

# **HP 12978A**

## **Writable Control Store**

### **Reference Manual**



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# LIST OF EFFECTIVE PAGES

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This manual describes the HP 12978A Writable Control Store (WCS) Interface Kit used with the 21MX Computers. This manual covers general information, installation, programming, and general theory of operation. It is written for the individual who already has experience as an assembly language programmer.

In addition to this manual, the following may be of use:

*Microprogramming 21MX Computers Operating and Reference Manual*, 02108-90008, for a description of writing 21MX microprograms.

*DOS 12908 WCS Driver Operating Manual*, 12908-90004, for information on how to use the DOS WCS driver.

*BCS 12908 WCS Driver Operating Manual*, 12908-90003, for information on how to use the BCS WCS driver.

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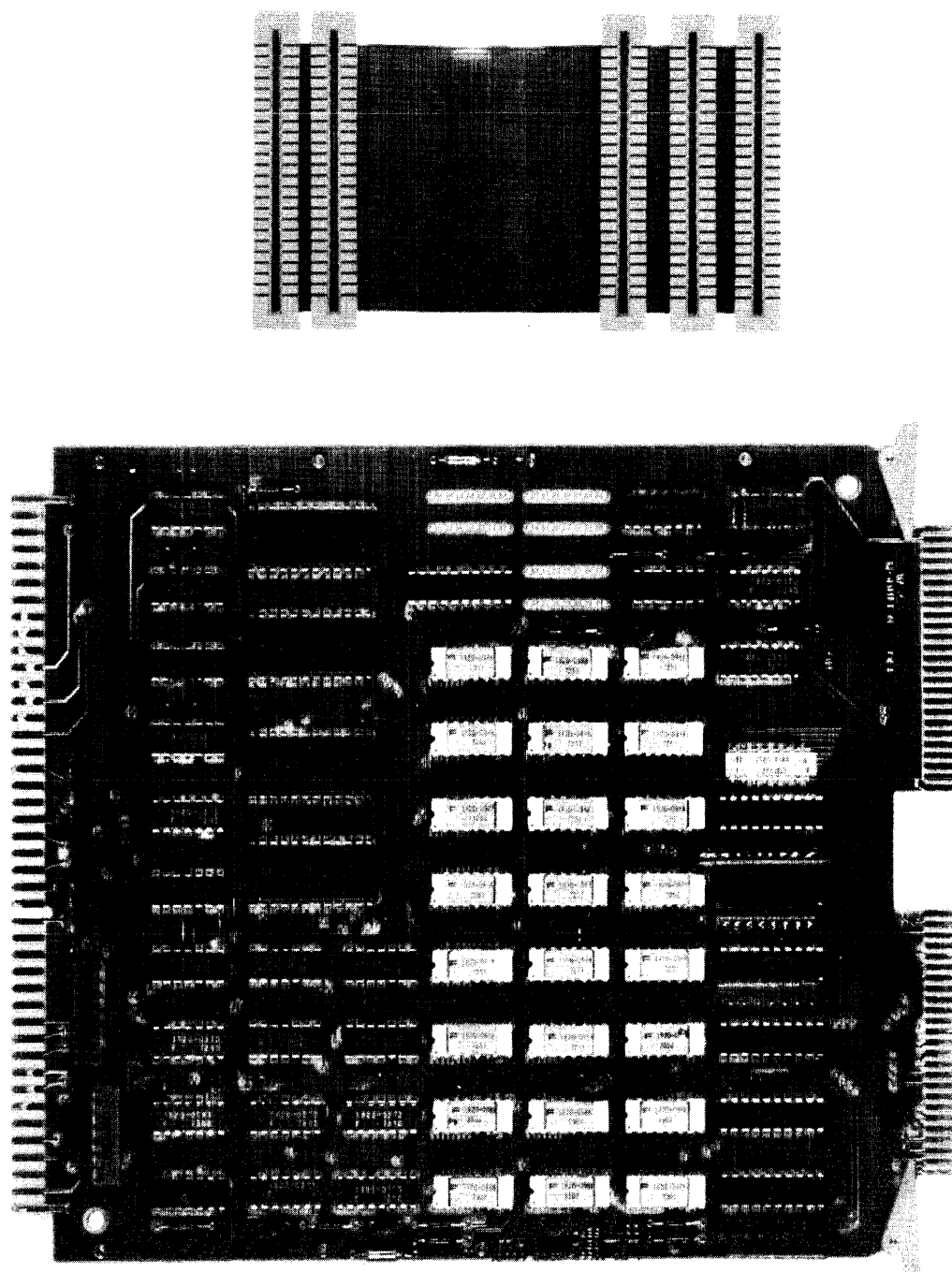


Figure 1-1. HP 12978A Writable Control Store Interface Kit

# GENERAL INFORMATION

## SECTION

## I

The HP 12978 WCS holds 256 words of control store (one control store module). Terminal board jumpers determine which control store module is stored by the HP 12978A WCS.

