

Computer Automation Naked Mini and MegaByter (LSI-2 Series)

MANAGEMENT SUMMARY

Computer Automation introduced an entirely new marketing concept when it announced the first LSI-2 minicomputer (the Naked Mini 16) in April 1971. Previously, computer manufacturers had offered only full systems or, at least, complete central processors. Computer Automation instead offered a "naked" (or un-packaged) computer consisting of a basic processor and memory, and, if desired, a chassis and power supply to round out the package. In doing so, CA addressed itself to the OEM market, and has maintained that orientation ever since.

Prior to the introduction of the Naked Mini, the end-user market was dominant, with nearly all computer systems sold directly to their ultimate owners. Specialized products and devices employed specially designed components whose functions were rigidly fixed. General-purpose processors were virtually unheard of in these specialized applications due to their high cost and, in most cases, excessive capabilities.

The Naked Mini, a three-board TTL processor, was offered in skeleton form, to make the design of specialized machines more economical, based on the premise that it would be easier to change instructions in memory than to change logic chips and PC board traces. That obviously correct premise has been one of the principal motivating forces behind the mushrooming growth of the micro-processor field during the past few years.

The original Naked Mini 16, and the more compact Naked Mini/LSI (or LSI-1) that followed it, have been superseded by the improved LSI-2 Series. The LSI-2 ➤

The LSI-2 Series minicomputers have been around since 1971 and are strong competitors in the OEM marketplace. Computer Automation offers both board-only (Naked Mini) configurations and the more conventional packaged arrangements with chassis, power supply, and front panel. The latest enhancement to the LSI-2 line is an analog I/O system for laboratory and industrial applications.

CHARACTERISTICS

MANUFACTURER: Computer Automation, Inc., 18651 Von Karman, Irvine, California 92664. Telephone (714) 833-8830.

MODELS: Naked Mini and Alpha LSI-2/10, LSI-2/20, and LSI-2/60 (MegaByter). Previous models: Naked Mini 16 and Alpha 16.

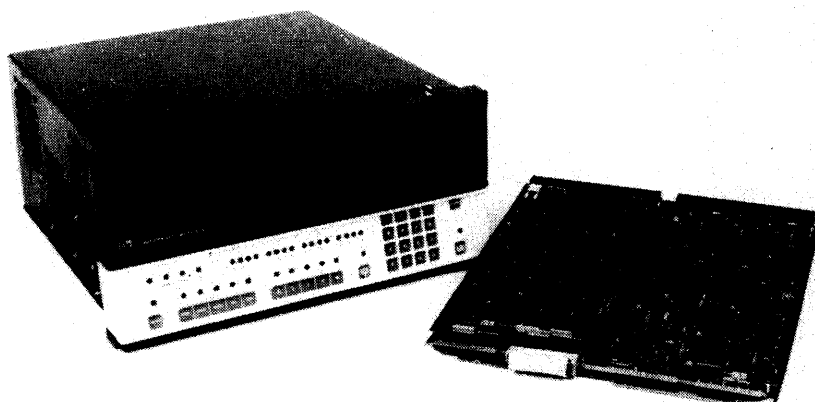
DATA FORMATS

BASIC UNIT: 16-bit word or 8-bit byte. Optional byte parity bit on core memories only.

FIXED-POINT OPERANDS: 16-bit words consisting of 15-bit integer and one sign bit. Negative numbers are in two's-complement form. Larger fixed-point operands can be implemented in the LSI-2/60 MegaByter through the use of variable-length byte string instructions.

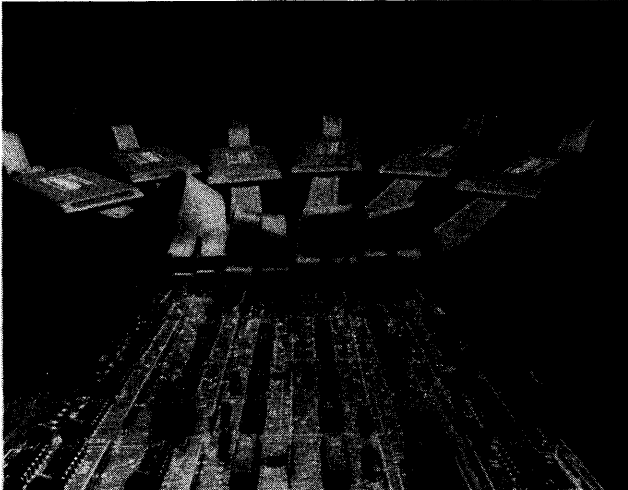
FLOATING POINT OPERANDS: No hardware facilities; two-word or three-word formats through software sub-routines only.

INSTRUCTIONS: One- or two-word instructions with 11 different formats. Single-word memory reference instruc- ➤



A packaged Alpha LSI-2 system that includes processor, memory, chassis, and power supply is shown on the left, and an LSI-2 Naked Mini on the right. The naked version shown features a full-sized 15-by-17 inch PC card plus two 8 1/2-by-15-inch half-cards mounted piggyback on the larger board.

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CA's Distributed I/O System puts the basic circuitry for interfacing on a single half-card-size I/O distributor. The distributor can be shared by as many as eight "intelligent cables," each of which contains a microprogrammed PicoProcessor for functional control of a specific peripheral device.

➤ family presently includes the LSI-2/10, -2/20, and -2/60 MegaByter minicomputers. Still OEM-oriented, the LSI-2 minis are intended for use as components of larger systems, and the "naked" versions are available only in quantities of five or more.

All members of the LSI-2 and LSI-3 family are completely compatible and, according to CA, are the only minicomputers whose processors are electrically and mechanically interchangeable up and down the line. All programs written for the very small Naked Milli LSI-3/05 (Report M11-168-201) will run on any other family member, including the million-byte LSI-2/60 MegaByter.

