



# REAL TIME EXECUTIVE

## HP 2300E

software bulletin 1/73

The HP 2300E RTE is a modular, disc-based, real-time operating system capable of handling multiple user tasks in a multiprogramming and hardware-protected environment. It provides on-line editing and compilation or assembly of user's programs simultaneously with real-time operations. Program processing software included with the system works with programs written in FORTRAN IV, FORTRAN II, ALGOL, or HP Assembly language. The HP 2300E is a fully-debugged, fully-supported software package that is user proven in years of operation in many highly-successful installations. An optional File Manager (option Y01) is available to facilitate handling of the programs and data accumulated during the course of system operations over the years. This optional module is covered in a separate software bulletin (HP Literature Request Number 5952-1641).

The HP 2300E is typically used for . . .

. . . Data Acquisition . . . Stimulus-Response and Sensor-Based Industrial Testing . . . Process Monitoring and Automation . . . Experiment Control and Data Processing . . . Coordination of Distributed Systems.

The HP 2300E Real Time Executive works with a wide range of instruments and peripherals, including high-resolution and high-speed analog-to-digital subsystems, digital input/output interfaces, data communication interfaces, displays, plotters, line printers, magnetic tape units, tape punches, and card readers.

### FEATURES

- \* Multiprogramming
  - Core and disc-resident programs
  - Unlimited numbers of tasks
  - Flexible Priority Structure
  - Re-entrant library routines
- \* Multi-Language Support
  - FORTRAN IV with ISA Real Time Extensions
  - FORTRAN II
  - ALGOL
  - Assembly language
- \* Human Engineering
  - Comprehensive operator commands
  - Rapid system generation and modification
  - On-line task installation and removal
- \* System Protection
  - System hardware protection
  - Automatic power fail and recovery
  - Dynamic protection of both core and disc memory
- \* I/O Management
  - Device independence
  - On-line device reassignment
  - Output buffering for slow devices
  - Automatic queuing of I/O requests
  - Time-out check of I/O operations
- \* File Management (Option Y01)
  - Organizes programs and data in named files
  - Provides any desired level of file integrity and file security
  - Facilitates program development
- \* Hierarchical Systems
  - Works with HP distributed systems software

## PROGRAM SCHEDULING AND EXECUTION

### Scheduled List

A scheduled list contains all programs in order of priority that are ready for execution. Programs are placed in this list when it is time for them to run, when requested by another program or by an operator, or as the system's response to an external event. The RTE Scheduler recognizes priority levels from 1 through 99, providing very fine discrimination among the relative urgencies of programs in the multiprogramming environment. More than one program may use any given priority level. The only limitation on the number of programs in the system is disc memory availability and requirements for system throughput.

### Time Scheduling

Current time is updated every ten milliseconds. Whenever this occurs, a list of the time-scheduled programs is checked and those programs scheduled to execute are placed in the scheduled list. Thus, programs can be initiated on resolutions of hours, minutes, seconds, or even tens of milliseconds.

### Program Execution and Swapping

Execution is initiated immediately for the highest priority program if it is in core memory. Real-time, core-resident programs are normally given highest priority. If the program is on disc and is to be executed in the real-time disc-resident area of memory, and an uncompleted program already occupies that space, the uncompleted program is transferred out to the disc. It is saved in its uncompleted and modified state and the new program is transferred into core. This swapping feature grants processing time to higher-priority disc resident real-time programs without waiting for the completion of the current program.

## INTERRUPT PROCESSING

The HP 2300E uses the multi-priority level interrupt system of the HP 2100A Computer for power fail detection, memory protect violation, and time base generator inputs, as well as for peripheral I/O and user-interfaced equipment. When one or more interrupts occur simultaneously, the interrupt with the highest priority is recognized first, but the computer's hardware interrupt system also remembers the other interrupts. None can be lost.

Since all responses to interrupts require some house-keeping, such as saving registers, program control is transferred to a Central Interrupt Control (CIC) routine (except for power fail and privileged interrupts). After completing the housekeeping chores, the CIC routine decides what action is to be taken. It will initiate routines to handle memory protect violations, time keeping, I/O operations, and requests for program execution.

