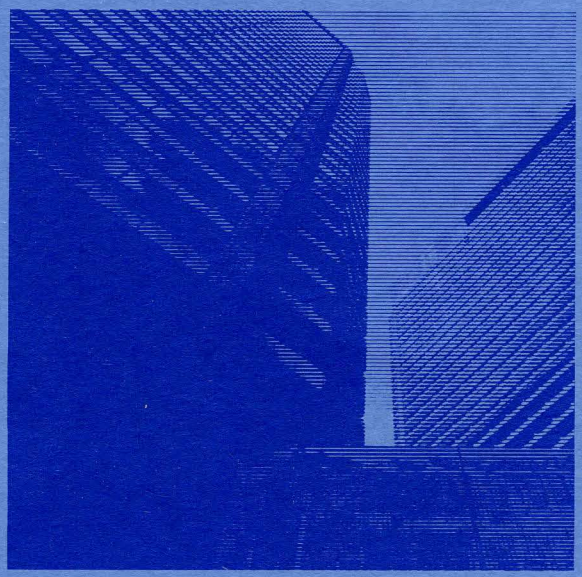
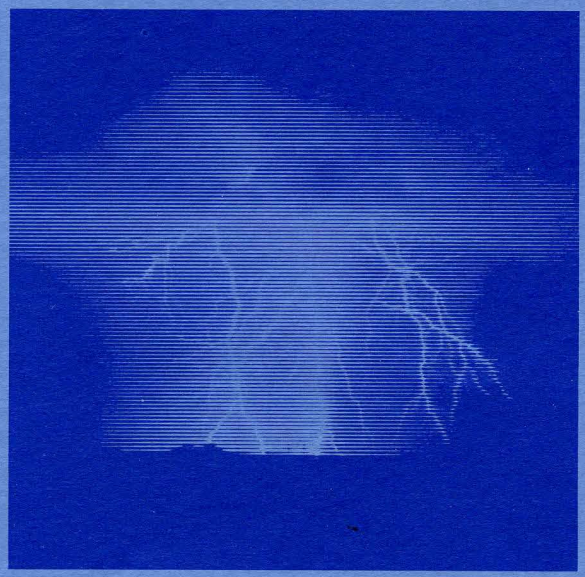
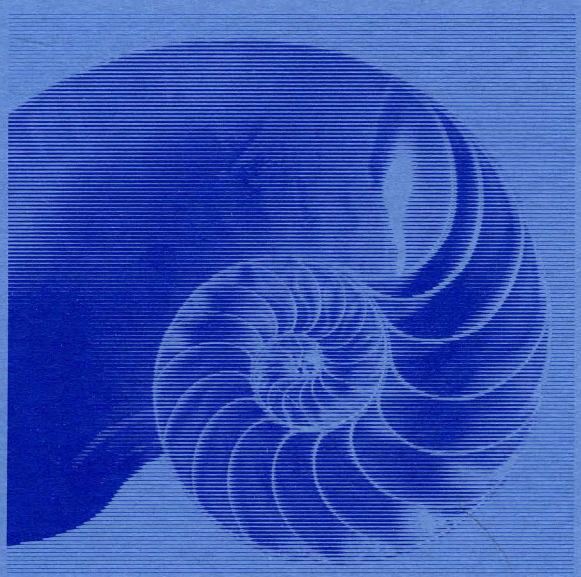
SPERRY

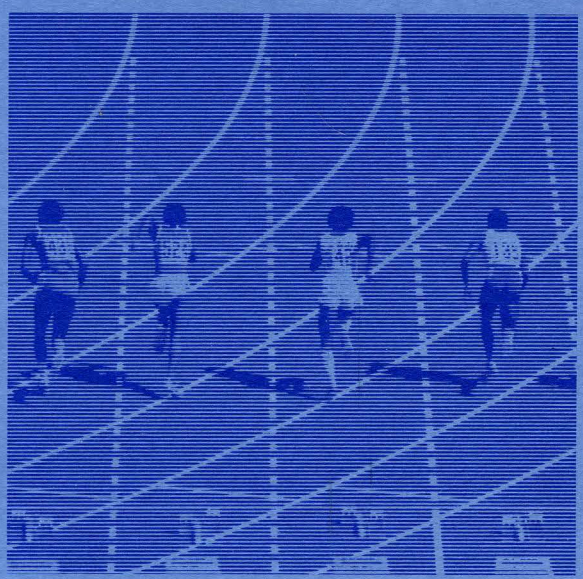
Integrated Scientific Processor System

Facts and Figures









SPERRY

Introducing the SPERRY Integrated Scientific Processor System

When computing power was first applied to scientific problems, Sperry was there with the 1108 system—the first in a long line of high performance scientific processors dedicated to helping solve the most complex mathematical and analytical problems. That tradition extends to the general purpose SPERRY 1100/90 System, the most powerful member of the Series 1100 family.

