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IBM Systems Reference Library

IBM 1800 System Summary

This publication introduces system concepts, units, features, and programs for the 1800 system. This information will help the user achieve a basic understanding of the system and the interrelationship of its many parts.

Publications providing detailed information on the subjects described in this summary are listed in the IBM 1800 Bibliography (Form A26-5921).

PREFACE

This publication is intended for those who have no knowledge of the IBM 1800 Data Acquisition and Control System and need only a general introduction to the system.

This summary briefly describes typical applications, basic functions, system language, components, and programs of the IBM 1800 system.

Publications providing detailed information on the subjects described in this summary are listed in the IBM 1800 Bibliography (Form A26-5921).

Fifth Edition (June 1969)

This is a major revision of, and makes obsolete, A26-5920-3. This edition reflects the announcement of Communication Adapters, Selector Channel, additional Data Channels, additional core storage capacities, and attachment of the IBM 2790 Data Communication System for the 1800 system. Also, the entire Programming Systems section has been rewritten to include the Multiprogramming Executive Operating system.

Changes to the text, and small changes to illustrations, are indicated by a vertical line to the left of the change; changed or added illustrations are denoted by the symbol ● to the left of the caption.

The illustrations in this manual have a code number in the lower corner. This is a publishing control number and is not related to the subject matter.

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This manual was prepared by the IBM Systems Development Division, Product Publications, Department G24, San Jose, California 95114.

Current technology, industry, and business demand more and more reliable, up-to-date information to operate efficiently. Data of many kinds, available from a myriad of sources, must be collected, analyzed, and translated into information that can be used to optimize performance.

The IBM 1800 Data Acquisition and Control System answers the demand for real-time data acquisition, analysis, and control. The 1800 system is designed to handle a wide variety of real-time applications, process control, and high-speed data acquisition. Each system is individually tailored with modular building blocks that are easily integrated to meet specific system requirements. The 1800 system uses solid logic technology (SLT) with its micro-miniature electronic components.

The system includes a large family of real-time process input/output (I/O) devices and features, such as analog input, analog output, digital input, and digital output; as well as data processing I/O units, such as magnetic tape, disk storage, line printer, graph plotter, card and paper tape input and output. Other available features include a System/360 adapter, communications adapters, a selector channel, and 2790 adapters.

Data is received and transmitted on either a high-speed data channel (cycle-steal) or under program control, depending on the intrinsic data rate of the I/O device. These capabilities not only meet today's requirements, but those of the future as well.

The 1800 system includes a processor-controller (P-C) for editing, supervisory control, or data analysis. A control and data path provides for the attachment of the IBM System/360 where more powerful supervision is required. For example, the System/360 may be used to integrate the commercial aspects of an application with the controlling operations exercised by the 1800 system. This multiprocessor system capability enables the handling of real-time applications of any size or complexity.

A communications adapter (maximum of four) provides one or two communication paths (line adapters) for connection, over voice grade lines, to remote System/360's, IBM 1130 Computing Systems, IBM 2780 Data Transmission Terminals, or other 1800's. This allows the 1800 system to be integrated into large scale control systems without consideration of the physical location of control systems above or below the 1800 in the control hierarchy.

The selector channel provides the facilities for attaching an IBM 2841 Storage Control with up to eight IBM 2311 Disk Storage Drives. Through the use of the two-channel switch (a 2841 feature) or by physically moving a 1316 disk pack from one 2311 to another, the 1800 can exchange data with System/360 or another 1800.

The 2790 Adapter (maximum of 2) provides the interface facilities for attaching an IBM 2790 Data Communication System to the 1800 Processor-Controller. This 1800/2790 combination provides real-time data collection or plant communication capabilities with the 1800 being the system controller for the 2790 system.

APPLICATIONS

The 1800 is capable of accepting electrical signals, both analog and digital, from such devices as thermocouples, pressure and temperature transducers, flow meters, analytical instruments, and contacts. It provides electrical on/off and analog control signals for the customer's controlling devices. With these capabilities and remote communication facilities, the 1800 system can be integrated into large multiprocessor systems with varied real-time applications. Typical applications exist in the area of process control, high speed data acquisition, and data collection or plant communications.

Process Control

System configurations for industrial processing applications include minimum systems that are field expandable to larger systems. Applications include petroleum refining, butadiene reactor control, chemical processing, electric utility dispatching and generation control, steel rolling, and many others. A complete range of process control, from off-line operator guidance to on-line supervisory control, may be exercised. The IBM 1800 system may control:

1. Data acquisition.
2. Data collection and analysis.
3. Data evaluation and operator guidance.
4. Process study.
5. Process optimization.
6. Supervisory control.

High-Speed Data Acquisition (HSDA)

High-speed data acquisition includes the collection, evaluation, and recording of data. The 1800 collects data at analog rates up to 24,000 conversions per second per ADC and at digital rates up to 100,000 samples per second. Telemetry data can be acquired in bursts at rates up to 500,000 words (8,000,000 bits) per second. The 1800 provides flexible scanning rates and patterns through random or sequential multiplexer addressing during a test or experiment.

HSDA system operations range from recording data on magnetic tape or disk storage with a minimum of editing and checking, to operations including data reduction and real-time display. Typical applications include:

1. Missile pre-launch and manufacturing checkout.
2. Wind tunnels.
3. Static test stands.
4. Missile telemetry.
5. Nuclear reactor research and testing.
6. Environment chambers.
7. Flight simulators.
8. Low-energy particle research.
9. Medical research and clinical systems.
10. Hybrid systems.

Data Collection and Plant Communications

The 1800/2790 Data Communications System combines, within a single powerful system, the sensor-based capabilities of the 1800 system and the man-machine interface of the 2790 system. This system features a high-speed two-way data communications network specifically designed to accommodate a large volume of short messages from many in-house locations to a central processing area.

Data communications systems have applications in many types of installations. Among these are installations involved in manufacturing or assembly-line processes. In this type of installation, each step in the manufacturing or assembly process is usually dependent on completion of a previous step. These installations are usually susceptible to work stoppages due to failure of one or more steps in the assembly process. Through remote data entry units or area stations located throughout the installation, data concerning the progress of each phase or station along the line can be entered by the workers. Since data entry is real-time, the over-all status of the complete installation is always available from the 1800 system. This real-time reporting capability can be used to ensure smooth and continuous operation of the entire installation.

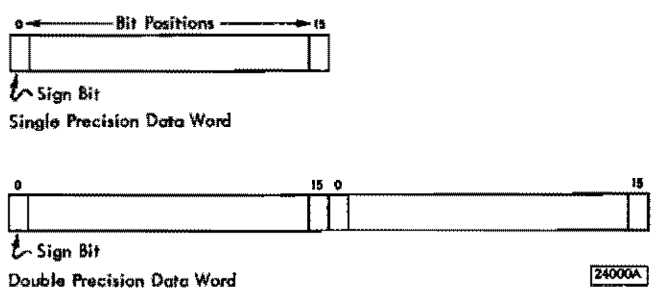
Other Acquisition and Control

The 1800 system may be applied to a diverse group of applications from general research to specific manufacturing tasks. Applications here include:

1. Research instrumentation and testing.
2. Traffic control.
3. Engine testing.
4. Components manufacturing control.
5. Automatic assembly and control.
6. Component inspection and sorting.
7. Automatic quality control.

SYSTEM LANGUAGE

The 1800 system processes information in binary form for fast parallel manipulation of data. Data is stored and processed in fixed-length 16-bit words with provisions for addressing and processing of double-precision words (32 bits). Two additional bits are provided for parity and storage-protect purposes.



The basic instructions and their numerous modifications are included in the following five classes:

1. Load and store.
2. Arithmetic and logic
3. Shift.
4. Branch.
5. I/O

PROCESSOR-CONTROLLER

Two processor-controllers are available: the IBM 1801 and the IBM 1802 (Figure 1). Each has ten models based on speed and size of core storage. (Core storage size may be expanded with the addition of an IBM 1803 Core Storage Unit.) The 1801 has no provision for magnetic tape, while the 1802 includes the Tape Control Unit for the IBM 2401/2402 Magnetic Tape Units.

