Four S-100 RAM Cards

by Bill Machrone

The 2K by 8-bit low-power memory chip, both CMOS and NMOS, as offered by Hitachi, Toshiba, and others, has wrought a revolution in S-100 memory systems. It made the 64K, low-power *static* card possible. Static memory is important for two major reasons. The first is compatibility with various DMA schemes and the second is speed, translated as unrestricted CPU access. The infinitesimal power requirement of the CMOS chips compares favorably with that of dynamic RAM counterparts, although dynamic RAM density is still an order of magnitude greater. The drop in prices of thse chips (and the subsequent drop in board prices) has put multipage memory systems within reach. The multiuser operating systems and the pseudo-disk and track buffering schemes benefit directly.

The four boards reviewed here are representative of the new breed. They are: CompuPro's RAM 17, CompuPro's RAM 16, Fulcrum's Omniram 64K, and Electronic Control Technology's 64K board. Two of the boards are straight 64K by 8 bit, and two can also be configured as 32K by 16. All of them support IEEE-696 24-bit extended addressing. All can disable pieces of memory in 2K blocks for disk controllers that use a portion of high memory. They also provide IMSAI-style front panel compatibility, albeit at reduced speed. The two 16-bit boards perform the proper IEEE handshaking to permit 16-bit data transfers.

The boards

Godbout's CompuPro RAM 17 was the first of the 64K static cards to hit the market. It was actually designed before the chips were available, then released when the price of the chips was about $40 apiece. It has come down steadily in price as the chips have become more available. Board selection was well thought out from the beginning, permitting boards addressed as "global" and those addressed for individual pages of memory to be intermixed. This, combined with the high-memory deselect, makes it easy to use multiple banks of the boards to support MP/M or Oasis. The board operates solely as a 64K-by-8 memory. As with all CompuPro equipment, the board is very well made, with easily read silk-screened legends. The manual tells you just what you need to know to use the board, and no more.

The CompuPro RAM 16 is a close kin to the RAM 17, the chief difference being that it can operate as a 32K by 16 memory. The additional circuitry for a 16-bit operation necessitated a new layout of the board. A unique feature of the layout is the location of the extended addressing dipswitch. It is at the top center of the board, making it accessible without removing the board. Sixteen-bit data transfers are actually a complex issue. The board has to tell the requesting bus master whether it is capable of handling 16-bit transfers. When the transfer is made, the board must know which is the low byte and which is the high byte and route them onto the proper internal bus. The logic is handled by a PLA and a few extra TTL chips. This feature carries a slight speed penalty, which will be discussed below.

Fulcrum's new Omniram 64K memory board is the most flexible S-100 memory card I have yet seen. It does everything and does it well. Some of the features that it implements are still on other designers' wish lists: 64K-by-8 or 32K-by-16 operation, IEEE extended addressing, bank select, IMSAI front panel compatibility, MP/M-Oasis-Cromix compatibility (the Omnicram splits into 16K + 48K or 32K + 32K), and fast, cool, low-power operation.

The board itself is well made with clean, if somewhat thin, traces, premium bypass capacitors, SIP resistor packs and sockets. Address and mode selection are done via a custom PROM, which results in high speed and a low parts count. The entire set of chips that implement bank select can be removed resulting in a power savings of several hundred milliamps from your 8-volt line if you do not require the feature. The options are selected by a combination of dipswitches and shorting jumper pins. One interesting feature of the board is that in the 16-bit mode, it will refuse transfers that begin on an odd (A0 = 1) boundary. This is not part of the IEEE specifications for the bus. Granted, the 8086 will not make such a request, but this may not be the case with other 16-bit processors that will be emerging for the S-100 bus.

ECT's 64K board, the fourth board tested, is also the newest. It is an analog to the CompuPro RAM 17. As in the others the board layout and construction are excellent. It uses premium-grade dipped bypass capacitors instead of the more conventional disk capacitors, and includes a kludge area large enough for a 20-pin DIP, should you have the need. It also has an LED at the top edge that tells you when the board is selected. This can be fun to watch in a multipage system, and is helpful in verifying that the board is addressed properly. The early version that I tested had a short run of wire-wrap wire running between two return (ground) points, evidently to prevent glitching. It was equipped with Mitsubishi 2K-x-8 chips, which are NMOS parts with automatic power-down. These parts did not pass even some of the simplest

