Chapter 1
Introduction

Learning Objectives

- Why process signals digitally?
- Definition of a real-time application.
- Why use Digital Signal Processing processors?
- What are the typical DSP algorithms?
- Parameters to consider when choosing a DSP processor.
- Programmable vs ASIC DSP.
- Texas Instruments' TMS320 family.

Why go digital?

- Digital signal processing techniques are now so powerful that sometimes it is extremely difficult, if not impossible, for analogue signal processing to achieve similar performance.
- Examples:
  - FIR filter with linear phase.
  - Adaptive filters.

Why go digital?

- Analogue signal processing is achieved by using analogue components such as:
  - Resistors.
  - Capacitors.
  - Inductors.
- The inherent tolerances associated with these components, temperature, voltage changes and mechanical vibrations can dramatically affect the effectiveness of the analogue circuitry.

Why go digital?

- With DSP it is easy to:
  - Change applications.
  - Correct applications.
  - Update applications.
- Additionally DSP reduces:
  - Noise susceptibility.
  - Chip count.
  - Development time.
  - Cost.
  - Power consumption.

Why NOT go digital?

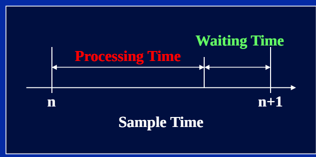
- High frequency signals cannot be processed digitally because of two reasons:
  - Analog to Digital Converters, ADC cannot work fast enough.
  - The application can be too complex to be performed in real-time.

Real-time processing

- DSP processors have to perform tasks in real-time, so how do we define real-time?
- The definition of real-time depends on the application.
- Example: a 100-tap FIR filter is performed in real-time if the DSP can perform and complete the following operation between two samples:

$$y(n)=\sum_{k=0}^{99} a(k)x(n-k)$$

Real-time processing



- We can say that we have a real-time application if:
  - Waiting Time ≥ 0

Why do we need DSP processors?

- Why not use a General Purpose Processor (GPP) such as a Pentium instead of a DSP processor?
  - What is the power consumption of a Pentium and a DSP processor?
  - What is the cost of a Pentium and a DSP processor?

Why do we need DSP processors?

- Use a DSP processor when the following are required:
  - Cost saving.
  - Smaller size.
  - Low power consumption.
  - Processing of many "high" frequency signals in real-time.
- Use a GPP processor when the following are required:
  - Large memory.
  - Advanced operating systems.

What are the typical DSP algorithms?

- The Sum of Products (SOP) is the key element in most DSP algorithms:

Algorithm	Equation
Finite Impulse Response Filter	$y(n)=\sum_{k=0}^{M} a_k\, x(n-k)$
Infinite Impulse Response Filter	$y(n)=\sum_{k=0}^{M} a_k\, x(n-k)+\sum_{k=1}^{N} b_k\, y(n-k)$
Convolution	$y(n)=\sum_{k=0}^{N} x(k)h(n-k)$
Discrete Fourier Transform	$X(k)=\sum_{n=0}^{N-1} x(n)\exp[-j(2\pi/N)nk]$
Discrete Cosine Transform	$F(u)=\sum_{x=0}^{N-1} c(u).f(x).\cos\left[\frac{\pi}{2N}u(2x+1)\right]$

Hardware vs. Microcode multiplication

- DSP processors are optimised to perform multiplication and addition operations.
- Multiplication and addition are done in hardware and in one cycle.
- Example: 4-bit multiply (unsigned).

```
Hardware          Microcode

    1011              1011
  x 1110            x 1110

10011010              0000    Cycle 1
                     1011.    Cycle 2
                    1011..    Cycle 3
                   1011...    Cycle 4
                  10011010    Cycle 5
```

Parameters to consider when choosing a DSP processor

Parameter	TMS320C6211 (@150MHz)	TMS320C6711 (@150MHz)
Arithmetic format	32-bit	32-bit
Extended floating point	N/A	64-bit
Extended Arithmetic	40-bit	40-bit
Performance (peak)	1200MIPS	1200MFLOPS
Number of hardware multipliers	2 (16 x 16-bit) with 32-bit result	2 (32 x 32-bit) with 32 or 64-bit result
Number of registers	32	32
Internal L1 program memory cache	32K	32K
Internal L1 data memory cache	32K	32K
Internal L2 cache	512K	512K

- C6711 Datasheet: \Links\TMS320C6711.pdf
- C6211 Datasheet: \Links\TMS320C6211.pdf

Parameters to consider when choosing a DSP processor

Parameter	TMS320C6211 (@150MHz)	TMS320C6711 (@150MHz)
I/O bandwidth: Serial Ports (number/speed)	2 x 75Mbps	2 x 75Mbps
DMA channels	16	16
Multiprocessor support	Not inherent	Not inherent
Supply voltage	3.3V I/O, 1.8V Core	3.3V I/O, 1.8V Core
Power management	Yes	Yes
On-chip timers (number/width)	2 x 32-bit	2 x 32-bit
Cost	US$ 21.54	US$ 21.54
Package	256 Pin BGA	256 Pin BGA
External memory interface controller	Yes	Yes
JTAG	Yes	Yes

Floating vs. Fixed point processors

- Applications which require:
  - High precision.
  - Wide dynamic range.
  - High signal-to-noise ratio.
  - Ease of use.

