Appendix 1

PIC16F87XA
Data Sheet

28/40/44-Pin Enhanced Flash Microcontrollers
**PIC16F87XA**

28/40/44-Pin Enhanced Flash Microcontrollers

**Devices Included in this Data Sheet:**
- PIC16F873A
- PIC16F874A
- PIC16F876A
- PIC16F877A

**High-Performance RISC CPU:**
- Only 35 single-word instructions to learn
- All single-cycle instructions except for program branches, which are two-cycle
- Operating speed: DC = 20 MHz clock input
  DC = 200 ns instruction cycle
- Up to 8K x 14 words of Flash Program Memory,
  Up to 368 x 8 bytes of Data Memory (RAM),
  Up to 256 x 8 bytes of EEPROM Data Memory
- Pinout compatible to other 28-pin or 40/44-pin PIC16CXX and PIC16FXX microcontrollers

**Peripheral Features:**
- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler, can be incremented during Sleep via external crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Two Capture, Compare, PWM modules
  - Capture is 16-bit, max. resolution is 12.5 ns
  - Compare is 16-bit, max. resolution is 200 ns
  - PWM max. resolution is 10-bit
- Synchronous Serial Port (SSP) with SPI™ (Master mode) and I²C™ (Master/Slave)
- Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with 9-bit address detection
- Parallel Slave Port (PSP) – 8 bits wide with external RD, WR and CS controls (40/44-pin only)
- Brown-out detection circuitry for Brown-out Reset (BOR)

**Analog Features:**
- 10-bit, up to 8-channel Analog-to-Digital Converter (A/D)
- Brown-out Reset (BOR)
- Analog Comparator module with:
  - Two analog comparators
  - Programmable on-chip voltage reference (VREF) module
  - Programmable input multiplexing from device inputs and internal voltage reference
  - Comparator outputs are externally accessible

**Special Microcontroller Features:**
- 100,000 erase/write cycle Enhanced Flash program memory typical
- 1,000,000 erase/write cycle Data EEPROM memory typical
- Data EEPROM Retention > 40 years
- Self-reprogrammable under software control
- In-Circuit Serial Programming™ (ICSP™) via two pins
- Single-supply 5V In-Circuit Serial Programming
- Watchdog Timer (MDT) with its own on-chip RC oscillator for reliable operation
- Programmable code protection
- Power saving Sleep mode
- Selectable oscillator options
- In-Circuit Debug (ICD) via two pins

**CMOS Technology:**
- Low-power, high-speed Flash/EEPROM technology
- Fully static design
- Wide operating voltage range (2.0V to 5.5V)
- Commercial and Industrial temperature ranges
- Low-power consumption

<table>
<thead>
<tr>
<th>Device</th>
<th>Program Memory (Bytes)</th>
<th>Data Memory (Bytes)</th>
<th>EEPROM (Bytes)</th>
<th>I/O</th>
<th>10-bit A/D (ch)</th>
<th>CCP (PWM)</th>
<th>MSSP</th>
<th>Master</th>
<th>USART</th>
<th>Timers</th>
<th>Comparators</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIC16F873A</td>
<td>7.2K</td>
<td>4096</td>
<td>192</td>
<td>128</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>2</td>
</tr>
<tr>
<td>PIC16F874A</td>
<td>7.2K</td>
<td>4096</td>
<td>192</td>
<td>128</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>2</td>
</tr>
<tr>
<td>PIC16F876A</td>
<td>14.3K</td>
<td>8192</td>
<td>368</td>
<td>256</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>2</td>
</tr>
<tr>
<td>PIC16F877A</td>
<td>14.3K</td>
<td>8192</td>
<td>368</td>
<td>256</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>2</td>
</tr>
</tbody>
</table>

© 2003 Microchip Technology Inc.
Appendix 2

LPC2141/42/44/46/48
Single-chip 16-bit/32-bit microcontrollers; up to 512 kB flash with ISP/IAP, USB 2.0 full-speed device, 10-bit ADC and DAC
Rev. 04 — 17 November 2008

Product data sheet
1. General description

The LPC2141/42/44/46/48 microcontrollers are based on a 16-bit/32-bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combine the microcontroller with embedded high-speed flash memory ranging from 32 kB to 512 kB. A 128-bit wide memory interface and a unique accelerator architecture enable 32-bit code execution at the maximum clock rate. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30% with minimal performance penalty.

