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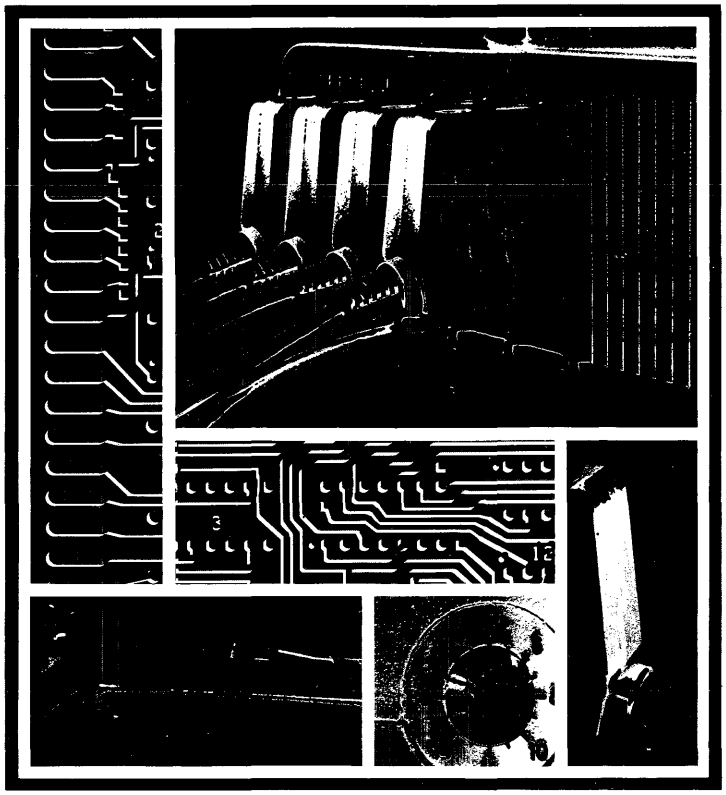
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Series 9800 Desktop Computers

HP 98035A
Installation and Service



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HP 98035A Real Time Clock Installation and Service Manual

Manual Part No. 98035-90000
Microfiche No. 98035-99000



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Chapter 1
General Information

Introduction

The HP 98035A is a real time clock in a standard interface housing. The HP 98035A Real Time Clock adds real time referencing and time related control to Hewlett-Packard's line of desktop computers.

Available to the computer is real time information containing the month, day, hour, minutes, and seconds in the U.S. or European date format. The date format is jumper selectable. A built-in rechargeable battery maintains back-up power for the Real Time Clock whenever the computer is switched off.

Also available in the Real Time Clock is access to four independent timing/counting units that can be operated in either interrupting (output) or counting (input) modes.

Some of the operations are performed with little or no interaction with the computer after initial setup.

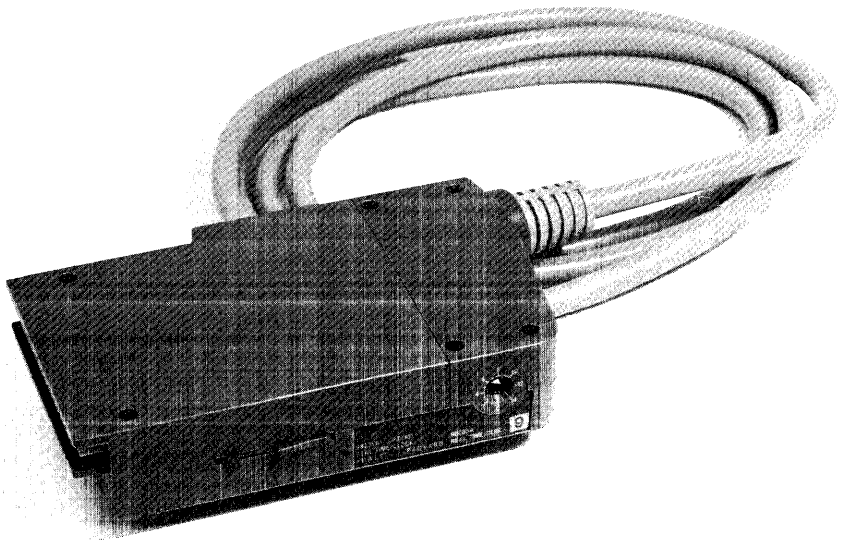


Figure 1-1: 98035A Real Time Clock, Option 100

System Configurations

Option 001

U.S. date format – real time output as month:day:hours:minutes:seconds

Option 002

European date format - real time output as day:month:hours:minutes:seconds

Option 025

Operating note for the HP 9825 desktop computer

Option 031

Operating note for the HP 9831 desktop computer

Option 035

Programming techniques for the HP 9835 desktop computer

Option 045

Programming techniques for the HP 9845 desktop computer

Option 100

HP 98035A Real Time Clock with approximately 1.8 meters (6 feet) of unterminated cable for I/O operations

Field-Installable Cable

A field-installable cable is available to convert the standard clock into an Option 100 type configuration. This cable is HP part number 98035-61600.

General Specifications

Power Requirements

Supplied by Computer

+5 volts at 300 mA

+12 volts at 20 mA

−12 volts at 5 mA

Internal Battery

2.5 volt rechargeable nickel-cadmium

Maximum recharge time: 16 hours

Minimum discharge time:

with clock chip outputs enabled: 10 hours (see pages 24, 41, and 47)

with clock chip outputs disabled: 2 months

Temperature Range

Operating: 5° C to 40° C

Storage: −20° C to 55° C

Accuracy (ms counter/interrupt functions)

Initial Accuracy

Factory adjusted to ±5 ppm at 25°C ambient after a one hour warmup.

Frequency Temperature Characteristic

Maximum drift of ±5 ppm from a 25°C reference over the range from 10°C to 40°C.

Accuracy (time-of-day functions)

Initial Accuracy

Typically within ±30 ppm at 25°C.

Frequency Temperature Characteristic

Maximum drift of +10 ppm, −30 ppm from a 27°C reference over the range from 10°C to 40°C.

Crystal Aging

Maximum drift of 5 ppm in the first year; less than 3 ppm in subsequent years.

Signal Lines[1]

Four data input lines, I1-I4. The inputs are low-power Schottky with internal pull-up resistors. The low level current is 2mA, and the logic sense is negative true (Low = "1" = True).

1 Option 100 only

Four data output lines, O1-O4. The outputs are open-collector types with a low-level drive capability of 8mA. The logic sense is negative true (Low = "1" = True).

There is also a synchronizing output that can be used in I/O operations. It provides a 4 microsecond wide pulse every millisecond and is an open-collector output.

For more information on interfacing external devices to the HP 98035A and the associated timing requirements, see Chapter 2, figures 2-5, 2-6, and 2-7.

Physical Description

The 98035A Real Time Clock is contained in a plastic housing, approximately 163 x 91 x 35 mm (6.4 x 3.6 x 1.4 in.). Figure 1-2 illustrates the clock housing. The front housing which plugs into the calculator contains the clock, nicad battery, interface, and associated control circuitry on two printed circuit boards. One of the boards has a 24-pin connector for the optional interface cable.

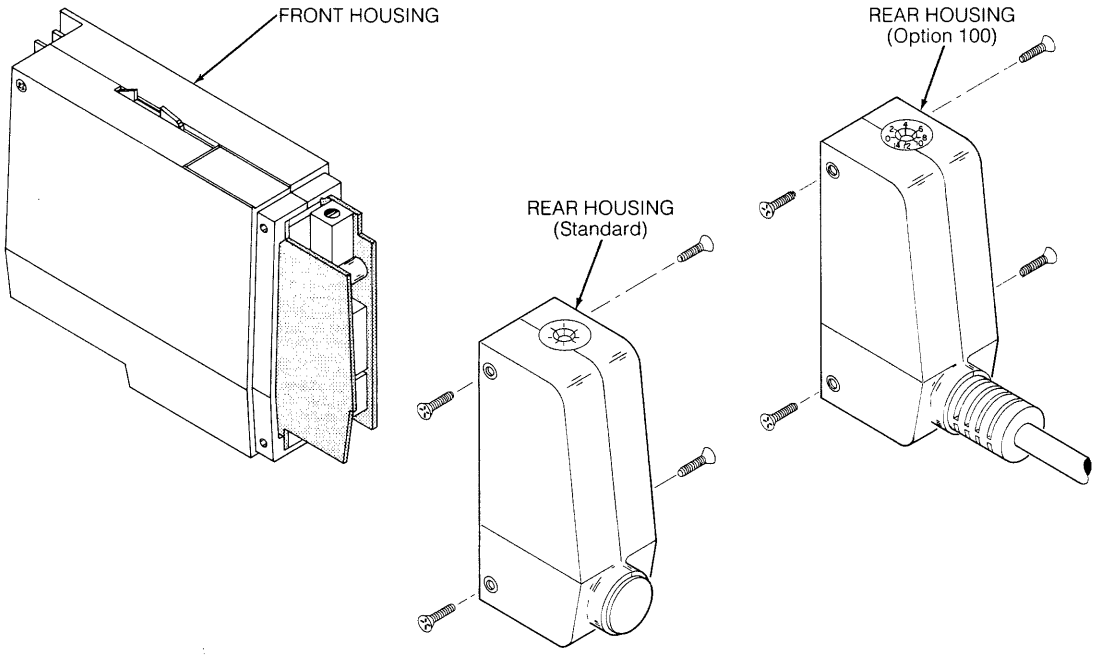


Figure 1-2: 98035A Housing

Chapter 2
Installation

Introduction

The standard 98035A Real Time Clock as shipped from the factory has no I/O cable. Installation consists of plugging the unit into one of the I/O slots on the back of the computer, letting the battery charge, and then setting the time. The Option 100 clock has an unterminated I/O cable, and thus requires you to install the necessary terminating connector for your application. The standard Real Time Clock can be reconfigured to an Option 100 type device by the addition of an I/O cable, HP part number 98035-61600.

Information concerning the operation of the 98035A Real Time Clock should be read and understood before attempting to install this peripheral (refer to Chapter 3).

If an external device is to be interfaced to an Option 100 clock, a thorough understanding of the operation of both devices and their interaction is recommended.

Select Code

All peripheral devices and interfaces attached to an HP desktop computer have a unique address that allows them to be individually selected. These addresses are called select codes and can be set by the user. The 98035A Real Time Clock is preset at the factory to select code 9. If it is necessary to change the setting, rotate the select code switch on the top of the rear housing to the desired position, using a small screwdriver as illustrated in Figure 2-1.

NOTE

Two interfaces or peripherals should not be set to the same select code.

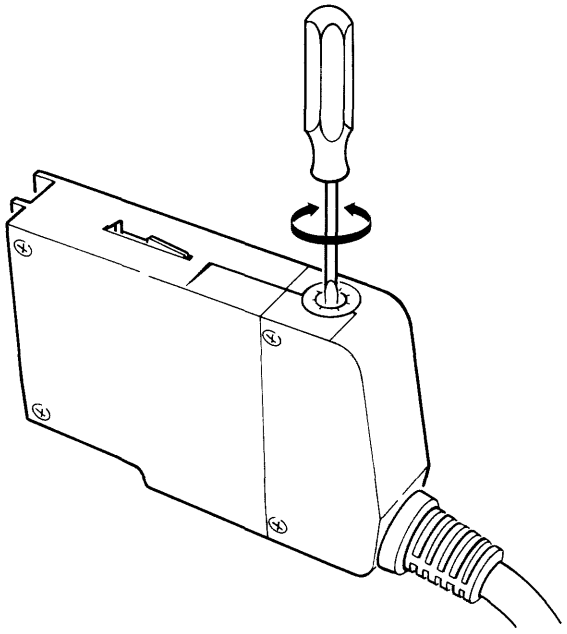


Figure 2-1. Setting the Select Code Switch

Peripherals internal to the computer such as built-in tape drives and printers have their own select codes. Care should be taken so that the 98035A's select code differs from those of the internal devices. For a listing of the internal peripheral select codes, please refer to your computer's operating manual.

NOTE[1]

Select codes 0 through 7 are on the low priority interrupt level and select codes 8 through 15 are on the high priority level. Devices requiring fast interrupt service should be set to the high level. Priority within a level is in order of the select code, with 7 and 15 having the highest priority. The Real Time Clock should be given a high priority number if it is to be used in the interrupt mode.

---

1 Applies only to computers with interrupt capabilities; many of these computers need an I/O ROM to implement interrupts. Please refer to the appropriate computer and ROM manuals.

Device Cable[2]

Identification

The 24 lines of the device cable are used for signals as shown in Table 2-1. Any input lines (I1-I4) to the 98035A Real Time Clock that are not used should be grounded. All other unused lines may be left unterminated.

Table 2-1. Cable

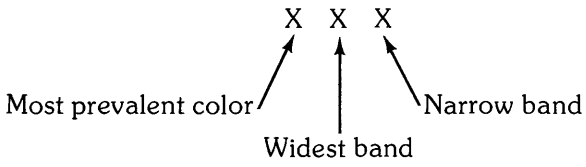
SIGNAL	COLOR	CONNECTOR PIN
I1	901	13
I2	902	14
I3	903	15
I4	904	16
SYNC	6	17
O1	1	18
O2	2	19
O3	3	20
O4	4	21
GND	9	5
GND	8	6
GND	98	8
GND	90	9
SHIELD	OUTER METAL BRAID	10
GND	INNER METAL BRAID	11
SPARE	93	
SPARE	5	
UNUSED	905	
UNUSED	97	
UNUSED	91	
UNUSED	94	
UNUSED	95	
UNUSED	96	
UNUSED	7	

2 Option 100 devices only.

NOTE

I1 = Input port 1	O1 = Output port 1
I2 = Input port 2	O2 = Output port 2
I3 = Input port 3	O3 = Output port 3
I4 = Input port 4	O4 = Output port 4

Wire color codes shown correspond to the standard resistor color code. Digits have the following significance:



0 - Black	5 - Green
1 - Brown	6 - Blue
2 - Red	7 - Violet
3 - Orange	8 - Gray
4 - Yellow	9 - White

NOTE

The outer shield (and drain wire) should not be connected to anything on the external device end.

Cable Preparation

Tools needed:

Safety razorblade or knife
Diagonal clippers
Wire strippers
Soldering iron, solder
Heatshrink tubing or tape

Prepare the end of the cable as shown in Figure 2-2. Notice that the outer shield and bare wire are not connected to the external devices.

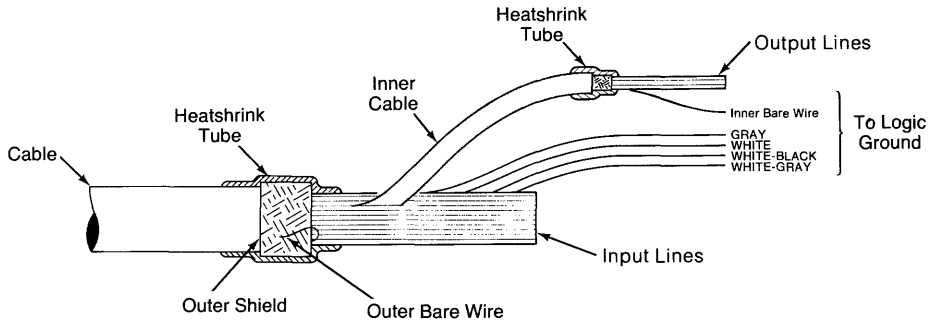


Figure 2-2. Cable Preparation

Procedure:

Refer to Figure 2-2.

