Texas Instruments 980B

With well over 4000 installed, the TI 980 has proven to be a successful product for the Houston-based Digital Systems Division of Texas Instruments. The latest version, the 980B, offers improvements over the 980A through the use of error-correcting memory, enhanced power supplies adapted for international markets, and a new physical package.

MANAGEMENT SUMMARY

Although the general-purpose 980B is a brother system to the TI 960B, the two systems are not program-compatible. They are, however, data-compatible and for the most part utilize the same peripheral equipment. Both the 980B and 960B use some common hardware in the mainframes to the extent that their power supplies and semiconductor memory modules can be interchanged. Whereas the 960B was designed primarily for process monitoring and control applications, the 960B is intended for use in data communications, batch processing, and scientific processing.

The lineage of the 980B goes back to May 1967, when the Model 980 was introduced. About 75 of those systems were delivered during the next 3 years. The Model 980A, announced in July 1972, differed from its predecessor primarily in that it used a 750-nanosecond MOS memory instead of the older one-microsecond core memory. It also had a new physical package.

The latest version of the 980, the 980B, is an enhanced version of the 980A. The improvements that set it apart from the 980A are new memories, this time with error detection and correction logic and 4K RAM chips in plug-in sockets, and improved power supplies for inter- ▷

The 16-bit TI 980B is a general-purpose scientific minicomputer with 16K to 128K bytes (8K to 64K words) of error-correcting memory. Standard features include hardware multiply/divide, hardware breakpoint, byte and bit string manipulations, bootstrap loader firmware, and power fail/restart. Unbundled software includes a range of operating systems, a Symbolic Assembly Processor, and FORTRAN IV.

CHARACTERISTICS

MANUFACTURER: Texas Instruments Incorporated, Digital Systems Division, P.O. Box 1444, Mail Stop 784, Houston, Texas 77001. Telephone (713) 494-5115.

Texas Instruments is a leading supplier of semiconductor products to all branches of the electronics industry. In addition, the company is active in the fields of process control, instrumentation, and computer peripheral equipment. Texas Instruments employs over 70,000 personnel in 47 plants located in 19 countries.

MODEL: 980B.

DATE ANNOUNCED: First quarter 1974.

DATE OF FIRST DELIVERY: May 1974.

NUMBER TO DATE: 3,150 in U.S.A.; 1,350 elsewhere.

DATA FORMATS

BASIC UNIT: 16-bit word plus 6 redundancy bits.

FIXED-POINT OPERANDS: 16 bits; the 980B also has bit, byte, and byte-string manipulation instructions.

FLOATING-POINT OPERANDS: There is no floating-point hardware for the 980B, but floating-point operations are supported through subroutines. The operands include "single-precision" numbers with an 8-bit exponent and 24-bit fraction, and "double-precision" numbers with an 8-bit exponent and 32-bit fraction.

INSTRUCTIONS: Instructions are one, two, or three words long. The register-memory format has a 5-bit operation code, 1-bit fields for indirect address/index/base register indicators, and an 8-bit displacement. Register-shift instructions have an 11-bit operation code and a 5-bit shift count field. Register-to-register instructions have a 9-bit operation code, a 3-bit source register indicator, a 1-bit status register flag, and a 3-bit destination register indicator.

Register-skip instructions have a 12-bit operation code, 1 unassigned bit, and a 3-bit register indicator. Status indicator skip or single-function instructions have a 16-bit operation code with no modifiers. Sense switch instructions have a 12-bit operation code and a 4-bit sense switch ▶

REFERENCE EDITION. This is a mature product line, and no significant further developments are anticipated. Because of its importance, coverage is being continued, but no future update is planned.

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national markets. The new memory corrects one-bit data errors and detects multi-bit errors, which create an interrupt. Light-emitting diodes (LEDs), located along the sides of the memory controller board, provide failure information so that single-bit errors can be identified at an individual RAM device level. Further, the chips are now mounted in sockets, allowing easy removal and replacement by on-site personnel. Early 980 users view this maintenance feature as a welcome relief, especially OEM's who normally do not purchase contract maintenance from TI. These users are now able to use the TI factory service plan in which bad modules can be swapped for a fee. Another important feature of the new memories is the use of 4K RAM chips, enabling TI to offer memory modules of 8K, 16K, or 24K words. Using these modules, users can assemble a full 64K memory in single chassis without additional cabling or other hardware.

Standard features of the 980B include bootstrap loader firmware, multiply/divide hardware, programmable memory protection, and power fail/restart. For many minicomputers of this class, some or all of these features are available only as separately priced options.

Compared to the TI 960B, the 980B adds byte and byte string manipulation capabilities, more arithmetic features, and different software packages to support general-purpose and scientific applications. The 980B also has an auxiliary processor port to interface specialized devices such as floating-point processors, Fast Fourier Transform processors, etc. However, the 980B does *not* have the Communications Register I/O Unit of the 960B, which permits the assignment of individual bits to specific devices in any arrangement.

The 980B is slightly more expensive than the 960B, selling for $5,150 with 8K words of memory. In contrast, the same basic 8K 960B configuration sells for $4,500. However, the cost of the CPU represents the only significant hardware price difference since all peripheral devices available to 960 systems are also used in 980 systems. The interface costs may differ slightly. The 960 and 980 systems also use the same memory modules and chassis.

Since the major differences between the TI 980A and 980B are in the memory and power supplies, all existing 980A software can run on the 980B.

At first, the TI 980 did not have a disc-based, real-time operating system, and market acceptance was slow. TI's tape-based operating system was effective but relatively slow, causing potential users to look to TI's competition despite the excellent reliability of the 980 systems. TI remedied this situation in March 1975, when the DX980 Disc Executive was released. This operating system is designed for medium-to-large-memory systems and provides real-time multiprogramming capabilities.

Generally, the software available for the 980B has been oriented toward small-to-medium-sized, general-purpose ▷

indicator. Multi-register instructions (2 words) have a 16-bit operation code and a 16-bit memory address.