Sperry now expands the power and functionality of the 1100/90 a generation ahead with the SPERRY Integrated Scientific Processor (ISP) System—a supercomputer class mainframe. The Integrated Scientific Processor System offers you supercomputer performance without sacrificing the mainframe program development and support environment. No longer will you have to operate in the supercomputer software development vacuum without sophisticated data base management systems or interactive screen editors, for example—or incur high maintenance expenses due to exotic architectures and the interaction of several groups of support personnel.

By joining user-oriented commercial software with a high performance processor new processing challenges to the scientific community can be met without a dedicated array processor or back-end processor. You can develop, test, run production, and view the graphic output of scientific applications using one superior machine, with one common set of hardware and peripherals, one common operating system, and one common data format.

The Integrated Scientific Processor System consists of an Integrated Scientific Processor, high performance memory contained in the Scientific Processor Storage Unit, an Instruction Processor Cooling Unit, and (optionally) a Multiple Unit Adapter. These elements, together with the 1100/90 Instruction Processor(s) and Input/Output Processor(s), combine to give you the performance of a Class VI supercomputer.

Uninterrupted growth is a characteristic of all Series 1100 systems; the ISP System can be expanded by adding additional 1100/90 Central Processing Units (up to four), Input/Output Processors (up to four), memory (up to 16 million words), and a second scientific processor. These components can be combined in any fashion, as your needs dictate.

Integrated Scientific Processor Highlights:

- Mainframe environment with supercomputer power
- Integrated directly into the SPERRY 1100/90
- 1100/90 data compatible
- 100 percent through checking
- Dual ISP configuration
- 1100/90 Extended Address Mode
- Dynamic reconfigurability
- Vector register architecture
- Instruction buffer
- Internal local storage cache
- Scalar vector instruction overlap
- Asynchronous functional units
- Pipelined architecture
- Loop instructions
- Vector mask
- Storage indexing
- History File
- High-speed memory
- SECDED
- Memory and CPU computational balance
- Multitasking capabilities
- 1100/90 Operating system (OS 1100)
- Vectorizing FORTRAN preprocessor
- UCS FORTRAN compiler

Inside the System

System Configuration

The following hardware components are added to an 1100/90 System to form an Integrated Scientific Processing System:

- Integrated Scientific Processor (one or two)
  The Integrated Scientifc Processor performs high-speed vector and scalar calculations. The processor uses new architecture, a pipelined machine organization, and instructions that increase performance for both vector operations and scalar operations embedded in the vectorized code. These enhancements increase throughput performance for scientific vector FORTRAN programs from six to nine times that of an 1100/90 Instruction Processor.

  You can incorporate one or two Integrated Scientific Processors within an 1100/90 System, resulting in configurations ranging from a 1X1X1 (one 1100/90 Instruction Processor, one 1100/90 Input/Output Processor, and one Scientific Processor) to a 4X4X2 system.

- Scientific Processor Storage Unit (one to four)
  The Scientific Processor Storage Unit can replace or complement standard 1100/90 Main Storage Units. The Scientific Processor Storage provides the higher bandwidth required to support the Integrated Scientific Processor's high speed. The storage units functional identically when executing Series 1100 code. However, Integrated Scientific Processors can only access code or data loaded into the Scientific Processor Storage Units. This allocation is transparent to the applications programmer, and is totally managed by the 1100 Executive.

  One Scientific Processor Storage Unit contains 4,193,304 words of storage. Up to a maximum of 16,777,216 words of storage is available when the maximum four storage units are attached. This storage is directly addressable by the Integrated Scientific Processor and the 1100/90 Instruction and Input/Output Processors.

- Multiple Unit Adapter (zero, one or two)
  The Multiple Unit Adapter allows the scientific processor to address more than one Scientific Processor Storage Unit. It is required when two or more storage units are used in a system. It is optional when one storage unit is used.

  One Multiple Unit Adapter can be used with each Integrated Scientific Processor and one to four Integrated Scientific Processor Storage Units.

