A/S NORSK DATA-ELEKTRONIKK NORD-50

OVERVIEW

Norsk Data's NORD-50 is a 32-bit word specialpurpose high-speed processor for heavy computing tasks in meteorological institutes, nuclear research, and other scientific environments. It is designed to be attached as a slave processor to a general-purpose NORD-10 real-time minicomputer (see Nord-10 report 180.7640.400). The NORD-10 performs all operating system and I/O control functions.

The NORD-50 has a multi-stage pipeline CPU that can perform instruction and operand fetches in parallel with three types of arithmetic operations. Its main arithmetic processor has two sets of 64 general-purpose 32-bit registers with 200 nanosecond read cycles that can also be used as 32 64-bit floating-point registers. Sixteen of the registers can also be used as base address and index registers. The 64 registers are duplicated, and the 16 base/index registers quadruplicated, to allow base and index addresses and two source operands to be fetched in parallel.

The NORD-50 instruction repertoire includes 23 threeaddress interregister instructions, 30 two-address memory reference instructions and 12 immediate operand instructions. Instruction fetch from main memory is overlapped with the execution of previous instructions. Effective instruction execution times thus range from a minimum of 500 nanoseconds for a 32-bit fixed-point addition, subtraction, or logical operation to a 3-8 microseconds for a 64-bit floating-point multiplication or division.

The NORD-50 can address up to 256K words (IM bytes) of 300 nanosecond MOS/RAM or 700 or 900 nanosecond core memory. Most NORD-50 systems are limited, however, to the 64K or 128K words (256K or 512K bytes) of memory that they can share with the NORD-10 master processor. The NORD-10 can control up to 2048 addressable peripheral devices, including 310K to 66M-byte disc drives, 600 to 120K bytes/sec magnetic tape drives, 180 cps to 1000 lpm printers, card and paper tape readers and punches, 10 and 30 cps teleprinters, 1920 character alphanumeric and two types of graphic display systems.

The NORD-10 master processor executes also all SINTRAN III operating system functions and all Assembler and FORTRAN IV compilations for the NORD-50. This frees the whole of the NORD-50's processing power and main memory for the execution of user programs. Programs are normally run to completion one at a time, but the can be programmed with breakpoints to allow more frequent references to the NORD-50 monitor executed by the NORD-10. This allows the NORD-50 to be used interactively in multi-terminal time-sharing environments.

Norsk Data-Elektronikk was founded in 1967 by engineers from a Norwegian electronic research establishment that delivered the first NORD-1 minicomputer in 1968. By the end of 1975, Norsk had delivered 476 computer systems and an additional 116 computers were on order at the beginning of 1976. Most of these were 16-bit word minicomputers in the earlier NORD-1 and NORD-20 series and the current NORD-10, 12 and 42 series. The NORD population count also includes three high-speed 32-bit NORD-5 processors delivered to the Norwegian Meteorological Institute in 1972 and two of the current NORD-50 processors delivered to ASEA, ATOM and the Oran Meteorological Centre in Algeria in 1975.

Norsk Data builds all NORD computers and the NORDCOM graphic display system at Oslo, Norway but buys all other peripherals on the international OEM market. It markets the NORD series throughout Scandinavia, France, and Switzerland. It is planning to open sales centers or to appoint agents in other European countries during 1976.

See Table 1 for NORD-50 mainframe specifications and Table 2 for a list of peripherals.

COMPETITIVE ANALYSIS

The NORD-50 is a difficult system to categorize. Its basic price of around \$150,000 for a working configuration with 256K bytes of main memory puts it into the category of "mega-minis" such as the DEC PDP-11/70 and Interdata 8/32. But its internal instruction execution speeds and the power of its instruction set far exceed those of any other "mega-mini" currently on the market. The NORD-50, however, falls short of large computer performance in main memory capacity. Its current maximum main memory of 256K 32-bit words (IM bytes) was quite respectable for a large general-purpose computer of the late 1960s but has ceased to be so in the middle 1970s when main memories expandable up to 4M



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bytes have become the norm for systems of the NORD-50's speed. Also, the NORD-50 does not have virtual memory facilities with which to extend the capacity of its main memory.

The limiting factor on the NORD-50 main memory is not the 18-bit width of its memory address line; this line could be widened to the 32-bit width of its base address and index registers.

