Preface

In December 2009[1] Federico Faggin (see p. 55) wrote "TWO inventions have shaped our modern world more that any other: the engine and the computer. Where the engine captured and extended the human capacity to do physical work, the computer did the same for the capacity of the human brain to think, organize and control...". Federico Faggin, who was part of the team that developed the Intel 4004, the world's first commercially successful microprocessor released in 1971, was commissioned to write this article by *New Scientist* to celebrate the microprocessor's victory in a poll to find the discovery that has had the greatest impact on the world in the past 50 years.[2] That having been said, this was from a field of only ten nominated discoveries, but nevertheless it won with 48% of the vote, followed by the World Wide Web at 31%; which in reality is only made possible by the microprocessor.

Microprocessors and their microcontroller derivatives are a widespread, if rather invisible, part of the infrastructure of our twenty-first-century electronic information-based society. In 1998, it was estimated[3] that hidden in every home there were about 100 microcontrollers and microprocessors: in the singing birthday card, washing machine, microwave oven, television controller, telephone, personal computer and so on. About 20 more lurked in the average family car, for example, monitoring in-tire radio pressure sensors and displaying critical data through a control area network (CAN). As anyone will testify if they have driven a modern car, these figures can be dramatically revised upwards. Your pocket alone will carry several disguised as smart credit, debit and employment cards, bus passes and so on. Even your pets may be chipped in case they stray too far. Indeed, there is more computing power in a singing birthday card than there was in the world in 1948, when the first von-Neumann computer was commissioned at the University of Manchester.

[1] *New Scientist*, Computers top the poll of modern discoveries, vol. 70, no. 2737, 2 December, 2009.

[2] http://newscientist.com/special/big-impact.

[3] *New Scientist*, vol. 59, no. 2141, 4 July 1998, p. 139.

Over 4 billion such devices are sold each year to implement the intelligence of these 'intelligent' electronic devices, ranging from smart eggtimers through to aircraft management systems. The evolution of the microprocessor from the first Intel device introduced in 1971 has revolutionised the structure of society, effectively creating the second Industrial Revolution at the beginning of the twenty-first century. Although the microprocessor is better known for its role in powering the ubiquitous PC, where raw computing power is the goal, sales of microprocessors such as the Intel Pentium represent only around 2% of the total volume. The vast majority of sales are of low-cost microcontrollers embedded into a dedicated-function digital electronic device, such as the smart card. Here the emphasis is on the integration of the core processor with memory and input/output resources in the one chip. This integrated computing system is known as a *microcontroller*.

In seeking to write a book in this area, the overall objective was to get the reader up-to-speed in designing small embedded microcontroller-based systems, rather than using microcontrollers as a vehicle to illustrate computer architecture in the traditional manner. This will hopefully give the reader confidence that, even at such an introductory level, he/she can design, construct, and program a complete working embedded system.

Given the practical nature of this material, real-world hardware and software products are used throughout to illustrate the material. The microcontroller market is still dominated by devices that operate on 8-bit data (although 4–16 and 32-bit examples are readily available) like early microprocessors and unlike the 64-bit Intel Pentium family 'heavy brigade'. In contrast, the essence of the microcontroller lies in its high system-integration/low-cost profile. Power can be increased by distributing processors throughout the system. Thus, for example, a robot arm may have a microcontroller for each joint implementing simple local processes and communicating with a more powerful processor making overall executive decisions.

In choosing a target architecture, acceptance in the industrial market, easy availability, and low-cost development software have made the Microchip family one of the most popular choices as the pedagogic vehicle in learning microprocessor/microcontroller technology at all levels of electronic engineering from grade school to university. In particular, the reduced instruction set, together with the relatively simple innovative architecture, reduces the learning curve. In addition to their industrial and educational roles, the PIC® MCU families are also the mainstay of hobbyist projects, as a leaf through any electronics magazine will show.

Microchip, Inc., is a relatively recent entrant to the microcontroller market with its family of Harvard architecture PIC devices introduced in 1989. By 2006, Microchip was the largest producer of 8-bit units—after a 20-year tousle with the market leaders Motorola; which is now spun-off its activities in this field to Freescale Semiconductor.

In 2001 (2nd edn. 2005) Springer published by first book on PIC microcontrollers; *The Quintessential PIC Microcontroller*. This is based on what was the mainstream mid-range 8-bit family, the PIC16 series. Although this range still continues to expand, with a new enhanced core introduced in 2009, the enhanced-range PIC18 has now become the mainstream as well as the most advanced 8-bit family.

With this in mind, a complete rewrite was in order. A new edition would not fit the bill, both because the PIC16 family is still very much alive and also although the PIC18 family is upwards compatible, there are considerable changes. However, the aims and structure very much follow the *Quintessential* format.

This book is split into three parts. Part I covers sufficient digital, logic and computer architecture to act as a foundation for the microcontroller engineering topics presented in the rest of the text. Inclusion of this material makes the text suitable for stand-alone usage, as it does not require a prerequisite digital systems module.

Part II looks mainly at the software aspects of the enhanced-range PIC microcontroller family, its instruction set, how to program it at assembly and high-level **C** coding levels, and how the microcontroller handles subroutines and interrupts. Although the PIC18 family is the exemplar, both architecture and software are comparable to earlier families and indeed the 16-bit PIC24 device range.

Part III moves on to the hardware aspects of interfacing and interrupt handling, with the integration of the hardware and software being a constant theme throughout. Parallel and serial input/output, timing, analog, and EEPROM data-handling techniques are covered. A practical build and program case study integrates the previous material into a working system, as well as illustrating simple testing strategies.

With the exception of the first two and last chapter, all chapters have both fully worked examples and self-assessment questions. As an extension to this, an associated Web site has the following facilities:

- Solutions to self-assessment questions.
- Further self-assessment questions.
- Additional material.
- Source code for all examples and questions in the text.
- Pointers to development software and data sheets for devices used in the book.
- Errata.
- Feedback from readers.

You can visit http://www.springer.com, search for the text and click on *Author's Manual* to find the current web location of this site.

Hopefully, any gremlins have been exorcised, but if you find any or have any other suggestions, I will be happy to acknowledge such communications via the Web site.

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Springer

http://www.springer.com/978-1-84996-228-5

The Essential PIC18® Microcontroller
Katzen, S.
2010, XII, 612 p., Hardcover
ISBN: 978-1-84996-228-5