you need to compile that main procedure with `{ $MC68881- }`. Note that this compiler option affects the entire file that contains the option, so you would need to separate any code that uses an FPU into another file.

After you determine that an FPU exists, you have to execute the following instructions by hand to initialize the FPU yourself:

```
PROCEDURE ClearTheFPU ( );
    INLINE      $42A7,          {clr.l -(a7)}
                $42A7,          {clr.l -(a7)}
```

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References

Inside Macintosh , Volume V-1, Compatibility Guidelines

Apple Numerics Manual , Second Edition

[M.OV.GestaltSysenvirons](#)

[M.HW.SpeedyMathCoProc](#)

MPW Pascal Reference Manual

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Change History

- 01-June-1990 Extended the warning about explicitly checking for the presence of an FPU if an application uses floating-point instructions to include the possibility of FPU-less MC68040 products and also raised the issue of extended values embedded in data structures.
- 01-June-1987 Originally written.

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