CIP-51 Performance for Standard Library Math Routines

Introduction

This document summarizes a collection of profiling tests for fixed and floating point math routines using Silicon Labs' CIP-51 Microcontroller Core. Code was developed using the Keil C51 Compiler and Keil 8051 Library Routines, and executed on a Silicon Labs C8051F005 device. Measurement was performed using an on-chip timer configured to count system clocks.

Floating-Point Characterization

These tests measured the execution time requirements for various floating-point math functions performed with the CIP-51 Microcontroller Core on a C8051F005 device. A pseudo-random number generator (based on the *rand( )* function) was used to generate input parameters; 10,000 samples were taken for each function. Input parameters for the *Sin( )*, *Cos( )*, and *Tan( )* functions were restricted to the input range -65535 to +65535; inputs for the *Sqrt( )*, *Log10( )* and *Log( )* functions were restricted to non-negative numbers; all other function inputs were limited to valid floating-point numbers. Samples were only counted if the result was a valid floating-point number (no overflows). All times are given in system clocks, where one system clock for the CIP-51 equals one oscillator clock and is independent of oscillator frequency.

Floating-point routine execution times are input-dependent; the table below lists the minimum, maximum, and mean execution times for the various routines. Each routine profile is detailed with an execution time histogram in the following pages. The x-axis represents each specific execution time; the y-axis represents the number of times that execution time occurred (out of 10,000 input samples).

Execution Times for Various Floating-Point Routines (in Oscillator Clocks)

Function	Mean	Minimum	Maximum	Standard 8051 (Mean)†	Speed Increase Factor vs. Standard 8051 (Mean)
Addition	173	156	320	1284	7.4
Subtraction	179	160	347	1356	7.6
Multiplication	225	98	307	1368	6.1
Division	877	111	1279	8244	9.4
Comparison	113	112	162	648	5.7
Square Root	2650	2433	3004	23232	8.8

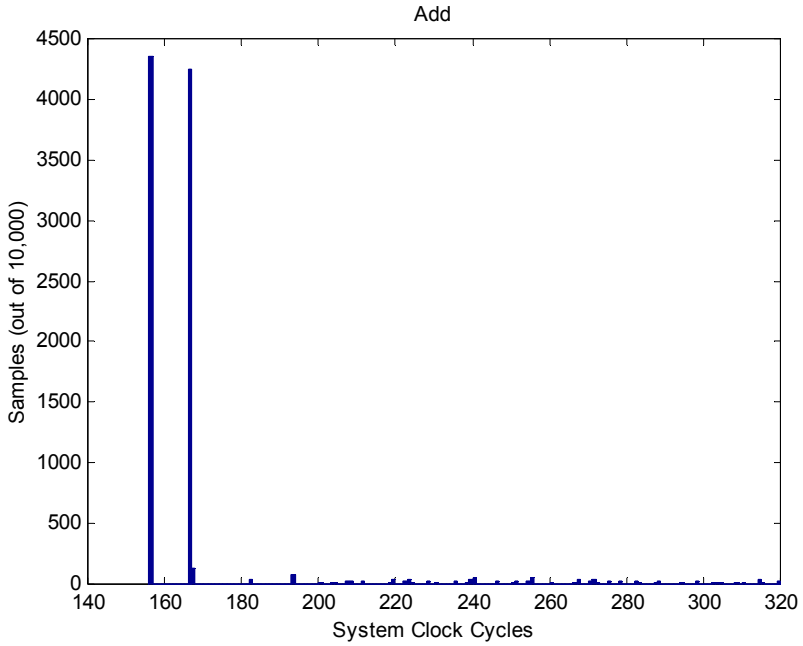
Execution Times for Various Floating-Point Routines (in Oscillator Clocks)

Function	Mean	Minimum	Maximum	Standard 8051 (Mean)†	Speed Increase Factor vs. Standard 8051 (Mean)
Sin	2033	823	5558	35136	17.3
Cos	1852	786	5587	35052	18.9
Tan	3707	1280	8001	59592	16.1
ArcSin	4461	3941	9847	83892	18.8
ArcCos	6513	5832	9883	90936	14.0
ArcTan	1810	734	6126	39840	22.0
Exponential	4245	295	6646	39768	9.4
Natural Log	4692	4208	5175	41184	8.8
Common Log	4931	4448	5376	43284	8.8

†Based on data taken from the Keil C51 User's Guide v1.97. Statistics in the Keil book are given in CPU machine cycles; the numbers presented here are adjusted to represent the number of oscillator clocks required (1 CPU machine cycle = 12 oscillator clocks for a Standard 8051).

