

FFT library v. 2.0 benchmarks

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Complex/real FFT, 16/32bit FFT, radix4/2 FFT, windowing, sqrt and magnitude functions for Cortex-M3.

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- All functions were written in hand optimized assembly code.
- Small speed improvement still possible especially for small sizes FFT or high latency configurations
- Not all benchmarks performed due to large number of combinations (function / size/ latency /worst or best case)
- Benchmark values include C call overhead (without C optimization, worst case)
- Tested on real hardware (STM32)
- Lat0, Lat1 and Lat2 in the benchmark table specify STM32 flash latency (0,1,2)
- Latency 0 benchmark directly applicable to other Cortex-M3 implementations
- Some functions ported to other ARM cores (e.g. ARM 9E)

Brief FFT library v 2.0 description:

- Three groups of functions:
 - Windowing function
 - Fast Fourier Transform
 - Complex magnitude (absolute value of complex frequency)
- Three library versions
 - GCC (Rowley CrossWorks, Raisonance, ...)
 - Keil MDK-ARM
 - IAR Embedded Workbench
- Windowing functions (e.g. Hamming window)
 - Perform speed optimized windowing of input signal before FFT
 - 16 to 32 bit version performs proper scaling of 16 bit signal for 32 bit FFT
- FFT functions
 - Complex and real FFT, 16 and 32bit FFT versions
 - Radix4/2 FFT – sizes 4,8,16,32,64,128,256,512,1024,2048 and 4096
 - Inverse FFT available
 - 32 bit FFT increases dynamic range by 90 dB , needs extra 20% to 50% cycles
 - Coefficients located in Flash. RAM location means faster FFT for higher latencies.
- Magnitude functions
 - Calculate complex frequency magnitude $\text{mag}=\sqrt{re^2 + im^2}$
 - Based on custom 32 bit square root algorithm (7 cycles)
 - Multiple precision/speed variants for 32 bit frequencies (64 bit sqrt needed)

Windowing functions benchmarks

Function	Points	Best case			Worse case		
		Lat0	Lat1	Lat2	Lat0	Lat1	Lat2
Window16b_real Window16to32b_real	16	123					
	32	217					
	64	405					
	128	781					
	256	1533					
	512	3037					
	1024	6045	6174	6303			
	2048	12061					
4096	24093						
Window16b_complex Window16to32b_complex	16	199					
	32	369					
	64	709					
	128	1389					
	256	2749					
	512	5469					
	1024	10909					
	2048	21789					
4096	43549						
Window32to32b_real	16	137					
	32	243					
	64	455					
	128	879					
	256	1727					
	512	3423					
	1024	6815	6950	7084	7842	7974	8108
	2048	13599					
4096	27167						
Window32to32b_complex	16	229					
	32	427					
	64	823					
	128	1615					
	256	3199					
	512	6367					
	1024	12703					
	2048	25375					
4096	50719						

1024 points	Coefficients in RAM			Coefficients in Flash		
	Lat0	Lat1	Lat2	Lat0	Lat1	Lat2
Window16b_real /16to32	6045	6174	6303	6045	6558	7324
Window16b_complex /16to32	10909	11038	11167	10909	11422	12188
Window32to32b_real	6815	6944	7073	6815	7584	8734
Window32to32b_complex	12703	12832	12961	12703	13472	14622

Magnitude functions benchmarks

Function	Points	Best case			Worse case		
		Lat0	Lat1	Lat2	Lat0	Lat1	Lat2
magnitude16_16bln	16	193					
	32	393					
	64	793					
	128	1593					
	256	3193					
	512	6393					
	1024	12793	14327	15860			
	2048	25593					
	4096	51193					
magnitude16_32bln	16	193					
	32	393					
	64	793					
	128	1593					
	256	3193					
	512	6393					
	1024	12793	14327	15860			
	2048	25593					
	4096	51193					
magnitude24_32bln	16	268					
	32	556					
	64	1132					
	128	2284					
	256	4588					
	512	9196					
	1024	18412	20457	24035			
	2048	36844					
magnitude32_32bln	16	240			275		
	32	496			571		
	64	1008			1163		
	128	2032			2347		
	256	4080			4715		
	512	8176			9451		
	1024	16368	18413	21991	18923	21479	25568
	2048	32752			37867		
4096	65520			75755			

FFT functions benchmarks

Function	Points	Best case			Worse case		
		Lat0	Lat1	Lat2	Lat0	Lat1	Lat2
real FFT 16b	16	494					
	32	1021					
	64	2548					
	128	5377					
	256	12652					
	512	26701					
	1024	60871	64959	80253			
	2048	127705					
	4096	285152					
complex FFT 16b	16						
	32	1659					
	64	3575	3797	4588			
	128	9027					
	256	19425	20685	25144			
	512	46298					
	1024	98541	105113	128070			
	2048	226820					
	4096						
complex IFFT 16b	16						
	64	3597					
	256	19475					
	1024	98803					
	4096						
real FFT 32b	16	604					
	32	1331					
	64	3262					
	128	7075					
	256	16334					
	512	35055					
	1024	78634	85205	94627	97386	103942	112592
	2048	167099					
	4096	368062					
complex FFT 32b	16	677					
	32	1924					
	64	4326					
	128	10772					
	256	23859					
	512	56171					
	1024	122111					
	2048	278015					
	4096						