- Instruction Processor Cooling Unit
  Instruction Processor Cooling Units provide water cooling for both the 1100/90 Instruction Processor(s) and Integrated Scientific Processor(s). One Instruction Processor Cooling Unit is required for each scientific processor installed, in addition to 1100/90 requirements.

Minimum Configuration Highlights

- One Instruction Processor
- One Input/Output Processor
- Two Instruction Processor Cooling Units
- One Integrated Scientific Processor
- One Scientific Processor Storage Unit
- One System Support Processor
- One Console
- One System Clock
- Two Motor Alternators

Expansion

You can expand the minimum configuration by adding one, two, or three additional Instruction Processors; one, two, or three Input/Output Processors; one, two or three Scientific Processor Storage or Main Storage Units for a total of 16 million words; and one or two Multiple Unit Adapters.

One Scientific Processor Storage Unit is required per system. A Multiple Unit Adapter is necessary when using two Scientific Processor Storage Units. Configuring dual scientific processors with Scientific Processor Storage Units requires a second Multiple Unit Adapter.

You can mix Scientific Processor Storage and Main Storage Units within a system. The Integrated Scientific Processor addresses only the scientific processor storage. The Instruction Processor and Input/Output Processor address both types of storage units.

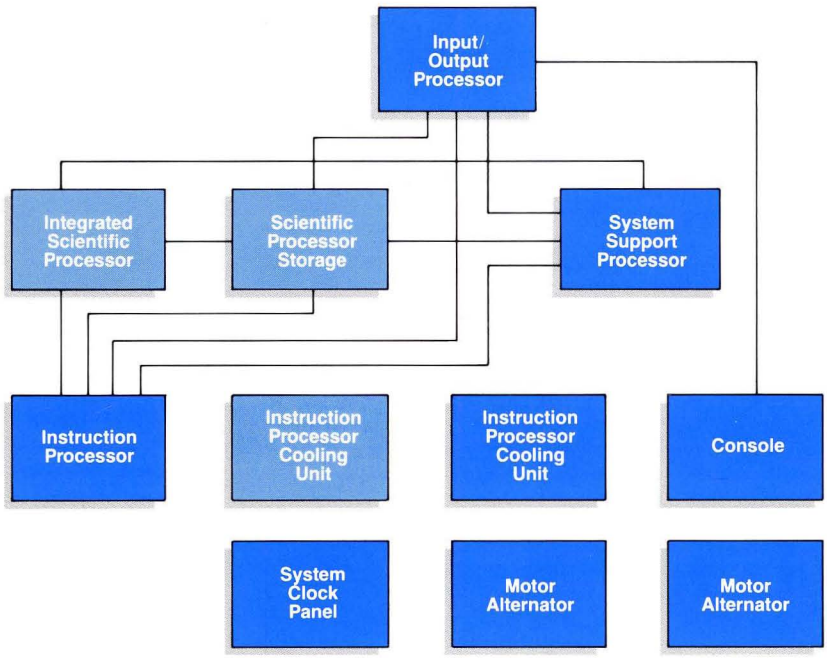


Figure 1. 1100/91 Integrated Scientific Processor System, Minimum Configuration

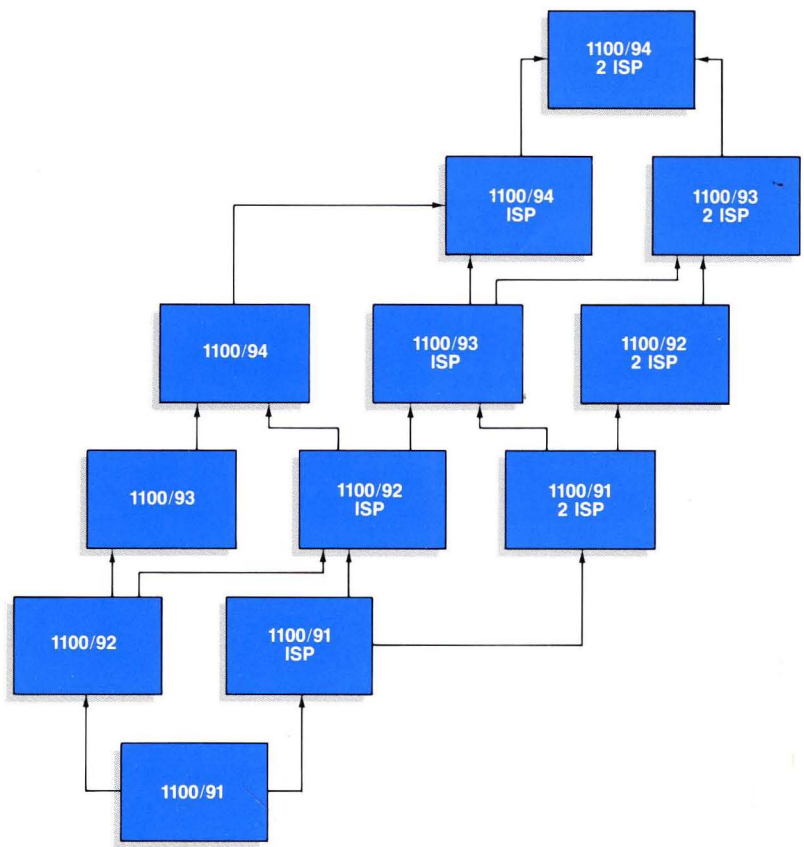
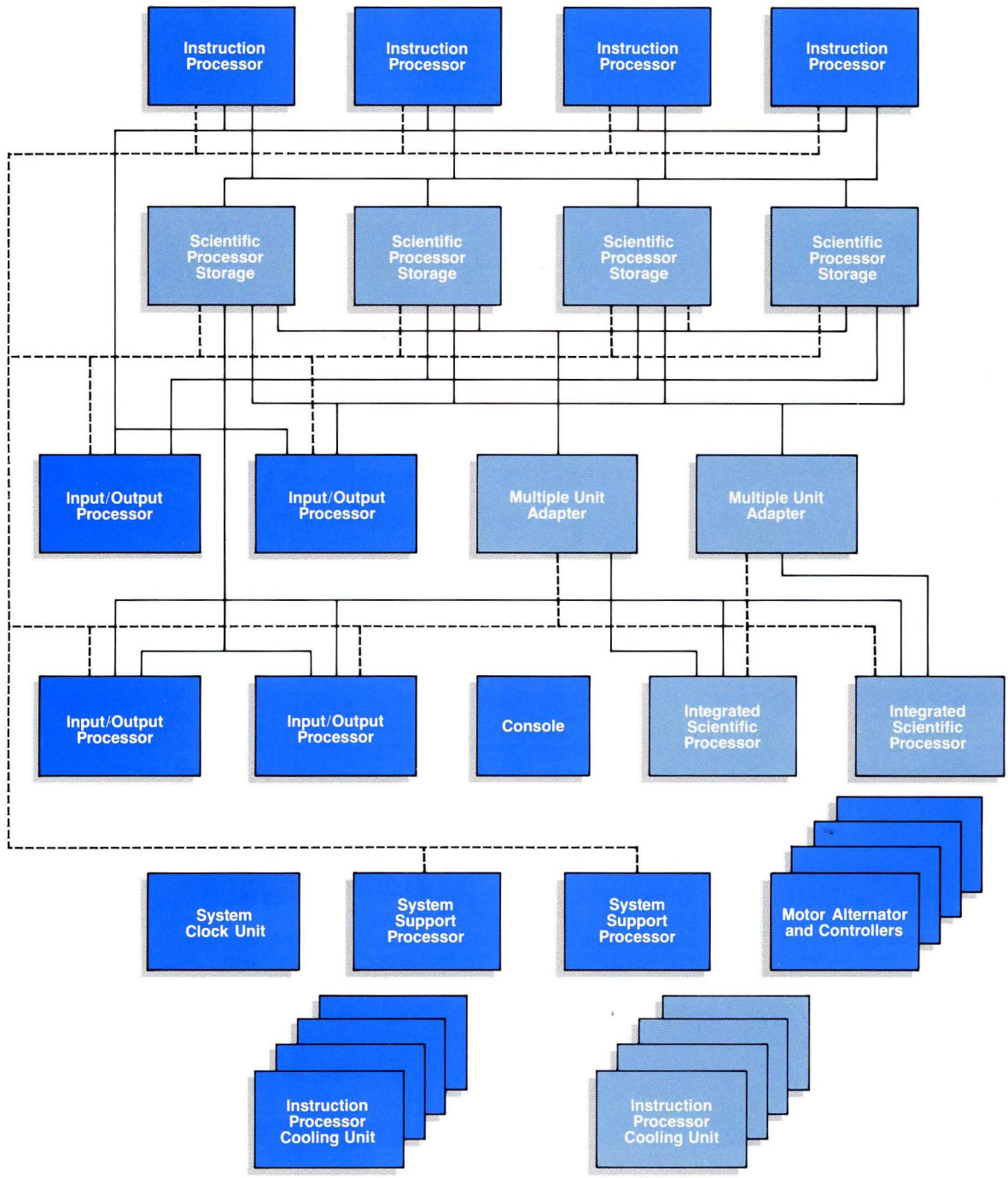