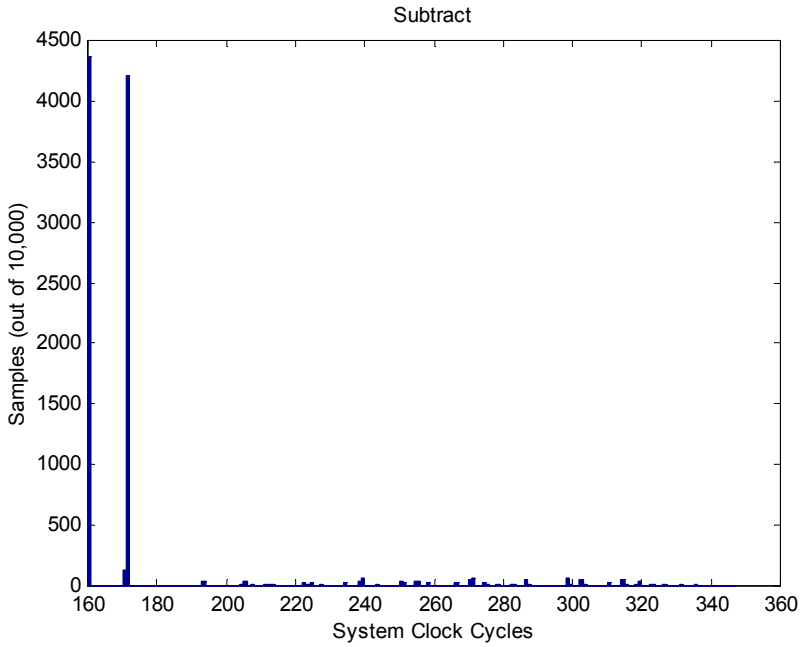
Addition

Mean: 173
Min: 156
Max: 320



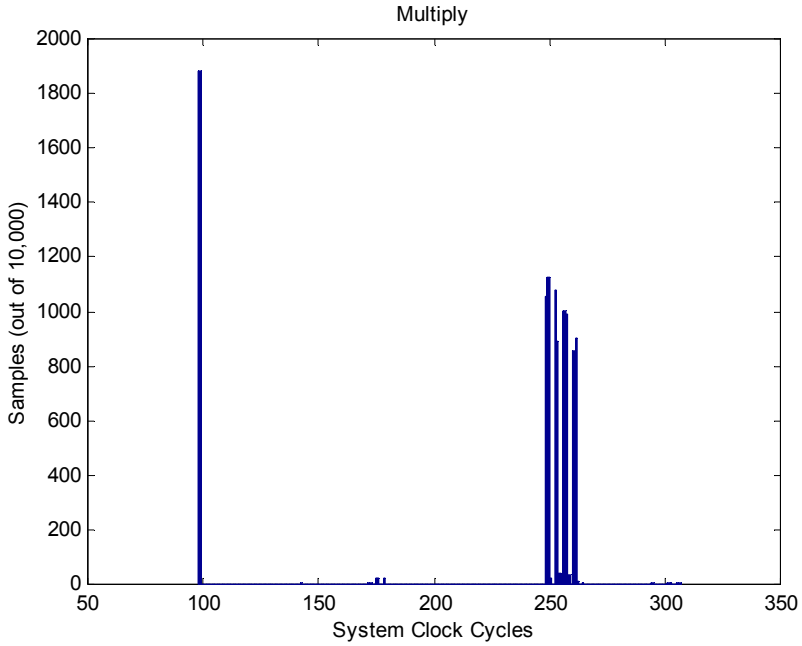
Subtraction

Mean: 179
Min: 160
Max: 347



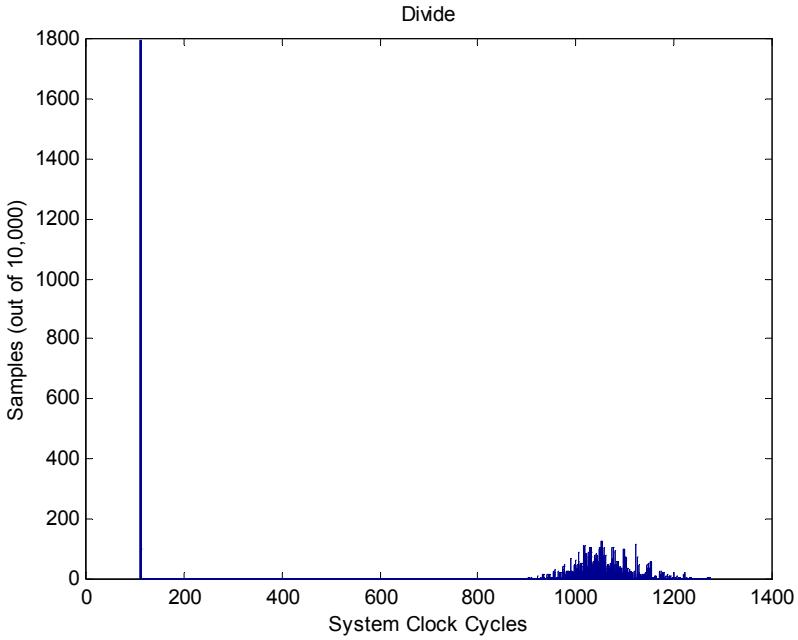
