

The System 2200T Central Processing Unit (CPU) offers a unique combination of flexibility, ease of programming, and expandability. The 2200T CPU can be configured with a wide range of peripherals, thus providing a system versatile enough to meet many diversified processing needs.

The CPU contains two types of memory: user memory and control memory. The control memory is read-only memory (ROM), which is used *exclusively* by the operating system and BASIC interpreter. Each CPU contains approximately 42.5K of control memory. The "memory size" of the system refers to the size of *user memory only*. User memory is random access memory (RAM); the 2200T supports from 16K (16,384) bytes to 32K (32,768) bytes of user memory. Approximately 700 bytes of user memory are reserved by the system for "housekeeping" purposes; the remainder is available for user programs and data.

The standard CPU contains 16K bytes of user memory and six input/output (I/O) slots. (Controller boards for peripheral devices are plugged into the I/O slots.) The 2200T CPU memory size may be expanded in 8K increments to 32K, thus providing ample storage area for most data processing needs. Users with a need for a great number of peripheral devices can order the 2200T with Option 20A in which 9 I/O slots are available.

Numerous other options, peripherals and controllers are also available to custom-configure a system to meet user needs.

A telecommunications capability is provided by the Model 2227B controller (which supports only asynchronous protocols), or by the Model 2228B and Model 2228C controllers (which support synchronous or asynchronous type protocols).

Wang offers the Model 2207A I/O Interface Controller (RS-232-C Compatible, Selectable BPS), the Model 2250 I/O Interface Controller (8 bit parallel), the Model 2252A Scanning Input Interface Controller (BCD 1-10 digit parallel), and the Model 2254 IEEE-488 Interface Controller to cover a wide variety of requirements for non-Wang instrument interfacing.



## SYSTEM 2200 T CENTRAL PROCESSOR UNIT

## 2200T INSTRUCTION SET

### GENERAL BASIC STATEMENTS, COMMANDS, AND FUNCTIONS

#### BASIC Commands

A BASIC command provides the user with a means of controlling the system. A BASIC command facilitates the running or modifying of a program, but is not part of the program. The BASIC commands are:

CLEAR	HALT/STEP	RENUMBER	RUN
CONTINUE	LIST	RESET	LOAD

#### BASIC Statements

A BASIC statement is a programmable instruction. BASIC statements are used to construct BASIC programs. The 2200T provides a BASIC instruction set consisting of a variety of general-purpose statements as well as an assortment of statements and functions used for special applications. Some general-purpose BASIC statements are:

COM	IF END THEN	READ
COM CLEAR	IF THEN	REM
DATA	(%)Image	RESTORE
DEFFN	INPUT	RETURN
DEFFN'	KEYIN	RETURN CLEAR
DIM	LET	SELECT
END	NEXT	STOP
FOR	ON GOTO/GOSUB	TRACE
GOSUB	ON ERROR	
GOSUB'	PLOT	
GOTO	PRINT	
	PRINTUSING	

The Wang BASIC instruction set contains, in addition to statements most commonly found in BASIC languages, a number of additions which extend the power and versatility of 2200T programming and data processing capabilities. For example, the PRINTUSING and % (Image) statements permit easy and concise formatting of printed reports that include leading dollar signs (\$), commas, and decimal point insertion. The COM and COM CLEAR statements allow the efficient use of memory for passing variable data between overlaid program modules. A number of statements permit extensive customization of the keyboard and display for program data entry. These statements include KEYIN (receives one keyboard character), and DEFFN' (use the 16 keyboard Special Function Keys to execute program subroutines, continue program execution at various points, and enter predetermined text strings of alphanumeric or hexadecimal characters). GOSUB' permits the passing of arguments to subroutines, PLOT provides flexible and efficient

plotting capabilities, and ON ERROR allows error recovery processing under program control.

#### Data Manipulation Statements and Functions

The Wang BASIC instruction set contains a number of statements to perform bit and byte manipulation, binary and logical arithmetic, and data searching and conversion. These statements permit the conversion, editing, and efficient use of data. The BASIC Data Manipulation and Function Statements are:

ADD	LEN	\$PACK
AND, OR, XOR	NUM	\$UNPACK
BIN	PACK	\$TRAN
BOOL	POS	
CONVERT	ROTATE	
HEX	STR	
HEXPRINT	UNPACK	
INIT	VAL	

The AND, OR, XOR and BOOL instructions perform all logical Boolean operations on two specified arguments. The BIN statement converts the decimal system value of an expression into a binary value and stores the results in a named alphanumeric value; VAL performs the inverse operation. To set every byte in one or more specified arguments equal to an indicated value, the INIT statement can be used. The ROTATE statement rotates the bits within each byte of a specified alphanumeric variable a designated number of positions.

