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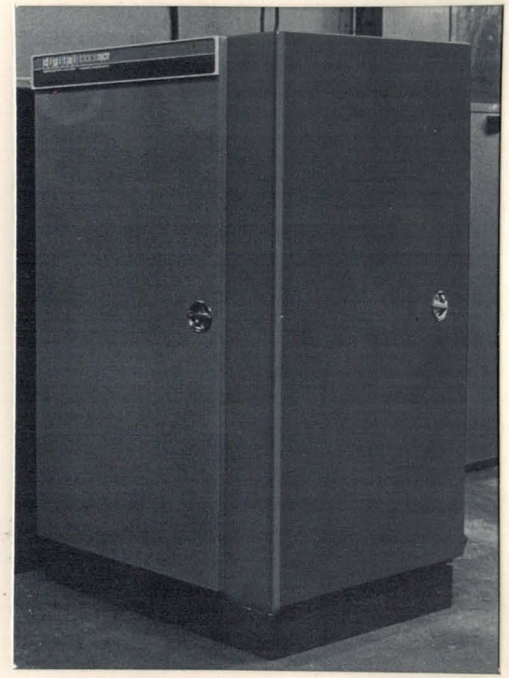
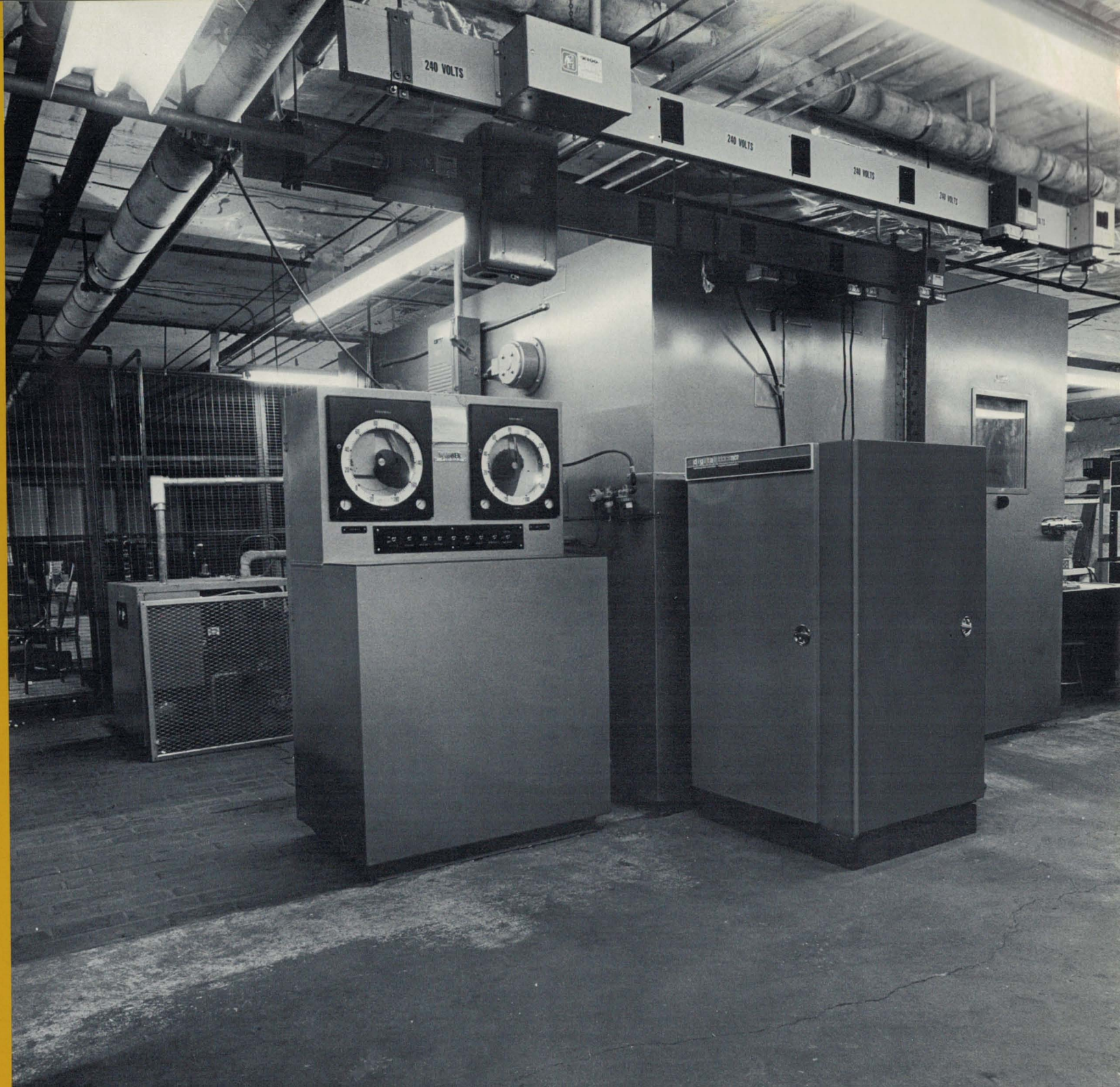
IDACS 11/07 INDUSTRIAL CONTROL SYSTEM

