Taking AIM

Here's an entry from Rockwell International: the 6502-based AIM 65.

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The AIM 65 from Rockwell International is a welcome new addition to the single-board microcomputer inventory. Based on the fast 6502, it has features and interfaces on-board that are well planned and useful. These include a small 20-column thermal printer, a 20-character alphanumeric display, a full keyboard, a computer-controlled dual-cassette interface, a TTY interface, an expansion area for static memory and read only memory (ROM), a powerful ROM monitor with mini-assembler, disassembler, cassette operating system and text editor.

Also included are two 44-pin connectors on board: one KIM-compatible expansion connector and one applications connector for TTY, cassette and parallel interfacing. A 6522 Versatile Interface Adapter (VIA) makes interfacing easier.

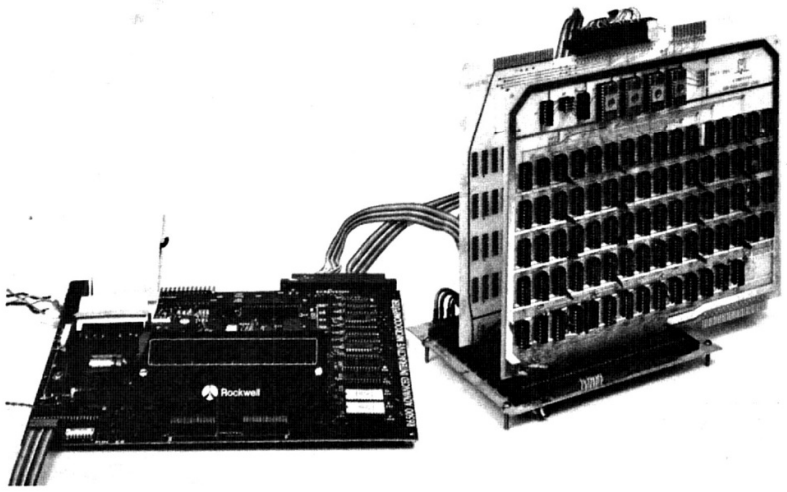
The AIM documentation consists of four well-bound paperback manuals and a large system schematic. No power supply is provided, however, nor any sort of video or graphics interface.

Priced at $375, the AIM 65 has features not available in other small microcomputer systems. Perhaps there is room for another 6502 system.

System Assembly and Power-up

The AIM arrived in a secure package, which included conductive foam on the underside of the printed circuit board to provide protection from static charges. The complete system consists of two separate modules—the keyboard and the PC board. The keyboard connects to the main board by a short, flat ribbon cable. Since there is no case, Rockwell has provided small self-adhesive plastic feet that support both modules. The AIM 65 user's guide contains helpful step-by-step assembly instructions with adequate drawings and diagrams.

Only two voltages are necessary to power the system: +5 V regulated at 2 A and +24 V unregulated at 2.5 A peak/.5 A average. The +24 V powers only the printer, so it is possible to run the AIM on a single 5 V supply without the printer. A heavy-duty terminal strip is provided at the left rear of the main board, thus allowing easy connection to the owner-provided power supply. The terminal strip also has connectors for +12 and −12 V dc, which provide the two 44-pin connectors with the extra voltages when needed for an interface. It took us at GSI Systems about ten minutes to unpack and connect the AIM. Upon original power-up, the display and printer indicated power-up reset by the sign-on message "Rockwell AIM 65."



The AIM main board and GSI 8K Static Memory Card. The flat ribbon on the left front of the AIM board is a longer cable to the keyboard (not pictured). The printer is smaller than a roll of paper. The memory card is Intel Multibus-compatible and has 4K of EAPROM (electrically alterable programmable read only memory).

The Keyboard, Printer and Display

The keyboard is a well-built, sturdy type conducive to fast and accurate touch-typing. The supplied ribbon cable that connects the keyboard to the master module should have been a little longer. We have inadvertently pulled the cable from the socket while moving

the modules. The keyboard has all the necessary keys for an uppercase-only system, including Escape and Delete and three user-defined function keys. A key labeled Print, when used simultaneously with the Control key, toggles the printer off and on. If the printer was off it is turned on, and vice versa.

At this time a printer-status message is displayed to indicate which of the two possible states the printer has entered—printer *down* or printer *up*. The keyboard is not decoded to ASCII before output to the system. The decoding occurs on the main module by a RAM I/O Interval Timer (RIOT), type R6532.

The printer is a 20-character-per-line dot-matrix thermal printer. A thermal printer actually burns the dots onto the paper to form alphanumeric characters and, therefore, requires special paper, which is available at $1.00 per roll. The paper is about the size of an adding-machine tape, and the characters appear in light blue color and can be difficult to read in a poorly lighted room. The printer is small and quiet, except when removing power from the system when it winds down, thus creating a sound like an electric motor losing speed. This is a small annoyance for a system full of so many other bonuses. Mounting the paper and feeding it to the printer is an easy task, and instructions are provided. The display is also 20 characters and is mounted at an angle making it easy to read. There are five four-digit 16-segment displays which allow full alphanumeric capabilities.