The POS statement allows efficient searching of alphanumeric data. The great power of the bit/byte manipulation statements and functions reduces programming requirements for many data processing and data reduction applications. The \$TRAN statement provides a high-speed character conversion capability implemented by a table look-up procedure or the replacement of specified characters. The \$PACK and \$UNPACK statements are designed to facilitate data packing and unpacking, by fields or delimiters, between a specified alphanumeric array buffer and specified BASIC numeric and/or alphanumeric variables in an argument list.

### ADVANCED BASIC STATEMENTS

#### Math Matrix Statements

These instructions perform matrix input/output and arithmetic operations such as addition, subtraction, multiplication, inversion and transposition. Array default dimensions are 10 by 10 with an alphanumeric element default size of 16 bytes. Redimensioning of arrays is automatic for many arithmetic matrix operations. The math matrix statements are:

BACKSPACE      LIST DC  
 DSKIP            VERIFY  
 SCRATCH DISK    LIMITS

The Absolute Sector Addressing statements are:

DATALOAD BA      COPY  
 DATASAVE BA      LOAD DA  
 DATALOAD DA      SAVE DA  
 DATASAVE DA

The Automatic File Cataloging mode provides rapid access to cataloged files on the disk. Catalog mode permits the user to save and load program and data files by name, without concern for where or how the files are actually stored on the disk. The system itself automatically keeps track of the size and location of each file.

Absolute Sector Addressing mode consists of

statements which permit the programmer to address specific sectors on the disk directly, thus enabling him to design his own disk operating system. Two of the eight Absolute Sector Addressing Mode instructions are special statements which can be used to read or write one sector (256 bytes) of unformatted data. These special statements enable the programmer to write his own control information in individual sectors.

### Program and Data Storage and Retrieval

The DATALOAD BA and DATASAVE BA disk statements enable the programmer to save and load records which do not contain standard System 2200T control information.

Since records saved and loaded in this manner are not automatically formatted by the system, the programmer is free to write his own control information and format his records in a manner appropriate for his application.

The DATALOAD DC or DA and DATASAVE DC or DA disk statements easily command read and write lists of variables and arrays from or onto a disk without preformatting.

Programs or specified sections of programs can be recorded on disk for future use. Stored programs can be identified by an alphanumeric name and then retrieved by searching for the specified program with the LOAD DC command. Programs can be loaded under operator or program control.

When several program modules are to be overlaid, variables used by all modules can be defined with a COM statement. Such variables are automatically passed from one module to the next. The COM CLEAR statement removes these variables and arrays when they are no longer needed by subsequent modules.

MAT addition

MAT CON

MAT IDN

MAT INPUT

MAT INV'D

MAT multiplication

MAT PRINT

MAT READ

MAT REDIM

MAT scalar multiplication

MAT subtraction

MAT TRN

MAT ZER

### Sort Statements

Wang BASIC also contains six matrix operations designed to facilitate the sorting, searching and moving of data. MAT CONVERT, MAT SORT, MAT MERGE and MAT MOVE are primarily used for data sorting operations. MAT SEARCH along with MAT MOVE provides a powerful capability to do statistical searching of data and text edit searching. Segments of data can be moved with the MAT COPY statement. The six SORT statements are:

MAT CONVERT

MAT COPY

MAT SEARCH

MAT MOVE

MAT MERGE

MAT SORT

### General I/O Statements

Two special statements are provided to perform custom I/O operations and data conversion:

\$GIO

\$IF ON

The \$GIO statement employs a technique similar to machine language programming to custom-tailor I/O operations sequences which are executable within the framework of the high-level BASIC language. \$GIO can be used to support the operation of non-Wang devices interfaced to a System 2200T via the Models 2207A, 2250, 2252A, and 2254 interface controllers. The \$IF ON statement is designed to test the device-ready condition of a specified output device or test the data-ready condition of a specified input device and initiate a branch to a specified line number if a ready or busy condition is sensed.

### Disk Statements and Commands

The 2200T can address several disk devices. With the 23 statements and commands in the disk instruction set, the System 2200T can control the Models 2260BC and 2260C Fixed/Removable Disk Drives, the Models 2270 and 2270A Diskette Drives, and minidiskette. The Automatic File Cataloging Mode statements are:

DATALOAD DC

DATALOAD DC OPEN MOVE

DATASAVE DC

DATASAVE DC CLOSE SAVE DC

DATASAVE DC OPEN SCRATCH

## ARITHMETIC OPERATORS, RELATIONAL SYMBOLS, AND MATHEMATICAL FUNCTIONS

Arithmetic operations are performed with an accuracy of 13 digits. Most trigonometric and exponential functions are calculated to 12 digits of accuracy. Calculations are performed over a range of  $10^{-99}$  to  $10^{99}$ .