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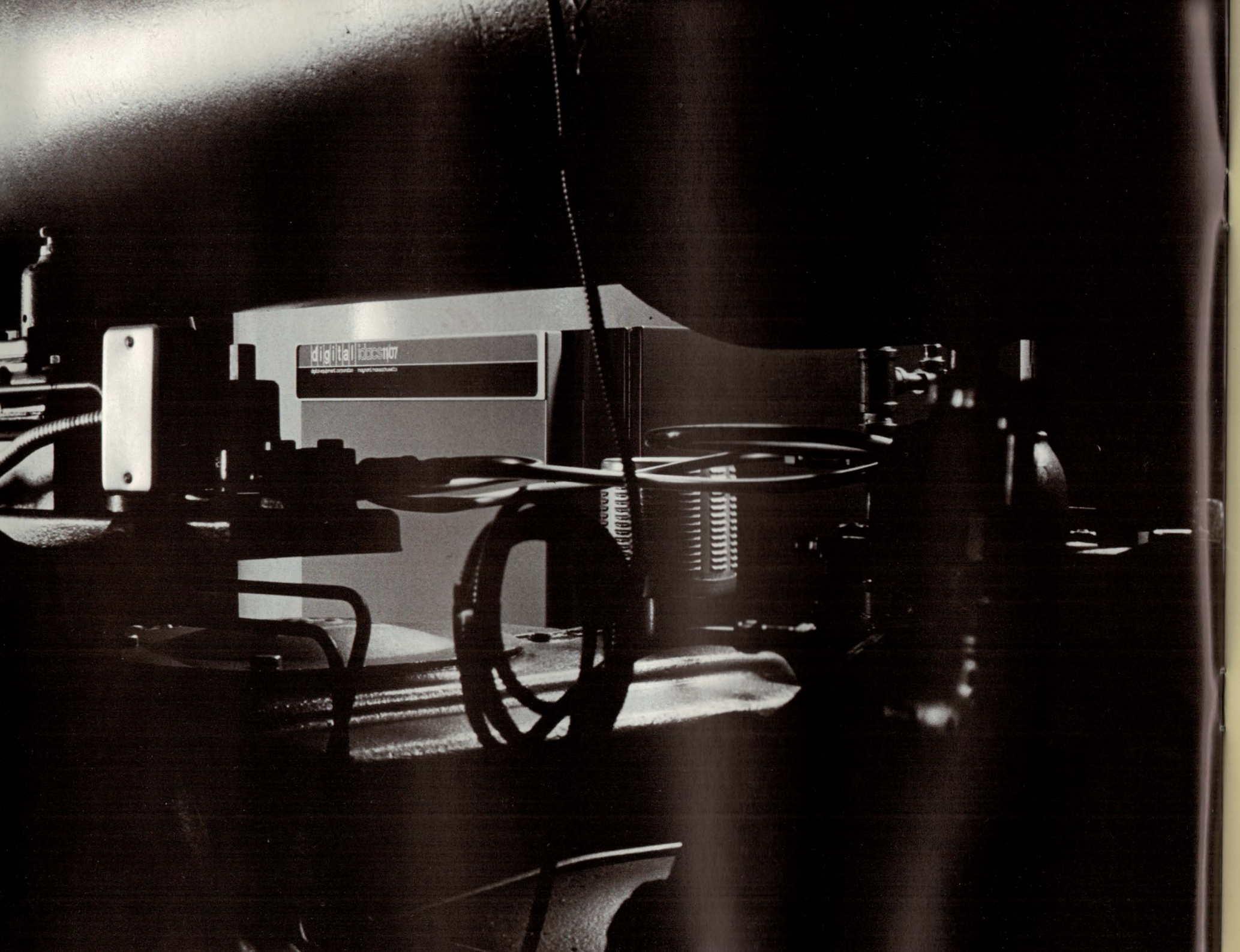
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IDACS 11/07 INDUSTRIAL CONTROL SYSTEM

From simple monitoring to complex control functions . . . as a stand alone system or one of many satellite controllers in a complex hierarchical system . . . IDACS 11/07 provides the processing power, input/output capability and flexibility required in today's industrial control environment.

Modular hardware and software of the IDACS 11/07 allow the user to start with a small system, then economically expand to meet growing requirements.

The system's powerful 16-bit processor provides the computing capability for direct digital control or supervisory control of analog controller setpoints . . . or to monitor and control sequential operations in a manufacturing process, a batching operation, or a test procedure.

The system's analog and digital subsystems contribute broad input/output capability with a wide range of interchangeable plug-in modules. Fully expanded, the system will accommodate up to 256 analog inputs, or up to 512 digital inputs and outputs, or some combination of analog and digital signals.

With the exception of special operator consoles, peripherals, and communication devices, the system is enclosed in a Nema-12 type housing - one which can be located on the plant floor, or at the test station or process site. This rugged housing isolates the system electronics, protecting them against dust, dirt, fumes, heat, and corrosive atmospheres. The system's closed circuit cooling systems (heat exchanger or optional air conditioner) assure long equipment life.

With the 11/07 system located at the plant level, information is readily accessible for current operations. For example, a foreman can use a local terminal to request production schedules, machinery status reports, or an exception report. A supervisor can enter data specifying a new batch of product, a new test procedure, or the tooling specifications for a new product.

Proximity to the process also reduces the expense of connection to field sensors and devices. Since less cabling is required, installation and expansion costs can be reduced.

In a hierarchical system, data from the 11/07 plant level computer can be transmitted to a larger PDP-11 and/or to higher level systems such as Digital's DECsystem-10; IBM's 1130, 1800, 360, and 370 systems, the CDC 1700; Burroughs 5500; or the XDS Sigma 5.

In a complex network, data from a large number of 11/07 plant "controllers" could be gathered and preprocessed on-line by one or more medium scale computing systems before being input to a large scale system. The higher level systems, in turn, can convert total plant or division data into production reports, materials and inventory reports, quality control trends, sales reports . . . providing the integrated information necessary for comprehensive management decisions.