The LSI-2/10 and 2/20 are identical machines except for speed. Execution times for the LSI-2/20 are about twice as fast as those of the LSI-2/10.

Among the significant internal design aspects of the LSI-2 Series is the instruction repertoire. The instruction set permits most operations to be performed through execution of a one-word instruction requiring a single machine cycle. Numerous memory reference instructions are included among the 188 instructions, including Exchange-Memory-And-A-Register, Memory-Scan, Three-Way-Compare, Double-Word-Normalize, Stacks, and Multiply/Divide. Also, most of the memory reference instructions can operate in either word or byte mode.

Another aspect of the LSI family is the asynchronous MaxiBus I/O bus that permits intermixing core and MOS memory modules with different speeds.

Typical products or systems in which the LSI-2 minicomputers have been employed include: 1) key-to-disk data entry systems (such as the General Computer Systems 2100); 2) control and monitoring of automated welding machines (Weltronic, Inc.); 3) control of automatic bank teller devices designed to dispense cash and accept ➤

➤ tions have a four-bit op code, an eight-bit address field, and three bits to specify address mode. Double-word memory reference instructions have a three-bit op code, a four-bit iteration count, a 15-bit operand address, and indicator bits to specify direct/indirect address mode, etc. Byte-immediate instructions have a four-bit operation code and an eight-bit immediate operand. Conditional jump instructions have a four-bit op code, a six-bit displacement, a five-bit field to indicate test conditions, and one bit to specify jump direction (forward/backward).

Single-register shift and register change instructions have an eight-bit control field that specifies source, operation, and location of results, a three-bit shift count (zero for register change) and a five-bit instruction type indicator. The double-register shift instructions are similar to the single-register shifts except that the shift control count field is four bits and the op code is seven bits. Control instructions have a one-bit instruction type indicator, a seven-bit op code, and an eight-bit halt or instruction counter.

I/O instructions have a two-bit instruction type indicator, a six-bit op code, a five-bit device address, and a three-bit function code. Block I/O instructions are similar to I/O types except for a three-bit instruction type indicator and an additional 15-bit base address field. Automatic I/O instructions use three words; the first has the same format as the I/O instruction, and the next two words hold a 15-bit byte/word count and a 15-bit address pointer.

The first 256 words/bytes in memory are referred to as "scratch pad." These locations are the only ones accessible to instructions using direct addressing, and therefore can be addressed from anywhere in memory. Addressing modes include direct (to scratchpad), relative (to current location), indexed, indexed thru scratchpad, indirect relative to current location, and indirect post-indexed.

INTERNAL CODE: ASCII.

MAIN STORAGE

STORAGE TYPE: Core or MOS.

CYCLE TIME: 0.98 and 1.2 microseconds for core; 0.85 and 1.2 microseconds for MOS. Core memories can be odd/even interleaved for faster effective cycle times.

CAPACITY: 4K to 262K words, in 256-word, 1K, 2K, 4K and 8K modules for MOS, or 4K, 8K, or 16K modules for core.

CHECKING: Optional parity bit associated with each eight-bit byte, for core memories only.

STORAGE PROTECTION: None.

RESERVED STORAGE: About 20 of the first 256 words (scratchpad or page 0) are normally reserved for device/interrupt addresses. These reserved words can be moved into page 1.

CENTRAL PROCESSOR

GENERAL: There are currently three LSI-2 models; LSI-2/10, LSI-2/20, and LSI-2/60. The LSI-2/10 and -2/20 are identical processors except for speed, the -2/20 being about twice as fast as the -2/10. The -2/60 MegaByter features an enhanced instruction set with the speed of the -2/20.

All three CPU's are contained on single 15-inch by 17-inch PC boards. Standard features include multiply/divide, five vectored priority interrupts, automatic input/output direct to memory, and a direct memory access (DMA) channel; ➤

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PERIPHERALS/TERMINALS

DEVICE	DESCRIPTION	MANUFACTURER
MAGNETIC TAPE UNIT		
22224-15	Industry-compatible, 25 ips, 9-track, 800 bpi, read/write, max. of 4 transports per controller (1 slot), 20KB/sec	Pertec 7820
LINE PRINTER		
22107-06	80 columns, 64-character set, 120 cps or 60-150 lpm (½ slot)	Centronics 306
22107-32	32 columns, 64-character set, 165 lpm (½ slot)	Centronics 103
CARD UNIT		
22077-20	Reader, 80-column, 285 cps (½ slot)	Documation M200
PAPER TAPE UNITS		
22223-11	Reader, 300 cps (½ slot)	Remex 305
22223-60	Reader/Punch, 300/75 cps (1 slot)	Remex 3075
TERMINALS		
22205-00	Hard-copy terminal with paper tape read/punch	Teletype ASR-33
22851-63	CRT keyboard/display terminal, 24 lines by 80 characters, 128-character set, selectable data rate, 75-9600 bps	Computer Automation

▷ deposits (Money Machine, Diebold); 4) monitoring of medical and other analytic instruments (Hycel, Inc.); 5) computer-controlled machine tool systems (Entrekin); and 6) computer-controlled mass spectrometer/gas chromatographs for toxicology analysis (Finnigan Corp.). A CAPABLE digital logic module tester based upon the LSI-2 Series is also available directly from CA at prices ranging from \$20,000 to \$96,900.

In keeping with the company's self-styled image as a strictly OEM-oriented vendor, Computer Automation actively recommends that users purchase their peripherals directly from the peripheral vendors. However, an extensive variety of interfaces for most of the popular mini-peripherals is available, and Computer Automation will deliver peripherals on a package basis at the user's request. In fact, CA did not make any peripherals itself until 1977. At the same time as the LSI-4 Series of minicomputers (Report M11-168-101) was announced, the company introduced a CRT display terminal manufactured for use with all of its LSI Series computers (see Peripherals/Terminals table).

