

# FPS-164 Scientific Computer

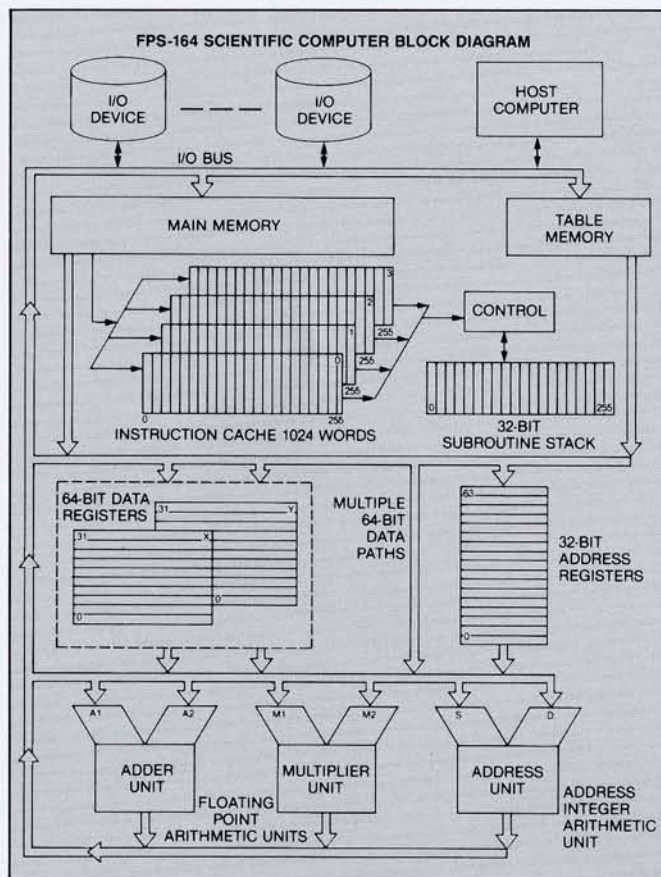
Floating Point Systems

Specifications



# General Description

The FPS-164 is designed for low-cost processing of large-scale scientific and engineering applications. This Scientific Computer provides a powerful combination of very high-speed 64-bit computation and large memory. With the host computer maintaining overall control, computationally-intensive jobs are offloaded to the FPS-164, which executes them while the host computer is performing other operations. The FPS-164 is programmed using an optimizing FORTRAN-77 Compiler. Additional performance may be obtained by the use of an extensive library of FORTRAN-callable matrix, simulation and mathematical subroutines.



## Benefits

Easy to use

High-speed

Concurrent operations

Fast floating-point operation

Accurate computations

Large memory space

Dependability

Availability

Outstanding price-performance

Support

## Features

All software necessary for effective program development including FORTRAN-77 Compiler, Overlay Linker, and System Job Executive (SJE), for complete job processing.

Eight independent pipelined functional units interconnected with seven dedicated data paths.

64-bit instruction word can initiate a new operation in each of the functional units in every instruction cycle.

Concurrent pipelined 64-bit add and multiply.

64-bit data word provides 15 decimal digit accuracy.

24-bit address space for 16-million word addressing.

Error-correcting memory, arithmetic exception interrupts, internal diagnostic buses, and an integral diagnostic microprocessor with mini Winchester disk.

Built-in error-logging, backed up by experts at Remote Diagnostic Centers.

Mainframe performance with a price in the "supermini" range.

Backed by a worldwide company —dedicated to providing cost-effective scientific computers.



# Hardware Specifications

## Data Formats

- Single-word floating-point format: 53-bit 2's complement mantissa and 11-bit binary exponent. Dynamic range:  $2.8 \times 10^{-309}$  to  $9.0 \times 10^{307}$ . Accuracy: one part in  $2^{51}$ , or 15.3 decimal digits. Rounding: unbiased rounding to 53 bits.
- Integer formats: 32-bit and 53-bit 2's complement integers.
- Logical format: 64-bits.