THE PDP-11 PROCESSOR

The PDP-11 embodies many new and unique processing concepts which are ideally suited to industrial applications. The processor's multilevel interrupt structure provides fast response for critical process variables . . . A powerful instruction set simplifies the programming of industrial control devices. With modular construction, the system is easy to expand and system components take less time to repair or replace.

All system elements - processor, memory, and process interfaces - plug into a common bus system known as the UNIBUS™. The system's asynchronous operation allows memories of different speeds to be intermixed on the same bus. Thus low cost memory can be employed if processing speed is not a critical requirement.

The 16-bit word size of the PDP-11 simplifies the programming of messages and communications, since data is stored and addressable in two 8-bit bytes. The 16-bit word also provides accuracy in mathematical operations and high signal resolution for analog to digital conversion.

Key to processor operation is a unique higher level assembly language that simplifies programming by allowing a single instruction to perform multiple operations. The versatile MOV instruction, for example, allows the programmer to transfer information from a process device to memory, memory to a device, device direct to device, and many other transfer combinations between registers, memories, devices, and terminals. In conventional machine language, each of these transfers would take several instructions.

Since the programmer has less instructions to master, PDP-11 assembly

language programs are easier to write and debug. Programs are shorter so they are easier to check and more core efficient.

The PDP-11, with its flexible addressing structure and general purpose registers, makes it easy to handle data structured in tables or stacks such as conversion tables and messages; and arrays of set points, loop scan frequencies, alarm limits, or multiplexer channel addresses.

The PDP-11 provides an almost limitless number of hardware priority levels in four separate lines. Each line can contain many devices, the priorities of which are dependent upon their positions on the line. The device closest to the processor on a line receives service first; the remaining devices are serviced in sequence.

When an interrupt occurs, it is immediately identified. Unlike other processors which poll to identify the interrupting device, the PDP-11 allows the device itself to provide a pointer to its own interrupt servicing routine. Thus no time is wasted determining which device interrupted and finding the proper routine.

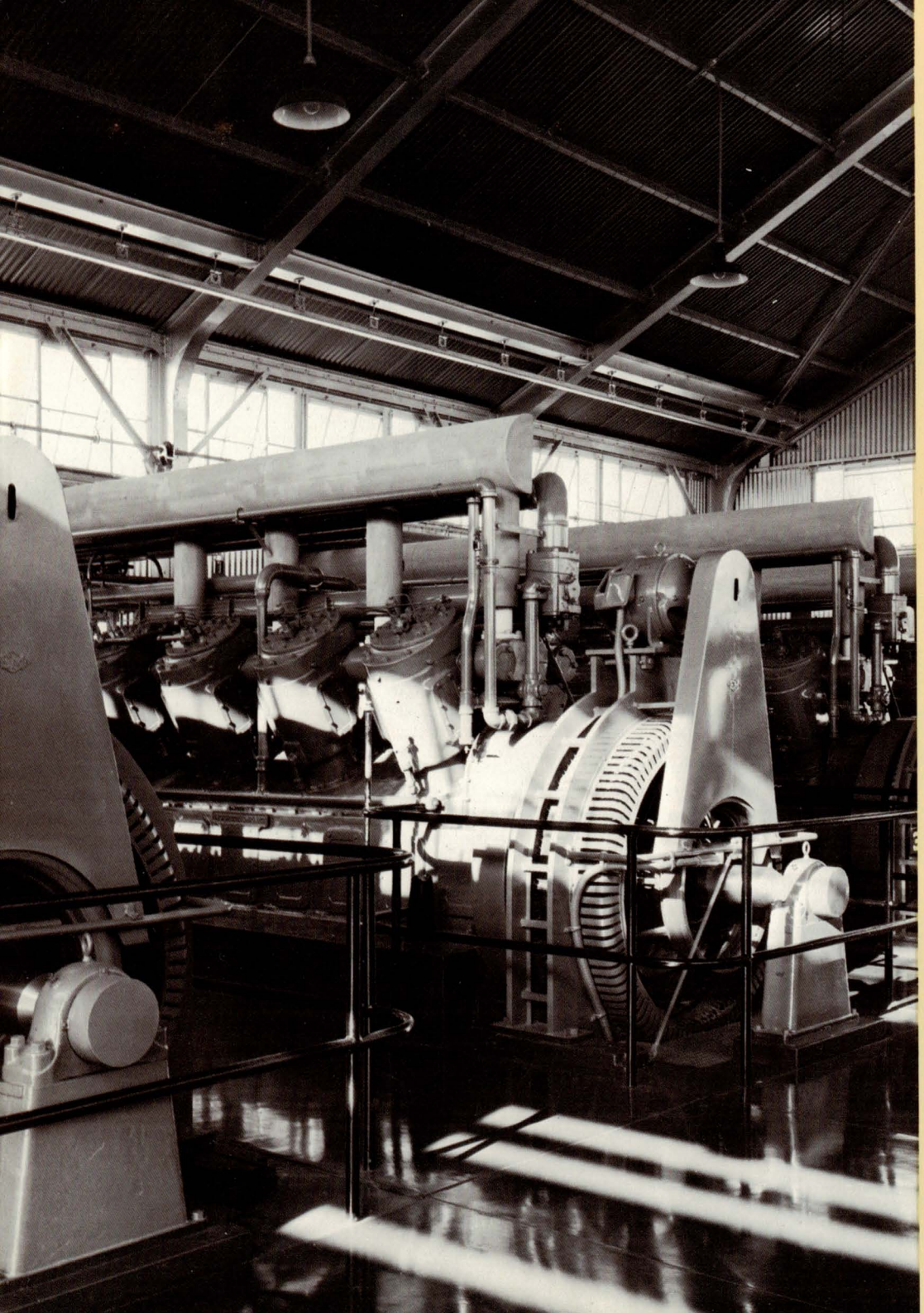
For flexibility, the priority of the service routine is programmable and completely independent of the interrupt priority of the device. Therefore, a device which interrupts on a low level can have its service routine operate at a higher level, selectively locking out other devices; or the service routine for a high priority device can operate at a lower level.