Competition for the Computer Automation LSI-2 Series comes from OEM versions of each major minicomputer maker's product line. Included in this list are many notables of the minicomputer world, such as DEC's PDP-11/04, LSI-11, and PDP-11/03 (Report M11-384-301), Data General's Nova 3 (Report M11-304-101), and Interdata's 6/16 (Report M11-530-101).

Of particular interest is DEC's PDP-11/03, an LSI-11 based minicomputer which directly competes with the Alpha LSI-2 and LSI-3/05 systems. The Alpha LSI-2 is priced about the same but features greater ease of interfacing, since the PDP-11/03 is not compatible with the ▷

▶ optional features include power-fail restart, real-time clock (0.1, 1.0, or 10.0 KHz), autoloader, and full-duplex Teletype/CRT interface. All options except the power-fail restart physically mount on a special piggyback option board; the power-fail restart option mounts on the main CPU board.

CONTROL STORAGE: The LSI-2/10 and -2/20 use 256 56-bit words of ROM control storage. The LSI-2/60 uses 512 words.

REGISTERS: Program-accessible registers include a 16-bit accumulator, a 16-bit index/secondary accumulator register, and one-bit control flip-flops for overflow, byte-mode operation, and interrupt enable. Internal registers which are affected by user programs include a one-bit status inhibit flag, two one-bit flip-flops for power-fail interrupt enable, and console interrupt enable. Other registers include the 16-bit instruction register and 16-bit program counter.

INDIRECT ADDRESSING: Multiple levels for word-mode operations and one level for byte-mode operations.

INDEXING: Memory addresses can be indexed by the X register. Post-indexing is also possible during indirect addressing operations.

INSTRUCTION REPERTOIRE: Each LSI-2 processor features 187 basic instructions made up of 42 single-word memory reference instructions, 3 double-word memory reference instruction, 10 byte-immediate instructions, 13 conditional jumps, 12 single-register shifts, 4 double-register shifts, 52 register change instructions, 18 control instructions, 27 I/O instructions, 4 automatic I/O instruction, and 2 block I/O instructions.

Included in the 42-single-word memory reference instructions are 15 stack instructions which allow any memory location to serve as a stack control pointer and maintain a stack elsewhere in memory. Any number of routines can maintain any number of stacks anywhere in memory. The LSI-2 stack instructions also make it possible for different stack pointers to access the same stack, which means that ▶

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➤ DEC Unibus and requires different controllers than are normally found on PDP-11 systems.

In some applications, competition comes from the light-weight "micros." In such competitive encounters, however, the microprocessors are often hampered by distinct limits on their speed, power, and peripheral availability. The only serious pressure applied to Computer Automation by the microprocessors is likely to be in low-cost applications where the LSI-2 family (or any standard minicomputer) represents too much computer. In those instances, the LSI-3/05, which is CA's low-end offering, could be a suitable answer.

Computer Automation enjoys a solid reputation as an OEM vendor, as evidenced by the user ratings that follow and by the more than 18,000 CA minicomputers delivered to date.

USER REACTION

Datapro contacted three companies which are OEM users of various models of the Naked Mini; each had purchased between 150 and 200 units to date. Below is a tally of their responses to the pertinent questions in the standard Datapro user survey. Please note that the questions regarding maintenance were answered by only two users, and that the question regarding responsiveness of maintenance service is taken to mean, in this case, whether the vendor's 30-day factory service turnaround times were being met. The questions on reliability of peripherals and on application programs were omitted as not applicable. Also, all three of the users we interviewed said that they were making very limited use of CA's operating system and compilers and assemblers, and none felt they could justify ratings in these areas.

	Excellent	Good	Fair	Poor	WA*
Ease of operation	0	2	0	0	3.0
Reliability of mainframe	2	1	0	0	3.7
Responsiveness of maintenance service	0	2	0	0	3.0
Effectiveness of maintenance service	0	2	0	0	3.0
Technical support	2	1	0	0	3.7
Overall satisfaction	2	1	0	0	3.7

*Weighted Average on a scale of 4.0 for Excellent.

As can be seen from the ratings, these users were quite happy with CA's LSI-2 Series. Interestingly, all of these users had also used DEC and Data General equipment, and each cited a different reason why he preferred the CA line. One said it was "much more reliable"; another was impressed with CA's OEM approach and technical support, stating that he felt he could "work with CA"; while the third user liked the I/O bus structure and the auto I/O. This last user also said he was planning to move to CA's new Naked Mini 4 line, commenting that "this is the highest recommendation I can give." Based on the impressive ratings and comments of these users, it would seem that Computer Automation's products will continue to be strong entries in the OEM and large-volume user marketplace for some time to come. □

➤ data in a single stack can be accessed at the top or bottom, or any point in between, concurrently.

The LSI-2/60 instruction repertoire of 224 instructions includes the foregoing plus, among others, four additional specialized stack instructions designed to facilitate re-entrant subroutines; two additional string manipulation instructions; two decimal string instructions, which permit hardware operations on strings of decimal numbers and facilitate business applications; four bit manipulation instructions that permit setting, resetting, complementing, and testing of any bit in memory; and a hardware cyclic redundancy check character instruction that can generate and check cyclic redundancy and longitudinal redundancy check characters in 15 microseconds.

INSTRUCTION TIMINGS: All times are in microseconds for full-word, fixed-point operands and direct addressing mode. Values shown are for the LSI-2/20 and -2/60 using core memories for two different speeds. Execution times for the LSI-2/10 are twice those shown. Systems using 1200-nanosecond semiconductor memory have execution times nearly identical with those using 1200-nanosecond core memory.