Data bus I/O instructions (2 words) have a 5-bit operation code, a 2-bit group indicator, eight 1-bit mode indicators, a 5-bit external register indicator, and a 3-bit internal register designator. DMA I/O instructions (2 words) have an 8-bit operation code, a 5-bit device-dependent field, a 3-bit device/channel address, and a 16-bit control word or memory address.

INTERNAL CODE: Binary.

MAIN STORAGE

STORAGE TYPE: Dynamic MOS. Memory employs 4K RAM chips in pluggable sockets. Light-emitting diodes (LED's), located along the sides of the memory controller boards, give failure information so that single-bit errors can be identified at an individual RAM-device level.

CYCLE TIME: 750 nanoseconds. Refresh time is one memory cycle every 32 microseconds.

CAPACITY: The 980B minimum memory capacity is 16,384 bytes (8,192 words), expandable to a maximum of 131,072 bytes (65,536 words) in 16,384, 32,768, or 49,152-byte increments. A full 131,072 bytes of memory can be accommodated in one 960B chassis.

CHECKING: An error checking and correcting system is employed on the 980B. The system employs a six-bit, modified Hamming code to identify erroneous bits. The memory controller generates a six-bit code during a memory write operation, and stores it, along with the 16-bit data word, in a 22-bit memory word. During a read operation, the controller retrieves the stored data, generates a new code, and compares that code with the stored code to determine whether an error has occurred. Single-bit errors in the word are detected and corrected on the fly. If a double-bit error occurs, the controller detects it and interrupts the CPU.

STORAGE PROTECTION: A memory protect/privileged instruction feature (MP/PIF) prohibits user programs from changing memory protection boundaries, setting the computer to the idle state, branching into or accessing protected memory space, changing the status register, or interfacing system I/O operations.

This protection mode is controlled through two status register bits, and can be fully or partly activated. One bit enables interrupts when either protected memory is accessed or a privileged instruction is used. Only one area in memory can be protected and is defined by two limit registers, upper and lower, which are loaded under program control.

The second status register bit controls automatic program relocation. When set, the computer indexes all memory accesses by the value of the lower limit register. This causes user programs to be automatically relocated and executed in a memory area other than the intended one.

RESERVED STORAGE: 136 words of memory are reserved for interrupt vectors, and 316 words are reserved for a basic loader and device driver.

CENTRAL PROCESSOR

GENERAL: The basic 980B CPU provides hardware program relocation and includes power fail detection/auto ▶

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PERIPHERALS/TERMINALS

DEVICE	DESCRIPTION & SPEED	MANUFACTURER
MAGNETIC TAPE EQUIPMENT 948206-0001	Transport Master Kit; master transport and controller for up to three transports; 9-track, 800 bpi, NRZI, 10.5-inch reels, 37.5 ips, vacuum columns; add-on transport is 948206-0004; 30 KBS	Texas Instruments 979A
PRINTERS 966792-0001	Printer Kit; controller and serial impact printer; 132 positions, 64-character set, 9 × 7 dot matrix, 4 to 14.8-inch paper, 6 lines per inch, 10 characters per inch, 2-channel VFU, one-line buffer; 165 cps	Centronics 101A
966792-0011	Same as 966792-0001	Centronics 102A
PUNCHED CARD EQUIPMENT 943900-0001	Card Reader Kit; controller and 80-column reader; 1000-card input hopper, 500-card output stacker, fiber-optic read station; 400 cps	True Data 804
PUNCHED TAPE EQUIPMENT 965946-0003	Reader; sprocket-driven, bidirectional, asynchronous, 5 to 8-level codes; 300 cps	Remex 6300
973526-0002	Reader/Punch; sprocket-driven, bidirectional, asynchronous, 5 to 8-level codes; 300/75 cps	Remex 6375
TERMINALS 966645-0001	733 ASR Terminal Kit; controller and Silent 700 terminal; 80-position thermal printer with 96 ASCII character set, 10 characters per inch, 6 lines per inch, friction feed and 5 × 7 dot matrix; twin magnetic tape cassette drives, write/read/copy capability with off-line edit, buffered transmit/receive, 800 bpi, PE, 8 ips, 330K characters, 120 or 250 cps; 55-key ASCII keyboard, EIA interface, full duplex; 30 cps print rate, 1200 bps data rate.	Texas Instruments 733
943932-0011	743 KSR Terminal Kit; Controller and Silent 700 terminal; 80-position thermal printer with 64 ASCII character set, 10 characters per inch, 6 lines per inch, friction feed and 5 × 7 dot matrix; limited ASCII keyboard, EIA interface, full duplex; 30 cps	Texas Instruments 743
973306-0012	Video Display Terminal; 12-inch, 5 × 7 dot matrix, 64 ASCII characters, 24 lines by 80 characters per line, MOS refresh memory, 61-key keyboard including 6 function keys and 4 direction cursor controls, EIA interface; switch-selectable data rates to 9600 bps	Texas Instruments 912

▷ systems requiring powerful arithmetic capabilities and using a wide range of peripherals. A cross-assembler for the 960B is available for the use on the 980B for off-line development of 960B programs.

Many of the 980 computers have been incorporated into packaged TI systems oriented toward Field Seismic Data Reduction (CFS, $50K to $100K), message switching/data concentration (EMS II, $75K to $250K), and Long Distance Control systems (LDC, $100K to $150K). Other 980-based packages, not available directly from TI, include Applied Kinetics' scrap metal smelting analyzer (from $125K) and the Japanese Electro-Optical Laboratories' JEOL Nuclear Magnetic Resonance Detector ($150K).

The 980B is offered on a purchase or lease basis with separately priced maintenance. Besides standard maintenance service with various options for extended coverage, Texas Instruments offers on-call service, shop service, and fixed-price repair service. Shop service is available during normal working hours at TI service centers for customer-delivered parts. Fixed-price repair service is offered on standard electronic interface assemblies only, and offers repair and/or exchange of ▷

► restart, hardware multiply/divide, programmable memory protect and privileged instructions, removable control panel with keylock, hardware breakpoint, program sense switches, and a hardware bootstrap loader as standard features. A privileged mode of operation is also provided. A plug-in battery pack, optionally available for the volatile semiconductor memory, can sustain an 8K-word memory module's contents for 20 hours at room temperature. An auxiliary processor port in the CPU is provided for dual-processor configurations.

