Atmel SAMV71 Automotive Reference Design

Presented at Embedded World 2015

SAMV7 Highlights

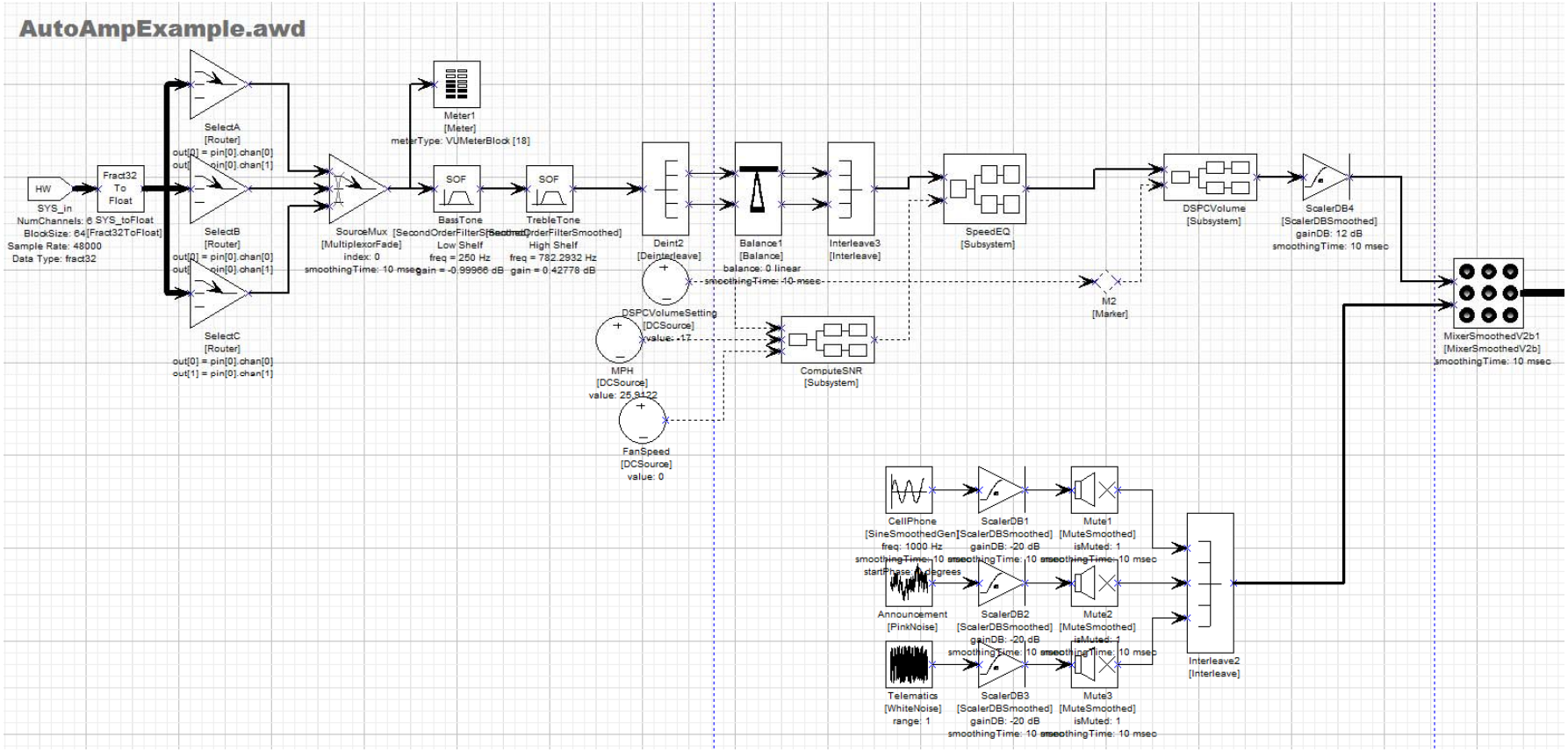
- ARM Cortex-M7 processor
- 1.5x the DSP performance of the M4 per cycle
- Highest clock speed – 300 MHz
- Tightly coupled data memory
- Automotive temperature qualified
- Ethernet AVB support
- CAN interface
- Internal flash and RAM
- 2 x audio serial ports with multichannel support