When a task must be interrupted to service a higher priority, return addresses must be saved for the interrupted routine. In the PDP-11, a hardware stack automatically performs this nesting of interrupts. In other systems, this function is performed by software which consumes vital memory space and is much slower in operation.

The stack also allows subroutines to be reentrant without major software overhead, For example, if a subroutine that is performing a temperature conversion is required by a higher priority interrupt, the stack allows the proper "return" addresses to be stored. Thus the conversion routine will be interrupted, performed for the higher priority interrupt, then reentered at the proper point to complete its original conversion task. Since only one subroutine is required and since stacking is automatic, both memory space and time are saved.

Power fail and restart features are standard on the PDP-11. When the system senses a brown-out (a reduction in voltage) or a total failure, it automatically initiates a power fail routine. This user-developed routine promotes orderly shutdown by storing process information, closing switches, etc., to safeguard the user's operation. When power returns, the processor automatically initiates the proper restart procedure.

The PDP-11 central processor is an important factor in the success of the IDACS 11/07 industrial system, providing easier, more efficient programming, fast response, and power fail protection. These features, plus the system's modular construction, make IDACS 11/07 the best price/performance automation system available today.



AFC11/07 ANALOG INPUT SUBSYSTEM

The AFC11/07 is a versatile two-wire differential analog input subsystem for the IDACS 11/07 which accepts signals from the full range of standard electronic transducers, including 1-5 volts, 4-20ma, and 10-50ma.

Through standard signal conditioning modules and eight program selectable input ranges, the subsystem provides maximum resolution and accuracy for low level voltages (10mv f.s.), high level voltages (100 v f.s.), and current inputs (1 to 50ma f.s.). At a 200 channel per second rate, the subsystem multiplexes up to 256 differential analog input signals, selects gain, and performs a 13-bit analog to digital conversion. Both gain and channel selection are under program control.

The AFC11/07 is designed to insure system accuracy and performance in severe industrial environments. To provide a high degree of noise immunity, the subsystem uses a flying capacitor multiplexing technique. When an input channel is selected under program control, the input signal is conditioned by a low-pass RC filter network that charges a second or "flying" capacitor. An isolation relay then closes to connect the charged capacitor to the programmable gain amplifier and analog to digital converter.

Since the input signal is never directly connected to the amplifier and converter, the system achieves extremely high isolation (10^{10} ohms) and can tolerate common mode voltages in excess of 200 volts.

High isolation allows wiring to be simplified so that site preparation costs can be reduced and operation is more reliable. With the AFC11/07 subsystem, signal sources can be either grounded or floating and simple twisted pairs can be used in place of expensive individually shielded wiring.

The subsystem is easy to configure, expand, or modify, since it is modularly constructed in 8-channel multiplexer groups. To expand the system, the user merely adds the appropriate multiplexer modules, 8-channel signal conditioning modules for signal scaling and filtering and screw terminal blocks for field connectors.

The system provides three types of signal conditioning modules.

Direct Voltage Input Signal Conditioning Module BA903 provides 8 channels of normal mode input filtering with a break frequency of 2.5 Hz. Attenuation at 60 Hz is greater than 50 db.

Scaled Voltage Input Signal Conditioning Module BA904 provides 8 channels of 10:1 attentuated input with the same normal mode filtering as direct input. Maximum full scale input is +100 volts.

Current/Voltage Input Signal Conditioning Module BA905 scales 8 channels of 50, 20, or 5ma full scale current inputs to 0.5, 0.2, or 0.05 volts full scale and provides the same normal mode filtering as the direct input module.

An IDACS 11/07 system can contain a mix of up to 32 analog and digital modules. For example, a system that incorporates both AFC and UDC subsystems could contain 24, 8-channel analog multiplexer modules and eight 16-point digital functional modules of the UDC 11/07 subsystem.

SPECIFICATIONS

	Direct Voltage (Module BA903)	Scaled Voltage (Module BA904)	Current/Voltage (Module BA905)	Programmed Gain Required
Range	-200mv to + 10.0v -200mv to + 5.0v -200mv to + 1.0v -200mv to + 500mv ±200mv ±100mv ±50mv ±10mv	-2.0 to + 100.0v -2.0 to + 50.0v -2.0 to + 10.0v -2.0 to +5.0v ±2.0v ±1.0v ±0.5v ±0.1v	— — — -20ma to +50ma ±20ma ±10ma ±5ma ±1ma	1 2 10 20 50 100 200 1000
Input Resistance	50 megohms	15,000 ohms ±0.1%	10.0 ohms ±0.05%	
Bandpass	2.5 Hz	2.5 Hz	2.5 Hz	
Filtering	2 pole RC, damping factor of 1.67			
Overload Protection	1/4 watt input resistors on each channel Amplifier fused against overload			