However, the addressing capability of the NORD-10 minicomputer that the NORD-50 uses as master processor for all operating system functions and I/O control routines is limited: the NORD-10 can address no more

Table 1. Norsk Data NORD-50: Mainframe **Characteristics**

CENTRAL PROCESSOR	NORD-50	NORD 10
Number of Processors	1-2+NORD-10	1-3
Microprogrammed	Yes	Yes
Number of Registers	64 duplicated	8 x 16 levels
Accumulators	64 (32 Floating Point)	1 + extension
Index	16	1
Addressing (words)		
Direct	4096	256
Indirect	1M x 15 levels	64K
Indexed	4.000M	64K
Mapping	None	256K
Instruction Set		
Implementation	Firmware	Firmware
Number	65	94 std + 16 opt
Floating-Point	10 std	10 std
Decimal	None	None
Hardware Stack	None	None
Writable Control Store	None	None
Interrupts	TUCHE	NONE
Levels	None	16 and
Type		Hardwara
MAIN STORAGE	_	I IGI CIVVALE
Type	MOS/DAM or	MOC/DAM
Type	NUS/HANI, OF	MUS/RAM or
Cualo Timo/unoo	0.2.07 0.0	
Butes per Asses	0.3; 0.7 or 0.9	0.3; 0.7 or 0,9
Basis Andressells Lisis	4 ¹	
Basic Addressable Unit	32-bit word	16-bit word
Capacity, bytes	4001/	(2)
Minimum	128K	128K12/
Maximum	IM	512K
Increment	16K	16K12/
Ports per Module	4	4
Error Checks	Parity, optional	Parity optional
Memory Protection	Read, Write, Fetch	Read, Write, Fetch, & Rings
Memory Management	None	Standard
Interloguine	Two wow	Standard
INDUT (OUTPUT	i wo-way	Two-way -/
Maximum Daviasa	No. (3)	2040
Addressable	None	2048
Programmed I/O	-	Yes
DMA	-	Std
DMA Transfer Rate	-	2M bytes/sec
Notes:		
(1) NORD-10 is required	as master process	or for evecution al

uting all operating systems and I/O control functions on allvORD-50 NORD-50 systems. (2)

When used as master processor on a NORD-50 system. When all I/O addressing and control are performed by (3) NORD-10 master.

Table 2. Norsk Data NORD Series: Peripherals

•	· · · · ·
Model No.	Description
Drums 501-509	Fixed-Head Drums, 256K, 512K, 1M or 2M bytes, 10ms access, 200Kbs
Discs	Floppy Dice Drive 210K hotes
	450ms access, 31Kbs, 1-3 drives/control
510, 511	Cartridge Disc, (5M fixed +) 5M bytes exch, 47.5 ms access, 312 Kbs, 1–4 drives/control
513, 514	Exch Disc Unit, 33M or 66M bytes, 4oms access, 1.2Mbs, 1–8 dr/control
Magnetic Tape 504	Cassette Tape Drive (Philips), 1-track, 7,5 ips, 600 bytes/sec
515	(Hewlett Packard 9700) 9-track, 800 bpi, 45 ips = 36Kbs, 1-4 dr/control
517, 518, 519	(Tandberg) 9-track, 800/1600 bpi, 75 ips = 60/120Kbs, 1-4 dr/control
Paper Tape	.
301	Reader (Digitronics), 300 cps Punch (Eacit), 70 or 150 cps
Punched Cards	Tunich (Facil), 70 01 150 cps
400, 401	Card Reader (Documation), 285 or
420	Card Punch 20 cards/min
Painters	
405, 406, 407	Line Printer (CDC), 200, 400, or 600
412	102A), 330 cps
414	Serial Matrix Printer (CDC 9316), 180 cps
603	Matrix Line Printer (Versatec LP- 1150), 500 lpm, 64-char set
604	Matrix Line Printer Plotter (Versatec 1110A), 1000 lpm, 96-char set
Teleprinters	Teletype ASB 33 10 cpc 74 ppl
205	Texas Silent KSR 733, 30 cps
206	DECwriter LA36, 30 cps, 132 ppl, 96- char set
211	Qume-45 Typewriter
212 Displaye	TET Text-Editing Terminal
204	Tektronix 4010-1 Graphic Display
208	Tandberg A/N Display, 24 lines of 80 characters
210	Infoton VISTAR GT A/N Display, 24 lines of 80 characters
659	NORDCOM Standard Graphic Dis-
	256×384 plotting points, 8 colors, 2
	intensities
FIGTIERS	Versales 1110A Printer/Plotter
651	Controller for CalComp 900 series
Data Communications	F
701	Synchronous Modem Control, single-
702	Asynchronous Modem Control, single-line up to 9600 bps, program-
704	Asynchronous Modem Multiplexor, 1– 8 lines 50–4800 brs. programmable
Process I/O	e intes, ee House pha, programmable
800	CAMAC Crate Controller
805	18-bit CAMAC Crate Connector
810	12 optically coupled Digital Inputs
811	16 optically coupled Digital Outputs
812	16-bit TTL Digital Inputs
813	16-bit TTL Digital Outputs