Cycle Time, Nanoseconds:	980	1200
Load/Store	2.06	2.4
Add/Subtract:	2.06	2.4
Multiply/Divide:	12.4/14.9	12.8/15.1
Compare and Branch:	1.08	1.2

INTERRUPTS: Five levels of interrupts are standard—two internal and three external. The third external level allows a virtually unlimited number of vectored priority interrupts, using a daisy-chain priority structure. Vectors are 16 bits long and are supplied by the interrupting devices.

External interrupts cause the LSI-2 to execute one instruction outside the main program. If the instruction does not modify the P register, execution of the main program continues. If the instruction modifies the P register, execution of the new program commences.

The most common instruction executed as a result of an interrupt is a Jump And Store Address. The LSI-2/60 has four additional instructions for this purpose, two versions of Jump And Stack All Registers and two versions of Return From Stack With All Registers. These instructions automatically place all significant registers in a designated stack and transfer control to a new program. Upon completion, the Return instructions transfer control back to the original program. The Automatic I/O instructions used as interrupt instructions do not alter the P register. Instead, they transfer a word or byte of data directly between the I/O device and memory, meanwhile maintaining their own counters. Thus, the instructions implement a complete I/O subroutine to save and restore registers and processor status.

The Enable Interrupt and Disable Interrupt instructions affect all interrupts to the CPU. Individual interrupts can be masked through the Select I/O instruction at the controller.

PHYSICAL SPECIFICATIONS: LSI-2 minicomputers are available in both PC board-only or packaged versions. In the PC board versions, the systems are referred to as Naked Minis, while the packaged versions are known as Alpha/LSI-2 systems.

The LSI-2 PC boards are 15 inches wide by 17 inches deep, and weigh 7½ pounds with all options installed. Power requirements are +5 VDC at 13.5A, +12 VDC at 0.6A, and -12 VDC at 2.8A. ➤

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► Packaged Alpha/LSI-2's are 19½ inches wide, 19½ inches deep, 8¾ inches high, and weigh 67 pounds including all options, power supply, and operator panel. Power requirements for the Alpha/LSI-2 are 98 to 127 or 196 to 254 VAC, 47 to 65 Hz, single-phase. Power consumption ranges between 275 and 675 watts.

Operating environment for all LSI-2 systems is 32 to 122 degrees Fahrenheit with humidity not exceeding 90 percent (non-condensing).

INPUT/OUTPUT CONTROL

I/O CHANNELS: The MaxiBus supports 5 data transfer methods with 58 parallel lines. The methods are high-speed block I/O, programmed I/O, conditional I/O, automatic I/O, and DMA. The standard block I/O feature allows data transfer over the MaxiBus at 411,000 words per second; with programmed I/O, the maximum data rate is 130,000 words or bytes per second. Programmed I/O direct to memory is also possible at a rate of up to 90,000 words or bytes per second. The automatic I/O provides cycle-stealing data transfer at up to 80,000 words per second under interrupt control. Direct memory access provides up to 1,020,000 words or bytes per second for a single memory bank and up to 1,666,000 with interleaved memories. Up to 128 direct memory channels are provided, and a total of up to 248 devices can be attached.

The Distributed I/O System, consisting of an I/O Distributor and "intelligent cable"—cable-mounted micro-processors (PicoProcessors) used as device controllers—is used for input/output control. Eight intelligent cables can be connected to each I/O Distributor. The PicoProcessor controllers operate through the four automatic I/O instructions.

The following PicoProcessor controllers are available:

- 14631-01 Line Printer controller for any Centronics line printer or equivalent.
- 14631-02 Card Reader controller for any Documentation card reader or equivalent.
- 14631-03 Paper Tape Reader controller for any Remex or equivalent 300-character-per-second reader.
- 14631-04 Paper Tape Punch controller for any Remex or equivalent 75-character-per-second punch.
- 14631-11 General-Purpose byte-parallel controller for use with most eight-bit input or output devices using negative-true logic and a "handshaking" I/O discipline.
- 14630-01, for a CRT.
- 14630-02, for a modem.
- 14632-01, for a teletypewriter.
- 14631-41 Magnetic Tape controller, for use with an external magnetic tape formatter to control up to four 7- or 9- track, NRZI or Phase-Encoded magnetic tape drives.
- 14676-01 IEEE controller, for interfacing the bus system defined by the IEEE 488-1975 specification. Up to 14 IEEE 488-compatible peripherals can be attached.
- 14722-01 32-Bit General-Purpose controller, for interfacing parallel, multi-byte wide devices. Word size is selectable in 8-bit increments up to 32 bits. Data is transferred under Automatic I/O Programming control using an I/O polling discipline. Other interface disciplines

can be implemented using a combination of computer software and PicoProcessor firmware control.

CONFIGURATION RULES

The basic Naked Mini LSI-2 CPU consists of one board and no chassis. The standard Alpha chassis has five full slots, four of which are available for interfacing half- or full-size boards for memory and/or peripheral/terminal devices (eight half-size memory or peripheral/terminal boards or four full-size boards in any mix). Each standard expansion chassis also has five full-size slots. A jumbo 9-slot chassis is also available.

Each core memory module requires one slot position; MOS RAM, ROM, and EPROM memories and general-purpose I/O options require half a slot each; the asynchronous modem multiplexer requires one slot; and other communications interfaces require one half-slot. See the Mass Storage section and Peripherals/Terminals table for individual device slot requirements. Up to 32K words can be contained in the basic mainframe using 16K core boards. For expansion beyond 32K words, the memory banking hardware is required. When memory exceeds the capacity of the main chassis, five-slot or nine-slot expansion chassis can be added.

