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Spear, Inc.

SPEAR, INC.

April 17, 1968

Mr. F. G. Snyder, Mgr.
Lockheed Electronics
6201 E Randolph Street
Los Angeles, California 90022

Dear Mr. Snyder:

Thank you for your interest in our micro-LINC-300 system. The enclosed "Interim Data Sheet" and Competitive Comparison will give you a feel for the physical attributes and capabilities of the system and its competitive advantages over similar type equipments from both a hardware and software standpoint.

As you can readily see, the micro-LINC-300, with its integrated circuit logic and modular design, is a very fast and flexible device. With a command lexicon of 62 instructions, a powerful array of machine orders is available to perform a variety of functions.

System price for the basic micro-LINC is $46,500. The system may be purchased or leased. An average monthly charge, based on a five-year lease plan, will run about $1,000. per month. Delivery of the system is four months after receipt of order.

If there is any additional information we may provide, please call or write.

Sincerely yours,

John N. Burns
Asst. Marketing Manager
SPEAR, INC.

JNB/ah
Enc.

SPEAR micro - LINC 300

(Interim Data Sheet)

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GENERAL CHARACTERISTICS

The new SPEAR micro-LINC-300 is a stored-program general purpose computer specifically designed for scientific and engineering computation and on-line data processing. This device, based on the original M.I.T.-Washington University LINC design, retains all of the unique operational features of this exceptional laboratory computing system and adds improved integrated circuit logic and greatly increased capability, which have earned it the name of "Super LINC".

The basic micro-LINC-300 offers 4,096 words of core memory (12-bit word), a dual magnetic tape unit, and several input/output devices. Included in the basic array are an Alpha-numeric keyboard, Cathode ray tube display, analog to digital conversion and a 16-channel analog multiplexer with independent sample and hold circuits for each channel.

SPECIAL FEATURES

- Memory access, 500 nanoseconds - cycle time, 1 microsecond.
- Buffered tape - Provides parallel processing feature during tape operation.
- Third generation design - MECL II integrated circuit logic.
- Memory expandable to 32,768 words of memory.
- RAM feature - Rapid Access to Memory.
- Expanded I/O.
- Automatic program Interrupt on power off.
- Outstanding program power.

MICRO-LINC-300 SPECIFICATIONS

CENTRAL PROCESSOR

Basic Memory:	4,096 Words (Expandable to 32K)
Word Length:	Twelve (12) Bits
Arithmetic:	One's Complement
Memory Access:	400 Nanoseconds
Memory Cycle Time:	1 Microsecond
Addition:	2 Microseconds
Multiplication:	14 Microseconds
A/D Conversion: 9 Bits	7 Microseconds
Digital I/O:	1 MHz Maximum

MAGNETIC TAPE

The standard micro-LINC-300 contains two (2) individual magnetic tape units. Each tape contains 512 consecutively numbered blocks capable of storing 256 12-bit words, for a total of over 3,000,000 bits. Two additional tape units may be added to increase storage to over 6 million bits of information.

Tape Specifications

3/4" Sandwich
400 BPI
2.5" Block Size
1/25 sec. Block Scan Time
1/10 sec. Start/Reversal Time

ALPHANUMERIC OSCILLOSCOPE DISPLAY

The alphanumeric oscilloscope's display letters and digits are generated by a special program instruction. This display feature is particularly useful for guiding unskilled operators in the use of the computer.

POWER

115V-60 cycle single phase. Approx. 1,000 watts. Can be provided for 220V or 50 cycle operation on request.

DIMENSIONS

Main Frame: 30" Wide x 30" Deep x 62" High.

Scope Table: 36" Wide x 30" Deep.

ANALOG INPUT

Sixteen (16) channels of A/D conversion are provided with the basic system, twelve (12) of which are for input of external signals and four (4) for potentiometer control.

Independent sample and hold circuits are provided for each channel.

Input Current:
Unipolar: 40 μa full-scale
Bipolar: ±20 μa for ±full-scale

Input Impedance: 50K (nom) @ ±1V F.S.

Frequency Response of Preamps:
Acquisition Time: 1.5 μsec.
Aperture Time: 100 nanosec.
Recovery Time: 10 μsec.

DIGITAL INPUT

Thirteen (13) digital input lines for program control.

OPR Class (500 KHz max)	One 12-bit parallel data entry to Accumulator. Twelve (12) input lines for control of pause.
RAM Class (1 MHz max)	One 12-bit parallel Rapid Access to Memory channel.
INTERRUPT	One Interrupt line under Program Control.
MISCELLANEOUS	Four (4) digital inputs for control of OPR & RAM.

