Micromega Corporation

Application Note 1

uM-FPU Instruction Timing

Introduction

Timing of instructions is dependant on a number of factors including the following:

- Maximum Data Rate
- Debug Tracing
- Data Values

Each of these factors is described below and two tables are attached that provide sample timing for uM-FPU instructions. The fastest instruction execution occurs when debug tracing is disabled.

If precise timing information is required, it is recommended that timing tests be conducted on the specific implementation used, with a range of numbers appropriate to your application.

Maximum Data Rate

The maximum bit transfer rate is specified as 1 Mhz, which means each data byte requires 8 microseconds to transmit. If debug tracing is disabled, the minimum data period is 20 microseconds, so a 12 microsecond delay is required between data bytes. If debug tracing is enabled, the minimum data period is 100 microseconds, so a 92 microsecond delay is required between data bytes. In many cases the overhead of the interface routines on the microcontroller will provide the necessary delay, but on a fast microcontroller it will be necessary to insert additional delay to ensure that the minimum data period is not exceeded.

Debug Tracing

The uM-FPU provides the capability of tracing instructions as they are executed. The trace data is output through the TSTOUT pin at 57,600 baud with no flow control. On average, each data byte generates approximately three trace characters. The trace buffer on the uM-FPU is 16 bytes in length. Each data byte that is transmitted or received produces about three trace characters on average and the serial interface runs at 57,600 baud, therefore approximately 521 microseconds is required to trace each data byte. The 16-byte trace buffer can accommodate short data bursts at a high data rate, but if the microcontroller can output data at a sustained rate faster than one byte every 521 microseconds, a suitable delay must be used to reduce the data rate while debugging. Table 2 shows the trace message and the exact trace delay for each instruction, but a simple way to account for the debug trace delay is to ensure that the minimum data period is 521 microseconds when debugging is enabled.

Data Values

Some instructions will execute in varying amounts of time depending on the data values involved. For example, FADD and FSUB must adjust the mantissas of the two number to account for different exponents before adding or subtracting. If one numbers is much smaller or larger than another number a slightly longer time is required to make the adjustment. Some math functions execute slightly longer or slightly different algorithms to compute the result depending on the values involved. Table 1 shows sample timing for all instructions with debug tracing disabled. The notes at the bottom of the table describe the test values.

Table 1 - Instruction Timing

The Last Byte to Ready column shows the elapsed time from the end of the last byte of an instruction until the Ready status is asserted. The Instruction Time column calculates the total instruction time from the beginning of the first data byte until the Ready status is asserted. It assumes a maximum bit rate of 1 Mhz and a minimum data period of 20 microseconds.

Name	Opcode	Arguments	Returns	# of Bytes	Last Byte to Ready (usec)	Instruction Time (usec)	
SELECTA	0x			1	30	38	
SELECTB	1x			1	30	38	
WRITEA	2x	yyyy zzzz		5	40	128	
WRITEB	3x	yyyy zzzz		5	40	128	
READ	4x		yyyy zzzz	5	35	123	
SET	5x			1	40	48	
FADD	6x			1	115-160	123-168	Note 1
FSUB	7x			1	115-160	123-168	Note 1
FMUL	8x			1	205-215	213-223	Note 1
FDIV	9x			1	315-330	323-338	Note 1
LADD	Ax			1	60	68	Note 2
LSUB	Bx			1	60	68	Note 2
LMUL	Cx			1	210	218	Note 2
LDIV	Dx			1	290	298	Note 2
SQRT	E0			1	2520	2528	Note 1
LOG	E1			1	2995-3250	3003-3258	Note 1
LOG10	E2			1	2855-3110	3003-3259	Note 1
EXP	E3			1	2290	2298	Note 1
EXP10	E4			1	2110	2118	Note 1
SIN	E5			1	2200-2375	2208-2383	Note 1
COS	E6			1	2215-2515	2223-2523	Note 1
TAN	E7			1	4660-5140	4668-5148	Note 1
FLOOR	E8			1	80-140	88-148	Note 1
CEIL	E9			1	160-200	168-208	Note 1
ROUND	EA			1	165-200	173-208	Note 1
NEGATE	EB			1	45	53	Note 1
ABS	EC			1	45	53	Note 1
INVERSE	ED			1	315	323	Note 1
DEGREES	EE			1	330	338	Note 1
RADIANS	EF			1	225	233	Note 1
SYNC	F0		5C	2	35	63	
FLOAT	F1			1	90	98	Note 2
FIX	F2			1	120-140	128-148	Note 1
COMPARE	F3		ss	2	35	63	Note 1
LOADBYTE	F4	bb		2	115	143	
LOADUBYTE	F5	bb		2	115	143	
LOADWORD	F6	wwww		3	95	143	
LOADUWORD	F7	wwww		3	95	143	
READSTR	F8		aa … 00	2+n	35	135-195	Note 3
ATOF	F9	aa … 00		2+n	105-410	205-530	Note 1
FTOA	FA	ff		2	4580	4608	Note 1
ATOL	FB	aa … 00		2+n	40	140-200	Note 2
LTOA	FC	ff		2	3200	3228	Note 2
STATUS	FD		ss	2	35	63	Note 1
FUNCTION	FE0n			2	-	28	Note 4
FUNCTION	FE1n			2	-	28	Note 4
FUNCTION	FE2n			2	-	28	Note 4