1. Cut the cable to the required length, allowing some length for slack.
2. Using the razorblade or knife, strip off about 10 cm (4 inches) of the outer plastic jacket.
3. Cut off the outer shield and outer bare wire even with the outer plastic jacket, taking care not to nick or otherwise damage the inner wires.
4. Cover the end of the jacket and outer shield with heatshrink tubing or tape.
5. Strip and connect the cable wires as required by your peripheral.
6. Be sure to connect the logic ground wires (refer to Table 2-1) to the peripheral's logic ground.
7. Isolate unused wires with heatshrink tubing or tape.

CAUTION

TO PREVENT POSSIBLE DAMAGE TO THE 98035A REAL TIME CLOCK, THE CABLE'S LOGIC GROUND WIRES MUST BE CONNECTED TO THE EXTERNAL PERIPHERAL'S LOGIC GROUND.

Field Installation of Option 100 Cable

The standard 98035A Real Time Clock can be fitted with an I/O cable, HP part number 98035-61600. This will convert it to an Option 100 device.

Tools required:

#1 pozidrive screwdriver

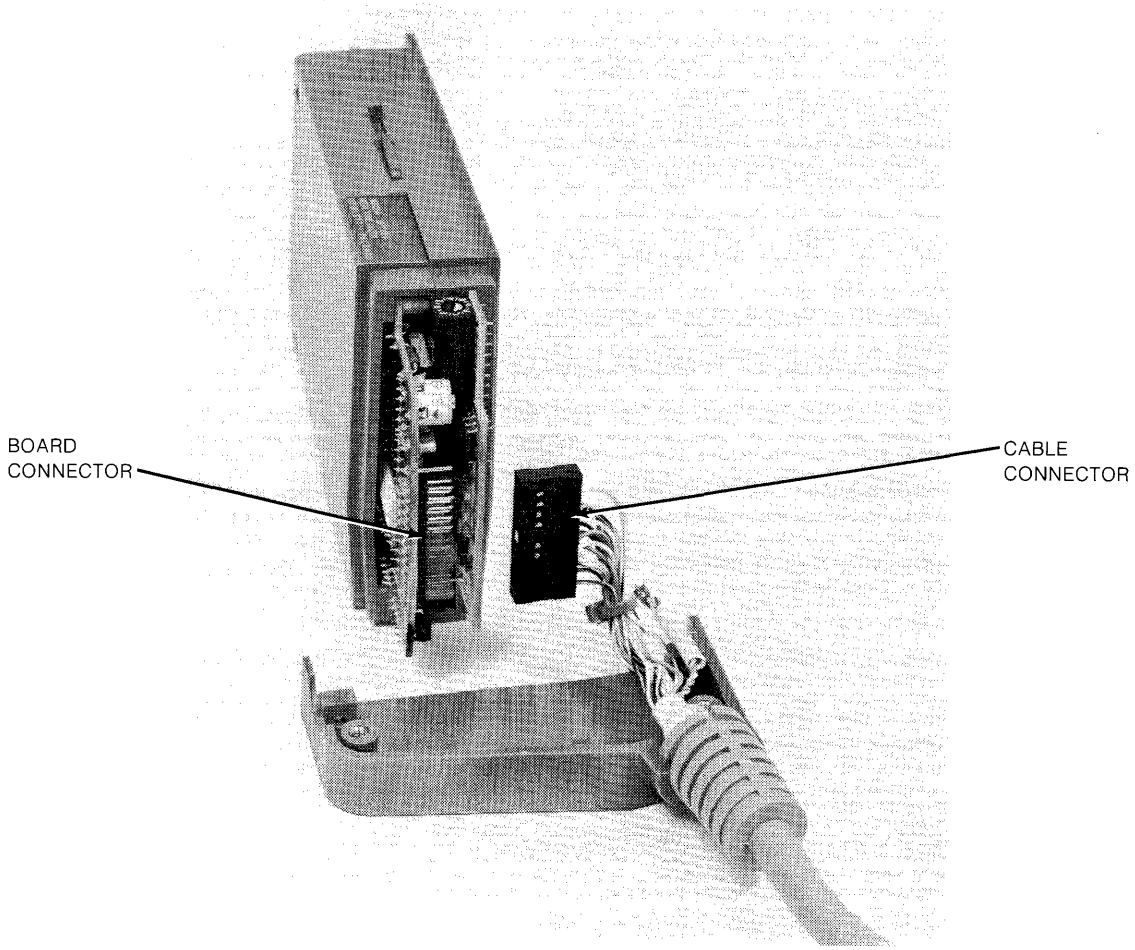


Figure 2-3. Cable Installation

Procedure:

Refer to Figure 2-3.

1. Remove the six screws on the rear housing of the Real Time Clock.
2. Separate the two halves and remove the cap from the cable feed-through hole.

CAUTION

THE REAL TIME CLOCK CONTAINS A RECHARGEABLE BATTERY THAT MAINTAINS POWER TO PARTS OF THE CLOCK AT ALL TIMES. WHEN ANY PART OF THE CASE IS REMOVED, DO NOT SHORT ANY OF THE TRACES OR COMPONENTS WITH A METALLIC OBJECT OR DAMAGE MAY RESULT.

NOTE

Errors in the real time may result if there is finger contact with the Real Time Clock circuit boards while any part of the case is removed.

3. Remove the connector supplied with the standard Real Time Clock from the rear of the processor board (refer to Figure 2-3). Install the new cable connector in place of the old connector. Note that the cable connector can be installed in one direction only.
4. Make sure that the groove in the cable strain-relief engages in the edge of the cable feed-through hole on the rear housing, and reassemble the clock case.
5. Prepare the cable end as described in cable preparation.

Changing the Date Code Format

Option 001 clocks are supplied properly formatted for the U.S. style, and Option 002 clocks are supplied properly formatted for the European style. If you change your mind or have the wrong option, you can select the format of your clock by moving a jumper.

European format:

Day:Month:Hours:Minutes:Seconds

U.S. format:

Month:Day:Hours:Minutes:Seconds

The date code format is selected via a jumper on the 98035-66501 printed circuit board inside the 98035A Real Time Clock. Refer to Figure 2-4.

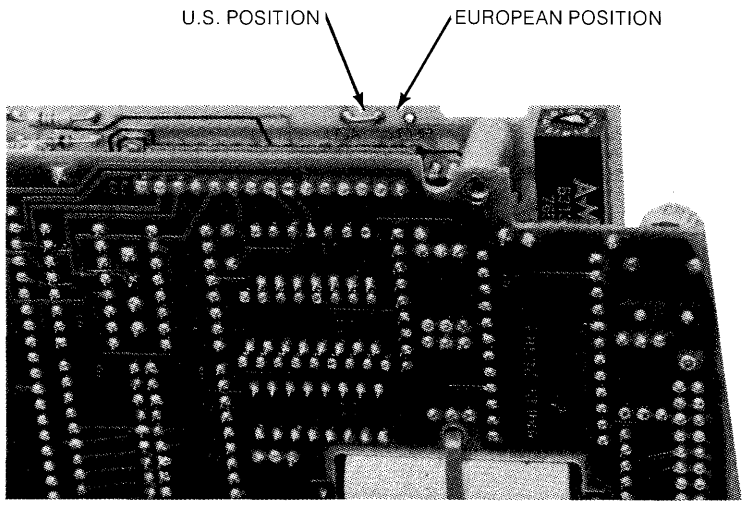


Figure 2-4. Date Code Format Jumper

Tools required:

Needle nose pliers
#1 pozidrive screwdriver
Low-power soldering iron
Solder

Procedure:

1. With the clock removed from the computer, remove the four screws that hold the rear housing in place and remove it. On Option 100 devices, unplug the external cable.
2. Remove the four screws that hold the front housing together, two on each side. Remove the front housing pieces, exposing the two printed circuit boards.Be aware of the latch arm at the top of the housing.

CAUTION

THE REAL TIME CLOCK CONTAINS A RECHARGEABLE BATTERY THAT MAINTAINS POWER TO PARTS OF THE CLOCK AT ALL TIMES. WHEN ANY PART OF THE CASE IS REMOVED, DO NOT SHORT ANY OF THE TRACES OR COMPONENTS WITH A METALLIC OBJECT OR DAMAGE MAY RESULT.

NOTE

Errors in the real time may result if there is finger contact with the Real Time Clock circuit boards while any part of the case is removed.

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3. The jumper can be moved with the board assembly intact or separated. If you choose to separate the two boards, do so gently. Do not bend any connecting pins or disturb the position of any components.
4. The Date Code jumper is located on the upper right-hand side of the board containing the select code switch (refer to Figure 2-4).
5. Using a pair of needle-nose pliers and a low-power soldering iron, grasp the jumper wire and carefully unsolder it.
6. Resolder the jumper in the desired location, and reassemble the unit.

Recommended Driver and Receiver Circuits[3]

To prevent possible damage to the 98035A Real Time Clock and external devices, it is recommended that you employ the following interface circuits.

Peripheral Driver Circuits

Each of the input lines on the 98035A Real Time Clock is connected to a low-power Schottky gate. A resistive divider is connected to each of the input lines (refer to Figure 2-5) to hold the input line voltage at +3.4 volts when the cable is disconnected. The input voltage to the input lines must not exceed +5.5 volts.

Input Drive Requirements

V_I	Maximum Input Voltage	5.5 Volts
V_{IH}	High Level Input Voltage (min)	2.0 Volts
V_{IL}	Low Level Input Voltage (max)	0.8 Volts
I_{IL}	Low Level Input Current (max)	−2.0 mA

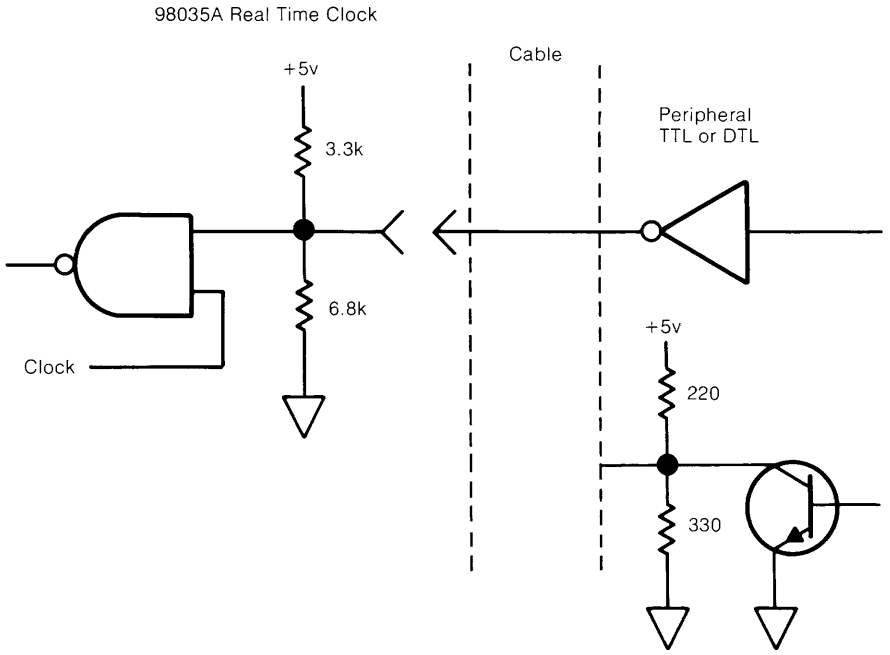


Figure 2-5. Recommended Peripheral Driver Circuits

3 Option 100 devices only.

Peripheral Receiver Circuits

Each output line from the 98035A Real Time Clock is driven by an open-collector circuit. The current sinking capability of each driver is 8 mA and the breakdown voltage is +15 volts. Do not apply a negative voltage to the output lines.

Output Drive Capability

V_{OH}	High level Output Voltage (max)	15 Volts
V_{OL}	Low Level Output Voltage (max)	0.4 Volts @ 4 mA 0.5 Volts @ 8 mA
I_{OL}	Low Level Output Current (max)	8.0 mA

Since each driver has an open-collector output, the external peripheral receiving circuit must have a pull-up to a positive voltage (not to exceed +15V), and must be restricted to sourcing less than 8mA. The recommended receiving circuit is shown in Figure 2-6.

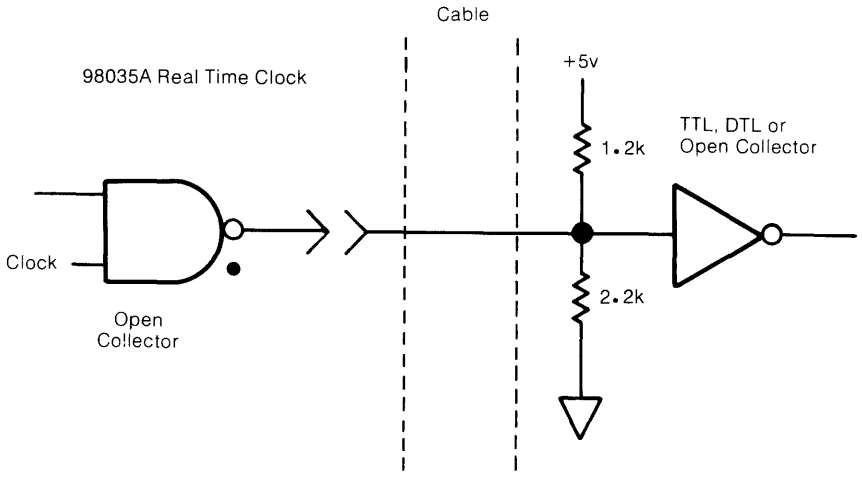


Figure 2-6: Recommended Peripheral Receiver Circuit

I/O Timing Considerations

The 98035A Real Time Clock has an additional output that is provided to synchronize the peripheral inputs with internal clock timing. The SYNC line will output a 4 microsecond wide pulse every millisecond. Refer to Figure 2-7.