Number of Inputs	8 to 256 in groups of 8
Type	Differential, 2 wire twisted pair
Connection	Solder lug, or screw terminal
Resolution	Sign + 12 bits (2's complement)
Accuracy (for direct input)	±.025 of f.s. or ±15μv (whichever is larger) ±1/2 l.s.b.
Repeatability (±3 sigma)	±3μv, same channel or ±15μv, channel-to-channel (whichever is larger) ±1/2 l.s.b.
Scan Rate, Including A/D Conversion	200 channels/second, maximum (20 samples/second, same channel)
Normal Mode Rejection	>50db for frequencies 60 Hz or above
Common Mode Rejection	>120db DC to 60 Hz
Common Mode Voltage Tolerance	400 volts p-p
Input Overload	Amplifier fused against overload
Effect of Overload	Recovers to within stated accuracy for next channel.
Channel-to-Channel Isolation	10^{10}ohms at DC, between channels on same multiplexer module.
Gain Accuracy	±0.02%
Gain Linearity	±0.01%
Temperature Coefficient	±.005%/°C or better
Offset	Adjustable to zero

UDC11/07 DIGITAL INPUT/OUTPUT SUBSYSTEM

The UDC11/07 is a highly flexible digital input/output option for such IDACS-11/07 applications as equipment monitoring, control of cyclic processes, in-process testing, and materials handling.

Through a wide selection of functional modules, the subsystem provides input/output control of such devices as relays, solenoids, contacts, limit switches, and provides counter input/output functions as well as analog outputs for recording and control.

The subsystem interrogates or drives up to 32 functional modules which, depending on the modules used, can represent up to 512 individual points. Such modules as the D/A converter or multi-function counter require the entire 16-bit word for operation. However, with contact closures, pulse outputs, and like modules, the 16-bit word represents 16 individual points.

Modules can be assigned to either of two PDP-11 hardware priority lines. Those on the higher level receive immediate service; lower level interrupts receive deferred service.

Interrupts from the functional modules are rapidly identified according to input module type and address by automatic hardware scan logic in the UDC11/07. The subsystem controller determines the type of request and initiates a scan to determine the interrupt address. Typical identifications are made within 5 μ sec.

Features of the UDC11/07 also preclude the noise, cabling, and grounding problems encountered in industrial environments. Through signal conditioning and high input isolation, the system provides high noise immunity without requiring field power supplies to be tied to the system ground.

Modular design and screw terminal connections permit the UDC11/07 to be easily configured and connected to both new and existing plant equipment.

Each functional module accepts a plug-in signal conditioning module to normalize input voltages, provide fusing and distribute field-supplied excitation and control power to the functional I/O modules. Cables for the field wiring screw terminal assemblies plug into each signal conditioning module.

An IDACS 11/07 system can contain a mix of up to 32 analog and digital modules. For example, a system that incorporates both UDC and AFC subsystems could contain 24 16-point digital functional modules and eight 8-channel analog multiplexer modules of the AFC11/07 subsystem.

FUNCTIONAL I/O MODULES

CONTACT SENSE

Contact Sense Module BW731—provides electrically isolated, differential inputs for 16 external customer contacts or voltages. Isolation of up to 250 volts is achieved by a miniature reed relay buffer on each input point. This module, which provides reliable and trouble free digital sensing in high noise environments, is used to monitor the status of relatively long duration contact or voltage level devices such as valves, thumbwheel switches, relays, etc.

CONTACT INTERRUPT

Contact Interrupt Module BW733—provides 16 electrically isolated, differential inputs for external customer contacts or voltages. It is electrically and mechanically similar to the BW731 Contact Sense Module.

The BW733 is used to economically and reliably interface asynchronous devices requiring fast service from the processor because of priority or short duration. Operator push buttons, limit or alarm switches, and control or synchronizing signals are typical of this class of inputs.

SINGLE SHOT DRIVER

Single Shot Driver Module BM687—provides a solid state pulse output to activate up to 16 field circuits such as lights, buzzers, or external control relays. Capable of switching control voltages of up to +55 VDC, the BM687 will switch up to 250 ma of field supplied power per point.

SINGLE SHOT RELAY

Single Shot Relay Module BM807—provides 16 electrically isolated normally open mercury wetted contact outputs for initiating alarms, controls, and field relays. Normally closed operation can be achieved through a module jumper change performed in the field by the customer or at the factory on a special order basis. The duration of the output is trimpot adjustable from 2 msec to 2 seconds.

FLIP FLOP DRIVER

Flip Flop Driver Module BM685—provides 16 solid state buffered driver circuits for control of solenoid valves, relays, lamps, displays, etc.

Capable of switching control voltages of up to +55 VDC, the BM685 will switch up to 250 ma of field supplied power per point.

LATCHING RELAY

Latching Relay Module BM803—provides "fail-safe" operation of 16 electrically isolated mercury wetted relay outputs. Magnetically latched, the relays remain set in the event of power failure, insuring the continuity and integrity of field circuits.

FLIP FLOP RELAY

Flip Flop Relay Module BM805—provides 16 electrically isolated normally open mercury wetted relay output contacts for buffered control of relays, contactors, displays, lamps, etc. Normally closed operation is possible by a module jumper change performed in the field by the customer or at the factory on a special order basis.

MULTI-FUNCTION COUNTER

Multi-function Counter Module BW734—is a 16-bit asynchronous binary "up" counter which updates an output buffer register after each counter increment. When the buffer is read (under program control), the update is inhibited, preventing any data change.

The counter is parallel loading, enabling it to be preset under program control. Count down is accomplished by presetting 2's complement.

The counter generates an interrupt upon overflowing and will continue counting. A jumper is provided to inhibit the counter on interrupt.

DIGITAL TO ANALOG CONVERTER

Digital to Analog Converter Module BA633— is interchangeable with any functional I/O module in the UDC11. It contains four complete channels of 10-bit digital to analog conversion. Single-ended output current or voltage is provided by one of four D/A converter signal conditioning modules.