- Ideal for low to mid-end automotive systems

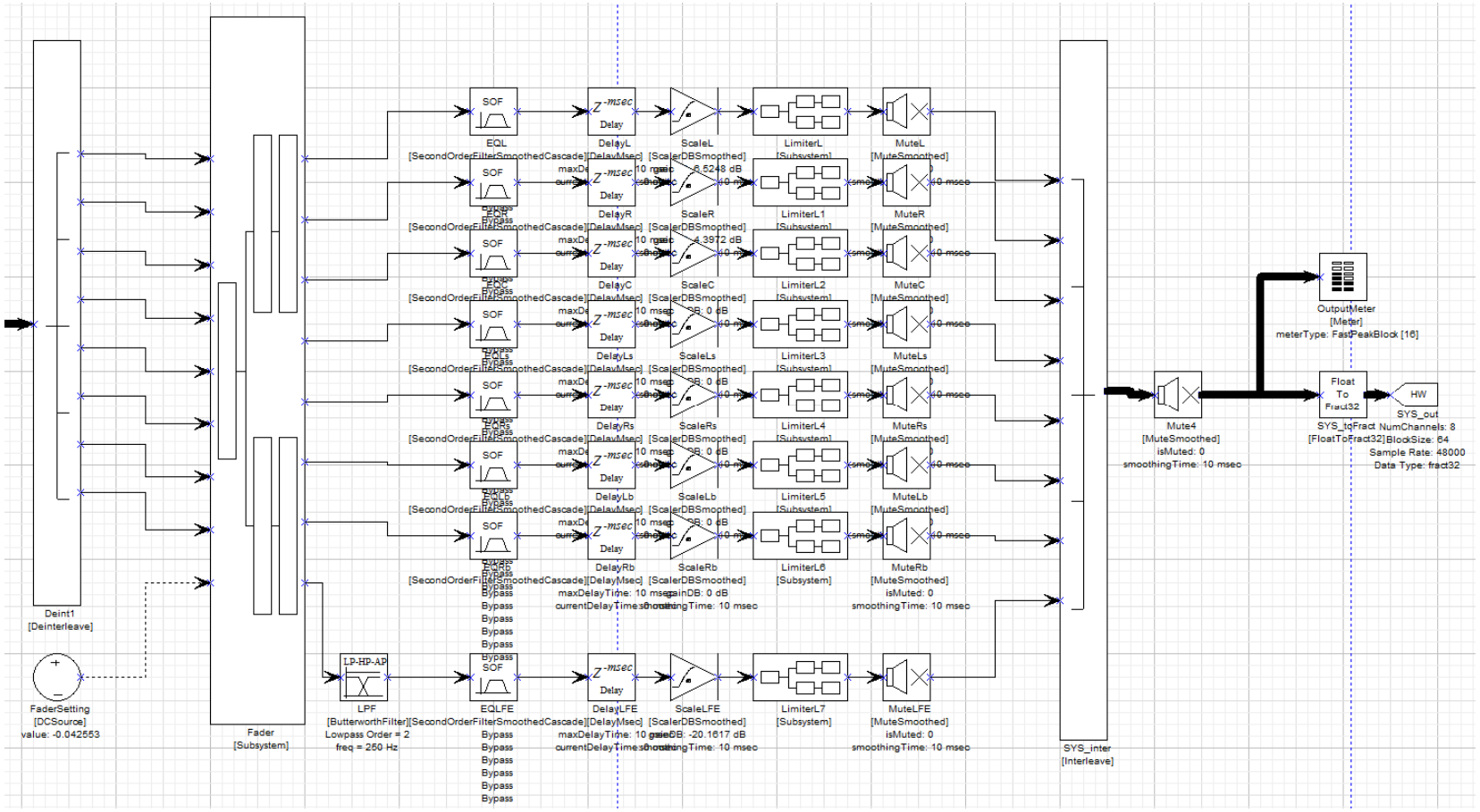
Automotive System

- Source selection
- Input Meter
- Tone controls
- Fader / balance
- Speed dependent EQ
- Table based loudness control
- 3 simulated announcement channels
- Simple 8 channel upmix
- 8 channels of speaker processing
  - 6 stages of Biquads
  - Delay
  - Scaler
  - Limiter
  - Mute
- Final Mute
- Output Meter

Block Diagram (1 of 2)



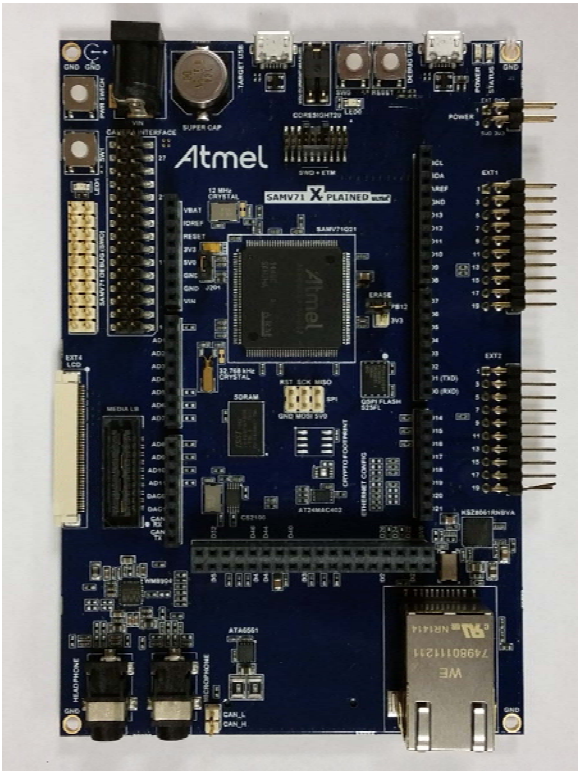
Block Diagram (2 of 2)