The Real Time Clock inputs data from the external lines 3 microseconds after the falling edge of the SYNC pulse. The data on these lines must be stable at least 2 microseconds after the falling edge of the SYNC pulse. Input signals may appear asynchronously. Refer to Figure 2.7

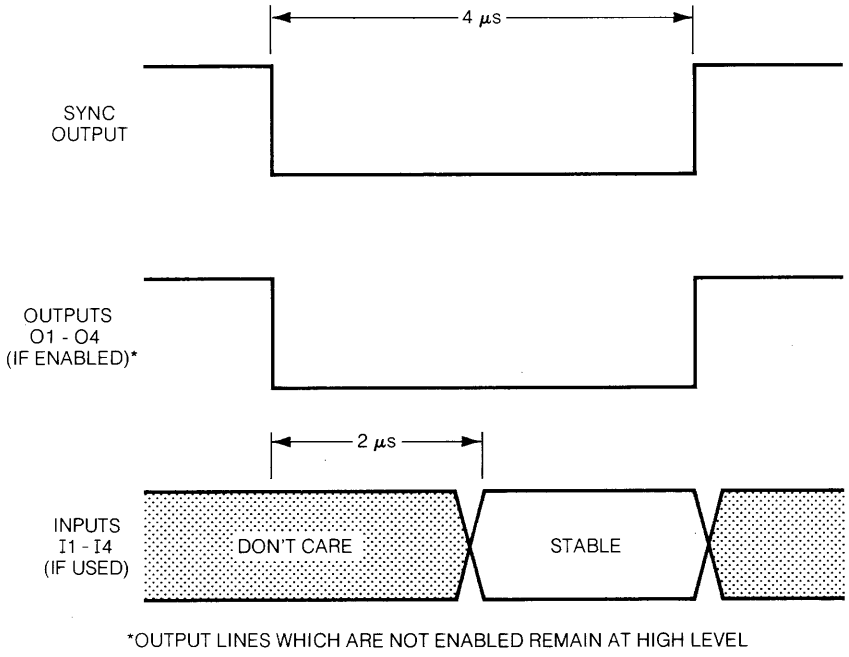


Figure 2-7. External I/O Timing

NOTES

Chapter 3
Operations

This chapter defines the instructions and operations of the HP 98035A Real Time Clock. It presents a general overview without referencing any specific model of computer. For programming examples with a specific desktop computer, refer to the operating note supplied with your option of the Real Time Clock.

NOTE

Information exchanges between the 98035A and the computer cannot be handled using DMA transfers and should not be handled using interrupt transfers. Data can be input and output using standard handshake transfers. Specific examples of recommended I/O instructions can be found in the appropriate operating note.

Simplified Theory of Operation

A functional block diagram of the 98035A Real Time Clock is shown in Figure 3-1. The Real Time Clock has six major functional groups: a clock circuit with rechargeable batteries, control circuitry, four timing/counting units, four input ports, four output ports, and an optional (Option 100) external cable.

The clock circuit is crystal controlled and power is maintained by a rechargeable battery. The clock is contained on a single LSI[1] chip, and its purpose is to maintain the real time while the desktop computer is switched off. This clock has a resolution of 1 second.

The control circuit decodes and executes all the instructions sent to the Real Time Clock by the desktop computer. When power is applied or a system reset is executed on the desktop computer, the control circuit performs a test of the Real Time Clock unit and then reads the real time from the clock chip. From this point on the control circuit alone maintains and updates the real time every millisecond.

1 Large Scale Integration

There are four timing/counting units which are software controlled. These units can be configured to any input or output port. When set to the output mode, a timing/counting unit will interrupt[2] the computer when selected real time specifications are met. If the Real Time Clock is equipped with the Option 100 I/O cable, a 4μs pulse will also be output on the selected line at this time. In the input mode, the Real Time Clock increments the timing/counting units once every millisecond. Option 100 Real Time Clocks increment a timing/counting unit once every millisecond when the input line is enabled.

The input ports act as buffers between the timing/counting units and external drivers. These buffers are scanned once every millisecond by the control circuit. The appropriate counter will be incremented each time the scanner sees a logic "true" input. Standard Real Time Clocks have all input ports connected so that a "true" signal is always present; hence the counters are incremented every millisecond. Option 100 clocks have an external cable connected to the ports so that you can input your own signals. Recommended driver circuits are shown in Chapter 2, Figure 2-5, and the input timing diagram is shown in Figure 2-7.

The output ports act as buffers between the timing/counting units and external receivers. Option 100 Real Time Clocks have an external cable connected to the ports so that the output signals can be used externally. No connection is made to the output pins on the standard clocks.

The Option 100 cable allows the Real Time Clock to monitor and trigger external devices. The cable is 1.8 metres (6 feet) long, and is unterminated on one end. Standard Real Time Clocks can be retrofitted with this cable, HP part number 98035-61600. For information on installing the cable, refer to Chapter 2.

Both the standard and Option 100 Real Time Clocks use the same instruction set.

2 Computer must be interruptable and the Real Time Clock enabled for interrupts

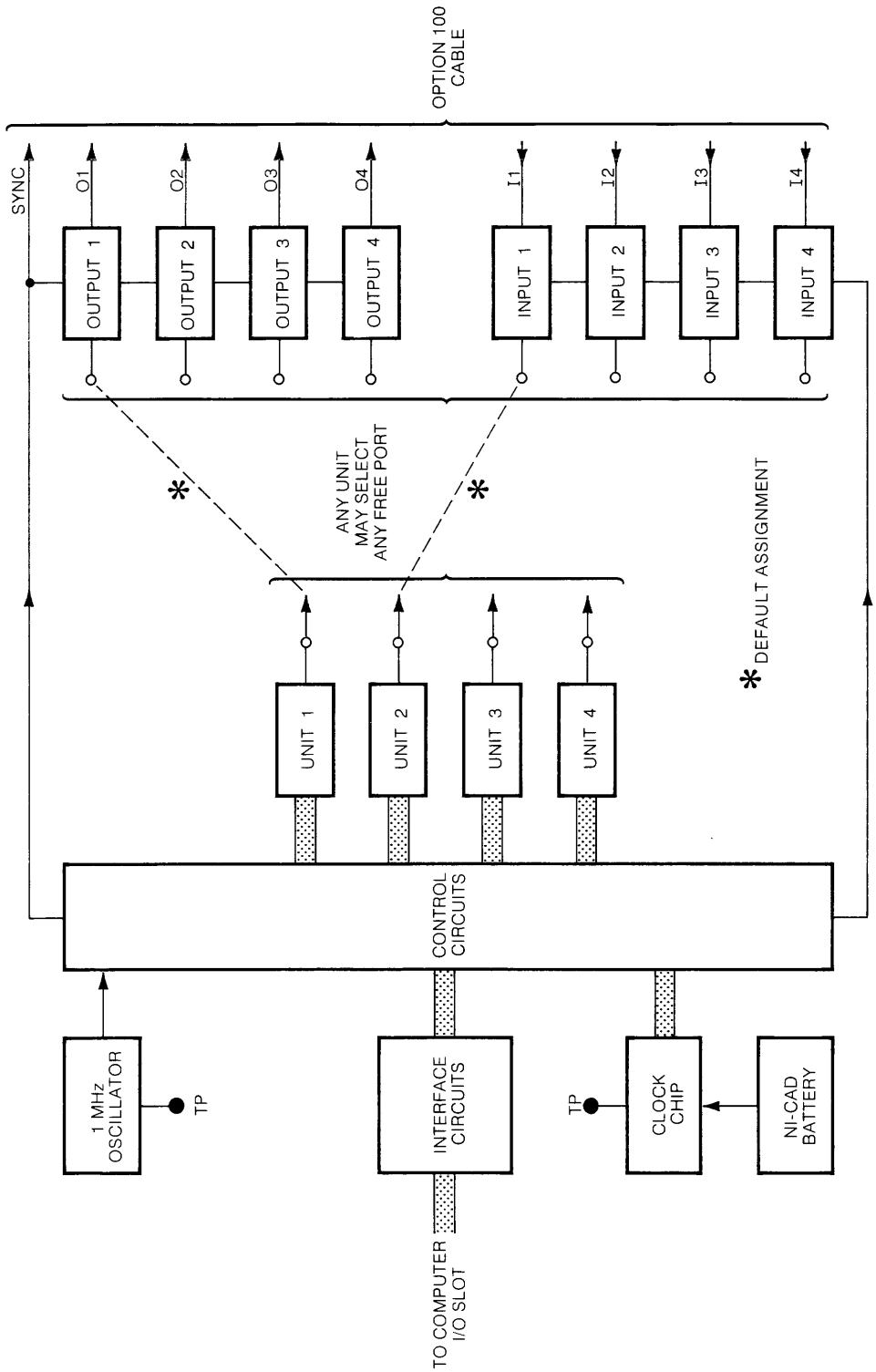


Figure 3-1: 98035A Functional Block Diagram

A Note About Syntax

Syntax is the way in which elements are arranged and connected to form an orderly combination. In the case of the 98035A Real Time Clock, the elements are the standard ASCII codes representing the following characters.

- the uppercase letters A through Z
- the numbers 0 through 9
- the characters = / LF (line feed)

All other characters are ignored by the Real Time Clock. This makes it convenient to use lowercase letters for comments in the clock's instructions. A listing of ASCII characters is contained in the Appendix.

The following general conventions will be used in this manual to described the way in which these elements may be combined to create instructions.

A – Color is used to represent actual characters which must be sent as shown.

number – When a label is used, it represents a set of characters from which the desired parameter may be chosen. A description of the set and its limits will be given in the text following the syntax listing.

[ ] – Items in square brackets are optional. The instruction will be valid whether or not these items are included. However, including an optional item will generally change the exact meaning of the instruction.

LF – The label "LF" is used to represent a data delimiter. For the Real Time Clock, this can be either an ASCII decimal 10 (LF) or an ASCII decimal 47 (/).

The syntax statements in this manual show only the characters which are sent to the 98035A. **The computer statements used to send those characters are not shown.** It is very important that you keep this distinction in mind. For example, assume that you wanted to send a "**U2H**" to the clock. On the 9825, this could be done with the statement `wrt 9, "U2H"`. On the 9835, this could be done with the statement `OUTPUT 9; "U2H"`, or the statement `WRITE BIN 9; 85, 50, 72`.

There are many desktop computers, and they all have a variety of output statements to chose from. If you want further information on specific computer statements, refer first to your Real Time Clock Operating Note or Programming Techniques manual. If you need even more detailed information, consult your I/O ROM Programming manual.

Real Time Information

The 98035A Real Time Clock has two operations for real time. These are "Set Real Time" for setting or changing the real time, and "Request Real Time" for reading the real time. The 98035A uses a 24 hour time format in which the day begins at 00 hours and ends at 23 hours, 59 minutes and 59 seconds.

Set Real Time

Syntax:

S time LF

This instruction is used to set or change the current time maintained in the Real Time Clock. This is accomplished by sending an "S" followed by the new real time and a delimiter (/ or LF). The real time is formatted in one of two ways.

Option 001, or US date format:

Month Day Hours Minutes Seconds

Option 002, or European date format:

Day Month Hours Minutes Seconds

The data field for each time group (month, day, hour, ...) must be two digits wide. If the number is less than ten, i.e. 0–9, that number must be preceeded by a zero. For example: 1 becomes 01, 0 becomes 00, and 9 becomes 09. This means that the variables used in the write statement must either be string types or be formatted so that leading zeros will not be removed. The Real Time Clock will allow any number of lower case comment characters to appear within the string, as long as none of these characters correspond to instructions used by the Real Time Clock (A-Z, /, or =). For example, if the real time to be set is June 18, 12:01:00, this string could be output to the Real Time Clock:

"Set real time; month 06, day 18, hours 12, minutes 01, seconds 00 / "

If only part of the real time needs to be changed, only that time group and the groups to the right need to be specified in the string. For example, if the real time was 07:13:16:58:17, and the minutes should actually be 59, the following could be output to the Real Time Clock:

"S59:17" LF

If there is not an even number of digits in the time data, or if the leading zeros are deleted, an error will result (see "Request Error"), and the setting will not be executed.

Upon receiving the delimiter terminating the string, the Real Time Clock will add 10 milliseconds to compensate for computer processing time, and then update the clock circuit and the registers containing the real time.

NOTE

The updating of the clock circuit which maintains the real time when the power is removed from computer can take up to 90 seconds, depending on the current real time and the desired real time. During this interval, do not remove power or RESET the computer, otherwise the real time will be lost and the clock circuit may be left in a high power state. This will cause the batteries to discharge in less than 24 hours.

The Real Time Clock tests each time group (month, day, hour, ...) for validity. The real time has the following limits:

Minutes and Seconds: 00–59

Hours: 00–23

Days: 01–31 for January, March, May, July, August, October, December

01–30 for April, June, September, November

01–29 for February

Months: 01–12

An error will be generated in the Real Time Clock (see "Request Error") and the time set will not be executed if the limits of any of these groups is exceeded. For example, if you attempted to set the time as

"04(april): 31(days): 12:00:00

the Real Time Clock would generate an error and abort the instruction since April has only 30 days.

When only part of the date is to be changed, (day in U.S. format and month in European format), the Real Time Clock uses the current unchanged part of the date to test the validity of the entered real time. For example, if the current month was June (in U.S. format), and you

attempted to change the real time to "day, 31, hours, 12, minutes, 00, seconds, 00", the Real Time Clock would abort the instruction since June has only 30 days.

Request Real Time

Syntax:

R

When an ASCII "R" is sent to the Real Time Clock by the desktop computer, the Real Time Clock will output the current real time in one of the following formats.

Option 001, or US date format:

Month:Day:Hours:Minutes:Seconds

Option 002, or European date format:

Day:Month:Hours:Minutes:Seconds

Each time group (Month, Day, Hour, ...) is two digits wide and is separated by a colon (:). The first digit sent from the Real Time Clock is the beginning of the month group (Option 001) or the day group (Option 002), and the last byte is a LF (ASCII decimal 10).

The Real Time Clock immediately stores the current real time in a buffer upon reception of the "R" instruction. This data remains in the output register indefinitely until it is read by the desktop computer or overwritten by the execution of another instruction in the Real Time Clock.

The entire real time can be input to the desktop computer by using a string variable dimensioned to 14 characters or by using five variables. The colons (:) will terminate the computer data input when using non-string variables, so the real time may be input to the desktop computer in five separate read operations. The transfer of the real time will be terminated any time another instruction is sent to the Real Time Clock. For example, consider the following sequence:

Output to Real Time Clock:	"R" LF
Input to the desktop computer:	read operation, store into A
	read operation, store into B
	read operation, store into C
	read operation, store into D
	read operation, store into E

The result of this sequence (assuming the Real Time Clock has the US date format) would be the month value stored in A, the day in B, hours in C, minutes in D, and seconds in E. If the programmer inserted a write operation to the Real Time Clock which output another instruction between the "read operation, store into B", and the "read operation, store into C", all the real time data that would have been input to C, D, and E would be lost.

If the Real Time Clock has lost the real time due to hardware problems, or the current real time is found to be in error, it will output to the computer

88:88:88:88:88 LF

in response to a real time request. An error will also be generated within the Real Time Clock (see "Request Error").

The Real Time Clock does not automatically identify leap years, therefore February always has 28 days. You can change the date to February 29 using the Set Real Time instruction without generating an error.

Timing/Counting Units

The 98035A Real Time Clock contains four timing/counting units. These units reside in read/write memory within the Real Time Clock and are controlled using program instructions.

A timing/counting unit can be in one of three modes. Figure 3-1 may help you visualize these alternatives. When in the counting (input) mode, a unit is assigned (connected) to one of the input ports. When in the interrupt (output) mode, a unit is connected to one of the output ports. The third possibility is that the unit is not connected to any port. In this mode, a unit is referred to as "unassigned".

When a timing/counting unit is in the counting (input) mode, the register is used to count milliseconds. The input lines (I1-I4) of the Option 100 cable can be used to control this counting. The numeric value in the register can range from zero to 9 999 999 999. More information on this mode of operation can be found in the "Input Operations" section.