  Need a floating point processor.
- Drawback of floating point processors:
  - Higher power consumption.
  - Can be more expensive.
  - Can be slower than fixed-point counterparts and larger in size.

Floating vs. Fixed point processors

- It is the application that dictates which device and platform to use in order to achieve optimum performance at a low cost.
- For educational purposes, use the floating-point device (C6711) as it can support both fixed and floating point operations.

General Purpose DSP vs. DSP in ASIC

- Application Specific Integrated Circuits (ASICs) are semiconductors designed for dedicated functions.
- The advantages and disadvantages of using ASICs are listed below:

Advantages	Disadvantages
• High throughput • Lower silicon area • Lower power consumption • Improved reliability • Reduction in system noise • Low overall system cost	• High investment cost • Less flexibility • Long time from design to market

Texas Instruments' TMS320 family

- Different families and sub-families exist to support different markets.

C2000

Lowest Cost

Control Systems
- Motor Control
- Storage
- Digital Ctrl Systems

C5000

Efficiency

Best MIPS per Watt / Dollar / Size
- Wireless phones
- Internet audio players
- Digital still cameras
- Modems
- Telephony
- VoIP

C6000

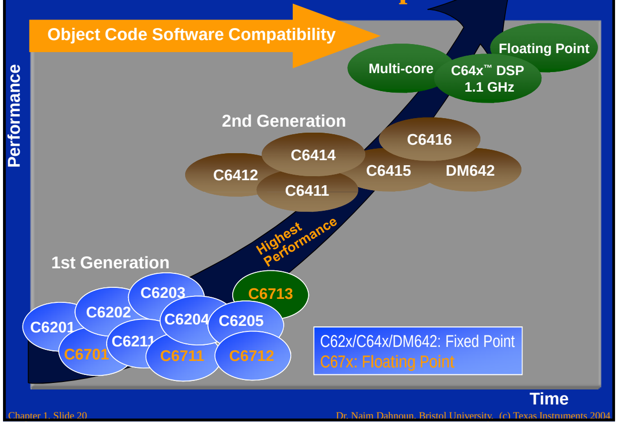
Performance & Best Ease-of-Use
- Multi Channel and Multi Function App's
- Comm Infrastructure
- Wireless Base-stations
- DSL
- Imaging
- Multi-media Servers
- Video

TMS320C64x: The C64x fixed-point DSPs offer the industry's highest level of performance to address the demands of the digital age. At clock rates of up to 1 GHz, C64x DSPs can process information at rates up to 8000 MIPS with costs as low as $19.95. In addition to a high clock rate, C64x DSPs can do more work each cycle with built-in extensions. These extensions include new instructions to accelerate performance in key application areas such as digital communications infrastructure and video and image processing.

TMS320C62x: These first-generation fixed-point DSPs represent breakthrough technology that enables new equipments and energizes existing implementations for multi-channel, multi-function applications, such as wireless base stations, remote access servers (RAS), digital subscriber loop (xDSL) systems, personalized home security systems, advanced imaging/biometrics, industrial scanners, precision instrumentation and multi-channel telephony systems.

TMS320C67x: For designers of high-precision applications, C67x floating-point DSPs offer the speed, precision, power savings and dynamic range to meet a wide variety of design needs. These dynamic DSPs are the ideal solution for demanding applications like audio, medical imaging, instrumentation and automotive.

C6000 Roadmap

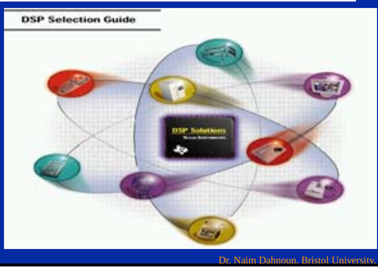


Useful Links

- Selection Guide:
  - \Links\DSP Selection Guide.pdf

    \Links\DSP Selection Guide.pdf (3Q 2004)

    \Links\DSP Selection Guide.pdf (4Q 2004)



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