CPU Profiling

- 63% CPU load
- 43800 bytes for data structures and wire buffers
- Measured on SAMV71 development board
- 48 kHz sample rate
- 64 sample block size

- Still room for Ethernet AVB stack or system control



Appendix

Cortex-M7 benchmarks

FIR Benchmarks

Num Taps	Cortex-M4	Cortex-M7	Cortex-A8	Cortex-A9	Cortex-A15	Blackfin 53x	Blackfin 70x	SHARC 21489
5	6743	4282	6467	6315	2673			1954
10	9871	6268	9793	9245	5142			2473
20	15650	9938	13598	14338	5031			3777
50	35801	22734	29310	32799	10267	27404	14456	7677
100	67833	43074	53913	62145	15525			14210

256 sample block size
Clock cycles are shown
Floating-point for all except Blackfin (Q31)
Measured using Audio Weaver

FIR Analysis

Cycles Per Sample Per Tap

Cortex-M4	Cortex-M7	Cortex-A8	Cortex-A9	Cortex-A15	Blackfin 53x	Blackfin 70x	SHARC 21489
2.65	1.68	2.11	2.43	0.61	2.14	1.13	0.56

Biquad Benchmarks

Num Stages	Cortex-M4	Cortex-M7	Cortex-A8	Cortex-A9	Cortex-A15	Blackfin BF53x	Blackfin BF70x	SHARC 21489
1	4480	2912	4867	4326	2439	4650	3338	1455
4	16700	10855	16712	17750	9040			5405
8	32900	21385	33354	32933	17825			10650
12	49100	31915	49274	50243	26664			15958

256 sample block size
Clock cycles are shown
Measured using Audio Weaver
Mono channel processing

Blackfin notes
Uses 32x32+64 math
Additional overhead for shifting of data

Biquad Analysis

Cycles Per Sample Per Stage

Cortex-M4	Cortex-M7	Cortex-A8	Cortex-A9	Cortex-A15	Blackfin BF53x	Blackfin BF70x	SHARC 21489
15.98	10.39	16.04	16.36	8.68	18.16	13.04	5.19

Faster Biquads

Cycles Per Sample Per Stage

Cortex-M4	Cortex-M7	Cortex-A8	Cortex-A9	Cortex-A15	SHARC 21489
15.98	9.28	14.36	9.49	6.01	2.64

- SHARC has 2-way SIMD and can process 2 channels in parallel
- NEON has 4-way SIMD and can process 4 channels in parallel (but we don't have this function)
- For NEON, we have a "Biquad Cascade Delay" function which implements a cascade by mono Biquad filters with a delay between stages. This allows NEON parallelization
- For Cortex-M7 we have a stereo function which makes better use of instruction ordering to reduce stalls.

FFT Benchmarks

Length	Cortex-M4	Cortex-M7	Cortex-A8	Cortex-A9	Cortex-A15	Blackfin BF53x	Blackfin BF70x	SHARC 21489
64	3709	2297	3773	3358	2264	2200	1526	783
128	9811	6018	6384	5682	3830	5249	3431	1334
256	21575	13881	11114	9891	6668	11744	7611	2542
512	37813	25551	21852	19448	13111	27385	17084	5189
1024	96630	63484	50738	45157	30443	60216	37568	10972

Complex transform
No bit reversal

FFT Analysis

FFT cycle count is proportional to K * N * log2(N)
K factor shown below
Smaller is better

Cortex-M4	Cortex-M7	Cortex-A8	Cortex-A9	Cortex-A15	Blackfin BF53x	Blackfin BF70x	SHARC 21489
9.44	6.20	4.95	4.41	2.97	5.88	3.67	1.07

Normalized Per Cycle Benchmarks

	Cortex-M4	Cortex-M7	Cortex-A8	Cortex-A9	Cortex-A15	Blackfin 53x	Blackfin 70x	SHARC 21489
FIR	0.21	0.33	0.26	0.23	0.92	0.26	0.49	1.00
Biquad	0.16	0.28	0.18	0.28	0.44	0.15	0.20	1.00
FFT	0.11	0.17	0.22	0.24	0.36	0.18	0.29	1.00

Performance normalized relative to SHARC
Higher numbers are better

With Processor Speed Differences

	Cortex-M4	Cortex-M7	Cortex-A8	Cortex-A9	Cortex-A15	Blackfin 53x	Blackfin 70x	SHARC 21489
FIR	0.09	0.22	0.59	0.51	3.05	0.40	0.44	1.00
Biquad	0.07	0.19	0.41	0.62	1.46	0.23	0.18	1.00
FFT	0.05	0.11	0.48	0.54	1.20	0.28	0.26	1.00

Takes into account maximum clock speeds

Cortex-M4: 204 MHz
Cortex-M7: 300 MHz
Cortex-A8: 1 GHz
Cortex-A9: 1 GHz
Cortex-A15: 1.5 GHz
Blackfin 53x: 700 MHz
Blackfin BF70x: 400 MHz
SHARC: 450 MHz

Bigger is better

Thank You!

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