When a timing/counting unit is in the interrupt (output) mode, real time information stored in the register can cause the Real Time Clock to interrupt the computer at a preset time and/or output a pulse on an output line (O1-O4) of the Option 100 cable. More information on this mode of operation can be found in the "Output Operations" section.

Define Output

Syntax:

U number **=** [**O** number]

This instruction defines (assigns) a specified timing unit to a specified output port for the purpose of interrupting the computer or pulsing an output line (Option 100).

The parameter "number" must be the integer 1, 2, 3, or 4. Any other integer causes the instruction to abort and an error is set in the Real Time Clock (see "Request Error"). Any character that is not a number is ignored. If a multi-digit number is sent, only the first digit is recognized; all extra digits are ignored. For example, if "−39.7" were sent as the parameter "number", the Real Time Clock would use the value "3". The minus sign is ignored because it is not a number and the "9.7" is ignored because the "3" satisfied the parameter requirements.

The Define Output instruction must be executed before the Set Match, Set Delay and Set Period instructions can be used. (These instructions are described later in the chapter.)

NOTE

When the Real Time Clock is initialized by a power-on, a system reset, or the "B" instruction, **unit 1** is automatically assigned to **output port 1**. To make output port 1 available to other units, send the instruction "**U1=**" LF.

Any number of lower case comment characters can be inserted into this instruction. For example, the Real Time Clock will interpret these two instruction sequences the same way:

"U1 = O1" or "Unit 1 is set = to Output 1"

A timing/counting unit must be in the halt state (see section on "Unit State Control") before it can be defined to an output port.

The most recent Define Output instruction overrides any previous Define Output instruction involving the same timing/counting unit. For example:

"Unit 1 = Output port 3"

•
•
•

"Unit 1 = Output port 4"

Unit 1 is assigned to output port 3 in the first part of the program, and later on is reassigned to output port 4. At that time, unit 1 is no longer assigned to output port 3.

Only one timing/counting unit per output port is allowed. If the following program sequence was sent to the Real Time Clock, an error would be generated.

"Unit 1 = Output port 3"
"Unit 2 = Output port 3"

The first instruction line causes output port 3 to be assigned to unit 1. The second instruction line attempts to assign unit 2 to output 3, which has already been assigned to unit 1. This causes an error to be generated within the Real Time Clock, and the second instruction sequence will not be executed. In order to assign output port 3 to unit 2 in the previous example, output port 3 must first be "freed" or undefined. In general, this is accomplished by sending to the Real Time Clock:

U number **=**

The previous example can then be changed so that it will work.

"Unit 1 = Output port 3"
"Unit 1 = "
"Unit 2 = Output port 3"

Define Input

Syntax:

U number **=** [**I** number]

This instruction defines (assigns) a specified timing unit to a specified input port for the purpose of counting milliseconds.

The parameter "number" must be the integer 1, 2, 3, or 4. Any other integer causes the instruction to abort and an error is set in the Real Time Clock (see "Request Error"). Any character that is not a number is ignored. If a multi-digit number is sent, only the first digit is recognized; all extra digits are ignored. For example, if "−39.7" were sent as the parameter "number", the Real Time Clock would use the value "3". The minus sign is ignored because it is not a number and the "9.7" is ignored because the "3" satisfied the parameter requirements.

The Define Input instruction must be executed before the Request Value and Clear Value instructions can be used. (These instructions are described later in the chapter.)

NOTE

When the Real Time Clock is initialized by a power-on, a system reset, or the "B" instruction, **unit 2** is automatically assigned to **input port 1**. To make input port 1 available to other units, send the instruction "**U2=**" LF.

Any number of lower case comment characters can be inserted in this instruction. For example the Real Time Clock will interpret these two instruction sequences the same way:

"U1 = I1"

or

"Unit 1 is set = to Input 1"

The most recent Define Input instruction overrides any previous Define Input instruction involving the same timing/counting unit. For example:

"Unit 1 = Input port 3"

•
•
•
•

"Unit 1 = Input port 4"

Unit 1 is assigned to input port 3 in the first part of the program, and later on is reassigned to input port 4. At that time, unit 1 is no longer assigned to input port 3.

Only one timing/counting unit per input port is allowed. If the following program sequence was sent to the Real Time Clock, an error would be generated.

"Unit 1 = Input port 3"
"Unit 2 = Input port 3"

The first instruction line causes input port 3 to be assigned to unit 1. The second instruction line attempts to assign unit 2 to input port 3, which has already been assigned to unit 1. This causes an error to be generated within the Real Time Clock, and the second instruction sequence will not be executed. In order to assign input port 3 to unit 2 in the previous example, input port 3 must first be "freed" or undefined. In general, this is accomplished by sending to the Real Time Clock:

U number =

The previous example can then be changed so that it will work.

"Unit 1 = Input port 3"
"Unit 1 = "
"Unit 2 = Input port 3"

A timing/counting unit must be in the halt state (see section on "Unit State Control") before it can be assigned to an input port.

If the Real Time Clock is an Option 100 device, the counters will be incremented each millisecond that an input is true on the appropriate line. On the standard Real Time Clock, the counting units will be incremented once per millisecond, thus making them millisecond timers. The Option 100 Real Time Clock units can be configured to perform as millisecond timers by connecting the desired input line to ground.

Unit State Control

A timing/counting unit can be in one of two states: Active (on) or Halt (off).

A timing/counting unit must be in the halt state before it can be reconfigured, (reassigning input and output ports), or before any time specifications are changed (real time, real time match, delay or period). A unit can be selectively placed in the halt state using the Halt Selected Unit instruction, or all units can be simutaneously halted using the Halt All Units instruction.

The Set Match instruction will halt the active unit when the match specifications are met and the interrupt and/or output pulse is sent out. This also applies to the Set Match accompanied by a Set Delay instruction.

A unit can be individually activated using the Activate Selected Unit instruction. All the timing/counting units can be simultaneously activated using the Activate All Units instruction.

The timing/counting units must be placed in the active state before they can provide the specified interrupts or act as counters.

Halt All Units

Syntax:

A

The Halt All Units instruction places all the timing/counting units in halt state. This instruction can be executed at any point in the program, and will not affect any of the input/output port assignments, counter values, match, delay, or period specifications.

Any number of lower case comment characters may appear in this instruction. For example:

"All units halt" LF

will perform the same function as the single capital "A". This instruction may be executed with units already in the halt state or with unassigned units without generating an error in the Real Time Clock.

NOTE

The "Halt All Units" instruction clears the Interrupt Enable Flag in the Real Time Clock. The Real Time Clock must be re-enabled for interrupts if they are to be serviced upon re-activation of the timing/counting units.

Activate All Units

Syntax:

F

The "Activate All Units" instruction simultaneously activates all the timing/counting units. This instruction may be executed at any point in the program without affecting any of the input/output port assignments, counter values, or changing the value of the match, delay, or period specifications.

Any number of lower case comment characters may appear in this instruction. For example:

"Fire all units" LF

will perform the same function as the single capital "F".

The "Activate All Units" instruction may be executed with units already in the active state, or with unassigned units without generating an error in the Real Time Clock.

Caution must be used when employing the Activate All Units instruction in a program as this instruction affects the operation of the Delay and Periodic instructions. The start of the Delay or Periodic interval occurs when the unit is either activated, or if used with the match instruction, when the real time match occurs. If an Activate All Units instruction is executed while a unit is active and processing a delay or periodic interval, the delay or periodic interval will be re-timed from the point of execution of the Activate All Units instruction.

Halt Selected Unit

Syntax:

U number **H**

This instruction causes the specified timing/counting unit to enter the halt state. The specified unit must be assigned to an input or output port before this halt instruction can be executed.

The parameter "number" must be the integer 1, 2, 3, or 4. See the "Define Output" section for a detailed explanation.

Any number of comment characters may appear in the instruction sequence. For example, unit 1 is placed in the halt state by the following sequence:

"Unit 1 is Halted" LF

Activate Selected Unit

Syntax:

U number **G**

This instruction causes the specified timing/counting unit to enter the active state. The specified unit must be assigned to an input or output port before this activate instruction can be executed.

The parameter "number" must be the integer 1, 2, 3, or 4. See the "Define Output" section for a detailed explanation.

Any number of comment characters may appear in the instruction sequence. For example, unit 3 is placed in the active state by the following sequence:

"Unit 3 may Go" LF

Output Operations: Interrupts

When one or more timing/counting units are in the output mode, the Real Time Clock can interrupt the computer, providing the computer in use is interruptable and the Real Time Clock is enabled for interrupts. These interrupts may be set for a specific time using the Set Match instruction. Other output instructions include Set Delay and Set Period. These instructions may be executed by themselves or in various combinations.

Set Match

Syntax:

U number **M** [time] LF

The Match instruction causes the Real Time Clock to interrupt the computer and/or output a pulse (Option 100) at a specified time.

The parameter "number" must be the integer 1, 2, 3, or 4. See the "Define Output" section for a detailed explanation.

The format for the "time" parameter is[3]:

Day Hours Minutes Seconds

The data field for each time group (day, hours, minutes, ...) must be two digits wide. If the number in the data field is less than ten, i.e. 0-9, that number must be preceeded by a zero. For example: 1 becomes 01, 0 becomes 00, 9 becomes 09. This format must be followed, otherwise an error will be generated (see "Request Error"), and the match specification will not be entered.

The Match instruction does not have the capablity to match at a preset month, although no error will be generated if a month group is entered.

It is not necessary to enter all eight digits of the match time, just the required time group and those groups to the right. As an example, unit 2 could be set to match daily at 11:30 AM to give a lunch break warning. The output sequence to the Real Time Clock could be:

U2M 11 30 00 LF

Any number of lower case comment characters may appear in the output sequence. The above example can be re-written as follows:

"Unit 2 will Match at 11:30:00 for lunch break" LF

3 The format examples in the "Set Match" section assume an Option 001 device. Option 002 devices have the format "Day Month Hours Minutes Seconds" even though the "Month" group is not used in the match.

The match specifications are cleared by writing:

U number **M** LF

The match time has a resolution of one second. The control section compares the match time to the real time when the real time is incremented, and begins the interrupt request and/or output pulse whenever the real time and match time correspond.

NOTE

The match time specifications must be entered and the unit activated (see "Unit State Control") at least one second before the real time becomes equal to the set match time.

In order to enter or change any of the match specifications, the appropriate unit must be in the halt state (see "Unit State Control") and assigned to an output port.

After the specifications have been entered the unit must be placed in the active state (see "Unit State Control") before the unit can match. After the Real Time Clock has matched and executed the interrupt and/or output pulse, that unit is placed in the halt state. In order to get that unit to match again, it must be returned to the active state.

In general, the following sequence of instructions would be used to set the match time:

A	Halt all units
U number **=** **O** number	Define to output
U number **M** time LF	Set match
U number **G**	Activate selected unit

The Real Time Clock does not use the month in the comparison with the real time, but does use it in the testing of the match time for validity. If no month is given, then the current month is used in the testing of the day limits. The limits on the Set Match instruction are the same as those used in the Set Real Time instruction.

If for example, the current month in the real time is April, the Real Time Clock would not accept the following instruction:

"Unit 3 is to Match at day: 31, hours: 12, minutes: 30;seconds: 00" LF

The Real Time Clock will test the day group against the limits for April, which is 1 to 30, will generate an error (see "Request Error"), and will not execute the match.

The above example can be modified so that it works by adding the month group:

"Unit 3 is to Match at month: 05, day: 31, hours: 12,
minutes: 30, seconds: 00." LF

Note that the month is used **only** to test the validity of the day group.

Set Delay

Syntax:

U number **D** [delay] LF

The Set Delay instruction causes the Real Time Clock to wait a specified time before interrupting the computer and/or outputting a pulse (Option 100). The delay may be specified to occur after a real time match or after a unit activation.

The parameter "number" must be the integer 1, 2, 3, or 4. See the "Define Output" section for a detailed explanation.

The parameter "delay" is an integer number up to 8 digits long that sets the delay time in milliseconds. This gives a delay range of one millisecond to 99 999 999 milliseconds or 27.78 hours.

Delay Time

$$\text{seconds} = \frac{\text{milliseconds}}{1000} \qquad \text{minutes} = \frac{\text{milliseconds}}{60\ 000} \qquad \text{hours} = \frac{\text{milliseconds}}{3\ 600\ 000}$$

The delay specification can be cleared by writing to the Real Time Clock:

U number **D** LF or **U** number **D0** LF

Note that to enter or clear the delay instruction and specifications, the unit must be assigned to an output port and be in the halt state (see "Unit State Control").

The Set Delay instruction may be used by itself to provide a single interrupt after a set interval regardless of the real time. When used by itself the delay begins immediately after the unit is activated (see "Unit State Control"). The following sequence of instructions could be used if a delay is to be executed by itself:

A	Halt all units
U number **=** **O** number	Assign to output
U number **D** delay LF	Set delay time
U number **G**	Activate selected unit

In general, the following sequence of instructions would be used to set a match time and enter a delay specification:

A	Halt all units
U number **=** **O** number	Define to output port
U number **M** time LF	Set match
U number **D** delay LF	Set delay
U number **G**	Activate selected unit.

Set Period

Syntax:

U number **P** [interval] LF

The Set Period instruction causes the Real Time Clock to interrupt the computer and/or output a pulse (Option 100) at a specified interval. This instruction can be executed immediately, after a Match, after a Delay, or after a Match with Delay, and it will continue until the specified unit is halted.

The parameter "number" must be the integer 1, 2, 3, or 4. See the "Define Output" section for a detailed explanation.

The parameter "interval" is an integer number up to 8 digits in length that sets the duration in milliseconds between interrupts and/or output pulses. This gives a range of one millisecond to 99 999 999 milliseconds or 27.78 hours.

Interval Time

$$\text{seconds} = \frac{\text{milliseconds}}{1000} \qquad \text{minutes} = \frac{\text{milliseconds}}{60\ 000} \qquad \text{hours} = \frac{\text{milliseconds}}{3\ 600\ 000}$$

The interval specification can be cleared by writing to the Real Time Clock:

U number **P** LF or **U** number **P0** LF

Note that to enter or clear the period instruction and interval specifications, the unit must be assigned to an output port, and be in the halt state (see "Unit State Control").

When the Set Period instruction is used by itself, the interrupts and/or output pulses begin immediately after the appropriate unit is set into the active state (see "Unit State Control").

In general, the following sequence of instructions would be used to set the periodic interval and execute it without a match.

A	Halt all units
U number **=** **O** number	Assign unit to output port
U number **P** interval LF	Set periodic interval
U number **G**	Activate selected unit

The Real Time Clock begins executing the Set Period instruction immediately after the Activate Unit instruction is received.

Any number of lower case comment characters can be used in the Set Period instruction. For example, the previous sequence of instructions can be executed as a single line with comment characters. In this example, unit one and output port four are used with a periodic interval of 12345 milliseconds.

"halt All units. Unit 1 is set = to Output 4. Unit 1 has a Periodic interval of 12.345 seconds/Unit 1 Go" LF

If the Set Period instruction is used with a real time match, the interrupt and/or output pulses begin at the match time. If a delay instruction is also used, these interrupts and/or output pulses begin after the match time plus delay.