Options available for the 980B include internal and external I/O bus expansion, ROM bootstrap loader for DS330-type disc systems, and an interval timer. The interval timer has a 12-bit counter with 10-millisecond to 40.96-second intervals which are selectable under program control.

CONTROL MEMORY: A read-only memory (ROM) with 256 16-bit words is available to provide bootstrap loading for up to 8 devices under switch control. Devices supported include teletypewriters, cassette tapes on a TI 733 ASR Data Terminal, paper tape readers, moving-head cartridge and disc pack drives, and card readers.

REGISTERS: A file of eight 16-bit general-purpose registers serve, respectively, as a primary arithmetic register (A), secondary or extension arithmetic register (E), index register (X), maintenance register (M), storage register (S), link register (L), base register (B), and program counter (P). ►

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parts. This service is normally for customers who perform their own equipment maintenance.

TI provides two one-week hardware or software training courses free with the purchase of each 980B system. Additional courses are available for fixed fees. All courses are conducted at the Digital Systems Division Education and Development Center in Austin, Texas.

Most software for the 980B is offered by license agreement with Texas Instruments. In addition to a one-time license fee, a monthly maintenance fee is also applicable.

USER REACTION

Detailed below are the combined results of a Datapro survey of TI 980 users selected from a list supplied by Texas Instruments and the response to Datapro's industry-wide 1977 computer survey. A total of more than 220 systems had been purchased and installed by the six users, all but one of whom were TI OEM accounts. Product applications included typesetting, text editing, simulator systems for the airlines, station processors for the armed services, spectrometric systems, and process control for numerical control machines.

The TI 980 users were well experienced with the hardware, since the minimum installation time was two years and the maximum time five years. Four of the six users were equally experienced with TI's software, both operating systems and compilers/assemblers. The overwhelming majority of their programming was being done in-house.

The users had typically purchased the processors, memory, and Silent 700 terminals from TI. Any other peripherals had been purchased from other sources. Most systems in the survey were operating with 64K bytes of memory.

The table below shows how these users rated the TI 980 product line.

	Excellent	Good	Fair	Poor	WA*
Ease of operation	3	3	0	0	3.5
Reliability of mainframe	3	2	0	1	3.3
Reliability of peripherals	1	3	1	1	2.8
Maintenance service:					
Responsiveness	2	1	0	1	3.0
Effectiveness	2	1	1	1	2.8
Technical support	0	4	1	1	2.5
Manufacturer's software:					
Operating system	2	1	0	1	3.0
Compilers and assemblers	1	2	1	0	3.0
Ease of programming	0	5	0	0	3.0
Ease of conversion	0	1	0	0	3.0
Overall satisfaction	2	3	0	1	3.0

*Weighted Average on a scale of 4.0 for Excellent.

The TI 980 has been an effective workhorse for Texas Instruments, as demonstrated by such user comments as "experience excellent," "price/performance is unusually good," and "fastest mathematical instruction set at a reasonable price."

ADDRESSING MODES: The 980B has 15 addressing modes. These include 8-, 16-, and 32-bit immediate; direct (16-bit); indexed; program-relative (+128 displacement); double indexed (program counter plus index register); indexed program-relative; program-relative indirect; program-relative indirect with pre-indexing; program-relative indirect with post-indexing; base displaced; base displaced indirect; and base displaced indexed. In addition, every bit of each memory location can be individually set, reset, or tested. Indirect addressing is to one level only.

INSTRUCTION REPERTOIRE: 98 instructions are standard: 24 register-to-storage, 20 register shift, 13 register-to-register, 8 register skips, 10 status indicator skips, 2 sense switch instructions, 5 multi-register instructions, 2 byte manipulation, 8 memory register bit manipulation, 1 auxiliary processor, 2 data bus I/O, 1 DMA I/O, and 2 single-function instructions.

INSTRUCTION TIMINGS: All times are in microseconds for full-word, fixed-point operations, using instructions which reference memory.

Load/Store:	1.75/2.0
Add/Subtract:	1.75/1.75
Multiply/Divide	2.65-6.25/2.75-6.75
Compare and Branch:	4.0

INTERRUPTS: A total of 37 internal and external interrupts can be implemented in four priority levels. Highest priority goes to three internal interrupts for illegal op codes, privileged instruction violation, unrecoverable memory error, and power failure/restart; 32 external interrupts have the next priority level, followed by one SMAC interrupt and one I/O Bus interrupt. A vectored interrupt module provides eight external priority interrupts, so that up to four modules can be accommodated.

A selected interrupt causes a direct branch to an instruction stored in two dedicated memory locations. If this instruction does not modify the program counter, the next instruction in the normal (uninterrupted) program sequence is executed.

PHYSICAL SPECIFICATIONS: The 980B is 12.25 inches high, 19 inches wide, and 24.125 inches deep, and weighs 80 pounds with 8K words of memory. Power requirements for the CPU are 115 VAC ±10 percent, 47 to 63 Hz, 600 watts.

The external I/O bus expansion chassis is 10½ inches high, 19 inches wide, 12 inches deep, and weighs 60 pounds including power supply. Power requirements for the I/O bus expansion chassis are the same as for the CPU, and power consumption is 300 watts maximum. The DMAC expansion chassis is 12¾ inches high, 19 inches wide, 25 inches deep, and weighs 70 pounds; power consumption is 450 watts maximum.

Operating environment for all 980B units is 32 to 122 degrees F., 0 to 95 percent relative humidity, noncondensing.

