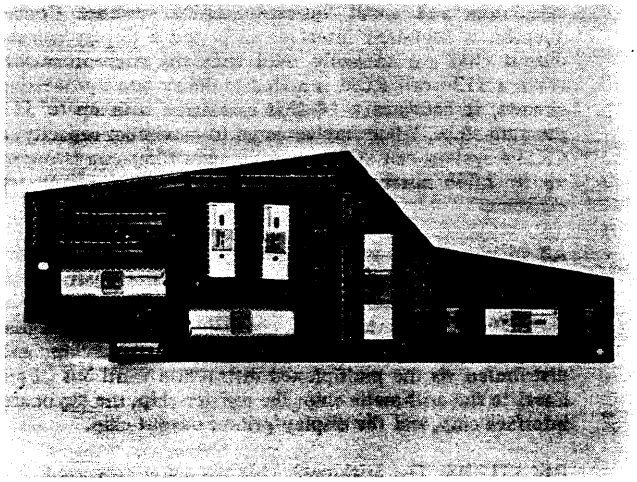
American Microsystems CK114 Microprocessor



The seven CK114 package types shown mounted on a circuit board contain the electronic circuits for the microprocessor used in a printing calculator. Total price for this set of circuits is $80 when purchased in quantities of 100 sets or more.

AMI, a leading MOS/LSI producer, offers its CK114 microprocessors to calculator and small business-machine manufacturers. With a micro-instruction repertoire of 75 instructions and maximum ROM storage of 2,048 words, these microprocessors are good candidates for either business or scientific calculators.

MANAGEMENT SUMMARY

American Microsystems, Incorporated, a pioneer in metal-oxide semiconductor, large-scale integration (MOS/LSI) technology, manufacturers the CK114, a set of seven MOS/LSI circuits (chips) used in calculators and small business-machine systems. The CK114 is a microprocessor whose processing functions are distributed among three chips; one for the instruction counter, one for arithmetic, and one for working registers.

Six of the seven available circuits are the minimum required to configure the electronics of a 14-digit calculator. These six electronic circuits include the instruction counter chip, a keyboard interface chip, a display/printer output chip, an arithmetic chip, a working register and memory chip, and 512 twelve-bit words of read-only memory (ROM) for microprogram storage. This CK114 electronic circuit set costs $80 when purchased in quantities of 100 sets.

A more powerful CK114 serial processor can be constructed to accommodate two input keyboards, a 16-digit light-emitting diode (LED) numeric display output, and a 17-column printer output. Such a configuration requires the following circuits: up to four 512-word ROM circuits providing up to 2,048 steps of microprogram storage; one instruction counter chip; one arithmetic chip; one working register and memory chip providing three 17-digit working registers and one 17-digit memory register; up to four extended memory chips with each chip contributing four 17-digit registers (a maximum enhancement of 16 registers is possible); two keyboard interface chips to support two eight-by-four matrix keyboards (32 keys and 16 switches); and two display/printer

CHARACTERISTICS

MANUFACTURER: American Microsystems, Incorporated, 3800 Homestead Road, Santa Clara, California 95051. Telephone (408) 246-0330.

MODEL: CK114.

DATA FORMATS

BASIC UNIT: Four-bit binary-coded-decimal (BCD) digits.

FIXED-POINT OPERANDS: None.

FLOATING-POINT OPERANDS: Basic arithmetic data consists of a 14-digit (56-bits) mantissa, plus one digit each for overflow, sign, and exponent. The four-bit exponent indicates decimal point location in reference to the mantissa's least significant digit.

INSTRUCTIONS: Twelve-bit single-word microinstructions are used in the CK114 microprocessor. Four bits of the microinstruction are used for register designation. The remaining eight bits of the instruction code provide control functions for the instruction counter, keyboard interface, arithmetic, working register and memory, and ROM chips. Instructions are designated as either branch or non-branch. Branch instructions are executed by the instruction counter chip, and non-branch by the arithmetic chip.

INTERNAL CODE: BCD.

MAIN STORAGE

STORAGE TYPE: MOS/LSI semiconductor read-only memory (ROM) for microprogram storage.

CYCLE TIME: Basic system timing is 5 microseconds per bit and 20 microseconds per digit (4 bit times per digit).

CAPACITY: Minimum ROM storage is 512 12-bit words and maximum storage is 2,048 12-bit words.

CHECKING: None.

STORAGE PROTECTION: Permanent microprogram storage is characteristic of ROM. The microprogram is written into ROM by the manufacturer and cannot be altered by the user. Since main storage is ROM, the entire storage is protected.

CENTRAL PROCESSOR

GENERAL: The CK114 is a microprogram-controlled serial processor whose processing functions are distributed among the following chips: instruction counter, arithmetic, and

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output chips (one chip for the numeric display the other for the printer). The cost of electronic circuit sets for this configuration (assuming four ROMs and four extended memory chips) would be $170 when purchased in quantities of 100 sets. A configuration similar to this is useful in small business machines; e.g., a cash register using this configuration can be equipped with a keyboard, a numeric display (LED), and a merchandise receipt printer.

