MODEL 2200 SERIES
OPTION 2250
PARALLEL INPUT/OUTPUT INTERFACE SPECIFICATION

1.0 INTRODUCTION

The 2250 PARALLEL INPUT/OUTPUT INTERFACE option allows external equipment to be interfaced directly to a 2200 Series Advanced Programmable Calculators. The option consists of an interface controller card which can be plugged directly into one of the six I/O connector slots in the 2200 CPU chassis or a 2219 I/O Extender chassis. A 36 pin female amphenol connector is mounted on this controller card to facilitate connection to external devices. Via this connector, sequential characters of parallel 8bit data can be transmitted from or received by the 2200 under program control. Either an input device, an output device or an input/output device can be interfaced with the 2250. It is also possible to transmit and receive 2200 Basic programs in ASCII character format.

Data transfers rates of up to 10,000 characters per second can be handled, under certain conditions.

The 2250 can be used with either the 2200A or 2200B. With the 2200A transmitted and received data is generally more limited to restriced data formats and the ASCII character codes and signal conventions. With the 2200B, a special General I/O Command option is available which allows extremely flexibility interface conventions and data format.

2.0 SCOPE

The information is of special interest to those who wish to interface other devices to the Model 2200 Series. The specifications describe the signals and signal functions required and appearing at the input/output connector under a variety of operations. The information is concerned primarily with the input/output connector, and associated programming control features of the Model 2200. Circuitry within the electronic unit beyond the input/output connector is considered proprietory and confidential, therefore, internal schematics are not included within these specifications.

Figure 1 2250 INPUT/OUTPUT CONNECTOR PIN DIAGRAM

NAME	PIN NO.	REMARKS
		INPUT DATA FROM EXTERNAL DEVICE (Buffered)
$\overline{IB_5}$	1	10 — HIGH ORDER
$\overline{IB_6}$	2	20
$\overline{IB_7}$	3	40
$\overline{IB_8}$	4	80
$\overline{IB_1}$	5	10 — LOW ORDER
$\overline{IB_2}$	6	20
$\overline{IB_3}$	7	40
$\overline{IB_4}$	8	80
$\overline{IBS}$	9	INPUT STROBE FROM EXTERNAL DEVICE
$\overline{PRMS}$	10	PRIME OUTPUT
$\overline{ENDI}$	11	END OF INPUT CONTROL LEVEL
	12	1 — CONTROL INFORMATION OUTPUT (Buffered)
	13	2
	14	4
	15	8
$\overline{CBS}$	16	CONTROL OUTPUT STROBE
$\overline{IRB}$	17	INPUT BUFFER READY/BUSY
$\overline{ACK}$	18	OUTPUT DEVICE ACKNOWLEDGE
$\overline{RB}$	19	OUTPUT DEVICE READY/BUSY

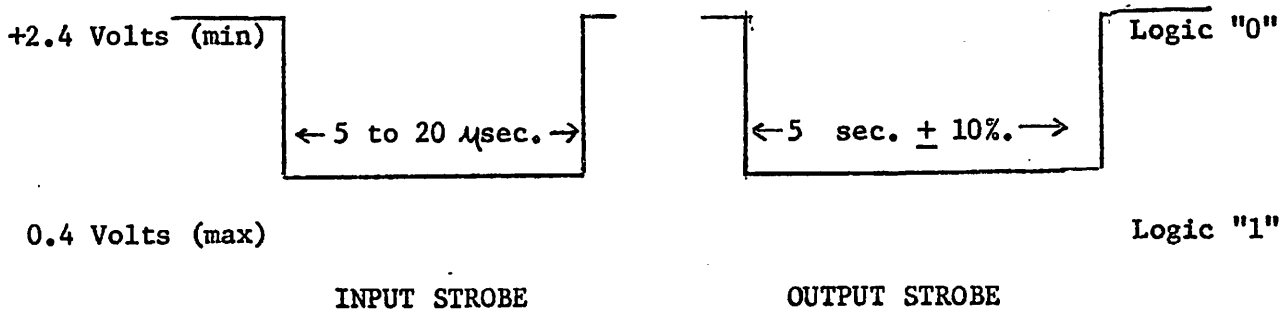
NAME	PIN NO.	REMARKS
		DATA OUTPUT (Buffered)
$\overline{OB_1}$	20	1 — LOW ORDER
$\overline{OB_2}$	21	2
$\overline{OB_3}$	22	4
$\overline{OB_4}$	23	8
$\overline{OB_5}$	24	10 — HIGH ORDER
$\overline{OB_6}$	25	20
$\overline{OB_7}$	26	40
$\overline{OB_8}$	27	80
$\overline{DORB}$	28	DATA OUTPUT BUFFER READY/BUSY LEVEL
	29	Spare
	30	Spare
$\overline{OBS}$	31	OUTPUT DATA STROBE
$\overline{CRB}$	32	CPU Ready/Busy
+0V	33	Common
+0V	34	Common
±0V	35	Common
Chassis Ground	36	Chassis Ground

FIGURE 1

3.0 SIGNAL LEVELS

3.1 Input/Output circuitry is TTL/DTL compatible.
3.2 Voltage levels for a logic "0" are between +2.4 to 3.6 volts.
3.3 Voltage levels for a logic "1" are between 0 to 0.4 volts.
3.4 Input and Output strobe pulses:

3.4.1 Input strobe pulse width can be 5 to 20 microseconds.
3.4.2 Output strobe pulse width is 5 microseconds, ± 10%.



INPUT STROBE OUTPUT STROBE

4.0 I/O CONNECTOR

The following pin diagram (Figure 1) shows signal location and code format used on the I/O amphenol connector P/N 57-40360. An open pin connection is equivalent to a logic "0" level (no signal).

4.1 DESCRIPTION OF I/O CONNECTOR SIGNALS

PINS	NAME	
1 - 8	$\overline{IB_1}$ thru $\overline{IB_8}$	Buffered Input Data From External Device. Data levels from an external device are made available on these pins for input to the 2250/2200.
9	$\overline{IBS}$	Input Strobe From External Device. When an input strobe is made available on this pin from an external device, the 8 input data levels (pins 1 - 8) are strobed into an 8 bit buffer on the 2250 interface, (or directly into the 2200 if the 2250 interface card is currently enabled by the 2200). The data in the input buffer will be subsequently automatically strobed into the CPU, when the 2250 card is enabled by the 2200, and the $\overline{CRB}$ (CPU Ready/Busy) level is set to logic "0", (Ready) by the 2200.
10	$\overline{PRMS}$	Prime Output. This output strobe is produced when the reset button on the 2200 is depressed This is generally used to reset and initialize the 2200 system and all peripherals.
11	$\overline{ENDI}$	This is an input data level which is set to logic "1" during an Input strobe, it can signal the End of Input when the General 2200B Input/Output Commands are used. (It should be permanently tied to logic "0" if this means of input termination is not used).
12 - 15	$\overline{COB_1}$ thru $\overline{COB_8}$	Control Information Output (Buffered). The 2250 contains a 4-bit output buffer which can be used to receive and hold 4 bits of control information. The levels from this buffer are available on pins 12 thru 15. This control buffer is normally loaded using 2200B General I/O Commands option. The buffer is loaded by a Control Output Strobe, $\overline{CBS}$, which is also available on the 2250 connector, (Pin 29). (When the $\overline{CBS}$ strobe is output the low order 4 bits of the 8-bit character output from the 2200 is strobed into this buffer. (The full 8 bits are also strobed into the Data Output Buffer, pins 20 thru 27).

In applications were the General I/O Command option is not available, a jumper wire on the 2250 will enable the buffer to be loaded via a normal Output Data Strobe, when the controller board is enabled with an Input address, (low order bit = 0).

16 $\overline{CBS}$ Control Output Data Strobe.
An additional 5 μsec 2200 output strobe that can be generated by the General I/O Commands in the 2200B. This strobe also loads both the Control Information Output Buffer and the Output Data Buffer on the 2250.

17 $\overline{IRB}$ Input Buffer Ready/Busy. When the 2250 input buffer contains a character, this level is set to a logic "1", (Ready). It can be used to control input, if it is undesirable to override a character in cases where the 2200 is not immediately available to receive the character, such as when scanning several input devices. It is set to logic "1" when the input buffer is loaded with a character by an input strobe from the device and reset to logic "0" when the character is strobed into the 2200.

18 $\overline{ACK}$ Output Device Acknowledge.
This pin can be used by an output device to strobe back an acknowledgement of each received character. This input strobe will reset the Data Output Buffer Level, pin 28, back to logic "0", (not Ready), in cases where longer output strobes are required.

19 $\overline{RB}$ Output Ready/Busy.
This is a pin available for a Ready/Busy D. C. level signal from External Output devices. The 2250 logic makes this signal available to the 2200 for testing when the 2250 interface is enabled by the 2200 with an output address. (Lower order address bit = logic "1"). The 2200 can be programmed to check this level for output operations, and will not generate an output strobe until a ready, logic "0" is sensed. (When each output character is acknowledged, via pin 18, $\overline{ACK}$, $\overline{RB}$ can be connected to pin 28, output buffer Ready/ Busy to produce to Ready).