### 1-1. IDENTIFICATION

Hewlett-Packard uses five digits and a letter (12978A) for standard kit designations. If the designation of your kit does not agree with this number, there are differences between your kit and the kit described here.

### 1-2. INTERFACE KIT CONTENTS

The printed-circuit assembly (PCA) and flat cable assembly contained in the HP 12978A WCS interface kit are shown in figure 1-1. Table 1-1 lists the contents of the kit including documentation (this manual) and software.

Table 1-1. Interface Kit Contents

| INTERFACE KIT                                                                     | CONTENTS                            | HP PART NO.  |
|-----------------------------------------------------------------------------------|-------------------------------------|--------------|
| 12978A                                                                            | Writable Control Store PCA          | 12908-60006* |
|                                                                                   | Flat Cable Assembly<br>5 Connectors | 5060-8393    |
|                                                                                   | Microprogramming<br>21MX Computers  | 02108-90008  |
|                                                                                   | Diagnostic Paper Tape               | 12908-60001  |
|                                                                                   | Diagnostic Manual                   | 12908-90013  |
| *Only PCAs with a date code of 1436 or higher are suitable for 21MX applications. |                                     |              |

### 1-3. CONTENTS OF INTERFACE KIT OPTIONS

There are two 12978A Interface Kit Options. They contain material in addition to that contained in the basic interface kit. Option 001 provides all the software required for use of the writable control store in the DOS-III system. Option 002 provides all the software required for the use in the BCS system. These two options are listed in Table 1-2.

Table 1-2. Additional Material for Interface Options

| OPTION     | ADDITIONAL MATERIAL        | HP PART NO. |
|------------|----------------------------|-------------|
| 12978A-001 | DOS-III WCS Driver         | 24278-60001 |
|            | DOS-III WCS I/O Utility    | 24333-60001 |
|            | DOS-III Micro-assembler    | 12978-16001 |
|            | DOS-III Micro Debug Editor | 12978-16002 |
|            | DOS WCS Driver Manual      | 12908-90004 |
| 12978A-002 | BCS WCS Driver             | 24277-60001 |
|            | BCS WCS I/O Utility        | 24283-60001 |
|            | BCS Micro-assembler        | 12978-16003 |
|            | BCS Micro Debug Editor     | 12978-16004 |
|            | BCS WCS Driver Manual      | 12908-90003 |

### 1-4. SPECIFICATIONS

Table 1-3 lists the characteristics and specifications of the HP 12978A Writable Control Store PCA.

Table 1-3. HP 12978A Writable Control Store PCA Specifications.

|                                                                                                                                                                                             |                                                                                                            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|
| <b>CAPACITY</b><br>Words Available: 256 per WCS PCA<br>Maximum WCS PCAs: one per HP 2105; two per HP 2108<br>Word Size: 24 bits                                                             | <b>INTERFACE CURRENT SUPPLIED BY COMPUTER</b><br>0.15A (-2V supply); 4.6A (+5V supply)                     |
| <b>MICRO-INSTRUCTION TIME</b><br>Access: 162 ns.<br>Full Micro-instruction Cycle: 325 ns.                                                                                                   | <b>PCA DIMENSIONS</b><br>Width: 7-3/4 inches (196.8 mm)<br>Height: 8-11/16 inches (220.7 mm)               |
| <b>INSTALLATION</b><br>One writable control store PCA requires the use of one Input/Output slot (slot 10). Writable control store may be used as any module, except modules 0, 1, 14 or 15. | <b>PCA WEIGHT</b><br>Net Weight: 18 oz (511.2 gm) (card and cable only)<br>Shipping Weight: 4 lb (2.27 kg) |
| <b>DATA STORAGE</b><br>Input/Output Group instructions or an HP 21MX Dual Channel Port Controller are used to load the WCS.                                                                 | <b>PCA INPUT LEVELS</b><br>"1" state: 1.9 volts minimum<br>"0" state: 1.1 volts maximum                    |
| <b>DATA READBACK</b><br>Input/Output Group instructions only are used to read data from the WCS.                                                                                            | <b>PCA OUTPUT LEVELS</b><br>"1" state: 2.4 volts minimum<br>"0" state: 0.7 volts maximum                   |