The processor-controllers are fixed-word-length, binary computers. Five core storage sizes (4,096; 8,192; 16,384; 24,576; or 32,768 words of 18 bits each) with core storage cycle times of 2 or 4 microseconds (μsec) are available. With the addition of an IBM 1803 Core Storage Unit, four additional system core storage sizes (40,960; 49,152; 57,344; and 65,536 words of 18 bits each) with core storage cycle time of 2.25 μsec are also available. One of

• Figure 1. 1801 or 1802 Processor-Controller

the 18 bits in a core storage word is used for storage protection and one bit is used for parity checking. The remaining 16 bits in each core storage word are data bits.

These features are standard on all processor-controllers:

1. Data channels.
2. Index registers.
3. Indirect addressing.
4. Interval timers.
5. Operation monitor.
6. Interrupt.
7. Parity and storage protect.

Data Channel: The high-speed input/output channel enables asynchronous I/O unit operations. In these operations the use of core storage to read or store data affects the main program execution only by a cycle delay per word (an operation called "cycle stealing"). The feature enables input/output operations at rates up to 500,000 words (8,000,000 bits) per second with the two-microsecond core storage. Three data channels are provided as standard features; twelve additional data channels are available as special features.

Index Registers: Three index registers provide a means of saving program steps, core storage, and computer processing time. Indexing an instruction causes the contents of an index register to be added to the instruction address to form the desired effective address for that instruction. The 1800 instruction set includes instructions to load, store, and modify index registers.

Indirect Addressing: Indirect addressing alters normal effective address generation by using the value stored in the core storage location defined by the address (or address + index register if specified) as the effective address, instead of directly using the address (or address + index register if specified) as the effective address.

Interval Timers: Three interval timers are provided to supply elapsed-time information to the program. Each timer has one permanent time base which can be selected from the following time base periods:

Core Storage Cycle Times	Available Time Bases (In Milliseconds)									
2 or 2.25 μsec	0.125	0.25	0.5	1	2	4	8	16	32	64
4 μsec	0.25	0.5	1	2	4	8	16	32	64	128

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Operation Monitor: This feature provides a means of sounding an alarm or setting an indicator if not reset by the program at periodic intervals.

Interrupt: The interrupt facility provides an automatic branch in the normal program sequence based upon external conditions. Some typical interrupt conditions are the interval timer reaching a preset time interval, an I/O device being ready to transfer data, an illegal operation code, or an external process condition that needs attention. Interrupt conditions are assigned priority levels according to the customer's requirements. Twelve levels of interrupt are standard, and 12 additional levels (two groups of six each) are available as special features.

Parity and Storage Protect: The core storage array provides 18 bits per word. Sixteen are used for data. One bit can be used to indicate that the word is storage protected or "read only." This bit provides flexible storage protection against the erroneous storing of information in a protected area during program execution or input/output operations on a data channel. The remaining bit provides odd parity on the other 17 bits. Detection of a parity check or attempted violation of storage protection causes an interrupt to the highest priority level.

PROCESS I/O UNITS AND FEATURES

Analog Input

The collection of analog data and its conversion for presentation to the digital processor-controller is the function of the analog input feature.

A physical phenomenon is first sensed and converted to an analog electrical signal by sensors or transducers, such as thermocouples or strain gages. All customer lines from transducers are terminated at the control system on screw-down terminals. The signals can also be conditioned at the terminals, including the filtering of extraneous signals, known as noise. Electrical signals from sensors or transducers may be in the millivolt, volt, or milliampere range. Low voltage signals (less than 0.5 volt) must be amplified to a level acceptable for conversion to digital form.

The amplification factor by which low-level signals are multiplied to reach the acceptable high level is termed the "gain" of the amplifier.

Conversion of analog signals from a voltage level to digital values is accomplished by an analog-to-digital converter (ADC). Such converters, however, are fast enough so that if multiple sources of analog signals are to be converted, they can share the use of one ADC. The switching of analog signals is accomplished by a multiplexer. The data path from sensor or transducer to processor is shown in Figure 2. The analog input units and features consisting of modular packaged equipment convert voltage or current signals into digital values. The features used to accomplish the conversions include analog-to-digital converters, multiplexers, amplifiers, and signal conditioning elements.

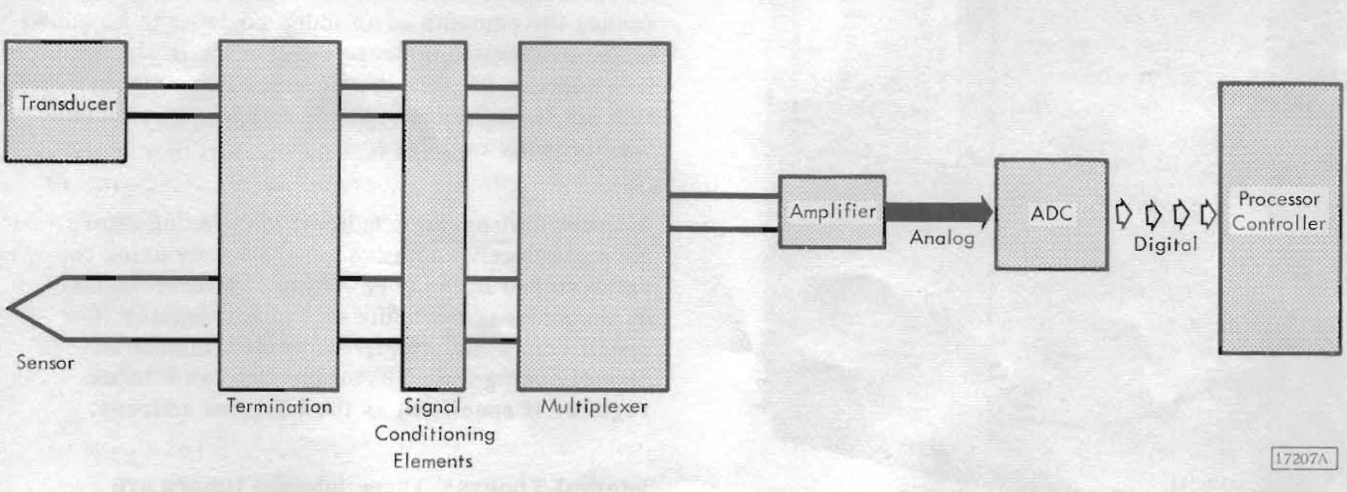


Figure 2. Data Path form Signal Source to Processor-Controller

Customer input signals are routed through terminals, signal conditioning elements, multiplexer switches, a differential amplifier, and into the analog-to-digital converter. The output of the ADC is presented to the processor-controller via programmed I/O control or the data channel from the ADC output register.

The major features that accomplish the analog input function are briefly introduced below. More detailed descriptions are given in the Systems Reference Library publication, IBM 1800 Functional Characteristics, Form A26-5918. Figure 3 illustrates the interrelationship of each of the features. There are two models of the IBM 1851 Multiplexer Terminal. The model 1 provides for insertion of up to 64 multiplexer points in groups of 16 points. Customer wires are terminated on screw-down terminals. Different types of signal matching elements are available for each multiplexer point used. The elements are mounted in the multiplexer terminal. Up to two differential amplifiers can also be mounted in each terminal.

The model 2 is modified to allow for thermal measurement of the terminals. Thus, thermocouple wires can be directly connected to the terminals, and the cold-junction temperature can be read by the P-C. The maximum capacity of the model 2 is 62 customer terminations.

All other functions of the model 2 terminal are the same as the model 1 terminal. Thus non-thermocouple signals may also be terminated in the model 2.

Multiplexer/R: This feature provides relay (R) multiplexing with high input impedance (greater than ten megohms), high common-mode voltage operation (200 volts) and high common-mode rejection. High- and low-level analog inputs are switched at a maximum speed of 100 points per second. The equipment is card mounted and plugs into the multiplexer terminal in groups of 16. For low-level signals, up to 16 groups can be combined to form the input to one differential amplifier providing up to 256 input points per amplifier. Each amplifier has a fixed gain, and the full-scale input range for any group of relay multiplexer points is dependent on the gain of the amplifier to which it is connected. Gains available are 500, 250, 100, 50, 25, and 10. High-level inputs (-0.5 to +5 volts) do not require an amplifier. Up to 256 high-level points can be included on any ADC in the system.

