CHAPTER 1

INTRODUCTION TO THE MC68000 EDUCATIONAL COMPUTER BOARD

The purpose of this manual is to provide the user with a comprehensive guide for understanding and utilizing the MC68000 Educational Computer Board. The computer board is intended primarily as a self-supporting means for evaluating and learning about the MC68000 16-bit microprocessor. Chapter 1 contains information describing the board and its system configuration.
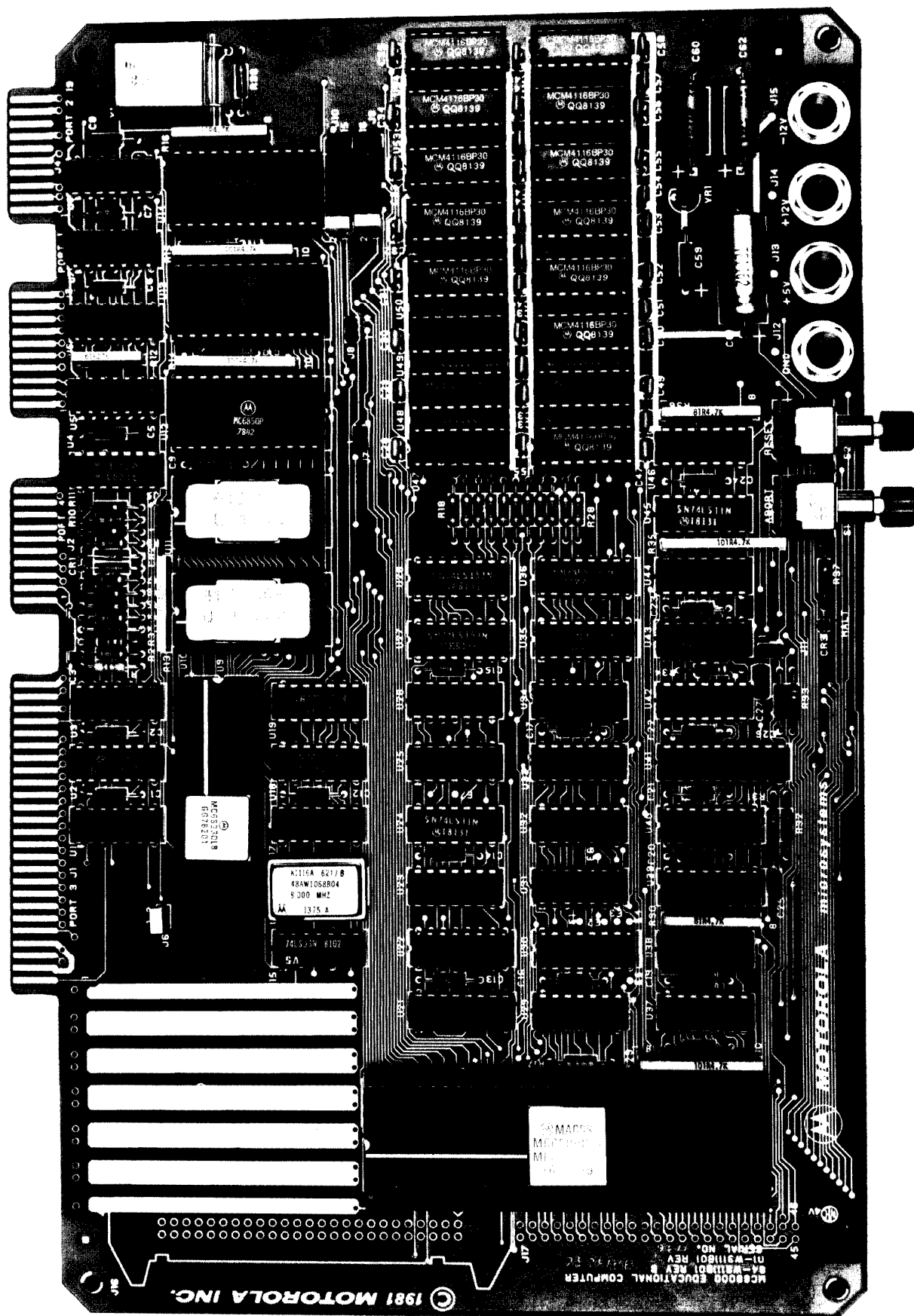
FIGURE 1-1. MC68000 Educational Computer Board