### Arithmetic Operators      Relational Symbols

↑ exponentiation	<	less than
* multiplication	≤	less than or equal to
/ division	>	greater than
+ addition	≥	greater than or equal to
- subtraction	< >	not equal
= equal		

### Mathematical Functions

LOG	— natural logarithm
ABS	— absolute value
SQR	— square root
RND	— random number
INT	— greatest integer function
SGN	— assigns 1 if positive, 0 if zero, or — 1 if negative
#PI ( $\pi$ )	— 3.14159265359
EXP	— $e^x$
SIN	— sine*
COS	— cosine*
TAN	— tangent*
ARCSIN	— arc/sine*
ARCCOS	— arc/cosine*
ARCTAN	— arc/tangent*

(\*trig arguments: degrees, radians, gradians)

### Variables

Up to 286 variable names can be assigned to each of the following: simple numeric variables, numeric array variables, string variables and string array variables. Either one- or two-dimensional numeric or alphanumeric string arrays can be used, dimensioned to a maximum of 255.

The lengths of alphanumeric variables and array elements are defined from 1 to 64 bytes, with a 16-byte default size.

## SYSTEM 2200T FEATURES

### Immediate and Program Modes

In the immediate mode, the user may enter un-numbered BASIC statements as one-line calculations. Multistatement lines can be entered and executed

without altering programs resident in memory, thus allowing the system to be used as a calculator.

- The system also processes numbered multistatement lines, which save keystrokes and memory in program mode.
- A total of 16 user-defined Special Function Keys can be used for single-keystroke access of up to 32 subroutines, program entry points, program functions, or entry of character strings, and pass multiple arguments to subroutines.
- The amount of unused memory is indicated on the CRT when the END statement is included at the completion of a program or at any time during immediate mode operation.

### Device Selection

- The SELECT statement to select a device for particular I/O operations (PRINT, DISK) is used both in the immediate mode and under program control.
- Device selections are maintained independently for input and output operations, allowing programs to be modified easily to work with any I/O device.
- Sector address parameters for up to 7 independent disk data files can be concurrently maintained in memory.

### Plotting Operation

- A powerful BASIC statement, PLOT controls any of the plotting devices offered with the System 2200T.
- The PLOT statement directs the plotting element to move the specified distance and then plot.

### Editing, Debugging, and Error Diagnostics

- When errors occur during program entry or execution, the program line is displayed and a Diagnostic Error Pointer/Error Code indicates the approximate location in the program line where an error is made and identifies the cause of the error with a specific code number.
- The programmable TRACE mode traces the program, thus producing a printout or display whenever a program variable receives a new value or a program transfer is made.
- The HALT/STEP key executes and displays one program statement each time it is