Figure 2. ISP Growth Paths



LEGEND: —— Connections are actually point-to-point, not bussed.
--- System Support Processor interfaces.

Figure 3. 1100/94 Integrated Scientific Processor System, Maximum Configuration

Maximum Configuration Highlights

- Four Instruction Processors
- Four Input/Output Processors
- Two Integrated Scientific Processors
- Four Instruction Processor Cooling Units (four additional units may be configured for redundancy)
- Four Scientific Processor Storage Units
- Two Multiple Unit Adapters
- Two System Support Processors
- One Console
- One System Clock
- Four Motor Alternators (four additional units may be configured for redundancy)

Integrated Scientific Processor

The Integrated Scientific Processor uses parallel processing techniques to perform vector and scalar operations simultaneously at very high speed. The processor includes vector and scalar processing modules, a control unit module, address control, instruction buffer, and local storage (Figure 4). The scientific processor uses special floating-point, vector, and loop control instructions to perform scientific calculations. The instruction set is unique to the ISP.

Data formats are identical to SPERRY Series 1100 data formats. The virtual address format is the same as the 1100/90 System extended mode, consisting of three fields: Level, Bank Descriptor Index, and Offset. However, the mechanism for translating virtual addresses to real addresses is unique to the ISP. Segment protection like that used with the 1100/90 is ensured by the translation mechanism.

The ISP has no privileged mode or privileged instructions. System services are provided by OS 1100 running on the 1100/90 in response to a scientific processor interrupt.

Because the Integrated Scientific Processor is tightly coupled to the 1100/90 System, it uses addressing methods consistent with the 1100/90 Instruction Processor.