DIGITAL OUTPUT

Twenty-two (22) digital output lines under program control.

OPR Class (500 KHz max)	One 12-bit parallel data output from Accumulator.
RAM Class (1 MHz max)	One 12-bit parallel Rapid Access to Memory channel.
RELAY Register	One 6-bit parallel data output from Relay Register.
MISCELLANEOUS	Twelve (12) Timing and Control outputs for use with RAM & OPR.

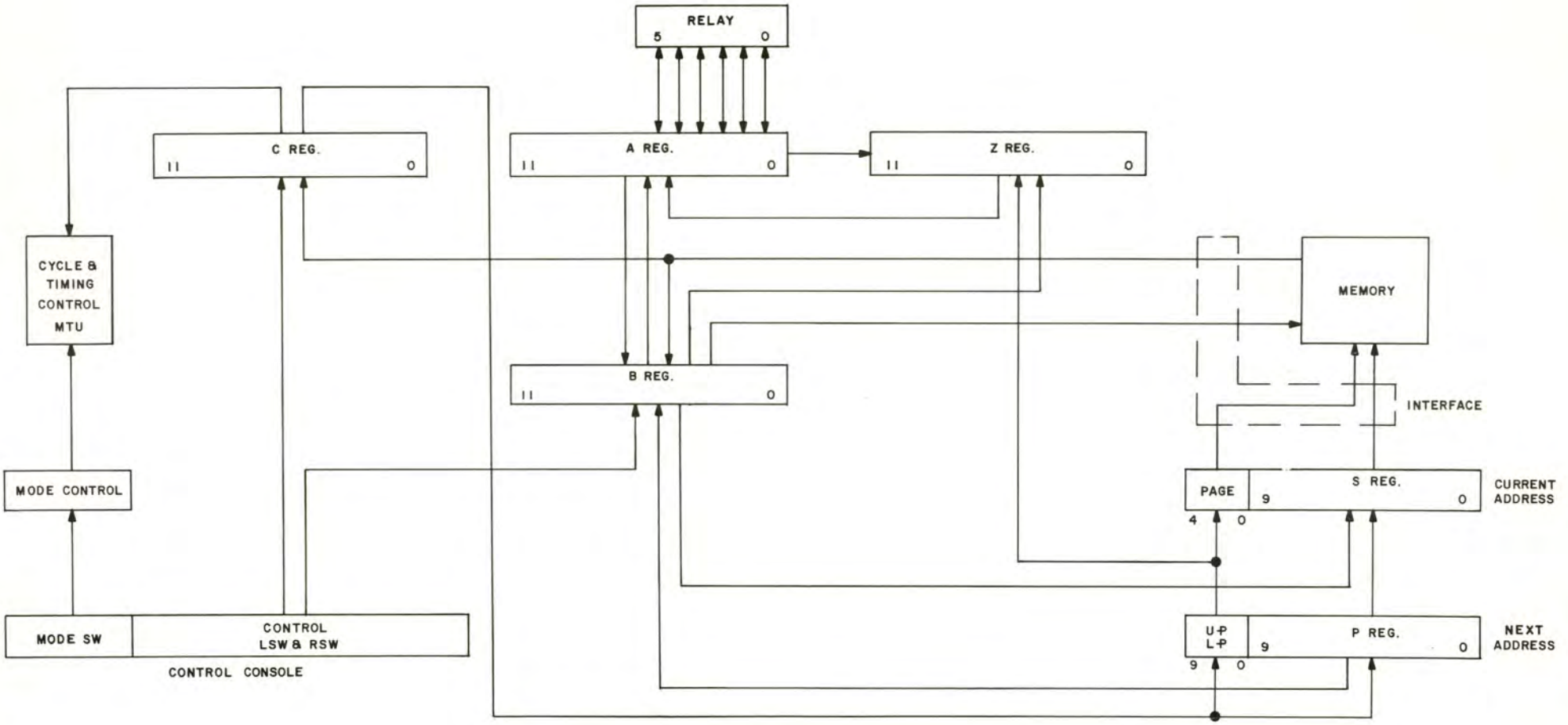
SPECIAL FEATURES

RAM - Rapid Access to Memory.

Buffered Tape Operation.

INPUT-OUTPUT

(48) different devices can be individually selected and addressed.



BASIC MICRO-LINC-300

ORDER CODE

The micro-LINC-300 command lexicon is comprised of 62 instructions which give the user a powerful and flexible array of machine orders. The following list indicates the instruction type, mnemonic code, execution time, and explanatory footnotes.