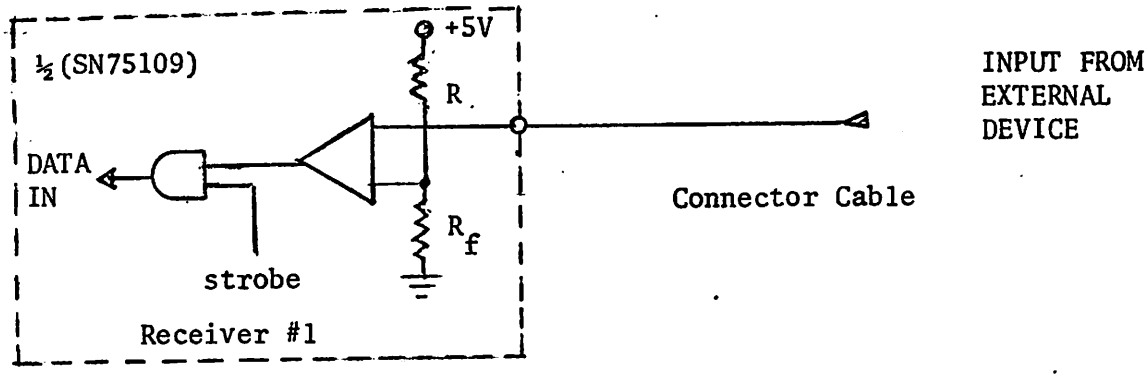
20 - 27	$\overline{OB}_1$ thru $\overline{OB}_8$	Data Output (Buffered). These 8 data levels reflect the contents of the Data Output Buffer on the 2250 Interface Card. During output operations, the Data Output Buffer is loaded with data strobed from the 2200. At the same time a 5 μsec Data Output strobe becomes available on pin 31, and the Data Output Buffer Ready/Busy level, pin 28, is set to logic "1", (Ready). When the output device indicates ready, the 2200 generates the next output.
28	$\overline{DORB}$	Data Output Buffer Ready/Busy. This pin can be used for an output strobe from the 2200/2250, when a device requires a longer output strobe. When the 2200 strobes data into the 2250 output buffer, a level on this pin is set to logic "1", (Ready). The device can then reset this level by inputting an acknowledge strobe on pin 18.
29		Spare
30		Spare
31	$\overline{OBS}$	Output Data Strobe. This pin provides a 5 μsec microsecond output strobe when 8-bits of data is strobed out from the 2200 to the 2250 Data Output Buffer. It is the standard means of outputting from the 2200/2250. (For outputs requiring longer strobes, the Output Buffer Ready/Busy level, pin 28, can be used and reset by the output device via an input strobe on pin 18, Output Device Acknowledge).
32	$\overline{CRB}$	CPU Ready/Busy. This pin contains a level which indicates whether the 2200 is ready to receive input strobes from the connected device. (Logic "0" = Ready). Since the 2250 contains an input buffer, this condition may not be necessary for devices which input asynchronously as slow data rates, but is generally necessary for normal data input. The Ready condition indicates that both the 2200 is awaiting input and the 2250 interface card has been enabled.

33	±0V	Common
34	±0V	Common
35	+0V	Common
36		Chassis Ground

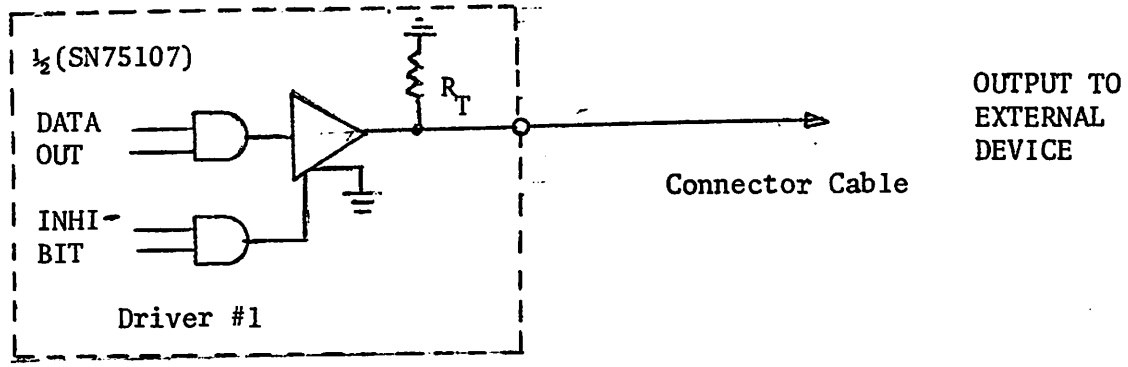
5.0 TYPICAL INPUT/OUTPUT CIRCUITS: (TTL/DTL Compatible)

Logic "0" = +2.4 to 3.6 volts
Logic "1" = 0 to 0.4 volts

5.1 INPUT CIRCUIT



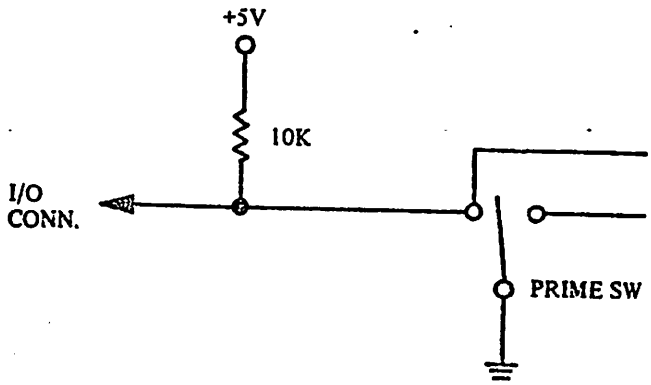
5.2 OUTPUT CIRCUIT



This single connecting wire system is adequate for short lines up to 100 feet where environmental noise is not severe.

The Input/Output circuitry in External Devices is recommended to use the same type of line driver - receiver or equivalent for minimum transmission error.

5.3 PRIME OUTPUT



6.0 CODE FORMAT

6.1 2200 BASIC DATA CODE FORMATS

The 2200A and 2200B offers an extremely powerful versions of the BASIC program language as the native programming language. The normal code format in which data is transmitted and received is 7-bit ASCII code with the 8th bit set to 0. Because, however, the language is so flexible, it is possible to convert data by programming to and from any code format and number format in BASIC. Therefore data can be transmitted or input in any single or packed 8-bit code format, EIA, 2 BCD digits, etc.

The 2200B offers a number of built-in bit and byte manipulation, and number conversion language features. If the overall speed at which numbers are to be converted or formatted is system design criteria, the 2200B should be considered instead of the 2200A. For example, the typical time required to specially format or convert a number with 2200A language feature would be approximately 50 milliseconds for a 4 digit number. On the 2200B, this could be done in 5 to 10 milliseconds.

2200 Basic programs could also be received or transmitted via the 2250 interface. These would be generally in ASCII code format.

The voltage level for 0 and 1 bit logic levels for the 2250 interface as follows:

Logic Level 0 : 2.4 volts
Logic Level 1 : 0.4 volts

Therefore typical code formats and logic levels for 2200 program or data 8-bit codes might be

CODE									
ASCII "A"	Logic Level:	0	1	0	0	0	0	0	1
	Voltage Level:	2.4	0.4	2.4	2.4	2.4	2.4	2.4	0.
ASCII "5"	Logic Level:	0	0	1	1	0	1	0	1
	Voltage Level:	0.4	0.4	2.4	2.4	2.4	0.4	2.4	0.
Packed BCD "34"	Logic Level:	0	0	1	1	0	1	0	0
	Voltage Level:	2.4	2.4	0.4	0.4	2.4	2.4	0.4	0.
Hexadecimal "7B"	Logic Level:	0	1	1	1	1	0	1	1
	Voltage Level:	2.4	0.4	2.4	0.4	0.4	2.4	0.4	0.

7.0 GENERAL I/O SEQUENCE

The 2200 is programmed in a high level language, Basic. A single Basic I/O statement in the 2200 is designed to complete an entire input or output operation sequence including enabling the controller for a peripheral device, transmitting a given amount of data from specified program variables or receiving a given amount of data and storing it in specified program variables, and then disabling the controller at the end of the operation. This section will describe several I/O signal sequences that typically result when using the 2250 for input/output operations, and the general characteristics of the 2250. Later sections will describe 2200 Basic statements available to produce the I/O operation and specific details on each.

7.0.1 2250 ENABLE LOGIC

The 2250 contains 7 address switches. They are used to set a device address on this interface card. The program language provides the ability to specify a device address within an I/O statement, or select the address indirectly by means of the SELECT statement or #N file designators. When the I/O statement is executed, the device address is strobed internally from the 2200 I/O bus to enable the controller card for a peripheral, (including the 2250). When the I/O operation is complete, a similar strobe disables the card. This is done automatically and does not require device interaction or programming control. When the 2250 is enabled, signal levels and strobes are gated between the 2200 I/O bus and the 2250 connector. When the 2250 is not enabled these levels and strobes are inhibited. Thus the 2200 and the connected I/O device are protected from other device interaction and noise. For Input Devices, a CPU Ready/Busy signal is available on pin 32 of the I/O connector. When a logic "0" signal is available on this pin, it indicates that the 2200 is waiting to receive data and the 2250 is enabled.

7.0.2 INPUT/OUTPUT SELECTION

The 2250 can be enabled for either Input or Output operations. This is done by utilizing the low order bit of the device address used to enable the card. When the low order bit is logic "0" the card is enabled for input. When the low order bit is logic "1" the card is enabled for output. (An 8-bit address is sent, only the upper 7 bits are used for card addressing purposes).

When enabled for Input the following conditions are set:

The 2200 will sense Ready/Busy from the input buffer Ready/Busy level on the 2250. For normal input operations the 2200 is Ready awaiting input; when information is strobed into the input buffer it is then read immediately into the 2200.

The 2200B, however, does have a command which permits scanning (the card is enabled, a test is made for input ready, and if it is not, processing continues).

When enabled for Output the following condition is set:

The 2200 will sense Ready/Busy from the output device Ready/Busy level provided from the device on pin 19. (In cases where output is acknowledged by an input acknowledge strobe from the device, the level available from the 2250 on pin 28, Data Output Buffer Ready/Busy level, could be tied to pin 19 for this purpose since it is reset by the acknowledgement.

7.1 GENERAL INPUT CHARACTERISTICS

Pins 1 through 8 of the 2250 connector are input data levels. For normal operations, when a 2200 Input statement is executed, the 2200 will strobe an address which enables the 2250, and set a level which indicates it is ready to receive data. A logic "0" level on pin 32 of the connector indicates that both of these conditions are set, (i.e., CPU awaiting data and 2250 enabled). The input device is then free to present a 5 to 20 microsecond input strobe on pin 9 $\overline{IBS}$, along with the data levels on pins 1 through 8 to input the connector. The data will be strobed into the input buffer on the card. For normal input operations, (CPU ready) the information will be immediately strobed into the 2200. When the data is received by the 2200, the CPU Ready/Busy level on pin 32 will be reset to Busy, logic "1". This will occur from approximately 400 nanoseconds to 3 microseconds after the leading edge of the input strobe sent into the 2250 from the device. The CPU Ready/Busy level on pin 32 will remain Busy until the 2200 is ready to receive another character at which time it will be reset back to logic "0". The input device may then strobe in another character.