CHAPTER 1

INTRODUCTION TO THE MC68000 EDUCATIONAL COMPUTER BOARD

1.1 WHAT IS THE MC68000 EDUCATIONAL COMPUTER BOARD?

Intended primarily for training and educational use, including college-level
courses and industrial in-plant training, the MC68000 Educational Computer Board
(ECB) serves as an economical yet comprehensive introduction to systems based on
the M68000 family of microcomputer products. Located on a single small printed
circuit (PC) card (Figure 1-1), a complete microprocessor system is provided,
including an MC68000 16-bit microprocessor, memory, parallel input/output (I/O),
and serial communications I/O. The user must only connect an RS-232C-compatible
"dumb" terminal and power supplies to have a functional system.

For ease-of-use, the ECB has a resident firmware package that provides a
self-contained programming and operating environment. The firmware, aptly named
"TUTOR", provides the user with monitor/debug, assembly/disassembly, program
entry, and I/O control functions. Utilizing the capabilities provided by the
system, the user can investigate and learn the computing power and architectural
features of the MC68000. This system also provides a working example of the
microprocessor external bus structure and interface to memory and peripheral
devices.

The Educational Computer Board's features include:

    a. 4-megahertz MC68000 16-bit MPU.

    b. 32K bytes of dynamic RAM (DRAM) arranged as 16K x 16.

    c. 16K-byte firmware ROM/EPROM monitor addressed as 8K x 16.

    d. Two serial communication ports provided for a terminal and a host. Both
       are RS-232C-compatible and have selectable baud rates.

    e. Programs can be downloaded from or uploaded to a host system.

    f. A parallel port (16 data lines with handshake) can be used for I/O or for
       a Centronics-compatible printer interface.

    g. Audio tape serial I/O port.

    h. Self-contained operating firmware that provides monitor, debug, and
       disassembly/assembly functions.

    i. 24-bit programmable timer.

    j. Wire-wrap area provided for custom circuitry.

    k. RESET and ABORT function switches.

1.2 GENERAL HARDWARE DESCRIPTION

The MC68000 Educational Computer Board provides the RAM, ROM, timer, and I/O necessary for learning and evaluating the attributes of the MC68000. This microprocessor has a 16-bit data bus and a 23-bit address bus (A1-A23). The address bus is, in effect, 24 bits and provides a memory addressing range of 16 megabytes. The processor also has eight 32-bit data registers, seven 32-bit address registers, two 32-bit stack pointers, a 32-bit program counter, and a 16-bit status register. The MC68000 Data Sheet and User's Manual (MC68000UM), which are included in the ECB's documentation, describe the device in detail.

A 4-MHz MC68000 MPU is used on the educational board (a functional block diagram is shown in Figure 1-2). All the memory and I/O devices communicate with the MPU via a common parallel bus. The various functional areas of the board are described briefly in the following paragraphs.

1.2.1 System Memory

The system memory consists of 32K bytes of dynamic RAM and 16K bytes of ROM or EPROM (two 8-bit bytes = 1 word). The RAM is used both for scratchpad space for the TUTOR firmware and for user programs. Approximately 2K bytes are reserved for the monitor scratchpad; the remaining RAM (approximately 30K bytes) is available to the user. The system firmware occupies the 16K-byte read-only memory.

1.2.2 Serial Communications Ports

Two asynchronous serial communication ports, designated Port 1 for the Terminal and Port 2 for the Host, are provided on the board. Both of these ports are RS-232C-compatible (an E.I.A. standard). The terminal that provides user interface is connected to the educational computer via Port 1, and Port 2 can be connected to a modem or directly to a host computer. The host computer can be used to provide more powerful software capabilities such as program assembly, file management, and editing, and for downloading or uploading programs. Also, an operational condition called transparent mode can be used on the MEX68KECB. This transparent mode effectively bypasses the board and allows the terminal to communicate directly with the host. The terminal and host baud rates must be the same for this mode.

