Section 8

Disk Drive
Microcontroller Circuits

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Section 8 Contents

![National Semiconductor logo] **National Semiconductor**

The 16-Bit HPC™ Family:
Optimized for Mass Storage System Performance

Key Applications

- Asynchronous/Synchronous SCSI Controller System
- Intelligent Drive Applications in Rigid Disk, Optical Disk, High Density Floppy Disk and Tape Drives

The high-performance HPC16083 16-bit microcontroller, for example, is ideally suited for synchronous SCSI (Small Computer System Interface) controller system's CPU and repository for the firmware. The device's intruction set, including fast multiply and divide, customizes it to real-time control applications. Spare CPU capacity enables designers to implement other software tasks, such as power on/off, disk spindle control, head positioning, and an expanded SCSI Common Command Set.

Key Features

- World's first 16-bit CMOS microcontroller
- World's fastest CMOS microcontroller
- 67 ns instruction-cycle time at 30 MHz
- Full 16-bit architecture and implementation
- 64 kbyte address space
- High code efficiency with single-byte, multiple-function instructions
- 16 x 16-bit multiply, 32 x 16-bit divide
- Eight vectored interrupt sources
- Watchdog logic monitors
- 16-bit timer/counters
- Up to 52 general-purpose high-speed I/O lines
- On-chip ROM to 16 kbytes
- On-chip RAM to 512 bytes
- On-chip peripherals
  - DMA
  - HDLC
  - Timers
  - Input-capture registers
  - A/D converter
  - UART
  - User-programmable memory
  - High speed SRAM
- M²CMOS fabrication
- MICROWIRE/PLUS™ serial interface
- ROMless versions available
- Wide operating voltage range:
  +4.5V to +5.5V

- Military temp range available
  (−55°C to +125°C)
- MIL-STD-883C versions available
- 68-pin PGA, PLCC, LDCC packages and 84-pin Tape-Pak®

National's High Performance Controller (HPC) family is not only the world's first 16-bit CMOS microcontroller family, but also the world's fastest.

Currently operating at a clock rate of 30 MHz, the HPC is fabricated in scalable M²CMOS™, allowing die-shrinks ultimately, to submicron levels. Meaning the HPC will be operating at much higher frequencies in the future.

The HPC is designed for high-performance applications. With its 67 ns instruction cycle and its 16 x 16-bit multiply and 32 x 16-bit divide, the HPC is appropriate for compute-intensive environments that used to be the sole domain of the microprocessor.

The Powerful HPC Core

The HPC is an "application-specific" microcontroller.

Based on a common, high-performance CPU "core", each HPC family member can be "customized" to meet the exact needs of a particular application.

The core, based on a microprocessor-like von Neumann architecture, contains seven key functional elements:

1. Arithmetic Logic Unit (ALU)
2. 6 working registers
3. 8 interrupts
4. 3 timers
5. Control logic
6. Watchdog circuitry
7. MICROWIRE/PLUS interface

The internal data paths, registers, timers, and ALU are all 16 bits wide.

So the HPC can directly address up to 64 kbytes of "external" memory.

The external data bus, however, is configurable as 8 or 16 bits, allowing it to efficiently interface with a variety of peripheral devices.

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Efficient Instruction Set

The HPC family achieves much of its performance through its unique, highly optimized instruction set. Unlike the instruction set of a typical microprocessor, the HPC instruction set is designed for maximum code efficiency. Because ROM-space is necessarily limited on a single-chip solution, programs must be compact and economical.

The HPC instruction set supports nine addressing modes, like a high-performance 16-bit microprocessor. And each instruction in the set is designed to execute a number of individual functions, so the same operations can be executed with tighter code.

As a result, the typical HPC instruction cycle is only 67 ns at 30 MHz. And the typical HPC 16-bit multiply or divide takes less than 4 μs.

To achieve the same level of performance in other 16-bit and high-end 8-bit microcontrollers, as indicated by recent benchmark studies, would require up to *two times the memory space* as the HPC.

Low Power Operation

The HPC uses power as efficiently as it uses memory space.

The HPC draws only 47 mA of current at 20 MHz. And its even less at lower clock rates.

In addition, the HPC has two software-selectable power-down modes:

1. IDLE, which stops all operations except for the oscillator and one timer, thereby maintaining all RAM, registers, and I/O in a static state.