Multiplication

Mean: 225
Min: 98
Max: 307



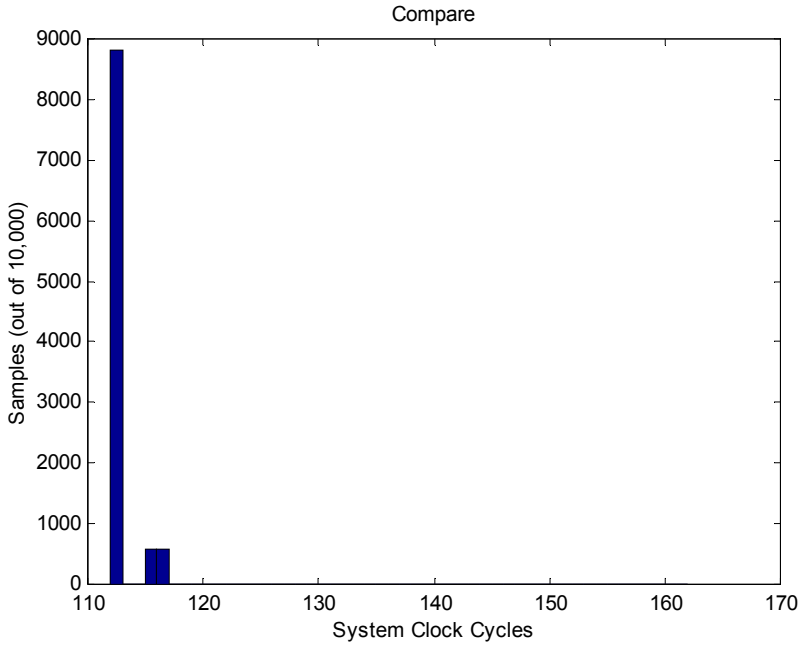
Division

Mean: 877
Min: 111
Max: 1279



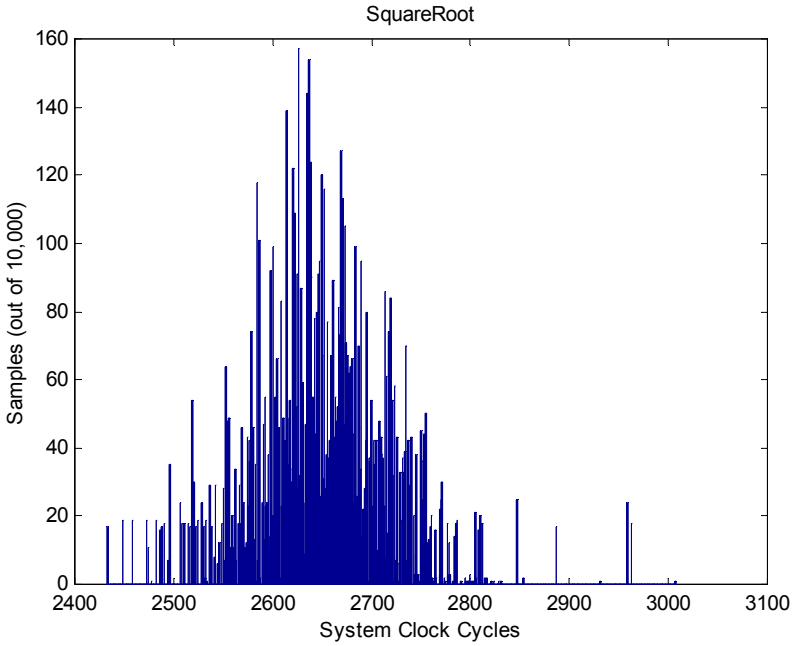
Comparison (a == b)

