EXCLUSIVE!

The First
Motorola/AMI '6800' MPU Computer Project

Features compact size, simplified construction, built-in TTY interface, and low cost.

By H. Edward Roberts & Paul Van Baalen

Large-scale integration (LSI) has provided many useful IC chips for the hobbyist. One of the latest LSI devices is the microprocessor unit (MPU), which has made it possible to build microcomputers that are fairly easy to assemble at moderate cost. The most popular MPU's are the 8008 and 8080 due to their reasonable cost and wide availability in computer kits.

However, many knowledgeable hobbyists have been looking for a microcomputer built around one of a number of other MPU's available (just as some people would like to try a diesel or steam engine to replace the gasoline motor). Most of these readers have told us they were interested in the Motorola M6800 MPU (for one reason or another). Many also felt that the price of a microcomputer was still too high. Popular Electronics is therefore pleased to introduce the first microcomputer using the 6800 MPU in a design that substantially reduces cost.

The Altair 680 is a complete microcomputer built around the 6800 MPU available from Motorola and American Micro-Systems, Inc. Measuring a very compact 11 1/16"W x 11 1/16"D x 4 11/16"H (28.1 x 28.1 x 11.9 cm), the 680 is less than one-third the size of the Altair 8800. Although both computers have MPU's with the same memory capacity, the 680's smaller enclosure makes internal expandability significantly less. However, it is more than adequate for most applications. More importantly, the 680 costs less than half the price of the 8800 when the two machines are configured similarly in a minimum system.

Other attributes of the new computer include ease of assembly (only one large pc board), built-in TTY interface, and high speed (4-μs minimum cycle time). The last is some 10 to 50 times faster than earlier small computers built around the 8008 MPU but half the speed of the 8800.

Another meaningful consideration in a 6800-MPU computer design is the raft of instructional material readily available from Motorola Semiconductor Products, Inc., including the "M6800 Microprocessor Programming Manual." Too, the 6800 is TTL compatible and uses just one 5-volt power supply.
**Basic System Philosophy.** The basic MPU, memory, I/O (input/output), and power-supply circuits in the Altair 680 are located on a single printed circuit board. The addition of a compact power transformer makes this assembly a complete computer system. (Front-panel switch programming can be used, but in the absence of this assembly, PROM's or ROM's must be installed for programming.)

The front-panel assembly contains all the logic needed to reset, halt, or start the processor. Also, any memory cell can be read or written into from the front panel via 16 ADDRESS and eight DATA switches. Mounted on the front-panel circuit board is a 100-contact edge connector that permits either a full-programmability or a "turn-key" front panel. The latter eliminates all controls except restarting the processor. There are a number of applications where this is desirable to eliminate the possibility of having an operator affect the contents of the memory or the computing cycle. An example might be in a sophisticated intruder-detection system where the only control provided for the operator is essentially on/off.

**Software.** The software associated with the 6800 MPU includes an editor, PROM monitor, and assembler, as contrasted to the editor, assembler, monitor and basic for the Altair 8800 computer.

**System Details.** The Altair 680 computer is composed of five sections: MPU and clock, memory, control and indication, I/O port, and power supply.

**MPU and Clock.** As mentioned earlier, the MPU and clock are the new 6800 LSI chip. Its basic internal arrangement is shown in Fig. 1. The main elements are instruction decode and control, instruction register, data buffer, address registers and buffers, and address registers and buffers. The 6800 chip includes an editor, PROM monitor, and assembler, as contrasted to the editor, assembler, monitor and basic for the Altair 8800 computer.

**Fig. 1. Basic internal arrangement of 6800 MPU used in computer is shown here in block-diagram form.**
Data bus D0 through D7—eight high active bidirectional lines for transfer to and from memory and peripherals.

HalT signal (HLT)—low active input that ceases activity in the computer.

Read/write signal (R/W)—in the high state, signals the memory and peripherals that the MPU is in the read condition; in the low state, signals that the MPU is in the write condition.

Valid memory address (VMA)—signals external devices (memory and I/O) that the MPU has a valid address on the memory bus.

Data bus enable (DBE)—enables the bus drivers.

Bus available (BA)—indicates machine has stopped and address bus is available.