For input devices which require initialization strobes, a device address, control information, data output strobes to read each character, or termination output strobes, these features are available using the General I/O Commands, (an option on the 2200B) and the Control Output Buffer and Control Output strobe on pins 12 thru 15 and pin 16. (Some of these are possible using Standard Basic commands and a jumper wire on the 2250). The control output buffer on the 2250 is loaded and available along with the CBS strobe for these procedures. These operations will be described in later sections.

Since the 2250 contains an input buffer, a second method of input is also possible. The character can be strobed into the 2250 input buffer, even though the CPU Ready/Busy is logic "1", Busy. (i.e. 2200 not awaiting data and/or card disabled). The 2250 will subsequently strobe the input data into 2200 when the card becomes enabled and the 2200 sets a level indicating to the 2250 it is awaiting data. This could be useful for low speed asynchronous type input devices and when the 2200 program has a limited amount of overhead processing, such that several devices can be simultaneously scanned. The 2200B and the General I/O - Command option provides input instructions which can scan, (i.e. test Ready, if not ready continue processing). In conjunction with this second method a signal is available on pin 17, $\overline{IRB}$, which indicates the input buffer is empty or full, (logic "1" = Full). The level is reset to logic "0" when the 2250 strobes the input buffer into the 2250. If a device strobes a subsequent character into a full input buffer, it will override the previous character.

Termination of input is possible by three different methods:

1. Last character read is a ASCII carriage return, HEX (0D)
   (Basic INPUT Command)

2. The number of characters to be read is specified in Basic statement. or a termination character is read that was specified in Basic statement.
   (Basic DATALOAD BT statement and General I/O Command Option)

3. Input Data Strobe with the data level on pin 11, $\overline{ENDI}$, set to a logic "1" (General I/O Command Option).
   The 8 data levels strobed in with this method are saved and can contain error information.

7.1.1 NORMAL INPUT SEQUENCE (The 2200 is always awaiting Input)

A typical Normal Sequence For Input Data:

1. Enable - A 2200 Basic statement for inputting is executed which enables the 2250 interface card.

2. 2200 Sets Ready - The 2200 sets a ready level which causes the level on pin 32, $\overline{CRB}$ to be logic "0", (Ready).

3. Device tests Ready - Input device: waits for CPU ready, $\overline{CRB}$, pin 32 = logic "0".

4. Input Strobe - Input Strobe (5 - 20 milliseconds) on pin 9 (Data levels for character must be available on pins 1 through 8 at leading edge of input strobe). Pin 32 becomes busy, logic "1" within 3 μsec and remains so until CPU is ready again.

5. Input Remaining Characters - Steps three and four repeated for all characters to read.

6. Terminate Input - Termination indicated by either:

   - Input strobe with ASCII carriage return.
   - Input strobe with other specified character.
   - Prearranged character count.
   - Input strobe with pin 11 set to logic "1".

This is a function of what type of Basic input statement is used, and specifications within the statement.

7.1.2 SCANNING INPUT SEQUENCE (2200 Scans Several Devices)

The 2200B has a program statement, KEYIN, which tests for input buffer ready, before proceeding. Test of Ready is also provided in the General I/O commands as a separate statement. If the input buffer or device is not ready, program processing will proceed to another statement. If ready, the I/O operation will proceed. A typical sequence for input scanning would be:

1. Input Strobe - Since in this procedure the CPU does not have to be ready, the input device can strobe at any time.

2. Enable - A 2200 Basic statement for inputting is executed. The 2200 first enables the 2250 controller card. It does not, however, set a level which indicates it is awaiting input.

3. Test Ready - The 2200 then tests for Ready/Busy. In this case, when the card is selected with an input address, it will test the input buffer Ready/Busy level in the 2250. (i.e. the level availabe on pin 17, $\overline{IRB}$).

4. If Not Ready Continue Processing - If the 2200 sees a busy, logic "0", the 2250 will be disabled, and processing will continue at the next sequential statement.

5. If Ready Read Character - If the 2200 sees a ready, it will set a level indicating to the 2250 it is awaiting data. This will cause the 2250 to strobe the contents of the input buffer into the 2200 and reset the input buffer Ready/Busy, $\overline{IRB}$ on pin 17.

6. Continue/ Terminate - For the KEYIN command, which receives one character, the 2200 will disable the 2250 at this point and continue processing at the specified statement number.

7.1.3 REQUESTED INPUT SEQUENCE (General I/O Commands)

The General I/O commands, which are an option on the 2200B provides a number of parameters within the program to specify an initialization output strobe, output strobes to read data, termination output strobes and other termination parameters. This permits a variety of input sequence alternatives which can be programmed. (A command in the 2200B, DataLoad BT also has a limited number of alternatives).

The following input sequence illustrates most of these.

1. Enable - The 2200 executes a General I/O statement for input. The 2200 first enables the 2250 controller.

2. Initiate Input - If this parameter is specified, the 2200 will then generate an output strobe which causes the Control Information Output Buffer to be loaded with the low order 4 bits of a specified character, (levels on pins 12 thru 15) and a 5 microsecond control output strobe to be available on pin 29, $\overline{CBS}$. The full 8 bits of data will also be available on pins 20 thru 27, the data output buffer. Although the controls on pins 12 thru 15 will be available until subsequently changed via another $\overline{CBS}$ strobe, it is good design practice to receive this information via a strobe.

3. Request a Character - If this parameter is specified, a 5 µsec output strobe, $\overline{OBS}$, will be generated on pin 28 which can be used to request the input strobe. Prior to generating the output strobe the 2200 will set a level indicating that it is awaiting data. This causes the CPU Ready/Busy level, CRB, on pin 32 to be set to logic "0", Ready, and will allow data strobed to be read directly into the 2200. If the parameter is not specified, Input will be identical to the normal input sequence.

4. Input Strobe - If specified, the output strobe sent from the 2200 can then cause the input device to generate an input strobe on pin 9, $\overline{IBS}$. When the 2250/2200 receives the input strobe, the input data levels on pins 1 thru 8 will be read into the 2250 input buffer and then the 2200.

5. Repeat 3 - 4 for all inputs - Steps 3 and 4 are repeated for all requested characters or until the input device sends in a termination signal or a specified number of characters are received.

6. Disable - The 2200 will then disable the 2250 interface card.

7.1.4 TESTING FOR INPUT DEVICE READY

Although in many instances Input Devices are not tested for a device ready condition, this can be done quite conveniently with a General I/O Command which only performs this function. This is done as follows:

1. Enable with Output Address - A general I/O command is executed with the 2250 output address selected for the command. This will cause the 2200 to enable the 2250 and allow it to sense the output device Ready/Busy signal, $\overline{RB}$, on pin 19 to be sensed by the 2200.

2. Test If Ready - If the device is ready, RB = logic "0", a transfer is made to the specified statement, if busy processing continues to the next sequential statement number.

7.1.5 DATA TRANSFER RATES FOR INPUT

The 2200 is generally capable of receiving sequentially input characters at intervals as small as approximately 50 microseconds under certain conditions.

There are, however, certain delays between groups of characters received, when more than one receiving variable is specified in a Basic input statement, approximately 1 ms maximum.

Data is normally received in an input buffer which can hold up to 256 characters, and then the information is transferred to the locations where variables are stored in memory. With certain commands such as DATALOAD BT in the 2200B and $ DATALOAD in the general I/O command group, information can be transferred directly in large alphanumeric array areas in memory. Thus relatively continuous high transfer rates are possible for large amounts of data.

7.3 GENERAL OUTPUT CHARACTERISTIC

The 2250 contains an output buffer which holds the 8 bits of data output from the 2200. Data levels from this buffer are available on pins 20 thru 27 of the 2250 I/O connector.

When a 2200 Basic output statement is executed, the 2200 enables the 2250 with an address strobe, and output characters obtained from variables, expressions, or literals in the argument list are sequentially output. They are sent on a device ready basis. When all characters have been sent, the 2200 then disables the 2250 controller card and continues processing.

The 2250 provides two general means of outputting depending upon the output strobe length required.

In the normal method characters are strobed from the 2200 to the 2250 output data buffer, where the data levels are provided on pins 20 thru 27 along with a 5 µsec output strobe on pin 31, $\overline{OBS}$. The data will be available until the output device indicates it is ready again by providing logic "0" on pin 19, $\overline{RB}$. The 2200 will then send another character. When the output device receives the data output strobe, it must set the $\overline{RB}$ signal to busy, logic "1" with 5 microseconds of the leading edge of the strobe, and hold it there until it is ready to receive another character.

An alternative method of output response is available where a longer output strobe is required, or where a Ready/Busy D. C. level response from the output device cannot be made available as required. In this method, the output device Ready/Busy signal, $\overline{RB}$, can be supplied from the 2250 by tieing the output buffer Ready/Busy signal on pin 28 to it. When a character is sent to the output buffer on the 2250, the Output Buffer Ready/Busy level available on pin 28 is set to logic "1", (Full). An output device may use this as a strobe instead of $\overline{OBS}$ on pin 28. When the output has had sufficient time to receive the data, it will send an acknowledge input strobe back to the 2250 on pin 18, $\overline{ACK}$. This input strobe will reset data output buffer Ready/Busy back to logic "0", (Empty), and the 2200 will then sense this signal as ready and send another character.

For these output devices that require special strobes for initialization, address control, or termination output strobes, a control information output buffer, pins 12 thru 15 and a control output strobe, $\overline{CBS}$ on pin 16 are available. The control output buffer can be loaded and the $\overline{CBS}$ strobe generated by specifying special parameters in the General I/O commands available as an option on the 2200B.

Some typical output sequences are described in the following sections.

7.3.1 NORMAL OUTPUT SEQUENCE (5 µsec Output Strobe, Device Ready/Busy Level Response)

1. Enable - A 2200 Basic Output Statement is executed, the 2200 first enables the 2250 interface controller by strobing an address which is preset on the card.

2. Test Ready - When the 2250 is enabled with an output address, (low order bit = 1), the level on pin 19, $\overline{RB}$, will be made available to the 2200 to test output device ready. When a logic "0" is set, ready is indicated. The 2200 will loop and test for ready, when ready it will output a character.