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than 512K bytes of main memory, which is also the effective limit on NORD-50 memory, since any memory above 512K bytes has to be effectively loaded and unloaded by the user program.

It will not be until Norsk Data designs and releases a more powerful and expandable master processor that the NORD-50 will be able to compete fully among the general-purpose giants. In the meantime NORD-50 offers a very attractive performance/cost ratio to any scientific or research institute with number-crunching requirements that can reduce object program segments to 256K bytes or less.

See Table 3 for a comparison of the NORD-50 and some of its competitors.

COMPATIBILITY

The NORD-50 is fully upward compatible at machine code level with the earlier NORD-5. It is not machine code compatible with any other computer system including the NORD-10 minicomputer that the NORD-50 uses as operating system and I/O control master processor, but it is source code compatible with any computer system that implements 1966 Standard ANSI FORTRAN IV.

The NORD-50 32-bit word length and 8-bit alphanumeric character length conform to current industry standards. This allows the NORD-50, via its NORD-10 master, to exchange data on magnetic or paper tape, punched cards, or on-line data communications links with most minicomputers and general-purpose computer systems that are currently on the market. The NORD-10 has IBM, CDC, Honeywell, and Univac RJE terminal emulator programs that allow it to exchange data on-line with any of these four mainframes.

Although they occupy the same amount of memory space, the NORD-50's short and long floating-point formats are not the same as those of the IBM Systems/360 and 370. The NORD-50's signed 8-bit exponent allows it to handle floating-point numbers of twice the magnitude of the IBM 7-bit exponent, but at the expense of precision, which is limited to 23 bits in the short format and 55 bits in the long format on the NORD-50.

CONFIGURATION GUIDE

A minimum NORD-50 system comprises a NORD-50 slave CPU, a NORD-10 master CPU, 64K 16-bit words (addressable as 32K 32-bit words by the NORD-50) of MOS or core memory, a 10-M or 33M-byte exchange disc system, a paper tape or card reader, line printer, and tele-printer console.

Main memory is shared by the NORD-50 and NORD-10 CPUs. It is divided into two or four equal modules each with its own access drives and controllers but with addresses interleaved between pairs of modules so that the NORD-50 can retrieve a 32-bit word in parallel by accessing two modules in parallel. Each module can be expanded in 8K 16-bit word (16K byte) increments to a maximum of 64K words (128K bytes). The maximum amount of main memory shareable by the NORD-50 and NORD-10 is 256K 16-bit words (512K bytes).

The NORD-50 can be equipped with additional main memory, unshared with the NORD-10, to a maximum combined capacity of 256K 32-bit words (IM bytes). Unshared main memory must, however, be loaded and unloaded by the user program itself, as all operating system functions are performed by the NORD-10 CPU.

The Multi-Port Memory Interface (MPMI) which controls the NORD-50 main memory has four ports. One is used by the NORD-50 CPU, one by the NORD-10 master CPU, and a third is normally used by the CMA Bus Controller to which the disc control units are connected. This leaves one spare port, which can be used by an additional NORD-50 CPU, an additional NORD-10, or an additional DMA Bus Controller.

The NORD-10 master CPU controls all I/O peripherals and transfers. It can address up to 2048 peripheral devices connected via I/O control cards to I/O Bus Controllers and extension chassis boxes which in turn are connected to an External I/O Bus. The NORD-10's peak combined throughput rate is 2M bytes/sec for DMA transfers whose parameters are held in special core registers on the DMA Bus Controllers.