Power fail backup can be provided to maintain the analog output constant at its last value in the event of system or line power failure.

SIGNAL CONDITIONING MODULES

ISOLATED POWER

Isolated Power Module BW400—provides the interface between individual points on the functional I/O modules and field signals. Differential pair field wiring is terminated on screw terminals, one pair for each of the 16 points on the functional module.

A resistor/jumper selection on each circuit allows field supplied excitation voltages of 6, 24, or 48 VDC to be scaled to 6 VDC at 15ma per point for proper operation of Contact Sense and Contact Interrupt Modules.

COMMON POWER

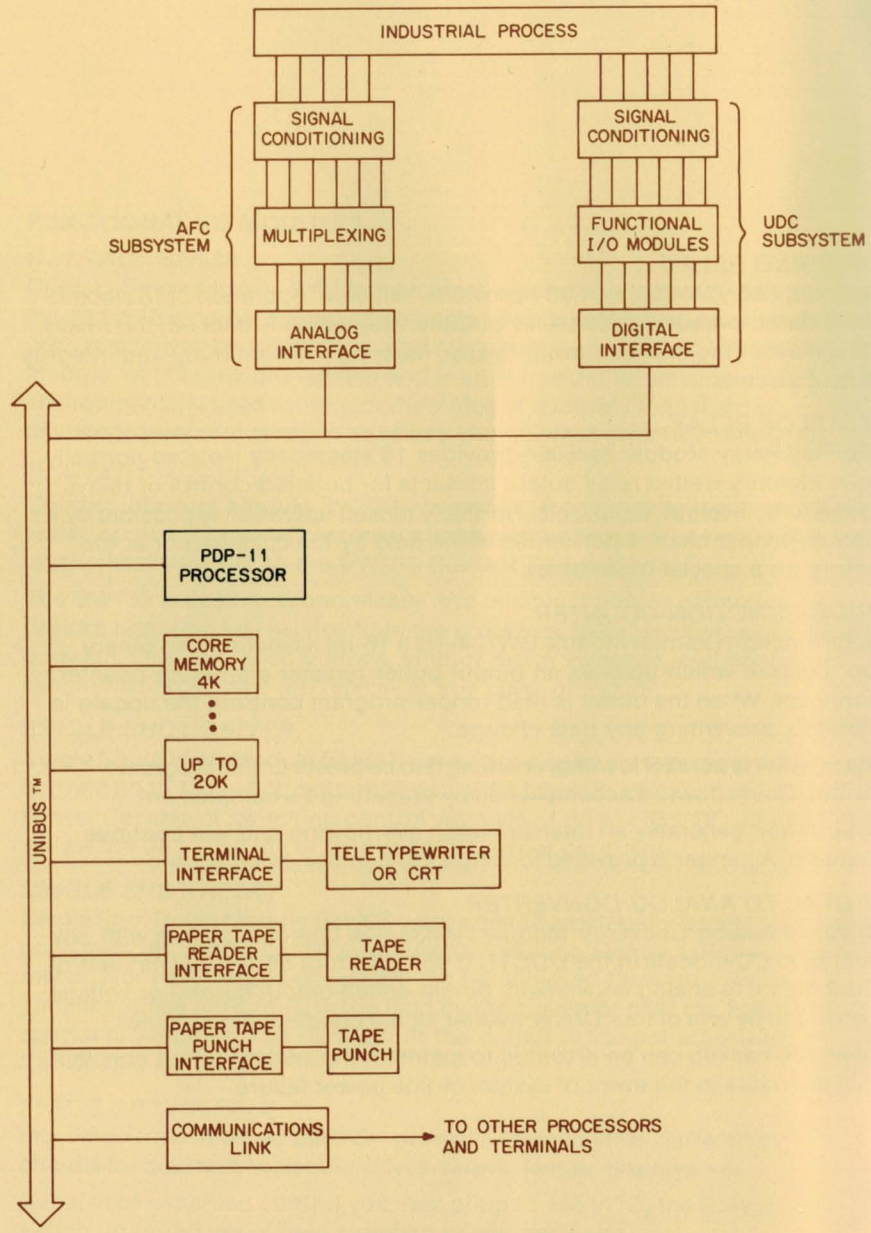
Common Power Module BW402—is similar to the BW400 except that a 17th input pair permits field supplied excitation or control power to be brought directly to the Signal Conditioning Module and distributed in parallel (common) to each of the 16 circuits on the module. The input is fused for 4 amperes. As with the BW400, the BW402 can supply signal conditioning and arc suppression, if required. When the combined relay output current exceeds 4 amperes on a module, the BW400 must be used for power distribution and conditioning.

DRIVER OUTPUT

Driver Output Module BW403—is similar to the BW402 Common Power Module except that a common ground return is provided for the open collector devices of the Single Shot Driver and Flip Flop Driver.

DIGITAL TO ANALOG CONVERTER

A Digital to Analog Converter Signal Conditioning Module is required for each BA633. Each module contains 4 channels of signal conditioning and scales the 4 analog outputs of the BA633 to the required current or voltage range. Module BA233, 0 to +10v@15ma; Module BA234, +1v to +5v@15ma; Module BA235, 4ma to 20ma; Module BA236, 10ma to 50ma.



IDACS 11/07 INDUSTRIAL CONTROL SYSTEM

RSX-11C SOFTWARE

RSX-11C is the executive system available for the IDACS 11/07. It handles input/output and schedules and controls up to 128 concurrent real-time tasks, i.e. such operations as the reading of temperatures and pressures, execution of control algorithms, and the operation of control valves. In addition to its primary functions, the system can also operate a single background task such as a program to calculate process efficiencies.