The memory capacity of any LSI Series computer can be expanded to 256K words using CA's Memory Bank Controller (MBC). The standard MBC consists of a control interface (half-board) and a cable having 16 individual sections with a plug for mating with a socket at the rear edge of each memory. Additional cable sections can be added to further expand memory to 512K words.

Normally, memory modules occupy unique address spaces within the computer's total addressing range of 32K. Memory banking allows multiple memory modules to occupy the same address space at different times. A maximum of 32 memory modules can be attached to the processor at any given time. Each memory module is individually controllable, and switching between memory modules occurs in a single instruction time. Modules are organized as a matrix of Primary and Alternate modules. A maximum of 32K words can be assigned as Primary modules, while the remaining are Alternate modules. Since many arrangements of memory modules are possible, the MBC electronics provide for a maximum of eight memory modules per address space and a maximum of eight address spaces.

MASS STORAGE

18530-00 MOVING HEAD DISK SUBSYSTEM: This 2.46-million-word cartridge disk system includes one fixed and one removable disk and interface for up to three additional 22530-00 drives. Average head positioning time is 35 milliseconds, average rotational delay is 12.5 milliseconds, and data transfer rate is 156K words per second. The interface and controller combined occupy two chassis slot positions.

18566-00 DUAL FLOPPY DISK SYSTEM: This unit includes two drives, power supply, cables, and controller/interface. It is compatible with the IBM 3740 system. Capacity is 243K bytes per drive. Average head positioning time is 176 milliseconds, average rotational delay is 83 milliseconds, and data transfer rate is 250K *bits* (not bytes) per second. The DMA-type controller can support an additional dual drive and requires ½ slot.

INPUT/OUTPUT UNITS

Computer Automation will supply paper tape equipment, a line printer, card readers, and magnetic tape/cassette drives. ►

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► but recommends that the user purchase only the interface from Computer Automation and the I/O devices directly from the manufacturers. General-purpose I/O interfaces for 16-, 32-, or 64-bit I/O modules are also available.

See also Peripherals/Terminals table.

COMMUNICATIONS CONTROL

14227 ASYNCHRONOUS CONTROLLER: This unit provides a single-channel, full-duplex interface for Bell System 103 and 202 or equivalent data sets with RS-232 or DTL interfaces. It occupies one half-slot position.

14236 DUAL TERMINAL INTERFACE: Provides a half-duplex interface for two CRT's, leased line modems, or Teletype ASR 33/35 terminals at data rates between 110 and 9600 bps. It occupies one half-slot position.

14311 SYNCHRONOUS MODEM CONTROLLER: This unit provides a double-buffered, full-duplex interface for Bell System 201 or equivalent data sets with speeds up to 50K bits per second and RS-232 characteristics. It occupies one half-slot position.

14512 ASYNCHRONOUS MODEM MULTIPLEXER: Provides an interface for either two or four programmable lines at speeds from 75 through 9600 bps.

ANALOG I/O SYSTEM

This system provides analog-to-digital (ADC) and digital-to-analog (DAC) converters for laboratory and industrial applications. It is available in two basic configurations: a dual DAC contained on a half-card, or a dual DAC together with an ADC on a half-card. Either half-card can be plugged into the mainframe of any LSI Series computer. This data acquisition system can process up to 16 input channels of analog data at a throughput rate of 35,000 acquisitions per second (28.5 microseconds per conversion), and 2 analog output channels with a full-scale settling time of 1.0 microsecond.

The ADC subsystem includes a programmable real-time clock, end-of-conversion interrupt, and externally triggered data conversion as standard features. The analog-to-digital converter includes internal voltage regulation, an analog input multiplexer, a sample-and-hold amplifier, and a 12-bit A/D converter. The multiplexer features random, sequential, and wrap-around addressing modes of operation for 8 differential or 16 single-ended analog input channels. Analog input channels are protected against overvoltage.

The DAC subsystem contains two 12-bit digital-to-analog converters, a buffer register for each channel, an output power amplifier for driving up to 50 feet of cable, 2-axis control, and selectable set-up delay for intensity control signals to devices such as an oscilloscope, strip-chart recorder, and analog plotter. Each of the two DAC's has full 12-bit resolution with full-scale settling to within 1.0 microsecond for any of 4 switch-selectable output voltage ranges. Separate output buffer registers assure the independence of each analog output channel and provide an infinite hold capacity.

SOFTWARE

OPERATING SYSTEMS: Three operating systems are available for the LSI-2 series, including a basic paper tape system. All are separately priced. The paper tape system can include the Omega conversational assembler/editor and the Automagic utility package with loaders and debuggers.

A *Real-Time Executive (RTX)* is offered as a modular system consisting of a multi-tasking executive, an I/O

supervisor, a communications supervisor, and a real-time debugging program. RTX is designed to help the OEM user construct real-time application programs.

A full *Disk Operating System (DOS)* is available to support disk, magnetic tape, and other standard peripheral devices. DOS is a device-independent, batch-oriented system that supports program development and provides automatic control of job sequencing, I/O, interrupt handling, library support, file management, and on-line operator communication.

LANGUAGES: The user has a choice of two assemblers. *Omega*, a conversational assembler/editor that operates in 8K, and *MACRO*, a full macro assembler used with DOS. CA also offers three levels of *BASIC*—advanced 4K, extended 8K, and extended multiple-user 16K—and *FORTRAN IV* for program development. The complete *FORTRAN IV* plus extensions compiles under DOS, and compiled programs can be executed under either DOS or RTX.

PASCAL, a high-level block-structured programming language, operates under DOS in a minimum of 32K bytes of memory. *PASCAL* incorporates features of *COBOL*, *ALGOL*, and *PL/1*. According to CA, *PASCAL* contains the data structuring capabilities of *COBOL*, the compact arithmetic expressions of *PL/1*, the block-structured organization of *ALGOL*, and a complete set of diagnostic functions. *PASCAL* is well suited for quick, efficient development of DOS-based utilities and support routines. It also has an enhanced I/O capability to take full advantage of the DOS I/O system.