Reset (RES)—resets and starts the MPU from a power-off condition. A positive-going edge on this input tells the MPU to begin the restart sequence.

Interrupt request (IRQ)—when low, tells the MPU to start an interrupt sequence (save the registers on the stack, set interrupt mask bit high so no other interrupts can occur, and vector to the interrupt address). This type of interrupt can only occur if the interrupt mask bit in the condition code register is low.

Nonmaskable interrupt (NMI)—essentially the same as the IRQ, except it is not dependent on the condition code register.

The clock is a 2-MHz crystal-controlled oscillator that uses a pair of inverters that drive flip-flops to form a 500-kHz, two-phase clock that is distributed to the MPU, memory, and I/O sections in the computer via inverters and buffers.

Memory. The memory system consists of 1024 words of 8-bit-wide RAM, using 2102-type 1024 x 1-bit devices, and up to 1024 words of PROM, using ultraviolet-erasable 1702 devices. The basic arrangement is shown in Fig. 2. The low-order address bits are fed to both the RAM’s and PROM’s.

Front Panel. The front panel assembly contains the RUN/HALT switch, with a LED for each switch position; a reset switch with no LED indicator; and the ac power LED indicator (Fig. 3). The 16 address switches and eight data switches each have their own LED indicator.

The DEPOSIT, RESET, DATA, and ADDRESS switches are enabled only when the RUN/HALT switch is in the HALT position, at which time, a retriggerable one-shot multivibrator drives the halt input of the MPU low. This, in turn, drives the bus-available (BA) signal high and also conditions the other switches. To view the data in any memory location, the RUN/HALT switch must be placed in the HALT position and the ADDRESS switches set to the required address. The data at that...
<table>
<thead>
<tr>
<th>Features</th>
<th>Altair 680</th>
<th>Altair 8800</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum word size</td>
<td>24 bits (byte oriented)</td>
<td>24 bits (byte oriented)</td>
</tr>
<tr>
<td>Arithmetic unit</td>
<td>8-bit parallel</td>
<td>8-bit parallel</td>
</tr>
<tr>
<td>Minimum cycle time</td>
<td>4 µs</td>
<td>2 µs</td>
</tr>
<tr>
<td>Program instructions</td>
<td>72</td>
<td>78</td>
</tr>
<tr>
<td>Maximum memory size</td>
<td>65k bytes</td>
<td>65k bytes</td>
</tr>
<tr>
<td>Internal expandability</td>
<td>5 interface cards</td>
<td>250 interface cards</td>
</tr>
<tr>
<td>Interrupt</td>
<td>3 levels</td>
<td>8 levels</td>
</tr>
<tr>
<td>MPU</td>
<td>6800 (Motorola, AMI)</td>
<td>8080 (Intel, TI)</td>
</tr>
<tr>
<td>Approximate system cost (lk memory, I/O, case, P/S)</td>
<td>$300</td>
<td>$600</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>Fewer parts</td>
<td>Minimum of 4 pc boards</td>
</tr>
</tbody>
</table>