## 2-1. UNPACKING AND INSPECTION

If the shipping carton is damaged upon receipt, request that the carrier's agent be present when the kit is unpacked. Inspect the kit for damage (cracked, broken parts, etc.). If the kit is damaged and fails to meet specifications, notify the carrier and the nearest HP Sales and Service immediately. (Sales and Service Offices are listed at the back of this manual.) Retain the shipping container and the packing material for the carrier's inspection. The HP Sales and Service Office will arrange for the repair or replacement of the damaged item without waiting for any claims against the carrier to be settled.

## 2-2. INSTALLATION

Install the writable control store kit as follows:

- a. Ensure that the computer operates properly prior to installing the writable control store interface kit.

### **WARNING**

**Hazardous voltages are exposed when the bottom cover is removed and AC power is applied.**

- b. Turn off power at the computer.
- c. Remove the bottom and back access covers from the computer.
- d. On the writable control store remove the appropriate jumper wires from TB1 to select the desired module number (see figure 2-1 for pin number configuration). Refer to table 2-1 for the desired module number and jumper removal. The jumpers should be configured for module 12 or 13, since these are reserved for the user.
- e. On the writable control store PCA place the WCS module 0 enable switch S1 in the OFF position.
- f. Place the first writable control store PCA in slot number 10 (select code 10) of the I/O section of the computer. Any additional writable control store PCAs should be placed in slot 11.

**Note:** When WCS PCAs are installed, computer software must be reconfigured because of the changed I/O slot usage. If adding WCS PCA(s) will overburden the Power Supply of the computer, it may be necessary to move some I/O PCAs to an I/O Extender, HP 12979A.

- g. Remove the ROM-CPU Interconnect assembly, part no. 5060-8344. Install the connectors of the flat cable assembly, part no. 5060-8393.

1. on J1 of the ROM Control PCA 1, A7
2. on J2 on the CPU A1
3. on J1 of each WCS PCA

as shown in side view on figure 2-2.

**Note:** If an I/O PCA is installed immediately above the WCS (refer to figure 2-2) that requires a cable (hood) connector on the back, then it may be necessary to double the flat cable assembly back or cut it to make room for the I/O cable connector.

- h. Replace the bottom and back access covers on the computer.
- i. Turn on power at the computer and perform the diagnostic test as outlined in the Diagnostic Program Procedures (part no. 12908-90009) shipped with the 12978A Interface Kit. Note that the diagnostic cannot test a WCS installed in modules 0, 1, 2, 14, or 15. If the diagnostic program is completed without error, the PCA is installed and operating properly. If the diagnostic program indicates errors, halt the computer, turn off power, and recheck all of the above installation procedures. Correct where necessary, then recheck and repeat the operating procedures of the diagnostic.

**Note:** In any correspondence identify the kit by model number. Refer any questions to the nearest Hewlett-Packard Sales and Service Office.

## 2-3. RESHIPMENT

If an item of the kit is to be shipped to Hewlett-Packard for service or repair, attach a tag to the item identifying the owner and indicating the service or repair to be accomplished. Include the model number of the kit. Package the item in the original factory packaging material, if available. If the original material is not available, standard factory packaging material can be obtained from a local Hewlett-Packard Sales and Service Office. If standard factory packaging material is not used, wrap the item in Air Cap TH-240 Cushioning (or equivalent) manufactured by Sealed Air Corp., Hawthorne, N.J. and place in a corrugated carton (200 pound test material). Seal the shipping carton securely and mark it "FRAGILE" to ensure careful handling.