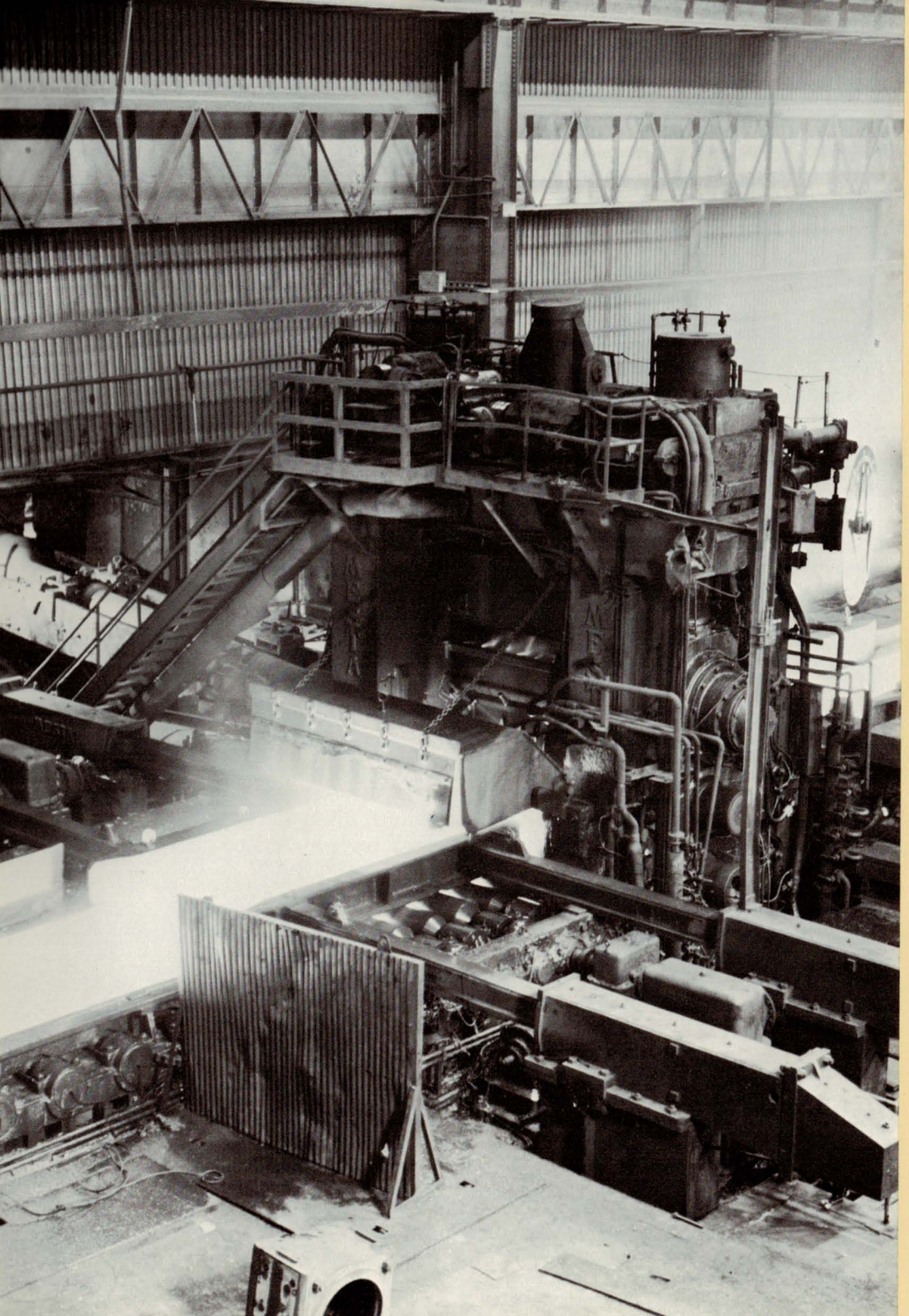
To simplify programming for the process engineer, most tasks can be written in FORTRAN. The executive system also allows flexibility in programming, since one FORTRAN task can call in another FORTRAN task or call a task written in machine language. The system can also utilize the mathematical subroutines of the FORTRAN library.

FORTRAN programs must be compiled on a PDP-11 DOS (disk operating) system. Machine language programs can be assembled and debugged on-line if sufficient core is available.

To meet varying response requirements, the user can assign each real-time task to one of three software priority levels - each with an associated processing time. If a high priority task exceeds its time limit, it is automatically moved to the next lower level until it reaches the lowest level. Bottom level tasks receive round robin time slices, provided no tasks of higher priority request service.

As a precautionary measure, each task is assigned a maximum run time; if the assigned time limit is exceeded, the system will produce an error message.

RSX-11C system operates with COMTEX-11 communications software for communication with terminals and other processors.