Processor has instructions which assist software implementation of the following:

- Double-word floating-point format: two 11-bit exponents and two 53-bit mantissas. Dynamic range: approximately  $2.8 \times 10^{-309}$  to  $9.0 \times 10^{307}$ . Accuracy: approximately 30 decimal digits.
- Halfword floating-point format: 8-bit binary exponent and 24-bit 2's complement mantissa. Dynamic range:  $1.5 \times 10^{-39}$  to  $3.4 \times 10^{38}$ . Accuracy: one part in  $2^{22}$ , or 6.6 decimal digits.
- Character format: eight ASCII characters per word.

## Computational Units

These are capable of up to 12-million data computations, and 6-million address computations per second.

- Adder Unit: 2-stage pipeline; one result per cycle, two cycles for completion. Performs 64-bit wide floating-point adds, 53-bit integer adds, logical operations, and shifts.
- Multiplier Unit: 3-stage pipeline; one result per cycle, three cycles for completion. Performs 64-bit wide floating-point and 53-bit wide integer multiplies.
- Address/Integer Unit: one operation per cycle. Performs 32-bit wide integer adds and logical operations.

## Registers

The registers receive and deliver data to and from the functional elements.

- Data Registers: 64 locations x 64-bits. Two reads and two writes per cycle.
- Address Registers: 64 locations x 32-bits. Two reads and one write per cycle.
- Subroutine Stack: 256 locations x 32-bits. One read or write per cycle.

## Memory Units

These concurrently deliver data, program, and constants to the register and computational units.

- Main Data Memory: 64-bit words plus 8-bit ECC. Expandable to 7.25M words. 3-stage pipeline; one access per cycle.
- Instruction Cache: 64-bit words plus parity. Four independent 256-word regions are automatically filled from Main Data Memory. Also includes a 1K-word ROM which contains operating system and utility primitives. One read to the execution unit, and one load from Main Data Memory per cycle.
- Table Memory: 64-bit words plus parity. 5.5K ROM for constant tables. RAM expandable to 32K words. 2-stage pipeline; one access per cycle.

## Functional Unit Interconnection

Seven dedicated buses provide non-conflicting data transfers between the functional units.

- Two buses for Adder Unit input arguments and one for Adder output results.
- Two buses for Multiplier Unit input arguments, and one for Multiplier output results.
- One bus for register/register and register/memory transfers.

## Multi-operation Instruction Word

The 64-bit instruction word allows simultaneous initiation of a new operation in each functional unit in each cycle.

- An Adder, a Multiplier, and an Address/Integer unit computation.
- Four Data Register accesses and three Address Register accesses.
- A Main Data Memory and a Table Memory access.
- A conditional branch.

## Real-time/Multi-user Features

- Vectored priority interrupts—typical case I/O interrupt latency of 20  $\mu$ sec.
- Privileged instructions—protect system resources from users.
- Memory Base and Limit relocation registers—separate one user's memory space from another.
- Programmable real-time clock—provides adjustable time-out interrupts.
- CPU cycle counter—measures CPU execution.



## Diagnostic/Reliability Features

- Main Data Memory single-error correction, double-error detection (SECEDED).
- Table Memory and Cache parity-error detection.
- Diagnostic Microprocessor System (DMP). This has a diagnostic bus connection to all major system elements. It performs three levels of fault isolation: (1) functional unit faults, (2) board level faults, and (3) DMP and mini Winchester disk faults. The diagnostics can be executed from a CRT connected to the DMP, or remotely via a modem and remote CRT.
- Confidence Tests. These verify correct operation of the FPS-164 hardware/software components by executing FPS-164 subroutines from a normal host job.

Additional reliability is built in through the manufacturing process. Chips are subjected to pre-conditioning and test before assembly. At the system level, comprehensive burn-in and testing contribute to additional reliability.

## Input/Output Features

- I/O Bus: up to 6-million words/second (48 megabytes/second) maximum bandwidth. Supports one host interface plus up to six optional I/O device controllers.
- Host Interface: connects to the host computer channel or I/O bus. A Host Interface Support Processor (HISP) imbedded in the interface allows transfer of multiple blocks of mixed format programs and data into Main Data Memory in a single transfer from the host. Format conversion hardware does "on-the-fly" conversion between host and FPS-164 floating-point and integer binary data formats.