Mean: 113
Min: 112
Max: 162



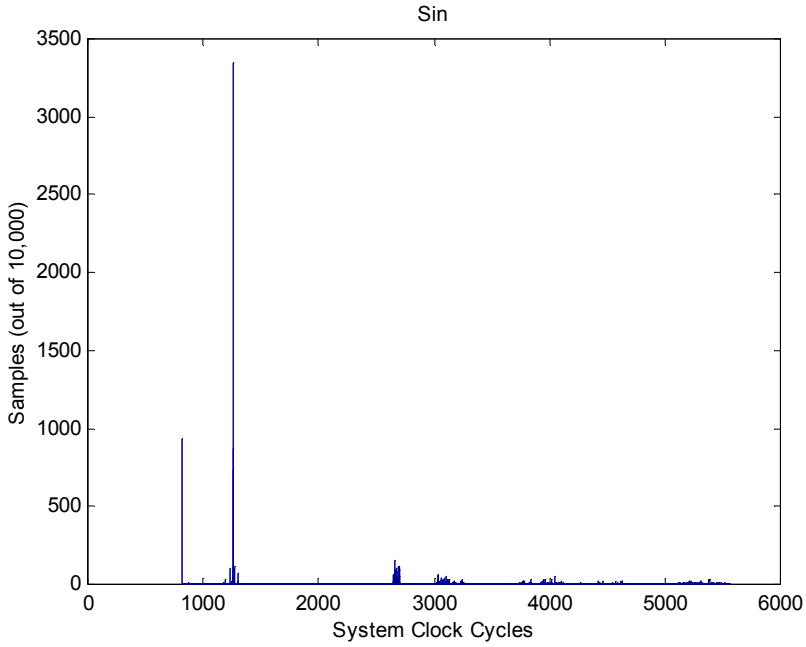
Square Root

Mean: 2650
Min: 2433
Max: 3004



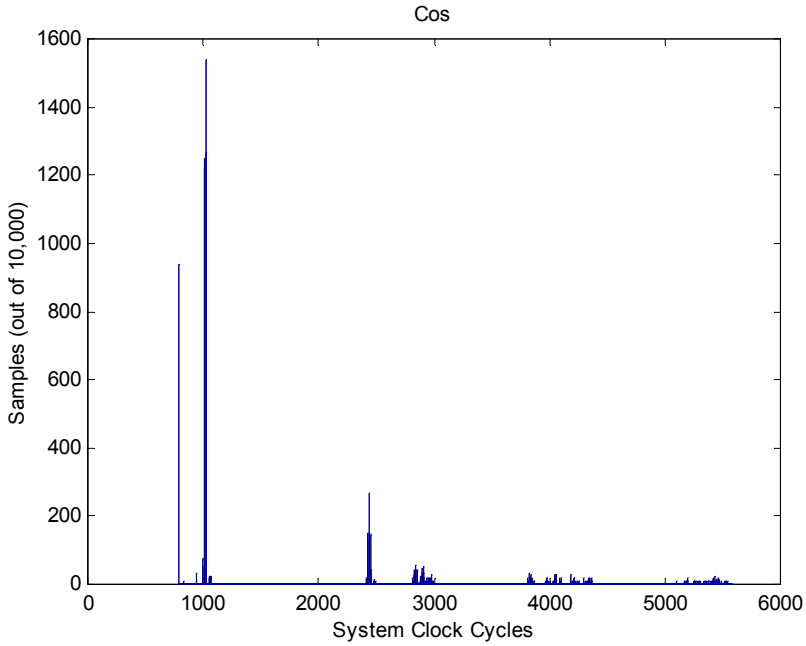
Sin

Mean: 2033
Min: 823
Max: 5558



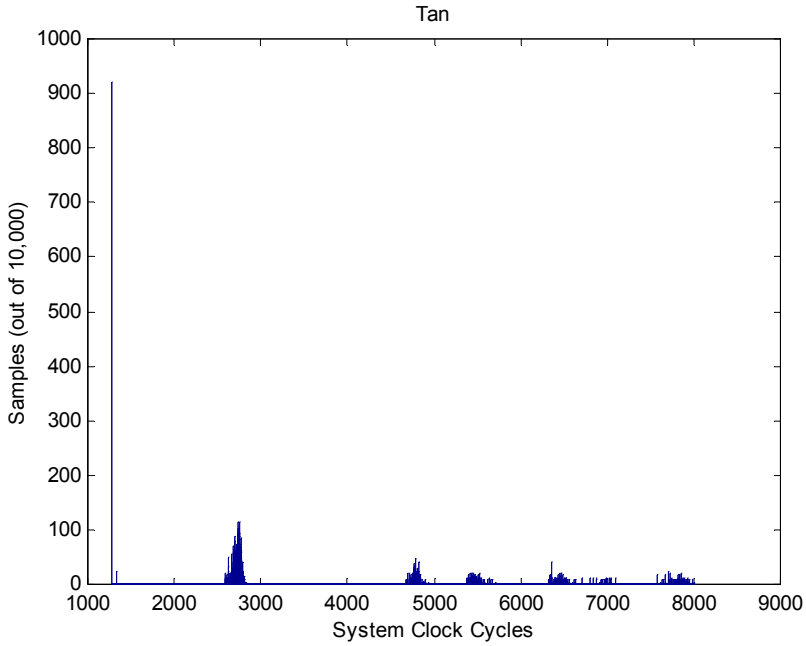
Cos

Mean: 1852
Min: 786