IDACS 11/07 SYSTEM SUMMARY

PDP-11 PROCESSOR

- Multilevel hardware interrupt structure for fast response
- Powerful higher level instruction set for simplified programming
- Modular construction for low cost and easy service
- Common interfacing for all system components through UNIBUS™ construction
- Up to 20K of non-volatile core memory
- Intermixing of memory speeds due to asynchronous operation
- Byte addressing capability and multiple registers for efficient data manipulation
- Hardware stack for nesting of interrupts and writing of reentrant sub-routines.
- 16-bit word length for accurate D/A conversion and mathematical manipulation
- Standard power fail and restart features

AFC11/07 ANALOG INPUT SUBSYSTEM

- Accepts signals from full range of standard electronic transducers, 1-5 volts, 4-20ma, 10-50ma
- Multiplexes up to 256 differential analog input signals
- Eight program selectable input ranges
- 13-bit analog to digital conversion
- Scan rate of 200 channels per second
- Flying capacitor multiplexing technique for high noise immunity and over voltage protection
- Signal sources can be either floating or grounded using simple twisted pairs
- Modularly constructed in 8-channel multiplexer modules
- Scan sequence variable through jumper wire selection
- Three signal conditioning modules
  - Direct Voltage Input
  - Scaled Voltage Input
  - Current/Voltage Input
- Screw terminals for easy connection to field equipment

UDC11/07 DIGITAL INPUT/OUTPUT SUBSYSTEM

- Input/output control of relays, solenoids, contacts and limit switches
- Counter input/output functions and analog output
- Modular field expansion of up to 32 functional modules or up to 512 points (depending upon modules selected)
- High speed identification of external interrupts - 5 μsec typical
- Isolation and noise immune differential inputs
- Isolated screw terminal connection area for security of electronic system and easy connection to field sensors
- Standard signal conditioning modules for voltage normalization and distribution of field suppled power
- Functional I/O Modules
  - Contact Sense BW731
  - Contact Interrupt BW733
  - Single Shot Driver BM687
  - Single Shot Relay BM807
  - Flip Flop Driver BM685
  - Latching Relay BM803
  - Flip Flop Relay BM805
  - Multi-function Counter BW734
  - Digital to Analog Converter BA633
- Signal Conditioning Modules
  - Isolated Power BW400
  - Common Power BW402
  - Driver Output BW403
  - D/A Signal Conditioning

RSX-11C SOFTWARE

- Scheduling and control of up to 128 concurrent real-time tasks
- Background operation
- Tasks can be written in FORTRAN
- FORTRAN library subroutines available
- Three software priority levels for scheduling efficiency

ENCLOSURE

- All steel Nema-12 type construction, 54 inches high, 32 inches wide, 30 inches deep (exclusive of additional 7 inch depth for heat exchanger or optional air conditioner)
- Housing designed to protect against
  - seepage of oils
  - flying particles, dust, dirt
  - corrosive atmospheres
- Heat exchanger or optional air conditioner protects system from ambient temperatures to 125°F
- Terminal strips are of gasketed feed-through design, protecting system electronics against ambient conditions.
- All doors neoprene gasketed for oil resistance and use 3 point latches
- Weight of fully implemented system - 1000 lbs.

HEAT EXCHANGER

- Closed circuit system filters, cools, and returns same cabinet air
- Wickless heat pipe construction
- At 1000 watts dissipation, internal temperature will be less than 20°F above external ambient
- No moving refrigeration parts for low vibration and noise
- Long life — in excess of 20,000 hours

AIR CONDITIONER

- Closed circuit system filters, cools, and returns same cabinet air
- Useful to 125°F ambient temperatures
- Temperature control by non-electrical, fluid operated pressure system
- Continuous compressor operation eliminates high current starting transients and extends compressor life
- Split capacitor motors eliminate all motor relays
- All rotating parts are shock mounted for minimum vibration and noise

WHY DIGITAL?
...EXPERIENCE, PRODUCTS, SERVICES

From the automotive production line to dockside loading of ocean-going freighters, Digital Equipment Corporation automation systems dot the globe.

As a supplier of products and systems, Digital offers more computer equipment than any other manufacturer. And with over 15,000 computers installed world-wide, the firm's expertise in designing, building, and applying computer equipment – particularly for the industrial and scientific user – is unsurpassed.

In serving the many industrial markets, the Digital philosophy is to provide the user with a large selection of hardware and software enabling him to adapt it to his own application needs.

For such dedicated applications as machine tool control, warehouse control, or automatic batching in food processing plants, Digital provides a complete line of solid-state noise-immune logic modules (K Series) and programmable solid-state controllers (PDP-14). For more complex operations such as power plant monitoring, chemical and petroleum refining, Digital's small (PDP-8) and medium scale (PDP-11) computer systems are offered, complete with standard analog and digital subsystems, displays, consoles, and operator interface equipment. To complete the product spectrum, DECsystem-10 provides timesharing, real-time, and remote station capability in a large-scale computing system.

Digital also provides industrially oriented software... real-time executive systems that allow the user to program tasks in popular FORTRAN or to use a high level language designed specifically to simplify industrial system development.

Both hardware and software are designed in modules for cost effectiveness, simplicity of system configuration, and ease of servicing. Modularity allows the user to build a small system, automating a portion of his operation, and expand modularly when technology and his budget allow. Through a program of gradual implementation, a user can achieve a fully integrated control hierarchy, tieing individual satellite controllers to large control or management information systems.

Digital is far from just a supplier of products. The development of customer services has paralleled the development of hardware and software.

Customer requirements for maintenance, software, and sales support are available through a world-wide network of over 100 sales and service centers. The service engineering staff alone comprises over 1000 engineers.

Maintenance contracts are extremely flexible, providing up to 24-hour round-the-clock service or on-site engineers during critical shifts. Startup and application programming assistance are also available through software specialists in world-wide regional field offices.

For training, customer personnel can attend regularly scheduled programming and maintenance courses at the Digital Training Centers, or courses can be arranged on-site at customer facilities. Formal training plus excellent documentation provide the operational assistance required for every successful industrial control system.

System checkout is another important Digital service. Before equipment is shipped from a Digital manufacturing plant, it is subjected to rigorous acceptance testing. These tests assure that the system performs to rigid operating specifications before it is shipped, thus reducing both the time and cost of installation and system startup.

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