On-Board Memory

The AIM is supplied with 1K of on-board random access memory (RAM) in the form of two 2114s organized as 1K by 4-bit chips. The 1K is 1024 decimal, so two 2114s provide 1024 8-bit bytes. There are six empty RAM sockets, which allow a total of 4K bytes of memory on-board. The 6502 uses addresses $0000 to $00FF hexadecimal for registers and pointers that are normally called zero page. Addresses $0100 to $01FF hex are used for the stack and some I/O pointers. Maximum available system memory is 10K hex, or 40K decimal when you use external memory.

The expansion connector is supposedly KIM-compatible; therefore, adding memory to the AIM should not be much of a problem. We interfaced to Intel-compatible memory because it was available in the lab.

There are five 24-pin read only memory (ROM) sockets on board. Rockwell has chosen high-density ROMs that hold 4096 decimal bytes of code each. They are addressed from $B000 to $FFFF hex.

Two ROMs that contain the monitor, text editor, mini-assembler and other goodies are supplied (see the Monitor section, which follows).

A full assembler and an 8K BASIC interpreter are now available in ROM form.

ROM Monitor and Other ROM Goodies

Two read only memories on-board contain: (1) system monitor; (2) mini-assembler; (3) disassembler; (4) cassette operating system; (5) text editor.

This area of the AIM has impressed me the most. A lot of programming has been done by Rockwell to make programming for us as easy as possible. A Step mode executes one instruction and then allows for register trace, instruction trace and breakpoint examination. Separate single-letter initialized commands allow altering the index register, stack, program counter, accumulator and processor status words. Instructions can be entered by using standard 6502 mnemonics or by machine-language entry in hexadecimal. Programs can be disassembled from machine language into mnemonics with outputs to the printer and display. As many as three user-defined programs can be executed by the user-function keys, F1, F2 and F3, on the keyboard.

The text editor mentioned above can receive or store data from the keyboard or cassette, from paper tape or any device properly interfaced to the AIM.

```
<E>
EDITOR
FROM=200  TO=400

IN=
*HELLO KILOBAUD AND
*READERS EVERYWHERE
*
 HERE IS A SAMPLE OF
*THE AIM TEXT EDITOR
*USING AN UNMODIFIED
*TELETYPE AND THE
*INTERFACE DESCRIBED
*IN THE USERS
*MANUAL/
*FOLLOWING THESE LINES
*WILL BE A MNEMONIC
*ENTRY OF A TRIVIAL
*PROGRAM AND THEN A
*SHORT DISASSEMBLY.


<*>=220

<I>
 0220    LDA #00     A9 00
 0222    TAY         A8
 0223    TAX         AA
 0224    CMP (50),Y     D1 50
 0226    BEQ 0230    F0 08
 0228    INY         C8
 0229    BNE 0224    D0 F9
 022B    BRK         00
 022C    *=0230
 0230    BRK         00
 0231
<K>*=220
/
 0220 A9 LDA #00
 0222 A8 TAY
 0223 AA TAX
 0224 D1 CMP (50),Y
 0226 F0 BEQ 0230
 0228 C8 INY
 0229 D0 BNE 0224
 022B 00 BRK
 022C 53 ???
 022D 20 JSR 2041
 0230 00 BRK
```

Sample output from the AIM text editor.

The editor is primarily line oriented, but with a maximum of 20 characters per line this is a minor burden.

In fact, just having a text editor in a system of this price is a bit of luxury. The editor, by default, can determine the available system memory and use all of it (except for page zero and page one), or the user can define the allowed buffer space.

The cassette operating system is interactive. Files can be recorded with names of up to five characters on either of two cassette recorders that can be turned on and off by the computer. When a file is loaded, a sequential search by file name is done automatically until the correct file is found and loaded. This cassette operating system is a great step forward for the small-system users who probably will never have a disk drive. We did, however, have some noteworthy problems with the cassette interface.

Cassette Interface

There are two on-board cas-

sette interfaces that can be controlled directly from the keyboard, or you may choose to operate the cassette-players manually. We were unable to find in the manuals a Rockwell-recommended cassette recorder, so we used the Panasonic RQ-2309 and the Apple-recommended Panasonic RQ-309. The user's manual does contain a program for testing the "write to" and "read from" functions. This program displays a Y or an N to indicate whether proper reading has occurred. The program listing has a few mistakes, but we fixed them (see the corrected listing). When properly entered, this program is useful for a quick test.

A whole chapter in the user's manual is devoted to all areas of cassette and Teletype interfaces, including proper connections for cassettes that might be grounded differently. But even with all of this information we had trouble obtaining a reliable cassette operation.