UTILITIES AND APPLICATIONS: A number of basic utilities and program development aids are available, but in general the user must develop his own applications programs.

PRICING

POLICY: Computer Automation provides the Naked Mini LSI-2 minicomputers for sale only in quantities of five or more units. Alpha systems are available in single-unit quantities. The strictly OEM-oriented company also recommends that buyers of its computers deal directly with other vendors for peripheral/terminal equipment, but will provide certain units if desired. More software is separately priced, as are all elements of the system that are not necessarily required by the OEM buyer.

SUPPORT: The amount of field support provided depends strictly upon individual negotiations and is related directly to the purchase quantity. Computer Automation provides system support from 15 U.S. locations as well as 13 other offices worldwide. The LSI-2 processors are covered by a one-year warranty.

On-site maintenance is generally the responsibility of the user, and can be performed rather easily through simple board replacement. Users, therefore, should keep a supply of spares on hand.

Computer Automation also provides one-week programming/maintenance training courses for \$2,000 per man per week. Training credits are granted to new customers, are relative to the total number of units sold via a purchase order, and are issued on an initial-order basis only. Training credits allocated to DOS customers are issued on an order-by-order basis, relative to the quantity sold. These credits are valid for six months after date of issue and can only be applied to courses taught at the Irvine facility. The current training credit allocation scale is:

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▶ 6-25 Units:	1 free week
25-50 units:	2 free weeks
50+ units:	3 free weeks
1-9 DOS:	2 free weeks
10+ DOS:	3 free weeks

TYPICAL ALPHA/LSI-2: Includes 4K words of semiconductor memory, power fail/restart, teletypewriter interface, and autoloader. Purchase price is \$2,595.

EQUIPMENT: A typical Naked Mini system delivered by Computer Automation is an 8K-word LSI-2 with real-time clock, autoloader, I/O Distributor, and four intelligent cable interfaces. Purchase price for this configuration is \$3,890 each, with a minimum order of five.

STANDARD DOS 60 SYSTEM: This relatively large-scale configuration consists of an LSI-2/60 processor with 32K words of 1200-nanosecond core memory, power fail/restart, ASR-33 terminal, real-time clock, RS-232 CRT interface, autoloader (including autoloader type 2 ROM), paper tape reader/punch, line printer, one 4.92-megabyte cartridge disk drive, programmer console, power supplies, cabinet, and supporting software including DOS and FORTRAN IV on a disk cartridge. Purchase price is \$33,500. ■

EQUIPMENT PRICES

	<u>Purchase Price</u>
PROCESSORS (PARTIAL SYSTEMS)	
Minimum order of 5	
10600-00 LSI-2/10 processor with power fail/restart	\$ 1,500
10400-00 LSI-2/20 processor with power fail/restart	1,900
10640-04 LSI-2/10 processor with 4K words of 980-nsec core memory	1,750
10640-08 LSI-2/10 processor with 8K words of 980-nsec core memory	2,120
10660-16 LSI-2/10 processor with 16K words of 1200-nsec core memory	3,300
10450-04 LSI-2/20 processor with 4K words of 980-nsec core memory and 5-slot chassis	2,300
10450-08 LSI-2/20 processor with 8K words of 980-nsec core memory and 5-slot chassis	2,695
10450-16 LSI-2/20 processor with 16K words of 1600-nsec core memory and 5-slot chassis	3,875
10740-04 LSI-2/10 processor with 4K words of 980-nsec core memory, power supply, programmer console, and 5-slot chassis	2,540
10740-08 Same as 10740-04 with 8K words of memory	2,910
10741-08 Same as 10740-04 with 8K words of memory and 9-slot chassis	3,665
10760-16 Same as 10740-04 with 16K words of 1200-nsec core memory	4,090
10761-16 Same as 10740-04 with 16K words of 1200-nsec core memory and 9-slot chassis	4,845
10550-24 LSI-2/20 processor with 4K words of 980-nsec core memory, power supply, operator console, and 5-slot chassis	2,765
10550-28 Same as 10550-24 with 8K words of memory	3,160
10551-28 Same as 10550-24 with 8K words of memory and 9-slot chassis	3,915
10560-36 Same as 10550-24 with 16K words of 1200-nsec core memory	4,340
10561-36 Same as 10550-24 with 16K words of 1200-nsec core memory and 9-slot chassis	5,095
PROCESSORS (PACKAGED ALPHA SYSTEMS)	
All prices for minimum of 5 systems except for LSI-2/60 configurations	
10740-04 LSI-2/10 processor with 4K words of 980-nsec core memory, power supply, operator console, and 5-slot chassis	2,540
10740-08 Same as 10740-04 with 8K words of memory	2,910
10741-08 Same as 10740-08 with 9-slot chassis	3,665
10760-16 Same as 10740-04 with 16K words of memory	4,090
10761-16 Same as 10760-16 with 9-slot chassis	4,845
10550-04 LSI-2/20 processor with 4K words of 980-nsec core memory, power supply, programmer console, and 5-slot chassis	2,865
10550-08 Same as 10550-04 with 8K words of memory	3,260
10551-08 Same as 10550-08 with 9-slot chassis	4,015
10560-16 Same as 10550-04 with 16K words of 1200-nsec core memory	4,440
10561-16 Same as 10560-16 with 9-slot chassis	5,195
10951-08 LSI-2/60 processor with 8K words of 980-nsec core memory, power supply, power fail/restart, basic variables option pack with ASR-33 and RS-232 CRT interfaces, real-time clock, and autoloader with type 2 ROM set, programmer console, and 9-slot chassis	6,850
10961-16 Same as 10951-08 with 16K words of 1200-nsec core memory	7,900
10951-16 Same as 10951-08 with 16K words of 980-nsec core memory made up of two interleaved 8K modules	8,765
PROCESSOR OPTIONS	
12500-00 Power Fail/Restart (cannot be used with 12500-01)	250
12500-01 Automatic Start-Up (cannot be used with 12500-00)	150
12505-01 Basic Variables Options package (required for all other 12505-XX options)	95
12505-02 ASR 33 Interface	100
12505-04 Real-Time Clock option	225
12505-16 CRT Interface, RS-232, for use with 12505-02 interface	75
12505-32 Autoloader option (requires both 12505-00 and 12505-01)	115
12505-39 Option Pack; includes 12505-01, -02, -04, and -32 (requires 12505-XX Autoloader ROM)	485
12505-55 Option Pack; same as 12505-39 plus RS-232 CRT interface	560