SYSTEM	NORD-50	DEC 1080	Honeywell 66/80	IBM 370/158	Univac 1100/20
Instruction Execution Times					
(microseconds)					
rixed-roint	é -				
Add	0.7	0.7	0.7	0.93	0.9
Multiply	4.75	2.4	3.5	1.6	2.5
Floating-Point					
Add	0.8	1.9	1.5	2.2	2.0
Multiply	3.75	NA	3.0	20	27
Main Memory (bytes)			0.0	4.0	2.7
Maximum Capacity	1M	20M	4M	4M	2M
				(-8M*)	
Note:					
* From PCM memory suppliers.					



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(Please refer to report 180.7640.500 for an OVERVIEW of the NORD-50.)

MAINFRAME

Norsk Data's NORD-50 is a special purpose, highspeed, 32-bit word processor designed to be attached as slave to a general-purpose NORD-10 real-time minicomputer. It is used mainly in meteorological institutes and nuclear research organizations.

Architecture. The NORD-50 are multi-processor systems that use Channel-to-Memory Controller architecture. The NORD-50 CPU itself has no I/O channels, and its only ports are to a Multi-Port Memory Interface (MPMI) controlling main memory modules, which it shares with one to three NORD-10 processors and/or DMA disc controllers. The NORD-10 controls all I/O peripherals, services all interrupts, and performs almost all system operating functions for the NORD-50. See Figure 1 for NORD-50 architecture.

Central Processor

The NORD-50 CPU is a multi-stage pipeline processor, in which the different stages of each instruction are performed in parallel with each other or with those of consecutive instructions. The NORD-50 CPU comprises two address decoding and fetching units and three specialized arithmetic units. These five units are as follows.

- Instruction decoding and prefetch unit.
- Operand address decoding and fetch unit.
- Parallel arithmetic and control unit, responsible for integer addition, subtraction, all logical operations, and the loading and storing of all registers.
- Serial arithmetic unit, responsible for bit handling, shifts, integer-to-floating point, floating-point-tointeger conversions, and floating-point addition and subtraction.
- Fast Multiplier, responsible for both integer and floating-point multiplication and division, both single-and double-length.

All units except the Fast Multiplier perform their share of each instruction in about 200 nanoseconds. Most fixedpoint arithmetic and logical instructions take 600 nanoseconds from start to finish, but overlapping reduces this to an effective average of 500 nanoseconds per instruction. Floating-point add and subtract take 1 microsecond; multiplication and division take 3 microseconds.

Data Structure. The basic addressable storage unit is the 32-bit word. This may represent an instruction, 32 Boolean variables, four 8-bit alphanumeric characters, a signed 31-bit binary integer or single-precision floatingpoint number, or part of a double-length signed 63-bit binary integer or double-precision floating-point number.

Although NORD-50 floating-point (FP) numbers have the same lengths as short and long floating-point numbers on the IBM 360 and 370, their format is different. NORD-50 FP numbers have a signed 8-bit hexadecimal exponent allowing them to represent numbers in the range 10-76.8 to 1076.8 whereas IBM 360 and 370 are limited to signed 7-bit exponents. This greater range has been achieved at the expense of precision, which is limited to a 23-bit mantissa in single-precision and 55-bit mantissa in double-precision on the NORD-50 against 24 and 56 bits respectively on the IBM 360 and 370. NORD-50 floating-point formats also differ from those of the NORD-10.

Registers. The NORD-50 CPU contains four independently-driven sets of MOS registers: two sets of 64 and two sets of 16 registers, each 32 bits long. The read/write cycle for each set of registers is 200 nanoseconds per 32-bit word.

Each of the two sets of 64 registers is a complete set of 32-bit wide general purpose addressable working and fixed-point accumulator registers. The 32 registers may be used as single-length, floating-point accumulators or be paired to form 32 double-length, 64-bit, fixed-point or floating-point accumulators. The contents of the two sets of 64 registers are always identical. They have been duplicated to allow operand A to be fetched from one set of registers simultaneously with fetching operand B from the other set within a single 200 nanosecond operand-fetch cycle. When the result of an operation is written to a destination register it is written to both copies of the same register simultaneously.