## Configuration Options

- Main Data Memory: 256K words standard to 7.25M words maximum.
- Table Memory: 16K or 32K words of RAM.
- D64 Disk Subsystem: minimum configuration per subsystem; one disk drive with secondary mass storage capability of 135 Megabytes, expandable in increments of one disk drive up to four, for 540 Megabytes total. Up to six Disk Subsystems may attach to the FPS-164, providing an overall total of more than 3,000 Megabytes of disk storage.

### Host Interfaces

- Digital Equipment Corp. VAX-11/780®, VAX-11/750® and VAX-11/730® series under VMS (UNIBUS\* Channel).
- IBM 370/303x/308x/4341 series under MVS or VM/CMS (Block Multiplexor Channel).
- Sperry 1100/60, 1100/70, 1100/80 series under OS 1100 (Word Channel).
- Apollo DOMAIN network under AEGIS (DSP-80).

## Environmental

### Electrical:

Voltage	180 to 264VRMS
Current (max)	75A@180V
Frequency	48-62Hz
Power Factor	0.7 approximately
Meets U.L.	478

### Temperature:

Operating	10 to 35 Degrees C
Storage	-40 to 65 Degrees C

### Humidity:

Relative Humidity	
Range:	10-92% non-condensing

### Physical:

Dimensions	64.5" H x 30" D x 83.5" W (164 x 76 x 212cm)
Weight (max)	1800 lbs. including power supplies (810Kg)

### Heat Dissipation:

(max)	35,000 BTU/hour
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\*VAX 11/780, VAX 11/750, VAX 11/730 and UNIBUS are registered trademarks of Digital Equipment Corporation.



# Software Specifications

To aid the user in developing and executing applications, three categories of software are offered with the FPS-164:

## Operating System Software

This run-time software provides the communications and control path between the host computer and the FPS-164.

The System Job Executive (SJE) supports complete job processing on the FPS-164. Specifically, SJE includes:

- Job Processing and Control.
- Overlay Loading.
- AP FORTRAN I/O.
- Asynchronous I/O Extensions.
- Permanent or Scratch Files on the D64 Disk Subsystem.
- Support for Binary and Text File Transfer between the host and the FPS-164.
- Interactive and/or Batch Support.

SJE host system software accepts commands either from interactive foreground sessions or from background batch job streams. These commands provide the user with the following functions:

- Attaching an FPS-164 for Exclusive Use.
- Copying Files between the Host and FPS-164.
- Executing the Complete Job on the FPS-164.
- Canceling the Job on the FPS-164.
- Detaching an FPS-164.
- Exiting from an SJE Session.

One FPS-D64 Disk Subsystem with two disk drives is required for SJE.

The FPS-164-resident software provides services such as job initialization and termination, memory allocation, overlay support and breakpoints. The resident software also supports the file management operations necessary to create and maintain named files.

The AP Executive (APEX64) is also available for the FPS-164. APEX64 supports the execution of host-called subroutines in the FPS-164. Not all SJE features are available under APEX64.

## Program Development Software

This software is used to create and debug FPS-164 programs. All PDS executes on the host computer.

- The SJE FORTRAN Compiler (APFTN64) generates code that optimizes the use of the FPS-164's parallel pipelined architecture. APFTN64 runs on the host CPU and supports a superset of the FORTRAN-77 language. The superset includes extensions for asynchronous I/O and compatibility with existing compilers. FORTRAN I/O is supported to the local disk, host files, and to the user's host terminal.
- The SJE Overlay Linker (APLINK64) supports the creation of run-time overlays. This feature permits the execution of programs whose memory requirements exceed the available FPS-164 physical memory. During program execution, overlay transfers take place automatically from local disks according to a user-specified overlay structure.
- Assembler (APAL64). Assembles FPS-164 Assembly Language into FPS-164 binary object modules.
- Object Librarian (APLIBR64). Allows creation and maintenance of user object libraries for the FPS-164.
- Interactive Debugger (APDEBUG64). Allows interactive examining/changing of FPS-164 memory and register locations, setting of breakpoints, and execution of programs inside the FPS-164.
- Interactive Simulator (APSIM64). Supports the exact simulation of FPS-164 arithmetic operations.

