

Embedded Systems Design

DSP Processors

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Digital Signal Processing

- Processing of digitally represented signals
- Signals represented digitally via sequence of samples
 - Digital signals obtained from physical signals via Transducers and Analog to digital convertors (ADC)
- Digital Signal Processor
 - Electronic system that processes digital signals

Definition

- A **digital signal processor (DSP)** is a specialized microprocessor with optimized architecture for fast operational needs of Digital Signal Processing.

DSP Applications

- Audio
 - Coding, Decoding, Surround-sound
- Communication
 - Scrambling, Cellular phones, software radios
- Control
 - Robotics, Disk drive control, motor control
- Medical
 - Diagnostics equipment, hearing aids
- Defense
 - Radar and sonar processing, missile guidance

Why DSP Processors ?

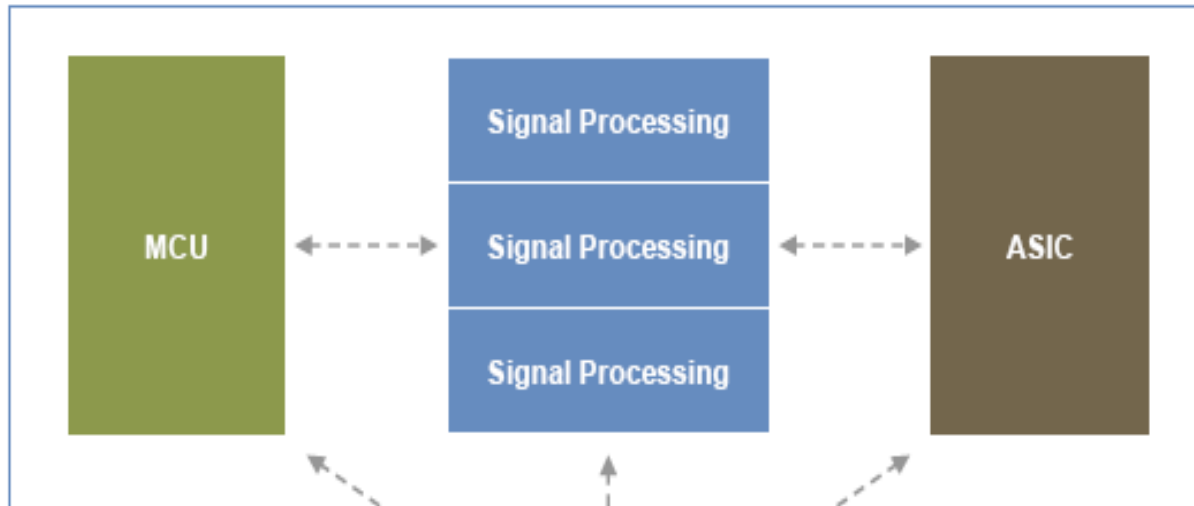
- Reprogrammable
- Cost effective
- Fast computation
- Energy Efficiency
- Fast Multipliers
- Multiple Execution Units
- Efficient Memory Accesses
- Circular Buffering
- Data Format
- Zero-Overhead Looping
- Streamlined I/O
- Specialized Instruction Sets
- SIMD

Reprogrammable

Traditional Model

MCU

- Control
- Networking
- RTC
- Watchdog
- RTOS
- MMU
- Byte addressable



ASIC

- Interfaces to sensors
- Broad peripheral mix
- Memory

New Model

Blackfin core can perform all of these functions



Cost Effective

- There is no need for a separate signal processing unit
- Signal processing and control functions can be performed on a single silicon chip

Faster computation

- Because of specialized Hardware for DSP application computation becomes vary fast
- Separate MAC units and fast multipliers are used for many DSP algorithms for faster execution i.e.
 - FIR Filter
 - IIR Filter
 - DCT
 - FFT