	MNEMONIC CODE		EXECUTION TIME	FOOTNOTE
INSTRUCTIONS	ADD X	Add contents of X to A	2	
ARITHMETIC	ADA i B	Add contents Y to A	2-3 1/8	1
	ADM i B	Add to contents Y	3-4 1/8	1
	LAM i B	Link-Add to contents Y	3-4 1/8	1
	MUL i B	Multiply by contents Y, results in A and Z	14-15 1/8	1
STORE/LOAD	STC X	Store contents of A in X and clear A	2	
	STA i B	Store contents of A in location Y	2-3 1/8	1
	STH i B	Store half word in location Y	2-3 1/8	1
	LDA i B	Load contents Y into A	2-3 1/8	1
	LDH i B	Load specified half of contents Y into A	2-3 1/8	1
	ZTA	Load 11 bits of Z into A	1	
	MSC 4	Load Tape Accumulator into A	1	
CONTROL/LOGICAL	HLT	Halt		
	MSC 2	Set Flag	1	
	MSC 12	Clear Flag	1	
	CLR	Clear A	1	
	NOP	No Operation	1	
	COM	Complement A	1	
	BCL i B	Bit clear (Reference word in Location Y)	2-3 1/8	1
	BCO i B	Bit complement (Reference word in Location Y)	2-3 1/8	1
	BSE i B	Bit Set (Reference word in Location Y)	2-3 1/8	1
	SET i B	Set Register B Equal to contents of P + 1 (if i = 1) or contents of address specified by P + 1 (if i = 0)	3-4	
	MSC 3	"Buffer" following Tape Instruction	1	
MEMORY	LMB P	Set Lower Memory Bank to Page P	1	
	UMB P	Set Upper Memory Bank to Page P	1	
SHIFT/ROTATE	ROL i n	Rotate Left	2-4	3
	ROR i n	Rotate Right and into Z	2-4	3
	SCR i n	Scale Right and into Z	2-4	3
SKIP/JUMP	SNS i n	Skip if sense switch n ($0 \leq n \leq 5$) is up	1	2
	SKP i 17	Skip if Flag is set	1	2
	SKP i 16	Skip if Tape Buffer is busy	1	2
	AZE i	Skip if A is zero	1	2
	APO i	Skip if A is positive	1	2
	OVF i	Skip if Overflow during addition	1	2
	IBZ i	Skip if tape is between blocks	1	2
	SXL i n	Skip if external level line n ($0 \leq n \leq 14$) is negative	1	2
	LZE i	Skip if Link-Bit zero	1	2
	ZZZ i	Skip if Bit Zero of Z is zero	1	2

	MNEMONIC CODE		EXECUTION TIME	FOOTNOTE
	PIN i	Skip if Pause interrupted	1	2
	KST i	Skip if key has been struck	1	2
	XSK i B	Skip if Register B ($0 \leq B \leq 17_8$) is 1777_8. Index register first if i = 1	2 1/8	1
	SAE i B	Skip if A equals contents Y	2-3 1/8	1
	SRO i B	Rotate contents Y; skip if bit 11 is zero	2 1/8 - 3 1/4	1
	SHD i B	Skip if right half A differs from Half of Y	2-3 1/8	1
	JMP X	Jump to register X	2	
IN-OUT	ATR	A to Relay buffer	1	
	RTA	Relay buffer to A	1	
OPR i n, OPR m functions include: Pausing & restarting; Levels produced on output line n; 6-bit code for i n, or m, available on output lines; Gating of digital inputs to A; Clearing of A by external signal; Contents of A available on output lines; Reading contents of console switches into A; Reading of keyboard into A; External control of skip; Eight control pulse outputs.	DSC i B	Display character on scope (pattern controlled by contents of Y)	15-28 1/8	1
	DIS i B	Display point on scope: vertical from A, horiz. from register B	4 1/8	
	SAM i n	Sample and A/D convert signal on input line n ($0 \leq n \leq 17$)	7	
	OPR i n OPR m	Operate channel n or m; pause if i = 1. The OPR instructions are a powerful set of in-out commands which are partially controlled by signals from external devices.	2	4
	ENI	Enable Interrupt	1	
	MSC 7	Disable Interrupt	1	
TAPE	RDC i u	Read and check block	2 + Pause	
	RCG i u	Read and check group of blocks	2 + Pause	
	RDE i u	Read block	2 + Pause	
	MTB i u	Move toward specified block	2 + Pause	
	WRC i u	Write and check block	2 + Pause	
	WCG i u	Write and check group	2 + Pause	
	WRI i u	Write block	2 + Pause	
	CHK i u	Check tape	2 + Pause	
	0013	Write clock track on unmarked tape	1	

All tape instructions are two-word instructions, with the exception of 0013. The first word specifies the instruction; selects one of two tape units (u = 0, 1); and either stops the tape or lets motion continue after instruction has been carried out (i = 0, 1). The second word specifies the memory quarters (s) and the tape block address (es) involved. A pause until the data transfers are completed is optional (MSC 3).