Max: 5587



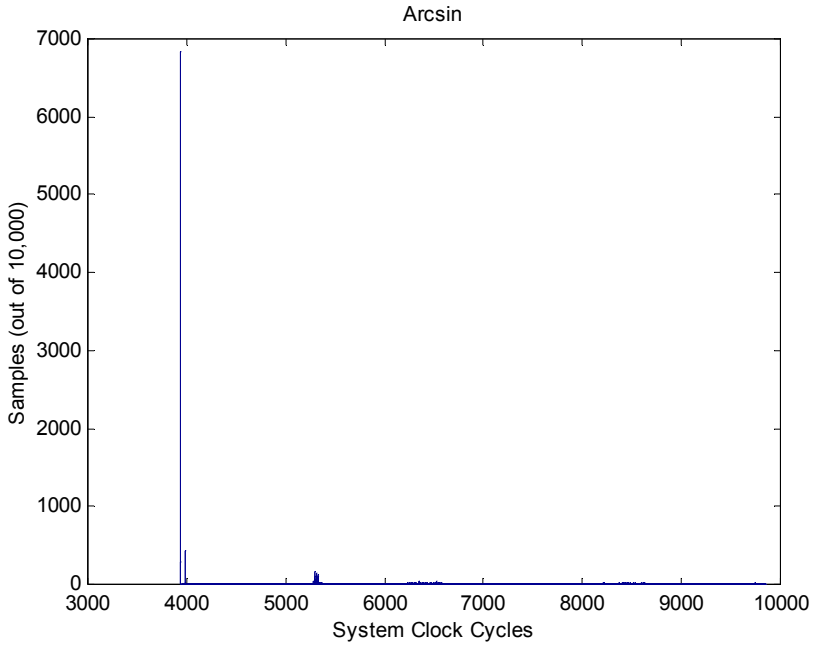
Tan

Mean: 3707
Min: 1280
Max: 8001



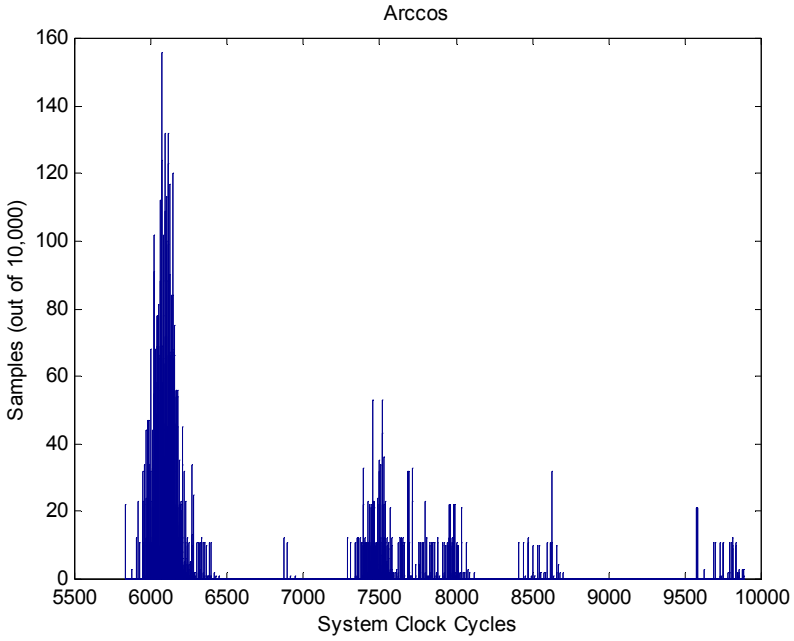
ArcSin

Mean: 4461
Min: 3941
Max: 9847



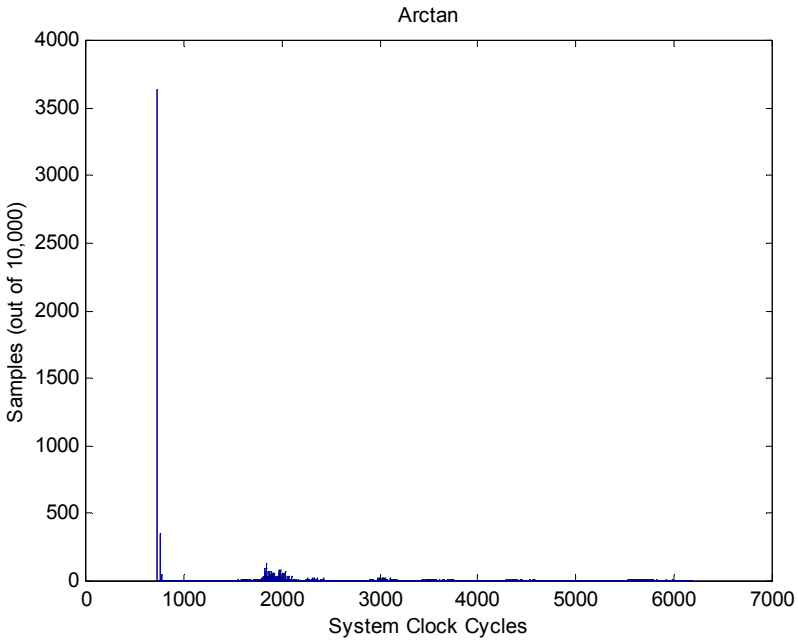
ArcCos

Mean: 6513
Min: 5832
Max: 9883