Both serial ports can be jumpered for various data transmission rates (110-9600 baud). Also, if required, either port can be modified to transmit and receive at different baud rates.

1.2.3 Programmable Timer

Contained within the MC68230 PI/T device is a 24-bit general purpose timer. The timer is a synchronous counter that can be used for generating or measuring both time delays and various frequencies. The timer can be clocked by a 5-bit prescaler or directly, and the clock source can be the 4-MHz system clock or an external clock.
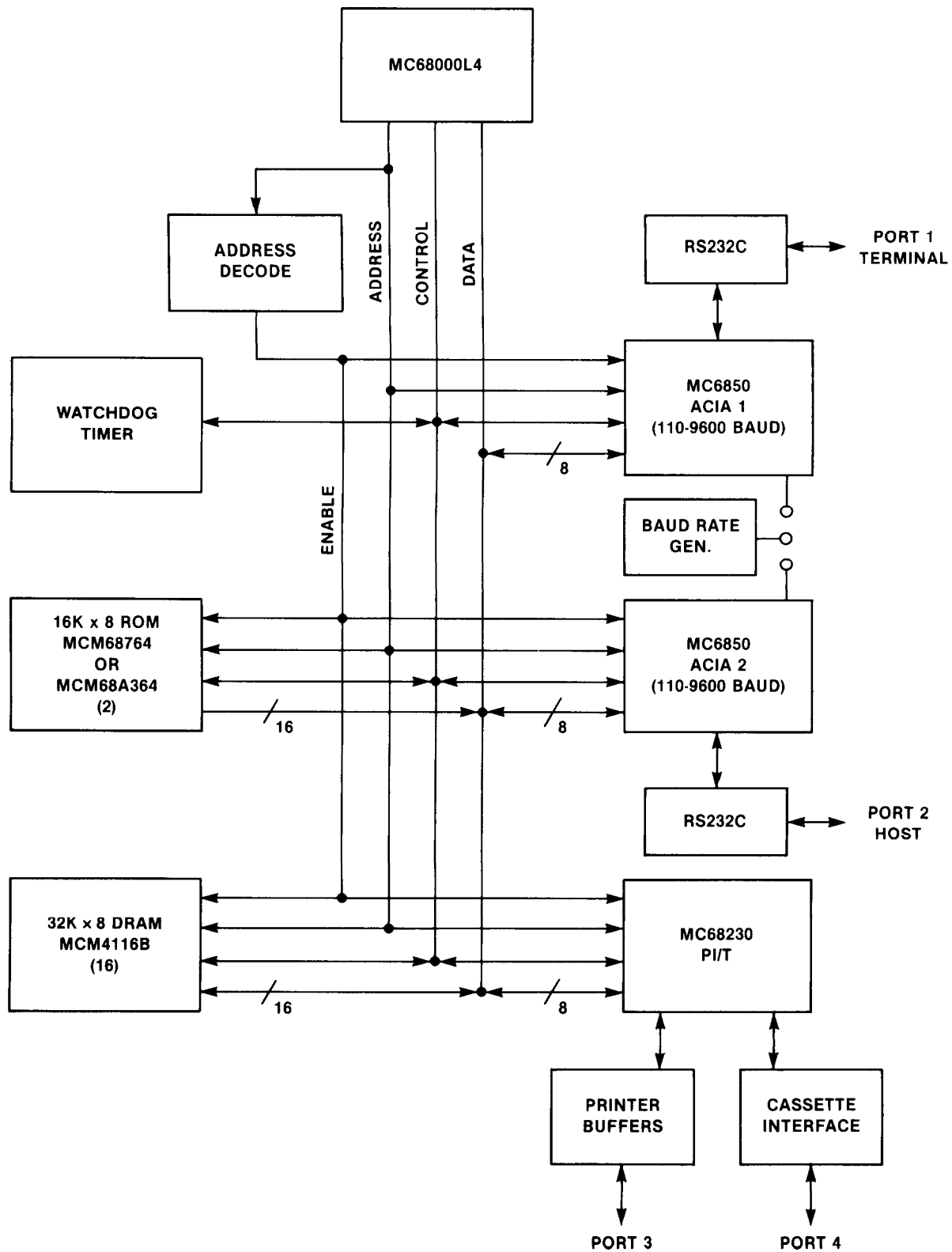
FIGURE 1-2. Functional Block Diagram

1.2.4 Parallel I/O Port (Printer Interface)

Also derived from the MC68230 PI/T device is the parallel I/O port (Port 3) that consists of eight buffered output lines plus two handshake lines, and eight unbuffered bidirectional lines plus two handshake lines. The buffering and port configuration is compatible with a Centronics-type printer interface. The I/O can also be used to interface into custom user devices.

