JUNE 1975

NATIONAL µSPEC 4

IMP-16F/400 FLOATING POINT FIRMWARE

FEATURES

- INCREASES APPLICATION POTENTIAL — allows easy manipulation and utilization of double-precision and floating-point numbers.
- EXTENDS SYSTEM POWER — a complete set of 24 arithmetic subroutines.
- REDUCES PROGRAMMING TIME — the easily accessed, comprehensive set of subroutines frees the programmer to concentrate on application software.
- SAVES MONEY — reduced programming time means lower development costs.

INTRODUCTION

Many applications require arithmetic precision greater than possible with a 16-bit word length, or demand the capability of manipulating numbers that vary widely in magnitude. However, development of the software to provide these expanded capabilities can be a very time-consuming and costly process.

Now, with the option of the IMP-16F/400 Floating Point Firmware, you can have the power of double-precision and floating-point arithmetic functions without the throes of writing your own routines.

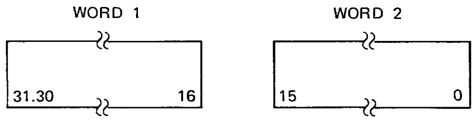
GENERAL CHARACTERISTICS

The IMP-16F/400 Floating Point Firmware can be implemented on any IMP-16 Microprocessor that has the extended instruction set (CROM II). The arithmetic-subroutine set is contained on four ROMs and uses 512 words of memory located at addresses FC00 through FDFF (64,512 and 65,023 decimal).

Double Precision

Double-precision numbers use two consecutive locations in memory and provide a precision of one part in 2^{31} (approximately 4.6×10^{-10}). Fractional notation is used with the binary point implied to the right of bit 31.

DOUBLE PRECISION (FRACTIONAL)



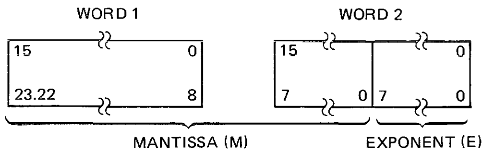
RANGE: $-1 \leq N < 1$
MAXIMUM PRECISION:
$1/2^{31} = 4.6 * 10^{-10}$
SMALLEST VALUE: 2^{-31}

EXAMPLES:
$1/2 = 4000\ 0000_{16}$
$-1/2 = C000\ 0000_{16}$
$-1 = 8000\ 0000_{16}$

Floating Point

In floating-point representation, numbers are expressed in a form similar to scientific notation, with a fractional mantissa and an exponent. Floating-point numbers use two consecutive words in memory. The mantissa consists of 24 bits; this gives a precision of one part in 2^{23}. The exponent has 8 bits and allows exponents in the range of -128 to +127.

FLOATING POINT



RANGE:
$-2^{127} \leq N < 2^{127}$
PRECISION:
2^{-23} ($2^{EXPONENT}$)
SMALLEST MAGNITUDE:
2^{-151}
LARGEST MAGNITUDE:
$(1 - 2^{-23})\ 2^{127}$

$N = M * 2^E$
EXAMPLES:
$1/2 = 4000\ 00_{16}\ (00_{16})$
$1/2 = 2000\ 00_{16}\ (01_{16})$
$1/2 = 1000\ 00_{16}\ (02_{16})$
$1/4 = 2000\ 00_{16}\ (00_{16})$
$1/4 = 4000\ 00_{16}\ (FF_{16})$

SUBROUTINE SET

The table below shows the 24 subroutines that are provided by the IMP-16F/400 option. All required constants are contained within the subroutine set, and the only memory locations written into (by the set) are in the range 00E0 through 00EF. All operands and results use the general registers (with the exception of DLNORM).

B15M65/Printed in U.S.A.

SUBROUTINE	MNEMONIC	EXECUTION TIME FORMULA	TYPICAL
Single Precision Multiply	MULT	30R + W + 243N	356
Single Precision Divide	DIV	49R + W + 343N	506
Double Precision Multiply	DPMUL	200R + 8W + 1125N	1683
Double Precision Divide	DPDIV	510R + 97W + 2578N	4357
Double Precision Square	DPSQUARE	202R + 8W + 1137N	1701
Double Precision Complement	DPCOMP	16R + 53N	83
Double Precision Shift	DPSH	Left 5R + 20N + [8R + 32N] M Right 7R + 26N + [4R + 21N] M	22 + 35M 28.6 + 22.5M
Double Precision Shift Right	DPSHR	5R + 20N + [8R + 32N] M	22 + 35M
Double Precision Shift Left	DPSHL	7R + 26N + [4R + 21N] M	22 + 22.5M
Quadrant tests	QUAD	47R + W + 175N	270
Sine	SIN	1697R + 82W + 9300N	13.94 msec
Cosine	COS	1677R + 82W + 9285N	13.91 msec
Arctangent	ARCTAN	2985R + 231W + 15892N	23.9 msec
Floating Point Add	FPADD	147R + 7W + 613N	938
Floating Point Multiply	FPMUL	1215R + 63W + 5077N	7768
Floating Point Divide	FPDIV	1540R + 152W + 6584N	10.08 msec
Floating Point Complement	FPCOMP	50R + 2W + 183N	283
Check Zero Exponent	CZERO	36R + 2W + 139N	214
Extract Exponent to Stack	EXTEXP	13R + W + 51N	79
Add Exponent from Stack	ADDEXP	13R + W + 51N	79
Left Normalize	LFNOR	449R + 24W + 1745N	2687
Double Left Normalize	DLNORM	947R + 52R + 3691N	5683
Fraction to Floating Point	FLOAT	3R + 9N	14
Floating Point to Fraction	SFO	207R + W + 822N	1260
		R = number of main memory read cycles. W = number of main memory write cycles. N = number of microprogram cycles. M = shift count.	All times approximate and expressed in microseconds except where noted. Times are based on IMP-16P basic 1.4-microsecond machine cycle time without any external clock-hold logic.

Manufactured under one or more of the following U.S. patents: 3083262, 3189758, 3231797, 3303356, 3317671, 3323071, 3381071, 3408542, 3421025, 3426423, 3440498, 3518750, 3519897, 3557431, 3560765, 3566218, 3571630, 3575609, 3579059, 3593069, 3597640, 3607469, 3617859, 3631312, 3633052, 3638131, 3648071, 3651565, 3683248.

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