The general sequence of instructions to the Real Time Clock would be as follows:

Match with Periodic:

A	Halt all units
U number **=** **O** number	Define unit to output port
U number **M** time LF	Set match
U number **P** interval LF	Set period
U number **G**	Activate selected unit

Delay with Periodic:

A	Halt all units
U number **=** **O** number	Assign unit to output port
U number **D** delay LF	Set delay
U number **P** interval LF	Set period
U number **G**	Activate selected unit

The pulse that appears on the Option 100 cable is shown in Figure 2-7.

Input Operations: Counting Milliseconds

When one or more timing/counting units are in the input mode, the Real Time Clock can measure the time of computer operations and external events (Options 100) with millisecond accuracy. Timing units are assigned with the Define Input instruction and monitored with the Request Value instruction. Control over the timing units is provided by the "Unit State Control" instructions, the Clear Value instruction, and the external input lines (Option 100).

Request Value

Syntax:

U number V

The Request Value instruction causes the Real Time Clock to output the current counter value of the specified timing/counting unit. This value can then be input to the computer with a standard read or enter operation. The value returned is a ten digit number indicating the number of milliseconds that the unit was active.

The parameter "number" must be the integer 1, 2, 3, or 4. See the "Define Input" section for a detailed explanation.

The specified unit must be assigned to an input port before the Request Value instruction can be executed. The Request Value instruction may be performed on a unit in either the active or halt state (see "Unit State Control") and any number of comment characters may be inserted. If the computer executes a read operation to the Real Time Clock without first requesting a counter value, the Real Time Clock will output a LF in response, without generating an error.

The standard Real Time Clocks are wired so that the counting units increment every millisecond. This means that the counting units may be used as millisecond timers. As an example, the Real Time Clock can be used as a stop watch to time a benchmark program. In the following example unit 2 and input port 1 are used because they are configured that way at power-up.

"Unit 2 Go" LF
Benchmark routine on computer
"Unit 2 Value request" LF
Read operation
Display results

The result of this program will be a display of the time that the benchmark routine took in milliseconds. The range of this operation is one to 9 999 999 999 milliseconds or 115.7 days.

Note that the Option 100 timing/counting units do not act as millisecond timers unless they are externally enabled. They can be enabled by connecting the input line low (to ground) for the desired input port. Table 2-1 lists the input lines and their respective colors.

Information on interfacing to the Option 100 Real Time Clock is contained in Chapter 2.

Clear Value

Syntax:

U number C

The Clear Value instruction resets the specified timing/counting unit to zero. The specified unit must be assigned to an input port before the Clear Value instruction can be executed. However, the unit may be in either the active or halt state. Any number of comment characters may be inserted in the instruction.

The parameter "number" must be the integer 1, 2, 3, or 4. See the "Define Input" section for a detailed explanation.

Status and Control

The Real Time Clock is both an intelligent peripheral device and an interface. The peripheral device portion maintains three registers which provide useful information about errors and interrupts. The interface portion is similar to a 98032A, which means that it has several registers used for communication with the computer. This section of the manual explains the function of these various registers and how they may be accessed.

Also in this section is a more detailed explanation of the initialization process in the Real Time Clock and the means used to control it.

Request Error

Syntax:

E

The Real Time Clock performs self tests on its control hardware whenever power is applied or when the controlling computer is reset. The Real Time Clock also tests instructions and data that are transferred to it by the computer. If hardware problems are found or if illegal instruction sequences are detected, bits are set within an error register. This error register is eight bits wide, with the lower four bits dedicated to software errors and the upper four bits reserved for hardware errors. The software errors are cleared each time the register is read by the computer.

NOTE

The error code should be input to the computer using a binary input operation.

Standard read operations use ASCII codes for data transfer. The error code read in this manner may not be recognizable. For example, the error code could be a binary 00111000, which in decimal is 56. A binary read of this error code will result in "56", but a standard read operation will result in an "8", which is the ASCII character corresponding to a code of 56.

The following is an explanation of the error codes.

Least Significant Bit

7	6	5	4	3	2	1	0
R/W BITS 4-7 DEFECTIVE	R/W BITS 0-3 DEFECTIVE	CLOCK HARDWARE DEFECTIVE	REAL TIME LOST	INSTRUCTION UNEXECUTABLE NOW	UNIT DEFINITION MISMATCH	BAD INSTRUCTION or DATA OUT OF RANGE	MISSED INTERRUPT
HARDWARE ERRORS				SOFTWARE ERRORS			

Bit 0: Is 1 when an interrupt has been missed. This could happen when two or more timing/counting units request interrupts at intervals to narrow to be serviced by the computer. This would also happen if a second interrupt occurred and the interface was not re-enabled for interrupts after the first occurrence. To determine which interrupting unit was missed, see "Request Unserviced Interrupt".

Bit 1: Is 1 when incorrect instructions or out-of-range data are sent to the Real Time Clock. It is set by incorrect usage of instructions, or when entered data (real time, match time,...) is invalid.

Bit 2: Is 1 when the instruction sent to the clock is inconsistent with the current assignment of units and ports. Some examples are: sending an interrupt instruction to a unit which is assigned to an input port, attempting to assign two units to the same port, or requesting the value of an unassigned unit.

Bit 3: Is 1 when attempting to execute a Set Real Time instruction when there is unit defined to an output port in the active state. This is also caused by trying to change the match, delay, or periodic specifications on an active unit, or by trying to reassign an active unit.

Bit 4: Is 1 when the real time maintained by the clock circuitry is lost. This generally occurs when the voltage of the ni-cad battery drops below a certain level. The battery can lose its charge if the storage temperature limits have been exceeded, if the Real Time Clock has not been used enough to allow the battery to recharge, or if the computer was turned off in the first 10 seconds after power-on (or a reset). This can leave the clock circuitry in a high power state, draining the battery. The clock circuit can take up to 90 seconds to perform a time set. During this period the removal of power or a computer reset will cause the real time to be lost and this error to be generated. The Real Time Clock outputs "88:88:88:88:88" in response to a real time request when this error is detected.

Bit 5: Is 1 when the clock hardware is found defective.

Bit 6: Is 1 when the block of read/write memory containing bits 0-3 is found defective.

Bit 7: Is 1 when the block of read/write memory containing bits 4-7 is found defective.

Request Trigger

Syntax:

T

Whenever a timing/counting unit generates an interrupt and/or outputs a pulse on the Option 100 cable, a register in the Real Time Clock remembers which output port triggered that action. This "trigger" code can be read at the beginning of the interrupt service routine to determine which timing/counting unit-output port pair requested the interrupt.

The trigger code should be input to the computer using a binary input operation. A detailed discussion of the reason is contained in the previous section on "Request Error".

The trigger word is structured in the following manner:

Least Significant Bit

7	6	5	4	3	2	1	0
ALWAYS ZERO				OUTPUT PORT 4	OUTPUT PORT 3	OUTPUT PORT 2	OUTPUT PORT 1

Bit 0: Is 1 when the timing/counting unit that is assigned to output port 1 has triggered.

Bit 1: Is 1 when the timing/counting unit that is assigned to output port 2 has triggered.

Bit 2: Is 1 when the timing/counting unit that is assigned to output port 3 has triggered.

Bit 3: Is 1 when the timing/counting unit that is assigned to output port 4 has triggered.

Bit 4: Is always 0.

Bit 5: Is always 0.

Bit 6: Is always 0.

Bit 7: Is always 0.

The trigger code register is cleared immediately after a Request Trigger instruction. If there has been more than one interrupt request since the last time the trigger code was read, only the most recent request will be retained in the trigger code register. The trigger code register will contain multiple interrupt requests only when the multiple requests occur simulateously.

Whenever the trigger code is requested, the code is stored in an output buffer in the Real Time Clock. This buffer holds the trigger code until the next read operation by the computer clears it, or another output operation by the Real Time Clock displaces it.

For example, the following instruction sequence could be output to the Real Time Clock, followed by a "read binary" operation.

"T" LF
"E" LF
Read Binary Operation

The result of the read operation is the error code because the trigger code was displaced by it.

Request Unserviced Interrupt

Syntax:

W

The Real Time Clock must be enabled for interrupts by the desktop computer in order to provide interrupts to the computer (refer to the appropriate I/O ROM manual of your specific computer). After the Real Time Clock has interrupted the computer, it is automatically disabled for interrupts. The Real Time Clock must be re-enabled by the computer in order to again request interrupts. During the period of time that the Real Time Clock is interrupt disabled, any interrupt requests generated by the timing/counting units will be ignored and an error will be generated within the Real Time Clock (see "Request Error"). When this situation occurs, a register within the Real Time Clock remembers which output port requested the interrupt.

The unserviced interrupt code should be input to the computer using an binary input operation. A detailed discussion of the reason is contained in a previous section on "Request Error".

The unserviced interrupt word is structured in the following manner:

Least Significant Bit

7	6	5	4	3	2	1	0
ALWAYS ZERO				OUTPUT PORT 4	OUTPUT PORT 3	OUTPUT PORT 2	OUTPUT PORT 1

Bit 0: Is 1 when the timing/counting unit that is assigned to output port 1 has requested an unserviced interrupt.

Bit 1: Is 1 when the timing/counting unit that is assigned to output port 2 has requested an unserviced interrupt.

Bit 2: Is 1 when the timing/counting unit that is assigned to output port 3 has requested an unserviced interrupt.

Bit 3: Is 1 when the timing/counting unit that is assigned to output port 4 has requested an unserviced interrupt.

Bit 4: Is always 0.

Bit 5: Is always 0.

Bit 6: Is always 0.

Bit 7: Is always 0.

The unserviced interrupt code register is cleared immediately after a Request Unserviced Interrupt instruction. If there has been more than one unserviced interrupt request since the last time the unserviced interrupt code was read, only the most recent request will be retained in the unserviced interrupt code register. The unserviced interrupt code register will contain multiple interrupt requests only when the multiple requests occur simultaneously.

Whenever the unserviced interrupt code is requested, the code is stored in an output buffer in the Real Time Clock. This buffer holds the unserviced interrupt code until the next read operation by the computer clears it, or another output operation by the Real Time Clock displaces it.

For example, the following sequence could be output to the Real Time Clock, followed by a "read binary" operation.

"W" LF
"E" LF
Read Binary Operation

The result of the read operation is the error code because the unserviced interrupt code was displaced by it.

If the Real Time Clock has never been enabled for interrupts, it cannot request any interrupts. In this case, no error due to an unserviced interrupt will be generated and the unserviced interrupt register will be zero.

Interface Communications

Read Status

A "read status" operation on the 98035A interface will transfer a status word from the interface to the calculator. The meaning of the various bits is shown below.

Least Significant Bit

8	7	6	5	4	3	2	1	0
PERIPHERAL OK	INTERRUPT STATUS	DMA	INTERFACE ID		INVERT INPUT	INVERT OUTPUT	INTERRUPT FLAG	ERROR FLAG
1	☆	0	1	0	0	0	◇	*

*Error Flag – 1 = ERROR; 0 = OK

◇Interrupt Flag – 1 = ENABLED; 0 = DISABLED
Set by interrupt enable or writing 128 to R5.
Cleared by power-on, reset, "A" or "B" instruction.

☆Interrupt Status – 1 = ENABLED; 0 = DISABLED
Controlled like bit 1, **except** bit 7 is also cleared by an interrupt service or writing 0 to R5.

Peripheral Status – 1 = OK
Will be "1" as long as the interface board has power and responds to its select code.

Using two bits to indicate the interrupt condition allows the Real Time Clock to identify missed interrupts. Bit 7 must be cleared by an interrupt service to prevent the same interrupt from recurring continuously while the computer is attempting to service that interrupt. Bit 1 is not cleared by an interrupt service and indicates whether or not you intended the interface to be enabled for interrupts. If an interrupt occurs while a previous interrupt is still being serviced, bit 1 will be set, but bit 7 will be clear. This condition indicates that the second request was a missed interrupt, generating an error in the Real Time Clock.

Interface Registers

Communication between the Real Time Clock and the computer is achieved by using five of the eight interface registers common to the 9803X family of interfaces. A detailed discussion about these registers can be found in an interface manual, such as 98032-90000. The functions of the interface registers in the Real Time Clock are summarized below.

Read R4 – Reads one byte of data from the Real Time Clock.

Write R4 – Writes one byte of data or instruction to the Real Time Clock

Read R5 – Reads the interface status byte. This is the lower eight bits of the status word described in the preceding section.

Write R5 – Writes a control byte to the interface. Bit 7 is the only bit that is used. Writing to R5 with bit 7 set enables the interface for interrupts.

Read R6 – Not used.

Write R6 – Not used.

Read R7 – Not used.

Write R7 – R7 does not actually store any bits. The act of writing to R7 generates a pulse which initiates an I/O operation in the interface.

By-Pass Self Test

Syntax:

B

A full initialization and self test are performed by the Real Time Clock whenever a power-up is detected or the computer system is reset. This process includes the following operations:

- Interrupt enable flag is cleared and all interrupts are disabled.
- All internal counters and registers are cleared to zero (except the error register).
- Internal read/write memory is tested.
- Error register is set according to the results of the self test.
- Clock chip is placed in the correct state for reading the real time. The time is read and stored in memory where it is managed by the internal processor.
- Timing/counting unit 1 is assigned to output port 1. Timing/counting unit 2 is assigned to input port 1. Units 3 and 4 are not assigned.
- A "line feed" character is placed in the output buffer and the Real Time Clock begins watching for the computer's next instruction.

The initialization sequence just described takes approximately 10 seconds to perform. The "B" instruction causes the Real Time Clock to initialize without executing the time consuming self test and real time read. This allows you to reset the internal counters, registers, and ports without waiting 10 seconds. The "B" instruction produces the following operations:

- Interrupt enable flag is cleared and all interrupts are disabled.
- All internal counters and registers are cleared to zero.
- Timing/counting units are assigned as described in power-on initialization.
- A "line feed" character is placed in the output buffer and the Real Time Clock begins watching for the computer's next instruction.

Activate Clock Chip Test Point

Syntax:

Q

The Real Time Clock has two test points that are used during frequency adjustments. The test point on the interface board is for the 1MHz control oscillator. This point is active whenever the Real Time Clock is plugged into the computer and the power is turned on.

The other test point is on the processor board. It is used to check a 170.667Hz derivative of the clock chip frequency. However, there is usually no signal present at this test point. If the clock chip crystal needs to be adjusted, the output to the clock chip test point must be activated. This is done by sending an ASCII "Q" to the Real Time Clock.

Be sure to deactivate the test point when the adjustments are complete. Activating the test point places the clock chip in its high power state. If the Real Time Clock is removed from the computer with the clock chip in the high power state, the internal battery will discharge in less than 24 hours.

Deactivate Clock Chip Test Point

Syntax:

X

Sending an ASCII "X" to the Real Time Clock clears the clock chip command register. This deactivates the clock chip test point and returns the clock chip to its normal (low power) state.

Direct I/O

Read External Input Lines

Syntax:

N

This instruction is used to read the state of the external input lines (I1-I4) available on Option 100 clocks. After receiving an "N", the Real Time Clock will drive the SYNC line low, input a four-bit code determined by the four input lines, and then drive the SYNC line high again. Any output lines (O1-O4) which are enabled (see "Pulse External Output Lines) will be pulsed along with the SYNC line during the external read.