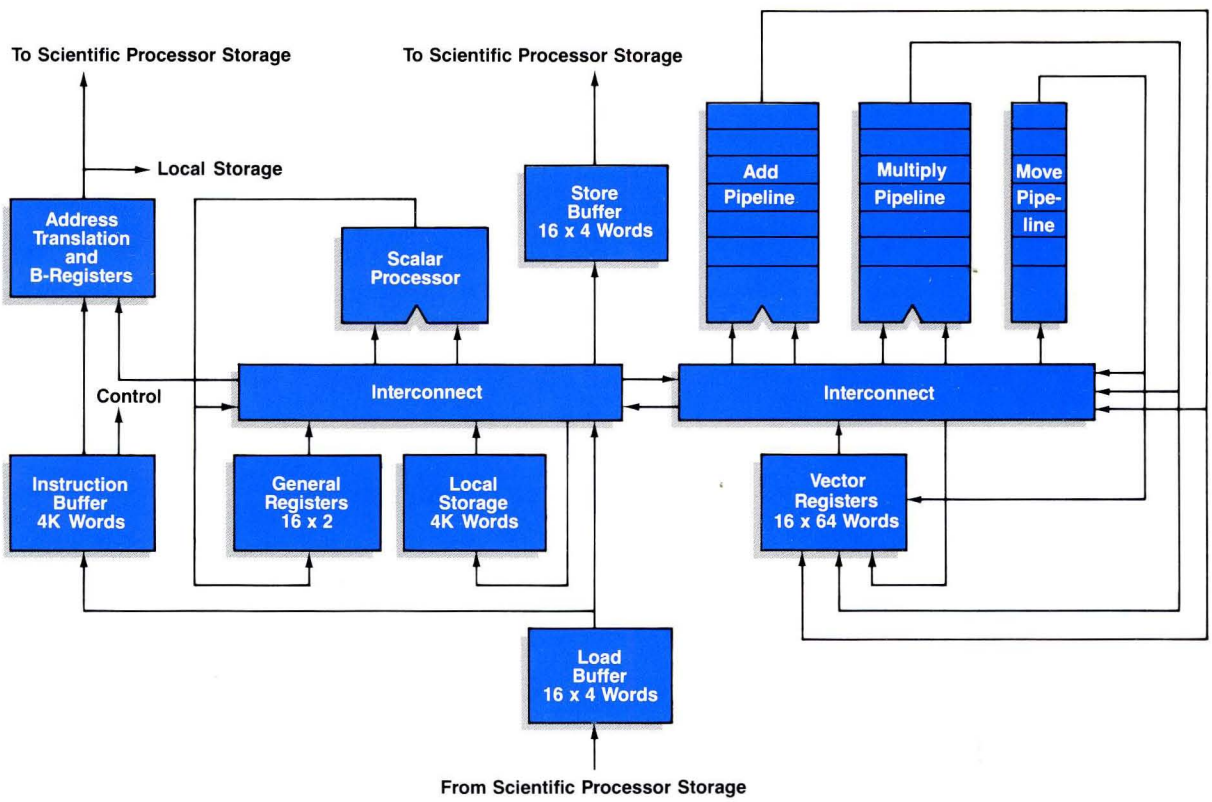


Figure 4. Integrated Scientific Processor Block Diagram

Scientific Processor Storage Unit

Scientific processor storage (Figure 5) is a free-standing unit with eight storage banks. Each bank contains 524,288 (524K) words. Each word has 44 bits (36 data, 6 check, 1 check parity, and 1 data parity). One storage unit contains a maximum of 4,194,304 (4,194K words).

When communicating with the ISP the Instruction Processor and Input/Output Processor use eight-word block transfers to and from the SPSU, while the ISP uses four-word block transfers.

The maximum aggregate memory bandwidth is 355 million words per second for a Scientific Processor Storage Unit. The memory bandwidth rate for the Integrated Scientific Processor is 133 million words per second (single precision). Bandwidth for each 1100/90 Instruction Processor and the Input/Output Processor is 15 million words per second.

The Scientific Processor Storage Units provide the identical functionality as the 1100/90 Main Storage Units while preserving essential timing. Functions provided include block read and write operations (eight words per block); double-word read operations; and partial-, single-, or double-word write operations. The partial word write capability is bit addressable for variable length fields. The Integrated Scientific Processor ports provide four-word read operations; and one-, two-, three-, and four-word write operations.

Scientific Processor Storage Unit Highlights

- Instruction Processor (up to four)
- Input/Output Processor (up to four)
- Integrated Scientific Processor (up to two)
- System Support Processor (two)
- System Panel
- System Clock
- Other main storage units in the system

System Performance

As noted, a key innovation of the Integrated Scientific Processor System is shared storage with the host processor. The peak performance of a single SPERRY Integrated Scientific Processor System is 133 MFLOPS (Millions of Floating point Operations Per Second) in single precision (36-bit word) and 67 MFLOPS in double precision (72-bit word).

Most significant, the ISP's high speed memory keeps pace with the arithmetic units, transferring data at 133 million words per second to each ISP.

An 1100/90 System with an Integrated Scientific Processor can sustain six to nine times the throughput of an 1100/90 Unit Processor System when handling the highly vectorized applications normally found in scientific processing.

The following vector operation rates are the internal computation speeds of the Integrated Scientific Processor.

A scientific processor that can execute an industry standard benchmark for scientific processors in the range of 20-60 MFLOPS is considered a Class VI supercomputer. The Integrated Scientific Processor System meets that requirement in double precision.

Operation	Single Precision Rate	Double Precision Rate
Multiply	66.6 MFLOPS	33.3 MFLOPS
Add or Subtract	66.6 MFLOPS	33.3 MFLOPS
Multiply and Add	133 MFLOPS	66.6 MFLOPS