- set of 96 characters includes uppercase and lowercase characters, numerics, and special characters. The 2221W also produces highlighted print of double width characters under program control.
- Model 2231W-1 Line Printer (112 columns) is a 10-pitch, 120 characters/second (60 to 300 lines/minute), 9-by-7 dot matrix printer. Its ASCII set of 96 characters can be generated under program control in upper- or lower-case, and highlighted double width.
  - Model 2231W-2 Line Printer (132 columns) is a 12-pitch, 120 characters/second (60 to 300 lines/minute), 9-by-7 dot matrix printer. Its ASCII set of 96 characters can be generated under program control in upper- or lower-case and highlighted double width.
  - Model 2231W-3 Line Printer (132 columns) is a 10-pitch, 120 characters/second (60 to 300 lines/minute), 7-by-8 dot matrix printer. The 2221W-3 is an accessory to the 2282 Graphic CRT only. When attached to the Model 2282 Graphic CRT, the 2231W-3 provides an accurate hardcopy of the graphic information on the CRT.
  - Model 2231W-6 Line Printer (132 columns) is a high density 20-by-12 dot matrix printer which produces typewriter-like quality output at the rate of approximately 70 characters/second (45 to 250 lines/minute). Its set of 96 characters includes upper- and lowercase characters, numerics, and special characters.
  - Model 2232B Digital Flatbed Plotter (31"x48") offers continuous line or print plotting of curves or data. The plotter uses any type paper. Fiber tip, ballpoint, or drafting pens may be used. The 2232B provides plotting in metric increments.
  - Model 2251 Line Printer (40 columns) is a 110 characters/second, 7-by-8 dot matrix printer. The 2251W prints a full ASCII set of 112 characters in both upper- and lower-case from a program-selectable red/blue ribbon.
  - Model 2261W High Speed Printer (132 columns) is a 220 lines/minute, 11-by-8 dot matrix printer. The 2261W uses four bidirectional printing heads to print a full set of 96 ASCII characters with expanded print capability.
  - Model 2263-1 "chain-type" Line Printer prints 400 lines/minute, 6 lines/inch, 132 characters/line using 64 upper- and lower-case ASCII characters.
  - Model 2263-2 "chain-type" Line Printer prints 600 lines/minute, 6 lines/inch, 132 characters/line using 64 upper- and lower-case ASCII characters.
  - Model 2272-2 Triple Pen Drum Plotter offers point, continuous line, and alphanumeric plotting. Its 64 ASCII character set may be output in 15 selectable sizes. The plot may be positioned and repositioned with the four selectable coordinate axis settings. Metric versions are also available.
  - Model 2281P Plotting Daisy Output Writer is a daisy character wheel printer which functions as a digital plotter and an output writer. It bidirectionally prints an 86-character ASCII set containing upper- and lower-case letters, numerics and symbols at 30 characters/second. The 2281P can generate output in 10-pitch (132 characters/line) or 12-pitch (157 characters/line).
  - Model 2282 Graphic CRT provides CRT plotting and alphanumeric lettering. When used with the Model 2231W-3 Line Printer, the 2282 Graphic CRT provides an accurate reproduction of the graphics information displayed on the CRT.
  - Model IP41L Image Printer is a page printer which prints 18 pages/minute in 10-, 12-, or 15-pitch. Three character fonts (two fixed and one loadable) may be combined per page. The printer offers portrait (vertical) and landscape (horizontal) printing capabilities on 8 1/2" x 11" or 8 1/2" x 14" single sheet (16-32 lb) paper.
  - All hardcopy peripherals except the 2232B can be connected to triple controller 22C31.
  - The Model 2221M printer multiplexer allows up to four print sources to share a single printer.

#### Input Peripherals

- Model 2244A Hopper-Feed Mark Sense/Punched Card Reader reads up to 300 cards/minute and can stack 500 cards in the input and output hoppers. The Model 2244A reads standard 80-column punch cards, 80-column optical mark sense cards

without clock marks (either punched or marked in pencil), and optical mark sense cards with timing marks and 80 columns or less of data (punched or marked). Data can be in Hollerith or binary code, and programs can be in Hollerith code.

### Mass Storage Peripherals

- Models 2209 and 2209A Nine-Track Tape Drives offer IBM compatible nine-track capability to the System 2200T. Written tapes conform to ANSI standards. Read-after-write and single track error correction capabilities are provided. The units accommodate tape reels up to 10.5 in. (26.7 cm) in diameter. The Model 2209A is 1600 BPI phase encoded. The 2209 is 800 BPI NRZ1.

- Model 2230MXA-1/B-1 Disk Multiplexer provides multiplexing capabilities that enable a single disk unit to be shared by a maximum of four separate 2200 systems. Multiple CPUs can share a common data base for efficient file interrogation and updating. Systems multiplexed to a disk via the 2230MX A-1/B-1 are connected in a daisy-chain; the maximum length of the chain is 500 feet.

- Model 2260BC Fixed/Removable Disk Drive is available in four versions that provide storage for up to 20 megabytes of information. Storage is divided equally between fixed and removable platters. The 2200BC Disk Drive can be multiplexed up to four 2200 systems.

- Model 2260C Fixed/Removable Disk Drive is available in four versions which provide storage for up to 20 megabytes of information. Storage is divided equally between fixed and removable platters. The 2260C is a desktop unit with an optional stand.

- Model 2270 Diskette Drive is available in one, two, and three drive configurations, each supporting a capacity of approximately 1/4 megabyte. The 2270A is a 2270 series diskette drive modified to accept both Wang and IBM diskettes.

### Telecommunications

- The Model 2227B Buffered Asynchronous Communications Controller adds data transmission and reception capabilities to

the standalone computer capabilities of the 2200T CPU. With the controller, the 2200T CPU can be user-programmed to emulate a variety of asynchronous terminals, or to communicate with another comparably-equipped Wang system. Wang-developed asynchronous communications software is available.