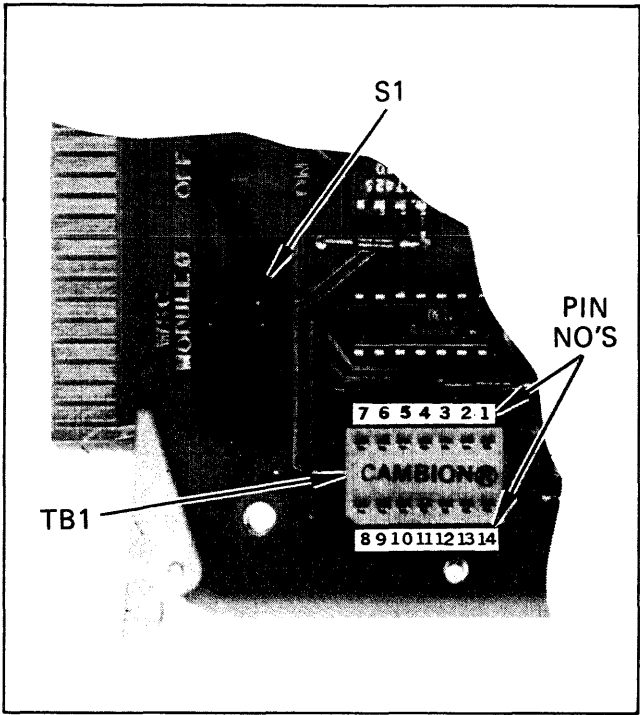


Figure 2-1. HP 12978A WCS Terminal Board for Selecting Module Number Position

Table 2-1. WCS PCA Jumper Removal and Terminal Board for Various Module Selections

| MODULE | JUMPERS TO BE REMOVED      |
|--------|----------------------------|
| 0      | None                       |
| 1      | Pins 6,9                   |
| 2      | Pins 5,10                  |
| 3      | Pins 6,9; 5,10             |
| 4      | Pins 4,11                  |
| 5      | Pins 6,9; 4,11             |
| 6      | Pins 5,10; 4,11            |
| 7      | Pins 6,9; 5,10; 4,11       |
| 8      | Pins 3,12                  |
| 9      | Pins 6,9; 3,12             |
| 10     | Pins 5,10; 3,12            |
| 11     | Pins 6,9; 5,10; 3,12       |
| 12     | Pins 4,11; 3,12            |
| 13     | Pins 6,9; 4,11; 3,12       |
| 14     | Pins 5,10; 4,11; 3,12      |
| 15     | Pins 6,9; 5,10; 4,11; 3,12 |

