COMPUTING SYSTEM FUNDAMENTALS

An Approach Based on Microcomputers

KENNETH J. DANHOF
CAROL L. SMITH
Southern Illinois University at Carbondale

ADDISON-WESLEY PUBLISHING COMPANY

Reading, Massachusetts • Menlo Park, California
London • Amsterdam • Don Mills, Ontario • Sydney

This book is in the
ADDISON-WESLEY SERIES IN COMPUTER SCIENCE

Consulting Editor: Michael A. Harrison

Library of Congress Cataloging in Publication Data

Danhof, Kenneth J
Computing system fundamentals.

Includes bibliographical references and index.
1. Electronic digital computers. 2. Microcomputers.
I. Smith, Carol L., joint author. II. Title.
QA76.5.D252 001.6'4 79-14933
ISBN 0-201-01298-7

ISBN 0-201-01298-7
ABCDEFGH-MA-89876543210

5.2 MICROPROCESSORS AND ASSOCIATED COMPONENTS

We now consider the structure of the microcomputer in somewhat greater detail and examine some specific products.

As indicated earlier, the heart of any microcomputer system is the *microprocessor*. The microprocessor is a central processing unit, which, through the use of the latest techniques in electronic circuit miniaturization, is typically contained on a 40-pin package known as a DIP (*d*ual *i*nline *p*ins). The "chip" or portion of the DIP that contains the circuitry may be less than one square centimeter in size and contain more than 20,000 transistors (the building blocks from which gates are formed).

We shall consider both the M6800 and I8085 microprocessors noting common elements as well as some of the differences.

5.2.1 The M6800 System

The Motorola M6800 microprocessor is described in the block diagram in Fig. 5.5. The various buffers indicated in the diagram can be viewed as registers for holding data until it can be read by the appropriate source. Lines A_0–A_{15} are address lines by which the microprocessor addresses memory and other external devices. Lines D_0–D_7 are bidirectional data lines. The remaining lines are for processor and bus control. In particular, the read/write (R/W) line indicates whether the microprocessor is in a Read or Write state and the Valid Memory Address line (VMA) signals to memory (and peripherals) that the address lines contain a valid address. A bar over the label on a line (e.g., $\overline{\text{HALT}}$ in Fig. 5.5) indicates that the line is low (or 0) active as opposed to the normal high (or 1) active.

The microprocessor operates in a synchronous manner; its operations are synchronized by the cycles of a clock (actually two phases of the clock are required). The minimal clock-cycle time for the M6800 is one microsecond (1 μs). As we shall see, relative to the execution of a given instruction, the processor must perform a specific series of subinstructions or *microinstructions*, which consist of the most basic acts the processor can perform. (This is exactly the passage from Level 2 to Level 1 in Fig. 1.1.) One or more microinstructions can be performed per clock cycle, and thus each instruction involves a number of cycles.

Before considering the details of instruction execution, we must regard the microprocessor as a component in a larger system. A typical small microcomputer system is displayed in Fig. 5.6.

In Fig. 5.6, the RAM is a *Random Access Memory*—a memory unit that can be both written into and read from. RAMs are constructed from basic memory elements (flip-flops), as indicated in Sec. 5.1, and are *volatile*, so that when the power to a RAM is turned off, its contents are lost. A RAM might typically be organized as 128 (K/8) eight-bit words and be placed on a single

