

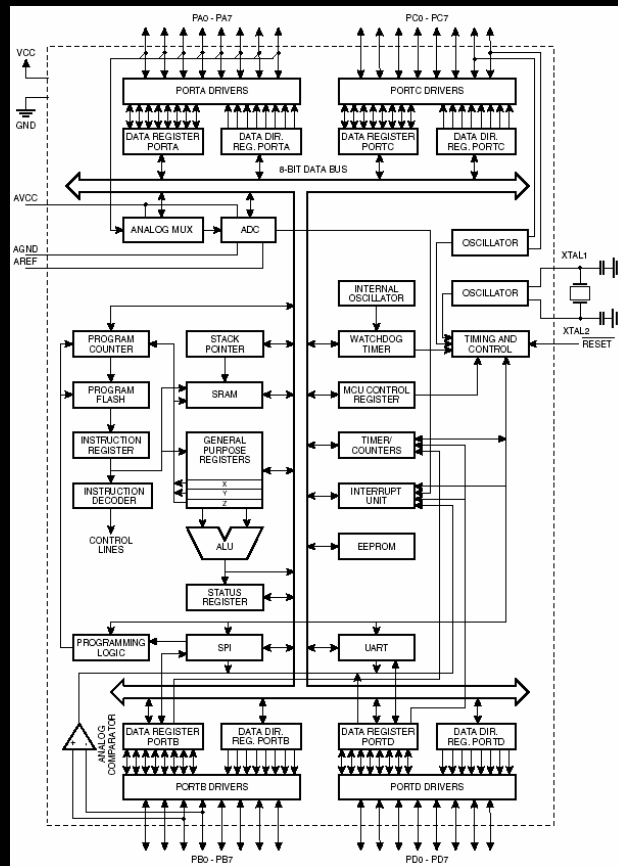
Erick Oberstar
Spring 2002

Optimization of a Narrow Band Fixed Point
Filter Implemented On A Low Cost MCU
- Issues and Performance

Motivations for IIR Filter Optimization

- Computational Throughput – Increased performance per dollar.
- Initially on part without multiplier 6.7 KHz loop rate
- Part with multiplier 19.5 KHz loop rate
- Lower Cost for given performance.
- AT90S8535-8AI
\$5.58/100 pcs.
- ATMEGA163-8AC
\$7.67/100 pcs.
- TMS320UC5402GGU
-80 \$8.58/100 pcs