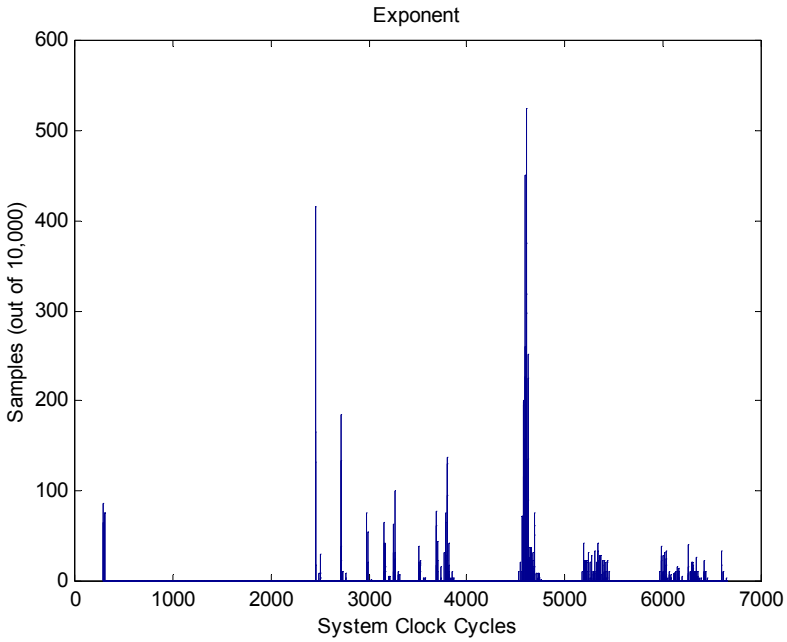
ArcTan

Mean: 1810
Min: 734
Max: 6126



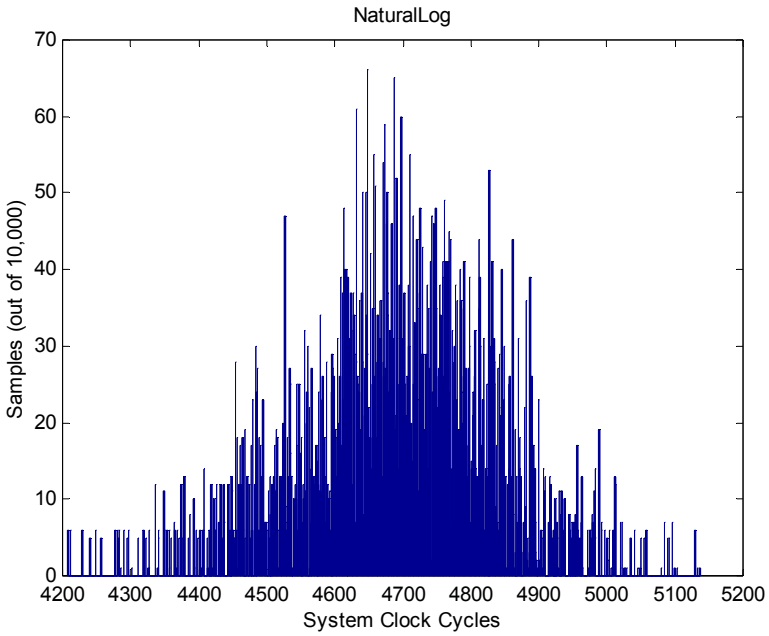
Exponential

Mean: 4245
Min: 295
Max: 6646



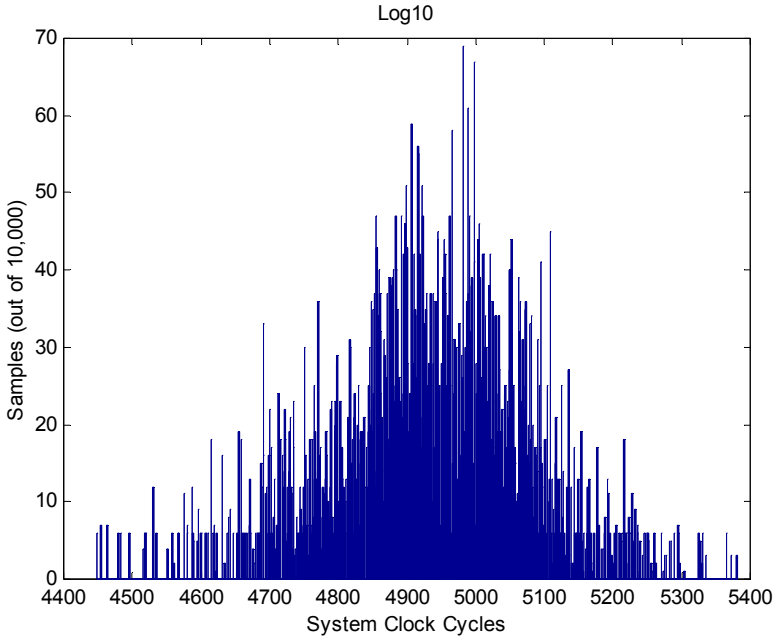
Natural Log

Mean: 4692
Min: 4208
Max: 5175



Log (Base 10)