Whenever the external input code is requested, it is stored in an output buffer in the Real Time Clock. This buffer holds the external input code until a read operation by the computer clears it, or another operation by the clock displaces it. The external input code should be input to the computer using a binary input operation. A detailed discussion of the reason is contained in the previous section on "Request Error". The external input word is structured in the following manner:

Least Significant Bit

7	6	5	4	3	2	1	0
ALWAYS ZERO				INPUT PORT 4	INPUT PORT 3	INPUT PORT 2	INPUT PORT 1

Bit 0: Is 1 if the input line to input port 1 was "low" or "true" at the time of the reading.

Bit 1: Is 1 if the input line to input port 2 was "low" or "true" at the time of the reading.

Bit 2: Is 1 if the input line to input port 3 was "low" or "true" at the time of the reading.

Bit 3: Is 1 if the input line to input port 4 was "low" or "true" at the time of the reading.

Bit 4: Is always 0.

Bit 5: Is always 0.

Bit 6: Is always 0.

Bit 7: Is always 0.

Pulse External Output Lines

Syntax:

L LF mask **N**

This instruction is used to pulse the external output lines (O1-O4) available on Option 100 clocks. The pulse will occur immediately after the Real Time Clock receives an "N" instruction. An extra pulse on the SYNC line will occur coincident with the output pulse.

The parameter "mask" is used to enable the output lines which will be pulsed. This byte must be sent to the clock using a "write binary" operation. The first four bits of this number correspond to the four output lines. Setting a bit enables the output line. The bits have the following meaning:

BIT POSITION	3	2	1	0
DECIMAL VALUE	8	4	2	1
OUTPUT LINE ENABLED	4	3	2	1

Any combination of lines can be selected. For example, if "12" were sent as the parameter "mask", external output lines #3 and #4 would be enabled. A value of "5" would enable lines #1 and #3, while "15" would enable all four lines.

The output lines enabled with the "L" instruction are pulsed by every subsequent "N" instruction. Only an initialization or another "L" instruction will change the external output code. An initialization caused by a power-on, a system reset, or a "B" instruction clears the external output code to 0.

The instruction sequence which sets the external output code is unusual because it requires a delimiter **before** its parameter, rather than **after**. (Notice the syntax "**L** LF mask".) Comment characters may be sent before the delimiter, but care must be taken to insure that no extra characters are sent between the delimiter and the "mask" parameter. The next byte received after the delimiter will be taken as the "mask", no matter how that byte got there.

The following instruction sequences show examples of both correct and incorrect ways to use the "L" instruction. These examples assume that the computer automatically sends a "carriage return, line feed" at the end of a normal "write" instruction. Remember that the Real Time Clock will accept either a slash (/) or a "line feed" as a delimiter.

RIGHT	WRONG
1. write "output Line code" write binary (2)	1. write "output Line code 2"
2. write "L" write binary (4)	2. write "L/" write binary (4)
3. write "L/8"	3. write "L/15"
4. write "Line mask" write binary (12)	4. write "Line mask" write "12"

Explanation of examples:

1. The correct sequence uses the automatic "line feed" character as a delimiter, then writes the binary mask. The incorrect sequence attempts to send the mask before the delimiter.
2. The incorrect sequence uses a slash as the delimiter. Although there is nothing wrong with using a slash, the next byte sent after the slash will be the automatic "carriage return" character.
3. The correct sequence is a special case. The next byte sent after the delimiter is an ASCII "8", not a binary number with the value of 8. However, the Real Time Clock uses only the lower four bits of the mask. Therefore, the ASCII numbers 0 through 9 can be sent in lieu of their binary values. The incorrect sequence points out that this special case applies to single-digit values only.
4. The "write" instruction of the incorrect sequence will send an ASCII "1" as the next byte after the delimiter. The correct sequence uses a "write binary" instruction to send a binary number with the value of 12.

Figure 3-2 shows an example of the output pulses which occur as a result of various instructions. The conditions for this diagram are as follows:

1. Unit 3 is assigned to output port 3; Unit 3 has received a "Periodic 2" instruction ("U3P2/").
2. Unit 4 is assigned to output port 4; Unit 4 has received a "Periodic 5" instruction ("U4P5/").
3. External output code is set to "8".
4. The Real Time Clock is not enabled for interrupts.
5. Unit 3 and Unit 4 are in the active state and an "N" instruction is sent to the Real Time Clock.

Notice that there is a pulse on the SYNC line every millisecond **and** for every direct I/O operation. Similarly, there is a pulse on an output line for every Match, Delay, or Periodic condition **and** for every direct I/O operation. Notice also that the Match, Delay, and Periodic output pulses occur coincident with the one millisecond synchronizing interval, while the direct I/O pulses ("N" instructions) do not coincide with this regular interval. For a detailed view of the direct I/O timing, refer to Figure 2-7.

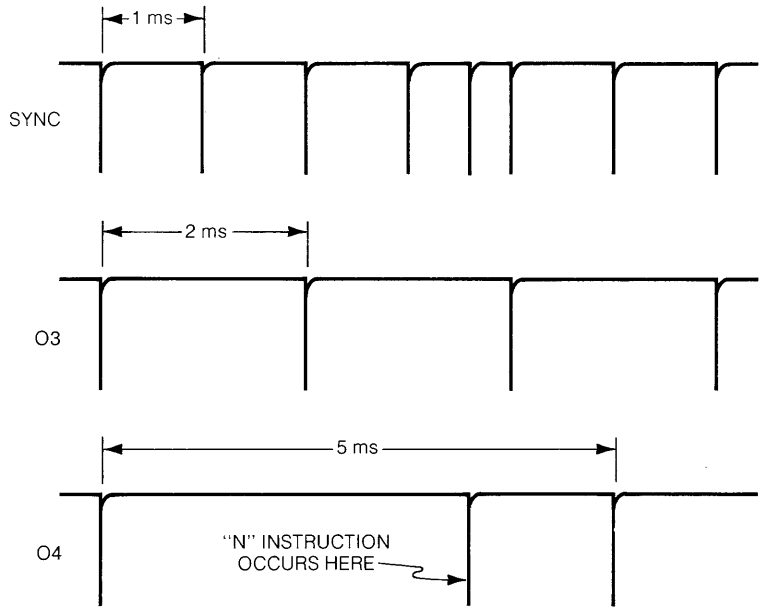


Figure 3-2: Output Actions

NOTES

Chapter 4
Service

Calibration Procedures

The Real Time Clock contains two crystal-controlled oscillators. Each oscillator has a test point and a trimming capacitor to facilitate precise adjustment. The test points and trimmers are shown in Figure 4-1 below.

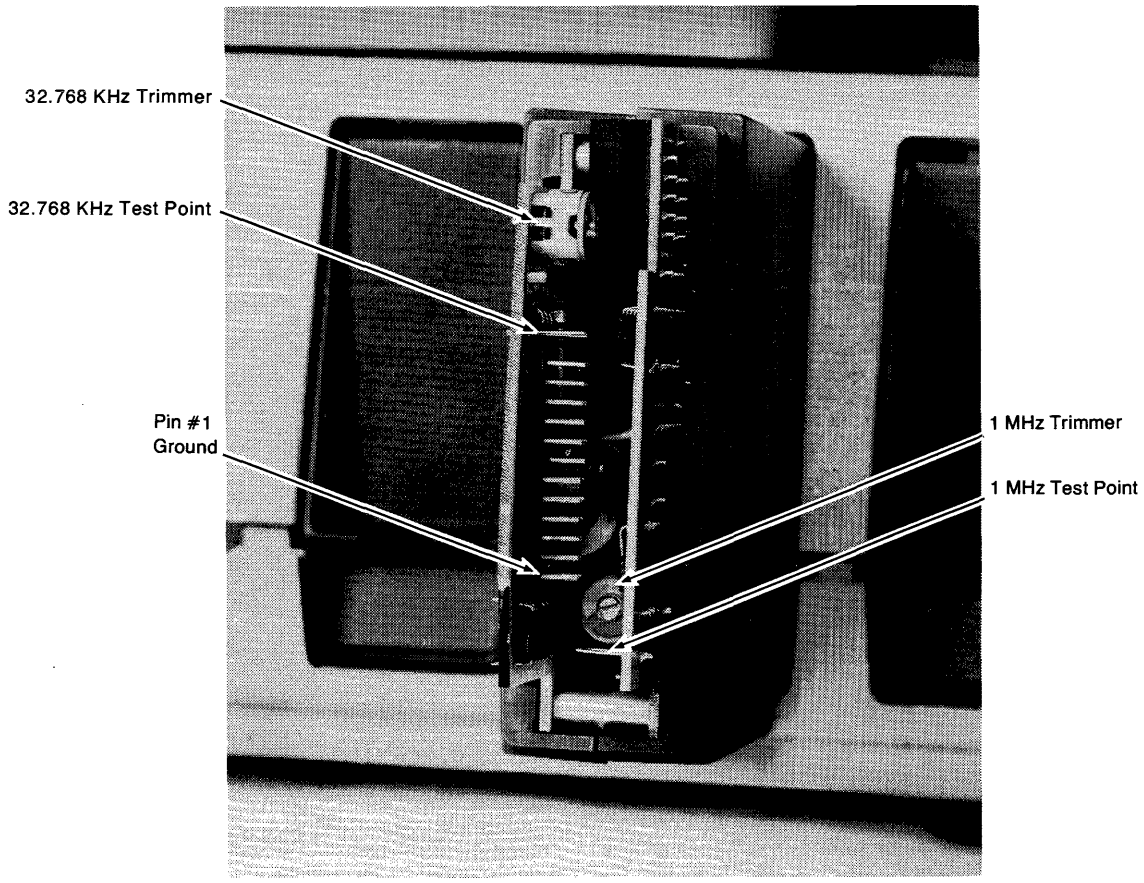


Figure 4-1. Back view of the 98035A with the rear housing removed

The 1 MHz oscillator is the time base for the millisecond intervals of the REQUEST VALUE, PERIODIC, and DELAY instructions. It also provides the system clock for the processor and maintains the real time when the clock is being powered by the computer. The 32.768 KHz oscillator maintains the real time during battery operation.

Calibrating the 1 MHz Oscillator

The 1 MHz oscillator can be calibrated with an accurate 8-digit frequency counter. The step-by-step procedure follows. Refer to Figure 4-1.

1. Turn off the computer and remove the Real Time Clock.
2. Remove the rear housing from the Real Time Clock.
3. Remove the connector from the rear of the processor board. On standard clocks, this connector has four short jumper wires attached to it. On Option 100 clocks, this connector has the I/O cable connected to it.
4. Plug the Real Time Clock into the computer.
5. Attach the ground lead of the frequency counter to pin #1 of the connector plug on the processor board.
6. Attach the signal lead of the frequency counter to the 1 MHz test point on the interface board.
7. Turn on the computer and adjust the trigger level on the frequency counter. If the clock is not already warmed up, calibration accuracy can be increased by allowing a 30 minute warm-up time.
8. Adjust the 1 MHz trimming capacitor to set the frequency reading as close to 1.000 000 MHz as possible. The recommended limits are .999 996 MHz and 1.000 004 MHz.
9. Remove the test leads; replace the connector and rear housing.

Calibrating the 32.768 KHz Oscillator

Calibration of the 32.768 KHz oscillator requires a period averaging frequency counter with a gate (sampling) interval of one second or greater. The recommended unit is an HP 5300B measuring system with an HP 5302A universal counter module or an HP 5308A timer/counter module. Use the "Period Average B" function and D.C. triggering. If you use the 5302A module, set the gate time to 1 s or 10 s. If you use the 5308A module, set it for 10^2 or 10^3 readings per sample. The step-by-step procedure follows. Refer to Figure 4-1.

1. Set up the Real Time Clock with the rear housing and connector removed as explained in steps 1 through 4 of the 1 MHz calibration procedure.
2. Attach the ground lead of the frequency counter to pin #1 of the connector plug on the processor board.
3. Attach the signal lead of the frequency counter to the 32.768 KHz test point on the processor board.
4. Turn on the computer.
5. Output a "Q" instruction from the computer to the Real Time Clock.

6. Adjust the trigger level on the frequency counter and observe the period reading. If the six most-significant digits do not remain stable for about ten samples, a synchronizing reset of the clock chip (U15) is required. If the period indications are sufficiently stable, go directly to step #7.

CAUTION

THE CLOCK CHIP MAY BE DAMAGED IF THE SYNCHRONIZING RESET IS NOT DONE PROPERLY. IF YOU NEED TO PERFORM THIS STEP, STUDY FIGURE 4-2 CLOSELY AND PROCEED VERY CAREFULLY. DO NOT PERFORM THE SYNCHRONIZING RESET UNLESS IT IS NECESSARY.

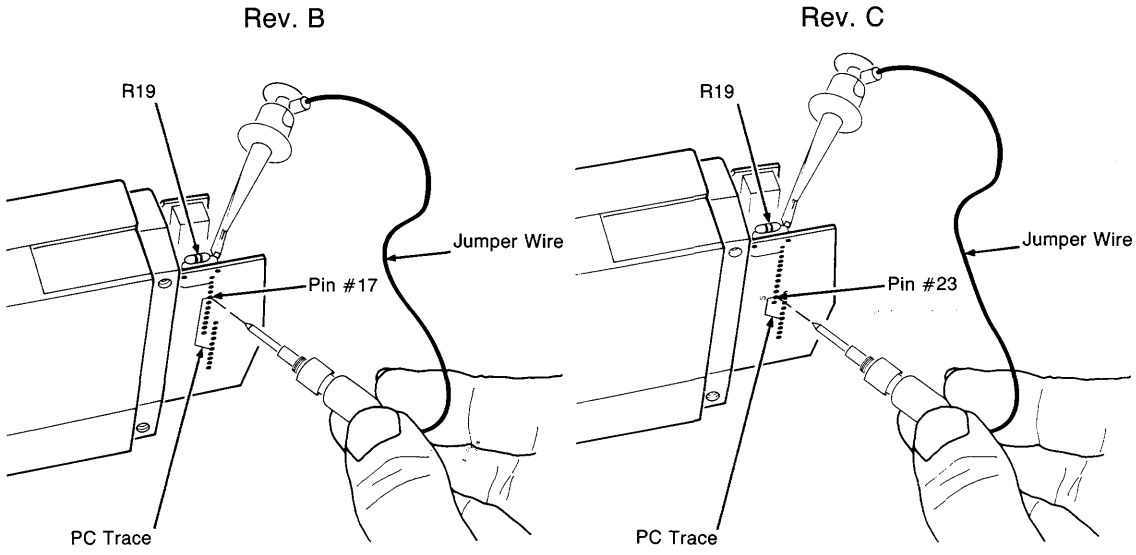


Figure 4-2. Jumper placement for a synchronizing reset

6A. If a synchronizing reset is necessary, you should very briefly touch +5 volts to the synchronizing pin of the clock chip (U15). Refer to Figure 4-2 above. Get a jumper wire or test lead with a miniature clip on one end. Attach the clip to the lead of R19 that is closest to the upper corner of the processor board. Then **very briefly** touch the other end of the jumper wire to the synchronizing pin of U15. To locate this pin, it is very important to **note the revision letter** of the processor board. **Rev-A and Rev-B** boards (left-hand drawing) use **pin #17**, identified by the vertical trace running to it on the circuit side of the PC board. **Rev-C and Rev-D** boards (right-hand drawing) use **pin #23**, identified by the "S" placed by it on the circuit side of the PC board. Do not attach the wire to U15; do not hold the wire on U15; and do not touch the wire to any other pin except the proper synchronizing pin. After you have applied a brief pulse to the proper pin, remove the jumper wire from R19.