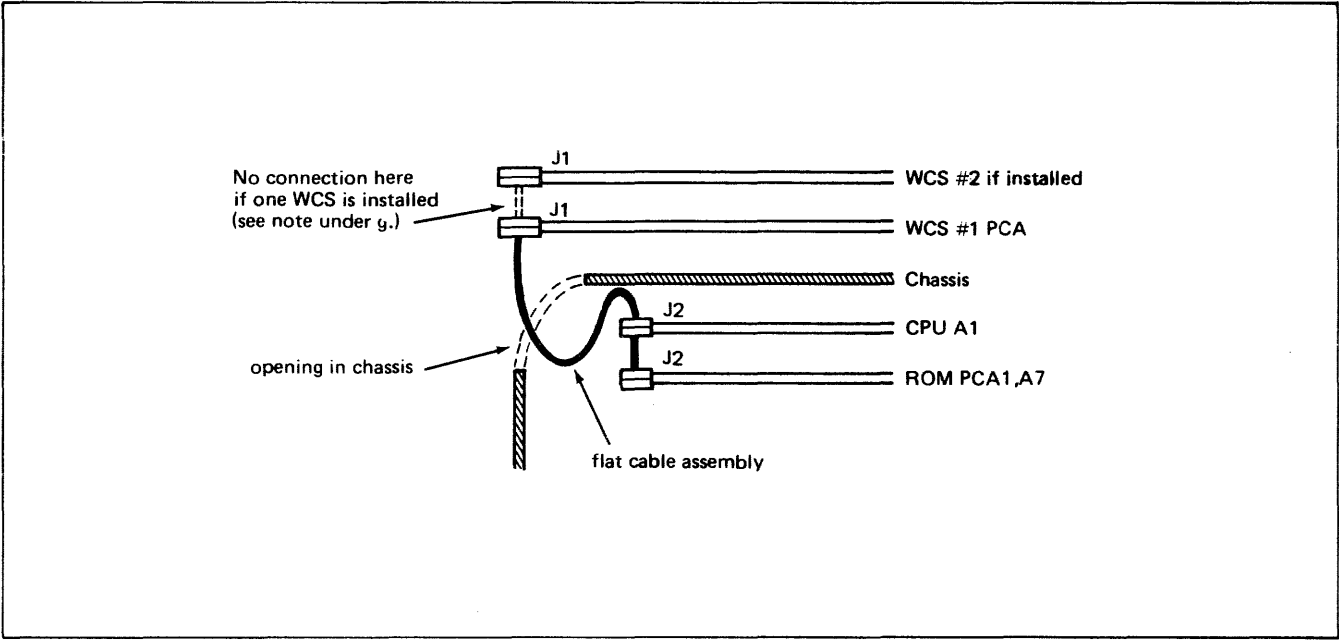


Figure 2-2. Installation of Flat Cable Assembly

Two methods exist for writing data into (loading) a WCS module: under program control and under control of the Dual Channel Port Controller (DCPC). Prior to initiating the load routine, the data to be loaded must be stored in the computer memory. This requires a main memory buffer of up to 512 words per module. The load routine will send two words from memory (32 bits which are mapped into an 8 bit address and a 24 bit microinstruction) to the WCS module issue a write command to that module and cause the data to be stored there. The load routine will repeat this process until the desired number of words has been stored in the WCS module.

Once loaded, the contents of the WCS module may be read back under program control via the I/O bus and compared with their counterpart in memory.

Timing sequences for flags used in the following examples are shown in figure 4-1.

### 3-1. PROGRAM EXAMPLE: LOADING WCS

The following is an example of the program sequence necessary for loading a WCS under program control. This example does not include block pointers, counters, etc., which are necessary for proper control.

Note: "SC" indicates select code of the WCS PCA.

|        |                                                                                                                                                                                  |
|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| STF SC | Initializes the Direction FF (flip-flop or flag)                                                                                                                                 |
| OTA SC | Loads the first computer word into first WCS buffer and toggles the Direction FF. This word comprises the 8 bit address and the 8 most significant bits of the microinstruction. |
| OTB SC | Loads the second computer word into the second WCS buffer and toggles the Direction FF. This word comprises the 16 least significant bits of the microinstruction.               |
| STC SC | Provides the write pulse to load the WCS buffers into the RAM.                                                                                                                   |

The OTA, OTB, and STC instructions are normally in a loop that is repeated until the desired number of microinstructions have been stored. OTA/OTB was chosen as an example; any combination of these instructions is allowable.

### 3-2. PROGRAM EXAMPLE: READING WCS

An example of reading from WCS under program control via the I/O bus is shown below. This example is shown without regard to the block pointers, counters, etc., which are necessary for proper control.

|        |                                                                                                                                                                                                                     |
|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| STF SC | Initializes the Direction FF.                                                                                                                                                                                       |
| OTA SC | Sends the 8 bit address to the WCS from the 8 most significant bits of the A-register (B-register could be used, as well).                                                                                          |
| STF SC | Re-initializes the Direction FF.                                                                                                                                                                                    |
| LIA SC | Places eight zeros into the 8 most significant bit positions of the A-register and places the eight most significant bits of the microinstruction into the eight least significant bit positions of the A-register. |
| LIB SC | Places the 16 least significant bits of the microinstruction into the B-register.                                                                                                                                   |

The STF, OTA, STF, LIA, and LIB sequence is normally in a loop that is repeated until the desired number of microinstructions have been read in from WCS. LIA/LIB was chosen as an example; any combination of these instructions is allowable.

### 3-3. PROGRAM EXAMPLE: LOADING WCS BY DUAL CHANNEL PORT CONTROLLER

Under Dual Channel Port Controller (DCPC) control, the load routine must send only the three DCPC control words to the selected channel. When the channel is turned on,

DCPC will utilize every I/O cycle until the entire block of data is sent to the WCS (maximum of 512 cycles). DCPC will transfer these words at a rate of  $1.62 \mu\text{s}/\text{word}$  (512 words will take  $830 \mu\text{s}$  to transfer.).