IIR Implementation on an AVR MCU Architecture

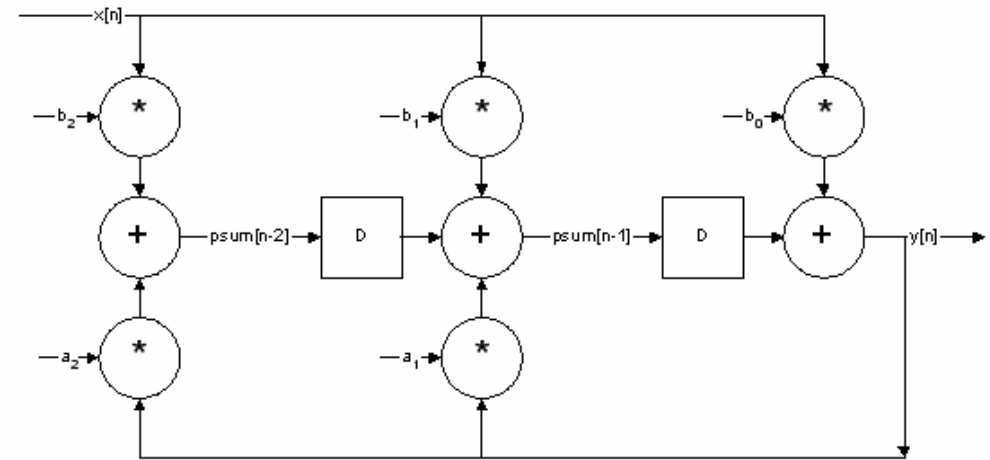
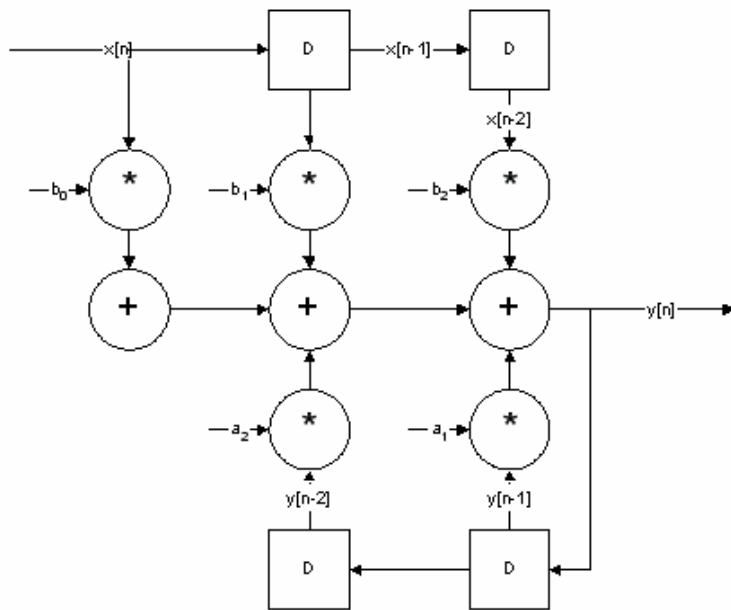


- Analyze and Optimize IIR for ATMEL AVR RISC MCU with/without hardware multiplier
- 8-bit 8MHz RISC-Most instrs. are single cycle
- 32 Registers
- Integrated A/D
- AT90S8535 has no hardware multiplier
- ATMEGA163 had hardware multiplier

Optimization Techniques

- Algorithm Transformation
- Compiler Based Optimization
- Look-Ahead Transformation - Inline Code / Loop Unrolling (Branch minimization)
- Constant Substitution
- Hand optimized assembly routines for each multiplication in algorithm

Algorithm Transformations



General Form IIR Filter Structure

Broadcast Form IIR Filter Structure

Optimization Results

Configuration Number	Filter Structure	Compiler Optimization		AT90S8535 (Codesize)	AT90S8535 (Critical Path)	ATMega163 (Codesize)	ATMega163 (Critical Path)
1	General	Speed		133	1138	126	408
2		Size		123	1173	126	408
3	Broadcast	Speed		132	1153	129	420
4		Size		115	1202	113	441
5	General	Speed w/Consts.		100	902	97	323
6	Broadcast	Speed w/Consts.		100	903	97	320
7	General	Unrolled Multiply on Speed w. Consts.		400	862	388	283
8	General	Speed, Hand ASM optimized multiply for each filter coefficient		92	92	26	30
				AT90S8535(Hand ASM) V.S. AT90S8535(1-7)		ATMEGA163(Hand ASM) V.S. ATMEGA163(1-7)	
		% improvement of 8 over configuration#	1	30.83	91.92	79.37	92.65
			2	25.20	92.16	79.37	92.65
			3	30.30	92.02	79.84	92.86
			4	20.00	92.35	76.99	93.20
			5	8.00	89.80	73.20	90.71
			6	8.00	89.81	73.20	90.63
			7	77.00	89.33	93.30	89.40
				AT90S8535(Hand ASM) V.S. ATMEGA163(1-7)		ATMEGA163(Hand ASM) V.S. AT90S8535(1-7)	
			1	26.98	77.45	80.45	97.36
			2	26.98	77.45	78.86	97.44
			3	28.68	78.10	80.30	97.40
			4	18.58	79.14	77.39	97.50
			5	5.15	71.52	74.00	96.67
			6	5.15	71.25	74.00	96.68
			7	76.29	67.49	93.50	96.52

Thank You