Sixteen of the 64 general-purpose registers may also be used as base address and/or index registers for memoryto-register instructions. These 16 registers are available in four copies, so that a base address, an index, and an operand may all be fetched simultaneously within the same 200 nanosecond cycle. The two independently driven sets of 16 registers thus represent additional copies of 16 of the 64 general purpose registers.

Addressing Facilities. NORD-50 memory addresses are always base-relative and may also be indexed and/or indirect at up to 15 levels.

Memory reference instructions contain a single-bit indirect addressing indicator I, two 4-bit register addresses (X and B), and a 12-bit displacement as well as a 6-bit function code and a 6-bit register address for the other operand. If

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Figure 1. Norsk Data NORD-50: Main Memory Design

the I indicator is set to 0, the effective memory operand address will be the sum of the 32-bit contents of the two registers addressed by the X and B fields and the 12-bit displacement. If the I indicator is set to 1, the sum of the X and B registers and the displacement will be the address of an Indirect Address Word.

Indirect Address Words also contain a single-bit I indicator, two 4-bit register address fields (X and B), but a 20-bit displacement. If the l indicator is set to 0, the sum of the two registers addressed by the X and B fields and of the 20-bit displacement will be the effective operand address, but if the l indicator is again set to 1, the address will be that of a further Indirect Address Word, progressively, for up to 15 indirect addressing levels.

The 12-bit length of the displacement field in memory reference instructions allows up to 4096 32-bit words to be addressed directly within a common memory area using a single base address. The 20-bit displacement field of Indirect Address Words allows indirectly addressed memory areas to be up to 1M words long. The 32-bit contents of the X and B registers allows the NORD-50 to address up to 4,000 million words. At this time, however, these last two figures are purely theoretical, held in reserve for future developments. Current NORD-50 address lines connecting the processor to the Multi-Port Memory Interface are 18 bits.wide, allowing it to address up to 256K words (1M bytes) of main memory.

Instruction Set. All instructions are one 32-bit word long. There are three different instruction formats for 23 inter-register, 30 memory reference and 12 immediate operand instructions respectively.

The 23 inter-register instructions are powerful threeaddress instructions containing three 6-bit register addresses: two source registers holding operands A and B respectively, and a destination register. The inter-register instructions include four fixed-point, four floating-point arithmetic and four logical instructions, two fixed/floating



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conversion, two shift, two bit manipulation, one register load, and four conditional skip instructions.

The 30 memory reference instructions are two-address instructions in which one operand is fetched from a directly or indirectly addressed main memory location and the other from a general-purpose register, with the result stored in the same register or same memory location. There are five fixed-point and four floating-point arithmetic instructions, one logical (AND), four compare, five load and store, two control, and nine conditional or unconditional branch instructions.

The 12 immediate operand instructions include four logical, four arithmetic, and four skip instructions in which the last 16 bits of the instruction itself represent one of the operands, while the other operand is found and the result stored in one of the 16 registers that can be used as base or index registers.

See Table 1 for typical instruction execution times.

Interrupt Control. The NORD-50 CPU has a single interrupt line connecting it to the master NORD-10 processor. The NORD-10 processes all external interrupts. If one of these requires the NORD-50's program to be interrupted and replaced by another, the NORD-10 will send an interrupt signal to this effect to the NORD-50. Conversely, the NORD-50 sends an interrupt signal to the NORD-10 whenever it requires an input or output operation to be performed.

Main Memory

The NORD-50 CPU must share at least part of its main memory with the master NORD-10 CPU that runs its operating system and I/O control routines. This shared memory comprises two or four independently driven blocks housed in two 16-slot extension chassis boxes. Each block comprises up to eight slot-in modules chosen from among the following:

- MOS/RAM read/write, 300 nanoseconds read cycle: 8K 16-bit words per module.
- Core read/write, 700 nanoseconds read/write cycle: 8K 16-bit words per module.
- Core read/write, 900 nanoseconds read/write cycle: 8K 16-bit words per module.

Each memory block's maximum capacity is thus 64K 16-bit words, and the combined capacity of four blocks 256K 16-bit words, which is the NORD-10 CPU's maximum addressing capability.

Each of the two extension chassis boxes housing one or two of the two or four memory blocks also holds a Multi-Port Memory Interface (MPMI) that acts as a switching device between the two memory blocks that it controls and up to four processors and/or DMA device controllers. On NORD-50 systems, one port on each MPMI is used by the NORD-50 CPU, one by the master NORD-10 and one by the DMA disc controller, leaving one port for use by an additional optional NORD-10 CPU or DMA disc controller.