I/O CONTROL

I/O CHANNELS: I/O operations can take place via the Direct Memory Access (DMA) Channel, the I/O Bus, or the auxiliary processor (AP) port. The standard DMA channel permits the attachment of up to eight high-speed device controllers with a maximum aggregate data transfer rate of one million 16-bit words per second. The standard I/O bus can attach from 1 to 256 low-speed devices with 16-bit data transfer rates to a maximum of 130K words per second. With the AP port, memory access is available to any controller attached to an auxiliary processor in a manner

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▷ The product line has not been without problems, however, as voiced by this user comment: "Maintenance responsiveness and effectiveness is the worst I have ever been exposed to in 19 years of D.P. experience." Users also complained about quality control procedures that allow defective boards and even peripherals to be installed at users' sites with little hope of getting the parts repaired or replaced within the 30-day warranty period. On the positive side, the fixed-price repair service, designed to assist users who normally do their own maintenance, drew praise as a program for replacement for defective boards.

This product line will be phased out sometime in the foreseeable future, and hopefully TI has learned from its experiences with users of the 980. If this leading semiconductor maker is to become a force in the minicomputer industry, mistakes such as those reflected by the above user comments must be rectified.☐

▶ similar to DMA access, except that for AP operation, the 980B enters a wait state until the AP releases control.

CONFIGURATION RULES: The basic 980B chassis has three memory slots, each of which can hold an 8K, 16K, or 24K MOS memory card. A single 980B system can support 64K words of MOS memory. For memory expansion beyond two modules, the sum of the memory on the first two modules must be 32K or greater.

Also included in the basic chassis are four I/O ports (with an I/O interface), a DMA port, and an auxiliary processor port. A single DMAC controller, either for disc or for magnetic tape, can be mounted in the I/O expansion space of the CPU. If multiple DMAC controllers are configured in the system, then external expansion via rack-mounting is required for one or more of the DMAC peripheral subsystems. Internal I/O expansion up to 13 I/O ports is possible only if no DMAC controller is mounted internal to the basic 980B chassis.

A single 980B system can support up to 256 I/O bus devices (low-speed peripherals) and up to 8 high-speed device controllers on a DMA channel (for magnetic disc drives or tape transports). Each of the 4 allowed 980 I/O Expansion Cards provides expansion logic for up to 64 addresses maximum and plugs into one of the 4 standard I/O ports. Each 980 External I/O Bus Chassis provides 10 I/O ports.

For external expansion of the DMA, an independent expansion chassis can be factory-wired to provide up to 56 card slots. An Auxiliary Processor (AP) port is available to attach an additional processor for multiprocessing.

I/O port requirements of various devices include the following: each interrupt module (eight external interrupt lines), one; each 980 Communications Module, one; each interval timer module, one; each synchronous communications module, one (one-inch spacing); each 733 or 743 Terminal, one; and each 912 Video Display Terminal, one port. Also, each punched tape reader requires one I/O port; each punched tape reader/punch, two I/O ports; each card reader, one I/O port; and each printer, one I/O port.

MASS STORAGE

DS330 MAGNETIC DISC SUBSYSTEM: Consists of a controller capable of interfacing up to four IBM 3330-type drives and one primary drive. Each drive has a capacity of 49 million 16-bit words, for a total system capacity of 196 million words. The drive rotates at 3600 rpm with an average rotational delay of 8.4 milliseconds. The data transfer rate is 403K words per second with a block size from 1 to 120K words. The controller allows blocks, sectors, and records to be independently variable in length. Records may be from 1 to 6,272 words long. The controller also provides for data chaining, error correction, and independent overlapped seek capabilities. Data chaining provides transfer to or from disc to noncontiguous memory locations. Track-to-track, average, and across-all-tracks head positioning times are 7, 27, and 50 milliseconds, respectively.

The disc drives store data on IBM 3336-1 12-platter disc packs, using 19 recording surfaces of 411 tracks each. The top and bottom platters are for disc pack protection, while the bottom surface of the 10th platter (reading top to bottom) is for servo use. Total unformatted track capacity is 6,650 16-bit words, while formatted track capacity can be as high as 6,272 16-bit words. The drives are manufactured by ISS/Univac (733-10).

DS31/DS32 MAGNETIC DISC SUBSYSTEM: Consists of one drive and a controller capable of interfacing up to four removable or nonremovable-cartridge disc drives. Each drive has a capacity of 1.14 million 16-bit words, for a total system capacity of 4.56 million 16-bit words. The 955157-0001 DS31 Magnetic Disc Master Kit consists of a rack-mountable DS31 Removable-Cartridge Disc Drive and controller. The first and third add-on DS31 Drives are the 955157-0002; the second add-on (with power supply) is the 955157-0003. The DS32 is a nonremovable version of the DS31. The first and third add-on DS32 Drives are the 966669-0002; the second add-on (with power supply) is the 966669-0003.

The drives rotate at 1500 rpm. Data transfer rate is 97.6K words per second, average rotational delay is 20 milliseconds, and average head positioning time is 70 milliseconds. Track-to-track and across-all-tracks head positioning times are 15 and 135 milliseconds, respectively.

Data is stored on a two-surface disc cartridge organized into 203 data tracks with 88 32-word sectors per track. There are 2816 words per track, 571, 648 words per surface, and 1,143,296 words per drive. Recording density is 2200 bpi. The drives use IBM 2315-type discs. The D31 Cartridge Disc Drive is a Diablo Model 31, while the D32 is a Diablo Model 33F.

DS44 MAGNETIC DISC SUBSYSTEM: Consists of one drive and a controller capable of interfacing up to four fixed and removable-cartridge disc drives. Each drive has a capacity of 4.56 million 16-bit words, for a total system capacity of 18.24 million 16-bit words. The 973674-0001 DS44 Magnetic Disk Master kit consists of a track mountable DS44 Cartridge Disc Drive and controller. The add-on drive is the 973674-0004.

Data is stored on 4 surfaces, each organized into 405 data tracks plus 3 spares per surface. There are 88 32-word sectors per track. Total track capacity is 2816 words. Recording track density is 2200 bpi (inner track). There are four tracks per cylinder and 408 cylinders per drive. Total drive capacity is 4,561,920 words.