3. Output A Character - The 2200 will strobe an 8-bit data character to the 2250 otuput buffer. This will cause the data levels to be available on pins 20 thru 27, and a 5 μsec output strobe to be available on pin 31, $\overline{OBS}$. (It will also set Data Output Buffer Ready/Busy level on pin 31 to be set to logic "1", Ready, but this signal is not generally used in the normal output sequence).

4. Output Device Busy Until Character Processed - When the output device receives the $\overline{OBS}$ strobe, it sets $\overline{RB}$ on pin 19 to logic "1" until it has processed the character then resets it to logic "0".

5. Repeat for All Characters - For successive characters, the 2200 will begin testing for device Ready/Busy set to ready, logic "0" immediately after the 5 μsec output strobe and steps 2, 3 and 4 are repeated for all characters to be output. (A ready test is not made after the final character).

6. Disable - The 2200 will then strobe out an address to disable the 2250 and continue processing.

7.3.2 ACKNOWLEDGED OUTPUT SEQUENCE, FOR LONGER OUTPUT STROBES (Assuming $\overline{DORB}$ on pin 28 tied to $\overline{RB}$ on pin 19)

1. Enable - The 2200 enables the 2250 with an address strobe.

2. Test For Ready - The 2200 test device Ready/Busy via the $\overline{RB}$ level on pin 19. (In effect it looks at $\overline{DORB}$, Output Buffer Ready/Busy which is initially ready. When ready, a logic "0" is sensed, the 2200 outputs the next character.

3. Output A Character - The 2200 strobes the next character into the 2250 Output buffer, pins 20 thru 27 and provides a 5 microsecond strobe on OBS. It also sets $\overline{DORB}$, Device Output Ready/Busy to a logic "1", (Buffer Full). This level can be used for the output strobe. It remains set and the data levels remain available until an input strobe acknowledgement is received from the device.

4. Output Device Acknowledges — The output device generates 5 μsec maximum acknowledgement input strobe on pin 18, $\overline{ACK}$. This will reset the data output buffer Ready/Busy on pin 31 back to logic "0", thus signalling the 2200 to proceed with the next character, (since the 2200 senses ready on $\overline{RB}$ which is tied to it).

5. Repeat for All Characters — Steps 2, 3, and 4 are repeated for data in the argument list. (A ready test is not made following the last character).

6. Disable — The 2200 strobes an address to the 2250 which disables it, and processing proceeds.

7.3.3 OUTPUT SEQUENCE WITH INITIALIZATION, TERMINATION, ETC

For those devices which may require an initialization, a control address, and/or a termination, the General I/O command option provides this capability utilizing, the Control Information Output buffer, pins 12 thru 15, and the control output strobe, CBS, pin 16 on the 2250. The output sequence could provide either or both of these.

1. Enable — The 2200 enables the 2250 by strobing an address.

2. Initialization (optional) — If specified in the output statement, the low-order 4 bits of a specified character is strobed by the 2200 into the 2250 Control Information Output Buffer, pins 12 thru 15. At the same time a 5 μsec control output strobe, $\overline{CBS}$ is made available on pin 16. (The full 8-bit character is also available in the Data Output Buffer, pins 20 thru 27.

3. Test Ready — The 2200 tests for device ready, logic "0" on pin 19, $\overline{RB}$.

4. Output A Character - When Ready, the 2200 outputs the next data character to the Data Output Buffer, pins 20 thru 27, sets the Output Buffer Ready/Busy level on pin 28, $\overline{DORB}$ to logic "1" and provides a 5 μsec output strobe on pin 31, $\overline{OBS}$.

5. Output Device Processes Character - The output devices processes the character and acknowledges ready by either the D. C. level on pin 19, $\overline{RB}$, or an input acknowledge strobe on pin 18, $\overline{ACK}$.

6. Repeat for All Characters - Steps 2, 3 and 4 are repeated for all characters specified in the argument list of the output statement.

7. Terminate (Optional) - If specified, the output control buffer pins 12 thru 15 are again loaded with the low order 4 bits, a specified character, and a 5 μsec $\overline{CBS}$ strobe is made available on pin 16. (The full character is available on bins 20 thru 27).

8. Disable - The 2200 then disables the 2250, by strobing a different address.

7.3.4 OUTPUT WITH HANDSHAKE AND/OR ERROR RESPONSE FROM DEVICE

The General I/O commands also provide an optional parameter which causes the 2200 to look for handshake input strobe response and error termination input response. This works as follows:

If the handshake parameter is specified in a General I/O output command, the 2200 will look for Output device Ready/Busy by either of the following.

1. The $\overline{RB}$ level on pin 19 is logic "0".

or

2. An input strobe generated by the device on pin 9, $\overline{IBS}$.

Therefore, either ready condition can be used for acknowledge by the device.

In addition, if acknowledgement is by an input strobe on pin 9 and if the input data levels strobed in with it on pins 1 thru 8 are not all logic "0", an error will be indicated and output will be terminated. The data strobed is stored in a variable specified in the statement, and can be examined in subsequent processing.

7.3.5 OUTPUT DATA RATES

Output data rates are generally controlled by device response. The 2200 is generally capable of responding in approximately 50 μsec for fast devices, if only one variable or array is specified in the argument list. If more than one variable or argument is specified, the overhead for setting up the next output data could be 1 ms maximum.

8.0 PROGRAMMING I/O OPERATIONS IN BASIC

8.0.1 PROGRAM LANGUAGE

The 2200 is extremely sophisticated programmable calculator which has a built-in higher level language, BASIC. Currently, two versions are available, the 2200A and the 2200B. The 2200A has most of the standard Basic language features and I/O language features to control I/O operation for the following peripherals:

2215, 2222	Keyboards
2216	CRT Display
2217	Magnetic Tape Cassette Drive
2201	Output Writer (Selectric)
2221, 2231	High Speed Printers

The 2200B has all 2200A features, and a number of additional language features and an excellent group of statements which facilitate data conversion, data formatting, and bit and byte manipulation, and I/O language features which control the following additional peripheral devices:

2202 Plotting Output Writer
2203 High Speed Paper Tape Reader
2207 Teletype Interface
2212 Flat bed Plotter
2214 Mark Sense Card Reader
2227 Telecommunication Interface
2230 Disk
2232 Digital Flat Bed Plotter

Because the 2200 was designed with a higher language, and the I/O operations for standard peripherals incorporate many special built-in features to optimize performance and capability, Wang does not generally recommend the use of these program statements for controlling specially interfaced devices. There are, however, several I/O program statements which provide relatively a straight forward I/O control sequence. They are:

INPUT	Receive Data via keyboard (2200A, 2200B)
PRINT, PRINTUSING	Output formatted or unformatted data to printer type device (2200A, 2200B)
DATALOAD BT	Receive data in any format from high speed tape reader (2200B)
KEYIN	Receive single character from keyboard, if ready (scanning) (2200B)

These will be described in detail. Information on other device operations is available by special request.

Wang has provided, however, a highly flexible language feature option at nominal cost on the 2200B. The General I/O Command option is specially designed for the 2250 Parallel Input/Output Interface. It provides five I/O statements which provide a general method for the input and output of data and programs and in addition provides a number of I/O characteristic control parameters in the statement syntax. The statements are:

$ LOAD	(Load Programs from Device)
$ DATALOAD	(Load Data from Device)
$ SAVE	(Save Programs on Device)
$ DATASAVE	(Save Data on Device)
$ READY	(Test Device Ready/Busy)

Their operation will also be described in detail. They are recommended by Wang, for all special device interfaces.

8.1 DEVICE ADDRESSES FOR THE 2250

8.1.0 ASSIGNING ADDRESSES

The 2200 utilizes a 3 hexadecimal digit, (12 bit) addressing scheme. The addresses can be assigned for use with a particular Basic I/O statement in several ways.

1. SELECT TO OPERATION

```
Example     10 SELECT PRINT 211
                ...
            90 PRINT A, B, C
```

In this example, statement 10, when executed, assigns the address 211 for all PRINT and PRINT USING statements subsequently executed, until another SELECT PRINT is encountered.

2. SELECT TO FILE DESIGNATOR

```
Example     10 SELECT #1 10B
            20 ...
            ......
            50 DATASAVE #1, A, B, C
```

In this example, the file designator, #1 is assigned an address 10B in statement 10. When #1 is subsequently used in an I/O statement, such as statement 50, the address assigned to it, 10B will be used. Six file designators, #1, #2, #3, #4, #5 and #6 are available.

3. SPECIFY WITHIN I/O STATEMENT

Example: DATALOAD BT (N=256) /10A, A$

In this example, the device address 10A is specified directly in the statement, proceeded by a / character.

4. DEFAULT

When the 2200 is initialized by turning power on, default addresses will be provided for PRINT, TAPE, DISK, PLOT, INPUT, CI (Console Input) and CO (Console Output) operations.

8.1.1 USE OF DEVICE ADDRESS FOR THE 2250

The three hexadecimal digit device address is interpreted in the fashion in the 2200:

X Y Y

X - The first hex digit signifies device type. This identifies standard Wang peripherals which requires special processing:

Example:

X = 1 Cassette
X = 2 Printing device which requires carriage return character without line feed.
X = 3 Disks
X = 4 Plotters
etc.

Special interfaces using the 2250 will generally use type = 0, 2.

YY - This represents the 8 bits of address to which the peripheral controller card for the device has been set. The 2200 will send out these 8 bits to enable the controller. The 2250 has seven address switches which when set represent the high order 7 bits of the address sent out. The low order bit represents input or output selection on the 2250, thus two 8-bit addresses can enable the 2250.

Although the 2250 can be set to any address, the following settings are standard:

1A or 1B (1st 2250)
1C or 1D (2nd 2250)
1E or 1F (3rd 2250)

(These are also assigned for teletypes and telecommunications)

8.2 THE BASIC STATEMENT, "INPUT" (2200A or 2200B)

The Basic statement, "INPUT" is available on both the 2200A and 2200B for inputting. It is normally used to enter data from a 2200 keyboard, but can be used for other input devices. It allows numeric or alphanumeric data to be inputted from a device and assigned to variables listed in the argument list of the statement. The device address for Input is assigned by the current selection of INPUT, therefore, this selection must be made prior to executing the input statement.