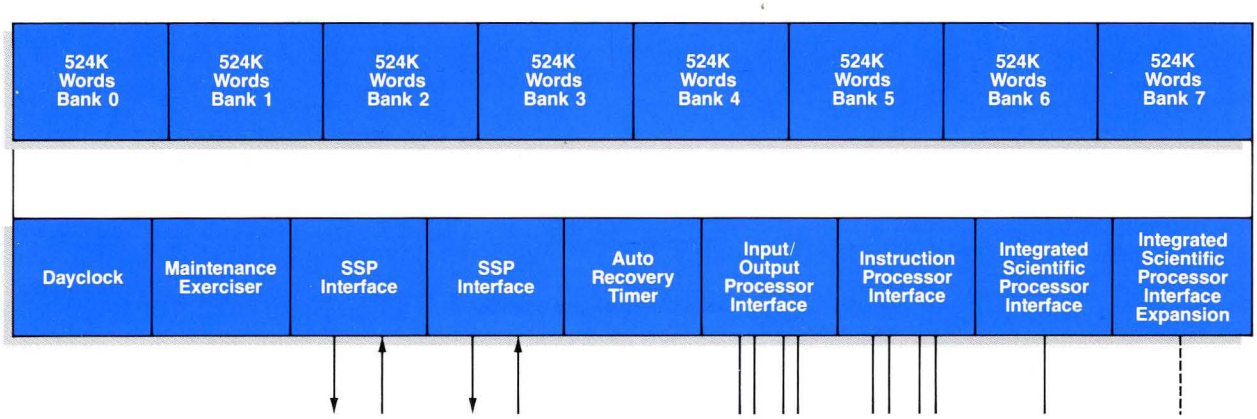


Figure 5. Scientific Processor Storage Unit

Software Support
Unlike other scientific processing systems, the Integrated Scientific Processor is totally integrated with its 1100/90 host computer. The ISP and the host computer use:

- A single operating system
- A common storage area
- A common data format
- Standard support software

Single Operating System
Both the Integrated Scientific Processor and the 1100/90 host computer operate under the Series 1100 Executive.

The Series 1100 Executive runs exclusively on the 1100/90 host. It handles all necessary system control tasks such as:

- Scheduling
- Resource allocation
- Input/output control
- Operational control

While the Executive runs on the 1100/90 host, the ISP can execute your site's scientific applications. The integrated system approach frees the ISP for its intended use—high-speed scientific processing. The 1100/90 host can also handle the less computationally intensive processing in parallel with the Scientific Processor. This will further increase your system's throughput.

Common Storage Area
The 1100/90 Instruction Processor and the Scientific Processor share a common storage area called the Scientific Processor Storage Unit.

The Scientific Storage Unit gives both the Scientific Processor and the 1100/90 Instruction Processor immediate access to instruction and common data. This integrated approcach eliminates the kind of overhead paid by systems that must take the time to transfer data between separate storage units.

Common Data Format
The ISP and the 1100/90 host represent data in identical formats. Thus, data in the common storage area may be manipulated by either the Scientific Processor or the 1100/90 Instruction Processor.

Standard Support Software
Following the integrated system approach, Sperry has enhanced its standard 1100 support software so that the software used for:

- Debugging,
- System analysis, and
- Run-time support

on the 1100/90 can also be used for programs that run on the Scientific Processor.

By using standard software aids, programmers can develop and execute programs that will run on either the Scientific Processor or the 1100/90 Instruction Processor.

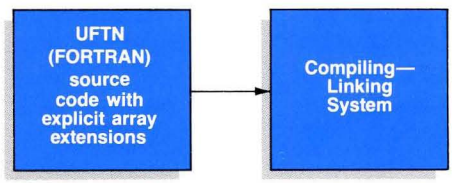


Figure 6. Program Compilation

Universal Compiling System FORTRAN (UFTN)
The ISP's vector architecture processes arrays in parallel; the emerging ANSI FORTRAN 8X standard is the primary programming language for scientific application programs that can utilize the parallel code execution capability of the Integrated Scientific Processor. The Universal Compiling System FORTRAN compiler is designed to process source code written to this standard.

UFTN conforms to American National Standard FORTRAN, ANSI X3.9-1978 (FORTRAN 77), but it also implements many of the array-programming extensions planned for the emerging 8X standard:

- Array-valued expressions and assignment statements
- Identified arrays
- Array partitions
- Conditional array statements
- PACK and UNPACK statements
- Array-valued intrinsics

By using UFTN with these extensions, programmers can structure source code explicitly for execution on the array-processing hardware of the Scientific Processor.

Vectorizer
To work efficiently, the Integrated Scientific Processor should execute code that uses the array extensions. Sometimes, however, your site may not have—or may not want to maintain—FORTRAN source programs structured with the explicit array extensions of UFTN. For this reason, Sperry offers the vectorizer.