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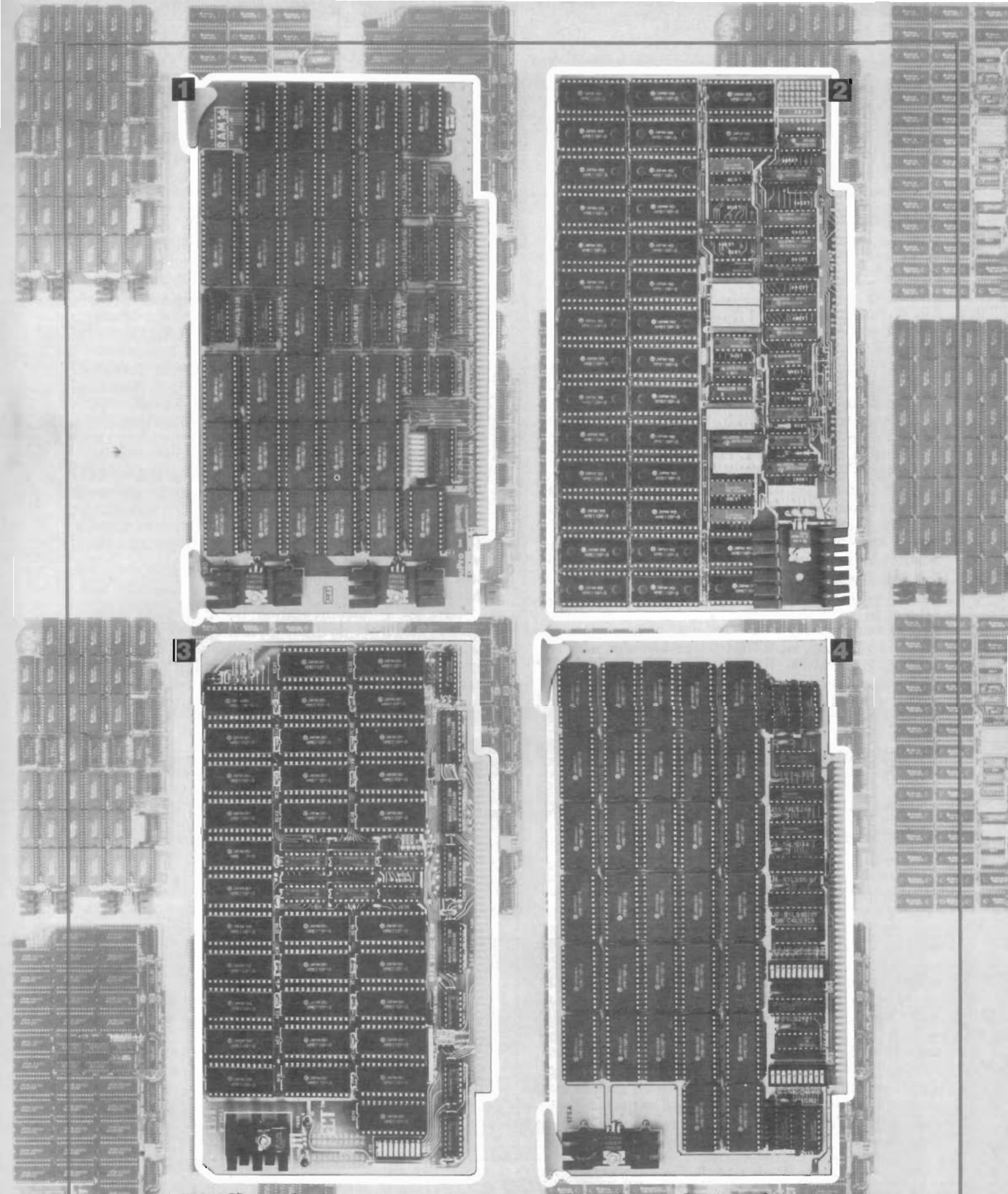

1. Godbout's CompuPro RAM 16 2. Fulcrum's Omniram 64K
3. ECT's 64K 4. Godbout's CompuPro RAM 17

memory tests, and I exchanged the board for an identical one with 200-nsec Hitachi chips. I also tested a newer revision of the board, one with larger return traces and 150-nsec Hitachi parts.

Performance

I tested the boards in every conceivable environment with a CompuPro 6MHz Z80 card and two Seattle Computer Products 8086 cards. The second 8086 was souped up to run at 10 MHz. The bus environments varied from unshielded and unterminated to fully shielded and terminated at both ends. None of the boards were sensitive to the bus environment. I used byte-transfer and DMA disk controllers with the boards and found no problems in either case.