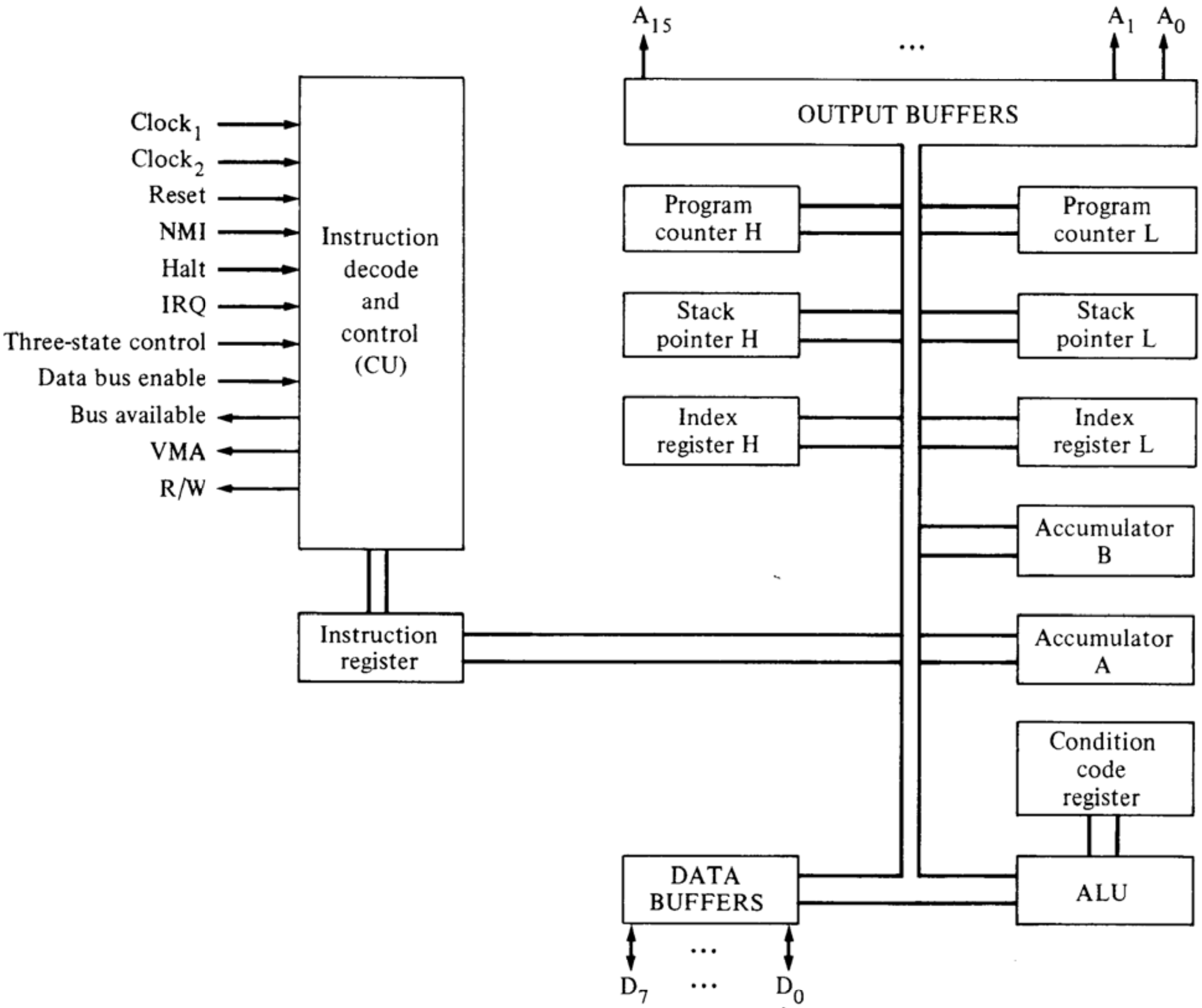

Fig. 5.5 Block diagram for M6800.

24-pin DIP (or it might occur as one of several components on a DIP). The individual storage cells of a RAM may be either *static* or *dynamic*. If static, the device need only be addressed when data is read or written. However, in dynamic RAMs the data must constantly be refreshed (read out and written back in) to preserve the quality of the data.

In the M6800-based system, lines A_{14}, A_{15} are used as RAM-select lines. Lines $A_0, \ldots, A_6$ select a particular word within the RAM and lines $A_7, \ldots, A_{13}$ select one from among several RAMs. The R/W control line selects the Read or Write mode within the RAM.