2. HALT, which stops all operations including the oscillator and timers, but holds RAM, registers, and I/O stable.

High Level Language Support

A C compiler is already available for software development on standard platforms: the IBM PC running DOS or UNIX® or the DEC™ VAX™ running VMS™ or UNIX.

With powerful tools such as these, the HPC can be quickly and efficiently programmed for any high-performance application.

HPC Family of Microcontrollers

Commercial Temp Version 0°C to +70°C	Industrial Temp Version −40°C to +85°C	Military Temp Version −55°C to +125°C	ROM (Bytes)	RAM (Bytes)	I/O Pins	Serial I/O	Interrupt	Stack	Timer Base Counters	Size (Pins)	Other*
HPC46003	HPC36003	HPC16003	ROMless	256	52	YES	8 Sources	In RAM	8	68	4 ICR's
HPC46004	HPC36004	HPC16004	ROMless	512	52	YES	8 Sources	In RAM	8	68	4 ICR's
HPC46064	HPC36064	HPC16064	16.0k	512	52	YES	8 Sources	In RAM	8		4 ICR's
HPC46083	HPC36083	HPC16083	8.0k	256	52	YES	8 Sources	In RAM	8	68	4 ICR's
HPC46104	HPC36104	HPC16104	ROMless	512	52	YES	8 Sources	In RAM	8		4 ICR's & 8 CH A/D
HPC46164	HPC36164	HPC16164	16.0k	512	52	YES	8 Sources	In RAM	8	68	4 ICR's & 8 CH A/D
HPC46400	HPC36400	HPC16400	N/A	256	56	YES	8 Sources	In RAM	4	68	HDLC & DMA

*ICR = Input Capture Registers
HDLC = High-Level Data Link Control
PEARL = Port Expanded and Recreation Logic

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PRELIMINARY

HPC16083/HPC26083/HPC36083/HPC46083/ HPC16003/HPC26003/HPC36003/HPC46003 High-Performance microControllers

General Description

The HPC16083 and HPC16003 are members of the HPC™ family of High Performance microControllers. Each member of the family has the same core CPU with a unique memory and I/O configuration to suit specific applications. The HPC16083 has 8k bytes of on-chip ROM. The HPC16003 has no on-chip ROM and is intended for use with external direct memory. Each part is fabricated in National's advanced microCMOS technology. This process combined with an advanced architecture provides fast, flexible I/O control, efficient data manipulation, and high speed computation.

The HPC devices are complete microcomputers on a single chip. All system timing, internal logic, ROM, RAM, and I/O are provided on the chip to produce a cost effective solution for high performance applications. On-chip functions such as UART, up to eight 16-bit timers with 4 input capture registers, vectored interrupts, WATCHDOG™ logic and MICRO-WIRE/PLUS™ provide a high level of system integration. The ability to address up to 64k bytes of external memory enables the HPC to be used in powerful applications typically performed by microprocessors and expensive peripheral chips. The term "HPC16083" is used throughout this datasheet to refer to the HPC16083 and HPC16003 devices unless otherwise specified.

The microCMOS process results in very low current drain and enables the user to select the optimum speed/power product for his system. The IDLE and HALT modes provide further current savings. The HPC is available in 68-pin PLCC, LCC, LDCC, PGA and 84-Pin TapePak® packages.

Features

- HPC family—core features:
  - 16-bit architecture, both byte and word
  - 16-bit data bus, ALU, and registers
  - 64k bytes of external direct memory addressing
  - FAST—200 ns for fastest instruction when using 20.0 MHz clock, 134 ns at 30 MHz
  - High code efficiency—most instructions are single byte
  - 16 x 16 multiply and 32 x 16 divide
  - Eight vectored interrupt sources
  - Four 16-bit timer/counters with 4 synchronous outputs and WATCHDOG logic
  - MICROWIRE/PLUS serial I/O interface
  - CMOS—very low power with two power save modes: IDLE and HALT
- UART—full duplex, programmable baud rate
- Four additional 16-bit timer/counters with pulse width modulated outputs
- Four input capture registers
- 52 general purpose I/O lines (memory mapped)
- 8k bytes of ROM, 256 bytes of RAM on chip
- ROMless version available (HPC16003)
- Commercial (0°C to +70°C), industrial (−40°C to +85°C), automotive (−40°C to +105°C) and military (−55°C to +125°C) temperature ranges

Block Diagram (HPC16083 with 8k ROM shown)