The drive rotates at 2400 rpm with an average rotational delay of 12.5 milliseconds. The data transfer rate is 156,250 words per second. Track-to-track, average, and across-all-tracks head positioning times are 10, 38, and 70 milliseconds, respectively. The drive employs IBM 5440-type disc cartridges. The DS44 Cartridge Disc Drive is a Diablo Model 44.

I/O UNITS

See Peripherals/Terminals table.

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▶ In addition to the conventional devices listed in the Peripherals/Terminals table, TI offers a broad line of interface devices particularly useful in measurement and control applications. These interfaces include 14 models of A/D and D/A converters and 13 general-purpose interfaces.

COMMUNICATIONS CONTROL

966637 FULL DUPLEX EIA COMMUNICATIONS INTERFACE: This module provides an interface between the I/O Bus and a Bell 103A, 103F, 202C, 202D or equivalent modem; any peripheral utilizing the standard RS-232C interface; or any device utilizing a 20-milliampere current loop interface. The unit features seven standard switch-selected data rates from 75 to 9600 bits per second.

966538 SYNCHRONOUS COMMUNICATIONS MODULE: This module features programmable sync character, selectable parity (odd, even, none), new sync character generation, transparent mode operation, and a 500-millisecond timer. The unit provides interfacing for Bell 201, 208, or equivalent modems. Speeds up to 9600 bps are supported.

SOFTWARE

OPERATING SYSTEMS: There are two operating systems available for the TI 980B: the Basic System Monitor (IOP) and the Disc Executive DX980 general-purpose operating system. IOP is a small single-program monitor, and DX980 is a multiprogramming system for medium-to-large memory systems with at least one disc drive. In general, applications programs written for DX980 systems will run under IOP, but certain precautions must be taken during program development. Both operating systems make use of privileged instructions and memory reallocating.

IOP is a basic monitor system that allows device-independent input or output through logical units. Each IOP is tailored for a specific system and is generated from selectable modules on various media. Included in these modules are device service routines for various peripherals, an operator communication package, and a sequential file management package.

IOP supports the Symbolic Assembly Processor (SAPG), the Overlay Link Editor (LINKG), the Terminal Source Editor (TSE), the Elementary Debug Program (DEBUG), the Copy Object Utility (CPYOBJ), the Run-Time Loader (RTL), the Stand-Alone Memory Dump program (MEMDP), and the Standard Bootstrap Loader. Support is provided for user-written programs under a single-program execution environment.

Two slightly different versions of IOP are available. *IOP7* is suitable for use with a system which uses a data terminal other than the TI733 ASR. Under IOP7, support is provided for the 743 KSR Data Terminal, 912 Video Display Terminal, ASR33/5JE Teletypewriter, 804 Card Reader, line printers, paper tape reader/punch, and DS31/DS32 Cartridge Disc Drives. DS44 or DS330 Disc Drives are not supported.

IOP8 is a slightly expanded version of IOP7, providing support for the symbolic cassette-oriented assembler (SAP733) and cassette utility routine (CUR) in addition to those mentioned under IOP7. Software interfaces are provided for the 733 ASR Data Terminal but not for the 743 KSR Data Terminal or the ASR33/5JE Teletypewriter. Other software interfaces provided for IOP7 are supported.

IOP7 requires a 980B with at least 16K words of memory, a 743 KSR or 733/5JE Teletypewriter, either paper tape or card input, and either paper tape or disc output. IOP8 requires a 980B with at least 16K words of memory and a 733 ASR Data Terminal.

▶ *DX980* is an interrupt-driven multiprogramming operating system that provides both multiprogramming and multitasking support for applications programs. DX980 job management assigns priority levels to user programs and initiates them. Memory is allocated to each program at initiation time from a dynamic user area, and is deallocated upon termination. Multiple tasks within the program vie for CPU time based on 31 levels of priority. The system also provides roll-in/roll-out functions for real-time programs, a batch processing subsystem for spooling both input and output to increase system efficiency, and an interactive terminal subsystem for interface communications between DX980 systems and local or remote terminals.

The DX980 I/O management system supports transfers between sequential-access peripherals. A disc file manager provides linked sequential, relative record, and indexed accessing. All disc files are mapped using a multi-level directory structure. The file manager features contiguous and non-contiguous allocation of disc storage, variable-length blocked data transfers, protection of data files through cataloging with password-controlled access, and shared access.

DX980 has a two-level job control language: expanded and abbreviated. The expanded control language is translated into an internal binary form and stored in the disc library. The abbreviated control language is used to access the disc library and permits parameter substitution at program submission time.

The DX980 roll-in/roll-out system utilizes a roll-out queue and a job queue to control the flow of programs in and out of memory on a high/low priority basis. The interactive terminal system also features facilities for interactive file editing and remote job entry and a structure that permits additional multi-terminal applications. As many as 29 hard-copy or CRT terminals are supported for these functions.

Currently, four versions of DX980 are available: DS31/DS44 Disc and Tape Package, DS330 Disc and Tape Package, Dual DS31 Disc Package, and DS44 Disk Package. These packages all include the following: the DX980 Operating System, Batch Processing and Interactive Terminal Subsystems, FORTRAN IV, Symbolic Assembler Processor, and a set of utilities. The source package for DX980 is also available.

DX980 requires a minimum of 48K words of memory, a moving-head disc, a console device which may be either a 733 KSR/ASR Data Terminal or a 743 KSR Data Terminal, and an internal timer. A magnetic tape drive is required only in the DS31/DS44 and DS330 versions. A wide variety of peripheral equipment is supported either by standard system software or by user-written device handlers.

LANGUAGES: Texas Instruments offers three programming languages for 980B: the Symbolic Assembler Processor (SAPG), the FORTRAN IV compiler, and the BASIC/980 Interpreter.

Symbolic Assembler Processor (SAPG) is a two-pass assembler featuring external references and definitions, expressions in all operand fields, relocatable or absolute object code, conditional assemblies, common directives, and specialized op code definition. Source code can be stored to eliminate reloading the second pass if the system includes magnetic tape or a disc.