Mean: 4931
Min: 4448
Max: 5376



Fixed-Point Characterization

These tests measured the execution time requirements for various fixed-point math functions performed with the CIP-51 Microcontroller Core on a C8051F005 device. A pseudo-random number generator (based on the *rand( )* function) was used to generate input parameters; 10,000 samples were taken for each function. All times are given in system clocks, where one system clock for the CIP-51 equals one oscillator clock and is independent of oscillator frequency. Note: all 16-bit routines produced a 16-bit result; all 32-bit routines produced a 32-bit result.

16- and 32-bit division routine execution times are input-dependent; the tables below list the minimum, maximum, and mean execution times for each division routine. Each division routine profile is detailed with an execution time histogram in the following pages. The x-axis represents each specific execution time; the y-axis represents the number of times that execution time occurred (out of 10,000 input samples).

Execution Times for 16-bit Fixed Math Routines (in Oscillator Clocks)

Function	Mean	Minimum	Maximum	Standard 8051 (Mean)†	Speed Increase Factor vs. Standard 8051 (Mean)
Addition (signed/unsigned)	12	12	12	72	6
Subtraction (signed/unsigned)	13	13	13	84	6.4
Multiplication (signed/unsigned)	47	47	47	348	7.4
Division (signed)	221	66	252	1692	7.6
Division (unsigned)	194	41	217	1536	7.9

†Based on data taken from the Keil C51 User's Guide v1.97. Statistics in the Keil book are given in CPU machine cycles; the numbers presented here are adjusted to represent the number of oscillator clocks required (1 CPU machine cycle = 12 oscillator clocks for a Standard 8051).

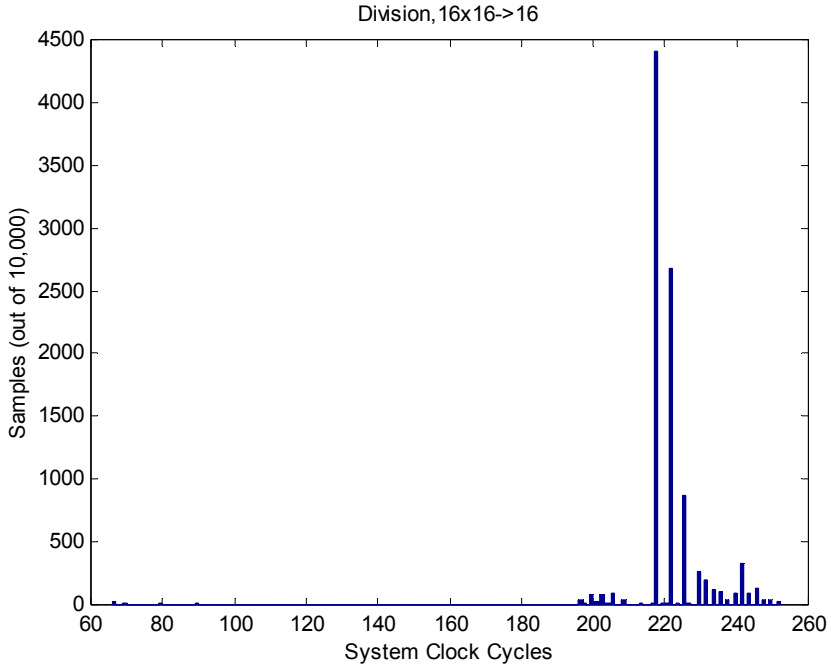
Execution Times for 32-bit Fixed Point Math Routines (in Oscillator Clocks)

Function	Mean	Minimum	Maximum	Standard 8051 (Mean)†	Speed Increase Factor vs. Standard 8051 (Mean)
Addition (signed/unsigned)	24	24	24	144	6
Subtraction (signed/unsigned)	25	25	25	156	6.2
Multiplication (signed/unsigned)	141	141	141	1272	9.0
Division (signed)	359	334	795	6768	18.8
Division (unsigned)	331	309	770	5964	18.0

†Based on data taken from the Keil C51 User's Guide 1.97. Statistics in the Keil book are given in CPU machine cycles; the numbers presented here are adjusted to represent the number of oscillator clocks required (1 CPU machine cycle = 12 oscillator clocks for a Standard 8051).