Example:

```
100 SELECT INPUT 01A
110 INPUT A, B(3), C$
120 INPUT A$(4, 2), B$, C
```

When INPUT is executed, the input device currently selected for INPUT will be enabled, and information will be read and assigned to the listed variables or array elements. Data for each argument is terminated by the input of a ASCII carriage return character, HEX(0D). Numeric data must be inputted in ASCII code format in any free form basic format, (i.e. 4.2, -34.1E+21, +.037). Space characters are ignored. Up to 64 characters of alphanumeric information can be read and assigned to alphanumeric variables or array elements. This can be in any code format, but the ASCII characters comma, HEX(2C), and carriage return, HEX(0D), will be treated as terminator characters. If the alphanumeric information begins with a quote, HEX(22), it must also be terminated by a quote; these quotes are not considered to be part of the alphanumeric information. Commas inside quotes are not terminators. The 2200 will continue receiving input until all specified arguments have received values or until a carriage return character, HEX(0D), is received, with no data proceeding it. In the latter case, values of the remaining arguments will be unchanged.

The INPUT statement also causes a ? character to be displayed on the 2200 CRT prior to receiving values, and each received character is echo displayed on the CRT. (This will take approximately 50 μsec overhead per character).

SIGNAL SEQUENCE FOR INPUT

1. Enable - When the INPUT statement is executed, the 2200 will strobe the address currently selected for Console Input to enable the 2250.

2. Set Ready - The 2200 will set a level which causes the $\overline{\text{CRB}}$ signal on pin 32 to be set to logic "0". This indicates the 2200/2250 is ready to receive an input strobe.

3. Input Strobe - The input device will send out 5 to 20μsec input strobes on pin 9 along with the input data levels on pins 1 thru 8.

4. Receive Character - The 2200 will receive the character, and set $\overline{CRB}$ on pin 32 to logic "1", Busy, (within 3 µsec of the input strobe leading edge). This level will remain busy until the 2200 is ready to receive another character. (The 2200 will temporarily disable the 2250, to display and process the character, approximately 100 µsec).

5. Receive Subsequent Characters For Variables - Steps 2, 3 and 4 are repeated for all characters in a receiveing variable.

6. Terminate Variable - The input device strobes in a ASCII CR character to indicate end of variable data, HEX(0D).

7. Complete Other Variables - The previous steps are repeated if more than one variable is listed in the input statement.

8. Terminate - When all listed variables have received data, or when the input device strobes CR character as the 1st character in a sequence, the 2250 is disabled and processing continues.

ERROR CONDITIONS

If a numeric value is entered that has illegal characters in it, the 2200 will generate an error message on the CRT display, and await the reentry of the value, If an alphanumeric value entered has more than the number of characters available in the receiving variable, the excess characters will be ignored. If more than 192 characters are received without a CR termination character, the 2200 will generate an error message and halt processing.

8.3 BASIC "PRINT" AND "PRINT USING" STATEMENTS (2200A and 2200B)

The Basic PRINT and PRINT USING statements provide a general means of outputting formatted or unformatted data. The 2200 BASIC REFERENCE MANUAL contains a complete description of these commands. A few important operational features are summarized here. With either statement, both numeric and alphanumeric variable values, or values of expressions or literals can be output. When numeric information is output, ASCII characters representing the final numeric values are printed as output. When alphanumeric information is output, any codes contained in these variables are output. Although this is generally ASCII characters, specially formatted information can be prepared in alpha variables to be sent out. The PRINT statement automatically formats numeric information. With PRINT USING both numeric and alphanumeric can be formatted via an Image statement.

Example:

```
90 SELECT PRINT 01B
100 A = 2.41 : B$ = "SAM" : C$ = HEX(313233)
110 PRINT "VALUE="; A, B$, C$
```

output VALUE = 2.41 SAM 123

Example:

```
90 SELECT PRINT 01B
100 A = 12.434 : B$ = "TYPE 1"
110 PRINT USING 120, B$; A
120 % ###### OPTION +##.##
```

output TYPE 1 OPTION +12.43

If the PRINT or PRINT USING statement does not have a trailing comma or semicolon, a CR carriage return character will be output following the last data character. If it does, only the characters from data values will be output. The 2200B offers a number of commands which can be conveniently used to pack and convert numeric data into and from alphanumeric variables, including a form for BCD.

SIGNAL SEQUENCE FOR PRINT, PRINT USING

1. Enable - When the 2200 executes a PRINT or PRINT USING statement, it first strobes a device address, (that currently selected for PRINT), to enable the 2250.

2. Test Ready - The 2200 then waits until the $\overline{RB}$ level on pin 19 of the 2250 I/O connector is logic "0", Ready. (This could either be the $\overline{RB}$ level sensed directly from the device, or it could be the Data Output Buffer Ready/Busy on the 2250, if pin 28 is tied to pin 19).

3. Output A Character - When the output device is sensed Ready, the 2200 strobes a character into the 2250 output buffer, pins 20 thru 27. A 5 microsecond output strobe is generated on pin 31, $\overline{OBS}$, and the Data Output Buffer level on pin 28 is set to logic "1",(Full).

4. Device Acknowledge - When the output device receives the output strobe, it will set the $\overline{RB}$ signal to logic "1", Busy (within the duration of the strobe), and leave it there until ready at which point it is reset to logic "0". (The alternate method of using $\overline{DORB}$ and an input acknowledge strobe on $\overline{ACK}$ can also be used).

5. Output Remaining Characters - Steps 2, 3 and 4 are repeated for all remaining characters.

6. Terminate - The 2200 disables the 2250 when all characters are transmitted.

8.5 KEYIN (2200B)

The 2200B provides this statement for single character input operations where the Basic program might scan several devices. The command will cause the 2200 to receive one character and store it in a specified position of a string variable or array element. Optionally, if a branch statement number is specified in the statement, the 2200 will first test, Ready/Busy (which indicates input buffer Full/Empty if the 2250 is enabled with an input address, or the level from the device on pin $\overline{RB}$, if an output address enables the 2250). If a logic "1", (Busy) is sensed, processing will continue at the next sequential statement number, and input will be terminated without receiving a character. If logic "0", (Ready) is sensed, the character will be input and a branch is made to a statement number specified in the KEYIN statement. The KEYIN statement will use the address currently selected for INPUT, thus INPUT should be selected to a 2250 address prior to the statement.

Example:
```
200 SELECT INPUT 014
210 KEYIN A$

300 SELECT INPUT 01A
310 KEYIN STR(A$,2, 1), 400
```

KEYIN INPUT SIGNAL SEQUENCE

1. Enable - The 2200 first enables the 2250 interface by strobing an address.

2. Test Ready (Optional) - If the optional statement number is specified in the KEYIN statement line, the 2200 will first test Ready/Busy from the 2250. If an input address has enabled the 2250, Input Buffer Ready/Busy will be read; if an output address enabled the 2250, $\overline{RB}$ on pin 19 will be sensed. If logic "0" is sensed, the input sequence will terminate and a branch is made to the next sequential statement number.

3. Receive Character - The 2200 will then set a level which indicates it is waiting input, this will cause the $\overline{CRB}$ level on pin 32 to become a logic "0". If the input buffer has already received an input strobe and contains a character, the character will then be automatically strobed into the 2200. If not, (output address enabled 2250) the 2200 will await the input strobe. The device may strobe the character on $\overline{IBS}$, pin 9.

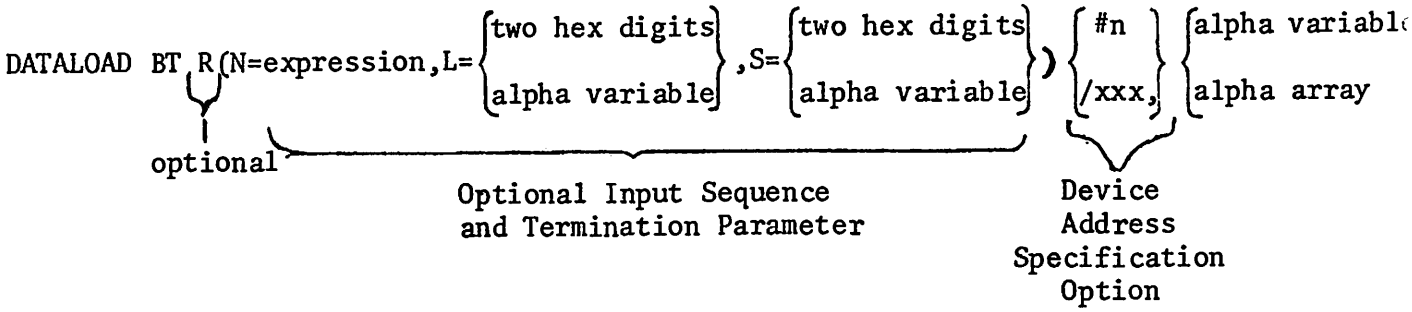
4. Terminate - When a character is received, the 2200 will disable the 2250 and continue processing at the specified statement number.

8.6 DATALOAD BT (TYPE=6) (2200B)

With the address type set = 6, this input instruction is available on the 2200B for reading unformatted data into an alpha variable or alpha array with the 2203 High Speed Tape Reader. It provides for a variety of parameters which can be specified in the statement for termination, and the input sequence contains both an initialization strobe and a request strobe for each character. These can be used or ignored. Because in the signal sequence, the 2200 continuously tests for device Ready/Busy, the 2250 should be enabled with its output address, such that $\overline{RB}$, on pin 19 will be sensed by the 2200. It may be used to indicate device Ready/Busy, or tied permanently to logic "0", Ready. The output addresses used for this command should be 61B, 61D, 61E, (i.e. output addresses with type = 6).

This command allows any number of characters, in any format to be read into a specified alphanumeric variable or array. From these, the data can be conveniently converted into numeric data using 2200B conversion commands and processed.

The general format for this statement is:



If the N parameter is included, it will specify the number of characters to be read, (value of the expression).

If L parameter is specified, the character indicated by the two hex digits or the alpha variable will be leader code. When input is initiated, these characters will be ignored until a different character is read.

If the S parameter is specified, the character specified by the two hex digits or contained in the alpha variable will cause input termination when read.