The following is an example of the program sequence necessary for loading WCS via DCPC. This example does not include block pointers, counters, etc., which are necessary for proper control.

|         |                                                                                                                                        |
|---------|----------------------------------------------------------------------------------------------------------------------------------------|
| LDA CW1 | Get the first DCPC control word.                                                                                                       |
| OTA 6   | Send the first DCPC control word to the selected DCPC channel (DCPC channel 1 has been selected here for demonstration purposes only). |
| CLC 2   | Prepare the selected DCPC channel to receive the second DCPC control word.                                                             |
| LDA CW2 | Get the second DCPC control word.                                                                                                      |
| OTA 2   | Send the second DCPC control word to the selected DCPC channel.                                                                        |

|                 |                                                                                         |
|-----------------|-----------------------------------------------------------------------------------------|
| STC 2           | Prepare the selected DCPC channel to receive the third DCPC word.                       |
| LDA CW3         | Get the third DCPC control word.                                                        |
| OTA 2           | Send the third DCPC control word to the selected DCPC channel.                          |
| STC 6,C         | Turn on the selected DCPC channel.                                                      |
| STF SC          | Initialize the Direction FF.                                                            |
| CLF SC          | Start DCPC transfer.                                                                    |
| SFS 6           | Test for the completion of the transfer.                                                |
| JMP *-1         | Loop until done.                                                                        |
| ⋮               |                                                                                         |
| CW1 OCT 1200 SC |                                                                                         |
| CW2 OCT 010000  | Specifies DCPC output and the starting address ( $10000_8$ ) of the block to be output. |
| CW3 OCT 177000  | Two's complement of the number ( $1000_8$ ) of computer words to be output.             |

# GENERAL THEORY OF OPERATION

## SECTION

## IV

The HP 12978A Writable Control Store (WCS) consists of a bipolar semiconductor Random Access Memory (RAM) containing 24 integrated circuit (IC) packages mounted on a 2100-size printed-circuit assembly (PCA). Also included is the flat jumper cable assembly necessary for complete mechanization within the HP 21MX Computer. The WCS PCA should be installed only in slots 10 (standard) and 11 of the computer I/O slots. Each IC package is configured in 256 bits and organized as one bit per word. Thus one module of WCS is capable of storing 256 words of 24 bits each.

For purpose of execution of WCS instructions, WCS can be configured to be addressed as any one of the computer's ROM modules except module 0. One WCS module can be installed on an HP 2105 Computer. Two WCS modules can be installed on an HP 2108 Computer.

### 4-1. WCS MODULE IDENTIFICATION

For proper addressing of WCS, an integrated circuit comparator and terminal board (with jumpers) on the WCS PCA is used to identify the PCA as a particular module of Control Store. For example, if the terminal board is configured for module 2, the PCA will be enabled when the ROM Address Register (RAR) contains the pattern "0010" in its four most significant bits (11-8), and disabled otherwise. When enabled, the word in WCS addressed by RAR bits 0 through 7 will be sent to the ROM Instruction Register (RIR) as singles ROM0 through ROM23. The computer will then execute this word (microinstruction) as though it came from a standard ROM PCA. The access time of data from WCS (162 ns.) allows the computer to operate at its normal clock rate. If it is desired to replace any module already existing in ROM with a WCS module, that ROM module must be removed in order to prevent unwanted "or" conditions on the data lines.

**Note:** The ON position of switch S1 (figure 2-1) is not intended for use in the 21MX computers. All Control Store is disabled, if S1 is set to ON.

### 4-2. WCS CONNECTION

WCS is connected to the computer central processor through the I/O structure (for loading and checking), and also through a 50 wire flat cable connector. It is this connector that enables WCS to be used as an extension of the computer's basic control store. The cable connects one or two WCS PCAs to ROM control PCA 1,A7 and to CPU A1. The ROM address register on the CPU sends a 12 bit address to the WCS PCA or PCAs through this cable, and the addressed PCA then sends its data (microinstruction) from that address back through this cable, where it is merged with the outputs of ROM. From there the data is sent to the ROM instruction register as through it was from ROM.

### 4-3. WCS ADDRESSING

To load the HP 12978A WCS RAM circuits, the WCS PCA must be addressed through the I/O interface structure of the computer. A 32 bit format is necessary and requires that a 2 word transfer be used in the loading procedure through the computer A- and/or B-registers. Two computer words and thus two transfer operations are required for one WCS word. The eight most significant bits of the first computer word transferred is the WCS RAM circuit address. The remaining eight bits of the first computer word and all 16 bits of the second computer word (total of 24 bits) are stored in WCS at the address specified.

Once loaded, WCS becomes an extension of the ROM. Thus the WCS may be used to alter the computer instruction set while the computer is in an operating condition. This feature permits dynamic expansion of the computer instruction set.