7. Adjust the 32.768 kHz trimming capacitor to set the period indication as close to 5859.180 μs as possible. The recommended limits are 5859.170 μs and 5859.190 μs.
8. After the adjustment has been made, you must return the clock chip to its normal condition. This can be done by outputting an "X" instruction from the computer to the Real Time Clock or by pressing "RESET" on the computer.
9. Remove the test leads; replace the connector and the rear housing.

General Troubleshooting Hints

If your Real Time Clock is not functioning properly, check first for poor connections. With power off, remove the 98035A from the computer. Using a soft eraser, gently clean the PC board contact strip which connects to the computer. Reinstall the Real Time Clock, insuring that it is firmly seated. Check its operation again; sometimes an interface can be "repaired" by this simple cleaning.

The troubleshooting of a defective Real Time Clock can be simplified if you have access to a known-good unit. Since the clock has two circuit boards, the initial troubleshooting step is isolating the defective board. By interchanging one of the circuit boards with the good unit, the trouble can be quickly isolated at the board level.

Isolating a defective board without the help of another 98035A can be more difficult. Problems relating to the maintenance of real time during battery operation indicate a defective processor board. Problems relating to the recognition of select code or interrupt poll usually point to the interface board. However, almost all 98035A operations involve some action from the processor. Also, the components on the interface board have a very good reliability history. This increases the odds that a given problem will be on the processor board. Keep in mind, however, that the time base for the processor is on the interface board. Do not suspect the processor board until you have verified that it is getting the necessary 1 MHz and 1 KHz clock signals. These and other internal signals are most easily viewed by removing the plastic housing from the clock and connecting the boards to the computer with an interface expander board (P/N 98241-67901). Signal paths can be traced using the schematic and component locator diagrams at the end of this chapter.

Another troubleshooting tool is the 98035A test available on those System Exerciser tapes produced since the introduction of the Real Time Clock. For test details, check the appropriate System Exerciser Booklet for your model of desktop computer. Note that these tests will work only when the test connector (P/N 98241-67935) is installed on the rear of the processor board.

Repair and Troubleshooting of the Processor Board

Handling Cautions

The processor board contains a battery that maintains power to parts of the board at all times. Do not set the processor board on a metallic surface or short any circuit traces. Shorting the battery could result in damage to the battery or the circuit board or both.

Never apply power to the 98035A if the battery is removed. This will damage the clock chip (U15).

The processor chip (U3), the ROM chip (U1), and the RAM chips (U6 & U8) are vulnerable to damage from static discharge. If one of these chips is removed, put it in conductive foam or wrap it with aluminum foil.

Whenever an integrated circuit is installed, be sure that pin #1 is properly oriented. Installing a chip backwards can damage that chip and others connected to it. The circuit board has a square pad to indicate the location of pin #1 for each chip.

Processor Replacement

The processor chip (U3) is marked with a specific value of back-bias voltage. This voltage may not be the same for all chips and will be within the range of −2.0 volts to −5.0 volts. When replacing the processor chip, check to see if the voltage marked on the replacement is the same as the voltage marked on the original. If both chips have the same back-bias requirement, then a direct replacement can be made. If the new processor is marked with a different voltage, the bias network **must** be adjusted before the new processor can be operated. This adjustment is made by changing R2. The proper value for R2 can be determined by checking the following table.

Back-Bias Voltage	R2 Resistance Value (ohms)	Resistor Part Number
−2.0	365	0757-0412
−2.5	475	0757-0415
−3.0	604	0757-0161
−3.5	750	0757-0420
−4.0	909	0757-0422
−4.5	1100	0757-0424
−5.0	1300	0757-0426

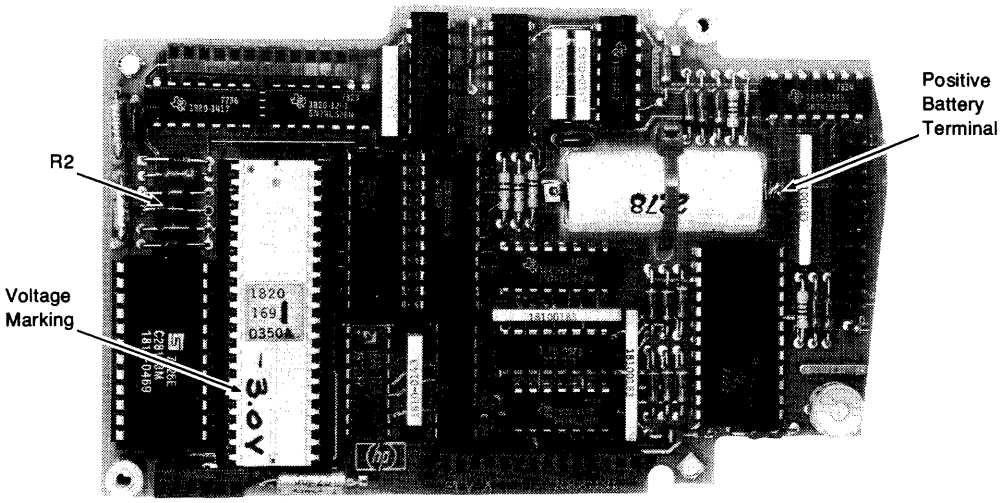


Figure 4-3. Top view of the processor board

Refer to Figure 4-3 and the A2 board component locator to determine the location of R2. Most processor boards have solderless connectors for the leads of R2. If your board has these connectors, simply remove the old resistor, trim and bend the leads of the new resistor, and insert it into the connector holes. Some early versions of the processor board have R2 soldered in place. If you need to unsolder R2, use a low-power soldering iron and work very carefully.

98035A RAM Testing

The Real Time Clock performs a self-test during power-on or RESET initialization. This self-test includes a test of the CMOS memory on the processor board. If only a small number of errors are found, the processor has the capability of by-passing the bad section of memory during normal operation. However, any memory error could be indicative of intermittant operation or pending failure. It is a good practice to replace the RAM chips at the first sign of error. A special instruction has been provided to return the results of the automatic RAM test performed during initialization. To obtain the results of this test, follow this sequence:

1. With the 98035A plugged in and the computer turned on, press "RESET" on the computer. Wait ten seconds.
2. Output a "J" instruction from the computer to the clock.
3. Output the number 62 using **binary** format.
4. Perform a **binary** read operation from the clock to any variable.
5. Print or display that variable. If the clock's memory is good, that variable will be "0". Any value other than zero indicates some form of memory error.

Battery Testing and Replacement

If the 98035A fails to maintain the real time while the computer is shut off, the problem might be in the clock chip (U15), the battery, or the battery charging circuit. To isolate the exact cause, some battery tests are necessary. The battery tests should be performed with the plastic housing removed and the clock installed on an extender board (P/N 98241-67901). This setup provides easy access to both battery terminals.

Measure the voltage of the battery with computer power turned off. Then turn on the computer and measure the battery voltage while it is being trickle charged. A good battery should indicate between 1.8 volts and 2.8 volts without charging current and the voltage should rise at least 200 mv after a few minutes of charging. If the battery voltages are acceptable, but the clock does not maintain the real time while battery powered, suspect the clock chip (U15). If the battery voltage does not rise when charging current is applied, suspect the battery charging circuit (R18 and CR2). If the battery voltage is below 1.5 volts, the battery is probably defective. If the battery voltage raises above 3.2 volts when power is applied, the battery is probably defective and the clock chip may be damaged. If the battery voltage is below 2.0 volts, but rises as charging current is applied, the battery is severely discharged. In this case, leave the power on for a couple of hours to allow the battery a chance to recover, then repeat the tests. The complete recharging of a "dead" battery can take as long as 16 hours.

If you need to replace the battery, work carefully. Use a low-power soldering iron to unsolder the battery tabs from the PC board.

CAUTION

DO NOT ATTEMPT TO UNSOLDER THE TABS FROM THE BATTERY. NEVER APPLY POWER TO THE 98035A WHEN THE BATTERY IS REMOVED. BE SURE TO MAINTAIN PROPER BATTERY POLARITY.

Double check the polarity of the new battery before installing it in the circuit. The negative terminal is the one attached to the flat outer case of the battery. The positive terminal is centered on the end of the battery and is slightly rounded.

Replaceable Parts List

REFERENCE DESIGNATOR	–hp– PART NO.	CK DG	TQ	DESCRIPTION
A1	**98035-66501**	**6**	**1**	**Interface Assembly**
C1,C2	0160-3847	9	2	C: fxd .01μf 50V
C3	0180-0106	9	1	C: fxd 60μf 6V
C4,C5,C9	0160-3622	8	3	C: fxd 0.1μf
C6			1	C:fxd, selected value
	0140-0190	7		39 pf 300 V
	0160-2307	2		47 pf 300 V
	0140-0191	8		56 pf 300 V
	0140-0192	9		68 pf 300 V
	0140-0193	0		82 pf 300 V
C7	0160-0205	7	1	C:fxd 10 pf 500 V
C8	0121-0180	5	1	C: trimmer, 15-60pf
CR1,CR3	1901-0040	1	2	Diode, Si. 50ma 30V
CR2	1902-3160	4	1	Diode, Zener, 10.0V
P1-P3	1251-4326	5	1	Connector, 36 pin
Q1	1853-0016	8	1	Transistor, PNP, 2N3638
Q2	1854-0071	7	1	Transistor, NPN, SPS5103
R1	0683-5615	1	1	R: fxd 560ohm 5%
R2,R5	0683-2025	1	2	R: fxd 2.0K 5%
R3	0683-5625	3	1	R: fxd 5.6K 5%
R4	0683-1065	7	1	R: fxd 10Meg 5%
R6	0683-2415	3	1	R: fxd 240ohm 5%
R7	0683-1005	5	1	R: fxd 10ohm 5%
R8	0683-7545	0	1	R: fxd 750K 5%
R9	0698-3132	4	1	R: fxd 261ohm 1%
R10	1810-0326	3	1	Resistor-Diode Network
R11	1810-0143	2	1	Resistor Network, 3.3K
S1	3100-3364	2	1	Switch, Hex
U1	1820-1297	0	1	IC: 74LS266
U2	1820-1198	0	1	IC: 74LS03
U3	1820-1427	8	1	IC: 74LS156
U4,U5,U9,U10	1820-1296	9	4	IC: 74LS295A
U6	1820-1199	1	1	IC: 74LS04
U7	1820-1284	5	1	IC: 74LS55
U8	1820-1491	6	1	IC: 74LS367
U11	1820-1245	8	1	IC: 74LS155
U12	1820-1440	5	1	IC: 74LS279
U13	1820-1112	8	1	IC: 74LS74
U14	1820-1492	7	1	IC: 74LS368
U15	1820-1592	8	1	IC: MC14069
U16,U19	1820-1122	0	2	IC: MC14518
U17	1820-1425	6	1	IC: 74LS132
U18	1820-1216	3	1	IC: 74LS138
Y1	0410-0142	2	1	Crystal, 1.0000 MHz

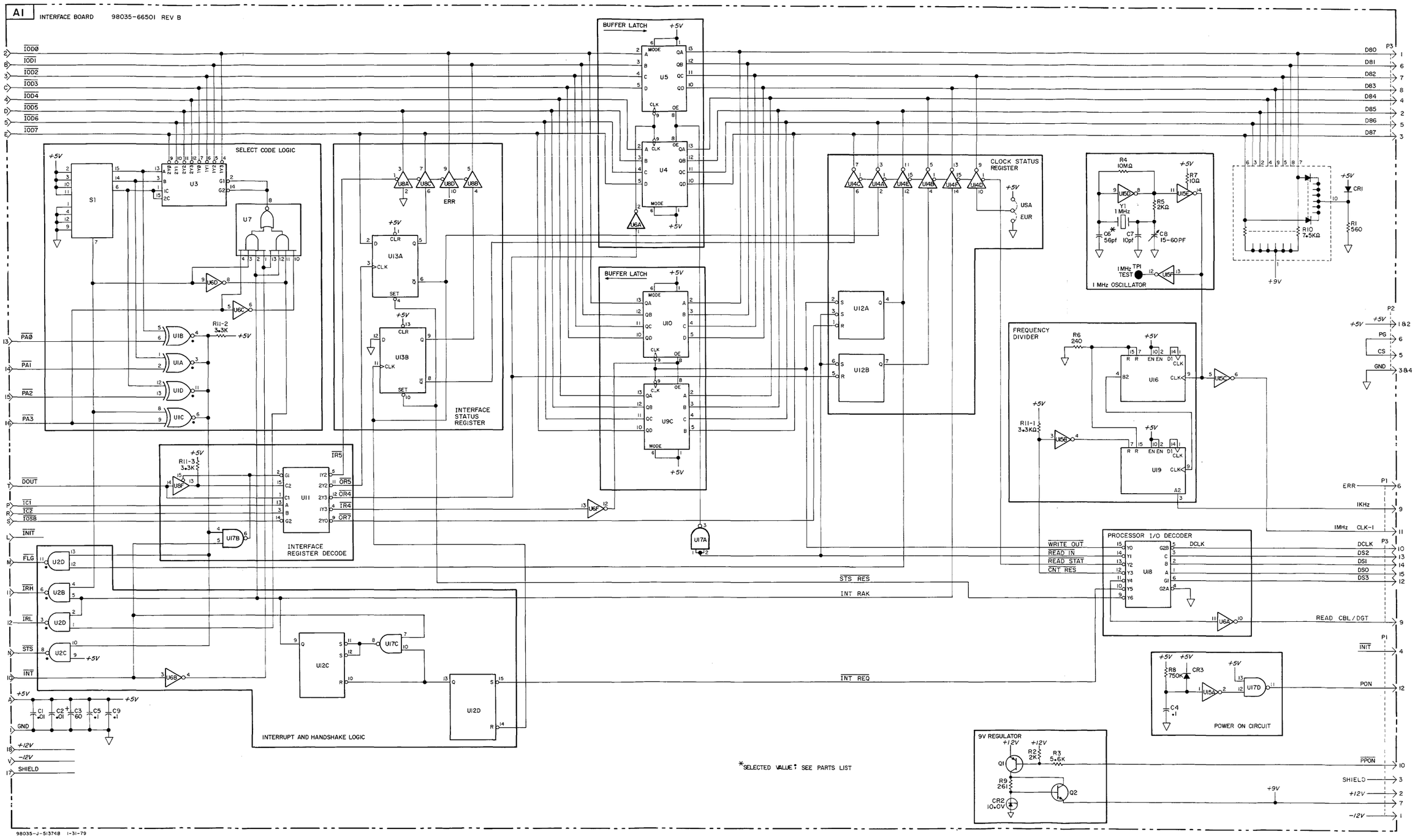
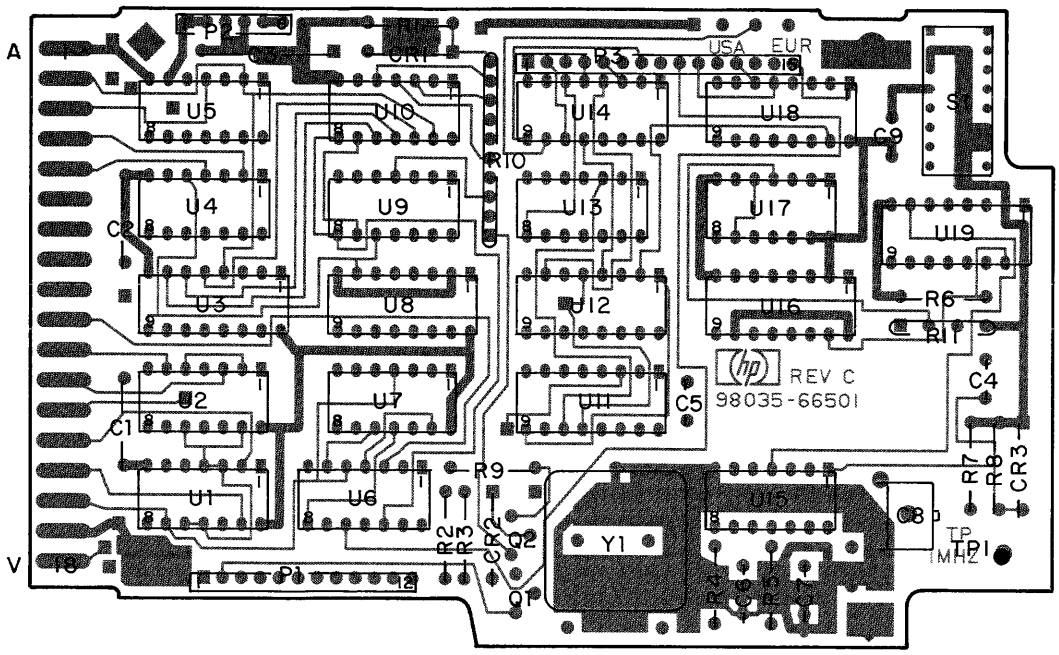