(Both N and S termination can be specified, the first one to occur will apply).

Optionally, the 2250 device address can be specified by a file designator or absolutely. If neither is specified, the current TAPE address will apply.

Example:

```
100 DATALOAD BT  (N=40, S=FF) /61B, A$

200 DATALOAD BT  (N=64,L=00,S=0D)#3, B$()
```

DATALOAD BT SIGNAL SEQUENCE

1. Enable - When the Dataload BT instruction is executed, the 2200 first strobes the device address to enable the 2250.

2. Test For Ready - The 2200 will then test and wait until the $\overline{RB}$ level on pin 19 is logic "0", Ready.

3. Initialize Output Strobe - A 5 µsec output device initialization strobe which then be generated on pin 31, $\overline{OBS}$. Along with it, a value of HEX(00) or HEX(01) will be availabe as D.C. levels from the output buffer, pins 20 thru 27. (A HEX(01) is generate if the "R" is specified in the DATALOAD BT statement following BT). (This strobe can be ignored, if not required).

4. Test Ready - The 2200 will delay the duration of the strobe and then wait for a logic "0" on pin 30, $\overline{RB}$, (Ready).

5. Set CPU Ready For Input - The 2200 will then set a level which causes the CPU Ready/Busy signal on pin 32, $\overline{CRB}$, to become logic "0", (Ready). When set at this level an input strobe will cause the character to be read immediately into the 2200.

6. Output Request Strobe - The 2200 will then generate a 5 µsec data request strobe on pin 16. $\overline{CBS}$, to request a character. It can be used to cause the device to initiate an input strobe on $\overline{IBS}$, pin 9, along with data levels presented on pins 1 thru 8. (If not required, this strobe can be ignored and the $\overline{CRB}$ level on pin 32 can be used to allow input.

7. Input Strobe - The input device generates a 5 to 20 µsec input strobe on pin 9, $\overline{IBS}$, along with providing data levels on pin 1 thru 8. The data will be received by the 2200 and within 3 µsec from the input strobe leading edge, the CPU Ready/Busy signal on pin will be set to logic "1", Busy until the CPU is ready to receive another character.

8. Input Remaining Characters - Steps 4 thru 7 will be repeated for all remaining input characters until termination is indicated by.

   (1) Receiving the specified number of characters, (N parameter)

   or

   (2) Receiving a specified termination character, (S parameter)

   or

   (3) The array or variable is full.

9. Disable - When termination occurs, the 2200 will disable the 2250 and continue processing.

8.7 GENERAL I/O COMMANDS

8.7.0 GENERAL I/O COMMANDS

This option is available on the 2200B. It provides five Basic statements for the input and output of Data and Programs.

$ DATALOAD	(Input Data)
$ LOAD	(Input Basic Program)
$ DATASAVE	(Output Data)
$ SAVE	(Output Basic Program)
$ READY	(Test if Device Ready)

The use of these commands is recommended when any peripheral device is interfaced to the 2200 using the 2250 Parallel INPUT/OUTPUT interface. They are specially designed for this purpose. A major feature provided with these commands is the ability to optionally specify signal sequence parameters for a particular device within the statement syntax. This not only simplifies interfacing requirements, but it provides the capability to optimize data transfer rates, transmit and receive data in any format or character code. In addition, it will provide a standard convention for general 2200 interfacing.

The General I/O commands, and typical signal sequences are presented in the following sections.

8.7.1 $ DATALOAD AND $ LOAD (INPUT)

These statements provide the general capability to input Data or Data Records, and Basic Programs into the 2200.

Most optional device control parameters specifiable within the two statements are similar.

A typical Input Signal Sequence for $ DATALOAD and $ LOAD is:

1. Enable - When the statement is executed in the 2200 it first enables 2250 with a device address strobe.

2. Initialize Strobe (optional) - If the I parameter is included, a 5 μsec device initialization strobe is output on CBS, pin 16. In addition, an 8-bit character specified will be available during the strobe in the data output buffer, pins 20 thru 27 and the low order four bits will be permanently retained in the Control Information Output Buffer, pins 12 thru 15.

3. CPU Ready - The 2200 will then set a level which makes the level on pin 32, $\overline{\text{CRB}}$, become logic "0", (CPU Ready). The 2200 is then available to receive a character.

4. Character Request Strobe (Optional) - If the C parameter is specified, a 5 µsec strobe will be output on pin 28, $\overline{\text{OBS}}$, to request an input character.

5. Input Strobe - When $\overline{\text{CRB}}$ is logic "0", (Ready) and/or when the request strobe is output, the Input device will generate a 5 to 20 µsec strobe on pin 9, $\overline{\text{IBS}}$, along with input data levels on pins 1 thru 8. The characters will be received by the 2200 within 3 µsec, and the $\overline{\text{CRB}}$, (CPU Ready/Busy) level on pin 32 will be set to logic "1", (Busy).

6. Process Character - The 2200 will process the received character. This will normally be done in approximately 50 µsec. If however, data or a program is being loaded and the character terminates a line or unit record, the delay could be much longer (100 ms to several seconds).

7. Receive Remaining Characters - Steps 3 thru 6 are repeated for remaining characters. (Steps 2 thru 6 for unit record program loading).

8. Input Termination - The input sequence is terminated by one of the following specifiable termination procedures. (More than one can be specified).

   - An input is received with the level on pin 11, $\overline{\text{ENDI}}$, set to logic "1" (T parameter) (The received data character is saved).
   - A specified termination code is input (E parameter)

- A specified character count has been read (N or M parameters).
- The argument list is satisfied.

9. Disable - The 2200 will then disable the 2250 by an address strobe.

2200B BASIC STATEMENT

$ DATALOAD

INPUT DATA VALUES — External Device

General Form:

$ DATALOAD [([I=XX][,][C=XX][,] [{ T=alpha variable / N=expression / M=expression / E=XX alpha variable }])] [#n, / /xxx,] ['argument list']

Device Control Information

where:

I = Initiate Input. The 8-bit control character specified by the hex digits xx will be strobed to the device via CBS to initiate Read Operations. (Low order 4 bits retained in control information-output buffer) in the 2250.

C = Character Request. For devices which are not unit record oriented, each character will be requested by an OBS strobe with the character specified xx being output.

Termination (Several termination parameters can be specified)

T = Terminate by input strobe. The input sequence will be terminated by a input strobe which sets a termination bit, ENDI, pin 11, to logic "1". The character with this termination input strobe will be stored in the specified alphanumeric variable and can be subsequently tested. Normally it will =0 if successful read ≠0 if an error or END of file

N = Terminate by Count (unit record). The number of characters specified by the expression will be read and input will then terminate. This must be < 256.

M = Terminate by count (unit record) with the addition that only a single alphanumeric variable or array will be specified in the argument list. Information will be read directly into the variable area for high speed input. The unit record can be larger than 256 characters. (Size of array)

E = Terminate by Character. Input will terminate when the character specified by the hex digit xx of the alpha variable is read.

PURPOSE

The $ DATALOAD statement provides a general means of inputting data into the 2200 from an input device, and storing the values into variables specified in the argument list. This can include numeric variables or arrays and alphanumeric variables or arrays. The statement provides the facility to directly specify by optional parameters, a number of alternative signal sequences for input and the input record format.
This includes:

I - Send out device initialization strobe, $\overline{CBS}$, prior to input.

C - Send out a strobe, $\overline{OBS}$, to request each character input strobe.

T - Terminate input by receiving an input strobe with the $\overline{ENDI}$ data levels on pin 11set to logic "1". The received 8-bit data character is also saved in variable for later examination in case of error termination.

N - Terminate by count, (i.e. read a unit record of a specified length, maximum 256 characters).

M - Terminate by count (unit record), by reading a record of any length directly into a specified string variable or array. This always optimizes input rates, large records or data bursts, and permits a record of any format of character code to be read.

E - Terminate by specified termination code.

More than one termination condition can be specified, which ever occurs first will apply.

There are two general formats available for the input data:

1. When several variables are specified in the argument and/or a numeric variable is specified,the record format and character codes must be identical to those produced by the $ DATASAVE statement. That is:

   . Numeric variable data is made up of ASCII code characters. It is Basic free format, (i.e 4.2, +937.422E-05). Space characters are ignored.

   . Alpha numeric variables can be any code format other than the ASCII carriage return character, which acts as an argument element terminator.

   An ASCII carriage return character must follow the value for each variable or array element, (numeric or alphanumeric).

   . A unit record of specified length may be padded at the end with ASCII space characters. If the E parameter is specified for load, that termination code should be in the last position of the unit record.

2. When the M parameter is specified, a record in any format and character code can be read directly into a single alphanumeric variable or array in the argument list. Termination can be by T, E, or the record count specified with M, or a combination of these.

   The record length can be any size legally specifiable for an alpha array within the 2200, (limited only by memory capacity). Since the data is read directly into the variable area of memory, input rate is optimized. A number of 2200B statements available to provide convenient means of converting the data to internal 2200 numbers and using them, (CONVERT, UNPACK, etc).

   Example:

```
100 $ DATALOAD (I=04, C=00, T=A$, N=64) A, B( ), C$

100 $ DATALOAD (I=IF, M=512, E=B$) A$( )
```

General Form:

$ LOAD [([I=XX][,][C=XX][,][{T=alpha variable / N=expression / E=XX / E=alpha variable}])][#n, / /xxx] ['line number']['line number']

Device Control Information

I = Initiate Input. The 8-bit control character specified by the hex digits xx will be strobed to the device by a $\overline{CBS}$ to initiate Read Operations.

C = Character Request. For devices which are not unit record oriented, each character will be requested by an $\overline{OBS}$ strobe with the character specified xx being output.

Termination (Several termination parameters can be specified)

T = Terminate by input strobe. The input sequence will be terminated by a input strobe which sets a termination bit, $\overline{ENDI}$ on pin 11. The character with this termination input strobe will be stored in the specified alphanumeric variable and can be subsequently tested. Normally, it will =0 if successful read
≠0 if an error or END of file

N = Terminate By Count. (unit record) The number of characters specified by the expression will be read and input will then terminate.

E = Terminate by Character. Input will terminate when the character specified by the hex digit xx of the alpha variable is read.