FUNCTION	FE3n			2	-	28	Note 4
LWRITEA	FEAx	yyyy zzzz		6	40	148	
LWRITEB	FEBx	yyyy zzzz		6	40	148	
LREAD	FECx		yyyy zzzz	6	35	143	
LUDIV	FEDx			2	455	483	Note 2
POWER	FEE0			2	5415	5443	Note 1
ROOT	FEE1			2	5615	5643	Note 1
MIN	FEE2			2	85	113	Note 1
MAX	FEE3			2	80	108	Note 1
FRACTION	FEE4			2	160-175	188-203	Note 1
ASIN	FEE5			2	4430	4458	Note 1
ACOS	FEE6			2	4530	4558	Note 1
ATAN	FEE7			2	2210	2238	Note 1
ATAN2	FEE8			2	2455	2483	Note 1
LCOMPARE	FEE9		ss	3	35	83	Note 2
LUCOMPARE	FEEA		ss	3	35	83	Note 2
LSTATUS	FEEB		ss	3	35	83	Note 2
LNEGATE	FEEC			2	45	73	Note 2
LABS	FEED			2	40	68	Note 2
LEFT	FEEE			2	45	73	
RIGHT	FEEF			2	50	78	
LOADZERO	FEF0			2	55	83	
LOADONE	FEF1			2	55	83	
LOADE	FEF2			2	55	83	
LOADPI	FEF3			2	55	83	
LONGBYTE	FEF4	bb		3	40	88	
LONGUBYTE	FEF5	bb		3	35	83	
LONGWORD	FEF6	wwww		4	35	103	
LONGUWORD	FEF7	wwww		4	35	103	
IEEEMODE	FEF8			2	40	68	
PICMODE	FEF9			2	40	68	
BREAK	FEFB			2		28	Note 5
TRACEOFF	FEFC			2	40	68	
TRACEON	FEFD			2	40	68	
TRACESTR	FEFE		aa … 00	2+n	50	150	Note 6
CHECKSUM	FEFF			2	43790	43818	
VERSION	FF			1	60	68	
RESET							Note 7

Notes:

1. The floating point values 1000.0 and 0.001 used for timing.
2. The long Integer values 1000 and 100000 used for timing.
3. Timing shown for a four digit and seven digit string.
4. Timing varies depending on the defined function.
5. Busy state is held indefinitely until user continues execution from debugger.
6. Timing shown for four character trace string.
7. Reset timing requires minimum reset pulse of 100 microseconds and a delay of 2 milliseconds.