The multiplexer overlap feature allows overlapping of switching times for the multiplexer and solid-state multiplexer points.

The maximum 100 point-per-second multiplexing rate applies randomly, while 50 point-per-second applies as a repetition rate on any one point. To meet the common-mode rejection ratio specification, the repetition rate for any one point should not exceed three samples per second.

Multiplexer/S: This feature provides for solid-state (S) multiplexing of high-level single-ended analog inputs. Input sampling rates up to 24 kHz are possible with the mod 2 ADC. The multiplexer overlap feature allows the overlapping of relay and solid-state within any single-ADC system. Solid-state groups are mounted in the model 1 multiplexer terminal and cannot be intermixed with relay multiplexer points within a terminal.

The input voltage range is 0 to ±5 volts full scale.

Multiplexer/R Control and Multiplexer/R Control Additional: These features provide the necessary control circuitry to operate the relay multiplexer points. Each feature can control up to 256 points.

Multiplexer/S Control: Control circuitry to operate the solid-state multiplexer points is provided by this feature.

Multiplexer Overlap: This feature allows the operations of multiplexer/R and miltiplexer/S to be overlapped. (Note: Overlap of multiplexer/R operations with other operations for multiplexer/R is not possible.)

Overlapping can occur without the multiplexer overlap special feature under these conditions:

1. Under programmed control, solid-state conversions can be performed while a relay point is being selected.
2. If a discrete conversion of a relay point is started (a relay point is being selected) under programmed control, a sequence of conversions of solid-state points can be started on data channels.

With the multiplexer overlap special feature, another means of overlapping is possible. Under two-data-channel operation, relay addresses can be interleaved with solid-state multiplexer addresses.

Signal Conditioning Functions: The signal conditioning features that are available provide for:

1. Conversion of 4 to 20 milliampere signals into either 0.1 to 0.5 volt or 1 to 5 volt input signals.
2. Low-pass, passive filtering, to reject normal-mode ac noise (for multiplexer/R only).

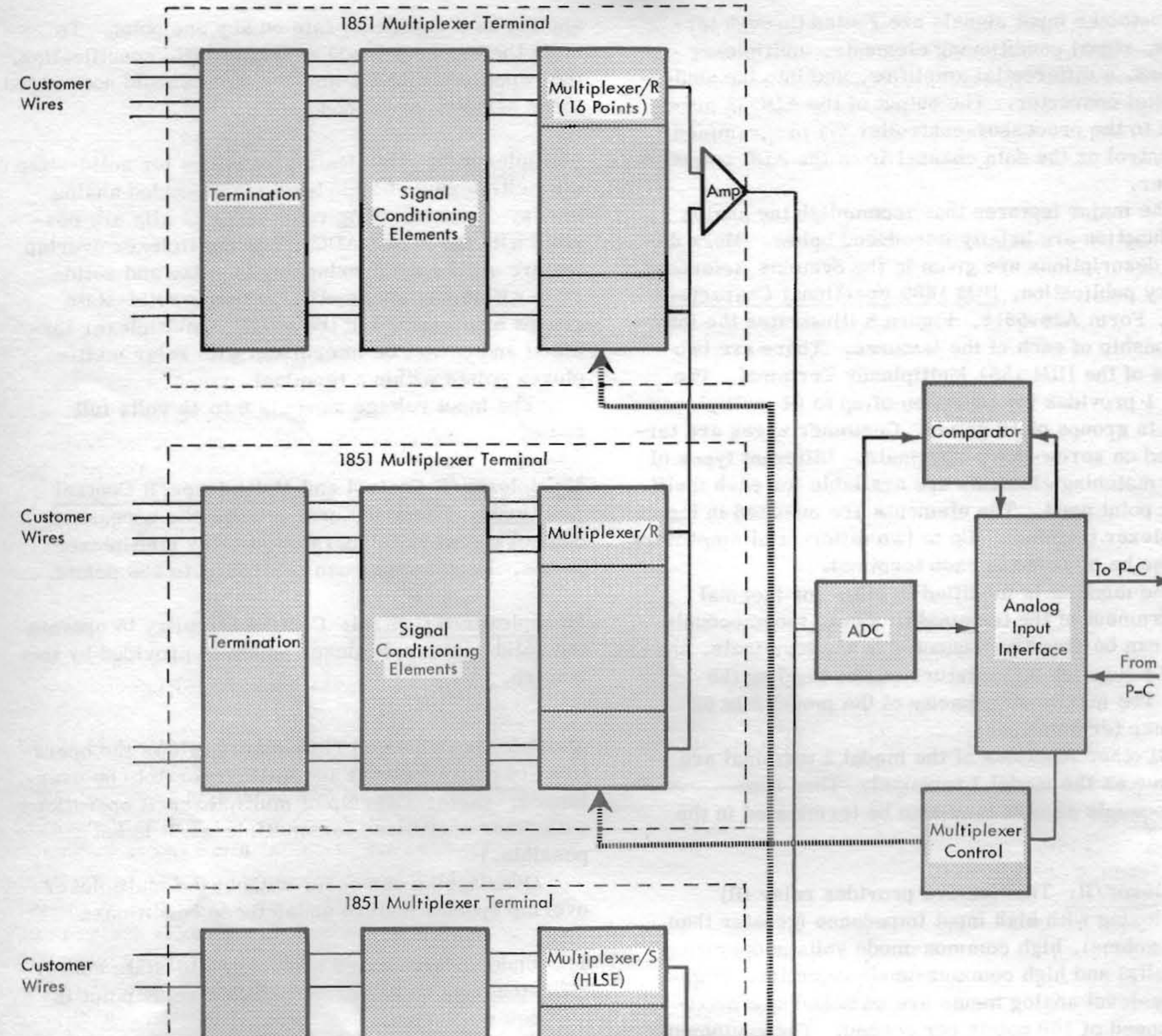


Figure 3. Schematic of Analog Input Features

3. 2:1 voltage attenuation. For example, 100-millivolt signals may be read as 50-millivolt signals.
4. Elements for special components. A mounting facility for customized signal conditioning. The components that perform the customized function are provided for RPQ* or the customer.

Differential Amplifier: This feature is a time-shared amplifier that is used in conjunction with the multiplexer/R to raise analog signals to the ADC input level of ±5 volts.

Preselected gains of 500, 250, 100, 50, 25, and 10 are available. This provides for amplification of input voltage levels of ±10, ±20, ±50, ±100, ±200, or ±500 millivolts. A maximum of two amplifiers can be installed in any 1851 terminal housing multiplexer/R.

Up to two amplifiers can be mounted in one multiplexer terminal. Thus, multiple amplifiers can be used for voltage-range changing in place of using passive voltage elements.

Analog-to-Digital Converter (ADC): The feature provides the 1800 with the ability to convert analog signals (±5-volt signal range) to digital values. Two ADCs are available: Mod 1 includes a buffer amplifier and has program selectable resolutions of 8, 11, and 14 bits. Mod 2 is a similar to mod 1 but includes a sample-and-hold amplifier, which provides for an increased system speed of conversion.

The ADC conversion time depends upon the number of bits of output that are to be developed. Conversion times are as follows: 8 bits, 29 microseconds; 11 bits, 36 microseconds; and 14 bits, 44 microseconds. Therefore, actual ADC conversion rates vary from 35,000 conversions per second to 23,000 conversions per second. (This does not include settling time for the amplifier within the ADC.)

System conversion rates vary from 9,000 to 24,000 samples per second.

Comparator: This feature performs selective checking on the digital values converted by the ADC. A range-type check is made to confirm that the converted values are within specified limits. The limits are obtained from the multiplexer address data table whenever a check is required (one P-C cycle delay allows both limits to be acquired). The P-C is informed of an out-of-limits condition by an interrupt.

Analog Input Data Channel Adapter-1: Allows chained sequential mode of analog input operation by connecting a data channel to the analog input interface.

Analog Input Data Channel Adapter-2: Allows random mode of analog input operation by connecting a second data channel to the analog input interface.

Analog Input Expander: This feature provides two principal advantages:

1. It doubles the capacity of the analog input features.
2. It allows the analog input features to be located separate from the processor-controller.