The CK114 microprogram is developed from a repertoire of 75 instructions. Each of these instructions falls into one of two classes: it is either a branch instruction or a non-branch instruction. All branch instructions are executed by the instruction counter chip, while non-branch instructions are executed by the arithmetic chip. Twleve-bit microinstructions are fetched from ROM and are decoded by the instruction counter to determine whether they are branch or non-branch instructions. Branch instructions are executed under the instruction counter's control. When non-branch instructions are decoded, they are time-multiplexed over three lines to the other system circuits and system control is transferred to the arithmetic chip. After instruction execution, the arithmetic chip returns control to the instruction counter.

ROM microprogram development for the most part is undertaken by the CK114 user. This is the approach taken by users who have fairly sophisticated systems design staffs backed by in-house programming personnel and computer systems. For these manufacturers, AMI offers cross assembler and simulator software packages to compile and list the desired microprograms. Other manufacturers who are not as strongly staffed can take advantage of AMI facilities for microprogram development.

These AMI development facilities include software and hardware simulators. In order to avail himself of this service, the user submits a program written from the CK114 microinstruction set to AMI. AMI then assembles the program and runs it through the simulator. After the program has been debugged, the ROM is ready to be programmed. For large-volume users (10,000 or more chips per year), AMI will develop and program ROMs working from flowcharts supplied by the user.

AMI's involvement in MOS/LSI circuit production dates from 1966. Since then, the company has produced millions of MOS/LSI circuits, and over one million of these circuits have been CK114s. Like other MOS/LSI circuit producers, AMI sees bright prospects for future sales. Applications for these products are diversified and include, in addition to calculators: computer memories for minicomputer and large-scale systems utilizing microprogramming processor techniques; computer terminals, and particularly keyboard entry devices (point of sale, cash register systems, etc.); automobile devices to improve safety and reliability, such as anti-skid systems, excessive

working register and memory. These microprocessors are arithmetic processing systems which are implemented in calculators and small business-machine systems. Consequently, a keyboard interface chip and a display/printer output chip are normally used with the microprocessor. When a 512-word ROM is added to the system's processing circuits, it becomes a 14-digit calculator with up to 512 program steps. When implemented to maximum capacity, a CK114 system can store machine algorithms consisting of up to 2,048 microinstructions using 17 working/memory registers.

All arithmetic operations are serially processed between the arithmetic and working register memory chips. Instructions are fetched from ROM locations by the instruction counter chip. The 12-bit instructions, consisting of four 3-bit signal groups, are multiplexed by the instruction chip and distributed via the multiplexed instruction word bus (three lines) to the arithmetic chip, the register chip, the keyboard interface chip, and the display/printer output chip.

REGISTERS: The arithmetic chip has a non-programmable 12-bit instruction register and 2 programmable general-purpose 4-bit registers. Three 68-bit data registers controlled by a 4-bit instruction register are located on the working register memory chip and work in conjunction with the arthmetic chip during arithmetic operations. A fourth 68-bit register is a dummy register also on the working register memory chip whose contents are zero. These four registers can be designated as either X or Y registers by the last four bits of an instruction. The four instruction bits specify the working registers containing data for a given arithmetic operation.

Additional working register storage can be implemented by adding up to four extended memory chips. Each extended memory chip contains four 68-bit (17-digit) dynamic registers controlled by an 8-bit instruction register.

INDIRECT ADDRESSING: No.

INSTRUCTION REPERTOIRE: Seventy-five instructions comprise the CK114 instruction set: 21 arithmetic instructions, 9 logic instructions, 8 memory instructions, 5 input/output instructions, 9 branching instructions, and 23 special instructions.

The CK114 uses two sequencers to control microinstruction execution: the instruction counter chip sequencer executes branch instructions and controls multiplexing of non-branch instructions to other chips; the arithmetic chip sequencer controls execution of the non-branch instructions.

INSTRUCTION TIMINGS: All instruction timings are in microseconds, and arithmetic operands are full 17-digit numbers consisting of a 14-digit mantissa and 1 digit each for overflow, sign, and exponent.

Load/Store:	360/360
Add/Subtract:	380/380
Multiply/Divide:	*
Compare and Branch:	40

*By subroutine only.

INTERRUPTS: None

CONTROL STORAGE: Main memory comprises ROM control storage.

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speed alarms, automatic fuel injection, electronic ignition systems, and seatbelt alarms; and consumer-oriented items such as household appliance controls, digital wrist watches, and electronic organs. Based on market surveys and AMI estimates, the world-wide market for MOS/LSI circuits will be $999 million by 1975.

AMI sells MOS/LSI circuits in large volumes to calculator manufacturers such as Hewlett-Packard, which uses these circuits in its HP-35, HP-45, HP-65, and HP-80 calculators. CK114 circuits are also used in cash register systems to check customer credit, ring up sales, track movement of inventory, and print sales reports or audits on demand. AMI's competitors in calculator chips and other MOS/LSI circuits include Intel, Rockwell International, National Semiconductor Corporation, Fairchild, and Motorola.