We purchased two AIM 65 systems in two days, and both of them required much attention before satisfactory cassette operation was achieved. (On the positive side, we should say that we bought the second system because we liked the first one.)

The first area of difficulty was the course-adjustment VR1. The voltage on both boards was out of tolerance. According to the user's guide it should have been within one-tenth of a volt of two and a half volts.

The second difficult area was harder to find but easy to remedy. The AIM writes data out to the cassette in blocks of 80 characters. In between the blocks is an inter-record gap of characters (ASCII 16), which is four times the amount contained in memory location $A409.

The assembly comment in the monitor listing for address $A409 is "Timing Gap Between Blocks." Eric Johansson of the GSI R and D staff found that operation became reliable when the inter-record gap was increased. He changed the $08 in location $A409 to $20. He also found differing reliability in the same system when the remote-control interface was not used. That is, it worked better using one cassette recorder manually than when using the same system and recorder under remote control. We also found that removing the ac line cord and operating on batteries improved the cassette operation in some instances. Obviously some hacking around was necessary for us.

The only problem we have encountered using the AIM 65 has been in the cassette area, but it is a real plus for a small system to have dual remote-controlled cassette interfaces.

```
0300    JSR F21D    20 1D F2
0303    JSR F24A    20 4A F2
0306    JMP 0303    4C 03 03
0309    *=0310
0310    LDX #00     A2 00
0312    LDA #CE     A9 CE
0314    JSR EF7B    20 7B EF
0317    JSR EDEA    20 EA ED
031A    LDX #00     A2 00
031C    LDA #D9     A9 D9
031E    JSR EF7B    20 7B EF
0321    JSR EE29    20 29 EE
0324    CMP #16     C9 16
0326    BEQ 0321    F0 F9
0328    BNE 0310    D0 E6
</> 0309 EA EA EA EA
</> 030D EA EA EA
<K>*=300
0300 20 JSR F21D
0303 20 JSR F24A
0306 4C JMP 0303
0309 EA NOP
030A EA NOP
030B EA NOP
030C EA NOP
030D EA NOP
030E EA NOP
030F EA NOP
0310 A2 LDX #00
0312 A9 LDA #CE
0314 20 JSR EF7B
0317 20 JSR EDEA
031A A2 LDX #00
031C A9 LDA #D9
031E 20 JSR EF7B
0321 20 JSR EE29
0324 C9 CMP #16
0326 F0 BEQ 0321
0328 D0 BNE 0310
```

Corrected test program.

Zero Page, Stack and the 6532

The 6532 is a powerful I/O interface chip with interval timer and two software-controlled 8-bit data ports. Also on the chip are 128 bytes of static RAM, which is used by the AIM monitor for storage of keyboard, printer and tape variables, monitor registers and a zero-page simulator. This RAM is addressed at $A400 to $A4FF and does not interfere with precious page zero or RAM available for programs. When the text editor is not being used, virtually all of the zero page is available to the programmer.

The stack in 6502 systems begins at $01FF and works down toward $0100. Because it is rare that the stack ever uses the lower half of page one, the AIM monitor uses that area—$0100 to $016F—for the disassembler and assembler, I/O handlers and breakpoints. The use of the 6532 RAM and lower part of the stack area allows clean access to contiguous memory from $0200 to $9FFF with most of zero page available.

Documentation

Congratulations to Rockwell. Rare it is indeed that a recently available small system arrives with such complete and easy-to-read manuals. Two of the four well-bound manuals are nearly identical copies of the MOS 6500 hardware and programming manuals. The Rockwell programming manual explains the addressing modes and registers and flags of the 6500 series microprocessors. Another manual is a complete, well-commented, monitor listing that includes headings for each function.

The fourth manual, the user's guide, covers all topics peculiar to the AIM 65, such as instructions for use of all monitor commands, memory map, keyboard interface and VIA interface. This last manual contains a few errors and, unfortunately, most of them occur in the program listings.

Also provided with the AIM are two handy-size reference cards. The AIM 65 Summary Card has a complete list of all monitor commands as well as a list of monitor subroutines that might be used often. The R6500 Microprocessor Programming Reference Card contains everything a programmer might need to reference including addressing modes, hexadecimal and decimal conversion, relative branch tables, ASCII table and register diagram. The documentation package is impressive.

Conclusion

We have here a single-board system with an alphanumeric display. It needs a power supply but has a nice little printer. An assembler and BASIC are available as options to add to the fine monitor. A 20 mA Teletype interface and a cassette interface are on-board. It can read and write KIM-compatible cassettes and has a cassette operating system. On-board memory is expanded to 4K, and a powerful I/O chip is provided for further expansion to any peripheral. The system is well documented. The AIM 65 is quite a lot of little system. ■