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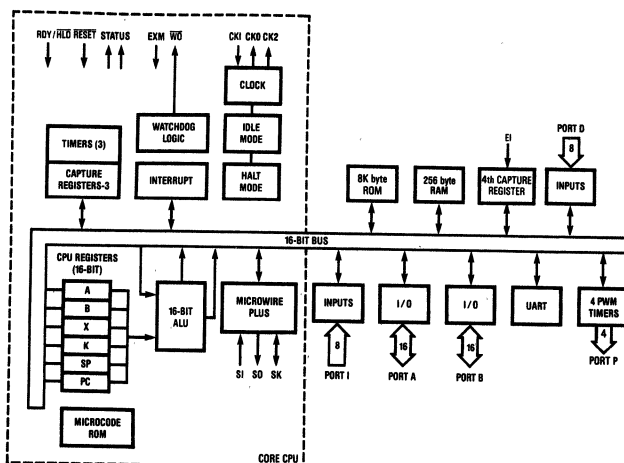
HPC16164/26164/36164/46164
HPC16104/26104/36104/46104
HPC16064/26064/36064/46064
HPC16004/26004/36004/46004
High-Performance microControllers with A/D

General Description

The HPC16164, HPC16104, HPC16064 and HPC16004 are members of the HPC™ family of High Performance micro-Controllers. Each member of the family has the same core CPU with a unique memory and I/O configuration to suit specific applications. The HPC16164 and HPC16104 have 16k bytes of on-chip ROM. The HPC16104 and HPC16104 have no on-chip ROM and is intended for use with external memory. Each part is fabricated in National's advanced microCMOS technology. This process combined with an advanced architecture provides fast, flexible I/O control, efficient data manipulation, and high speed computation.

The HPC devices are complete microcomputers on a single chip. All system timing, internal logic, ROM, RAM, and I/O are provided on the chip to produce a cost effective solution for high performance applications. On-chip functions such as UART, up to eight 16-bit timers with 4 input capture registers, vectored interrupts, WATCHDOG logic and MICRO-WIRE/PLUS™ provide a high level of system integration. The ability to address up to 64k bytes of external memory enables the HPC to be used in powerful applications typically performed by microprocessors and expensive peripheral chips. The term "HPC16164" is used throughout this datasheet to refer to the HPC16164, HPC16104, HPC16064 and HPC16004 devices unless otherwise specified.

The HPC16164 and HPC16104 have, as an on-board peripheral, an 8-channel 8-bit Analog-to-Digital Converter. This A/D converter can operate in single-ended mode where the analog input voltage is applied across one of the eight in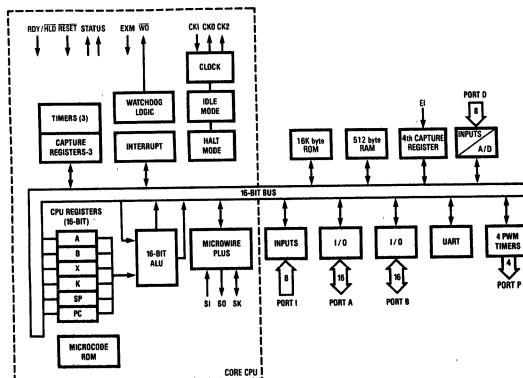put channels (D0–D7) and AGND. The A/D converter can also operate in differential mode where the analog input voltage is applied across two adjacent input channels. The A/D converter will convert up to eight channels in single-ended mode and up to four channel pairs in differential mode. The HPC16064 and HPC16004 do not have onboard A/D.

The microCMOS process results in very low current drain and enables the user to select the optimum speed/power product for his system. The IDLE and HALT modes provide further current savings. The HPC is available in 68-pin PLCC, LCC, LDCC, PGA and 84-pin TapePak® packages.

Features

- HPC family—core features:
  — 16-bit architecture, both byte and word
  — 16-bit data bus, ALU, and registers
  — 64k bytes of external direct memory addressing
  — FAST—200 ns for fastest instruction when using 20.0 MHz clock
  — High code efficiency—most instructions are single byte
  — 16 x 16 multiply and 32 x 16 divide
  — Eight vectored interrupt sources
  — Four 16-bit timer/counters with 4 synchronous outputs and WATCHDOG logic
  — MICROWIRE/PLUS serial I/O interface
  — CMOS—very low power with two power save modes: IDLE and HALT
- A/D—8-channel 8-bit analog-to-digital converter with conversion time minimum 6.6 μs for single conversion
- A/D—supports conversions in "quiet mode"

Block Diagram (HPC16164 with 16k ROM shown)

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