- The Model 2228B Synchronous Communications Controller can emulate the binary synchronous communications protocol of IBM 2780, 3780, or 3741 terminals, and HASP multileaving workstations. Wang-developed terminal emulator software automatically loads the microcode defining synchronous protocol tasks into the controller. With the controller and one of the BSC protocols, the 2200T CPU can operate as a remote batch terminal or a workstation in communication with an IBM 360/370 host computer and require no changes in existing IBM 360/370 software, or the 2200T CPU can communicate with any mainframe computer which supports the 2780, 3780, 3741, or HASP multileaving protocols.
- The Model 2228C Synchronous/Asynchronous Communications Controller can emulate the binary communications protocol of IBM 3275 as well as 2780, 3780, and 3741 terminals.

### Instrumentation Interfacing

- The Model 2207A I/O Interface Controller allows the following non-Wang equipment to be interfaced directly to a 2200T CPU:
  - an RS-232-C compatible teletype, or
  - a teletype equivalent terminal, or
  - an RS-232-C compatible asynchronous transmission laboratory instrument.

- The Model 2250 8-Bit-Parallel I/O Interface Controller facilitates direct connection of a non-Wang device to a 2200T CPU for an on-line instrumentation application where data transfer is to be serial-by-character and parallel-by-bit. The non-Wang device may be one of the following types: (1) input only, (2) output only, or (3) input and output.

- The Model 2252A Scanning Input Interface Controller (BCD 1-to-10 Digit Parallel) is an input-only interface directly compatible with

many digital meters for on-line applications using the System 2200T CPU. The interface accepts, in parallel, a readout consisting of a sign-bit and up to ten BCD digits or up to 41 bits of discrete data. Four "number of digits" switches are provided to indicate the exact number of BCD digits (or the number of 4-bit groups of discrete binary data) to be processed per readout. The number-of-digits selectivity feature offers two advantages for applications involving readouts of fewer than 10 BCD digits: less time is required to transfer each readout to the CPU and less memory is required when storing multi-readouts in alphanumeric arrays.

- The Model 2254 IEEE Interface Controller allows a 2200T CPU to be compatible with other devices using the IEEE 488-1975 standard. Digital information is transferred between systems components in byte serial and bit parallel modes along with BUS control and management information.

The Model 2254 supports Controllers, Listeners, and Talkers/ Listeners.

**Software**

Wang Laboratories, Inc., provides an extensive software library which is continually updated and expanded to meet the changing needs of the user. Our software library is divided into six application areas: Business; Education; Medicine; Public Service; Science, Engineering, and Mathematics; and Utilities. Each application area consists of a number of systems to fit varying needs.

**SPECIFICATIONS**

**Average Execution Time (milliseconds)\***

Add/Subtract .....	0.8
Multiply .....	3.8
Divide .....	7.4
Square Root .....	46.4
e <sup>x</sup> .....	25.3
log .....	23.2
x <sup>4</sup> .....	45.4
Integer Value .....	0.24
Absolute Value .....	0.25
Sign .....	0.25
Sine .....	38.3
Cosine .....	38.9
Tangent .....	78.5
Arctangent .....	72.5
Read/Write Cycle .....	1.6 msec

**Memory Size**

16K — 32K (in 8K increments)

**Power Requirements**

115 or 230 VAC = 10%, 50 or 60 Hz = 1/2 Hz

**Wattage**

220W

**Fuse Size**

3ASB @ 115V  
1.5ASB @ 230V

**Operating Environment**

50°F to 90°F (10°C to 32°C)  
20% to 80% relative humidity, noncondensing, allowable  
35% to 65% relative humidity, recommended

**Size of 2200T CPU**

Height ..... 9.8 in. (24.8 cm)  
Depth ..... 21 in. (53.3 cm)  
Width ..... 14.5 in. (36.8 cm)

**Weight**

40lb(18kg)

\*Average execution times determined using Random Number Arguments with 13 digits of precision. Speeds are generally faster in calculations with arguments of less precision.

**ORDERING SPECIFICATIONS**

A keyboard programmable Central Processing Unit (CPU) with hardwired BASIC language interpreter. The CPU must have at least 16,384 bytes of memory, expandable in 8,192-byte modules to 32,588 bytes. The character EDIT mode, Disk Instruction Set, General I/O Instruction Set, SORT Instruction Set, and MATRIX Instruction Set must be standard features. The CPU must be capable of supporting all Wang Laboratories, Inc., peripherals and ancillary equipment presently available and the following options: Option 20A 9 I/O slots; Option 31 Audio Signal for 2210 & 2226 CRT; and Option 32, Keyboard Clicker.



LABORATORIES, INC.

ONE INDUSTRIAL AVENUE, LOWELL, MASSACHUSETTS 01851, TEL. (617) 851-4111, TWX 710 343-6769, TELEX 94-7421