1.2.5 Audio Tape Interface

Another I/O port (Port 4) is configured to provide a two-wire audio tape interface. A tape recorder can be connected to store and retrieve user programs. The audio tape interface has a data transmission rate of between 1000 and 2000 baud, depending on the bit stream.

1.3 SYSTEM CONFIGURATIONS

The MC68000 Educational Computer Board requires only the following items for the minimum system configuration (Figure 1-3):

    a. The MEX68KECB board
    b. Power supplies (+5 Vdc, +12 Vdc, -12 Vdc)
    c. RS-232C-compatible terminal
    d. Interface cables

With this configuration, the user can exercise the system, generate and modify code, and run programs. For hard copy (printout), tape storage, and/or interface to a host system, additional equipment is required. Any of these optional items can be used with the ECB.

Cables to interface the terminal, host, and printer can be manufactured by the user (directions are contained in this manual) or can be purchased from Motorola Systems. These include:

PART #	DESCRIPTION
M68RS232M	RS232 – Edge Connector/Male DB25 Conn
M68RS232F	RS232 – Edge Connector/Female DB25 Conn
MEX68PIC	Centronix Printer Cable

NOTE: It may be necessary to relocate the key in the edge connector for the specific port.

1.4 SOFTWARE CAPABILITIES

The Educational Computer Board operates under control of the "TUTOR" firmware. This 16K-byte package provides easy interface into the ECB and has excellent functionality. TUTOR is basically a system monitor which controls communication with the terminal and exercises other elements of the system. It provides debug capability, disassembly, assembly, and I/O control. All commands within TUTOR retain the same command line syntax and format as other Motorola MC68000-based products.

MINIMUM CONFIGURATION

TERMINAL
•"DUMB"
•RS232C COMP.

TO HOST
OR MODEM
(OPTIONAL)