### PRIVILEGED INTERRUPT

The Executive offers a special feature, known as privileged interrupt, which is based on the hardware priority structure of the computer. Privileged interrupts bypass the normal interrupt processing of the system to achieve the fastest re-

sponse. This feature meets the needs of interrupts having the greatest urgency. (A special privileged interrupt control card, HP 12620A, is required to implement this feature.)

## INPUT/OUTPUT PROCESSING

An I/O Scheduling and Control Monitor (IOC) coordinates the I/O transfers of all standard devices in the system. It provides for referencing I/O devices by a logical unit number rather than the actual physical channel. This saves you time and money when you change the hardware configuration of your system because it minimizes change to your programs. IOC provides for stacking of I/O requests by priority of the calling program and allows for automatic memory buffering of output directed to low or medium speed devices. The slowing effect of peripheral devices is largely circumvented, speeding the processing and output of finished results.

All I/O operations are performed concurrently with program computation in the overall system. One I/O driver is used for each group of like devices. Each device has a table associated with it to store the variable information required.

When a request is made for action by a busy device, the request is placed in a waiting list according to the priority of the requesting program. This keeps each device optimally utilized.

At the user's option, operation of any or all I/O devices may be timed out. This provides a valuable check on operation. An I/O device that has not completed a directed action within the timeout period is put on 'down' status by the system and a 'timed-out' message on the teleprinter or keyboard-display terminal notifies the operator.

## MEMORY PROTECTION

Dynamic memory protection is provided for both core and disc memory. The core memory protect uses a hardware fence register in the HP 2100A Computer. The fence position in memory is set by the system. The protected memory area is the area with addresses below (less than) the address in the fence register.

The memory protect fence is dynamically changed by the Executive to the locations A, B, and C, as shown on the core allocation diagram (facing page). The Executive also protects the system from errors in user's programs that could circumvent hardware protection of memory. A program being executed in the background area of core is isolated from other areas of core so that real-time user programs and the Executive are not altered because of an error in a background program.

Disc memory tracks are dynamically assigned to user's programs upon request and are protected from being overwritten by other programs until released by the requesting program. For flexibility, the software also permits specified tracks to be made accessible, without restrictions, to many programs, through global track assignments.

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*Core Allocations in a  
Configured Real-Time System*

Protected Basic Binary Loader	Addresses: (32K)77777 (24K)57777 (16K)37777
General Purpose "Background" Disc-Resident Area	Memory Protect Fence Positions
Background Resident Area	
Background Common	
System Available Memory For Buffering and Re-Entrant Processing	
Real-Time Disc-Resident Area	C
Real-Time Resident Area	B
Real-Time Common	
Resident Library Re-Entrant and Privileged	
R/T Executive - Interrupt and I/O Control - Scheduling - Operator Communication - Allocation and Control - I/O Drivers	A
System Communication Area	2000
Base Page Linkage Area	

## SYSTEM COMMUNICATIONS

User programs contact the Real Time Executive by system requests. These are made in the form of an assembly language subroutine call or a standard FORTRAN or ALGOL statement, to perform any of the following functions:

1. Read from any input device or disc.
2. Write to any output device or disc.
3. Control functions on devices such as magnetic tape unit.
4. Check the status of an I/O device.
5. Schedule programs to be run.
6. Turn off running program when it is completed.
7. Request the current time and day of the year.
8. Request change in time scheduling of programs.
9. Request disc track allocations.
10. Make 'global' tracks available to all programs.
11. Release disc tracks.

## PROGRAM PROCESSING

In addition to Real Time operations, the HP 2300E provides for compilation, assembly, and editing of programs on-line, in the background. The program processing software works with programs written in FORTRAN II, FORTRAN IV, HP Assembly language, and ALGOL (in systems with at least 24K of core). The availability of program processing while the system is on-line, in Real Time, makes it possible to get your system up and running on its most crucial assignments, then to add to and refine its capabilities without interrupting its current operations.

## OPERATOR COMMUNICATIONS

The HP 2300E provides for monitoring and control of Real Time operations via the system teleprinter or keyboard-display unit. The operator may:

1. Start or terminate any user program.
2. Change priority and timing of any non-scheduled user program.
3. Initialize time.
4. Suspend any user program which is executing or scheduled.
5. Return any user program to active status.
6. Request current status of any user program.
7. Specify timeout of any I/O device.
8. Request loading and execution of background programs (Assembler, FORTRAN II/IV or ALGOL Compilers, etc.).
9. Load relocatable programs and subroutines into the Real-Time (foreground) disc-resident area and into the background area.
10. Alter I/O logical unit assignments.
11. Control I/O device availability.
12. Release program tracks.