	Operand Length	Execution Time (microseconds)	
Instruction	(bits)	RR	RM
Integer Arithmetic			
Load, Add	32	0.75	1.56
Subtract	32	0.8	1.62
Multiply	32	4.75	5.77
Divide	32		2.5-5.8
Floating-Point Arithmetic			
Add, Subtract	32	0.84	1.84
	64	0.84	2.51
Multiply	32	3,74	4.76
	64	7.18	
Divide	32	3.74	4,76
	64		8.97
Shift	32 or 64	0.84N	-

Table 1. Norsk Data NORD-50: Instruction

Execution Time

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N = Number of bits in Shift

RR = Register-to-Register instruction

RM = Register-Memory instruction

The ports connecting each MPMI to the NORD-10 CPU and DMA disc controller are linked in series, so that the two MPMIs look like one to the NORD-10, providing access to up to four memory blocks. The NORD-50 CPU, on the other hand, has two separate and parallel port connections to each MPMI. It can thus fetch two 16-bit words in parallel, one from the memory block on each MPMI, to form a single NORD-50 32-bit word. The addresses of memory blocks on the two MPMIs are thus interleaved; however, address logic is not held in the MPMIs but in the CPUs' memory channels. The same pair of interleaved memory blocks may thus have addresses 0-64K (32-bit) on the NORD-50, but addresses 0-128K (16-bit) or 128K-256K (16-bit) on the NORD-10. (See Figure 1.)

NORD-50 address lines to main memory are currently 18 bits wide. Up to 256K 32-bit words (1M bytes) of main memory can thus be connected to it via two pairs of MPMIs accessed in parallel. No more than 128K words on one pair of MPMIs can be shared with the master NORD-10 CPU, since its addressing capability is restricted to 256K 16-bit words. Since the NORD-10 master executes the operating system and all I/O control routines, it is only in this shared main memory that programs and/or data can be loaded, input, output or dumped by the operating system. Loading of NORD-50 main memory above the first 128K 32-bit words and dumping at breakpoints must be the responsibility of the user program.

In practice, the amount of main memory shared between the NORD-50 and the NORD-10 master is a great deal less than 128K 32-bit words, and in most cases does not exceed 64K 32-bit words, because there is no point to the NORD-50 sharing access to those parts of NORD-10 main memory in which the operating system and I/O control routines are held.

Error Checks. Parity is available as standard on NORD-10 and NORD-50 main memory. An additional



parity bit is associated with each 8-bit byte, lengthening the width of access to each memory block to 18 bits.

Whenever a parity bit error is encountered, this sets an internal interrupt that is handled by the NORD-10.

Memory Protection. The NORD-50 CPU's address bus may be optionally equipped with two base/limit breakpoint registers. These can be used to protect either the memory area bounded by the addresses within the two registers, or the memory area outside these bounds against any of the following:

- All accesses by the current program.
- Instruction fetches.
- Data read and write.
- Data write only.

When this mechanism is used, protected memory cycles are extended by an additional 100 nanoseconds.

Input/Output Control

The NORD-50 CPU has no input/output channels of its own. All I/O devices and transfers are controlled by the NORD-10 master, which can address up to 2048 peripheral devices via single- or multi-device control cards slotted into one of 8 I/O slots on the NORD-10 mainframe chassis, or one of 16 I/O slots on any number of extension chassis boxes connected to an External I/O Bus.

The NORD-10 CPU uses programmed transfers to/from all slow byte or word-serial I/O devices up to a combined maximum throughput rate of 140K to 200K bytes or words/second. DMA Bus Controllers equipped with core memory registers for I/O transfer parameters can transfer blocks of data directly into main memory to a combined maximum throughput rate of IM words/sec (16-bit), using either the NORD-10 CPU Bus on a cycle-stealing basis, or a direct-port connection to the Multi-Port Memory Interface.

See the report on the NORD-10 minicomputer (180.7640.403) for a more detailed description of NORD-10 I/O structures and procedures.

PERIPHERALS

Since all NORD-50 I/O transfers are controlled by the master NORD-10, NORD-50 peripherals are identical with those that can be connected to NORD-10 systems.