TI FORTRAN IV is based on ANSI Standard X3.9-1966 with some enhancements. The extensions to the standard FORTRAN IV language include insertion of assembly-language statements in the program stream; general integer expressions in subscripts; computed GO TO statements, I/O unit designators, and DO statement parameters; alteration ▶

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of DO parameters with a DO loop; unlimited continuation lines; identifiers of any length with truncation to six characters; and format conversion facilities that can be used without performing any I/O operations. In a stand-alone FORTRAN system, a memory size of 24K is required.

BASIC/980 Interpreter is a stand-alone programming system based on Dartmouth BASIC that includes all vocabulary, syntax, language statements, mathematical functions, operational commands, and error-reporting facilities to permit up to eight users to enter and edit programs from separate terminals. It does not include string variables or matrix operations. After execution, a program is available for alteration or error correction. The BASIC/980 Interpreter is available on paper tape, cards, or magnetic tape cassette, and requires a 980B with a minimum of 16K words of memory and up to eight 733 ASR, 743 KSR, or Model 912 CRT terminals.

UTILITIES: Six utility packages are offered with the 980B IOP Monitor: the Extended Debug Package (DEB980); the Terminal Source Editor (TSE); the Disc Utility Package; the Conversion Utility Subroutine Library; the Copy Object Utility; and the Cassette Utility Routine (CUR980).

Numerous utility routines are offered as a standard part of the DX980 package. Among these are the Extended Debug Routine (DEB980); JCL Translator (JCLTRN); Source Maintenance Routine (SMR); Merge/Concatenate Utility (MERGE); General-Purpose Copy/List Utilities; File/User Directory Utilities; and Load Module, Library, and Linkable Parts File Utilities.

DEB980 is a batch and interactive software tool that permits the user to modify or display the contents of memory and registers. It also controls the execution of the program being debugged, from loading and setting of breakpoints to specifying traces. DEB980 checks for the validity of supervisor calls when feasible, checks for validity of instructions, and checks for memory references or branch addresses outside the area assigned to the program being debugged. The latter is to prevent accesses outside the range of DEB980.

APPLICATIONS PROGRAMS: Users must develop their own application programs. Numerous utility routines are provided to support program development.

PRICING

POLICY: Texas Instruments offers the 980B Series computers on a purchase or lease basis with separately priced maintenance. Monthly leasing charges are based on 9.1 to 2.46 percent of the purchase price for lease terms ranging from one to five years, respectively. OEM discounts up to 20 percent are allowed on quantities of 25 units or more.

Basic-coverage maintenance prices, as detailed in the Equipment Prices section of this report, apply for eight hours during the period from 8 a.m. to 5 p.m., Monday through Friday, excluding holidays. Extended-coverage service on equipment for 16 consecutive hours during the period from 8 a.m. to midnight each day, Monday through Friday, and during the period from 8 a.m. to 5 p.m. on Saturday, excluding holidays, is priced at 1.5 times the basic coverage prices. For full 24-hour, 7-days-a-week coverage, including holidays, maintenance is priced at two times the basic monthly maintenance charges. In addition, a per-zone monthly surcharge of five percent of the basic monthly maintenance charges is accessed for travel beyond (zone maintenance charges is accessed for travel beyond zone 0 (a 25-mile radius of the field service office).

Service on an on-call basis is provided for customers without a basic-coverage maintenance contract and for service performed outside the hours of agreement. On-call service is

STORAGE REQUIREMENTS OF 980B SOFTWARE

	Main Memory (words)	
	Minimum	Typical
IOP Sysgen Package	*	*
IOP7 Monitor	*	*
IOP8 Monitor	*	*
DX980 Operating System:		
DS31 Disc and Tape Version	20K	20K
DS330 Disc and Tape Version	20K	20K
Dual DS31 Disc Version	20K	20K
DS44 Disc Version	20K	20K
DX980 Interactive Terminal Subsystem	*	*
DX980 Batch Processing Subsystem	3.4K	3.8K
Batch Input Reader	1.8K	1.8K
Batch Input Spooler	2.2K	2.2K
Batch Output Spooler	1.6K	1.6K
BASIC 980 Stand-Alone Intepreter System	16K	24K
Symbolic Assembly Processor	5K	6K
Cassette-Oriented Symbolic Assembly Processor	*	*
FORTRAN IV Compiler	8K	11K
FORTRAN IV Runtime Package	*	*
Elementary Debug Package	4.5K	6.5K
Extended Debug Package	11K	14K
DX980 Overlay Link Editor	*	*
Terminal Source Editor	*	*
DX980 Source Maintenance Routine	13.5K	13.5K
Disc Utility Package	*	*
Conversion Utility Subroutine Library	*	*
Copy Object Utility	*	*
Cassette Utility Routine	*	*
DX980 Copy Utility	5K	5K
PDT Package	*	*
CPU PAT Package	*	*

*Texas Instruments could not supply data on these programs.

charged at $40 per hour between 8 a.m. and 5 p.m., Monday through Friday, excluding holidays, and at $50 per hour (4-hour emergency call-out minimum) for calls exceeding 8 hours during standard working hours, for calls made before 8 a.m. and after 5 p.m. Monday through Friday, and for calls made any time on Saturday. Double-time charges of $60 per hour (4-hour emergency call-out minimum) are made for Sundays and holidays. The transportation charge for on-call service is 15 cents per mile plus commercial travel cost, if any.

Shop service is available at $25 per man-hour or part thereof during normal working hours if the customer delivers the equipment in need of repair to a Texas Instruments service center.

A fixed-price repair service is offered on standard electronic interface assemblies for those customers who stock their own spares of standard 980 computer family products and service their own equipment. The service offers a 14-day repair or exchange of most assemblies for the cost of labor and material. For an additional per-part charge of $25, Texas Instruments will either repair and return to the user the same customer-modified serial-numbered assembly or replace a single standard part within 48 hours (subject to availability).

Two one-week software or hardware training courses are provided free with each 980 system purchased. Courses are conducted at the Digital Systems Division Education and Development Center in Austin, Texas. The courses include both classroom lectures and laboratory projects. Course ▶

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prices average about $800 each. Prices for special courses conducted at customer locations will be quoted upon request.