**Computer Automation Naked Mini and MegaByter
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EQUIPMENT PRICES

		<u>Purchase Price</u>
PROCESSOR OPTIONS (Continued)		
13505-01	Autoload ROM, Type 1; includes loaders for ASR-33, high-speed paper tape, magnetic tape, cassette, and moving-head disk (requires 12505-33 or higher)	60
13505-02	Autoload ROM, Type 2; includes all loaders of Type 1 ROM, plus loaders for floppy disk and a microdiagnostic program for CPU, memory, and I/O (requires 12505-33 or higher)	145
13505-03	Autoload ROM, Type 3; includes loaders for ASR-33, high-speed paper tape, PicoProcessor, current-loop serial PicoProcessor, floppy disk, magnetic tape, and moving-head disk; also contains microdiagnostic programs for CPU, memory, and I/O (requires 12505-33 or higher)	145
NOTE: There is a \$200 charge for retrofit and testing of any 12505-XX options installed on returned equipment.		
12090-40	On-Card Battery Backup for RAM/ROM memories (cannot be added as field upgrade)	95
12085-20	On-Card Battery Backup for RAM/EPROM memories (cannot be added as field upgrade)	95
12542-00	Memory Bank Control for configurations greater than 32K words (full-card memories only)	900
30100-0X	EPROM Programmer for programming and erasing EPROM memories (110VAC, 60Hz or 220VAC, 50Hz)	2,950
SEMICONDUCTOR MEMORY		
11650-38	RAM/ROM Memory Boards; includes 256 words of SC RAM and sockets for 8K words of ROM	290
11650-58	Same as 11650-38 with 1K words of SC RAM	400
11650-68	Same as 11650-38 with 2K words of SC RAM	550
11642-04	4K words of SC RAM	550
11642-08	8K words of SC RAM	900
11530-50	1K words of SC RAM plus sockets for 4K words of erasable programmable ROM (EPROM)	450
11530-60	Same as 11530-50 with 2K words of SC RAM	600
11530-52	1K words of SC RAM plus 2K words of erasable programmable ROM (EPROM)	1,425
11530-62	2K words of SC RAM plus 2K words of EPROM	1,575
11530-54	1K words of SC RAM plus 4K words of EPROM	2,450
11530-64	2K words of SC RAM plus 4K words of EPROM	2,600
CORE MEMORY		
11671-04	4K words of half-card memory	985
11550-08	8K words of 980-nsec core memory	1,950
11560-16	16K words of 1200-nsec core memory	3,050
I/O DISTRIBUTOR		
14629-14	I/O Distributor for 4 parallel or serial interfaces	445
14629-18	I/O Distributor for 8 parallel or serial interfaces	530
14674-01	DMA I/O Distributor	862
INTELLIGENT CABLES		
14631-11	General-purpose, 8-bit parallel interface	145
14631-01	Line Printer interface	145
14631-02	Card Reader interface	145
14631-03	Paper Tape Reader interface	145
14631-04	Paper Tape Punch interface	145
14632-01	Current-loop serial asynchronous interface	145
14630-01	CRT serial asynchronous interface	145
14630-02	Modem serial interface	145
14631-41	Magnetic tape interface	300
14676-01	IEEE interface	300
14722-01	32-bit interface	300
14640-14	4-channel I/O Distributor/interface	495
14640-18	8-channel I/O Distributor/interface	680
MASS STORAGE		
Moving Head Disks:		
18530-00	Disk drive and controller with one fixed and one removable disk; 4.92 million bytes; includes one pack	12,300
22530-00	Add-on drive for 18530-00 above	10,200
14530-0X	Controller for up to four 1500- or 2400-rpm disk drives (Diablo Model 21, 33, 43, or 44; Pertec D3000 Series)	2,550
Floppy Disks:		
18566-00	Dual-drive unit and controller; 243K bytes per drive	4,300
22566-00	Add-on drive for 18566-00 above	3,700
14566-01	Controller for up to 4 IBM-compatible drives	930
MAGNETIC TAPE		
18224-15	Magnetic tape transport and controller; 9-track, 25 ips, 800 bpi; for 7-inch reels	8,275
22224-15	Add-on drive for 18224-15 above	6,300
14224-15	Controller for up to 4 standard 9-track drives	2,400
LINE PRINTERS		
22107-06	Line printer; 80 columns, 60-150 lpm (requires 14223-00 or 14631-01 interface)	4,950
22107-32	Line printer; 132 columns, 165 lpm (requires 14223-00 or 14631-01 interface)	8,438

Computer Automation Naked Mini and MegaByter (LSI-2 Series)