Slow-Speed I/O Devices. These include Teletype ASR-33, Texas KSR Silent 733, and DECwriter LA36 console teleprinters, paper tape and card readers and punches, serial matrix and line printers ranging from 180 cps to 1,000 lpm.

High-Speed Mass Backing Storage. This includes 600 bytes/sec single-track cassette tape, 36K to 120Kbs 9-track magnetic tape drives, and disc drives ranging from 310K to 66M bytes capacity per drive, 310K to 528M bytes capacity per controller, and transfer rates from 31K to 1.2M bytes/sec. **Special-Purpose Devices.** These include Versatec 1110A printer-plotters with a 1000 lines/minute printing and 120 steps/second plotting speed, interfaces for Cal-Comp plotters, and two graphic display systems: the Tektronix 4010-1 display with 2590 chars screen capacity and 780 x 1024 plotting points, and the modular NORDCOM graphic display system offering 32 or 42 lines of 64 characters in up to 8 colors.

For a more detailed description of these peripheral devices, see the Detail Report on the NORD-10, 12 and 42 minicomputers (AUERBACH report no. 180.7640.403).

DATA COMMUNICATIONS

The NORD-10 master controls all data communications for the NORD-50. Communications interfaces include DC current loop, asynchronous and synchronous voice-grade line modem interfaces with speeds in the range 50 to 9600 bits/second, and local terminal and asynchronous voice grade line modem multiplexors for up to 8 lines within the speed range 110 to 4800 bps.

NORD-10 terminals include 10 cps Teletype ASR 33, 30 cps Texas Silent KSR 733 and DECwriter LA36 teleprinters, and both Infoton VISTAR GT and Tandberg TTY-compatible A/N displays with 1920 character screens arranged as 24 lines of 80 characters.

SOFTWARE

Norsk Data offers NORD-50 users a mixed-mode multiprogramming operating system, two languages, and a number of utilities. All software except the user object programs is run by the master NORD-10.

Operating System

The SINTRAN III operating system released in 1974 is the standard operating system for all NORD computer systems, including the NORD-50. It is a mixed-mode system that can multiprogram any combination of real-time, multi-access time-sharing and background batch programs. All routines within it are always executed by the master NORD-10 CPU. This allows the NORD-50 CPU to concentrate its computing power on large user programs. The NORD-50 Monitor is basically designed to allow the NORD-50 to execute one program to completion at a time. When it has completed a task, it sends a Monitor Call to the NORD-50, which initiates a NORD-10 interrupt. The NORD-10 examines the nature of the interrupt and performs the required housekeeping procedures: it unloads the completed program, prints the results, and loads its successor.

While this form of organization is suitable mainly for background batch processing, it is also possible to use the NORD-50 interactively in multi-terminal time sharing environments by inserting breakpoints into user programs. Whenever the NORD-50 encounters a breakpoint, it stops and asks the NORD-50 Monitor whether to proceed with this program or replace it with another program of higher



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priority. If a higher priority program is to take over, the NORD-50 Monitor preserves all the registers of the interrupted program so it can resume processing at a later point.

Languages

The only programming languages currently available on the NORD-50 include an assembler and 1966 ANSI Standard FORTRAN IV. Source programs in either language are compiled into NORD-50 machine code by the NORD-10 master processor. When required, object programs are loaded into shared main memory by the NORD-50 Loader, executed by the NORD-10, and then executed by the NORD-50.

Utilities

NORD-50 utilities include a FORTRAN Library, and the QED interactive text editing program for inserting, deleting, and changing lines of text on any file, including a source program. This is the same as the NORD-10 QED and is executed by the NORD-10. All NORD-10 utilities can also be used for preprocessing input data to a NORD-50 program and editing the output. Utilities include NORD SORT for sorting and merging data on alphanumeric integer and/or floating point keys, the RUNOFF output report generator, and the NORD PLOT graphic output system.

Data Management

Data management is performed by the NORD-10 for NORD-50 files. SINTRAN III offers a general purpose file management system for permanent, scratch and peripheral device files held on mass backing storage. They may be accessed in sequential or random mode. A flexible file security mechanism allows the programmer to specify the degree of file security required.

The SIBAS data base system allows multi-terminal time-sharing system users to represent complex data structures and separate applications programs from the data base. SIBAS data handling routines follow the specifications given in the CODASYL Data Base Task Group April 1971 Report.