## HARDWARE REQUIREMENTS

The HP 2300E Real Time Executive requires the following Hewlett-Packard hardware (not included) for operation:

1. HP 2100A-016 Computer (minimum 16K memory required).
2. Direct Memory Access (HP 12895A).
3. Time Base Generator (HP 12539B).
4. High Speed Punched Tape Reader (HP 2748A) interfaced to the computer.
5. Cartridge Disc Drive Subsystem (HP 12960A or HP 12961A).
6. Teleprinter (HP 2752A or HP 2754B) interfaced to the computer.

## SYSTEM GENERATION

User's real-time programs, background programs, and Real Time Executive modules are incorporated into a configured Real Time system by the Real-Time Generator (RTGEN). Because Hewlett-Packard Real Time software is modular and of a general nature, the user easily configures his particular programs and I/O device drivers into a Real-Time system tailored to his specific needs. The RTGEN converts relocatable software modules and user programs into a Configured Real Time System in absolute binary format. The remaining disc storage is dynamically allocated by the

configured system to user programs or is utilized by the scheduler for swapping operations.

## CORE MEMORY REQUIREMENTS

1. Real Time Executive: 6.8K words.
2. Drivers used in minimum system: 1.2K words.
3. Program Processing Software (compilers, assembler, etc.): 5K words of background, except for ALGOL, which requires 8K words.

## HP 2300E REAL TIME EXECUTIVE SUMMARY

The HP 2300E includes:

\*One week of training in RTE system configuration, operation, and programming, which includes a student's manual and all other course materials.

\*One day of system analyst's assistance with installation of the HP 2300E Real Time Executive.

\*The following software and documentation:

	TAPE NUMBER	MANUAL/LISTING NUMBER
RTE Software System, Programming and Operating Manual		02005-90001-1
Real-Time Disc Driver Routine (DVR 31)	29013-60001	29013-90001-1
Moving-Head RTE Generator (MH-RTGEN)	29014-60001	29014-90001-1
Real Time Executive (RTE EXEC)	29016-60001	29016-90001-1
Real Time Scheduler (RTE SCHED)	29016-60002	29016-90002-1
Real Time Input/Output Control (RTIOC)	29016-60003	29016-90003-1
Real-Time Multiple-Device System Control Driver Routine (DVR 00)	29029-60001	29029-91001-1
Relocatable Loader	29022-60001	29022-90001
Real Time Assembler, main control, segment D, and segments 1 through 5	20874-60001 through -60007	
Real Time FORTRAN II Compiler	20875-60001 through -60005	
Real Time FORTRAN IV Compiler (usable in 16K or larger system)	24170-60001 through -60003	
Alternate Real Time FORTRAN IV Compiler (usable only in 32K system; supplied on request in place of 24170-60001 through 60003 Compiler)	24177-60001 and -60002	
Real Time ALGOL Compiler (usable only in 24K or 32K system)	24129-60001 and -60002	
Real Time Relocatable Library-EAU	24151-60001	
Real Time FORTRAN IV Library	24152-60001	
Real Time FORTRAN/ALGOL Formatter	24153-60001	
Real Time Editor	20805-60001	
System Dump	20802-60001	

## ORDERING INFORMATION

The HP 2300E Real Time Executive may be ordered through your local Hewlett-Packard Field Sales Office. Your HP System Sales Engineer or Data Systems Sales Engineer will provide information on price, delivery, and the terms and conditions under which the HP 2300E Real Time Executive is supplied. He will also arrange for scheduling of the RTE training and system analyst time which is included with the HP 2300E.



For more information, call your local HP Sales Office or East (210) 265-5000 • Midwest (312) 677-0400 • South (404) 436-6181 • West (213) 877-1281. Or write: Hewlett-Packard, 1501 Page Mill Road, Palo Alto, CA 94304. In Canada: 275 Hymus Blvd., Point Claire, Quebec. In Europe: Hewlett-Packard, P.O. Box 85, CH-1217 Meyrin 2, Geneva, Switzerland. In Japan: Yokogawa-Hewlett-Packard, 1-59-1, Yoyogi, Shibuya-ku, Tokyo, 151.