Figure 4-4. A1 Interface Board Circuit Diagram



COMPONENT SIDE

A1

-hp- Part No. 98035-66501 Rev B,C

Replaceable Parts List (cont.)

REFERENCE DESIGNATOR	-hp- PART NO.	CK DG	TQ	DESCRIPTION
	98035-61601	**7**	**1**	**Standard Connector**
	1251-4332	3	1	Connector Housing
	1251-0688	4	8	Connector Terminal
	1251-3808	6	1	Polarizing Plug
	98241-67935	**2**	**0**	**Test Connector**
	1251-4332	3	1	Connector Housing
	1251-0688	4	8	Connector Terminal
	1251-3808	6	1	Polarizing Plug
	98035-61600	**6**	**1**	**Option 100 Cable Assembly**
	5040-7859	2	1	Molded Cable
	1251-4332	3	1	Connector Housing
	1251-0688	4	18	Connector Terminal
	1251-3808	6	1	Polarizing Plug
				Front Housing
	5040-8163	3	1	Case, Right
	5040-8161	1	1	Case, Left
	5040-8158	6	1	Spring-latch
	2200-0536	5	4	Screw, 4-40x.44
				Rear Housing
	5040-7998	0	1	Case, Right
	5040-8174	6	1	Case, Left
	2200-0510	5	2	Screw, 4-40
	2200-0536	5	4	Screw, 4-40x.44
	7120-6747	7	1	Label, ID

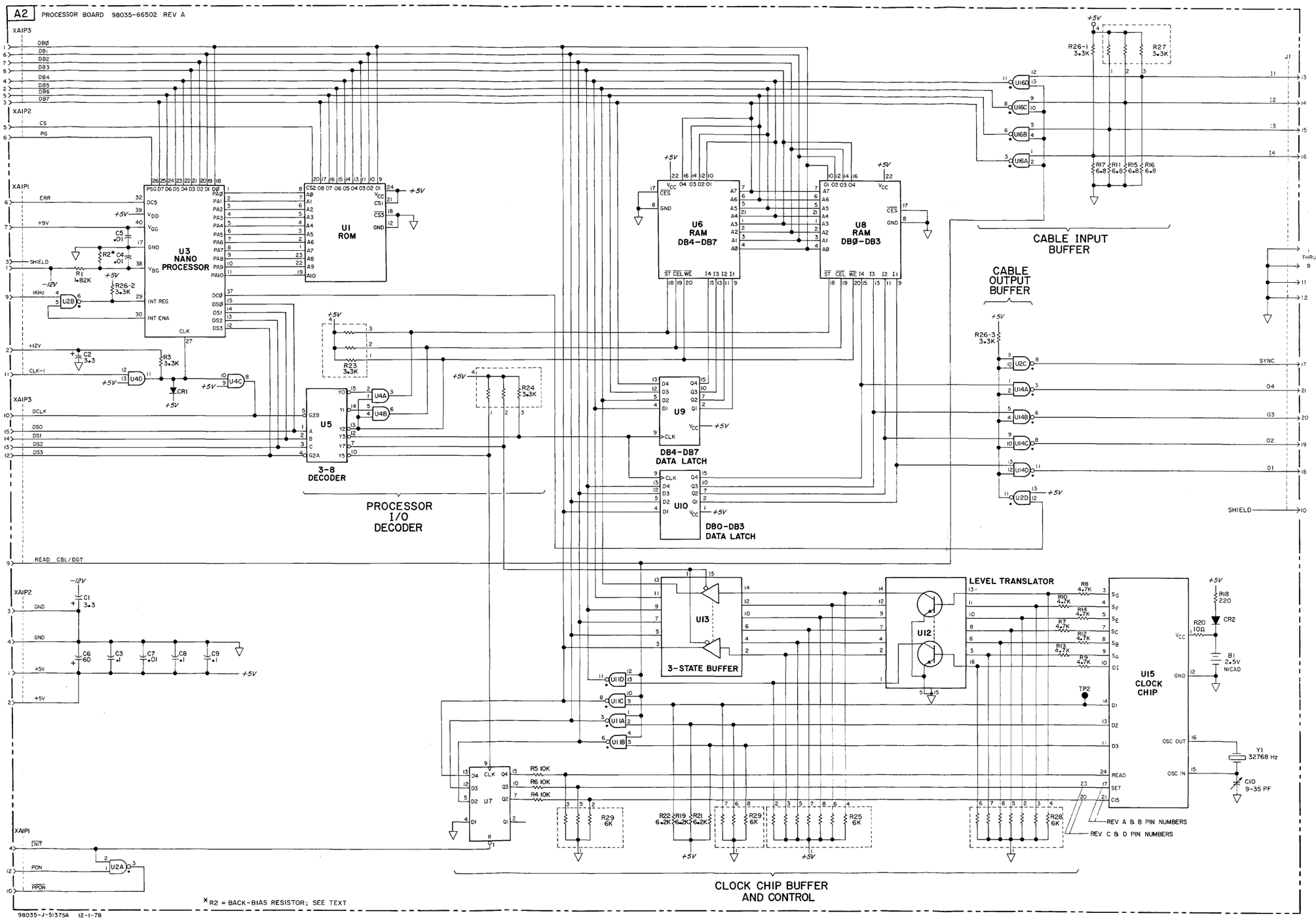
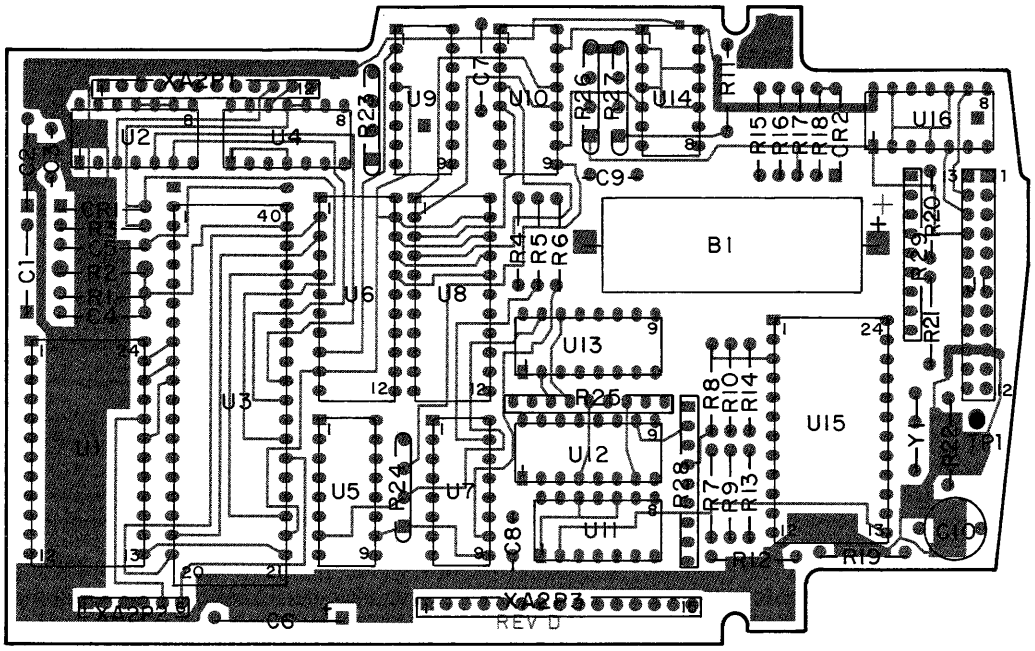


Figure 4-5. A2 Processor Board Circuit Diagram



COMPONENT SIDE

A2

-hp- Part No. 98035-66502 Rev B,C,D

Appendix

98035A Instruction Set

Instruction	Description
"A"	Halt all units (also disables interrupts)
"B"	Fast initialize
"C"	Clear selected counter
"D"	Delay interval specification (needs data delimiter)
"E"	Error code request
"F"	Activate all units synchronously
"G"	Activate selected unit (unit must be assigned)
"H"	Halt selected unit (unit must be assigned)
"I"	Assign unit to selected input port
"J"	Read RAM location
"K"	(Reserved for factory use)
"L"	Enable selected external output lines
"M"	Match time specification (needs data delimiter)
"N"	Read external input lines
"O"	Assign unit to selected output port
"P"	Periodic interval specification (needs data delimiter)
"Q"	Activate clock chip test point
"R"	Real time request
"S"	Set real time (needs data delimiter)
"T"	Trigger code request
"U"	Unit selection specification
"V"	Selected counter value request
"W"	Missed interrupt code request
"X"	Deactivate clock chip test point
"Y"	(Reserved for factory use)
"Z"	No operation
"="	Unit assignment specification
"/"	Data delimiter
LF	Data delimiter

ASCII Character Codes

ASCII Char.	EQUIVALENT FORMS			
	Binary	Oct	Hex	Dec
NULL	00000000	000	00	0
SOH	00000001	001	01	1
STX	00000010	002	02	2
ETX	00000011	003	03	3
EOT	00000100	004	04	4
ENQ	00000101	005	05	5
ACK	00000110	006	06	6
BELL	00000111	007	07	7
BS	00001000	010	08	8
HT	00001001	011	09	9
LF	00001010	012	0A	10
VT	00001011	013	0B	11
FF	00001100	014	0C	12
CR	00001101	015	0D	13
SO	00001110	016	0E	14
SI	00001111	017	0F	15
DLE	00010000	020	10	16
DC1	00010001	021	11	17
DC2	00010010	022	12	18
DC3	00010011	023	13	19
DC4	00010100	024	14	20
NAK	00010101	025	15	21
SYNC	00010110	026	16	22
ETB	00010111	027	17	23
CAN	00011000	030	18	24
EM	00011001	031	19	25
SUB	00011010	032	1A	26
ESC	00011011	033	1B	27
FS	00011100	034	1C	28
GS	00011101	035	1D	29
RS	00011110	036	1E	30
US	00011111	037	1F	31

ASCII Char.	EQUIVALENT FORMS			
	Binary	Oct	Hex	Dec
space	00100000	040	20	32
!	00100001	041	21	33
"	00100010	042	22	34
#	00100011	043	23	35
$	00100100	044	24	36
%	00100101	045	25	37
&	00100110	046	26	38
'	00100111	047	27	39
(	00101000	050	28	40
)	00101001	051	29	41
*	00101010	052	2A	42
+	00101011	053	2B	43
,	00101100	054	2C	44
-	00101101	055	2D	45
.	00101110	056	2E	46
/	00101111	057	2F	47
0	00110000	060	30	48
1	00110001	061	31	49
2	00110010	062	32	50
3	00110011	063	33	51
4	00110100	064	34	52
5	00110101	065	35	53
6	00110110	066	36	54
7	00110111	067	37	55
8	00111000	070	38	56
9	00111001	071	39	57
:	00111010	072	3A	58
;	00111011	073	3B	59
<	00111100	074	3C	60
=	00111101	075	3D	61
>	00111110	076	3E	62
?	00111111	077	3F	63

ASCII Char.	EQUIVALENT FORMS			
	Binary	Oct	Hex	Dec
@	01000000	100	40	64
A	01000001	101	41	65
B	01000010	102	42	66
C	01000011	103	43	67
D	01000100	104	44	68
E	01000101	105	45	69
F	01000110	106	46	70
G	01000111	107	47	71
H	01001000	110	48	72
I	01001001	111	49	73
J	01001010	112	4A	74
K	01001011	113	4B	75
L	01001100	114	4C	76
M	01001101	115	4D	77
N	01001110	116	4E	78
O	01001111	117	4F	79
P	01010000	120	50	80
Q	01010001	121	51	81
R	01010010	122	52	82
S	01010011	123	53	83
T	01010100	124	54	84
U	01010101	125	55	85
V	01010110	126	56	86
W	01010111	127	57	87
X	01011000	130	58	88
Y	01011001	131	59	89
Z	01011010	132	5A	90
[	01011011	133	5B	91
\	01011100	134	5C	92
]	01011101	135	5D	93
^	01011110	136	5E	94
_	01011111	137	5F	95

ASCII Char.	EQUIVALENT FORMS			
	Binary	Oct	Hex	Dec
`	01100000	140	60	96
a	01100001	141	61	97
b	01100010	142	62	98
c	01100011	143	63	99
d	01100100	144	64	100
e	01100101	145	65	101
f	01100110	146	66	102
g	01100111	147	67	103
h	01101000	150	68	104
i	01101001	151	69	105
j	01101010	152	6A	106
k	01101011	153	6B	107
l	01101100	154	6C	108
m	01101101	155	6D	109
n	01101110	156	6E	110
o	01101111	157	6F	111
p	01110000	160	70	112
q	01110001	161	71	113
r	01110010	162	72	114
s	01110011	163	73	115
t	01110100	164	74	116
u	01110101	165	75	117
v	01110110	166	76	118
w	01110111	167	77	119
x	01111000	170	78	120
y	01111001	171	79	121
z	01111010	172	7A	122
{	01111011	173	7B	123
|	01111100	174	7C	124
}	01111101	175	7D	125
~	01111110	176	7E	126
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