Due to their tiny size and low power consumption, LPC2141/42/44/46/48 are ideal for applications where miniaturization is a key requirement, such as access control and point-of-sale. Serial communications interfaces ranging from a USB 2.0 Full-speed device, multiple UARTs, SPI, SSP to PC-bus and on-chip SRAM of 8 kB up to 40 kB, make these devices very well suited for communication gateways and protocol converters, soft modems, voice recognition and low end imaging, providing both large buffer size and high processing power. Various 32-bit timers, single or dual 10-bit ADC(s), 10-bit DAC, PWM channels and 45 fast GPIO lines with up to nine edge or level sensitive external interrupt pins make these microcontrollers suitable for industrial control and medical systems.

2. Features

2.1 Key features

- 16-bit/32-bit ARM7TDMI-S microcontroller in a tiny LQFP64 package.
- 8 kB to 40 kB of on-chip static RAM and 32 kB to 512 kB of on-chip flash memory.
- 128-bit wide interface/accelerator enables high-speed 60 MHz operation.
- In-System Programming/In-Application Programming (ISP/IAP) via on-chip boot loader software. Single flash sector or full chip erase in 400 ms and programming of 256 B in 1 ms.
- EmbeddedICE RT and Embedded Trace interfaces offer real-time debugging with the on-chip RealMonitor software and high-speed tracing of instruction execution.
- USB 2.0 Full-speed compliant device controller with 2 kB of endpoint RAM. In addition, the LPC2146/48 provides 8 kB of on-chip RAM accessible to USB by DMA.
- One or two (LPC2141/42 vs. LPC2144/46/48) 10-bit ADCs provide a total of 6/14 analog inputs, with conversion times as low as 2.44 µs per channel.
- Single 10-bit DAC provides variable analog output (LPC2142/44/46/48 only).
- Two 32-bit timers/external event counters (with four capture and four compare channels each), PWM unit (six outputs) and watchdog.
NXP Semiconductors

LPC2141/2/4/44/46/48
Single-chip 16-bit/32-bit microcontrollers

- Low power Real-Time Clock (RTC) with independent power and 32 kHz clock input.
- Multiple serial interfaces including two UARTs (16C550), two Fast I²C-bus (400 kbit/s), SPI and SSP with buffering and variable data length capabilities.
- Vectored Interrupt Controller (VIC) with configurable priorities and vector addresses.
- Up to 45 of 5 V tolerant fast general purpose I/O pins in a tiny LQFP64 package.
- Up to 21 external interrupt pins available.
- 60 MHz maximum CPU clock available from programmable on-chip PLL with settling time of 100 µs.
- On-chip integrated oscillator operates with an external crystal from 1 MHz to 25 MHz.
- Power saving modes include Idle and Power-down.
- Individual enable/disable of peripheral functions as well as peripheral clock scaling for additional power optimization.
- Processor wake-up from Power-down mode via external interrupt or BOD.
- Single power supply chip with POR and BOD circuits:
  - CPU operating voltage range of 3.0 V to 3.6 V (3.3 V ± 10 %) with 5 V tolerant I/O pads.

3. Ordering information

Table 1. Ordering information

<table>
<thead>
<tr>
<th>Type number</th>
<th>Package</th>
<th>Description</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPC2141FBD64</td>
<td>LQFP64</td>
<td>plastic low profile quad flat package; 64 leads; body 10 × 10 × 1.4 mm</td>
<td>SOT314-2</td>
</tr>
<tr>
<td>LPC2142FBD64</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LPC2144FBD64</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LPC2146FBD64</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LPC2148FBD64</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.1 Ordering options