The analog input expander (a feature of the IBM 1826 Data Adapter Unit) provides the basic capability for attachment of an ADC, a comparator, the multiplexer terminals, etc. This second analog input system attaches to I/O control and data channels in a manner similar to the first analog input system. Thus, the system conversion rates can be doubled, neglecting I/O interaction.

Digital Input

These features enable the processor-controller of the system to accept real-time digital information in a digital format.

Digital input is brought into the system in 16-bit groups. The format may be in any form, for example: 1) unrelated bits from contact or voltage levels, 2) related bits such as binary-coded-decimal digits. Any mixture of digital formats can be handled. Conversion from one base to another can be easily and quickly implemented by programming. Input is via program control or a data channel. One instruction is used in program control to bring 16 bits of data into core storage. Where a data channel is used, one instruction initiates a cycle-stealing operation that brings many 16-bit groups of data into core storage (one group per core storage cycle). The number of groups read - sequentially, randomly, or singly - as well as synchronization of the input data to the processor-controller is handled automatically.

The 1800 digital input capability (see IBM 1800 Configurator, Form A26-5919) is made up of these features and their prerequisite features:

Digital Input (Contact): Each input group consists of 16 bits. Read speed rates of up to 500,000 words (8,000,000 bits) per second are possible when a data channel is used on a system having a 2 μsec core storage cycle.

Digital Input (Voltage): Sensing and termination are provided for groups of 16 voltage-level source inputs. The voltage levels are:

* Request Price Quotation from IBM

Binary one:	-1v min. to +30v max.
Binary zero:	-6v min. to -30v max.

Read speed rates up to 500,000 words (8,000,000 bits) per second are possible. Digital registers, including telemetry registers, are coupled to the system using one or more modified voltage-level groups, depending on register size and the number coding of the register. Conversion of the various number bases is accomplished via programming. Speeds up to a repetitive rate of 100,000 words (1,600,000 bits) per second can be handled.

Digital Input Channel: Process operator console (POC) input devices such as decade switches and sense switches and other low-speed inputs can be brought into the system by the formation of a "digital input channel" using electronic contact operate to select various groups of 16 bits over a single digital input group. POC input devices and cabling are handled via RPQ.

Pulse Counter: This feature accepts discrete pulses as input information and advances by one per received pulse. The customer pulse rate should not exceed 5 kHz (5,000 cycles per second) unless RPQ filters are used. Two eight-bit counters (or one 16-bit counter) are read from one address into the P-C in the same manner as the digital input group. Binary counters available: 8-bit or 16-bit. Voltage levels are the same as those for digital input (voltage).

Process Interrupt (Contact): This feature provides termination and sensing of 16 customer contacts per group. (See Interrupt.)

Process Interrupt (Voltage): This feature provides termination and sensing of 16 customer voltage levels per group.

Process interrupts are initiated by a contact closing, or a voltage level changing from "0" to "1". Process conditions may interrupt the P-C on a multi-level priority basis. (See Interrupt.)

Digital and Analog Output

The digital and analog output (DAO) features provide versatile control capability for the 1800 system. DAO features permit the exercising of computer control over the many types of auxiliary devices required in a control system. Equipment that can be controlled includes set-point positioners, actuators, displays, and telemetry systems. These control outputs are available with the DAO features:

1. Pulse output.
2. Electronic "contact" operate.
3. High-speed digital register output.
4. High-speed analog voltage output.

Digital Output

Digital output features are attached to the P-C through the digital output control and the digital output adapter. Output is in groups of 16 bits. Each adapter connects 64 bits of digital output, and each digital output control provides for up to four adapters.

Pulse Output: The electrical output of the pulse output features has the characteristics required to operate set-point positioners and stepping motors. Sixteen points may be set simultaneously by an execute I/O (XIO) instruction. A data bit of 1 causes an output, and a data bit of 0 causes no output. The duration of the pulse is determined by when an XIO "control" instruction is given in relation to the XIO "set" instruction. All points are reset 3 ms after the XIO control instruction.

Electronic Contact Operate: This latching-switching function is provided by a solid-state device requiring only 10 microseconds (μsec) to latch, or 10 μsec to unlatch. The rating of the switching device is 450 milliamperes (ma) at 48 volts dc. Sixteen points are latched simultaneously. The switching commands are identical to those for pulse output, with a data bit of "1" causing a latch. This switching action can operate alarms, console indicator lights and other displays, and operating process equipment such as relays, conveyor belts, and pumps.

Register Output: Digital output information is transferred from core storage (16 bits per transfer) to an output register. With this type of digital output, the entire 16 bits may be simultaneously transferred to another register which is part of an external device, such as a telemetry system. The feature may be used with a data channel to transfer repetitively to a single register or to several registers on a cycle stealing basis. An external sync signal may be used to synchronize the transfer.

The maximum data rate is 500,000 words per second, 16 bits per word. The electrical characteristics of the signal provide 32 milliamperes of current, including termination and customer load, supplied at +3 volts.

Analog Output

The analog output features are connected to the 1800 system through an IBM 1856 Analog Output Terminal.

To provide the most flexible capacity expansion, the analog output points may be added in groups of one or two points.

1856 Analog Output Terminal: There are two models of this unit:

- Model 1-Provides power and housing for eight points of analog output (any mod digital-to-analog converter) and control for 16 points of analog output. The model 1 is repeated for each multiple of 16 points required.
- Model 2-Provides power and housing for eight points of analog output (any mod digital-to-analog converter). One model 2 can be installed for each model 1, if the additional points are required.

Digital-to-Analog Converter (DAC): There are four mods of this feature.

DAC Mod 1 -- One digital-to-analog converter providing unipolar 10-bit resolution for one analog output point.
DAC Mod 2 -- Two independent digital-to-analog converters providing unipolar 10-bit resolution for two independent analog output points.
DAC Mod 3 -- One digital-to-analog converter providing bipolar 13-bit high accuracy resolution for one analog output point.
DAC Mod 4 -- Two independent digital-to-analog converters providing bipolar 13-bit high accuracy resolution for two independent analog output points.

Analog output points are addressed one point at a time.

The DAC's precision voltage reference (PVR) feature must be used to obtain analog output voltages from the DACs listed above.

Buffer Register (DAC Mods 3 and 4 Only): When the buffer register feature is added to the 13-bit DAC, an additional signal is required to "load broadside" the output DAC registers from the buffer registers. The buffer registers (one per point) are loaded as the data is received from the processor-controller. When the program has loaded all of the specified buffer registers, an I/O control command is given to load the DAC registers from the buffer register.

Precision Voltage Reference (PVR): This feature provides a precision voltage reference for use with the DAC. One PVR serves up to eight points of analog output in one 1856. There are two mods:

PVR Mod 1 -- Provides a +20-volt reference for DACs converting from 10-bit input.
PVR Mod 2 -- Provides a ±20-volt reference for DACs converting 10-bit or 13-bit input.

For example, a 10-bit point can be installed in the 1856 Analog Output Terminal with other 13-bit points, and the available PVR mod 2 reference can be used with the 10-bit point.

Analog Driver Amplifier: The output impedance of the digital-to analog converters is 10,000 ohms. When it is desired to match loads differing greatly from this value, an analog driver amplifier having an output impedance of less than one ohm may be used. This driver amplifier is applied on an individual point basis to provide load impedance matching and voltage amplification. The driver amplifier will also be used when it is desired to increase the analog output voltage from its nominal five volts to ten volts.

DATA PROCESSING I/O UNITS

The following IBM units are available for attachment to the 1800 system.

IBM 1816 Printer-Keyboard

The 1816 (Figure 4) provides printed output at a maximum rate of 14.8 characters per second and provides for data entry into the processor-controller via a keyboard.

IBM 1053 Printer, Model 3

The 1053 (Figure 5) provides printed output at a maximum rate of 14.8 characters per second. When multiple 1053s are installed, they can simultaneously print independent messages from the processor-controller.