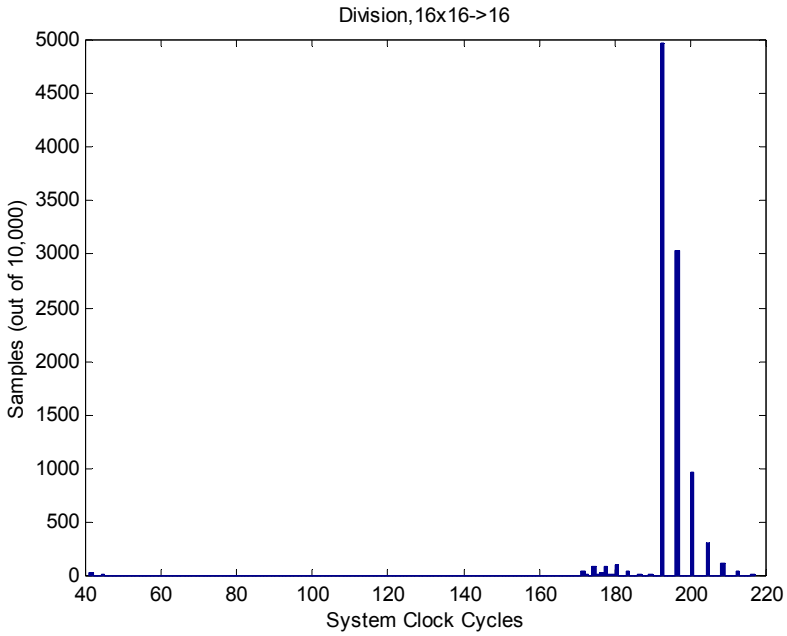
Signed 16-bit Division

Mean: 221
Min: 66
Max: 252



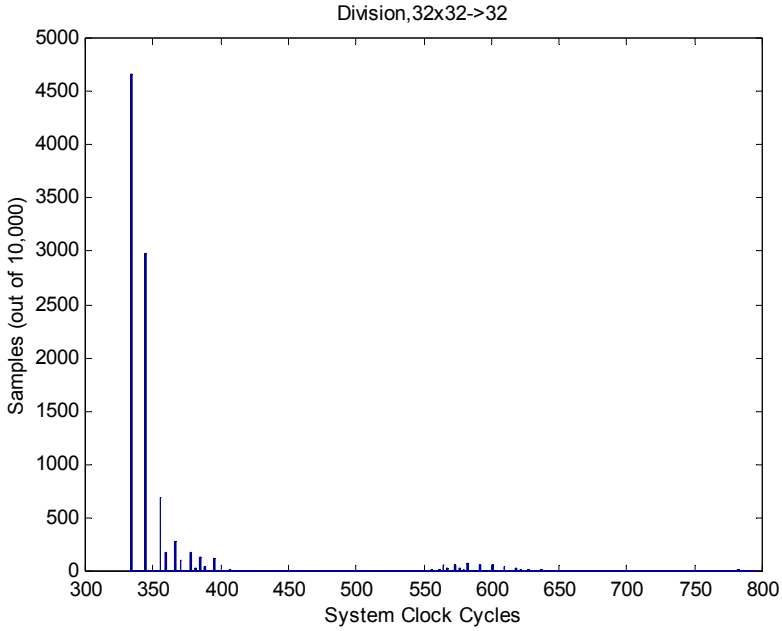
Unsigned 16-bit Division

Mean: 194
Min: 41
Max: 217



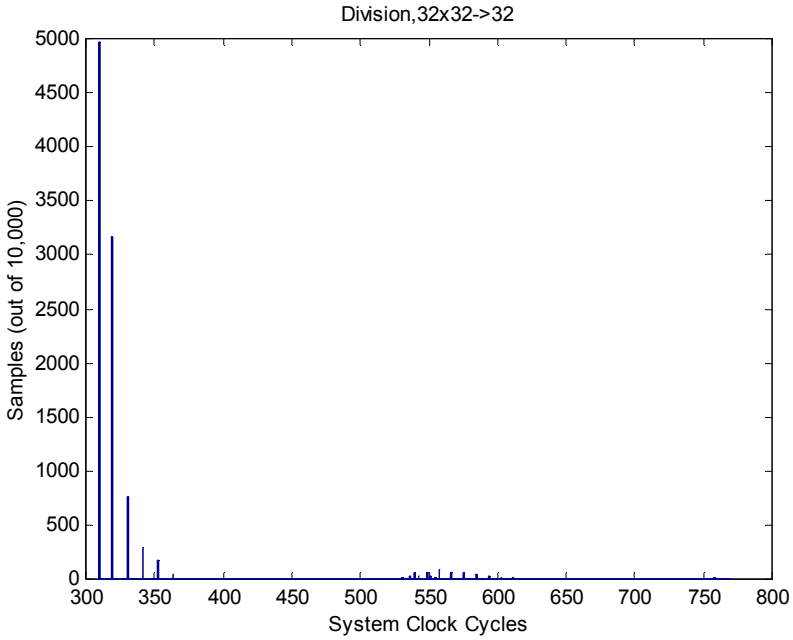
Signed 32-bit Division

Mean: 359
Min: 334
Max: 795



Unsigned 32-bit Division

Mean: 331
Min: 309
Max: 770



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