## Applications Software

### APMATH64 Library

- Basic Math Library. Real and complex vector and matrix operations.
- Advanced Math Library. Integration, Eigenvalue/ Eigenvectors, and equation solver subroutines.
- Utilities Library. Includes Fast Fourier Transform (FFT) subroutines.
- Signal Processing Library. Histogram analysis, window functions, and spectral averaging.
- FORTRAN Support Library.
- Double Precision Library.
- Sparse Matrix Library.
- Data Formatting Library.
- LINPACK BLAS Library.
- Image Processing Library.
- Geophysical Processing Library.
- Simulation Library.

### BCSLIB—Boeing Computer Services Library

### FMSLIB—Fast Matrix Solution Library

Additional application software for FPS-164 is available from third-party vendors. Contact your local FPS representative for further information.



# FPS-D64 Disk Storage



## General Description

Floating Point Systems offers the FPS-D64 Disk Subsystem to support the large data storage applications on the FPS-164 Scientific Computer. Interfaced to the FPS-164 through an intelligent controller, the FPS-D64 Disk Subsystem allows the transfer of data and programs to and from the FPS-164's main data memory.

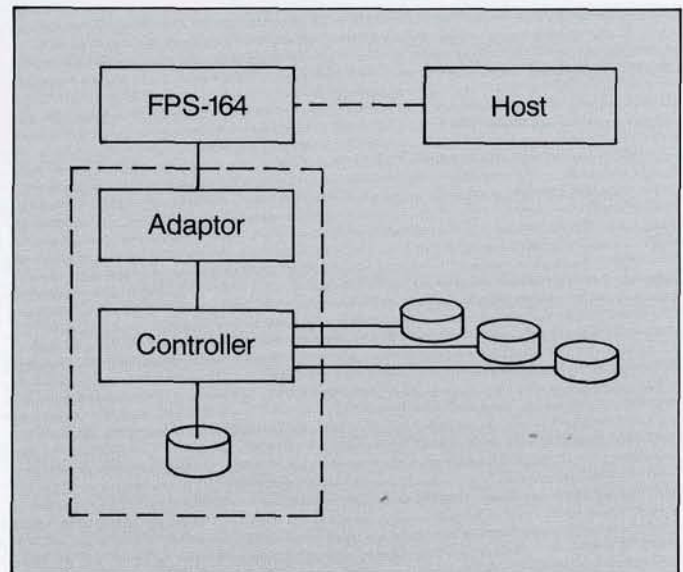
The use of a local disk for direct access to program and data files from the FPS-164 relieves the I/O burden on the host.

## System Design Offers Modular Configuration

The disk drive, disk controller, and disk adapter comprise the three major components of the FPS-D64 Disk Subsystem. While the disk provides the storage media, the disk controller provides control functions compatible with the disk drive. The disk adapter interfaces to the FPS-164 CPU I/O bus, and provides overall control of disk operations. The minimum FPS-D64 Disk Subsystem configuration consists of one disk drive, one disk controller, and one disk adapter, providing secondary mass storage capability of 135 megabytes of data. Optionally, one, two, or three additional drives may be added to increase capacity to 270, 405 or 540 megabytes respectively.

## Providing the User with Multiple Subsystems

The FPS-D64 Disk Subsystem is designed to allow installation of multiple disk subsystems on a single FPS-164. The maximum number allowed is six, giving the user up to 24 disk drives, and more than 3000 megabytes of disk storage.



## Software

Software access to the FPS-D64 Disk Subsystem is performed by the File Management System (FMS). FMS is a software component of the SJE and APEX operating systems.

FMS performs two primary services in support of FORTRAN-77 I/O operations to the D64 Disk. First, it allocates disk space and catalogs files. Through this service the user is able to maintain and manage file allocation and extension, file attributes, and file access rights over both scratch and permanent files.

Second, FMS performs I/O operations on open files. FMS supports the full set of standard FORTRAN-77 I/O operations plus the Department of Energy (DOE) extensions for asynchronous I/O. Where possible, FMS performs optimized disk head movement, overlapped seek operations and concurrent data transfers in order to maximize I/O performance. Additional features of FMS are:

- Two level file directory
- Access keys allowing read only or read/write capabilities
- Spanned files over multiple disks
- Optional user control of file placement and attributes
- Concurrent I/O and FPS-164 execution
- Error detection and management functions

## Proven Technology – Reliable – Maintainable

Incorporating the use of Winchester Technology and combined with the FPS-164 Diagnostic Micro Processor (DMP), the FPS-D64 offers high reliability and maintainability. Error Correction Code (ECC) provides automatic hardware detection and correction of all recoverable errors and automatic retry of all other most commonly occurring faults. Diagnostic action facilitates error correction. All errors are reported to the DMP and logged to an external I/O error device.