Certain developmental software is supplied free of charge, dependent on hardware configuration and purchase agreement. Included in this category are the CPU performance assurance tests (PAT's) and performance demonstration tests (PDT's).

A one-year software subscription service is available for the 980, providing software updates on media supplied by Texas Instruments. The option for annual renewal of the subscription service is available for a 60-day period after the initial one-year term lapses. An "update subscription service" is aimed at those who have never had the subscription service or have allowed it to lapse.

Support for noncurrent software releases is limited to correcting any deficiencies deemed necessary by Texas Instruments, and will be available for only six months from the date of the most current release.

EQUIPMENT: The following typical purchase prices include controllers and adapters.

STAND-ALONE/PROGRAM DEVELOPMENT SYSTEM: Consists of 980B CPU with 16K words of memory and twin-cassette "Silent 700" ASR. Purchase price is $10,470.

MEDIUM-SCALE GENERAL-PURPOSE SYSTEM: Consists of 980B CPU with 16K words of memory, twin-cassette "Silent 700" ASR, card reader, magnetic tape unit, line printer, and two cartridge disc drives. Purchase price is $47,220.■

EQUIPMENT PRICES

		Purchase Price	Monthly Maintenance
PROCESSORS			
980B processors are configured with standard features including three ports for semiconductor memory modules, hardware multiply/divide, memory error detection/correction, programmable memory protect and privileged instructions, power-fail warning interrupt, and auto restart (with battery); also ROM bootstrap loader, removable control panel with key lock, hardware breakpoint, program sense switches, 1 auxiliary processor port, 1 DMAC interface port, 4 I/O bus interface ports including interrupt, 4 levels of priority interrupt expandable at level two to 32 levels of priority interrupts, power supply and line filters, rack-mount chassis with slides, and selected software.			
943866-0100	With 8K words of MOS memory	$5,150	$ 95
943866-0101	With 8K words of MOS memory and battery pack for power-up interrupt feature	5,250	100
PROCESSOR OPTIONS			
960703-0001	Internal I/O Bus Expansion connector plate; provides 9 additional I/O ports; includes I/O bus expansion cable, I/O interface cards with interrupt expansion, and one port for 22685 ±15V regulator	500	8
966796-0001	External I/O bus Expansion Kit; includes chassis, I/O bus expansion cable, I/O bus expander cards with interrupt expansion, connector plate for 10 I/O bus ports, and power supply rated at 7.5 amps at ±15 VDC	1,200	17
966796-0002	Same as 966796-0001 with 14.5 amps at 5 VDC	1,200	12
960757-0001	I/O Expansion Card; provides I/O bus expansion logic for one 966796 external I/O bus kit; requires one I/O bus kit; requires one I/O slot in CPU or external expansion chassis for expansion to 64 addresses; one I/O expansion card is provided with CPU	200	6
973300-0001	Vectored Interrupt Module; provides 8 external priority interrupts maskable by program control; internal I/O ports accommodate up to 4 modules or 32 interrupts	550	7
966580-0001	Interval Timer Module; has 12-bit counter with selectable intervals under program control; interrupts of 10 ms to 40.96 seconds; 4 maximum	300	5
973671-0001	ROM Bootstrap Loader for 3330-type disc systems	250	—
943659-0001	Battery pack	100	5
226853-0001	Plug-In Power Supply Extender Board	150	—
975170-0001	Plug-In AU Extender Board	200	—
MEMORY			
975155-0002	8K MOS Memory Add-on Module; requires 943740-0002	1,400	7
975155-0004	16K MOS Memory Add-on Module; requires 943740-0002	2,800	14
975155-0006	24K MOS Memory Add-on Module; requires 943740-0002	4,200	21
975155-0104	8K to 16K Memory Expansion Kit	1,400	7
975155-0106	8K to 24K Memory Expansion Kit	2,800	14
943740-0002	Memory expansion internal connector	100	—
MASS STORAGE			
942541-0001	Magnetic Disc Master kit; for moving-head, 3330-type pack disc drive; includes controller, drive, and disc pack	33,600	280
942541-0004	First add-on moving-head pack drive; includes pack	20,000	170
942541-0005	Second add-on moving-head pack disc drive; includes pack	20,000	170
942508-0001	Disc pack for 942541 disc drives	1,000	—
955157-0001	Magnetic Disc Master Kit for moving-head, removable-cartridge disc drives; requires DMAC; includes controller and one drive	8,000	90
955157-0007	DMAC Interface Kit for 955157 series; requires DMAC	2,800	25
955157-0002	Third add-on moving-head disc drive; requires 955157-0001	5,000	60
955157-0003	Second add-on moving-head removable disc drive with power supply; requires 955157-0001	5,400	65
966669-0002	First and third add-on moving-head disc drive with non-removable disc; requires 955157-0001	3,000	60
966669-0003	Second add-on moving-head, non-removable disc drive with power supply; requires 955157-0001	3,400	65
961687-0001	Disc Cartridge for 955157 Disc Drives	175	—
973674-0001	Magnetic Disc Master kit for moving-head, fixed and removable-cartridge disc drive; includes controller and one drive	12,000	115
973674-0002	DMAC Interface kit for 973674 series; requires DMAC	2,800	25
973674-0004	Second, third, or fourth add-on moving-head, fixed and removable-cartridge disc drive	9,200	90
973681-0001	Disc Cartridge for 973674 Disc Drives	175	—

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		Purchase Price	Monthly Maintenance

MAGNETIC TAPE EQUIPMENT

948206-0001	Magnetic Tape Transport, Master kit; includes controller and 9-track, 800-bpi, 37.5-ips transport; requires DMAC	11,000	120
948206-0004	First and second add-on transport; 9-track, 800 bpi, 37.5 ips	8,000	95

PRINTERS

966792-0001	Line Printer, 132-column, medium duty, 165 cps; includes interface	6,250	95
966792-0011	Line Printer, 132-column, medium duty, 330 cps; includes interface	6,850	100
966792-0002	Line Printer interface; for user-supplied 966767 line printer	800	7
966765-003	Line Printer Stand	350	—