Figure 4. 1816 Printer-Keyboard

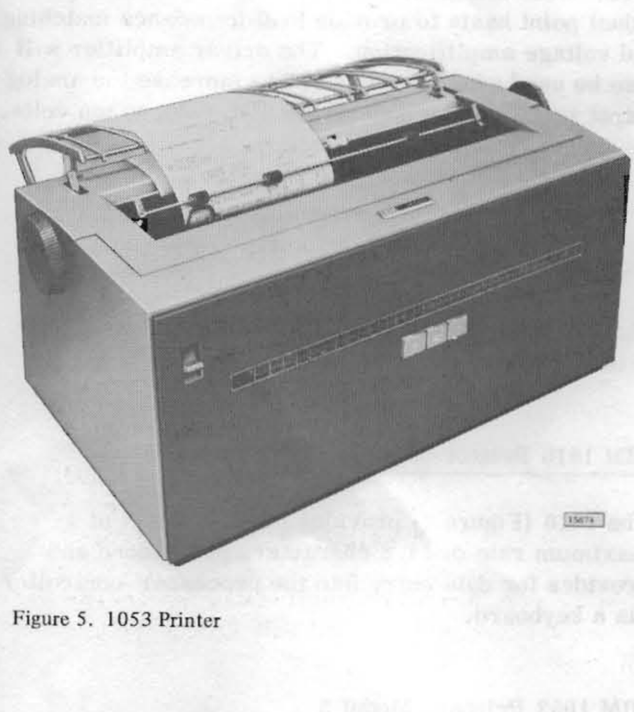


Figure 5. 1053 Printer

IBM 1442 Card Read Punch

The 1442 (Figure 6) operates on a data channel and provides serial reading and punching cards. Two models are available for attachment to the 1800.

Model 6 -- 300 cards per minute read.
80 columns per second punch.
Model 7 -- 400 cards per minute read
160 columns per second punch.

Figure 6. 1442 Card Punch

IBM 1443 Printer

The 1443 Printer (Figure 7) operates on a data channel to provide on-line printing with a minimum amount of processor-controller time and attention. Two models are available. Printing speeds are:

Model 1 -- 120 to 430 lines per minute.
Model 2 -- 200 to 600 lines per minute.

Figure 7. 1443 Printer

IBM 1054 Paper Tape Reader, Model 2

The 1054 Paper Tape Reader (Figure 8) reads one-inch eight-track paper tape at a maximum rate of 14.8 characters per second. Data is read into the processor-controller core storage as an image of the holes in the tape, with each punched character being read into one addressed core storage location.

Figure 8. 1054 Paper Tape Reader

IBM 1055 Paper Tape Punch, Model 2

The 1055 Paper Tape Punch (Figure 9) punches one-inch eight-track paper tape at a maximum punching rate of 14.8 characters per second. Data characters are punched as an image of the data in core storage.

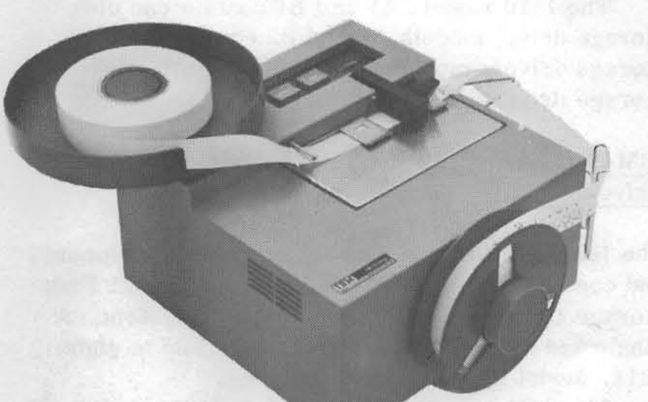


Figure 9. 1055 Paper Tape Punch

IBM 1627 Plotter

Models 1 and 2 of this incremental plotter (Figure 10) are available on the 1800 to record digital information in any desired graphical form. The plotter operates up to a maximum rate of 200 or 300 steps per second, depending upon the model.

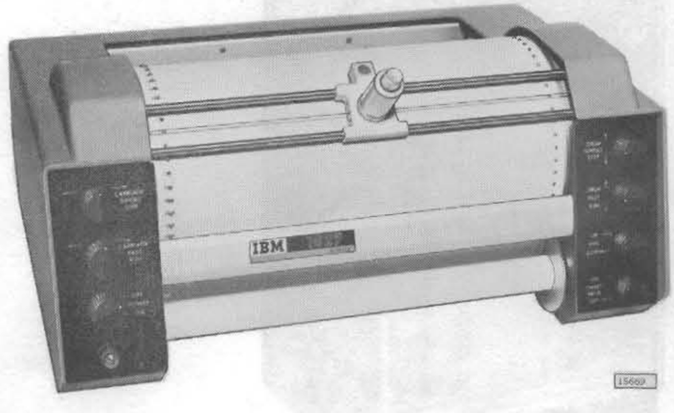


Figure 10. 1627 Plotter

IBM 2401/2402 Magnetic Tape Units

The 1802 Processor-Controller includes tape control circuitry for the connection of IBM magnetic tape units to the 1800 system via a data channel. A maximum of two tape drives can be attached to an 1802. The following IBM magnetic tape units can be attached:

2401 -- single nine-track tape unit (Figure 11):
- Model 1 -- 30,000 eight-bit bytes per second.
- Model 2 -- 60,000 eight-bit bytes per second.
- Model 3 -- 90,000 eight-bit bytes per second.

2402 -- double nine-track tape unit (Figure 12):
- Model 1 -- 30,000 eight-bit bytes per second.
- Model 2 -- 60,000 eight-bit bytes per second.
- Model 3 -- 90,000 eight-bit bytes per second.

The seven-track read/write head feature for 2400 series tape units is available for the 1800 system.

IBM 1810 Disk Storage

The 1810 Disk Storage (Figure 13) is a storage device with both random and sequential access capabilities. Its storage medium is an oxide-coated disk in an interchangeable cartridge. A magnetic head for each surface performs reading and writing functions. There

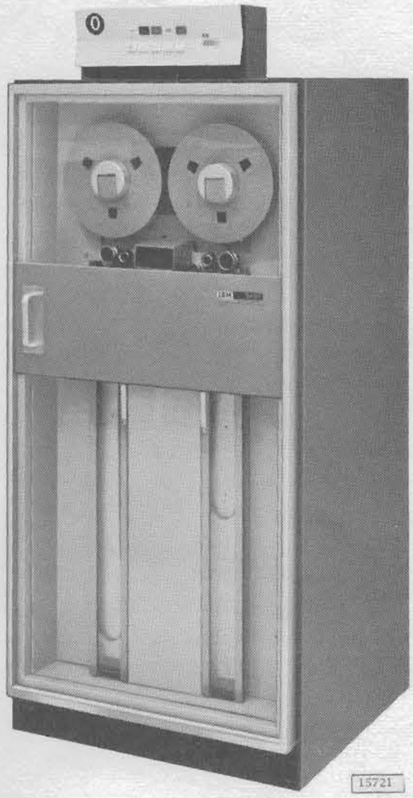


Figure 11. 2401 Magnetic Tape Unit

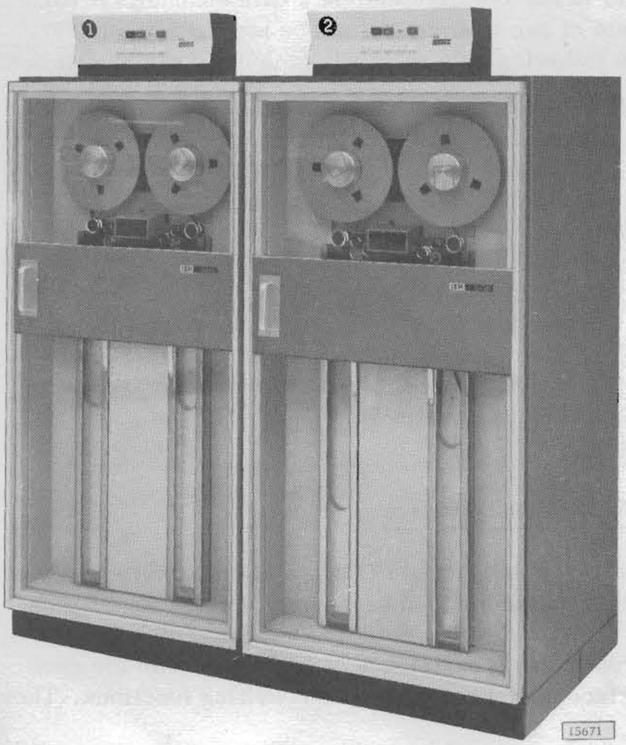
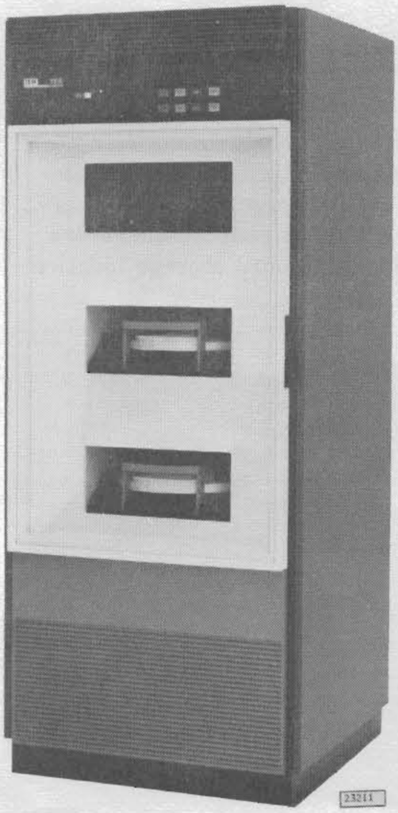