The ROM of Fig. 5.6 is a *Read Only Memory*. A ROM is essentially a combinational circuit that is written into once and may then be repeatedly read from. ROMs are nonvolatile and are consequently used to hold programs that are needed repeatedly in a computing system. For example, monitor programs

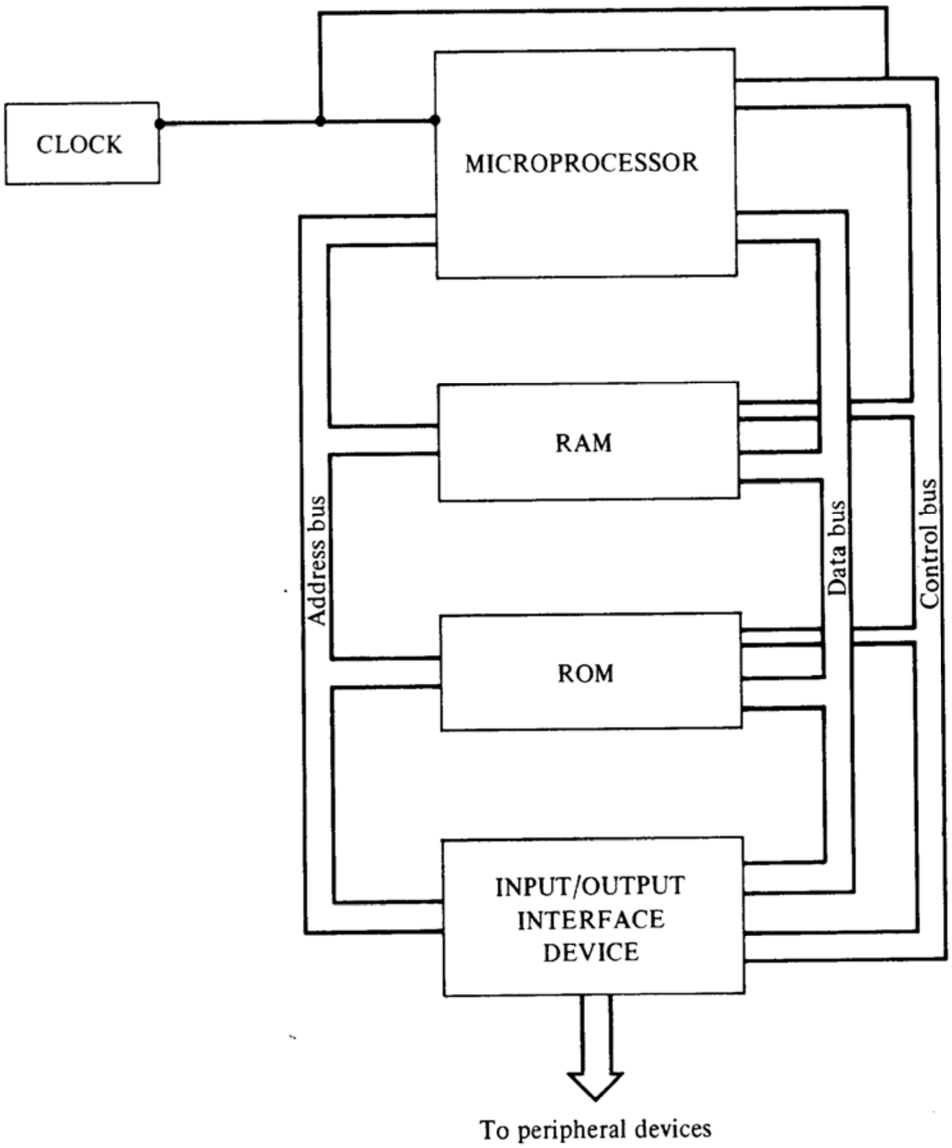

Fig. 5.6 Typical small system.

for microcomputers are generally stored in ROMs. Although ROMs are often "mask-programmed" at the factory, Programmable ROMs (PROMs) are somewhat easier and less expensive to program on a low-volume basis. Some PROMs are erasable: EPROMs can be erased by exposure to ultraviolet light.

In the M6800-based system, lines A_{14}, A_{15} are again used as ROM-select lines. $A_{10}, \ldots, A_{13}$ select one of several ROMs and $A_0, \ldots, A_9$ select a particular word within a ROM.

In general, the instructions of a program are stored in consecutive locations in a RAM or ROM. Prior to execution of the program, the address of the first instruction of the program is loaded into the microcomputer's program counter (PC).