AUDIO
CASSETTE
RECORDER
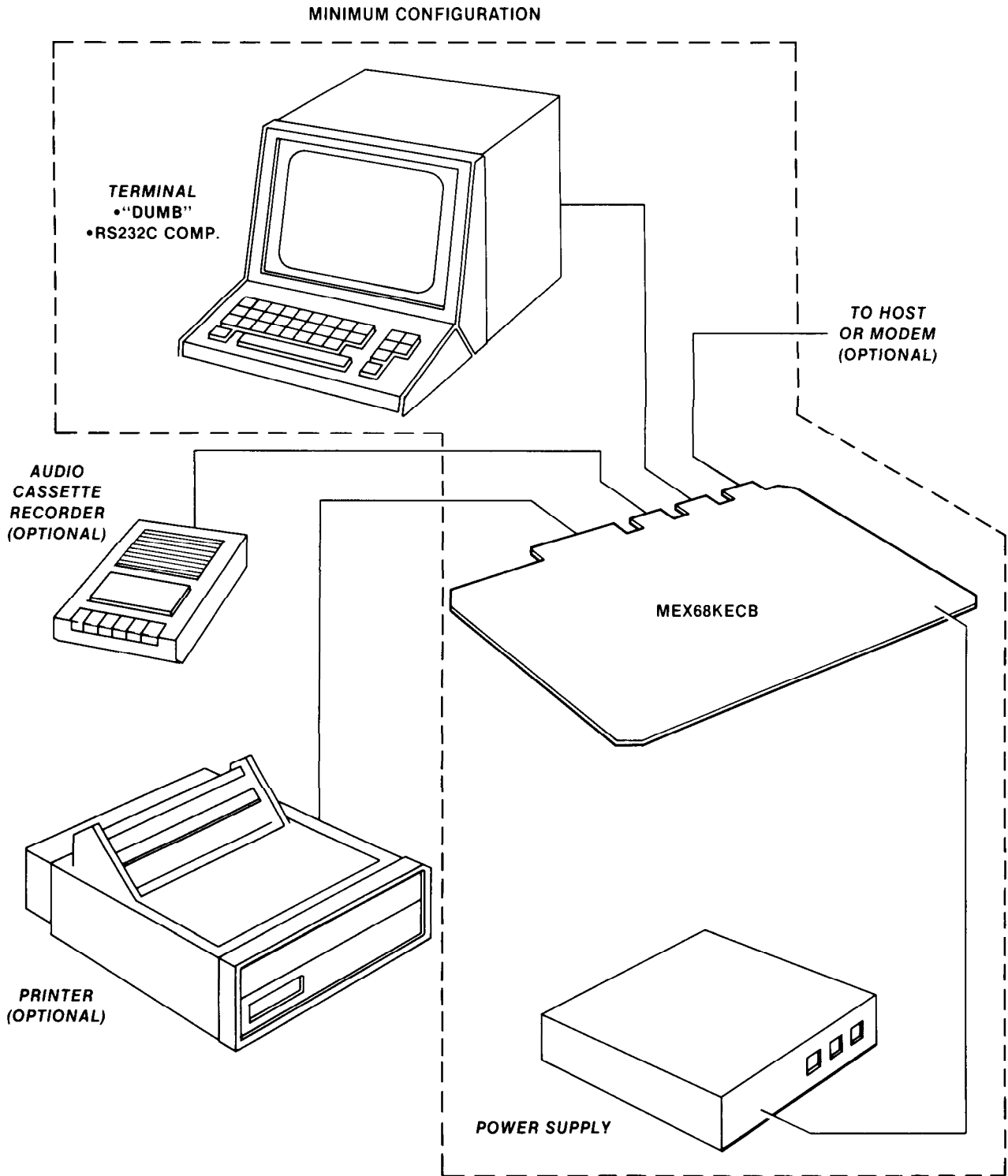(OPTIONAL)

MEX68KECB

PRINTER
(OPTIONAL)

POWER SUPPLY

FIGURE 1-3. System Configurations

An assembly listing of the TUTOR firmware, excluding the interactive assembler and disassembler modules, can be purchased from Motorola under the part number M68KTUTOR. Machine-readable source for all the modules can be purchased under part numbers:

M68KTUTORS — VERSAdos 8" floppy diskette
M68KTUTORT — VERSAdos hard disk cartridge

For program development, an interactive assembler/editor function is used in which the source program is not saved. Each instruction is translated into the proper object code and is stored in memory on a line-by-line basis at the time of entry. The assembler source statement is composed of operation and operand fields; line numbers, labels, and comments are not allowed.

In order to display an instruction, the firmware disassembles the object code and displays the instruction mnemonic and operands. Editing is done by re-entering a source statement.

If higher-level assembly capabilities are required, a macro assembler or cross assembler can be run on a host computer. Data can be uploaded and downloaded to the host via serial Port 2.

1.5 SPECIFICATIONS

Table 1-1 lists basic specifications for the MC68000 Educational Computer Board (MEX68KECB).

TABLE 1-1. Specifications

Microprocessor	MC68000 (4 MHz)
Input/Output	
Parallel I/O	MC68230 (16 data lines, 4 control lines) normally configured as Centronics-type printer interface. 24-bit programmable timer included in MC68230.
Cassette Interface	1300 baud serial audio tape.
Serial I/O Ports	Two — one terminal and one host (modem).
Interface	RS-232C interface.
Baud rate	Strap selectable: 110, 150, 300, 600, 1200, 2400 4800, 9600.
System clock	8-MHz crystal providing 4-MHz processor operation.
Memory	32K bytes RAM 16K bytes ROM
Power requirements (Typical)	+5.0 V/750 mA, +12 V/50 mA, -12 V/50 mA
Operating temperature	0 to 50° C
Board Dimensions (Approx.)	
L x W x H	7.5 in. x 10.5 in. x 1.5 in. (19 cm x 27 cm x 4 cm)