Figure 12. 2402 Magnetic Tape Unit



• Figure 13. 1810 Disk Storage

are 200 "cylinders" of two tracks each, providing a storage capacity of 512,000 sixteen-bit words. The 1810 operates on a data channel with a maximum reading/writing rate of 36,000 words per second. One 1810 (containing up to three disk storage drives) can be attached to an 1800 system.

The 1810 models A1 and B1 contain one disk storage drive; models A2 and B2 contain two disk storage drives; models A3 and B3 contain three disk storage drives.

IBM 2841 Storage Control and 2311 Disk Storage Drive

The IBM 2841 Storage Control provides attachment and control facilities for connecting IBM 2311 Disk Storage Drives (Figure 14) to the 1800 system. A single 2841 provides for attachment of up to eight 2311, Model 1, Disk Storage Drives.

The 2841 two-channel switch feature provides the ability for sharing a 2841 by two separate channels and also allows individual devices (2311) to be reserved for the exclusive use of either of the channels. The two channels may be selector channels from separate 1800 systems or a selector channel from an 1800 system and a channel from System/360.

• Figure 14. IBM 2311 Disk Storage Drive

Channel switching and device reservation in the 2841 are performed under control of the system program.

IBM 2311 Disk Storage Drives: The 2311 is a random access storage device designed as a key component of systems that require medium-size files to be available to the system. The 2311 features a removable and interchangeable disk pack storage which allows the customer to store much of his total file capacity off-line. The 2311 operates only as a slave to the IBM 2841 Storage Control which in turn operates under control of the 1800 Selector Channel.

A single 1316 Disk Pack, used with the 2311, can contain over 7.3 million alphameric bytes, or over 14.7 million packed decimal digits and signs. The average time for "random" accesses is approximately 75 milliseconds. The data transfer rate is 156,000 bytes per second.

COMMUNICATIONS ADAPTER

The Communication Adapter (CA) extends the capabilities of the 1800 system by enabling communication with the following:

1. System/360 with Synchronous Data Adapter II on the 2701 Data Adapter Unit.
2. System/360 with 2703 Transmission Control Unit.
3. 1130 system with Synchronous Communications Adapter.
4. Other 1800 systems with the CA feature.
5. 2780 Data Transmission Terminal and other BSC devices.

The CA provides half-duplex, synchronous (by bit and by character) data transmission. The CA may also operate in full-duplex mode, thus reducing line turnaround delays, but message transmission is half-duplex only (transmission in one direction at a time). In dialup network operation, the CA will automatically answer calls originated by a remote station (Auto Answer function).

Up to four CA basic units can be attached to an 1800 system. Either one or two communication lines can be attached to each CA basic unit, providing a maximum of eight communication lines, all of which may be used simultaneously.

A communication line may be selected to operate at a speed of 600 (World Trade Corp. only), 1200, 2000, 2400 or 4800 (domestic only) baud. Choice of line speed depends on the data set and the quality of lines used.

SELECTOR CHANNEL

The selector channel provides a means of attaching the IBM 2841 Storage Control (see 2841 Storage Control – Component Description, A26-5988) with up to eight IBM 2311 Disk Storage Drives to the 1801/1802 processor-controller.

The selector channel operates in burst mode only, using the cycle-stealing facilities of a data channel. The maximum data rate that can be handled by the selector channel is 333,000 bytes per second.

SYSTEM/360 ADAPTER

The System/360 Adapter permits communication between the 1800 system processor-controller and the System/360. Each system regards the other as an I/O device capable of requesting service on a random basis. The System/360 Adapter is functionally equivalent to the corresponding System/360 device, the channel-to-channel adapter.

The channel provides the ability to transfer blocks of data and/or programs at rates up to 250,000 bytes per second between the System/360 and the 1800 system.

1800 PROGRAMMING SYSTEMS

Three programming systems support the IBM 1800 Data Acquisition and Control System:

1. IBM 1800 Card/Paper Tape Programming System.
2. IBM 1800 Time Sharing Executive System.
3. IBM 1800 Multiprogramming Executive Operating System.

Each of these systems is intended for a specific range of user applications and hardware configurations. This section presents an overview of each programming system. For more detailed information on each of the systems and its component parts, see the IBM 1800 Bibliography (Form A26-5921).

CARD/PAPER TAPE PROGRAMMING SYSTEM

The Card/Paper Tape Programming System is designed to fulfill the requirements of the small or dedicated system application. It is available as either a card or paper tape input system and is made up of the following four distinct components:

1. Assembler
2. FORTRAN Compiler
3. Subroutine Library
4. Utility Routines

These components provide a simple method of writing, loading, and executing a user's programs which have been written to the specifications of his process. A brief description of each of the components follows:

ASSEMBLER

The 1800 system assembler language permits the programmer to write (code) source programs in a symbolic language that is more meaningful and easier to use than the binary machine language. The symbolic language provides the programmer with mnemonic operation codes, special characters, and other necessary symbols. The use of symbolic labels (names) makes a program independent of actual machine locations. Unique mnemonic operation codes relieve the programmer of coding the machine-language instruction modifications.

Instructions are included which (in conjunction with the program loaders) automatically provide linkages to the IBM-supplied subroutines. The subroutines provided are described later. Instructions may also be added for communication with customer-provided subroutines.

The assembler converts the symbolic language to machine language instructions and provides this information in either card or paper tape output. This information can then be loaded and executed by using one of the utility routines provided by the system.

FORTRAN COMPILER

FORTRAN (FORmula TRANslation) is a programming language that allows the engineer and scientist with only a slight knowledge of the computer to utilize a computer for problem solving. To satisfy the requirements of the computer, FORTRAN statements are converted to machine language. To satisfy the engineer and scientist, as many of the detailed computer operations as possible are eliminated from the job of writing programs, and a statement format similar to that of the mathematical equation is used.

The output of the FORTRAN compiler is machine language instructions punched in cards or paper tape that can be loaded and executed by using one of the utility routines provided with the system.

SUBROUTINE LIBRARY

The subroutines for the 1800 system are a package of commonly used routines for data input/output, data conversion, and arithmetic functions. These routines relieve the user of the burden of writing the instructions to perform these functions. The routines may be called from either an assembler or FORTRAN language program and are automatically loaded along with the mainline program.

UTILITY ROUTINES

The utility routines provide general functions which are useful in most 1800 applications. Among these are the loading of users' programs; core dump programs, which are useful in program debugging; and simplified data manipulation routines.

FEATURE SUPPORT

The Card/Paper Tape Programming System supports the following 1800 system features:

1. Up to eight 1053 Printers, or two 1816 Printer-Keyboards and six 1053 Printers.
2. A 1443 Printer.
3. Up to two 2401 Magnetic Tape Units.
4. Up to three 1810 Disk Storage Drives.
5. A 1627 Plotter.
6. Up to two 1442 Card Read Punch Units.
7. A 1054 Paper Tape Reader.

8. A 1055 Paper Tape Punch
9. Analog input.
10. Digital input.
11. Digital/Analog output.
12. Core storage of up to 32,768 words.
13. Up to nine data channels.
14. Up to twenty-four interrupt levels.