EQUIPMENT PRICES

	Purchase Price
PAPER TAPE EQUIPMENT	
22223-11 High-speed reader, 300 cps (requires 14223-00 or 14631-03 interface)	1,945
22223-60 High-speed reader/punch system, 300 cps/75 cps (requires 14223-00 or 14631-03 and 14631-04 interface)	5,625
CARD EQUIPMENT	
22077-20 Card reader system, 285 cpm (requires 14223-00 or 14631-02 interface)	4,425
TERMINALS	
22205-00 Teletypewriter; modified ASR 33 (requires 12635-01, 14632-01, 12505-02, or 14263)	1,695
22215-00 Modification kit for teletypewriter	90
22851-63 Keyboard-display terminal; 24 lines by 80 characters, 128-character ASCII set; 75-9600 bits/second (requires 14630-01, 12505-16, 14236-1X, or 14236-21 interface)	1,900
14223-00 Utility I/O Interface Module for line printer, card reader, paper tape reader, or paper tape punch	600
COMMUNICATIONS	
14236-1X Dual interface for 2 CRT's	575
14236-21 Dual interface for 2 teletypewriters	500
14236-5X Dual interface for 1 CRT and 1 current loop teletypewriter interface	600
14535-01 Asynchronous modem controller for RS-232C interface	600
14535-02 Asynchronous modem controller for current loop interface	575
14512-21 Asynchronous modem multiplexer for 2 RS-232C lines	950
14512-22 Asynchronous modem multiplexer for 2 current loop interfaces	850
14512-41 Asynchronous modem multiplexer for 4 RS-232C lines	1,400
14512-42 Asynchronous modem multiplexer for 4 current loop interfaces	1,200
14513-00 Synchronous modem controller	1,200
14513-01 Synchronous modem controller with internal clock option	1,400
14523-02 Automatic Calling Unit multiplexer for 2 ACU's	800
14523-04 Automatic Calling Unit multiplexer for 4 ACU's	1,200
ANALOG I/O SYSTEMS	
High-Level A/D Converter Systems	
All converters are 12 bits, two's complement with a 28.5-microsecond conversion time; switch-selectable full-scale analog inputs of 0-5V, +5V, +10V and 0-10V; maximum sampling rate is software-dependent, but typically will be 35,000 samples/second; the real-time clock is programmable from 1 microsecond to 40 seconds; an optional programmable input gain amplifier multiplies the input by 1, 2, 4, or 8.	
11030-16 16 single-ended input channels	1,575
11130-16 16 single-ended input channels with programmable gain	1,750
11030-32 32 single-ended input channels	1,975
11130-32 32 single-ended input channels with programmable gain	2,150
11030-64 64 single-ended input channels	2,275
11130-64 64 single-ended input channels with programmable gain	2,450
11031-08 8 differential input channels	1,575
11131-08 8 differential input channels with programmable gain	1,750
11031-16 16 differential input channels	1,975
11131-16 16 differential input channels with programmable gain	2,150
11031-32 32 differential input channels	2,275
11131-32 32 differential input channels with programmable gain	2,450
General Purpose D/A Converter System	
Two 12-bit, two's-complement converters are provided along with switch-selectable output ranges of 0-5V, +5V, +10V, and 0-10V; maximum settling time of 1.0 microsecond; Z-axis intensity control and set-up delay; four TTL-compatible output lines for the transmission of control signals to analog devices.	
12031-00 2 output channels	950
A/D-D/A Converter Combinations	
Analog-to-digital converter and digital-to-analog converter contain the same features as described above.	
12031-08 8 differential input channels and 2 output channels	2,495
12131-08 8 differential input channels with programmable gain and 2 output channels	2,670
12031-16 16 single-ended input channels and 2 output channels	2,495
12131-16 16 single-ended input channels with programmable gain and 2 output channels	2,670
CHASSIS AND POWER SUPPLIES	
12036-00 Programmer Console	395
12457-50 Operator Console	125

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EQUIPMENT PRICES

		<u>Purchase Price</u>
CHASSIS AND POWER SUPPLIES (Continued)		
12034-00	5-slot chassis with fans	275
12044-00	Power supply for 12034-00 above	520
12098-00	5-slot expansion chassis and power supply	940
20500-01	9-slot chassis with fans	525
20441-00	Power supply for 20500-01 above	980
12099-00	9-slot expansion chassis and power supply	1,775

SOFTWARE PRICES

		<u>Purchase Price</u>
19001-00	Advanced BASIC (4K minimum)	\$ 300
19001-10	Extended BASIC (8K minimum)	400
19001-20	Extended Multi-User BASIC (8K min., 16K recommended)	500
19001-3X	OS BASIC	400
19001-40	Controller BASIC	400
19014-4X	Pascal	900
20570-00	FORTRAN IV; runs under DOS or RTX; available on cartridge disk only	1,700
19005-02	Real-Time Executive (RTX) for LSI-2 systems only	500
19007-00	Operating System (OS)	2,000
20629-02	Distributed I/O System diagnostic package for LSI-2 systems only	50
20223-XX	Paper Peripherals driver and diagnostic package (for paper tape reader/punch, line printer, and card reader)	50
20224-00	Magnetic Tape driver, file manager, and diagnostic package	100
20566-02	Floppy Disk driver, formatter, and diagnostic package	75
20530-00	Moving-Head Disk driver, file manager, formatter, and diagnostic package	100
20535-00	Asynchronous Modem Controller diagnostic package	50
20512-00	Asynchronous Modem Multiplexer diagnostic package	50
20513-00	Synchronous Modem Controller diagnostic package	50
20523-00	Automatic Calling Unit Multiplexer diagnostic package	50
20020-00	Minicomputer package; includes Omega, MACRO, utility, fixed-point and floating-point arithmetic, and diagnostic routines	190
20020-60	MegaByter package; includes quality control diagnostic and MegaByter macro file	75
20631-00	Distributed I/O System user microcode kit	1,000