Table 2 - Debug Trace Delay

Name	Opcode	Arguments	Returns	# of Bytes	Trace String	Trace Delay (usec)
SELECTA	0x			1	_0x	521
SELECTB	1x			1	_1x	521
WRITEA	2x	yyyy zzzz		5	_2x:xxxxxxxx	2083
WRITEB	3x	yyyy zzzz		5	_3x:xxxxxxxx	2083
READ	4x		yyyy zzzz	5	_4x:xxxxxxxx	2083
SET	5x			1	_5x	521
FADD	6x			1	_6x	521
FSUB	7x			1	_7x	521
FMUL	8x			1	_8x	521
FDIV	9x			1	_9x	521
LADD	Ax			1	_Ax	521
LSUB	Bx			1	_Bx	521
LMUL	Cx			1	_Cx	521
LDIV	Dx			1	_Dx	521
SQRT	E0			1	_E0	521
LOG	E1			1	_E1	521
LOG10	E2			1	_E2	521
EXP	E3			1	_E3	521
EXP10	E4			1	_E4	521
SIN	E5			1	_E5	521
COS	E6			1	_E6	521
TAN	E7			1	_E7	521
FLOOR	E8			1	_E8	521
CEIL	E9			1	_E9	521
ROUND	EA			1	_EA	521
NEGATE	EB			1	_EB	521
ABS	EC			1	_EC	521
INVERSE	ED			1	_ED	521
DEGREES	EE			1	_EE	521
RADIANS	EF			1	_EF	521
SYNC	F0		5C	2	_F0:5C	1042
FLOAT	F1			1	_F1	521
FIX	F2			1	_F2	521
COMPARE	F3		ss	2	_F3:xx	1042
LOADBYTE	F4	bb		2	_F4:xx	1042
LOADUBYTE	F5	bb		2	_F5:xx	1042
LOADWORD	F6	wwww		3	_F6:xxxx	1389
LOADUWORD	F7	wwww		3	_F7:xxxx	1389
READSTR	F8		aa … 00	2+n	_F8"nnnnnnnnnnnnnnnn"	3646
ATOF	F9	aa … 00		2+n	_F9"nnnnnnnnnnnnnnnn"	3646
FTOA	FA	ff		2	_FA:xx	1042
ATOL	FB	aa … 00		2+n	_FB"nnnnnnnnnnnnnnnn"	3646
LTOA	FC	ff		2	_FC:xx	1042
STATUS	FD		ss	2	_FD:xx	1042
FUNCTION	FE0n			2	_FE0x	868
FUNCTION	FE1n			2	_FE1x	868
FUNCTION	FE2n			2	_FE2x	868
FUNCTION	FE3n			2	_FE3x	868
LWRITEA	FEAx	yyyy zzzz		6	_FEAx:xxxxxxxx	2431
LWRITEB	FEBx	yyyy zzzz		6	_FEBx:xxxxxxxx	2431
LREAD	FECx		yyyy zzzz	6	_FECx:xxxxxxxx	2431
LUDIV	FEDx			2	_FEDx	868
POWER	FEE0			2	_FEE0	868
ROOT	FEE1			2	_FEE1	868

MIN	FEE2			2	_FEE2	868
MAX	FEE3			2	_FEE3	868
FRACTION	FEE4			2	_FEE4	868
ASIN	FEE5			2	_FEE5	868
ACOS	FEE6			2	_FEE6	868
ATAN	FEE7			2	_FEE7	868
ATAN2	FEE8			2	_FEE8	868
LCOMPARE	FEE9		ss	3	_FEE9:xx	1389
LUCOMPARE	FEEA		ss	3	_FEEA:xx	1389
LSTATUS	FEEB		ss	3	_FEEB:xx	1389
LNEGATE	FEEC			2	_FEEC	868
LABS	FEED			2	_FEED	868
LEFT	FEEE			2	_FEEE	868
RIGHT	FEEF			2	_FEEF	868
LOADZERO	FEF0			2	_FEF0	868
LOADONE	FEF1			2	_FEF1	868
LOADE	FEF2			2	_FEF2	868
LOADPI	FEF3			2	_FEF3	868
LONGBYTE	FEF4	bb		3	_FEF4:xx	1389
LONGUBYTE	FEF5	bb		3	_FEF5:xx	1389
LONGWORD	FEF6	wwww		4	_FEF6:xxxx	1736
LONGUWORD	FEF7	wwww		4	_FEF7:xxxx	1736
IEEEMODE	FEF8			2	_FEF8	868
PICMODE	FEF9			2	_FEF9	868
BREAK	FEFB			2	_FEFB:||{BREAK}||>	3125
TRACEOFF	FEFC			2	_FEFC||{TRACE OFF}||	3472
TRACEON	FEFD			2	_FEFD||{TRACE ON}||	3299
TRACESTR	FEFE		aa … 00	2+n	_FEFE|| {"xxxxxxxxxxxxxxxx"}||	5035
CHECKSUM	FEFF			2	_FEFF	868
VERSION	FF			1	_FF	521
RESET					||{RESET}||	1910

Notes:

1. In the trace string shown in the table above, the _ character is used to indicate a space, and the || characters are used to indicate a carriage return, linefeed sequence.
2. The trace delay is calculated based on the number of characters transmitted at 57,600 baud. Each character requires 174 microseconds at 57,600 baud.
3. The READSTR, ATOF, LTOF, and TRACESTR trace delays are shown for a string of 16 characters. This represents a maximum value. If fewer characters are transmitted, the trace delay would be shorter.