The $ LOAD statement provides a general means of loading Basic programs into a 2200 from an external device. A number of optional parameters can be specified within the statement to meet the specific requirements of the input device. These include:

I - Send initialization strobe, $\overline{CBS}$, prior to input of program or a unit record.

C - Output an $\overline{OBS}$ strobe to request each input.

T - Terminate program input, or unit record input by an input strobe, $\overline{IBS}$, with the data level on pin 11, $\overline{ENDI}$, set to "1".

E - Terminate program input by reading a specified termination code.

N - Input program in unit records with several program lines per record.

The Basic program read must be made up of program lines in ASCII character code. Certain nexadecimal codes can be substituted for Basic statement verbs and functions.

If $ LOAD is used as a program statement, optional line numbers can be included in the statement.

If no program line numbers are included in a $ LOAD program statement, the existing program in memory will be cleared before loading. If one program line number is provided, all program lines equal or greater to that line number will be deleted before loading. If two program line numbers are included in the statement, the section of program from the first to the second line number will be deleted before loading. If $ LOAD is used as a command, no program deletion is done.

The Basic program read can be in one of two different formats depending upon whether the N parameter is specified or not. These are identical to the format produced by a $ SAVE statement.

If no N parameter is specified, each program line is terminated by an ASCII carriage return character. The lines will be read a line at a time sequentially, with a delay between each line for loading and scan processing. (i.e. CPU will remain busy). If the S parameter is specified, the specified termination code will terminate program loading. Alternatively, program input can be terminated by a T parameter type of input strobe.

If the N parameter is specified, the program is loaded in unit records, with one or more lines per unit record. Each program must be in ASCII character code format, with an ASCII carriage return character following each line. An unused portion at the end of the record can be padded with ASCII space characters. If the I and T parameters are specified, the I strobe will occur prior to each unit record, the T strobe will terminate each unit record. Program input will be terminated by sensing a specified termination code as the last character in the last record, (S parameter), or by the termination input strobe, (T parameter)

Example:

```
$LOAD   (I=01, C=00, E=A$)

100$LOAD   (N=256, T=A$) 100, 300
```

8.7.2 $ DATASAVE and $SAVE (OUTPUT)

These statements provide a general capability to output Data, Unit Data Records and Basic Programs on the 2200.

Most optional device control parameters for the two statements are similar.

A typical Output Signal Sequence for $ DATASAVE and $ SAVE is:

1. Enable - When the statement is executed, the 2200 first enables the 2250 interface with an address strobe.

2. Initialize Strobe (optional) - If the I parameter is included, a 5 μsec device initialization strobe is output on $\overline{CBS}$, pin 16. In addition the 8-bit character specified is available until the output device is ready on pins 20 thru 27, Data Output Buffer, and the low order 4 bits are permanently retained in the Control Information Buffer, pins 12 thru 15.

3. Wait For Device Ready (Two options) - If the initialization strobe is specified, the 2200 will wait for device ready by either sensing a logic "0" on pin 19, $\overline{RB}$, and/or if the H parameter is specified by waiting for an input strobe on pin 9, $\overline{IBS}$. (The latter case, either $\overline{RB}$ or $\overline{IBS}$ signify ready).

   (Note, if pin 28 is tied to pin 19, an input strobe on pin 18, $\overline{ACK}$, will provide the proper $\overline{RB}$ level from with the 2250).

4. Output A Data Character - When the device is ready, a data character will be output by a 5 μsec strobe on pin 31, $\overline{OBS}$, along with the 8 data levels on pins 20 thru 27, Data Output. (The $\overline{DORB}$, $\overline{ACK}$ output method also applies).

5. Output Remaining Characters -Steps 3 and 4 are repeated for all remaining characters.

6. Terminate Strobe (Optional) -If the T parameter is specified, a termination strobe will be output on pin 16,, $\overline{CBS}$, along with the specified character on pins 20 thru 27 and 12 thru 15.

7. Output For Other Unit Records -If a Basic program is output by unit record format output, $ SAVE, steps 2 thru 6 will be repeated for all unit records until the program is completely output.

8. Disable - The 2200 will then disable the 2250 with an address strobe.

2200B BASIC STATEMENT

$ DATASAVE

OUTPUT DATA VALUES

External Device

General Form:

$ DATASAVE [([I=XX][,][H=alpha variable][,] { N=exp / M=exp } [,][S=XX][,][T=XX])] [#n, / /xxx,] 'argument list'

Device Control Information

where:

I = Initiate Output. If required by the device, the 8-bit code specified by the 2 hex digits xx, will be strobed to the device via a $\overline{CBS}$ strobe to indicate a output operation is being initiated. The low order 4 bits will be retained in the control information output buffer on 2250.

H = Handshake After Output. If specified, after each output character, an input strobe $\overline{IBS}$, pin 9 , will be checked for, which will acknowledge the receipt of the previous character, until the device becomes ready. A non-zero character strobed in will indicate device error and will terminate operation. The last received handshake character will be stored in the specified alpha variable for later testing.

N = Unit Record Size. If the output device is a unit record type device which requires an exact number of characters, this number is specified by the expression after the = sign. If less characters are specified in the argument list, the output will be "padded" with space characters. The argument list cannot be more than the specified record size, a maximum of 256 characters.

M = Unit Record Size. This is similar to the N parameter except the argument list will contain a single alpha-numeric variable or array information will be read directly from the variable area of memory for high speed output. More than 256 characters can be output. If the specified alpha variable or array is smaller than the expression in the N parameter, the remaining character will be "padded" with ASCII space characters.

S = Termination Code. The character specified by the hex digits, XX, will be output following the last data characters.

T = If required, the end of output will be specified by a special $\overline{CBS}$ strobe with the character specified by the two hex digits xx sent out. The low order 4 bits will be left in the Control Information Output Buffer.

PURPOSE

$ DATASAVE provides a general means of outputting numeric or alphanumeric data to an external device. A number of optional device control signal sequence or record format parameters can be specified within the statement text. These include:

I = Send out a device initialization output strobe ($\overline{CBS}$) prior to output.

H = Handshake - Receive an input strobe, $\overline{IBS}$, to acknowledge each output character.

N = Output data as padded unit record of 256 characters or less.

M = Output a larger block of data at optimum speed from an alpha variable or array.

T = Send out a device termination strobe, $\overline{CBS}$, after output is complete.

1. The argument list can include, numeric variables or arrays, alphanumeric variables or arrays, expressions, and HEX or STR functions.

2. If numeric variables or expressions are included they will be output in as ASCII characters in free format. Alphanumeric data from alphanumeric variables or arrays will be output character by character as it is currently stored.

3. If neither the N or M parameter is specified, the numeric or alphanumeric data from the argument list will be sequencially output, and a ASCII carriage return character will be output following each variable, array element, expression or function. If a termination code parameter is present, the specified termination character will be output following the carriage return of the last argument.

4. If the N parameter is specified, the arguments will be padded into the unit record size with the remaining characters filled with ASCII space characters. Again each variable, array element, etc. will be followed by a carriage return character. The argument list and/or unit record size cannot exceed 256 bytes. If a termination code parameter is specified, the termination code will be inserted in the last position of the unit record.

5. The M parameter provides the user with the ability to format his own record. Only information from a single alphanumeric variable or array will be output. Only the actual contents of the variable or array will be sent with no extra control characters. This allows the user the ability to format data in any format or character code within the alpha variable or array and then transmit it. Alpha arrays can be any size legally contained with available 2200 memory. The 2200B provides a number of statements for converting and formatting conveniently.

   Examples

```
100 $ DATASAVE (I=0F, H=A$, N=64) A, B, C(), D$

100 $ DATASAVE (I=01, M=256, T=02) /01B  A$( )
```

$ SAVE

OUTPUT PROGRAM

External Device

General Form:

$ SAVE [([I=XX][,][H=alpha var.][,][N=XXX][,][S=XX][,][T=XX])] #n, /xxx, ['line no.][,'line n

Device Control Information

I = Initiate Output. If required by the device, the 8-bit code specified by the 2 hex digits xx, will be strobed to the device via a CBS strobe to indicate a output operation is being initiated. The low order 4 bits will be retained in the Control Information Buffer on the 2250.

H = Handshake after Input. If specified, after each output character, an input strobe, IBS, pin 9, will be checked for, until the device becomes ready. (RB = logic "0"). A non-zero character received in will indicate device error and will terminate operation. The last received handshake character will be stored in the specified alpha variable for later testing.

N = Unit Record Size. If the output device is a unit record type device which requires an exact number of characters per record, this number is specified by the expression after the =sign. The maximum is 256 characters. If this parameter is specified, the specified program lines to be packed are sequentially packed into a unit record, each followed by a carriage return, and output. As many unit records use necessary are output. Only complete lines will be packed into a record, extra space will be "padded" with space character. (If n is not specified, the program will be sequentially output with no additional unit record Initialization).

T = If required, the end of output will be specified by a special CBS strobe at the end of each unit record and/or the end of output. The low order 4 bits will be left in the control information output buffer on the 2250.

PURPOSE

The $ SAVE operation provides a general means of outputting a Basic program to be saved on an external device. Device Control Information parameters can be optionally specified within the statement to meet the individual signal sequence of the output device. These include.

I - Generate device initialization strobe, $\overline{CBS}$, prior to outputting each program line or unit record.

H - Receive a handshake input acknowledge strobe on $\overline{IBS}$, pin 9 after each output. (If non-zero data with it, terminate).

T - Generate a device termination strobe, $\overline{CBS}$, upon end of output or each unit record.

S - Output a specified termination code follow the last output character.

All or part of the program will be output. If no optional line numbers are listed in the statement, the entire program will be output. If only one line number is specified, the program starting from that line number to the last line number in the program will be output. If both line numbers are specified, the section of program include within them will be output.

The program lines will be output as ASCII characters, with no special atom codes.

The program can be output in two different formats depending upon whether the unit record, N parameter is specified or not.

If N is not specified each program line is output followed by an ASCII carriage return character, in a sequentiation fashion. If the S parameter is specified, that character will be output following the last line. If the initialization and termination strobe parameters are specified, they will be outputted only once, before and after output of the entire program.