The vectorizer, a source code-to-source code translator, changes the syntax of FORTRAN (FORTRAN 77, ASCII FORTRAN, or UFTN) source of programs so that they can be

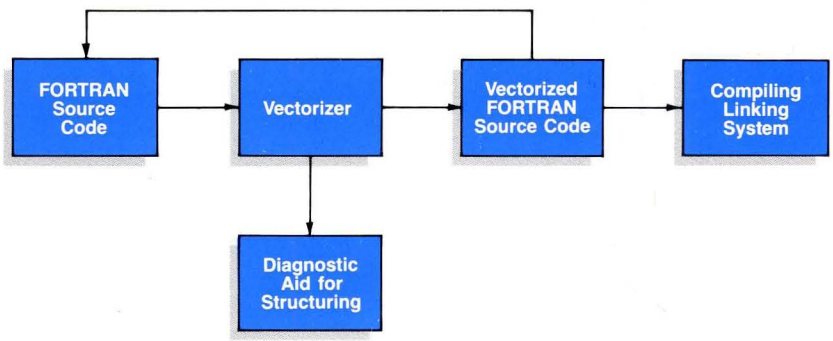


Figure 7. Program Vectorization

recompiled to execute more efficiently on the Scientific Processor. The vectorizer:

- Examines FORTRAN source programs for implicit parallel operations often found in DO loops.
- Translates (vectorizes) the implicit parallel operations into explicit array extensions.
- Produces a second, vectorized source program that is input to UFTN to execute on the scientific processor.
- Prints messages that tell why particular DO loops were or were not vectorized.

Sometimes the vectorizer's messages indicate that manually restructuring the FORTRAN source program will improve vectorization. To produce a fully vectorized program, the programmer:

- Inputs the FORTRAN source program to the vectorizer.
- Reviews the vectorizer's messages and, where indicated, restructures the FORTRAN source program.
- Inputs the restructured program.
- Repeats the cycle until all DO loops are restructured or until the performance gain does not justify further effort.

Extended Math Library

The Sperry Extended Math Library (EML) provides FORTRAN callable mathematical functions and subroutines beyond those provided with the FORTRAN compilers (FTN or UFTN), or the Common Mathematical Library (CML), which is part of UFTN.

Many EML routines have the same name and function as routines available in the public domain or on other computer systems. However, the SPERRY EML is specifically designed to make the best possible use of expanded features available with Sperry systems. The EML includes functions and subroutines most used by the scientific computing community today, including the Basic Linear Algebra Subroutines (BLAS), a basic building set for many other programs.

All EML routines may be executed on either the 1100/90 Instruction Processor, or the Integrated Scientific Processor. Additionally, some routines are written in assembler language for the Integrated Scientific Processor version.

EML Highlights

- Fast Fourier Transforms (FFTs)
- Convolutions
- Correlation routines
- Solution to the Wiener-Levinson equation
- Geophysical calculations
- BLAS (Basic Linear Algebra Subroutines)

Performance Execution Evaluation Routine (PEER)

To use the Integrated Scientific Processing system to its fullest you need to determine if a given program should execute on the Integrated Scientific Processor or on the 1100/90 Instruction Processor. PEER uses statistical sampling and analysis to allow you to pinpoint the most likely candidates for scientific processing and user optimization. You can also make informed judgments about executing on the Integrated Scientific Processor or the 1100/90 Instruction Processor.

Meta-Assembler for the Scientific Processor (MASP)

Programmers can improve the efficiency of a standard FORTRAN or UFTN program by writing subprograms—library routines or special constructs—in assembly language source code.

Then, by including a few simple directives in the assembly language code, programmers can direct the MASP assembler to generate assembler object modules that can be:

- Called by the FORTRAN program
- Linked, and
- Executed on the Scientific Processor.

In Summary

The SPERRY Integrated Scientific Processor System is a totally integrated system that eliminates the movement of data, data reformatting and system incompatibility inherent when using back end processors or array processors. The ISP's design combines the power and speed of a supercomputer with the versatility, ease of use, and reliability of a mainframe system.

The Integrated Scientific Processor System provides significant system throughput gains to the SPERRY 1100/90 System when your workload contains large amounts of vector and multidimensional array processing.

The Integrated Scientific Processor attaches to an 1100/90 System through the Scientific Processor Storage Unit, that is substituted for the normal 1100/90 Main Storage Unit.

This forms a tightly coupled system where the Scientific Processor Storage is accessible by the 1100/90 Instruction Processors and Input/Output processors, and by the Integrated Scientific Processors; the SPSU emphasizes the balanced architecture of the ISP system.

The Integrated Scientific Processor System, offers approximately six to nine times the performance of an 1100/91 when running scientific vector FORTRAN programs.

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