Several of the currently available dual-width memory boards are limited in their speed when handling 16-bit transfers. This is generally due not so much to the speed of the chips as to the decoding requirements in detecting a valid memory read or write cycle on the S-100 bus. As processor speed goes up, the "window" for enabling the proper internal bus (for even- and odd-byte transfers) gets smaller and smaller. The Omniram won the speed contest. It ran at 10 MHz, needing no wait states, with the 8086, while the CompuPro RAM 16 quit after 8 MHz. Fulcrum's custom PROM takes the necessary bus lines (there are half a dozen) as input and responds with the proper bus signals and internal bus control. Even Bob Snider, a principal at Fulcrum, was surprised that the board ran at 10 MHz without wait states. The difference in the test system's performance was negligible, as it took only one wait state for the RAM 16 to run, but the speed attests to the good design of the Fulcrum board.

The RAM 17 ran at 6 MHz with no wait states with the Z80, and at 8 MHz with the 8086 doing 8-bit transfers. It required a wait state at 10 MHz. The RAM 16 required a wait state at 6 MHz with the 8086.

As mentioned above, the ECT board with the Mitsubishi NMOS devices did not operate satisfactorily in any of the environments I was able to provide, but the same board with CMOS chips worked well. The board with 150-nsec parts did not require wait states in any mode of operation, while the board with the 200-nsec parts required an M1 wait state with the 6 MHz Z80 and no waits with either of the 8086 boards.

The CompuPro boards are constructed with unusually wide power and return traces, such that virtually any area of the board that is not carrying signal or control lines is covered with copper at ground or five volts potential. I had expected that these large traces would reduce the amount of radio frequency emissions radiated by the board, but if there was a difference, it was not measurable. There were, however, fewer and smaller noise spikes on the power traces of the CompuPro boards.

Documentation

The documentation that I received with the Omniram was preliminary. It was complete in terms of the topics covered, and it included numerous sample pin and switch settings for specific configurations such as Cromix and IEEE extended addressing. The documentation was not "pretty" in that it was printed on a dot matrix printer and photocopied. The content, however, will be quite satisfactory when printed on a letter-quality printer or typeset. Neither an experienced S-100 hacker nor a neophyte will have any difficulty in setting the board up.

The manuals for the two CompuPro boards are similar to each other in that they tell you exactly what you need to know to use the boards and no more. There are precious few examples and they are "dense," in that several important pieces of information may be contained in a single paragraph, without emphasis. The information is there, but inexperienced CompuPro manual readers will have to ferret it out.

The ECT documentation is, in a word, adequate. There are no illustrations, but the manual is well organized and all of the options are explained in detail. A new engineering drawing and schematic are in preparation for revision 2 of the board and will be available by the time this article is published.

Conclusion

The Fulcrum Omniram is a state-of-the-art product for the S-100 bus. It is refreshing to see such a "mature" product introduced by a relatively new company. It packs more features than any of its competitors and is priced attractively. I would recommend it to anyone who is thinking of moving to a 16-bit system in the near future, or who is building one now.

The RAM 17 and RAM 16 are true workhorse memory boards. There are probably more of them in service than all other 64K static boards combined. They are the standard by which the others are to be compared, both for features and performance. The RAM 16 compares favorably to the Omniram if you don't need all the features available on the latter.

The ECT 64K has come on the market at a very good price and promises to give the more established boards some competition. Although there are copies of this board in use with the NMOS parts that are apparently operating satisfactorily, I would recommend the CMOS parts.

They all support IEEE-696 extended addressing and can disable 2K blocks to accommodate ROM. The CompuPro RAM 16 and Fulcrum Omniram can operate in either 64K-x-8 or 32K-x-16 modes.

Four RAM Cards continued . . .

The reliability of these new memory chips and boards is legendary. Once you have found the features your system requires, shop for price. You won't go wrong with any of the ones reviewed here.

Prices

RAM 16 A&T, $650
RAM 17 48K, $549; 64K, $599 A&T
CompuPro Division,
Godbout Electronics
Oakland Airport, CA 94614
(415) 562-0636

Omniram 64K, $425
Fulcrum
1771 Junction Ave.
San Jose, CA 95112
(408) 295-7171

ECT 64K RAM, $399
Electronic Control Technology
763 Ramsey Ave.
Hillside, NJ 07205
(201) 686-8080

Bill Machrone is a systems designer with wide experience in putting business applications on mainframes, minis, and micros. His special interest is database management systems for micros—doing a big job on a small machine.