## Hardware Performance Specifications FPS-D64\*

Maximum Transfer Rate (Byte) . . . . .	1.2MHz
Rotational Speed . . . . .	3600 rpm
Average Latency . . . . .	8.33 msec
Average Seek Time . . . . .	30 msec
Cylinders Per Drive . . . . .	823
Tracks Per Cylinder . . . . .	10
Recording Density (Innertrack) . . . . .	6220 BPI
Disk Storage Capacity (Formatted) . . . . .	135 Mbytes
Physical Dimensions	
Height . . . . .	66.8 inches
Width . . . . .	24 inches
Length . . . . .	42 inches
Length (Extended) . . . . .	82 inches
Input Power . . . . .	120 VAC @ 60 Hz 220/240 VAC @ 50 Hz





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### Overview

The Single Job Executive (SJE) is a software product which provides complete job processing on the FPS-164 Attached Processor. Capabilities include job management commands, temporary and scratch file management supporting FORTRAN-77 I/O, and run-time overlays. Specifically, SJE includes:

- Complete AP Job Processing
- Overlay Structuring and Loading
- AP FORTRAN I/O
- Asynchronous I/O Extensions
- Temporary Named or Scratch Files on AP Disk
- Support for Binary and Text File Transfer
- Interactive and/or Batch Support
- Upward Compatibility with APEX64

### Software

The SJE FORTRAN Compiler (APFTN64) generates code that optimizes the use of the FPS-164's parallel pipelined architecture. APFTN64 runs on the host CPU and supports a superset of the FORTRAN-77 language. The superset includes extensions for asynchronous I/O and compatibility with existing compilers. FORTRAN I/O is supported to the local AP disk and the user's host terminal.

The SJE Overlay Linker (APLINK64) supports the creation of run-time overlays. This feature permits the execution of programs whose memory requirements exceed the available FPS-164 physical memory. During program execution, overlay transfers take place automatically from local AP disks according to a user-specified overlay structure.

Additional Program Development Software (PDS) support is provided by an Assembler (APAL64), an Object Module Librarian (APLIBR64), and a Symbolic Interactive Debugger (APDEBUG64).

SJE system software accepts commands either from interactive foreground sessions or from background batch job streams. These commands provide the user with the following functions:

- Attaching an FPS-164 for Exclusive Use
- Copying Files between the Host and the FPS-164
- Executing the Complete Job in the FPS-164
- Canceling the Job on the FPS-164
- Detaching an FPS-164
- Exiting from an SJE Session

### SJE Job Flow

Using SJE is straightforward—the steps are:

1. Prepare source FORTRAN code using the host system EDITOR.
2. Optionally include references to the FPS Math Library for additional performance improvement.
3. Compile the source using the FPS FORTRAN-77 compiler (APFTN64) on the host computer.
4. Link the compiled code using the host-resident link editor (APLINK64) to produce a load module. At this stage all external references to FORTRAN functions and the FPS Math Library are resolved.
5. Run the job. During execution the user may interact with the job as if it were running on the host.
6. Transfer the results of the job back to the host for output or analysis.

Using this approach, the host computer performs processing for which it is best suited, while the AP processes computationally intensive jobs in parallel with the host.

The FPS-164 resident software provides services such as job initialization and termination, memory allocation, overlay support and breakpoints. The resident software also supports the file management operations necessary to create and maintain named files for the duration of a job.

Supporting the execution of user software are the following subroutine libraries: FORTRAN-77 Run-time I/O Library, the System Subroutine Library and the Math Library (APMATH64). APMATH64 contains over 250 highly optimized routines.

Installation of SJE is performed by a Floating Point Systems Customer Service Representative. Comprehensive support for SJE is available under an FPS Software Maintenance Agreement.

### Hardware

Minimum required hardware for the Single Job Executive System includes the host mainframe CPU, the FPS-164 Attached Processor with 128K words of memory (164-002-00) and the FPS-D64 Disk Subsystem with two drives (D64-002-10).





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