PUNCHED CARD EQUIPMENT

943900-0001	Card Reader kit; includes 400-cpm card reader and CRU interface	3,300	55
943900-0002	Card Reader Interface; for user-supplied 943760 reader	550	7

PAPER TAPE EQUIPMENT

965946-0003	High-Speed Reader; 300 cps	1,375	25
973526-0003	High-Speed Reader/Punch; 300/75 cps	5,950	50
965946-0002	High-Speed Reader interface	550	4
973526-0002	High-Speed Reader/Punch Interface	750	7

TERMINALS

966645-0001	733 ASR Twin-Cassette Silent 700 Data Terminal Kit; includes terminal and interface	3,920	44
966645-0002	Interface for user-supplied 733 ASR Twin-Cassette Silent 700 Data Terminal	550	7
943932-0001	743 KSR Printer Keyboard Data Terminal Kit; includes terminal and EIA interface	1,900	25
943932-0002	Interface for user-supplied 743 KSR Printer Keyboard Data Terminal	550	7
981336-0001	Stand for any Silent 700	150	—
973346-0002	Interface for user-supplied ASR 33-5JE	550	7
973306-0012	Video Display Terminal; 1920 characters	2,300	30
973306-0002	Interface Kit for 973305-0013; requires ±15V power	550	7

COMMUNICATIONS CONTROL

966637-0001	Communications Module; serial, full-duplex, TTY/EIA; interfaces Bell 103A, 103F, 202C, 202D, or equivalent modems, any RS-232C device, or any current loop device; 8 switch-selectable data rates between 75 and 9600 bps; switch-selectable character length, parity, stop element, and I/O address; requires 226855-0001 and 960703-0001 expansion	450	7
965538-0001	Synchronous Communications Module; interfaces Bell 201, 208, or equivalent modems; includes programmable sync, parity selection, 500-msec timer, and transport mode operation; requires 226855-0001 and 960703-0001 expansion	700	7
973597-0001	980 Communications Module Test kit	60	—
942055-0001	Synchronous Communications Module Test Kit	360	—

I/O CONTROL

965955-000X	Parallel Interface; TTL output with level translators on input; full interrupt capability, 510 ohm (option 0001) pull-up or 100 ohm (option 0002) parallel termination	350	7
966390-0002	DMAC interface for any DMA peripheral; used for one or more DMA devices	250	5
973357-0001	Parallel Interface Test kit	50	—
214082-0001	Universal Solder I/O Interface Board; single-ended card	95	—
214084-0001	Double-ended card	100	—
217862-0001	Universal Wire-Wrap I/O Interface PC Board; single-ended card	200	—
217863-0001	Double-ended card	250	—
226853-0001	Plug-In I/O Interface and DMA Extender Board	150	—

HARDWARE

945080-0001	Standard 19-inch Rack-mounting Cabinet with removable doors, vertical AC power strip, system circuit breaker, removable air filters and blowers; 63-inch vertical mounting space	1,000	—
945130-0001	Vertical Blank Front Panel; 1.75 inches high	12	—
945130-0002	3.5 inches high	14	—
945130-0003	7 inches high	16	—
945130-0005	10.5 inches high	18	—
957482-0004	Single DMAC Controller Mounting Kit for moving-head cartridge disc interface; mounts in CRU expansion space of CPU	600	7
957482-0006	For magnetic tape transport interface	600	7
966340-0001	Single DMAC Controller Mounting for moving-head cartridge disc interface; rack mounts in 8.75 inches of vertical space	1,100	12
966340-0003	For magnetic tape transport interface	1,100	12
966423-0001	DMAC expansion chassis, for up to 56 DMAC controller cards; requires 966555-0001	1,400	14
966555-0001	External DMAC expansion kit	1,300	20
226855-0001	±15V Regulator; for 960703-0001	200	6

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SOFTWARE PRICES

		Purchase Price	Update Price	New Subscription, Including Update	Renewal Subscription
943258	Configuration 7; includes 943254, 943253, 966958, 969773, 967157, Run-Time Loader (RTL), Stand-Alone Memory Dump (MEMDP), and bootstrap loader	$600	$300	$500	$100
943259	Configuration 8; includes all of configuration 7 except that 943254 is replaced with 943255; additionally, 969749 and 969774 are included	900	450	650	100
944194	DX980 Software Package; includes DX980 Operating System, Interactive Terminal Subsystem, Batch Processing Subsystem, and Standard Utility Library (SAPG and FORTRAN IV)	900	450	650	100
	DS31 Disc and Tape Version	4,000	250	575	325
	DS330 Disc and Tape Version	4,000	250	575	325
	Dual DS31 Disc Version	4,200	450	1,200	750
	DS44 Disc Version	4,200	450	1,200	750
943257	BASIC 980 Stand-Alone Interpreter System	250	100	175	75
943254	IOP7 Monitor Package	50	25	**	**
943255	IOP8 Monitor Package	50	25	**	**
943264	IOP Sysgen Package	125	60	150	75
943253	Symbolic Assembly Processor (SAPG)	50	25	—	—
969749	Cassette-Oriented Symbolic Assembly Processor (SAP733)	50	25		
943270	FORTRAN IV Compiler and Run-Time Package	250	100	175	75
967157	Elementary Debug Package	20	10	—	—
943262	Extended Debug Package (DEB980)	75	40	115	75
966958	Overlay Link Editor (LINKG)	50	25	—	—
969773	Terminal Source Editor (TSE)	40	20	—	—
943265	Disc Utility Package	100	30	**	**
943272	Conversion Utility Subroutine Library	25	15	—	—
966959	Copy Object Utility	20	10	—	—
060774	Cassette Utility Routine (CUR980)	30	15	—	—
943256	PAT/PDT Cassette	120	60	**	**
943269	PDT Package	150	70	**	**
967058	CPU PAT Package	90	45	300	125

* Software is available in object form on paper tape (option 0001), cards (option 0002), or magnetic tape cassette (option 0003).
**Subscription service is offered for this software only as part of another package.