1 Location Y is specified as follows:
i = 0, B = 0; Y is address given in P + 1
i = 1, B = 0; Y is P + 1
i = 0, $1 \leq B \leq 17$; Y is address in register B
i = 1, $1 \leq B \leq 17$; Y is address in register B after indexing

2 When i = 0, instruction is as stated; when i = 1, condition for skip is reversed

3 n (0 through 17_8) specifies number of places shifted. i [0 or 1] determines whether LINK BIT is included or excluded

4 $0 \leq n \leq 17$, $40 \leq m \leq 77$

COMPETITIVE ANALYSIS

In view of the fact that the new micro-LINC-300 and the DEC LINC-8 are both based on the original LINC (Laboratory Instrument Computer) developed at M.I.T. and Washington University, there has been occasional confusion, with some people believing that the two machines are fundamentally the same. This discussion is intended to give a prospective user a factual view of the principal differences of these two machines.

DEC upgraded the original LINC concept by melding a portion of a LINC with their conventional PDP-8. SPEAR, on the other hand, took the LINC concept as originally conceived, and completely redesigned it to extend its capability while retaining the unique qualities of the LINC. These two differing design approaches have a direct effect on the relative power of the machines, as well as an impact on the degree of difficulty placed on the user. Comparative specifications and a brief user discussion follow:

In order to use the LINC-8 as a LINC, it is essential that you load an interpretive routine (PROGOFOP) in for LINC programs. This occupies 25% of core memory, thereby reducing the useful size of the core memory. Many people have also presumed that, since a FORTRAN compiler is available for the LINC-8, this is then suitable for the LINC portion of the LINC-8; but this is not the case. The FORTRAN compiler has no bearing on any LINC programs. Moreover, it is important to recognize that virtually any FORTRAN compiler in a 4,000-word core memory machine is virtually useless. This is due to the fact that the FORTRAN compiler must be abbreviated to fit within a 4,000-word memory, thereby eliminating a great deal of the assumed power; and, secondly, the DEC FORTRAN occupies approximately 75% of memory just for the compiler alone, leaving minimal working area in memory. Users will almost always prefer the powerful arithmetic subroutines which have been developed by Washington University or by various LINC users. These routines are available to LINC-8 and micro-LINC-300 customers alike. One of the major differences between the LINC-8 and the micro-LINC-300 is the fact that, by virtue of the LINC-8 design approach, we are told that it is no longer equivalent in ease of use to the traditional LINC and the micro-LINC-300. It is essential to understand both LINC and PDP-8 programming languages in order for successful utilization. Since the PDP-8 language is inferior to the LINC language, there is no advantage to the user in having to use both; it is merely a restriction placed on the user by virtue of the design approach.

In contrast, none of these limitations exists in the micro-LINC-300. The machine has a few instructions beyond the traditional LINC repertoire, to take advantage of the greater capability; but, beyond this, the matter in programming and operating is directly relatable to the traditional LINC approach.

There are numerous additional differences in the programming and operation of the two machines which are often subtle but significant to the user. These should be carefully investigated and evaluated. The following is a comparison of some of the operating characteristics of the two machines. LINC-8 specifications were taken from the DEC Small Computer Handbook.

MICRO-LINC-300	LINC-8
Buffered Tape	No Buffered Tape
This is a major addition to the LINC design concept to maximize the advantages of the low cost tape storage. This permits parallel processing while tape operations are being carried out.	LINC program processing ceases during tape operation.
Speed: 1 microsecond	1.5 microsecond
Note: Micro-LINC-300 is apparently only 50% faster. However, a comparison of instruction execution times shows the micro-LINC-300 to be a significantly faster, more powerful system.	

	M-L-300	LINC-8
Multiply	14-15 1/8 usec	33-34.5 usec
Display Character	14-26 usec	75-149 usec
Display Point	4 1/8 usec	18 usec
OPR I/O Control	2 usec	150 usec
Rotate Instruction	2-4 usec	3-13.5 usec
Sample Analog Channel N and A/D Convert	7 usec	21 usec

Rapid Access to Memory RAM Feature	Data Break
Analog to Digital Conversion: 7 usec	21 usec
Sample and hold for each channel	1 sample and hold
Memory: 4,096 words standard	4,096 words standard
Useful memory 25% greater than LINC-8	PROGOFOP reduces useful memory size by 25%