### MAIN BOARD PARTS LIST

- BD1—Bridge rectifier (VJ048)
- C1—3300-µF, 50-V electrolytic capacitor
- C2—C3—100-µF, 50-V electrolytic capacitor
- C4 to C9—0.33-µF, 50-V disc ceramic capacitor
- C10,C11—0.1-µF, 16-V disc capacitor
- C12—0.33-µF, 16-V disc capacitor
- C14—0.01-µF, 16-V disc capacitor
- C15—1-µF, 50-V electrolytic capacitor
- D1,D2,D7 to D12—1N4004 diode
- D3 to D6—IN4359A, 9.1-V zener diode
- F1—1-A, 250-V ac, 3-AG fuse
- ICA—7404
- ICB—7473
- ICC, ICU—7408
- IC, ID, ICS—4449
- ICF, IC—74LS01
- ICH, ICI, ICK, ICL, ICML, ICN, ICOC, ICR—2102
- ICT, ICU, ICCL, ICCH, ICOP, ICRR—74130
- ICV—74L00
- ICW—74L74
- ICX, ICY, ICTT—4050
- ICZ, ICAA, ICBB, ICCC—1702
- ICDD, ICFF—74L04
- ICF, ICMM—74L10
- ICJJ—6800
- ICOK, ICLL, ICSS—74LS05
- ICNN—74LS27
- Q1, Q3, Q4—TS598
- Q2—8N3907
- Except where noted, following resistors are 1/4 watt, 5%:
  - R1,R2—33 ohms, 2-watt, 5%  
  - R3,R4,R5,R7—100 ohms
  - R6—130 ohms, 1-watt, 5%
  - R8—220 ohms, 1-watt, 5%
  - R9,R10—220 ohms, 1-watt, 5%
  - R11—470 ohms
  - R12,R15,R16—1000 ohms
  - R13—470 ohms
  - R14,R20,R21—390 ohms
  - R18,R19—330 ohms
  - R22—33,000 ohms
  - R23,R24—10,000 ohms
  - R26,R27,R56,R57,R58,R59—not used
  - S11—Spdt toggle switch
  - T1—3- volt, 1.2-A transformer
  - VR1—7805 regulator
  - X1—2-MHz crystal
  - Misc.—Fuse holder (Buss HKP-CC, line cord, fan (1MC 3%), I/O socket (DB-25); sockets (14-pin, 22, 16-pin, 20; 24-pin, 4; 40-pin, 1), case optional.

*Note:* The following are available from MITS, 6326 Linn, N.E., Albuquerque, NM 87108: complete kit (all parts) #680F at $293; complete kit except for front panel board #680T at $240; kit #680M, including box board, 6800 MPU, I/O memory, and all main board components except power supply at $180; front panel and MPU box boards #680PC at $48; I/O socket kit at $29; fan kit at $16; 256 x 8-bit PROM kit at $42; construction information package is free, with self-addressed stamped 9” x 12” envelope.

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**Fig. 3. Front panel contains address and data switches A0 through A15 and D0 through D7, reset switch, and LED indicators.**

Memory address location will then appear as lighted and unlighted LED’s in the data display.

To change data in a location, the desired data is written via the data switches and entered by operating the deposit switch. This triggers a one-shot multivibrator, enabling the data information to the data bus and causing the R/W signal to go low. Since the address bus is already connected to the switches by being in the halt state, the write pulse causes the data to be written into the selected RAM address.

When the reset switch is operated, the CPU resets. This, in turn, initiates a restart sequence. That is, the address bus is pulled to the high state and causes the hard-wired data in the board jumpers to be used as the restart address.

Access to the I/O port is gained by addressing location 17577 (in octal). A sequence of events then occurs that
Cramer Electronics enters OEM computer kit market

The major reason for the tremendous success of the various computer kits on the market is that they save considerable time. One doesn’t have to hunt down the MPU’s, memories, etc., that must be accumulated before embarking on a home computer project. It appears that OEM engineers are also spending considerable time in hunting down computer kit business, with emphasis on the OEM market.

Cramer is starting with three kits, separately based on the Intel 8080, Motorola 6800, and Texas Instruments TMS8080 MPU’s. Each of the kits shares a common $495 price tag.

You get a lot for $495: complete color-coded schematic diagram; RAM with 1024 (8-bit) bytes, expandable to 64 k bytes; erasable PROM with 1024 (8-bit) bytes; support circuitry, including clock, complete buffering, control and synchronization logic, interrupts, DMA controls; etc. The PROM gives you a program to run at the outset. There are at least four 8-bit-wide input and output ports, with expandability to 512 ports, decoding for 16 of which is included.

The PROM contains a system monitor to permit the computer to be used as soon as it is assembled. Programs can be entered, modified, examined, and executed under switch control or by typed-in commands. A cassette program, included with the kit, can be used to debug the computer. Finally, a complete user manual gives hints on programming and how to expand the computer.

All together, there are about 190 parts in each kit, adding up to a total catalog value of some $700. Software is included in the kits to help in programming via front-panel switches and LED’s, cassette tape, Teletypewriter, or any RS-232-compatible terminal. Not supplied are printed circuit boards, power supply, and cabinet.

For more information about the new computer kits, write to: Cramer Electronics, Inc., 65 Wells Ave., Newton, MA 02159.

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