If the N parameter is specified, one or more lines will be packed into a unit record of the specified size, each line followed by a ASCII carriage return character, with ASCII space "padding" the end of the record. A number of unit records will be outputted, until all program lines have been sent. If the S parameter is specified, the specified termination code will be placed in the last character of the last unit record. If the initialization and/or termination strobe parameters are specified, they will be outputted before and after each unit record. The unit record can be a maximum of 256 characters.

Example:

```
$ SAVE  (I=01, H=A$, T=02)

100 $ SAVE  (I=04, N=256, S=FF) 100, 400

200 $ SAVE (I=FF) 500
```

8.7.3 $ READY

This command is provided so that an independent test for device Ready/Busy can be made before executing a General I/O input or output statement. This could be useful when several devices are to be scanned simultaneously, and an input or output operation cannot be initiated until a device is ready. In other words, the 2200 would not be tied up by a device until the I/O operation can be completed.

The general format of the statement is.

$ READY [#n / /xxx] , 'statement number'

where #n - is the file designator containing the device address.

/xxx - is the absolute specification of the device address.

(If neither of the above is specified the address currently assigned for TAPE is used)

'statement number' - the statement number at which the execution of the Basic program will continue, if the device is Ready. Processing will continue at the next sequential statement if the device is not ready.

SIGNAL SEQUENCE

1. Enable - The 2200 will first enable the 2250 with an address.

2. Test Ready - The 2200 will then test device Ready/Busy. It will do this by either examining:

   . The $\overline{RB}$ level on pin 19, if the 2250 is enabled with an output address.
   logic "0" = Ready
   logic "1" = Busy

   or

   . The input buffer Ready/Busy level available on the 2250 controller, $\overline{IRB}$, pin 11 if the 2250 is enabled with an Input Device Address.

Ready (Buffer Full)
Busy (Buffer Empty)

Note - Either input or output devices can be enabled with an Output Address to test $\overline{RB}$.

3. Disable - The 2200 will then disable the 2250 with an address strobe.

4. Branch - Basic program execution is continued at:

   . The next sequential program statement if not ready.

   . The specified 'statement number' if Ready.

WANG LABORATORIES, INC.

M E M O R A N D U M

TO: 2200 Committee

FROM: Bob Kolk

DATE: July 18, 1973

SUBJECT: I/O Interface Specifications for the 2200

We will currently announce three different General I/O Interface options for the 2200. Each will consist of a Controller card which will plug into a 2200A and/or 2200B. Each option should be priced at approximately $300.

The options will be:

(1) 2250 - Parallel I/O Interface (2200A or 2200B)

This interface is the one we generally recommend for new parallel interface jobs on the 2200. It provides a general capability to input or output 8-bit parallel information at rates of up to 4,000 characters/sec., (25 usec/char.). A 36-pin connector will be provided on the interface card to devices.

In addition to the parallel Input and Output data paths, one input strobe, two output strobes, an output Ready/Busy, an initialization output strobe and an 8-bit device address are provided.

The 2250 will operate on either the 2200A or the 2200B. With the 2200A, input and output operations are generally done using Input, Print, and Print Using Basic language commands. With the 2200B, additional commands are available to individually send, receive, and sense strobes and data.

(2) 2251 - 600/700 Emulation I/O Interface (2200B)

This interface will duplicate the general I/O interface specification for the Wang 700 Series and 600 Series Programable calculators. It specifically provides the capability to:

(a) Interface specially designed instrumentation and equipment to the 2200B which has been designed to be interfaced with a 600 or 700 programable calculator in compliance with the INPUT/OUTPUT Interfacing specifications for this equipment.

(b) Provide a means of interfacing 600 and 700 calculators to a 2200.

It does not, however, permit all 600 and 700 peripheral equipment to be attached to the 2200 since in many cases this equipment has special interface control requirements.

Input is accomplished by accepting 600/700 GROUP 1 XXXX or GROUP 2 XXXX input strobe data via special 2200B input commands which allows a program a specific termination character, (which can be a 700 or 600 "GO" code). Input characters are read into a Basic string variable; from there they can be converted from 600 or 700 characters and processed.

Output is accomplished by strobing out 10 characters to the buffers in the 2251 control card, where they are held and made available via the I/O connector on a scan basis as the Display Digit position of "X" register, Display "X" register, general outputs and I/O Bus and Group I and II Code.

The standard 600/700 I/O connector is available on this card.

(3) 2252 - 605/705 Microface Emulation Interface (2200A or 2200B)

This interface will duplicate the 605/705 Microface Interface specifications. With it, all devices and instruments currently interfaceable via these interfaces can be attached to a 2200A or a 2200B.

Externally, the 2252 operates identically to the 605-1A and 705, with 7 BCN parallel BCD digits, Sign, "EXECUTE" and "PRINT" signals available on an identical 36 pin connector. The interface then strobes and converts the digits to ASCII characters. It strobes them into the 2200 followed by a carriage return character, in a format compatible with the 2200A or 2200B Basic "INPUT" statement.

BK/fjv

FENN
The Fenn Manufacturing Company
DIVISION OF AMTEL, INC.
Fenn Road, Newington, Connecticut 06111 · (203) 666-2471
amtel

Bob Kolb - worthwhile?

June 6, 1974

JUN 13 1974 AM

Dear Mr. Cunningham:

Because of the rising interest in computer interface standards, especially by the independent peripheral industry and the user community, the ANSI technical subcommittee on computer interface standards (ANSI X3T9) has directed me to conduct an expanded survey of the mini- and micro-computer industry and user community to determine the level of interest in interface standards.

I am enclosing an updated copy of the original survey to acquaint you with the background of this inquiry. Currently, the ANSI subcommittee is primarily interested in your answers to the following two questions:

1. Do you feel that the U. S. should develop interface standards for mini- and micro-computers?

2. Would you actively participate in the development of such standards?

Any further comments you have on this issue are also welcome. If you have any further questions on this survey, you can contact me directly or call Mr. Del Shoemaker, Acting Chairman X3T9 at (202) 254-5178. Further information on active membership in X3T9 can also be obtained from Mr. Shoemaker.

Sincerely yours,

Thomas J. Alshuk, EIT
Manager, Process Control
For ANSI X3T9

TJA/lcm
Enc.

MEMORANDUM

June 6, 1974

To: Director EDP Marketing

Subject: Proposed Minicomputer Input/Output Interface Standardization Activity within ISO/TC97/SC13*

Purpose. The purpose of this memorandum is to advise a greater segment of the computer industry and users of the proposed initiation of a new interface standardization activity within the ISO/TC97/SC13 organization; and to solicit related information from interested suppliers and users of minicomputer systems and subsystems.

The information received will assist the appropriate X3 committees in determining the level of interest in the subject standardization efforts, and assist in objectively determining the "need and justification" for a standard.

Background. Since 1967, there has been a national standards development activity underway within the United States (American National Standards X3 Committee) to determine the need for and specifications of standard input/output interfaces for digital computers. Concurrent interface standards development activities exists in several European countries, within Japan, and within the relevant international standards organization (ISO/TC97).

In recent years these efforts have been directed towards the computer subsystem interface located between the channel and the device controller, and has been designated a "channel-level" interface. This interface was selected as the best point for standardization primarily because of its independence from the characteristics of the various input/output devices, and because of the resultant longer lifetime for such an interface.

At present, a channel-level interface specification proposed by Japan is the only potential international interface standard being seriously considered by ISO/TC97/SC13. Although the specification is not yet complete, draft versions have been reviewed by the United States and other member countries of ISO/TC97/SC13 and a complete specification is expected in 1974.

*ISO/TC97/SC13 is the ISO, Computer and Information Processing Subcommittee on the Interconnection of Equipment.

An interest in additional or alternative interface standards prompted a resolution at the June 1973 meeting of ISO/TC97/SC13, which reads as follows:

> ISO/TC97/SC13 accepts document 97/13/N29 as a contribution in view of the establishment of a new project for the standardization of a low-level standard I/O interface applicable, for instance, to minicomputers. Member bodies of SC13 are invited to evaluate the need and justification of a standard along that line in their respective countries in order to ascertain the interest of initiating such a new project and determine the desirable level(s) of interchangeability and to contribute to SC13 before December 31, 1973.
>
> If a substantial interest appears from the survey, the secretariat would invite member bodies to submit proposals for:
>
> . Functional, Electrical, Mechanical, and Operational Requirements necessary to achieve the level of interchangeability envisaged and evaluation of administrative problems involved.
>
> . Corresponding specifications generated as required.

Information Needs. The American National Standards X3T9 Technical Committee on input/output interface standards, intends to formulate the appropriate U. S. response to the "need and justification" request by December 31, 1973. Since the present membership of X3T9 represents only a small part of the vast body of manufacturers, users and others concerned with minicomputers, it was considered desirable to solicit the advice and opinions of others.

The primary information requested of you pertains to the need and justification for a low-level standard input/output interface, such as would be used on minicomputers. Your responses will be considered by X3T9 along with all others received, and an appropriate reply formulated for submission to ISO/TC97/SC13. Depending on the responses received and upon the action subsequently taken by ISO, further written contributions and in-person participation are likely to be solicited during 1974.

Although a simple expression of the need and justification for a minicomputer interface standard would be welcomed, a more useful response would include rationale, data and other comments which support your view. As a stimulus for such a discussion in your response, you may wish to consider the following relevant questions:

1. What benefits can be anticipated from a standard minicomputer interface? (Consider intrinsic, interchange, educational and economic advantages.)

2. What disadvantages are possible if such a national or international standard is adopted? (Consider evolutionary constraints, product costs, administration and other factors.)

3. Is the development and implementation of such a standard technically and economically feasible? (Consider existing practice, development cost, development resources and conversion or implementation costs.)

4. If there already existed an applicable I/O interface standard for larger-scale computers, is there justification for a second standard for minicomputer interfaces? Are there benefits from using the same interface standard for both? Are there specific features normally required in large-scale computer I/O interfaces which are not required in minicomputer I/O interfaces? Are there any specific features which are unique to minicomputer I/O interfaces?

Summary. To be useful in formulating or influencing the U. S. position on this matter, your response should be received by July 17, 1974.

If further information is desired on this subject, please contact Mr. Del Shoemaker, Acting Chairman X3T9, directly. Mr. Shoemaker's phone is (202) 254-5178.

TJA/lcm