The minimum machine configuration required for operation of the 1800 Card/Paper Tape Programming System is as follows:

1. One IBM 1801 or 1802 Processor-Controller with 4,096 words of core storage.
2. An IBM 1442 Card Read Punch, or IBM 1054 Paper Tape Reader and IBM 1055 Paper Tape Punch.

TIME SHARING EXECUTIVE SYSTEM

Recognizing the formidable programming task associated with real-time processing systems, IBM has developed the 1800 Time Sharing Executive System (TSX). This system relieves the user of much of the required programming effort by freeing him to concentrate on the primary task of problem solution. TSX is a FORTRAN-oriented disk-resident operating system which permits the user to use an IBM 1800 Data Acquisition and Control System (DACS) for its primary purpose, the control of processes and similar complex environments, as well as providing him with an effective off-line monitor system for data processing and scientific computation.

TSX greatly improves the versatility of a DACS by making it possible for background jobs to be processed when the real-time foreground task relinquishes control of the processor-controller. This concept, known as time-sharing, greatly improves the efficiency of the system. Programs may be written in FORTRAN and/or symbolic assembler language.

The IBM 1800 Time Sharing Executive System consists essentially of two main parts:

1. A skeleton executive.
2. A nonprocess monitor.

It is through the skeleton executive that process control and data acquisition applications are serviced in the on-line mode, while the nonprocess monitor acts as an independent programming system to provide data processing functions in a standard off-line mode. Each of these modes is brought into use by an appropriate and corresponding system generation procedure. The user has the option of constructing an on-line or off-line system tailored to individual specifications.

On-Line Mode

TSX operates in this mode under control of the skeleton executive. In an on-line environment, user-written programs monitor and/or control a process operation on a scheduled and/or a demand basis. The process programs are also permitted to be time-shared by nonprocess work; that is, off-line work may be interleaved with on-line work.

Off-Line Mode

The off-line TSX system operates in this mode under control of the temporary assembled skeleton (TASK) as a dedicated nonprocess monitor system. It can be used to test programs before they are permanently catalogued on the system disk or to build an on-line disk-resident system.

TIME SHARING

TSX is capable of time sharing when operating in the on-line mode. As previously stated, this allows background jobs to be processed when the real-time foreground task relinquishes control of the processor-controller. Time sharing is accomplished by dividing core storage into two major sections which are known as 1) the system skeleton and 2) variable core.

The system skeleton is the core-resident portion of the system. It contains system programs that can perform the necessary general functions such as common input/output operations, the scheduling of core load execution, the handling of interrupts, the operation of the interval timers, and the control of time sharing.

Variable core is used for the execution of the users' programs and core loads and also by the nonprocess monitor programs. Process core loads are scheduled by a program in the system skeleton using sophisticated priority queueing techniques. These core loads are then individually loaded into variable core and executed according to the user-established priority within the queue. The process core loads can be queued sequentially or as a result of an event in the process.

If the system skeleton detects that variable core is idle, it saves the current process core load on the disk and loads one of the nonprocess monitor programs or a user's background program. While time-sharing, the nonprocess monitor operates under the direction of the user through the use of control cards. As the nonprocess function is performed, the system skeleton continuously monitors the process. When the system skeleton detects that the process again requires the processor controller, it saves the current background job and restores the previously saved foreground job. It is through the time-sharing feature that the TSX system is able to utilize the processor-controller and input/output capabilities of the 1800 system.

NONPROCESS MONITOR

The nonprocess monitor is a group of programs designed to simplify the generation of a TSX system, the writing of the user programs, and the maintenance of the system. These programs are disk resident and are loaded into core storage as a result of the use of time sharing or at the command of the operator.

Some of the programs that make up the nonprocess monitor are:

1. A supervisor for the reading and interpretation of user-provided control cards and the implementation of the desired function.
2. An assembler, a FORTRAN compiler, and a subroutine library, all of which provide similar functions as to their counterparts in the Card/Paper Tape System.
3. A disk utility program, which performs the frequently required operations of disk maintenance. These operations include storing, deleting, and providing output of user's programs; defining system and machine parameters; and maintaining communications areas.
4. A core load builder, which combines a user-written relocatable program together with all referenced subroutines into the format required for execution.

TSX FEATURES

TSX provides the following features:

- Automatic program scheduling which provides high throughput and fast response to a process.
- Time sharing between foreground (process) operations and background (nonprocess) operations.
- System residence on the 1810 disk.
- Additional core storage of up to 32,768 words.
- Nine software timers.

In addition to supporting all of the 1800 hardware features described with the Card/Paper System, TSX will support the three hardware interval timers.

The TSX System is modular in design and may be tailored to the specific user application during the system generation procedure.

MINIMUM SYSTEM REQUIREMENTS

The minimum machine configuration required for the operation of the 1800 Time Sharing Executive System is as follows:

1. One IBM 1801 or 1802 Processor-Controller with a minimum of 8,192 words of core storage.
2. One IBM 1810 Disk Storage Unit, Model A1 or B1.
3. One IBM 1442 Card Read Punch.
4. One IBM 1053 Printer or one IBM 1443 Printer or one IBM 1816 Printer-Keyboard.

MULTIPROGRAMMING EXECUTIVE OPERATING SYSTEM

The IBM 1800 Multiprogramming Executive Operating System (MPX) is designed to satisfy the demands of process or data acquisition applications that are beyond the scope of the Card/Paper Tape System or the Time Sharing Executive System. The applications require an operating system which is capable of extremely fast response, very high throughput, and which supports additional hardware features.

MPX provides fast response and high throughput through the use of partitioned core and sophisticated input/output handling techniques which make the central processing unit available during I/O and interval timer operations. Through the use of these features, MPX is able to provide asynchronous control of independent processes while additionally performing batch processing (background) functions. In addition, MPX supports the full range of hardware devices available with the 1800 system.

Multiprogramming

In unpartitioned operating systems, process and batch processing functions are performed sequentially; that is, a new function is not begun until the current function is completed. The average function performed by a computing system requires, at any given moment, only a fraction of the total available resources of the system. Many parts of the system are, therefore, often idle for significant periods of time. For example, a data conversion and printing function requires only intermittent use of the processor-controller and a fraction of the available storage space and input/output devices.

To increase throughput, the IBM 1800 Multiprogramming Executive Operating System enables programs, core storage space, input/output facilities, and control of the processor-controller to be allocated and concurrently shared among several process functions. These facilities permit multiprogramming; that is, they permit several process functions to be performed concurrently and to share the basic resources of the computing system. The MPX operating system helps to ensure that the total system is kept busy performing productive work as much of the time as possible.

Thus, MPX efficiently allocates the available resources of the system to more than one function by switching control from one function to another as a delay is encountered while awaiting an event, such as the completion of an input/output operation or the end of a timing interval.

Among the services provided by MPX to allow concurrent operation are:

1. Loading core loads into available partitions (core areas) while executing in other areas.
2. Scheduling the use of core loads in all partitions.
3. Switching control of the processor-controller from one function to another while waiting for an I/O operation to be completed.

Multiprogramming is regulated on the basis of I/O operation. When an input/output or timer operation is initiated in one partition, that area can be placed in a suspended state until the I/O function is completed. Concurrently with this, a program residing in a lower priority partition can be executed. Since a partition can be assigned to an interrupt level, the programmed interrupt technique is used by the system to direct these levels of operation, thereby controlling the execution of any one of 24 possible partitions at any moment in time. This program interrupt technique, utilizing the hardware interrupt features of the 1800, enables MPX to eliminate time-consuming list searching operations.

The MPX system provides for unlimited queueing of I/O operations as well as the ability to achieve maximum overlap of I/O and computing. In addition, interrupt programs may be queued and executed on interrupt levels within a hierarchy of priorities chosen by the user. Queueing and I/O overlap, as used in the MPX system, provide the ability to gain full advantage of 15 cycle-stealing data channels, 24 interrupt levels, and in general, the potential of the IBM 1800 Data Acquisition and Control System.