This company offers over seven years of MOS/LSI technology experience gained by the members of its engineering staff, who have already developed nearly 1,000 LSI circuits for virtually every MOS/LSI application. AMI has one of the largest MOS/LSI manufacturing facilities in the world and intends to expand these facilities to meet growing industrial demands. Its off shore marketing includes design centers and sales offices in England, Japan, Germany, and Italy. Future prospects for AMI are excellent. As MOS/LSI demands increase, the company should benefit since it is involved in a diversity of areas: consumer, computer, automotive, avionic, industrial, and government. □

INPUT/OUTPUT CONTROL

I/O CHANNELS: All input/output functions are performed under microprogram control. Serial data flows over two data busses (data in and data out) into and out of the arithmetic chip, where a general-purpose register (a four-bit register in the arithmetic logic unit) provides data linkage between the arithmetic chip and the working registers (working registers and memory chip). The data busses link input data from the keyboard input chip and output data to the display/printer output chip through the arithmetic chip. Two keyboard input chips, each interfacing an eight-by-four matrix keyboard, can be used in one system. Two output chips, display/printer output, can be used in a system. Each chip can drive either a 17-column hammer-driven parallel printer (Seiko Model Number 102, or equivalent) or a 16-digit display.

SIMULTANEOUS OPERATIONS: The CK114 is a serial microprocessor, and simultaneous operations are not performed.

CONFIGURATION RULES: A minimum chip configuration for a 14-digit display calculator consists of a instruction counter chip, a keyboard input interface chip, a display/printer output chip, an arithmetic chip, a working register and memory chip, and a 512-word microprogrammable ROM. This configuration can interface a 31-key, 8-static-switch keyboard, and either a 16-digit display (such as LED) or a 17-column printer.

The microprocessor can support a maximum configuration consisting of 4 ROM chips containing 2,048 12-bit words (512 words per chip), an instruction counter chip, an arithmetic chip, a working register and memory chip, 4 extended memory chips with 4 working registers on each chip, 2 keyboard interface chips (each chip supports 1 keyboard), and 2 display/printer output chips (each chip supports either a display or a printer). (In both configurations described, the keyboard interface chip and the display/printer output chip provide the necessary interfacing for input and output devices, respectively.)

MASS STORAGE

None.

INPUT/OUTPUT UNITS

KEYBOARD INPUT: The CK114 system input is through the keyboard and interface chip. The chip handles 31 keys and 16 static switch lines. Key and switch functions are defined by the system's ROM instructions. One system configured with two keyboard interface chips can support two keyboards.

DISPLAY/PRINTER OUTPUT: The display/printer output chip provides system output under program control for either a display or a printer. Two chips are needed to provide simultaneous display and printer output because of the programming differences in the print and display functions. The same chip provides both functions, but it can perform only one of these functions for either a display or printing device at any given time. Printing devices used with the CK114 are 17-column Seiko Model Number 102, or equivalent.

SOFTWARE

OPERATING SYSTEMS: None is required for CK114 configurations since these systems are used in calculators and small business machines.

PROGRAMMING: ROM microprograms are written based on the CK114 microinstruction set. The microprograms are submitted to AMI, which uses its own cross assemblers and software/hardware simulators to prepare the coding for making the ROM masks (photo-lithographic plates) which are used to program the chip physically.

PRICING

POLICY: CK114 circuit sets are available on a purchase-only basis in quantity prices up to 10,000 sets. Quantity prices beyond 10,000 sets can be negotiated between the user and the manufacturer. Although there is no warranty on the circuits, AMI performs 100 percent testing on the chips before they leave the factory. Chips determined to be factory defective can be replaced.

A one-time ROM masking charge of $1,000 is made on minimum orders of 500 CK114 sets. A $5,000 ROM masking charge is made for orders of less than 500 sets. It should be noted that these masking charges apply over and above the costs of the chips themselves (see Equipment Prices) and include 10 to 25 prototype ROMs. On orders of 10,000 sets or more, ROM masking charges are negotiable.

SUPPORT: Sales support is provided through 20 offices in the United States, Europe, and Asia. On-site software training is available for large-volume (10,000 chips or more per year) users' personnel. Personnel with programming background can receive this training in Santa Clara for domestic users or in Swindon, England, for offshore users. ■

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EQUIPMENT PRICES

		Quantity	Purchase Price Per Set	Purchase Price Per Chip
CK114	Printing calculator set consisting of the following seven chips: S1893 instruction counter chip, 40-pin dual-in-line package (DIP); S1896 arithmetic chip, 28-pin DIP; S1898 working register and memory chip; two ROM chips, 512 12-bit words each (without microprogram), 28-pin DIP; S1894 keyboard interface chip, 40-pin DIP; S1895 display/printer output chip, 40-pin DIP.	1-24	$170	$24.30
		25-99	120	17.14
		100-999	80	11.40
		1,000-4,999	63	9.00
		5,000-9,999	58	8.30
		10,000 up	Negotiable	—