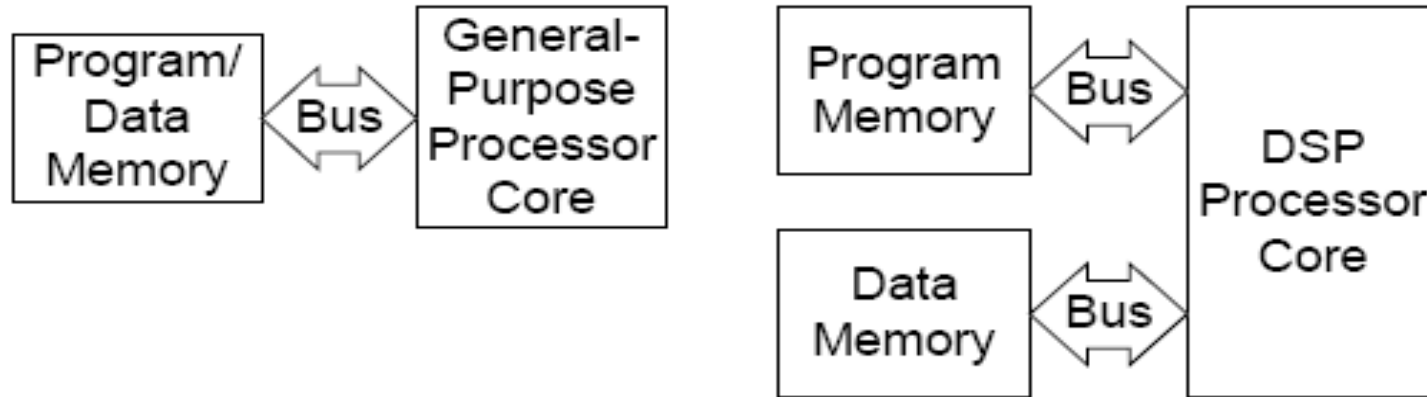
Fast Multipliers

- Originally, microprocessors implemented multiplications by a series of shift and add operations, each of which consumed one or more clock cycles.
- Most DSP processors can only take one clock cycle for the multiplication operation.
- modern DSP processors include at least one dedicated single-cycle multiplier or combined multiply-accumulate (MAC) unit

Multiple Execution Units

- DSP applications typically have very high computational requirements in comparison to other types of computing tasks, since they often must execute DSP algorithms (such as FIR filtering) in real time on lengthy segments of signals sampled at 10-100 KHz or higher. Hence, DSP processors often include several independent execution units that are capable of operating in parallel—for example, in addition to the MAC unit, they typically contain an arithmetic- logic unit (ALU) and a shifter.

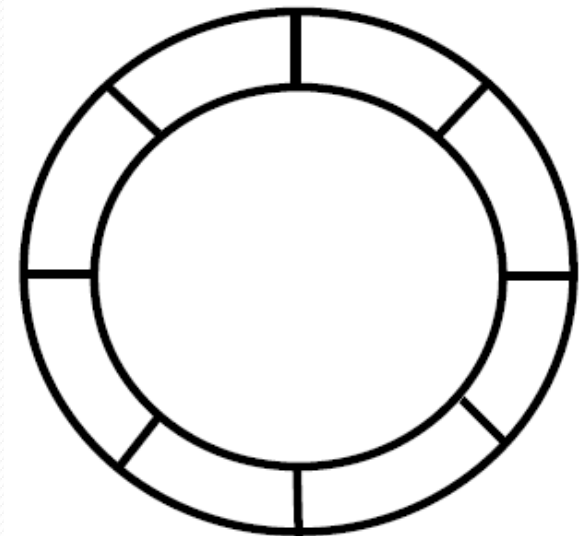
Efficient Memory Accesses



- Small bank of RAM near the processor core that is used as an instruction cache
- Many DSP processors also support “circular addressing,” which allows the processor to access a block of data sequentially and then automatically wrap around to the beginning address

Circular Buffering

- The process by which the Data Address Generator (DAG) “wraps around” or repeatedly steps through a range of registers.
- Instructions Accommodate 3 elements
 - Buffer Address
 - Buffer Size
 - Increment



Data Format

- Fixed point and floating point processors.
- Use of Accumulator to reduce the overflow.

Assignment # 2

- Highlight the difference between the Architecture of Fixed point and Floating point DSP processors with at least 2 examples from TI and Blackfin processors.
- www.TI.com
- www.analog.com

Zero-Overhead Looping

Special loop or repeat instruction is provided which allows the programmer to implement a for-next loop without expending any clock cycles for updating and testing the loop counter or branching back to the top of the loop. This feature is often referred to as “zero-overhead looping.”

Streamlined I/O

- To allow low-cost, high-performance input and output, most DSP processors incorporate one or more specialized serial or parallel I/O interfaces, and streamlined I/O handling mechanisms, such as low-overhead interrupts and direct memory access (DMA), to allow data transfers to proceed with little or no intervention from the processor's computational units.

Specialized Instruction Sets

- DSP processor instruction sets have traditionally been designed with two goals in mind
 - Maximum use of the processor's underlying hardware
 - Minimize the amount of memory space required to store DSP programs
- Highly Specialized
- Complicated
- Irregular
- Use Assembly instead of C for maximum benefit

SIMD

- SIMD, or single-instruction, multiple-data, is not a class of architecture itself, but is instead an architectural technique that can be used within any of the classes of architectures
- Improves performance on some algorithms by allowing the processor to execute multiple instances of the same operation
- For example, a SIMD multiplication instruction could perform two or more multiplications on different sets of input operands in parallel in a single clock cycle.