Microprocessors and Microcomputer Systems

Second Edition

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preface

This topical state-of-the-art analysis is an integrated digest of the large volume of information presently available on the subject of digital computers as oriented toward the latest innovations, microprocessor and microcomputer.

With an unpredictably short learning phase covering more than 25 years of changing technology, the digital computer has swiftly moved at an accelerated pace of development, from the relay to the vacuum tube, from the tube to the discrete solid-state temperature-sensitive germanium transistor, parametrics and tunnel diode, from the discrete transistor to the stable silicon monolithic individual integrated circuit (IC), then from the IC to the small- and medium-scale integration (MSI) of the minis, and finally from the MSI to the high-technology of the mass-produced *very large-scale* integrated form of microelectronics, VLSI, to present eventually a dedicated powerful Microcomputer-on-a-chip that performs at speeds enhanced by 4 to 6 orders of magnitude—as compared to the original vacuum-tube versions. Chapter 12 presents a brief exposition of the escalating popularity of the application of low-cost CRT-keyboard microcomputer systems in Personal Computing, by using available BASIC and PASCAL programs on tape cassettes and mini floppy diskettes.

With each advance in the reduction of size, the digital computer has achieved progressively higher reliability in operation. With regard to its flexibility and its computation capacity, the microcomputer is more powerful than the first- and second-generation digital computers built during the 1950s to occupy oversized rooms.

The author presents this analysis on the presently available microprocessors and microcomputer systems, and the associated LSI hardware and firmware, at a time when the technology of microelectronics is fairly well established. The various topics in the text are chosen in order to facilitate communication between not only hardware and software specialists, but also marketing and training personnel. In view of the unavoidable terminology involved, two complete readings are recommended for a better grasp of the hardware and software terms.

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1-1. SCOPE

New digital computer systems under stored program control, using microprocessors and programmable read-only memories (PROM) and random-access read/write memories (RAM), allow greater capacity and flexibility at low cost and minimum requirements of space and power. Even seemingly small desk-sets have a capability to turn into interactive computer terminals. And, with the introduction of optical links via fiber-optic mini-waveguide cables, high-capacity, interoffice or intersystem data exchange is a feasible proposition today in business, defense, and communications systems. A **microcomputer on a single-chip** is indeed a new powerful microtool that is comparable in performance to many of the original versions of minicomputers.

The **microprocessor** enables:

1. **A bus-oriented architecture**, thus requiring a minimum of hardware for peripheral support.
2. **Cost effectiveness** through built-in auxiliary features without any elaborate extra hardware, by replacing existing voluminous disk, drum, and core random-access memory designs with extendable, high-density, fast-access, large-scale integrated (LSI), and very-large-scale integrated (VLSI) semi-conductor RAMs as working memory.
3. **Achievement of a "smart" or "intelligent" terminal** that can execute a sequence of instructions under the command of a built-in, extendable read-only memory (ROM).

The latest developments in the following **real-time and off-line digital computer applications** demand expedited progress in improved techniques of solid-state LSI and VLSI.

1. Large-network data communications.
2. Small-scale or large-scale, coded information exchange by radio, satellite, cable and land lines, and associated message-switching systems.

3. Transportation and navigation; dedicated mobile digital computers: and personal computing in home and business.
4. Automated process and numerical control; instrumentation in manufacturing and production; computer simulation; and interactive graphics/color portraits.
5. General-purpose digital computer systems in defense applications and government administration.
6. Business, statistics, and related data-processing systems.
7. Medical care, chemical analyses, medical diagnosis, and decisionmaking.
8. Education, recreation, printing, word processing, and video games.
9. Research in energy and pollution; prediction and optimization/pattern recognition.
10. Research in academic establishments, such as implementation of mathematical models for complex problems in Operations Research, etc.

LSI and **VLSI**, in turn, are enabling the evolution of more and more sophisticated microprocessors and programmable logic arrays (PLAs) and high-density, high-speed, semiconductor memories. The PLAs replace the previous and present hard-wired logic using small- and medium-scale integrated circuits. These new LSI/VLSI components simply outperform and undersell the older alternative technologies in the relevant fields, and considerably extend the scope of their performance and create large-scale usage in yet newer areas of applications. Fairly low-priced, low-power, desktop microcomputer systems have an equivalent capability, via suitable interface, to replace at least some of the previous simpler, leased, high-priced, medium-scale, general-purpose digital computer operating systems. These new systems incidentally enable greater flexibility, by means of plug-in firmware, to meet routine software requirements. Some microprocessors in instrumentation provide not only internal and external controls, but also reduce maintenance costs by furnishing auxiliary internal fault-diagnosis, self-test, and self-calibration. The latest dedicated single-chip microcomputer can be squeezed onto a 200-mil-square substrate, requiring not more than a few hundred milliwatts. And all this happened within an amazingly short span of 15 years; a **silicon monolithic substrate**, less than a quarter of an inch on an edge can incorporate well over 100,000 solid-state components. The cost of each functional component has dropped by a factor of more than 1,000 or so—from several dollars, to 30 cents, to presently a small fraction of a cent.

In fact, it is the so-called desktop **central processing unit (CPU)** of the minicomputer of the 1960s that started the revolution of the microelectronics by way of hybrid and medium-scale integration (MSI). They were based on the relevant thin-film and monolithic solid-state technologies. Today, the turnover has arrived for the less-complex full-fledged minicomputer operating systems, which use built-in assemblers and compilers for high-level languages (as plug-in tape cassettes or random-access floppy-disk auxiliary-memory libraries) and mini-CRT display and keyboard along with an adjoining mini-printer as peripherals. The latest IBM-5120 portable computer, using a built-in mini-CRT and associated keyboard and TV adapter, and the Digital Equipment Corporation's PDP-11/2 and 11/23 microcomputer systems occupy the high-end of these microcomputer operating systems from the viewpoints of cost and on-line operating facility. Brief data on these systems and other microcomputer systems presently available are included in this analysis for a comparative study of their architecture and facilities. The cross-reference tables in Chapter 9 for the various microprocessor types present a comparative set of reference data on their performance and capability. Chapter 12 is devoted to the large-scale application of microprocessors and microcomputer systems to personal computing in small-business and home hobby applications.