### 4-4. HP 12978A WCS LOADING TIMING DIAGRAM RAM

Figure 4-1 illustrates the WCS timing.

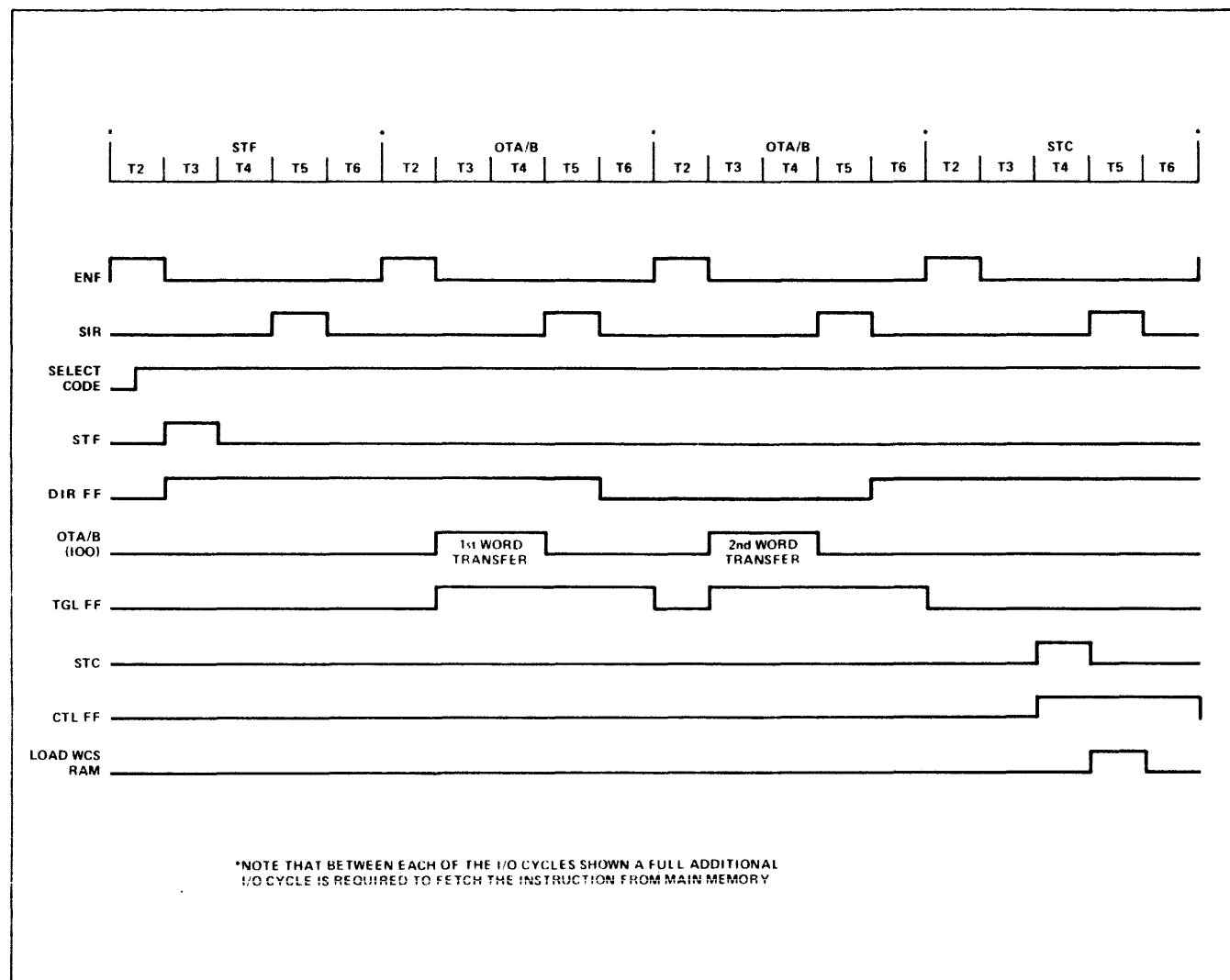


Figure 4-1. WCS Loading Timing Diagram



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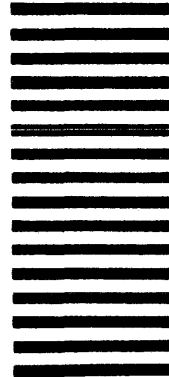
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