MPX COMPONENTS

The IBM 1800 Multiprogramming Executive Operating System, like TSX, can be considered, functionally, to be composed of two main components: 1) a core-resident portion called the system executive and 2) a conventional batch processing monitor. As in TSX, the system executive is core resident and controls the loading and execution of the user's control programs when operating in the real-time mode. The batch processing monitor operates in the time-shared mode under control of the system executive or can function as an independent non-process monitor in the off-line mode. The components of the batch processing monitor are essentially the same as described for the TSX nonprocess monitor. However, some expanded functions have been added which add new capabilities and provide ease of operation. For example, unlike TSX, MPX is able to assemble or compile programs from source files on the disk.

The modularity of MPX, in conjunction with many system generation options, allows the user to generate a system to meet the requirements of his application without being burdened with features in which he is not interested. The system may be constructed with up to 24 partitions for multiprogramming capabilities or may be built as a single-area, time-sharing system similar to TSX. It is also possible to generate a batch processing monitor system for off-line use.

MPX FEATURES

The following features are available with MPX:

- High throughput.
- Fast response to the process.
- Ease in the scheduling of program execution.
- Ability to modify IBM system programs as well as user programs on-line.
- On-line diagnostics for critical I/O devices.
- Time sharing of multiple foreground (process) and background (batch processing) operations.
- System residence on either 1810 or 2311 disk drives and full support for both.
- Sharing of 2311 data files by two 1800s or an 1800 and a System/360.
- Up to 32 software timers.

In addition to supporting all of the 1800 hardware features described with the Card/Paper Tape System and the Time Sharing Executive System, MPX will support the following:

- Core storage of up to 65,536 words.
- Up to three 1810 and eight 2311 disk storage drives.
- Binary synchronous communication support to System/360, the 1130, the 2780, and other 1800's.
- Support for the 2790 Data Communication System, to include the following devices:

  2791 Area Station, Model 1 or Model 2
  2793 Area Station
  2795 Data Entry Unit
  2796 Data Entry Unit

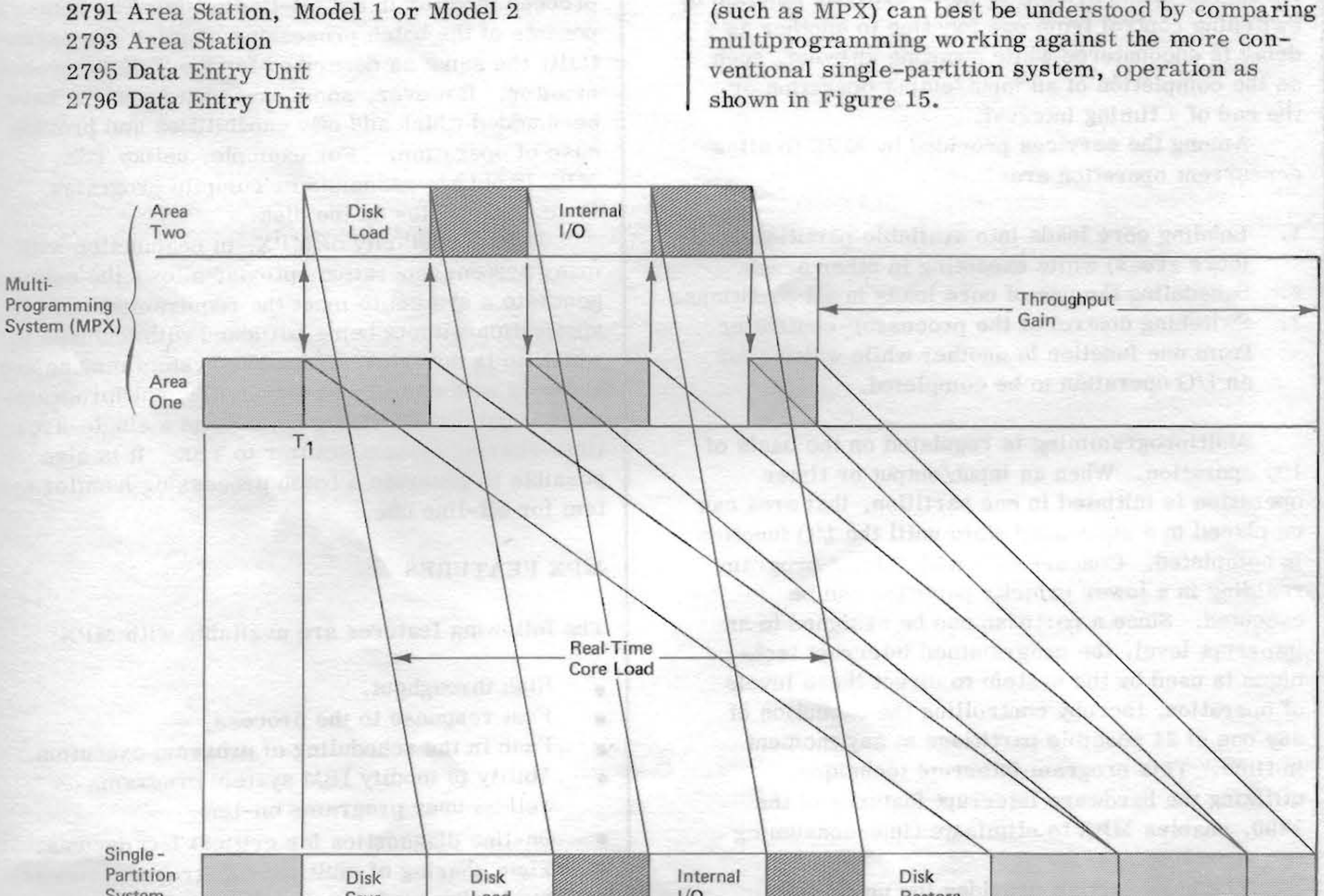
MINIMUM SYSTEM REQUIREMENTS

The minimum machine configuration required for the operation of the IBM 1800 Multiprogramming Executive Operating System is as follows:

1. One IBM 1801 or 1802 Processor-Controller with a minimum of 16,384 words of core storage.
2. One IBM 1053 Printer or one IBM 1816 Printer-Keyboard.
3. One IBM 1442 Card Read Punch.
4. One IBM 1810 Disk Storage Unit, Model A1 or B1, or one 2311 Disk Storage Unit.

ADVANTAGES OF MPX

The advantages of a multiprogramming system (such as MPX) can best be understood by comparing multiprogramming working against the more conventional single-partition system, operation as shown in Figure 15.



• Figure 15. Multiprogramming (MPX) versus Single-Partition System (TSX)

In a single-partition system, assume that a logging program, SCAN, is currently executing in variable core. A process interrupt is now received on a higher interrupt level than the level on which SCAN is executing, and immediately interrupts the logging program. An exchange of core takes place: SCAN is saved on disk and the servicing program, OPT, for this higher level interrupt is read into core overlaying SCAN. OPT now executes, computes, and outputs in this sequence until completion. When completed, the SCAN program is restored to core, overlaying OPT, and resumes operation until completion. The sequence of events repeats itself.

It is evident from this method of operation that there is a lack of overlap of I/O, as well as a lack of overlap of I/O and computing. The operations are strictly sequential. This is generally the case with single-partition systems.

In contrast, consider the case of a two-partition MPX system. As before, assume SCAN is currently executing in area 1. At time T_1, a process interrupt is received on a higher interrupt level. The system can now immediately proceed to load the OPT program into area 2. We thus see an immediate saving of the disk save time required in a single-partition system.

During the loading time interval of OPT into area 2, the SCAN program in area 1 continues to execute. When the loading of OPT is completed, OPT begins to execute and continues to do so until the OPT program carries out some I/O operation which requires a time delay until the input-output function is complete. At this point, execution of SCAN in area 1 resumes until the I/O function initiated by OPT is completed, thereby utilizing time otherwise unavailable in a single-partition system.

At the completion of the input-output operation, OPT resumes execution and continues until completion, then the SCAN program in area 1 resumes control. A time advantage is realized, when compared with single-partition system operation, because the restore disk operation is not necessary in multiprogramming.

From the above, we can see that the gain in throughput brought about by multiprogramming is achieved as follows:

1. No disk save operation is required
2. Continued execution of SCAN during the disk loading of OPT
3. Continued execution of SCAN during the interval of I/O operation of OPT
4. No disk restore operation is necessary, thus allowing immediate resumption of execution of SCAN following the completion of OPT

INDEX