Table 2. Ordering options

<table>
<thead>
<tr>
<th>Type number</th>
<th>Flash memory</th>
<th>RAM</th>
<th>Endpoint USB RAM</th>
<th>ADC (channels overall)</th>
<th>DAC</th>
<th>Temperature range</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPC2141FBD64</td>
<td>32 kB</td>
<td>8 kB</td>
<td>2 kB</td>
<td>1 (6 channels)</td>
<td></td>
<td>-40 °C to +85 °C</td>
</tr>
<tr>
<td>LPC2142FBD64</td>
<td>64 kB</td>
<td>16 kB</td>
<td>2 kB</td>
<td>1 (6 channels)</td>
<td>1</td>
<td>-40 °C to +85 °C</td>
</tr>
<tr>
<td>LPC2144FBD64</td>
<td>128 kB</td>
<td>16 kB</td>
<td>2 kB</td>
<td>2 (14 channels)</td>
<td>1</td>
<td>-40 °C to +85 °C</td>
</tr>
<tr>
<td>LPC2146FBD64</td>
<td>256 kB</td>
<td>32 kB + 8 kB shared with USB DMA[1]</td>
<td>2 kB</td>
<td>2 (14 channels)</td>
<td>1</td>
<td>-40 °C to +85 °C</td>
</tr>
<tr>
<td>LPC2148FBD64</td>
<td>512 kB</td>
<td>32 kB + 8 kB shared with USB DMA[1]</td>
<td>2 kB</td>
<td>2 (14 channels)</td>
<td>1</td>
<td>-40 °C to +85 °C</td>
</tr>
</tbody>
</table>

[1] While the USB DMA is the primary user of the additional 8 kB RAM, this RAM is also accessible at any time by the CPU as a general purpose RAM for data and code storage.
Appendix 3

ATMEL Corporation

ATMEGA16 Datasheet
Features

- High-performance, Low-power Atmel® AVR® 8-bit Microcontroller
- Advanced RISC Architecture
  - 131 Powerful Instructions — Most Single-cycle Cycle Execution
  - 32 x 8 General Purpose Working Registers
  - Fully Static Operation
  - Up to 16 MIPS Throughput at 16 MHz
  - On-chip 2-cycle Multiplier
- High Endurance Non-volatile Memory segments
  - 16 Kbytes of In-System Self-programmable Flash program memory
  - 512 Bytes EEPROM
  - 1 Kbyte Internal SRAM
  - Write/Erase Cycles: 10,000 Flash/100,000 EEPROM
  - Data retention: 20 years at 85°C/100 years at 25°C
  - Optional Boot Code Section with Independent Lock Bits
  - In-System Programming by On-chip Boot Program
  - True Read-While-Write Operation
  - Programming Lock for Software Security
- JTAG (IEEE std. 1149.1 Compliant) Interface
  - Boundary-scan Capabilities According to the JTAG Standard
  - Extensive On-chip Debug Support
  - Programming of Flash, EEPROM, Fuses, and Lock Bits through the JTAG Interface
- Peripheral Features
  - Two 8-bit Timer/Counters with Separate Prescalers and Compare Modes
  - One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
  - Real Time Counter with Separate Oscillator
  - Four PWM Channels
  - 8-channel, 10-bit ADC
  - 8 Single-ended Channels
  - 7 Differential Channels in TQFP Package Only
  - 2 Differential Channels with Programmable Gain at 1x, 10x, or 200x
  - Byte-oriented Two-wire Serial Interface
  - Programmable Serial USART
  - Master/Slave SPI Serial Interface
  - Programmable Watchdog Timer with Separate On-chip Oscillator
  - On-chip Analog Comparator
- Special Microcontroller Features
  - Power-on Reset and Programmable Brown-out Detection
  - Internal Calibrated RC Oscillator
  - External and Internal Interrupt Sources
  - Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby and Extended Standby
- I/O and Packages
  - 32 Programmable I/O Lines
  - 40-pin PDIP, 44-lead TQFP, and 44-pad QFN/MLF
- Operating Voltages
  - 2.7V - 5.5V for ATmega16L
  - 4.5V - 5.5V for ATmega16
- Speed Grades
  - 0 - 8 MHz for ATmega16L
  - 0 - 16 MHz for ATmega16
- Power Consumption @ 1 MHz, 3V, and 25°C for ATmega16L
  - Active: 1.1 mA
  - Idle Mode: 0.35 mA
  - Power-down Mode: < 1 µA

ATmega16
ATmega16L

Summary
Overview

The ATmega16 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega16 achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.

Block Diagram

Figure 2. Block Diagram